

|                                                                                                                              |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
|------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-------------------------------------------------------|---------------|--------|-------------------------------|-----------------|-------------------|-----------------|------------|------|-------------------|----|
| CONSULTING ENGINEERS                                                                                                         |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |               |        |                               | Job No.         | Sheet No.         |                 | Rev.       |      |                   |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               | jXXX            | 1                 |                 |            |      |                   |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               | Member/Location |                   |                 |            |      |                   |    |
| Job Title                                                                                                                    | Member Design - Reinforced Concrete Beam BS8110, |                                                       |               |        |                               | Drg. Ref.       |                   |                 |            |      |                   |    |
| Member Design - RC Beam                                                                                                      |                                                  |                                                       |               |        |                               | Made by         | XX                | Date            | 24/10/2026 | Chd. |                   |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Effects From Structural Analysis                                                                                             |                                                  |                                                       |               |        | Do not adopt code equivalence |                 |                   | ▼               |            |      |                   |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Design axial force, F (tension -ve and comp. +ve) (ensure < 0.1f <sub>cu</sub> b <sub>w</sub> h)                             |                                                  |                                                       |               |        |                               |                 | 0                 | kN              | OK         |      |                   |    |
| Design shear force, V <sub>d</sub>                                                                                           |                                                  |                                                       | Full shear Vd | ▼      | 2.00d                         | ▼               | 30.0              | 1170            | kN         |      |                   |    |
| Design bending moment, M                                                                                                     |                                                  |                                                       |               |        |                               |                 | 1849              | kNm             |            |      |                   |    |
| Design torsion moment, T                                                                                                     |                                                  |                                                       |               |        |                               |                 | 0                 | kNm             |            |      |                   |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Material Properties                                                                                                          |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Characteristic strength of concrete, f <sub>cu</sub> / f <sub>ck</sub>   f <sub>c</sub> ' (f <sub>cu</sub> ≤ 75 or 105N/     |                                                  |                                                       |               |        |                               |                 | 35                | ▼               | 28         | ▼    | N/mm <sup>2</sup> | OK |
| Yield strength of longitudinal steel, f <sub>y</sub>                                                                         |                                                  |                                                       |               |        |                               |                 | Higher            | ▼               | 500        | ▼    | N/mm <sup>2</sup> |    |
| Yield strength of shear and torsion link steel, f <sub>yv</sub>                                                              |                                                  |                                                       |               |        |                               |                 | Higher            | ▼               | 500        | ▼    | N/mm <sup>2</sup> |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Section Dimensions                                                                                                           |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Span (effective width, deflection, long'l shear and deep beam calcs)                                                         |                                                  |                                                       |               |        |                               |                 | 10.000            | m               |            |      |                   |    |
| Available beam spacing                                                                                                       |                                                  |                                                       |               |        |                               |                 | 1.000             | m               |            |      |                   |    |
| (effective width calcs; usual spacing for interior beams; half for edge beams)                                               |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Beam section type and support condition                                                                                      |                                                  |                                                       |               |        |                               |                 | Rect - continuous | ▼               |            |      |                   |    |
| (section type for bending, defl'n calcs; support condition for LTB restraint, eff width, defl'n, long'l shear calcs)         |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Ratio β <sub>b</sub> (1.0 for no moment redistribution, ≥0.70, ≤1.30)                                                        |                                                  |                                                       |               |        |                               |                 | 1.00              |                 | OK         |      |                   |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Section Type and Support Condition Option Selection                                                                          |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Downstand Beam                                                                                                               |                                                  |                                                       |               |        | Upstand Beam                  |                 |                   |                 |            |      |                   |    |
| Support                                                                                                                      | Effect                                           | Slab                                                  | Type          | Defl'n | Support                       | Effect          | Slab              | Type            | Defl'n     |      |                   |    |
| S/S                                                                                                                          | Sag                                              | Precast                                               | Rect-s/s      | Yes    | S/S                           | Sag             | Precast           | Rect-s/s        | Yes        |      |                   |    |
| S/S                                                                                                                          | Sag                                              | Insitu                                                | T/L-s/s       | Yes    | S/S                           | Sag             | Insitu            | Rect-s/s        | Yes        |      |                   |    |
| Cont.                                                                                                                        | Sag                                              | Precast                                               | Rect-cont.    | Yes    | Cont.                         | Sag             | Precast           | Rect-cont.      | Yes        |      |                   |    |
| Cont.                                                                                                                        | Sag                                              | Insitu                                                | T/L-cont.     | Yes    | Cont.                         | Sag             | Insitu            | Rect-cont.      | Yes        |      |                   |    |
| Cont.                                                                                                                        | Hog                                              | Precast                                               | Rect-cont.    | N/A    | Cont.                         | Hog             | Precast           | Rect-cont.      | N/A        |      |                   |    |
| Cont.                                                                                                                        | Hog                                              | Insitu                                                | Rect-cont.    | N/A    | Cont.                         | Hog             | Insitu            | T/L-cont.       | N/A        |      |                   |    |
| Cant.                                                                                                                        | Hog                                              | Precast                                               | Rect-cant.    | Yes    | Cant.                         | Hog             | Precast           | Rect-cant.      | Yes        |      |                   |    |
| Cant.                                                                                                                        | Hog                                              | Insitu                                                | Rect-cant.    | Yes    | Cant.                         | Hog             | Insitu            | T/L-cant.       | Yes        |      |                   |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Overall depth, h (includes insitu slab thks; excludes precast slab thks; span/                                               |                                                  |                                                       |               |        |                               |                 | 1000              | mm              | OK         |      |                   |    |
| Depth of flange, h <sub>f</sub> (bending flanged beam, longitudinal shear calcs)                                             |                                                  |                                                       |               |        |                               |                 | 200               | mm              |            |      |                   |    |
| Width (rectangular) or web width (flanged), b <sub>w</sub>                                                                   |                                                  |                                                       |               |        |                               |                 | 500               | mm              |            |      |                   |    |
| Cover to all reinforcement, cover (usually 35 (C35) or 30 (C40) internal; 40                                                 |                                                  |                                                       |               |        |                               |                 | 25                | mm              |            |      |                   |    |
| Add cover to tension steel (due to transverse steel layer(s)), cover <sub>add,t</sub>                                        |                                                  |                                                       |               |        |                               |                 | 0                 | mm              |            |      |                   |    |
| Add cover to compression steel (due to transverse steel layer(s)), cover <sub>add,c</sub>                                    |                                                  |                                                       |               |        |                               |                 | 0                 | mm              |            |      |                   |    |
| Effective depth to tension steel, d = h - cover - MAX(φ <sub>link,r</sub> φ <sub>link,t,r</sub> cover <sub>add,t</sub> ) - [ |                                                  |                                                       |               |        |                               |                 | 917               | mm              |            |      |                   |    |
| Effective depth to compression steel, d' = cover + MAX(φ <sub>link,r</sub> φ <sub>link,t,r</sub> cover <sub>add,c</sub> )    |                                                  |                                                       |               |        |                               |                 | 35                | mm              |            |      |                   |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Longitudinal Reinforcement Details                                                                                           |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |
| Tension steel reinforcement diameter, φ <sub>t</sub>                                                                         |                                                  |                                                       |               |        |                               |                 | 32                | ▼               | mm         |      |                   |    |
| Tension steel reinforcement number, n <sub>t</sub>                                                                           |                                                  |                                                       |               |        |                               |                 | 8                 |                 |            |      |                   |    |
| Tension steel area provided, A <sub>s,prov</sub> = n <sub>t</sub> .π.φ <sub>t</sub> <sup>2</sup> /4                          |                                                  |                                                       |               |        |                               |                 | 6434              | mm <sup>2</sup> |            |      |                   |    |
| Compression steel reinforcement diameter, φ <sub>c</sub> (where applicable)                                                  |                                                  |                                                       |               |        |                               |                 | None              | ▼               | mm         |      |                   |    |
| Compression steel reinforcement number, n <sub>c</sub>                                                                       |                                                  |                                                       |               |        |                               |                 | 0                 |                 |            |      |                   |    |
| Compression steel area provided, A <sub>s,prov</sub> ' = n <sub>c</sub> .π.φ <sub>c</sub> <sup>2</sup> /4                    |                                                  |                                                       |               |        |                               |                 | 0                 | mm <sup>2</sup> |            |      |                   |    |
| Number of layers of tension steel, n <sub>layers,tens</sub>                                                                  |                                                  |                                                       |               |        |                               |                 | 2                 | layer(s)        |            |      |                   |    |
| Spacer for tension steel, s <sub>r,tens</sub> (≥ MAX (φ <sub>t,r</sub> 25mm))                                                |                                                  |                                                       |               |        |                               |                 | 32                | mm              | OK         |      |                   |    |
| Number of layers of compression steel, n <sub>layers,comp</sub>                                                              |                                                  |                                                       |               |        |                               |                 | 1                 | layer(s)        |            |      |                   |    |
| Spacer for compression steel, s <sub>r,comp</sub> = MAX (φ <sub>c,r</sub> 25mm)                                              |                                                  |                                                       |               |        |                               |                 | 25                | mm              |            |      |                   |    |
|                                                                                                                              |                                                  |                                                       |               |        |                               |                 |                   |                 |            |      |                   |    |

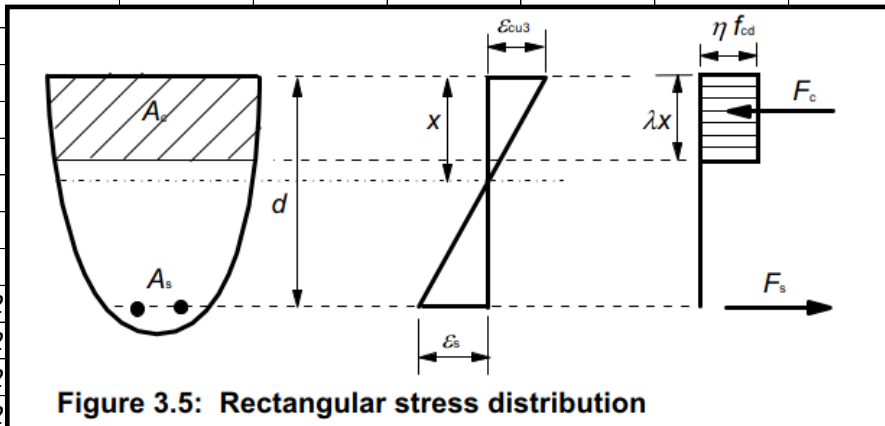
|                                                                                                          |                                                                                                                                                                                                   |                                                       |             |     |                      |                 |           |                   |                 |        |      |
|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|-------------|-----|----------------------|-----------------|-----------|-------------------|-----------------|--------|------|
| CONSULTING<br>ENGINEERS                                                                                  |                                                                                                                                                                                                   | Engineering Calculation Sheet<br>Consulting Engineers |             |     |                      | Job No.         | Sheet No. |                   | Rev.            |        |      |
|                                                                                                          |                                                                                                                                                                                                   |                                                       |             |     |                      | jXXX            | 2         |                   |                 |        |      |
|                                                                                                          |                                                                                                                                                                                                   |                                                       |             |     |                      | Member/Location |           |                   |                 |        |      |
| Job Title                                                                                                | Member Design - Reinforced Concrete Beam BS8110,                                                                                                                                                  |                                                       |             |     |                      | Org. Ref.       |           |                   |                 |        |      |
| Member Design - RC Beam                                                                                  |                                                                                                                                                                                                   |                                                       |             |     |                      | Made by         | XX        | Date              | 24/10/2026      |        | Chd. |
|                                                                                                          |                                                                                                                                                                                                   |                                                       |             |     |                      |                 |           |                   |                 |        |      |
| Shear Reinforcement Details                                                                              |                                                                                                                                                                                                   |                                                       |             |     |                      |                 |           |                   |                 |        |      |
|                                                                                                          |                                                                                                                                                                                                   |                                                       |             |     |                      |                 |           |                   |                 |        |      |
| Shear link diameter, $\phi_{link}$                                                                       |                                                                                                                                                                                                   |                                                       |             |     |                      | 10              | ▼         | mm                |                 |        |      |
| Number of shear links in a cross section, i.e. number of legs, $n_{leg}$                                 |                                                                                                                                                                                                   |                                                       |             |     |                      |                 | 4         |                   |                 |        |      |
| Area provided by all shear links in a cross-section, $A_{sv,prov} = \pi.\phi_{link}^2/4.n_{leg}$         |                                                                                                                                                                                                   |                                                       |             |     |                      |                 | 314       |                   | mm <sup>2</sup> |        |      |
| Pitch of shear links, S                                                                                  |                                                                                                                                                                                                   |                                                       |             |     |                      |                 | 100       |                   | mm              |        |      |
|                                                                                                          |                                                                                                                                                                                                   |                                                       |             |     |                      |                 |           |                   |                 |        |      |
| Torsion Reinforcement Details                                                                            |                                                                                                                                                                                                   |                                                       |             |     |                      |                 |           |                   |                 |        |      |
|                                                                                                          |                                                                                                                                                                                                   |                                                       |             |     |                      |                 |           |                   |                 |        |      |
| Torsion link diameter, $\phi_{link,t}$                                                                   |                                                                                                                                                                                                   |                                                       |             |     |                      | None            | ▼         | mm                |                 |        |      |
| Number of torsion links in a cross section, i.e. number of legs, $n_{leg,t} = 2$                         |                                                                                                                                                                                                   |                                                       |             |     |                      |                 | 2         |                   |                 |        |      |
| Area provided by all torsion links in a cross-section, $A_{sv,prov,t} = \pi.\phi_{link,t}^2/4.n_{leg,t}$ |                                                                                                                                                                                                   |                                                       |             |     |                      |                 | 0         |                   | mm <sup>2</sup> |        |      |
| Pitch of torsion links, $S_t$                                                                            |                                                                                                                                                                                                   |                                                       |             |     |                      |                 | 0         |                   | mm              |        |      |
| Add. longitudinal steel (for torsion), $A_{s,t}$                                                         |                                                                                                                                                                                                   | 0                                                     | 0           | 0   | 0                    | 0               |           | mm <sup>2</sup>   |                 |        |      |
|                                                                                                          |                                                                                                                                                                                                   |                                                       |             |     |                      |                 |           |                   |                 |        |      |
| Utilisation Summary                                                                                      |                                                                                                                                                                                                   |                                                       |             |     |                      |                 |           |                   |                 |        |      |
|                                                                                                          |                                                                                                                                                                                                   |                                                       |             |     |                      |                 |           |                   |                 |        |      |
|                                                                                                          | Item                                                                                                                                                                                              |                                                       |             |     |                      | UT              | Remark    |                   |                 |        |      |
|                                                                                                          | RB tens steel                                                                                                                                                                                     |                                                       | 86%         | 86% | 79%                  | 86%             | OK        |                   |                 |        |      |
|                                                                                                          | RB comp steel                                                                                                                                                                                     |                                                       | N/A         | N/A | N/A                  | N/A             | N/A       |                   |                 |        |      |
|                                                                                                          | RB % min tens reinf.                                                                                                                                                                              |                                                       | 10%         | 10% | 20%                  | 20%             | OK        |                   |                 |        |      |
|                                                                                                          | RB % min comp reinf.                                                                                                                                                                              |                                                       | N/A         | N/A |                      | N/A             | N/A       |                   |                 |        |      |
|                                                                                                          | RB % max tens and c                                                                                                                                                                               |                                                       | 32%         | 32% |                      | 32%             | OK        |                   |                 |        |      |
|                                                                                                          | FB tens steel                                                                                                                                                                                     |                                                       | N/A         | N/A |                      | N/A             | N/A       |                   |                 |        |      |
|                                                                                                          | FB comp steel                                                                                                                                                                                     |                                                       | N/A         | N/A |                      | N/A             | N/A       |                   |                 |        |      |
|                                                                                                          | FB % min tens reinf.                                                                                                                                                                              |                                                       | N/A         | N/A |                      | N/A             | N/A       |                   |                 |        |      |
|                                                                                                          | FB % min comp reinf.                                                                                                                                                                              |                                                       | N/A         | N/A |                      | N/A             | N/A       |                   |                 |        |      |
|                                                                                                          | FB % max tens and c                                                                                                                                                                               |                                                       | N/A         | N/A |                      | N/A             | N/A       |                   |                 |        |      |
|                                                                                                          | RB shear ultimate str                                                                                                                                                                             |                                                       | 54%         | 57% | 77%                  | 77%             | OK        |                   |                 |        |      |
|                                                                                                          | RB shear design capa                                                                                                                                                                              |                                                       | 72%         | 66% | 94%                  | 94%             | OK        |                   |                 |        |      |
|                                                                                                          | RB torsion ultimate st                                                                                                                                                                            |                                                       | 0%          | 0%  | 0%                   | 0%              | OK        |                   |                 |        |      |
|                                                                                                          | RB torsion design cap                                                                                                                                                                             |                                                       | 0%          | 0%  | 0%                   | 0%              | OK        |                   |                 |        |      |
|                                                                                                          | RB shear and torsion                                                                                                                                                                              |                                                       | 72%         | 66% | 94%                  | 94%             | OK        |                   |                 |        |      |
|                                                                                                          | RB or FB deflection re                                                                                                                                                                            |                                                       | 49%         | 62% | 43%                  | 62%             | OK        |                   |                 |        |      |
|                                                                                                          | Total utilisation rectangular beam                                                                                                                                                                |                                                       |             |     |                      | 94%             | OK        |                   |                 |        |      |
|                                                                                                          | Total utilisation rectangular beam (excluding def                                                                                                                                                 |                                                       |             |     |                      | 94%             | OK        |                   |                 |        |      |
|                                                                                                          | Total utilisation flanged beam                                                                                                                                                                    |                                                       |             |     |                      | N/A             | N/A       |                   |                 |        |      |
|                                                                                                          | Detailing requirements                                                                                                                                                                            |                                                       |             |     |                      | OK              |           |                   |                 |        |      |
|                                                                                                          | Note RB = rectangular beam, FB = flanged beam;                                                                                                                                                    |                                                       |             |     |                      |                 |           |                   |                 |        |      |
|                                                                                                          | % Tension reinforcement (rectangular)                                                                                                                                                             |                                                       |             |     |                      |                 | 1.29      | %                 |                 |        |      |
|                                                                                                          | % Compression reinforcement (rectangular)                                                                                                                                                         |                                                       |             |     |                      |                 | N/A       | %                 |                 |        |      |
|                                                                                                          | % Tension reinforcement (flanged)                                                                                                                                                                 |                                                       |             |     |                      |                 | N/A       | %                 |                 |        |      |
|                                                                                                          | % Compression reinforcement (flanged)                                                                                                                                                             |                                                       |             |     |                      |                 | N/A       | %                 |                 |        |      |
|                                                                                                          | Estimated steel reinforcement quantity (125 – 160kg/m <sup>3</sup> )                                                                                                                              |                                                       |             |     |                      |                 | 158       | kg/m <sup>3</sup> |                 |        |      |
|                                                                                                          | $7850 \cdot [(A_{s,prov} + A_{s,prov'}) / (b_w \text{ or } b).(h \text{ or } h_f) + (A_{sv,prov}.(h+anc.)/S + A_{sv,prov,t}.(h+b_w+anc.)/S_t)]$                                                   |                                                       |             |     |                      |                 |           |                   |                 |        |      |
|                                                                                                          | Estimated steel reinforcement quantity (125 – 160kg/m <sup>3</sup> )                                                                                                                              |                                                       |             |     |                      |                 | 222       | kg/m <sup>3</sup> | IStructE        |        |      |
|                                                                                                          | $11000 \cdot [(A_{s,prov} + A_{s,prov'}) / (b_w \text{ or } b).(h \text{ or } h_f) + (A_{sv,prov}.(h+anc.)/S + A_{sv,prov,t}.(h+b_w+anc.)/S_t)]$                                                  |                                                       |             |     |                      |                 |           |                   |                 |        |      |
|                                                                                                          | [Note that steel quantity in kg/m <sup>3</sup> can be obtained from 110.0 x % rebar];                                                                                                             |                                                       |             |     |                      |                 |           |                   |                 |        |      |
|                                                                                                          | Material cost:                                                                                                                                                                                    |                                                       | concrete, c | 315 | units/m <sup>3</sup> | steel, s        | 4600      | units/tonne       |                 |        |      |
|                                                                                                          | Reinforced concrete material cost = [c+(est. rebar quant).s].(b <sub>w</sub> or b).L <sub>LTB</sub>                                                                                               |                                                       |             |     |                      |                 | 667       | units/m           |                 |        |      |
|                                                                                                          |                                                                                                                                                                                                   |                                                       |             |     |                      |                 |           |                   |                 |        |      |
|                                                                                                          | Ductility of failure mechanis                                                                                                                                                                     |                                                       |             |     | Consider             | ▼               | Ductile   | Ductile           |                 | OK     |      |
|                                                                                                          | Rectangular beam crack width                                                                                                                                                                      |                                                       |             |     |                      |                 | 101%      |                   |                 | NOT OK |      |
|                                                                                                          | Max LTB stability (compression flange) restraints spacing, L <sub>LTB</sub>                                                                                                                       |                                                       |             |     |                      |                 | 30.0      | m                 |                 |        |      |
|                                                                                                          | Note s/s / cont L <sub>LTB</sub> = MIN (60(b <sub>w</sub> or b), 250(b <sub>w</sub> or b) <sup>2</sup> /d) and cant L <sub>LTB</sub> = MIN (25b <sub>w</sub> , 100b <sub>w</sub> <sup>2</sup> /d) |                                                       |             |     |                      |                 |           |                   |                 |        |      |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  |                                                                                      |                   |                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-------------------------------------------------------|--|--------------------------------------------------------------------------------------|-------------------|-----------------|
| CONSULTING ENGINEERS                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |  | Job No.                                                                              | Sheet No.         | Rev.            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  | jXXX                                                                                 | 3                 |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  | Member/Location                                                                      |                   |                 |
| Job Title                                                                                                                                                                                                                                                                                                                                                                                                                                       | Member Design - Reinforced Concrete Beam BS8110, |                                                       |  | Drg. Ref.                                                                            |                   |                 |
| Member Design - RC Beam                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                                       |  | Made by                                                                              | XX                | Date 24/10/2026 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  |                                                                                      |                   | Chd.            |
| Material Stresses                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  |                                                       |  |                                                                                      |                   |                 |
| Axial stress, $F/b_w h$                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                                       |  | 0.00                                                                                 | N/mm <sup>2</sup> |                 |
| Shear stress, $V_d/b_w d$                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |  | 2.55                                                                                 | N/mm <sup>2</sup> |                 |
| Bending stress, $6M/b_w d^2$                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |  | 26.39                                                                                | N/mm <sup>2</sup> |                 |
| Torsion stress, $2T/((h_{min})^2(h_{max}-h_{min}/3))$                                                                                                                                                                                                                                                                                                                                                                                           |                                                  |                                                       |  | 0.00                                                                                 | N/mm <sup>2</sup> |                 |
| Material Stress-Strain Curves                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                  |                                                       |  |                                                                                      |                   |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  |                                                                                      |                   |                 |
| Figure 2.1 — Short term design stress-strain curve for normal-weight concrete                                                                                                                                                                                                                                                                                                                                                                   |                                                  |                                                       |  | Figure 2.2 — Short term design stress-strain curve for reinforcement                 |                   |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  | For $f_{cu} \leq 60$ N/mm <sup>2</sup> , $\epsilon_{cu} = 0.0035$                    |                   |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  | For $f_{cu} > 60$ N/mm <sup>2</sup> , $\epsilon_{cu} = 0.0035 + (f_{cu} - 60)/50000$ |                   |                 |
| Detailing Instructions                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                  |                                                       |  |                                                                                      |                   |                 |
| <p>Not to Scale</p> <p>h = 1000 mm</p> <p>h<sub>f</sub> = N/A</p> <p>Comp Steel = N/A</p> <p>d = 917 mm</p> <p>d' = 35 mm</p> <p>Shear Links = 4 legs of T10@100mm pitch</p> <p>Torsion Links = 2 legs of T0@0mm pitch</p> <p>Cover = 25 mm</p> <p>b<sub>w</sub> = 500 mm</p> <p>Concrete, f<sub>cu</sub> = 35 MPa</p> <p>Rebars, f<sub>y</sub> = 500 MPa</p> <p>Links, f<sub>yv</sub> = 500 MPa</p> <p>Tension Steel = 8 T32@133mm centres</p> |                                                  |                                                       |  |                                                                                      |                   |                 |
| Diagram Produced for Sagging Design; Flip if Hogging Design;                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |  |                                                                                      |                   |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  |                                                                                      |                   |                 |
| a) Continuous member (approximately equal spans)                                                                                                                                                                                                                                                                                                                                                                                                |                                                  |                                                       |  | b) Simple support                                                                    |                   |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  |                                                                                      |                   |                 |
| c) Cantilever                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                  |                                                       |  |                                                                                      |                   |                 |

|                                                                                       |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
|---------------------------------------------------------------------------------------|--------------------------------------------------|-------------------------------------------------------|--|--|-----------------------------|-----------------|-----------|------|------------|------|
| CONSULTING<br>ENGINEERS                                                               |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |  |  |                             | Job No.         | Sheet No. |      | Rev.       |      |
|                                                                                       |                                                  |                                                       |  |  |                             | jXXX            | 4         |      |            |      |
|                                                                                       |                                                  |                                                       |  |  |                             | Member/Location |           |      |            |      |
| Job Title                                                                             | Member Design - Reinforced Concrete Beam BS8110, |                                                       |  |  |                             | Drg. Ref.       |           |      |            |      |
| Member Design - RC Beam                                                               |                                                  |                                                       |  |  |                             | Made by         | XX        | Date | 24/10/2026 | Chd. |
|                                                                                       |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Additional Longitudinal Shear Rectangular or Flanged Beam Utilisation Summary         |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
|                                                                                       |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Longitudinal shear between web and flange                                             |                                                  |                                                       |  |  | Consider only if applicable |                 | ▼         |      |            |      |
| Longitudinal shear within web                                                         |                                                  |                                                       |  |  | Consider only if applicable |                 | ▼         |      |            |      |
| Length under consideration, Δx (span/2 s/s, span/4 cont, span cant)                   |                                                  |                                                       |  |  |                             |                 | 2500      | mm   |            |      |
| Applicability of longitudinal shear design                                            |                                                  |                                                       |  |  | Applicable                  |                 |           |      |            |      |
|                                                                                       |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Longitudinal Shear Between Web and Flange (EC2)                                       |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Longitudinal shear stress limit to prevent crushing                                   |                                                  |                                                       |  |  | 32%                         |                 |           |      | OK         |      |
| Longitudinal shear stress limit for no transverse reinforcement                       |                                                  |                                                       |  |  | 311%                        |                 |           |      | NOT OK     |      |
| Required design transverse reinforcement per unit length                              |                                                  |                                                       |  |  | 94%                         |                 |           |      | OK         |      |
| Longitudinal Shear Between Web and Flange (BS5400-4)                                  |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Longitudinal shear force limit per unit length                                        |                                                  |                                                       |  |  | 64%                         |                 |           |      | OK         |      |
| Required nominal transverse reinforcement per unit length                             |                                                  |                                                       |  |  | 38%                         |                 |           |      | OK         |      |
| Longitudinal Shear Between Web and Flange Mandatory Cr                                |                                                  |                                                       |  |  | 94%                         |                 |           |      | OK         |      |
|                                                                                       |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Longitudinal Shear Within Web (EC2)                                                   |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Longitudinal shear stress limit                                                       |                                                  |                                                       |  |  | 63%                         |                 |           |      | OK         |      |
| Longitudinal Shear Within Web (BS8110)                                                |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Longitudinal shear stress limit for no nominal / design vertical rei                  |                                                  |                                                       |  |  | 110%                        |                 |           |      | NOT OK     |      |
| Required nominal vertical reinforcement per unit length                               |                                                  |                                                       |  |  | 24%                         |                 |           |      | OK         |      |
| Required design vertical reinforcement per unit length                                |                                                  |                                                       |  |  | 94%                         |                 |           |      | OK         |      |
| Longitudinal Shear Within Web (BS5400-4)                                              |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Longitudinal shear force limit per unit length                                        |                                                  |                                                       |  |  | 79%                         |                 |           |      | OK         |      |
| Required nominal vertical reinforcement per unit length                               |                                                  |                                                       |  |  | 24%                         |                 |           |      | OK         |      |
| Longitudinal Shear Within Web Mandatory Criteria                                      |                                                  |                                                       |  |  | 94%                         |                 |           |      | OK         |      |
|                                                                                       |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Additional Deep Beam Rectangular Beam Utilisation Summary                             |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
|                                                                                       |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Deep beam design                                                                      |                                                  |                                                       |  |  | Consider only if applicable |                 | ▼         |      |            |      |
| Span to depth ratio, span / h                                                         |                                                  |                                                       |  |  | 10.00                       |                 |           |      | OK         |      |
| Applicability of deep beam design                                                     |                                                  |                                                       |  |  | Not Applicable              |                 |           |      |            |      |
| Concrete type                                                                         |                                                  |                                                       |  |  | Normal weight               |                 | ▼         |      |            |      |
| Horizontal shear link diameter, ϕ <sub>link,h</sub>                                   |                                                  |                                                       |  |  | None                        |                 | ▼         | mm   |            |      |
| Number of horizontal shear links in a horizontal section, i.e. number of legs,        |                                                  |                                                       |  |  | 0                           |                 |           |      |            |      |
| Pitch of horizontal shear links, S <sub>h</sub>                                       |                                                  |                                                       |  |  | 0                           |                 | mm        |      |            |      |
| Clear distance from edge of load to face of support, a <sub>1</sub> o DL @ mid 0.625h |                                                  |                                                       |  |  | ▼                           | N/A             | mm        |      |            |      |
| Detailing requirements                                                                |                                                  |                                                       |  |  | N/A                         |                 |           |      |            |      |
|                                                                                       |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Reynolds                                                                              |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Tension steel (deep beam)                                                             |                                                  |                                                       |  |  | N/A                         |                 |           |      | N/A        |      |
| Tension steel zone depth, T <sub>zone</sub> (sag s/s, sag cont, hog cant)             |                                                  |                                                       |  |  | N/A                         |                 | mm        |      |            |      |
| Tension steel zone depth, T <sub>zone</sub> (hog cont)                                |                                                  |                                                       |  |  | N/A                         |                 | mm        |      |            |      |
| Minimum breadth for deep beam, b <sub>w</sub>                                         |                                                  |                                                       |  |  | N/A                         |                 | mm        | N/A  |            |      |
| Shear ultimate force (deep beam)                                                      |                                                  |                                                       |  |  | N/A                         |                 |           |      | N/A        |      |
| Shear design capacity (deep beam)                                                     |                                                  |                                                       |  |  | N/A                         |                 |           |      | N/A        |      |
|                                                                                       |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| CIRIA Guide 2                                                                         |                                                  |                                                       |  |  |                             |                 |           |      |            |      |
| Bending ultimate moment (deep beam)                                                   |                                                  |                                                       |  |  | N/A                         |                 |           |      | N/A        |      |
| Tension steel (deep beam)                                                             |                                                  |                                                       |  |  | N/A                         |                 |           |      | N/A        |      |
| Tension steel zone depth, T <sub>zone</sub> (sag s/s, sag cont, hog cant)             |                                                  |                                                       |  |  | N/A                         |                 | mm        |      |            |      |
| Tension steel zone depth, T <sub>zone</sub> (hog cont) upper band                     |                                                  |                                                       |  |  | N/A                         | N/A             | mm        |      |            |      |
| Tension steel zone depth, T <sub>zone</sub> (hog cont) lower band                     |                                                  |                                                       |  |  | N/A                         | N/A             | mm        |      |            |      |
| Shear ultimate force (deep beam)                                                      |                                                  |                                                       |  |  | N/A                         |                 |           |      | N/A        |      |
| Shear design capacity (deep beam)                                                     |                                                  |                                                       |  |  | N/A                         |                 |           |      | N/A        |      |
|                                                                                       |                                                  |                                                       |  |  |                             |                 |           |      |            |      |

|                                                                                                                                                                                                                              |                                                       |  |  |  |                                 |           |                      |
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| CONSULTING<br>ENGINEERS                                                                                                                                                                                                      | Engineering Calculation Sheet<br>Consulting Engineers |  |  |  | Job No.                         | Sheet No. | Rev.                 |
|                                                                                                                                                                                                                              |                                                       |  |  |  | jXXX                            | 5         |                      |
|                                                                                                                                                                                                                              |                                                       |  |  |  | Member/Location                 |           |                      |
| Job Title                                                                                                                                                                                                                    | Member Design - Reinforced Concrete Beam BS8110,      |  |  |  | Drg. Ref.                       |           |                      |
| Member Design - RC Beam                                                                                                                                                                                                      |                                                       |  |  |  | Made by                         | XX        | Date 24/10/2026 Chd. |
|                                                                                                                                                                                                                              |                                                       |  |  |  | BS8110                          |           |                      |
| Bending Rectangular Beam (Singly or Doubly Reinforced) (BS8110)                                                                                                                                                              |                                                       |  |  |  |                                 |           |                      |
| <p>Figure 3.3 (amended) – Simplified stress block for concrete at ultimate limit state</p>                                                                                                                                   |                                                       |  |  |  |                                 |           |                      |
| $M_u = K' f_{cu} b d^2$                                                                                                                                                                                                      |                                                       |  |  |  | Note $b$ here is $b_w$ ;        |           |                      |
| Ratio, $K'$                                                                                                                                                                                                                  |                                                       |  |  |  | 2296 kNm                        |           |                      |
| $K' =$                                                                                                                                                                                                                       |                                                       |  |  |  | 0.156                           |           |                      |
| $K' =$                                                                                                                                                                                                                       |                                                       |  |  |  | 0.156                           |           |                      |
| $K' =$                                                                                                                                                                                                                       |                                                       |  |  |  | N/A                             |           |                      |
| $K' =$                                                                                                                                                                                                                       |                                                       |  |  |  | N/A                             |           |                      |
| $K' =$                                                                                                                                                                                                                       |                                                       |  |  |  | N/A                             |           |                      |
| Note the expression for $K'$ ensures that the section remains ductile i.e. ensuring that failure occurs with the gradual yielding of the tension steel and not by a sudden catastrophic compression failure of the concrete; |                                                       |  |  |  |                                 |           |                      |
| If: $M < M_u \rightarrow$ no compression steel                                                                                                                                                                               |                                                       |  |  |  | VALID                           |           |                      |
| $K = M / b d^2 f_{cu}$                                                                                                                                                                                                       |                                                       |  |  |  | Note $b$ here is $b_w$ ;        |           |                      |
| To scheme beam, choose $d$ such that $K = M / (b_w d^2 f_{cu}) < K'$ (0.156 for $\beta_b = 1.0$ and NSC)                                                                                                                     |                                                       |  |  |  | 0.126                           |           |                      |
| for no compression steel,                                                                                                                                                                                                    |                                                       |  |  |  | i.e. $d > 823$ and $h > 906$ mm |           |                      |
| $z = d \left\{ 0.5 + \sqrt{0.25 - \frac{K}{0.9}} \right\}$                                                                                                                                                                   |                                                       |  |  |  | $z \leq 0.95d$                  |           |                      |
| Depth of neutral axis, $x \leq x_{limit}$                                                                                                                                                                                    |                                                       |  |  |  | 342 ≤ 459 mm                    |           |                      |
| Neutral axis, $x =$                                                                                                                                                                                                          |                                                       |  |  |  | 342 mm                          |           |                      |
| Neutral axis, $x =$                                                                                                                                                                                                          |                                                       |  |  |  | N/A mm                          |           |                      |
| Neutral axis, $x =$                                                                                                                                                                                                          |                                                       |  |  |  | N/A mm                          |           |                      |
| Neutral axis, $x =$                                                                                                                                                                                                          |                                                       |  |  |  | 459 mm                          |           |                      |
| Neutral axis, $x =$                                                                                                                                                                                                          |                                                       |  |  |  | N/A mm                          |           |                      |
| Neutral axis, $x =$                                                                                                                                                                                                          |                                                       |  |  |  | N/A mm                          |           |                      |
| Neutral axis, $x =$                                                                                                                                                                                                          |                                                       |  |  |  | N/A mm                          |           |                      |
| Tension steel                                                                                                                                                                                                                |                                                       |  |  |  | 5544 mm²                        |           |                      |
| Back-analysis of $x$ in $(0.67 f_{cu} / 1.5) \cdot (s \cdot b_w) = (f_y / 1.05) \cdot (A_{s,prov})$ , $f_y \leq 460$                                                                                                         |                                                       |  |  |  | 401 mm                          |           |                      |
| $s =$                                                                                                                                                                                                                        |                                                       |  |  |  | 0.90x mm                        |           |                      |
| $s =$                                                                                                                                                                                                                        |                                                       |  |  |  | N/A mm                          |           |                      |
| $s =$                                                                                                                                                                                                                        |                                                       |  |  |  | N/A mm                          |           |                      |
| Note for an under reinforced section, require $x \leq x_{limit}$ for yielding of tension steel;                                                                                                                              |                                                       |  |  |  |                                 |           |                      |

[illegible]

|                                                                                                                                                                                                                            |  |                                                       |  |  |                                                                                                                                                                                      |           |                            |
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| CONSULTING ENGINEERS                                                                                                                                                                                                       |  | Engineering Calculation Sheet<br>Consulting Engineers |  |  | Job No.                                                                                                                                                                              | Sheet No. | Rev.                       |
|                                                                                                                                                                                                                            |  |                                                       |  |  | jXXX                                                                                                                                                                                 | 7         |                            |
|                                                                                                                                                                                                                            |  |                                                       |  |  | Member/Location                                                                                                                                                                      |           |                            |
| Job Title    Member Design - Reinforced Concrete Beam BS8110,                                                                                                                                                              |  |                                                       |  |  | Drg. Ref.                                                                                                                                                                            |           |                            |
| Member Design - RC Beam                                                                                                                                                                                                    |  |                                                       |  |  | Made by                                                                                                                                                                              | XX        | Date    24/10/2026    Chd. |
| Bending Rectangular Beam (Singly or Doubly Reinforced) (EC2)                                                                                                                                                               |  |                                                       |  |  | EC2                                                                                                                                                                                  |           |                            |
|                                                                                                                                          |  |                                                       |  |  | <div>λ = 0.8 for fck ≤ 50 MPa<br/>λ = 0.8 - (fck - 50)/400 for 50 &lt; fck ≤ 90 MPa<br/>and<br/>η = 1.0 for fck ≤ 50 MPa<br/>η = 1.0 - (fck - 50)/200 for 50 &lt; fck ≤ 90 MPa</div> |           |                            |
| Mu = K'fckbd²                                                                                                                                                                                                              |  |                                                       |  |  | 1962 kNm                                                                                                                                                                             |           |                            |
| Note b here is bw;                                                                                                                                                                                                         |  |                                                       |  |  | 0.167                                                                                                                                                                                |           |                            |
| Ratio, K'                                                                                                                                                                                                                  |  |                                                       |  |  | 0.167                                                                                                                                                                                |           |                            |
| $K' = \frac{\eta \alpha_{cc}}{\gamma_c} \cdot \lambda \cdot \left(\frac{x}{d}\right)_{limit} \cdot \left(1 - \frac{\lambda}{2} \left(\frac{x}{d}\right)_{limit}\right)$                                                    |  |                                                       |  |  | cl.3.1.7(3)                                                                                                                                                                          |           |                            |
| Partial factor for concrete, γc = 1.50                                                                                                                                                                                     |  |                                                       |  |  | 1.5                                                                                                                                                                                  |           |                            |
| Strength coefficient, αcc = 1.00   0.85                                                                                                                                                                                    |  |                                                       |  |  | EC2 UK                                                                                                                                                                               |           |                            |
| Stress block factor, η = MIN[1.0, 1.0 - (fck - 50)/200]                                                                                                                                                                    |  |                                                       |  |  | 1.00                                                                                                                                                                                 |           |                            |
| Stress block factor, λ = MIN[0.8, 0.8 - (fck - 50)/400]                                                                                                                                                                    |  |                                                       |  |  | 0.80                                                                                                                                                                                 |           |                            |
| Note the expression for K' ensures that the section remains ductile i.e. ensuring that failure occurs with the gradual yielding of the tension steel and not by a sudden catastrophic compression failure of the concrete; |  |                                                       |  |  |                                                                                                                                                                                      |           |                            |
| If: M < Mu → no compression steel                                                                                                                                                                                          |  |                                                       |  |  | VALID                                                                                                                                                                                |           |                            |
| $K = \frac{M}{bd^2 f_{ck}}$                                                                                                                                                                                                |  |                                                       |  |  | 0.157                                                                                                                                                                                |           |                            |
| Note b here is bw;                                                                                                                                                                                                         |  |                                                       |  |  |                                                                                                                                                                                      |           |                            |
| $z = d \left[ 0.5 + \sqrt{0.25 - \frac{K}{C}} \right], \quad C = \frac{2\eta \alpha_{cc}}{\gamma_c}$                                                                                                                       |  |                                                       |  |  | z ≤ 0.95d                                                                                                                                                                            |           |                            |
| 765 mm                                                                                                                                                                                                                     |  |                                                       |  |  | cl.3.1.7(3)                                                                                                                                                                          |           |                            |
| Depth of neutral axis, x ≤ xlimit                                                                                                                                                                                          |  |                                                       |  |  | 381 ≤ 411 mm                                                                                                                                                                         |           |                            |
| OK                                                                                                                                                                                                                         |  |                                                       |  |  |                                                                                                                                                                                      |           |                            |
| Neutral axis, x                                                                                                                                                                                                            |  |                                                       |  |  | x = 2(d-z)/λ                                                                                                                                                                         |           |                            |
| 381 mm                                                                                                                                                                                                                     |  |                                                       |  |  | cl.3.1.7(3)                                                                                                                                                                          |           |                            |
| Neutral axis limit, xlimit                                                                                                                                                                                                 |  |                                                       |  |  | xlimit = [(βb - k1)/k2].d for fck ≤ 50MPa                                                                                                                                            |           |                            |
| EC2                                                                                                                                                                                                                        |  |                                                       |  |  | 411 mm                                                                                                                                                                               |           |                            |
| cl.5.5(4)                                                                                                                                                                                                                  |  |                                                       |  |  |                                                                                                                                                                                      |           |                            |
| k1 = 0.44   0.40                                                                                                                                                                                                           |  |                                                       |  |  | 0.44                                                                                                                                                                                 |           |                            |
| cl.5.5(4)                                                                                                                                                                                                                  |  |                                                       |  |  |                                                                                                                                                                                      |           |                            |
| k2 = 1.25(0.6 + 0.0014/εcu2)   0.6 + 0.0014/εcu2                                                                                                                                                                           |  |                                                       |  |  | 1.25                                                                                                                                                                                 |           |                            |
| cl.5.5(4)                                                                                                                                                                                                                  |  |                                                       |  |  |                                                                                                                                                                                      |           |                            |
| xlimit = [(βb - k3)/k4].d for fck > 50MPa                                                                                                                                                                                  |  |                                                       |  |  | EC2                                                                                                                                                                                  |           |                            |
| N/A mm                                                                                                                                                                                                                     |  |                                                       |  |  | cl.5.5(4)                                                                                                                                                                            |           |                            |
| k3 = 0.54   0.40                                                                                                                                                                                                           |  |                                                       |  |  | N/A                                                                                                                                                                                  |           |                            |
| cl.5.5(4)                                                                                                                                                                                                                  |  |                                                       |  |  |                                                                                                                                                                                      |           |                            |
| k4 = 1.25(0.6 + 0.0014/εcu2)   0.6 + 0.0014/εcu2                                                                                                                                                                           |  |                                                       |  |  | N/A                                                                                                                                                                                  |           |                            |
| cl.5.5(4)                                                                                                                                                                                                                  |  |                                                       |  |  |                                                                                                                                                                                      |           |                            |
| εcu2 = 0.0035 for fck ≤ 50MPa                                                                                                                                                                                              |  |                                                       |  |  | 0.0035                                                                                                                                                                               |           |                            |
| T.3.1                                                                                                                                                                                                                      |  |                                                       |  |  |                                                                                                                                                                                      |           |                            |
| εcu2 = [2.6 + 35[(90 - fck)/100]⁴]/1000 for fck > 50MPa                                                                                                                                                                    |  |                                                       |  |  | N/A                                                                                                                                                                                  |           |                            |
| T.3.1                                                                                                                                                                                                                      |  |                                                       |  |  |                                                                                                                                                                                      |           |                            |
| Tension steel                                                                                                                                                                                                              |  |                                                       |  |  | As = M / ((0.87fy)z)                                                                                                                                                                 |           |                            |
| 5559 mm²                                                                                                                                                                                                                   |  |                                                       |  |  | cl.3.2.7(2)                                                                                                                                                                          |           |                            |

[illegible]

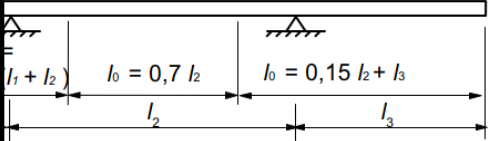
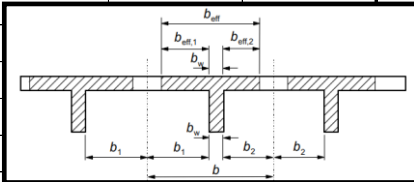
|                                                                                                                                                |                                                       |                                       |                   |                      |
|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|---------------------------------------|-------------------|----------------------|
| CONSULTING<br>ENGINEERS                                                                                                                        | Engineering Calculation Sheet<br>Consulting Engineers | Job No.                               | Sheet No.         | Rev.                 |
|                                                                                                                                                |                                                       | jXXX                                  | 9                 |                      |
|                                                                                                                                                |                                                       | Member/Location                       |                   |                      |
| Job Title                                                                                                                                      | Member Design - Reinforced Concrete Beam BS8110,      | Drg. Ref.                             |                   |                      |
| Member Design - RC Beam                                                                                                                        |                                                       | Made by                               | XX                | Date 24/10/2026 Chd. |
|                                                                                                                                                |                                                       | ACI318                                |                   |                      |
| Bending Rectangular Beam (Singly or Doubly Reinforced) (ACI318)                                                                                |                                                       |                                       |                   |                      |
|                                                                                                                                                |                                                       |                                       |                   |                      |
| Singly Reinforced Rectangular Section                                                                                                          |                                                       | Doubly Reinforced Rectangular Section |                   |                      |
| Required nominal flexural strength coefficient of resistance, $R_n = M^* / \phi b_w d^2$                                                       |                                                       | 4.89                                  | N/mm <sup>2</sup> |                      |
| Strength reduction factor for tension-controlled sections, $\phi = 0.90$                                                                       |                                                       | 0.90                                  |                   |                      |
| Ratio of $A_s$ to $b_w d$ , $\rho_w = 0.85f'_c / f_y \cdot [1 - \sqrt{(1 - 2R_n / (0.85f'_c))}]$ , $f_y \leq 550 \text{ N/mm}^2$               |                                                       | 1.11                                  | %                 |                      |
| Tension steel, $A_s = \text{MAX}(\rho_w b_w d, A_{s,\text{min}})$                                                                              |                                                       | 5070                                  | mm <sup>2</sup>   |                      |
| $A_{s,\text{min}} = \text{MAX}(0.25b_w d \sqrt{f'_c} / f_y, 1.4b_w d / f_y)$ , $f_y \leq 550 \text{ N/mm}^2$                                   |                                                       | 1284                                  | mm <sup>2</sup>   |                      |
| Factor, $\beta_1 = \text{MAX}(\text{MIN}(0.85 - (0.05/7) \cdot (f'_c - 28), 0.85), 0.65)$                                                      |                                                       | 0.85                                  |                   |                      |
| Note $\beta_1$ is the factor relating depth of equivalent rectangular compressive stress block to neutral axis depth;                          |                                                       |                                       |                   |                      |
| Depth of equivalent rectangular stress block, $a = A_s f_y / (0.85f'_c b_w)$ , $f_y \leq 550 \text{ N/mm}^2$                                   |                                                       | 213                                   | mm                |                      |
| Distance, $c = a / \beta_1$                                                                                                                    |                                                       | 251                                   | mm                |                      |
| Note $c$ is the distance from extreme compression fiber to neutral axis (for singly reinforced section);                                       |                                                       |                                       |                   |                      |
| Distance, $d_t = h - \text{cover} - \text{MAX}(\phi_{\text{link}}, \phi_{\text{link},t}, \text{cover}_{\text{add},t}) - \phi_t / 2$            |                                                       | 949                                   | mm                |                      |
| Note $d_t$ is the distance from extreme compression fiber to centroid of extreme layer of longitudinal tension steel;                          |                                                       |                                       |                   |                      |
| $\epsilon_t = 0.003(d_t/c - 1)$                                                                                                                |                                                       | 0.008                                 |                   |                      |
| Note $\epsilon_t$ is the net tensile strain in extreme layer of longitudinal tension steel at nominal strength;                                |                                                       |                                       |                   |                      |
| $\epsilon_t > 0.005$                                                                                                                           | →                                                     | no compression steel                  | VALID             |                      |
| Tension steel, $A_s$                                                                                                                           |                                                       | 5070                                  | mm <sup>2</sup>   |                      |
| $0.004 < \epsilon_t \leq 0.005$                                                                                                                | →                                                     | compression steel required            | N/A               |                      |
| Ratio of $A_s$ to $b_w d$ , $\rho_w = 0.319\beta_1 f'_c / f_y \cdot d_t / d$ , $f_y \leq 550 \text{ N/mm}^2$                                   |                                                       | N/A                                   | %                 |                      |
| $R_{nt} = \rho_w f_y (1 - 0.59\rho_w f_y / f'_c)$ , $f_y \leq 550 \text{ N/mm}^2$                                                              |                                                       | N/A                                   | N/mm <sup>2</sup> |                      |
| Note $R_{nt}$ is the required nominal flexural strength coefficient of resistance for rectangular beam corresponding to $\epsilon_t = 0.005$ ; |                                                       |                                       |                   |                      |
| $M_{nt} = R_{nt} b_w d^2$                                                                                                                      |                                                       | N/A                                   | kNm               |                      |
| Note $M_{nt}$ is the required nominal flexural strength corresponding to $\epsilon_t = 0.005$ ;                                                |                                                       |                                       |                   |                      |
| $M_n' = M^* / \phi - M_{nt}$                                                                                                                   |                                                       | N/A                                   | kNm               |                      |
| Note $M_n'$ is the required nominal flexural strength that need to be resisted by the compression reinforcement;                               |                                                       |                                       |                   |                      |
| Distance, $c_t = 0.375d_t$                                                                                                                     |                                                       | N/A                                   | mm                |                      |
| Note $c_t$ is the distance from extreme compression fiber to neutral axis (for doubly reinforced section);                                     |                                                       |                                       |                   |                      |
| Stress in compression reinforcement, $f'_s = 0.003E_s(1 - d'/c_t) \leq f_y$ , $f_y \leq 550 \text{ N/mm}^2$                                    |                                                       | N/A                                   | N/mm <sup>2</sup> |                      |
| Modulus of elasticity of reinforcement, $E_s = 200,000$                                                                                        |                                                       | N/A                                   | N/mm <sup>2</sup> |                      |
| Compression steel, $A'_s = M_n' / [f'_s(d - d')]$                                                                                              |                                                       | N/A                                   | mm <sup>2</sup>   |                      |
| Tension steel, $A_s = \rho_w b_w d + M_n' / [f_y(d - d')]$ , $f_y \leq 550 \text{ N/mm}^2$                                                     |                                                       | N/A                                   | mm <sup>2</sup>   |                      |
| $\epsilon_t \leq 0.004$                                                                                                                        | →                                                     | no valid solution                     | N/A               |                      |

[illegible]

|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  |                                                                                                           |           |                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|--|-----------------------------------------------------------------------------------------------------------|-----------|--------------------------|
| CONSULTING ENGINEERS                                                                                                                                                                                                         |                                                  | Engineering Calculation Sheet<br>Consulting Engineers                                                                                            |  | Job No.                                                                                                   | Sheet No. | Rev.                     |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | jXXX                                                                                                      | 11        |                          |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | Member/Location                                                                                           |           |                          |
| Job Title                                                                                                                                                                                                                    | Member Design - Reinforced Concrete Beam BS8110, |                                                                                                                                                  |  | Drg. Ref.                                                                                                 |           |                          |
| Member Design - RC Beam                                                                                                                                                                                                      |                                                  |                                                                                                                                                  |  | Made by                                                                                                   | XX        | Date 24/10/2026          |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  |                                                                                                           |           | Chd. BS8110              |
| Bending Flanged Beam (Singly or Doubly Reinforced)                                                                                                                                                                           |                                                  |                                                                                                                                                  |  |                                                                                                           |           |                          |
|                                                                                                                                                                                                                              |                                                  | Simply supported                                                                                                                                 |  | Continuous                                                                                                |           | Cantilever               |
| T-Beam                                                                                                                                                                                                                       |                                                  | $b_w + L / 5$                                                                                                                                    |  | $b_w + L / 7.14$                                                                                          |           | $b_w$                    |
| L-Beam                                                                                                                                                                                                                       |                                                  | $b_w + L / 10$                                                                                                                                   |  | $b_w + L / 14.29$                                                                                         |           | $b_w$                    |
|                                                                                                                                                                                                                              |                                                  | and $\leq$ (i) actual flange width,                                                                                                              |  | (ii) beam spacing                                                                                         |           |                          |
| For cantilevers, width shown is applicable for downstand beams as rect- sections. For upstand beams, T- or L- sections will apply with insitu                                                                                |                                                  |                                                                                                                                                  |  |                                                                                                           |           |                          |
| Span                                                                                                                                                                                                                         |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           | m                        |
| Depth of flange, $h_f$                                                                                                                                                                                                       |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           | mm                       |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           | N/A                      |
| Effective width, $b = \text{MIN}(b_w + \text{function (span, section, structure), beam spacing})$                                                                                                                            |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           | mm                       |
| (bending flanged beam, deflection calcs flanged beam)                                                                                                                                                                        |                                                  |                                                                                                                                                  |  |                                                                                                           |           |                          |
| $K = M/bd^2f_{cu}$                                                                                                                                                                                                           |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           |                          |
| $z = d.[0.5+(0.25-K/0.9)^{0.5}]$                                                                                                                                                                                             |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           | mm                       |
| Depth of compression stress block, $s = 2.(d-z)$ (applicable for all $f_{cu}$ )                                                                                                                                              |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           | mm                       |
| Compression Stress Block in Flange ( $s \leq h_f$ )                                                                                                                                                                          |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           |                          |
| $M_u = K'f_{cu}bd^2$                                                                                                                                                                                                         |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           | kNm                      |
| Ratio, $K'$                                                                                                                                                                                                                  |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           |                          |
| $\beta_b \leq 1.10$                                                                                                                                                                                                          |                                                  | $K' =$                                                                                                                                           |  | 0.156 for $f_{cu} \leq 60 \text{ N/mm}^2$                                                                 |           | N/A mm 3.4.4.4 BC        |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | 0.120 for $60 < f_{cu} \leq 75 \text{ N/mm}^2$                                                            |           | N/A mm 3.4.4.4 BC        |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | 0.094 for $75 < f_{cu} \leq 105 \text{ N/mm}^2$ [ $\beta_b = 1.0$ ]                                       |           | N/A mm 3.4.4.4 BC        |
| $\beta_b > 1.10$                                                                                                                                                                                                             |                                                  | $K' =$                                                                                                                                           |  | 0.402( $\beta_b - 0.4$ ) - 0.18( $\beta_b - 0.4$ ) <sup>2</sup> , for $f_{cu} \leq 60 \text{ N/mm}^2$     |           | N/A mm 3.4.4.4 BC        |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | 0.357( $\beta_b - 0.5$ ) - 0.143( $\beta_b - 0.5$ ) <sup>2</sup> for $60 < f_{cu} \leq 75 \text{ N/mm}^2$ |           | N/A mm 3.4.4.4 BC        |
| Note the expression for $K'$ ensures that the section remains ductile i.e. ensuring that failure occurs with the gradual yielding of the tension steel and not by a sudden catastrophic compression failure of the concrete; |                                                  |                                                                                                                                                  |  |                                                                                                           |           |                          |
| If: $M < M_u \rightarrow$ no compression steel                                                                                                                                                                               |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           |                          |
| $K = M/bd^2f_{cu}$                                                                                                                                                                                                           |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           |                          |
| To scheme beam, choose $d$ such that $K = M/(bd^2f_{cu}) < K'$ (0.156 for $\beta_b = 1.0$ and NSC)                                                                                                                           |                                                  |                                                                                                                                                  |  |                                                                                                           |           |                          |
| for no compression steel,                                                                                                                                                                                                    |                                                  | i.e. $d >$                                                                                                                                       |  | N/A                                                                                                       |           | and $h >$ N/A mm         |
| $z = d \left\{ 0.5 + \sqrt{0.25 - \frac{K}{0.9}} \right\}$                                                                                                                                                                   |                                                  | $z \leq 0.95d$                                                                                                                                   |  | N/A                                                                                                       |           | mm                       |
| Depth of neutral axis, $x \leq x_{limit}$                                                                                                                                                                                    |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           | mm                       |
| Neutral axis, $x$                                                                                                                                                                                                            |                                                  | $x =$                                                                                                                                            |  | (d - z)/0.45, for $f_{cu} \leq 60 \text{ N/mm}^2$                                                         |           | N/A mm 3.4.4.4 BC        |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | (d - z)/0.40, for $60 < f_{cu} \leq 75 \text{ N/mm}^2$                                                    |           | N/A mm 3.4.4.4 BC        |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | (d - z)/0.36, for $75 < f_{cu} \leq 105 \text{ N/mm}^2$                                                   |           | N/A mm 3.4.4.4 BC        |
| Neutral axis limit, $x_{limit}$                                                                                                                                                                                              |                                                  | $\beta_b \leq 1.10$                                                                                                                              |  | $x \leq 0.5d$ for $f_{cu} \leq 60 \text{ N/mm}^2$                                                         |           | N/A mm 3.4.4.4 BC        |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | $x \leq 0.4d$ for $60 < f_{cu} \leq 75 \text{ N/mm}^2$                                                    |           | N/A mm 3.4.4.4 BC        |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | $x \leq 0.33d$ , for $75 < f_{cu} \leq 105 \text{ N/mm}^2$ [ $\beta_b = 1.0$ ]                            |           | N/A mm 3.4.4.4 BC        |
|                                                                                                                                                                                                                              |                                                  | $\beta_b > 1.10$                                                                                                                                 |  | $x \leq (\beta_b - 0.4)d$ for $f_{cu} \leq 60 \text{ N/mm}^2$                                             |           | N/A mm 3.4.4.4 BC        |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | $x \leq (\beta_b - 0.5)d$ for $60 < f_{cu} \leq 75 \text{ N/mm}^2$                                        |           | N/A mm 3.4.4.4 BC        |
| Tension steel                                                                                                                                                                                                                |                                                  | $A_s = \frac{M}{(0.95f_y)z}$ , $f_y \leq 460 \text{ N/mm}^2$                                                                                     |  | N/A                                                                                                       |           | mm <sup>2</sup> Foreword |
| Back-analysis of $x$ in $(0.67f_{cu}/1.5).(s.b)=(f_y/1.05).(A_{s,prov})$ , $f_y \leq 460$                                                                                                                                    |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           | mm N/A                   |
| $s =$                                                                                                                                                                                                                        |                                                  | 0.9x for $f_{cu} \leq 60 \text{ N/mm}^2$ ;<br>0.8x for $60 < f_{cu} \leq 75 \text{ N/mm}^2$ ;<br>0.72x for $75 < f_{cu} \leq 105 \text{ N/mm}^2$ |  | N/A                                                                                                       |           | mm 3.4.4.4 BC            |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           | mm 3.4.4.4 BC            |
|                                                                                                                                                                                                                              |                                                  |                                                                                                                                                  |  | N/A                                                                                                       |           | mm 3.4.4.4 BC            |
| Note for an under reinforced section, require $x \leq x_{limit}$ for yielding of tension steel;                                                                                                                              |                                                  |                                                                                                                                                  |  |                                                                                                           |           |                          |

|                                                                                                                                                                   |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------------------------------|--|--|-----|-------------------------------|-----------|-----------------|-----------------|----------|
| CONSULTING<br>ENGINEERS                                                                                                                                           |                                                          | Engineering Calculation Sheet<br>Consulting Engineers                                                      |  |  |     | Job No.                       | Sheet No. | Rev.            |                 |          |
|                                                                                                                                                                   |                                                          |                                                                                                            |  |  |     | jXXX                          | 12        |                 |                 |          |
|                                                                                                                                                                   |                                                          |                                                                                                            |  |  |     | Member/Location               |           |                 |                 |          |
| Job Title                                                                                                                                                         | Member Design - Reinforced Concrete Beam BS8110,         |                                                                                                            |  |  |     | Drg. Ref.                     |           |                 |                 |          |
| Member Design - RC Beam                                                                                                                                           |                                                          |                                                                                                            |  |  |     | Made by                       | XX        | Date            | 24/10/2026      | Chd.     |
|                                                                                                                                                                   |                                                          |                                                                                                            |  |  |     | BS8110                        |           |                 |                 |          |
| If: $M > M_u \rightarrow$ compression steel required                                                                                                              |                                                          |                                                                                                            |  |  |     | N/A                           |           |                 |                 |          |
| To scheme beam, with compression steel, choose $d$ such that $K = M/(b d^2 f_{cu}) < 10/f_{cu}$                                                                   |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |
| for non-excessive comp steel, i.e. $d >$                                                                                                                          |                                                          |                                                                                                            |  |  |     | N/A                           | and $h >$ |                 | N/A             | mm       |
| $z = d \left\{ 0.5 + \sqrt{0.25 - \frac{K'}{0.9}} \right\}$                                                                                                       |                                                          |                                                                                                            |  |  |     | N/A mm                        |           |                 |                 |          |
| Depth of neutral axis, $x \leq x_{limit}$                                                                                                                         |                                                          |                                                                                                            |  |  |     | N/A                           | $\leq$    |                 | N/A             | mm       |
| Neutral axis, $x$                                                                                                                                                 | $x =$                                                    | $(d - z)/0.45, \text{ for } f_{cu} \leq 60 \text{ N/mm}^2$                                                 |  |  |     | N/A                           |           | mm              | 3.4.4.4 BC      |          |
|                                                                                                                                                                   |                                                          | $(d - z)/0.40, \text{ for } 60 < f_{cu} \leq 75 \text{ N/mm}^2$                                            |  |  |     | N/A                           |           | mm              | 3.4.4.4 BC      |          |
|                                                                                                                                                                   |                                                          | $(d - z)/0.36, \text{ for } 75 < f_{cu} \leq 105 \text{ N/mm}^2$                                           |  |  |     | N/A                           |           | mm              | 3.4.4.4 BC      |          |
| Neutral axis limit, $x_{limit}$                                                                                                                                   | $0.90 \leq \beta_b \leq 1.10$                            | $x \leq 0.5d \text{ for } f_{cu} \leq 60 \text{ N/mm}^2$                                                   |  |  |     | N/A                           |           | mm              | 3.4.4.4 BC      |          |
|                                                                                                                                                                   |                                                          | $x \leq 0.4d \text{ for } 60 < f_{cu} \leq 75 \text{ N/mm}^2$                                              |  |  |     | N/A                           |           | mm              | 3.4.4.4 BC      |          |
|                                                                                                                                                                   |                                                          | $x \leq 0.33d, \text{ for } 75 < f_{cu} \leq 105 \text{ N/mm}^2$                                           |  |  |     | N/A                           |           | mm              | 3.4.4.4 BC      |          |
|                                                                                                                                                                   |                                                          | $x \leq (\beta_b - 0.4)d \text{ for } f_{cu} \leq 60 \text{ N/mm}^2$                                       |  |  |     | N/A                           |           | mm              | 3.4.4.4 BC      |          |
|                                                                                                                                                                   |                                                          | $x \leq (\beta_b - 0.5)d \text{ for } 60 < f_{cu} \leq 75 \text{ N/mm}^2$                                  |  |  |     | N/A                           |           | mm              | 3.4.4.4 BC      |          |
|                                                                                                                                                                   |                                                          | $\beta_b = 1.0$                                                                                            |  |  |     | N/A                           |           | mm              | 3.4.4.4 BC      |          |
| 2                                                                                                                                                                 | Compression steel                                        | $A'_s = \frac{M - K' f_{cu} b d^2}{0.95 f_y (d - d')}$                                                     |  |  |     | $f_y \leq 460 \text{ N/mm}^2$ |           | N/A             | mm <sup>2</sup> | Foreword |
| 2                                                                                                                                                                 |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |
| 2                                                                                                                                                                 | Tension steel                                            | $A_s = \frac{M_u}{0.95 f_y z} + A'_s$                                                                      |  |  |     | $f_y \leq 460 \text{ N/mm}^2$ |           | N/A             | mm <sup>2</sup> | Foreword |
| 2                                                                                                                                                                 |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |
| 2                                                                                                                                                                 |                                                          | If $d' > \left(1 - \frac{f_y}{735}\right)x$ , use $700\left(1 - \frac{d'}{x}\right)$ in lieu of $0.95 f_y$ |  |  |     | $f_y \leq 460 \text{ N/mm}^2$ |           | N/A             |                 | Foreword |
| Back-analysis of $x$ in $(0.67 f_{cu}/1.5).(s.b) + (f_y/1.05).(A_{s,prov'}) = (f_y/1.$                                                                            |                                                          |                                                                                                            |  |  |     | N/A                           |           | mm              | N/A             |          |
| S =                                                                                                                                                               | $0.9x \text{ for } f_{cu} \leq 60 \text{ N/mm}^2;$       |                                                                                                            |  |  | N/A |                               | mm        | 3.4.4.4 BC      |                 |          |
|                                                                                                                                                                   | $0.8x \text{ for } 60 < f_{cu} \leq 75 \text{ N/mm}^2$   |                                                                                                            |  |  | N/A |                               | mm        | 3.4.4.4 BC      |                 |          |
|                                                                                                                                                                   | $0.72x \text{ for } 75 < f_{cu} \leq 105 \text{ N/mm}^2$ |                                                                                                            |  |  | N/A |                               | mm        | 3.4.4.4 BC      |                 |          |
| Note for an under reinforced section, require $\epsilon_{st} = \epsilon_{cc}(d-x)/x \geq \epsilon_y$ for yielding of tension steel                                |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |
| and $\epsilon_{sc} = \epsilon_{cc}(x-d')/x \geq \epsilon_y$ for yielding of compression steel, where $\epsilon_{cc} = 0.0035$ for $f_{cu} \leq 60 \text{ N/mm}^2$ |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |
| and $\epsilon_{cc} = 0.0035 - (f_{cu} - 60)/50000$ for $f_{cu} > 60 \text{ N/mm}^2$ and $\epsilon_y = (f_y/1.05)/E_s$ ;                                           |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |
| Tension steel area provided                                                                                                                                       |                                                          |                                                                                                            |  |  |     | N/A                           |           | mm <sup>2</sup> |                 |          |
| Tension steel area provided utilisation                                                                                                                           |                                                          |                                                                                                            |  |  |     | N/A                           |           |                 | N/A             |          |
| Compression steel area provided                                                                                                                                   |                                                          |                                                                                                            |  |  |     | N/A                           |           | mm <sup>2</sup> |                 |          |
| Compression steel area provided utilisation                                                                                                                       |                                                          |                                                                                                            |  |  |     | N/A                           |           |                 | N/A             |          |
| % Min tension reinforcement                                                                                                                                       |                                                          |                                                                                                            |  |  |     | N/A                           |           | %               | TR49            |          |
| % Min tension reinforcement ( $\geq 0.0032 b_w h$ G250; $\geq \text{MAX}(0.0018, 0.0018(f_{cu}/40)^{2/3}).b_w h$ G                                                |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |
| % Min tension reinforcement utilisation                                                                                                                           |                                                          |                                                                                                            |  |  |     | N/A                           |           |                 | N/A             |          |
| % Min compression reinforcement ( $\geq 0.004 b_h$ flange; $\geq 0.002 b_w$ web)                                                                                  |                                                          |                                                                                                            |  |  |     | N/A                           |           | %               |                 |          |
| % Min compression reinforcement utilisation                                                                                                                       |                                                          |                                                                                                            |  |  |     | N/A                           |           |                 | N/A             |          |
| % Max tension reinforcement ( $\leq 0.04 b_w h$ )                                                                                                                 |                                                          |                                                                                                            |  |  |     | N/A                           |           | %               |                 |          |
| % Max tension reinforcement utilisation                                                                                                                           |                                                          |                                                                                                            |  |  |     | N/A                           |           |                 | N/A             |          |
| % Max compression reinforcement ( $\leq 0.04 b_h$ flange; $\leq 0.04 b_w$ web)                                                                                    |                                                          |                                                                                                            |  |  |     | N/A                           |           | %               |                 |          |
| % Max compression reinforcement utilisation                                                                                                                       |                                                          |                                                                                                            |  |  |     | N/A                           |           |                 | N/A             |          |
| % Max tension or compression reinforcement utilisation                                                                                                            |                                                          |                                                                                                            |  |  |     | N/A                           |           |                 | N/A             |          |
| 2                                                                                                                                                                 |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |
| 2                                                                                                                                                                 |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |
| 2                                                                                                                                                                 |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |
|                                                                                                                                                                   |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |
|                                                                                                                                                                   |                                                          |                                                                                                            |  |  |     |                               |           |                 |                 |          |

|                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    |                                                                                                                                          |                 |                 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|
| CONSULTING ENGINEERS                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                         | Engineering Calculation Sheet<br>Consulting Engineers                                                                                                                     |                                                                                                                                                               |                                                                                                                                                                    | Job No.                                                                                                                                  | Sheet No.       | Rev.            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    | jXXX                                                                                                                                     | 13              |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    | Member/Location                                                                                                                          |                 |                 |
| Job Title                                                                                                                                                                                                                                                                                                                                                                                                                              | Member Design - Reinforced Concrete Beam BS8110,                                                                        |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    | Drg. Ref.                                                                                                                                |                 |                 |
| Member Design - RC Beam                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    | Made by                                                                                                                                  | XX              | Date 24/10/2026 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    | Chd. BS8110                                                                                                                              |                 |                 |
| Compression Stress Block in Web ( $s > h_f$ )                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    | N/A                                                                                                                                      |                 |                 |
| Note simplified method as equations within this section only valid for $\beta_b \geq 0.90$ and $\leq 1.10$ as $x = 0.5d$ ;                                                                                                                                                                                                                                                                                                             |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    |                                                                                                                                          |                 |                 |
| $h_f < 0.45d$ for $f_{cu} \leq 60$ N/mm <sup>2</sup> ; or<br>$h_f < 0.36d$ for $60 < f_{cu} \leq 75$ N/mm <sup>2</sup> ; or<br>$h_f < 0.30d$ for $75 < f_{cu} \leq 105$ N/mm <sup>2</sup> and no moment redistribution.                                                                                                                                                                                                                |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    | Note these checks for $h_f \leq \{0.45, 0.36, 0.30\}d$ and $\beta_b$ performed as part of the under reinforced section checks hereafter; |                 |                 |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                      | $M_{uf} = 0.45f_{cu}(b - b_w)h_f(d - 0.5h_f)$                                                                           |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    |                                                                                                                                          | N/A             | kNm             |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                      | $K_f = \frac{M - M_{uf}}{f_{cu}b_w d^2}$                                                                                |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    |                                                                                                                                          | N/A             |                 |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                      | Ratio, $K'$                                                                                                             |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    |                                                                                                                                          | N/A             |                 |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                      | $\beta_b$                                                                                                               | $K' =$                                                                                                                                                                    | $0.156$ for $f_{cu} \leq 60$ N/mm <sup>2</sup><br>$0.120$ for $60 < f_{cu} \leq 75$ N/mm <sup>2</sup><br>$0.094$ for $75 < f_{cu} \leq 105$ N/mm <sup>2</sup> |                                                                                                                                                                    | N/A                                                                                                                                      | mm              |                 |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                      | $0.90 \leq \beta_b \leq 1.10$                                                                                           |                                                                                                                                                                           | $[\beta_b = 1.0]$                                                                                                                                             |                                                                                                                                                                    | N/A                                                                                                                                      | mm              |                 |
| If $K_f < K' \rightarrow$ no compression steel                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    | N/A                                                                                                                                      |                 |                 |
| Tension steel                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                         | $A_s = \frac{M + k_1 f_{cu} b_w d (k_2 d - h_f)}{0.95 f_y (d - 0.5h_f)}$                                                                                                  |                                                                                                                                                               | $f_y \leq 460$ N/mm <sup>2</sup>                                                                                                                                   | N/A                                                                                                                                      | mm <sup>2</sup> |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                         | $k_1 =$ 0.1 for $f_{cu} \leq 60$ N/mm <sup>2</sup> ,<br>0.072 for $60 < f_{cu} \leq 75$ N/mm <sup>2</sup> and<br>0.054 for $75 < f_{cu} \leq 105$ N/mm <sup>2</sup> ; and |                                                                                                                                                               | $k_2 =$ 0.45 for $f_{cu} \leq 60$ N/mm <sup>2</sup> ,<br>0.32 for $60 < f_{cu} \leq 75$ N/mm <sup>2</sup> and<br>0.24 for $75 < f_{cu} \leq 105$ N/mm <sup>2</sup> |                                                                                                                                          |                 |                 |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                      | Back-analysis of $x$ in $(0.67f_{cu}/1.5) \cdot [b \cdot h_f + (s - h_f) \cdot b_w] = (f_y/1.05) \cdot (A_{s,t} - A_s)$ |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    |                                                                                                                                          | N/A             | mm              |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                      | $s =$                                                                                                                   | $0.9x$ for $f_{cu} \leq 60$ N/mm <sup>2</sup> ;<br>$0.8x$ for $60 < f_{cu} \leq 75$ N/mm <sup>2</sup> ;<br>$0.72x$ for $75 < f_{cu} \leq 105$ N/mm <sup>2</sup>           |                                                                                                                                                               | $x_{limit} = 0.5d$                                                                                                                                                 | N/A                                                                                                                                      | mm              |                 |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                      | Note for an under reinforced section, require $x \leq x_{limit}$ for yielding of tension steel;                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    |                                                                                                                                          |                 |                 |
| If $K_f > K' \rightarrow$ compression steel required                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    | N/A                                                                                                                                      |                 |                 |
| Compression steel                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                         | $A_s' = \frac{M - M_{uf} - K' f_{cu} b_w d^2}{0.95 f_y (d - d')}$                                                                                                         |                                                                                                                                                               | $f_y \leq 460$ N/mm <sup>2</sup>                                                                                                                                   | N/A                                                                                                                                      | mm <sup>2</sup> |                 |
| Tension steel, $A_s$                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               | $f_y \leq 460$ N/mm <sup>2</sup>                                                                                                                                   | N/A                                                                                                                                      | mm <sup>2</sup> |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                         | $A_s = \frac{\{0.20, 0.18, 0.16\} f_{cu} b_w d + 0.45 f_{cu} h_f (b - b_w)}{0.95 f_y} + A_s'$                                                                             |                                                                                                                                                               |                                                                                                                                                                    |                                                                                                                                          |                 |                 |
| Note the coefficient 0.20, 0.18 or 0.16 is used for $f_{cu} \leq 60, 75$ or $105$ N/mm <sup>2</sup> respectively;                                                                                                                                                                                                                                                                                                                      |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    |                                                                                                                                          |                 |                 |
| If $d' > \left(1 - \frac{f_y}{735}\right)x$ , use $700\left(1 - \frac{d'}{x}\right)$ in lieu of $0.95f_y$ ,                                                                                                                                                                                                                                                                                                                            |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    | $x = 0.5d$                                                                                                                               | $f_y \leq 460$  | N/A             |
| Back-analysis of $x$ in $(0.67f_{cu}/1.5) \cdot [b \cdot h_f + (s - h_f) \cdot b_w] + (f_y/1.05) \cdot (A_{s,t} - A_s)$                                                                                                                                                                                                                                                                                                                |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    | N/A                                                                                                                                      | mm              |                 |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                      | $s =$                                                                                                                   | $0.9x$ for $f_{cu} \leq 60$ N/mm <sup>2</sup> ;<br>$0.8x$ for $60 < f_{cu} \leq 75$ N/mm <sup>2</sup> ;<br>$0.72x$ for $75 < f_{cu} \leq 105$ N/mm <sup>2</sup>           |                                                                                                                                                               |                                                                                                                                                                    | N/A                                                                                                                                      | mm              |                 |
| Note for an under reinforced section, require $\epsilon_{st} = \epsilon_{cc}(d - x)/x \geq \epsilon_y$ for yielding of tension steel and $\epsilon_{sc} = \epsilon_{cc}(x - d')/x \geq \epsilon_y$ for yielding of compression steel, where $\epsilon_{cc} = 0.0035$ for $f_{cu} \leq 60$ N/mm <sup>2</sup> and $\epsilon_{cc} = 0.0035 - (f_{cu} - 60)/50000$ for $f_{cu} > 60$ N/mm <sup>2</sup> and $\epsilon_y = (f_y/1.05)/E_s$ ; |                                                                                                                         |                                                                                                                                                                           |                                                                                                                                                               |                                                                                                                                                                    |                                                                                                                                          |                 |                 |

|                                                                                                                                                                                                                                                                                                                               |  |                                                       |  |  |  |                                                                                     |           |                 |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------------------|--|--|--|-------------------------------------------------------------------------------------|-----------|-----------------|------------|
| CONSULTING<br>ENGINEERS                                                                                                                                                                                                                                                                                                       |  | Engineering Calculation Sheet<br>Consulting Engineers |  |  |  | Job No.                                                                             | Sheet No. | Rev.            |            |
|                                                                                                                                                                                                                                                                                                                               |  |                                                       |  |  |  | jXXX                                                                                | 14        |                 |            |
|                                                                                                                                                                                                                                                                                                                               |  |                                                       |  |  |  | Member/Location                                                                     |           |                 |            |
| Job Title                                                                                                                                                                                                                                                                                                                     |  |                                                       |  |  |  | Member Design - Reinforced Concrete Beam BS8110,                                    |           |                 |            |
| Member Design - RC Beam                                                                                                                                                                                                                                                                                                       |  |                                                       |  |  |  | Drg. Ref.                                                                           |           |                 |            |
|                                                                                                                                                                                                                                                                                                                               |  |                                                       |  |  |  | Made by                                                                             | XX        | Date            | 24/10/2026 |
|                                                                                                                                                                                                                                                                                                                               |  |                                                       |  |  |  | Chd.                                                                                |           |                 |            |
|                                                                                                                                                                                                                                                                                                                               |  |                                                       |  |  |  | EC2                                                                                 |           |                 |            |
| Bending Flanged Beam (Singly or Doubly Reinforced)                                                                                                                                                                                                                                                                            |  |                                                       |  |  |  |                                                                                     |           |                 |            |
| <div><div><math display="block">b_{eff} = \sum b_{eff,j} + b_w \leq b</math><p>where</p><math display="block">b_{eff,j} = 0,2b_i + 0,1l_0 \leq 0,2l_0</math><p>and</p><math display="block">b_{eff,j} \leq b_i</math></div><div></div></div> |  |                                                       |  |  |  |                                                                                     |           |                 |            |
|                                                                                                                                                                                                                                                                                                                               |  |                                                       |  |  |  |  |           |                 |            |
| Span                                                                                                                                                                                                                                                                                                                          |  |                                                       |  |  |  | N/A                                                                                 |           | m               |            |
| Depth of flange, hf                                                                                                                                                                                                                                                                                                           |  |                                                       |  |  |  | N/A                                                                                 |           | mm              |            |
| Effective width, b = MIN(bw + function (span, section, structure), beam spacing)                                                                                                                                                                                                                                              |  |                                                       |  |  |  | N/A                                                                                 |           | mm              |            |
| (bending flanged beam, deflection calcs flanged beam)                                                                                                                                                                                                                                                                         |  |                                                       |  |  |  |                                                                                     |           |                 |            |
| K = M/bd <sup>2</sup> f <sub>ck</sub>                                                                                                                                                                                                                                                                                         |  |                                                       |  |  |  | N/A                                                                                 |           |                 |            |
| z = d.[0.5+(0.25-K/C) <sup>0.5</sup> ], C=2ηα <sub>cc</sub> /γ <sub>c</sub>                                                                                                                                                                                                                                                   |  |                                                       |  |  |  | N/A                                                                                 |           | mm              |            |
| Depth of compression stress block, s = 2.(d-z) (applicable for all f <sub>ck</sub> )                                                                                                                                                                                                                                          |  |                                                       |  |  |  | N/A                                                                                 |           | mm              |            |
| Compression Stress Block in Flange (s <= hf)                                                                                                                                                                                                                                                                                  |  |                                                       |  |  |  | N/A                                                                                 |           |                 |            |
| M <sub>u</sub> = K'f <sub>ck</sub> bd <sup>2</sup>                                                                                                                                                                                                                                                                            |  |                                                       |  |  |  | N/A                                                                                 |           | kNm             |            |
| Ratio, K'                                                                                                                                                                                                                                                                                                                     |  |                                                       |  |  |  | N/A                                                                                 |           |                 |            |
| $K' = \frac{\eta \alpha_{cc}}{\gamma_c} \cdot \lambda \cdot \left(\frac{x}{d}\right)_{limit} \cdot \left(1 - \frac{\lambda}{2} \left(\frac{x}{d}\right)_{limit}\right)$                                                                                                                                                       |  |                                                       |  |  |  | N/A                                                                                 |           | cl.3.1.7(3)     |            |
| Partial factor for concrete, γ <sub>c</sub> = 1.50                                                                                                                                                                                                                                                                            |  |                                                       |  |  |  | N/A                                                                                 |           | cl.3.1.7(3)     |            |
| Strength coefficient, α <sub>cc</sub> = 1.00   0.85                                                                                                                                                                                                                                                                           |  |                                                       |  |  |  | EC2 UK                                                                              |           | cl.3.1.6(1)     |            |
| Stress block factor, η = MIN[1.0,1.0-(f <sub>ck</sub> -50)/200]                                                                                                                                                                                                                                                               |  |                                                       |  |  |  | N/A                                                                                 |           | cl.3.1.6(1)     |            |
| Stress block factor, λ = MIN[0.8,0.8-(f <sub>ck</sub> -50)/400]                                                                                                                                                                                                                                                               |  |                                                       |  |  |  | N/A                                                                                 |           | cl.3.1.7(3)     |            |
| Note the expression for K' ensures that the section remains ductile i.e. ensuring that failure occurs with the gradual yielding of the tension steel and not by a sudden catastrophic compression failure of the concrete;                                                                                                    |  |                                                       |  |  |  |                                                                                     |           |                 |            |
| If: M < M <sub>u</sub> → no compression steel                                                                                                                                                                                                                                                                                 |  |                                                       |  |  |  | N/A                                                                                 |           |                 |            |
| $K = \frac{M}{bd^2 f_{ck}}$                                                                                                                                                                                                                                                                                                   |  |                                                       |  |  |  | N/A                                                                                 |           |                 |            |
| $z = d \left[ 0.5 + \sqrt{0.25 - \frac{K}{C}} \right], \quad C = \frac{2\eta \alpha_{cc}}{\gamma_c}$                                                                                                                                                                                                                          |  |                                                       |  |  |  | N/A                                                                                 |           | mm              |            |
| z <= 0.95d                                                                                                                                                                                                                                                                                                                    |  |                                                       |  |  |  | N/A                                                                                 |           | cl.3.1.7(3)     |            |
| Depth of neutral axis, x ≤ x <sub>limit</sub>                                                                                                                                                                                                                                                                                 |  |                                                       |  |  |  | N/A                                                                                 |           | ≤               |            |
|                                                                                                                                                                                                                                                                                                                               |  |                                                       |  |  |  | N/A                                                                                 |           | mm              |            |
| Neutral axis, x                                                                                                                                                                                                                                                                                                               |  |                                                       |  |  |  | N/A                                                                                 |           | mm              |            |
| x = 2(d-z)/λ                                                                                                                                                                                                                                                                                                                  |  |                                                       |  |  |  | N/A                                                                                 |           | mm              |            |
| x <sub>limit</sub> = [(β <sub>b</sub> -k <sub>1</sub> )/k <sub>2</sub> ].d for f <sub>ck</sub> ≤ 50MPa                                                                                                                                                                                                                        |  |                                                       |  |  |  | EC2                                                                                 |           | cl.3.1.7(3)     |            |
| k <sub>1</sub> = 0.44   0.40                                                                                                                                                                                                                                                                                                  |  |                                                       |  |  |  | N/A                                                                                 |           | cl.5.5(4)       |            |
| k <sub>2</sub> = 1.25(0.6+0.0014/ε <sub>cu2</sub> )   0.6+0.0014/ε <sub>cu2</sub>                                                                                                                                                                                                                                             |  |                                                       |  |  |  | N/A                                                                                 |           | cl.5.5(4)       |            |
| Neutral axis limit, x <sub>limit</sub>                                                                                                                                                                                                                                                                                        |  |                                                       |  |  |  | N/A                                                                                 |           | mm              |            |
| x <sub>limit</sub> = [(β <sub>b</sub> -k <sub>3</sub> )/k <sub>4</sub> ].d for f <sub>ck</sub> > 50MPa                                                                                                                                                                                                                        |  |                                                       |  |  |  | EC2                                                                                 |           | cl.5.5(4)       |            |
| k <sub>3</sub> = 0.54   0.40                                                                                                                                                                                                                                                                                                  |  |                                                       |  |  |  | N/A                                                                                 |           | cl.5.5(4)       |            |
| k <sub>4</sub> = 1.25(0.6+0.0014/ε <sub>cu2</sub> )   0.6+0.0014/ε <sub>cu2</sub>                                                                                                                                                                                                                                             |  |                                                       |  |  |  | N/A                                                                                 |           | cl.5.5(4)       |            |
| ε <sub>cu2</sub> = 0.0035 for f <sub>ck</sub> ≤ 50MPa                                                                                                                                                                                                                                                                         |  |                                                       |  |  |  | N/A                                                                                 |           | T.3.1           |            |
| ε <sub>cu2</sub> = [2.6+35[(90-f <sub>ck</sub> )/100] <sup>4</sup> ]/1000 for f <sub>ck</sub> > 50MPa                                                                                                                                                                                                                         |  |                                                       |  |  |  | N/A                                                                                 |           | T.3.1           |            |
| Tension steel                                                                                                                                                                                                                                                                                                                 |  |                                                       |  |  |  | N/A                                                                                 |           | mm <sup>2</sup> |            |
| $A_s = \frac{M}{(0.87f_y)z}$                                                                                                                                                                                                                                                                                                  |  |                                                       |  |  |  | N/A                                                                                 |           | cl.3.2.7(2)     |            |

[illegible]

[illegible]

| CONSULTING<br>ENGINEERS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |                   |                   | Job No.           | Sheet No.           | Rev.              |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |                   |                   | Member/Location   |                     |                   |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Job Title                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Member Design - Reinforced Concrete Beam BS8110, |                                                       |                   |                   | Drg. Ref.         |                     |                   |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Member Design - RC Beam                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  |                                                       |                   |                   | Made by           | XX                  | Date              | 24/10/2026        | Chd.   |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |                   |                   |                   |                     |                   |                   | BS8110 |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Shear Rectangular Beam (BS8110)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |                   |                   |                   |                     |                   |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Note that this design check is performed for both rectangular and flanged sections, adopting rectangular section equations in the case of flanged sections;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                  |                                                       |                   |                   |                   |                     |                   |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Note that d is the effective depth to the tension reinforcement irrespective of whether the section is sagging at midspans or hogging at supports. It follows then, for midspans, tension steel is the bottom steel whilst for supports, tension steel is the top steel;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                  |                                                       |                   |                   |                   |                     |                   |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Ultimate shear stress, $v_{ult} = V_d/b_wd$ ( $< 0.8f_{cu}^{0.5}$ & $\{5.0, 7.0\}N/mm^2$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                                       |                   |                   | 2.55              | N/mm <sup>2</sup>   | 3.4.5.2 BC        |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Ultimate shear strength, $MIN\{0.8f_{cu}^{0.5}$ & $\{5.0, 7.0\}N/mm^2\}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                  |                                                       |                   |                   | 4.73              | N/mm <sup>2</sup>   | 3.4.5.2 BC        |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Ultimate shear stress utilisation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                  |                                                       |                   |                   | 54%               |                     | OK                |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Design shear stress, $v_d = V_{d,crit.}/b_wd$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |                   |                   | Full shear $V_d$  | 2.55                | N/mm <sup>2</sup> |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Enhanced shear strength, $2d/a_v.v_c$ ( $< 0.8f_{cu}^{0.5}$ & $\{5.0, 7.0\}N/mm^2$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  |                                                       |                   |                   | $\times 1.00$     | 0.79                | N/mm <sup>2</sup> | cl.3.4.5.8        |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Distance, $a_v$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |                   |                   | 2.00d             | 1834                | mm                |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| (Shear capacity enhancement by calculating $v_d$ within 2d of support and comparing against enhanced $v_c$ within 2d of the support as clause 3.4.5.8 BS8110 employed instead of calculating $v_d$ at d from support and comparing against unenhanced $v_c$ as clause 3.4.5.10 BS8110;)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  |                                                       |                   |                   |                   |                     |                   | Note              |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Area of tension steel reinforcement provided, $A_{s,prov}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                                       |                   |                   | 6434              | mm <sup>2</sup>     |                   |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| $\rho_w = 100A_{s,prov}/b_wd$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |                   |                   | 1.40              | %                   |                   |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| $v_c = (0.79/1.25)(\rho_w f_{cu}/25)^{1/3}(400/d)^{1/4}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                  |                                                       |                   |                   | 0.79              | N/mm <sup>2</sup>   | cl.3.4.5.4        |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| $\rho_w = 100A_{s,prov}/b_wd \leq 3$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  |                                                       |                   |                   | 1.40              | %                   | cl.3.4.5.4        |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| $f_{cu} = f_{cu} \leq 80N/mm^2$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |                   |                   | 35                | N/mm <sup>2</sup>   | 3.4.5.4 BC        |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| $(400/d)^{1/4} \geq (0.67 \text{ or } 1.00)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |                   |                   | 1.00              |                     | cl.3.4.5.4        |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| <div>Table 3.8 — Values of <math>v_c</math> design concrete shear stress</div> <table><tr><th rowspan="2"><math>\frac{100A_s}{b_wd}</math></th><th colspan="8">Effective depth mm</th></tr><tr><th>125</th><th>150</th><th>175</th><th>200</th><th>225</th><th>250</th><th>300</th><th>400</th></tr><tr><td></td><td>N/mm<sup>2</sup></td><td>N/mm<sup>2</sup></td><td>N/mm<sup>2</sup></td><td>N/mm<sup>2</sup></td><td>N/mm<sup>2</sup></td><td>N/mm<sup>2</sup></td><td>N/mm<sup>2</sup></td><td>N/mm<sup>2</sup></td></tr><tr><td><math>\leq 0.15</math></td><td>0.45</td><td>0.43</td><td>0.41</td><td>0.40</td><td>0.39</td><td>0.38</td><td>0.36</td><td>0.34</td></tr><tr><td>0.25</td><td>0.53</td><td>0.51</td><td>0.49</td><td>0.47</td><td>0.46</td><td>0.45</td><td>0.43</td><td>0.40</td></tr><tr><td>0.50</td><td>0.67</td><td>0.64</td><td>0.62</td><td>0.60</td><td>0.58</td><td>0.56</td><td>0.54</td><td>0.50</td></tr><tr><td>0.75</td><td>0.77</td><td>0.73</td><td>0.71</td><td>0.68</td><td>0.66</td><td>0.65</td><td>0.62</td><td>0.57</td></tr><tr><td>1.00</td><td>0.84</td><td>0.81</td><td>0.78</td><td>0.75</td><td>0.73</td><td>0.71</td><td>0.68</td><td>0.63</td></tr><tr><td>1.50</td><td>0.97</td><td>0.92</td><td>0.89</td><td>0.86</td><td>0.83</td><td>0.81</td><td>0.78</td><td>0.72</td></tr><tr><td>2.00</td><td>1.06</td><td>1.02</td><td>0.98</td><td>0.95</td><td>0.92</td><td>0.89</td><td>0.86</td><td>0.80</td></tr><tr><td><math>\geq 3.00</math></td><td>1.22</td><td>1.16</td><td>1.12</td><td>1.08</td><td>1.05</td><td>1.02</td><td>0.98</td><td>0.91</td></tr></table> <div>NOTE 1 Allowance has been made in these figures for a <math>\gamma_m</math> of 1.25.<br/>NOTE 2 The values in the table are derived from the expression:<br/><math>0.79(100A_s/(b_wd))^{1/3}(400/d)^{1/4}/\gamma_m</math><br/>where<br/><math>\frac{100A_s}{b_wd}</math> should not be taken as greater than 3.<br/><math>(\frac{400}{d})^{1/4}</math> should not be taken as less than 0.67 for members without shear reinforcement.<br/><math>(\frac{400}{d})^{1/4}</math> should not be taken as less than 1 for members with shear reinforcement providing a design shear resistance of <math>\geq 0.4 N/mm^2</math>.<br/>For characteristic concrete strengths greater than 25 N/mm<sup>2</sup>, the values in this table may be multiplied by <math>(f_{cu}/25)^{1/3}</math>. The value of <math>f_{cu}</math> should not be taken as greater than 40.</div> |                                                  |                                                       |                   |                   |                   |                     |                   |                   |        | $\frac{100A_s}{b_wd}$ | Effective depth mm |  |  |  |  |  |  |  | 125 | 150 | 175 | 200 | 225 | 250 | 300 | 400 |  | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup> | $\leq 0.15$ | 0.45 | 0.43 | 0.41 | 0.40 | 0.39 | 0.38 | 0.36 | 0.34 | 0.25 | 0.53 | 0.51 | 0.49 | 0.47 | 0.46 | 0.45 | 0.43 | 0.40 | 0.50 | 0.67 | 0.64 | 0.62 | 0.60 | 0.58 | 0.56 | 0.54 | 0.50 | 0.75 | 0.77 | 0.73 | 0.71 | 0.68 | 0.66 | 0.65 | 0.62 | 0.57 | 1.00 | 0.84 | 0.81 | 0.78 | 0.75 | 0.73 | 0.71 | 0.68 | 0.63 | 1.50 | 0.97 | 0.92 | 0.89 | 0.86 | 0.83 | 0.81 | 0.78 | 0.72 | 2.00 | 1.06 | 1.02 | 0.98 | 0.95 | 0.92 | 0.89 | 0.86 | 0.80 | $\geq 3.00$ | 1.22 | 1.16 | 1.12 | 1.08 | 1.05 | 1.02 | 0.98 | 0.91 |
| $\frac{100A_s}{b_wd}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Effective depth mm                               |                                                       |                   |                   |                   |                     |                   |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 125                                              | 150                                                   | 175               | 200               | 225               | 250                 | 300               | 400               |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | N/mm <sup>2</sup>                                | N/mm <sup>2</sup>                                     | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup>   | N/mm <sup>2</sup> | N/mm <sup>2</sup> |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| $\leq 0.15$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0.45                                             | 0.43                                                  | 0.41              | 0.40              | 0.39              | 0.38                | 0.36              | 0.34              |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| 0.25                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0.53                                             | 0.51                                                  | 0.49              | 0.47              | 0.46              | 0.45                | 0.43              | 0.40              |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| 0.50                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0.67                                             | 0.64                                                  | 0.62              | 0.60              | 0.58              | 0.56                | 0.54              | 0.50              |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| 0.75                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0.77                                             | 0.73                                                  | 0.71              | 0.68              | 0.66              | 0.65                | 0.62              | 0.57              |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| 1.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0.84                                             | 0.81                                                  | 0.78              | 0.75              | 0.73              | 0.71                | 0.68              | 0.63              |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| 1.50                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0.97                                             | 0.92                                                  | 0.89              | 0.86              | 0.83              | 0.81                | 0.78              | 0.72              |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| 2.00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1.06                                             | 1.02                                                  | 0.98              | 0.95              | 0.92              | 0.89                | 0.86              | 0.80              |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| $\geq 3.00$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1.22                                             | 1.16                                                  | 1.12              | 1.08              | 1.05              | 1.02                | 0.98              | 0.91              |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Minimum shear strength, $v_r = MAX(0.4, 0.4(f_{cu}/40)^{2/3})$ , $f_{cu} \leq 80N/mm^2$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  |                                                       |                   |                   | 0.40              | N/mm <sup>2</sup>   | 3.4.5.3 BC        |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Check $v_d < 0.5.2d/a_v.v_c$ for no links (minor elements)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                                       |                   |                   | INVALID           | 0.40                | cl.3.4.5.3        |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Concrete shear capacity $2d/a_v.v_c.(b_wd)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                  |                                                       |                   |                   | 363               | kN                  | 4.5.4, cl.3.4     |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Check $0.0 < v_d < v_r + 2d/a_v.v_c$ for nominal links                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                  |                                                       |                   |                   | 0.00              | N/A                 | 1.19              | cl.3.4.5.3        |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| $(A_{sv}/S)_{nom} > v_r.b_w/(0.95f_{yv})$ , $f_{yv} \leq 460N/mm^2$ i.e. $(A_{sv}/S)_{nom} >$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |                   |                   | 0.46              | mm <sup>2</sup> /mm | 4.5.3, cl.3.4     |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| $V_{cap,nom} = (v_r + 2d/a_v.v_c).(b_wd)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                  |                                                       |                   |                   | 546               | kN                  | 4.5.3, cl.3.4     |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Check $v_d > v_r + 2d/a_v.v_c$ for design links                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |                   |                   | 1.19              | VALID               | 4.73              | cl.3.4.5.3        |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| $A_{sv}/S > b_w(v_d - 2d/a_v.v_c)/(0.95f_{yv})$ , $f_{yv} \leq 460N/mm^2$ i.e. $A_{sv}/S >$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                  |                                                       |                   |                   | 2.01              | mm <sup>2</sup> /mm | cl.3.4.5.8,       |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| $V_{cap} = (A_{sv,prov}/S + A_{sv,prov,t}/S_t).(0.95f_{yv}).d + 2d/a_v.v_c.(b_wd)$ , $f_{yv} \leq 460$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                  |                                                       |                   |                   | 1622              | kN                  | cl.3.4.5.8,       |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Area prov. by all shear and torsion links in section, $A_{sv,prov} + A_{sv,prov,t}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                  |                                                       |                   |                   | 314               | mm <sup>2</sup>     |                   |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Tried $A_{sv,prov}/S + A_{sv,prov,t}/S_t$ value                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |                   |                   | 3.14              | mm <sup>2</sup> /mm |                   |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |
| Design shear resistance utilisation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                  |                                                       |                   |                   | 72%               |                     | OK                |                   |        |                       |                    |  |  |  |  |  |  |  |     |     |     |     |     |     |     |     |  |                   |                   |                   |                   |                   |                   |                   |                   |             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |             |      |      |      |      |      |      |      |      |

| CONSULTING ENGINEERS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                    | Engineering Calculation Sheet<br>Consulting Engineers |       | Job No.          | Sheet No.           | Rev.              |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
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| Job Title                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Member Design - Reinforced Concrete Beam BS8110,                                                                                   |                                                       |       | Drg. Ref.        |                     |                   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Member Design - RC Beam                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                    |                                                       |       | Made by          | XX                  | Date 24/10/2026   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
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| <b>Shear Rectangular Beam (EC2)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                    |                                                       |       |                  |                     |                   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Note that this design check is performed for both rectangular and flanged sections, adopting rectangular section equations in the case of flanged sections;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                    |                                                       |       |                  |                     |                   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Note that $d$ is the effective depth to the tension reinforcement irrespective of whether the section is sagging at midspans or hogging at supports. It follows then, for midspans, tension steel is the bottom steel whilst for supports, tension steel is the top steel;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                    |                                                       |       |                  |                     |                   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Ultimate shear stress, $v_{ult} = V_d/b_w d$ ( $< v_{Rd,max}(\theta=45^\circ)=0.18(1-f_{ck}/250).f_{ck}$ , $f_{ck} \leq 50$ N/mm <sup>2</sup> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                    |                                                       |       | 2.55             | N/mm <sup>2</sup>   | 3(3), cl.3.1      |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Ultimate shear strength, $v_{Rd,max}(\theta=45^\circ)=0.18(1-f_{ck}/250).f_{ck}$ , $f_{ck} \leq 50$ N/mm <sup>2</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                    |                                                       |       | 4.48             | N/mm <sup>2</sup>   | 3(3), cl.3.1      |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Ultimate shear stress utilisation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                    |                                                       |       | 57%              |                     | OK                |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Design shear stress, $v_d = V_{d,crit.}/b_w d$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                    |                                                       |       | Full shear $V_d$ | 2.55                | N/mm <sup>2</sup> |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Enhanced shear strength, $2d/a_v \cdot v_{Rd,c}$ ( $< v_{Rd,max}(\theta=45^\circ)=0.18(1-f_{ck}/250).f_{ck}$ , $f_{ck} \leq 50$ N/mm <sup>2</sup> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                    |                                                       |       | $\times 1.00$    | 0.60                | N/mm <sup>2</sup> |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Distance, $a_v$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                    |                                                       |       | 2.00d            | 1834                | mm                |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| (Shear capacity enhancement by calculating $v_d$ within $2d$ of support and comparing against enhanced $v_{Rd,c}$ within $2d$ of the support as clause 6.2.2(6) EC2 employed instead of calculating $v_d$ at $d$ from support and comparing against unenhanced $v_{Rd,c}$ ;) )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                    |                                                       |       |                  |                     | Note              |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Area of tension steel reinforcement provided, $A_{s,prov}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                    |                                                       |       | 6434             | mm <sup>2</sup>     |                   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| $\rho_w = 100A_{s,prov}/b_w d$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                    |                                                       |       | 1.40             | %                   |                   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| $v_{Rd,c} = C_{Rd,c} \cdot k(\rho_w f_{ck})^{1/3} + k_1 \cdot \sigma_{cp} \geq v_{min} + k_1 \cdot \sigma_{cp}$ ; $v_{min} = 0.035k^{3/2} f_{ck}^{0.5}$ , $k = 1 + \sqrt{200/d} \leq 2.0$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                    |                                                       |       | 0.60             | N/mm <sup>2</sup>   | 2(1), cl.3.1      |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| $C_{Rd,c} = 0.18/\gamma_c = 0.18/1.5 = 0.12$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                    |                                                       |       | 0.12             |                     | cl.6.2.2(1)       |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| $k = 1 + \sqrt{200/d} \leq 2.0$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                    |                                                       |       | 1.47             |                     | cl.6.2.2(1)       |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| $\rho_w = 100A_{s,prov}/b_w d \leq 2$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                    |                                                       |       | 1.40             | %                   | cl.6.2.2(1)       |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| $\sigma_{cp} = F/b_w h \leq 0.2f_{cd} = 0.2\alpha_{cc} \cdot f_{ck}/\gamma_c = 0.2(1.0 \cdot f_{ck}/1.5)$ , $f_{ck} \leq 50$ N/mm <sup>2</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                    |                                                       |       | 0.00             | N/mm <sup>2</sup>   | 2(1), cl.3.1      |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| <b>Table 8.2</b> Shear resistance of slabs without shear reinforcement $v_{Rd,c}$ N/mm <sup>2</sup> (Class C30/37 concrete)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                    |                                                       |       |                  |                     |                   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| <table border="1"> <thead> <tr> <th rowspan="2"><math>\rho_1 = A_s/bd</math></th> <th colspan="8">Effective depth, <math>d</math> (mm)</th> </tr> <tr> <th><math>\leq 200</math></th> <th>225</th> <th>250</th> <th>300</th> <th>350</th> <th>400</th> <th>500</th> <th>600</th> <th>750</th> </tr> </thead> <tbody> <tr> <td>0.25%</td> <td>0.54</td> <td>0.52</td> <td>0.50</td> <td>0.47</td> <td>0.45</td> <td>0.43</td> <td>0.40</td> <td>0.38</td> <td>0.36</td> </tr> <tr> <td>0.50%</td> <td>0.59</td> <td>0.57</td> <td>0.56</td> <td>0.54</td> <td>0.52</td> <td>0.51</td> <td>0.48</td> <td>0.47</td> <td>0.45</td> </tr> <tr> <td>0.75%</td> <td>0.68</td> <td>0.66</td> <td>0.64</td> <td>0.62</td> <td>0.59</td> <td>0.58</td> <td>0.55</td> <td>0.53</td> <td>0.51</td> </tr> <tr> <td>1.00%</td> <td>0.75</td> <td>0.72</td> <td>0.71</td> <td>0.68</td> <td>0.65</td> <td>0.64</td> <td>0.61</td> <td>0.59</td> <td>0.57</td> </tr> <tr> <td>1.25%</td> <td>0.80</td> <td>0.78</td> <td>0.76</td> <td>0.73</td> <td>0.71</td> <td>0.69</td> <td>0.66</td> <td>0.63</td> <td>0.61</td> </tr> <tr> <td>1.50%</td> <td>0.85</td> <td>0.83</td> <td>0.81</td> <td>0.78</td> <td>0.75</td> <td>0.73</td> <td>0.70</td> <td>0.67</td> <td>0.65</td> </tr> <tr> <td>2.00%</td> <td>0.94</td> <td>0.91</td> <td>0.89</td> <td>0.85</td> <td>0.82</td> <td>0.80</td> <td>0.77</td> <td>0.74</td> <td>0.71</td> </tr> <tr> <td><math>k</math></td> <td>2.000</td> <td>1.943</td> <td>1.894</td> <td>1.816</td> <td>1.756</td> <td>1.707</td> <td>1.632</td> <td>1.577</td> <td>1.516</td> </tr> </tbody> </table> |                                                                                                                                    |                                                       |       |                  |                     |                   | $\rho_1 = A_s/bd$             | Effective depth, $d$ (mm) |       |    |    |    |    |                     |      | $\leq 200$ | 225  | 250  | 300  | 350  | 400 | 500 | 600 | 750 | 0.25% | 0.54 | 0.52 | 0.50 | 0.47 | 0.45 | 0.43 | 0.40 | 0.38 | 0.36 | 0.50% | 0.59 | 0.57 | 0.56 | 0.54 | 0.52 | 0.51 | 0.48 | 0.47 | 0.45 | 0.75% | 0.68 | 0.66 | 0.64 | 0.62 | 0.59 | 0.58 | 0.55 | 0.53 | 0.51 | 1.00% | 0.75 | 0.72 | 0.71 | 0.68 | 0.65 | 0.64 | 0.61 | 0.59 | 0.57 | 1.25% | 0.80 | 0.78 | 0.76 | 0.73 | 0.71 | 0.69 | 0.66 | 0.63 | 0.61 | 1.50% | 0.85 | 0.83 | 0.81 | 0.78 | 0.75 | 0.73 | 0.70 | 0.67 | 0.65 | 2.00% | 0.94 | 0.91 | 0.89 | 0.85 | 0.82 | 0.80 | 0.77 | 0.74 | 0.71 | $k$ | 2.000 | 1.943 | 1.894 | 1.816 | 1.756 | 1.707 | 1.632 | 1.577 | 1.516 |
| $\rho_1 = A_s/bd$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Effective depth, $d$ (mm)                                                                                                          |                                                       |       |                  |                     |                   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | $\leq 200$                                                                                                                         | 225                                                   | 250   | 300              | 350                 | 400               | 500                           | 600                       | 750   |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| 0.25%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0.54                                                                                                                               | 0.52                                                  | 0.50  | 0.47             | 0.45                | 0.43              | 0.40                          | 0.38                      | 0.36  |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| 0.50%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0.59                                                                                                                               | 0.57                                                  | 0.56  | 0.54             | 0.52                | 0.51              | 0.48                          | 0.47                      | 0.45  |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| 0.75%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0.68                                                                                                                               | 0.66                                                  | 0.64  | 0.62             | 0.59                | 0.58              | 0.55                          | 0.53                      | 0.51  |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| 1.00%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0.75                                                                                                                               | 0.72                                                  | 0.71  | 0.68             | 0.65                | 0.64              | 0.61                          | 0.59                      | 0.57  |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| 1.25%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0.80                                                                                                                               | 0.78                                                  | 0.76  | 0.73             | 0.71                | 0.69              | 0.66                          | 0.63                      | 0.61  |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| 1.50%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0.85                                                                                                                               | 0.83                                                  | 0.81  | 0.78             | 0.75                | 0.73              | 0.70                          | 0.67                      | 0.65  |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| 2.00%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0.94                                                                                                                               | 0.91                                                  | 0.89  | 0.85             | 0.82                | 0.80              | 0.77                          | 0.74                      | 0.71  |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| $k$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 2.000                                                                                                                              | 1.943                                                 | 1.894 | 1.816            | 1.756               | 1.707             | 1.632                         | 1.577                     | 1.516 |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| <b>Table 8.3</b> Concrete strength modification factor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                    |                                                       |       |                  |                     |                   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| <table border="1"> <thead> <tr> <th><math>f_{ck}</math> (N/mm<sup>2</sup>)</th> <th>25</th> <th>30</th> <th>35</th> <th>40</th> <th>45</th> <th>50</th> </tr> </thead> <tbody> <tr> <td>Modification factor</td> <td>0.94</td> <td>1.00</td> <td>1.05</td> <td>1.10</td> <td>1.14</td> <td>1.19</td> </tr> </tbody> </table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                    |                                                       |       |                  |                     |                   | $f_{ck}$ (N/mm <sup>2</sup> ) | 25                        | 30    | 35 | 40 | 45 | 50 | Modification factor | 0.94 | 1.00       | 1.05 | 1.10 | 1.14 | 1.19 |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| $f_{ck}$ (N/mm <sup>2</sup> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 25                                                                                                                                 | 30                                                    | 35    | 40               | 45                  | 50                |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Modification factor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0.94                                                                                                                               | 1.00                                                  | 1.05  | 1.10             | 1.14                | 1.19              |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Minimum shear strength, $v_r = 0.08/\gamma_s \cdot f_{ck}^{0.5}$ , $\gamma_s = 1.15$ , $f_{ck} \leq 50$ N/mm <sup>2</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                    |                                                       |       | 0.37             | N/mm <sup>2</sup>   | 2(5), cl.3.1      |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| <b>Check <math>v_d &lt; 2d/a_v \cdot v_{Rd,c}</math> for no links (minor elements)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                    |                                                       |       | INVALID          | 0.60                | cl.6.2.1(3)       |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| 4.5.8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Concrete shear capacity $2d/a_v \cdot v_{Rd,c} \cdot (b_w d)$                                                                      |                                                       |       | 274              | kN                  | 2(1), cl.6.2.1    |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| <b>Check <math>0.0 &lt; v_d &lt; v_r</math> for nominal links</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                    |                                                       |       | 0.00             | N/A                 | 0.37              |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| 4.5.1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | $(A_{sv}/S)_{nom} > v_r \cdot b_w / (0.87f_{yv})$ , $f_{yv} \leq 600$ N/mm <sup>2</sup> i.e. $(A_{sv}/S)_{nom} >$                  |                                                       |       | 0.42             | mm <sup>2</sup> /mm | 3(3), cl.3.2      |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| 4.5.8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | $V_{cap,nom} = 2d/a_v \cdot (A_{sv}/S)_{nom} \cdot (0.87f_{yv}) \cdot 0.9d \cdot \cot\theta$ , $f_{yv} \leq 600$ N/mm <sup>2</sup> |                                                       |       | 263              | kN                  | cl.6.2.3(8)       |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| <b>Check <math>v_d &gt; v_r</math> for design links</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                    |                                                       |       | 0.37             | VALID               | 4.48              |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| cl.3.4.5.1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | $A_{sv}/S > b_w \cdot v_d / (0.9(0.87f_{yv}) \cdot \cot\theta) / (2d/a_v)$ , $f_{yv} \leq 600$ N/mm <sup>2</sup> i.e. $A_{sv}/S >$ |                                                       |       | 1.88             | mm <sup>2</sup> /mm | cl.6.2.3(8)       |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| cl.3.4.5.1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | $V_{cap} = \text{MIN} \{V_{Rd,s}, V_{Rd,max,\theta}\}$                                                                             |                                                       |       | 1777             | kN                  | cl.6.2.3(8)       |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| $V_{Rd,s} = 2d/a_v \cdot (A_{sv,prov}/S + A_{sv,prov,t}/S_t) \cdot (0.87f_{yv}) \cdot 0.9d \cdot \cot\theta$ , $f_{yv} \leq 600$ N/mm <sup>2</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                    |                                                       |       | 1953             | kN                  |                   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| $V_{Rd,max,\theta} = 0.36b_w d (1-f_{ck}/250) \cdot f_{ck} / [\cot\theta + \tan\theta]$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                    |                                                       |       | 1777             | kN                  | 3(3), cl.6.2.1    |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| $\theta = 22^\circ \leq 0.5 \sin^{-1} \{v_d / v_{Rd,max}(\theta=45^\circ) + T/T_{Rd,max}(\theta=45^\circ)\} \leq 45^\circ$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                    |                                                       |       | 30.0             | 22.0                | °                 |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Area prov. by all shear and torsion links in section, $A_{sv,prov} + A_{sv,prov,t}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                    |                                                       |       | 314              | mm <sup>2</sup>     |                   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Tried $A_{sv,prov}/S + A_{sv,prov,t}/S_t$ value                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                    |                                                       |       | 3.14             | mm <sup>2</sup> /mm |                   |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Design shear resistance utilisation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                    |                                                       |       | 66%              |                     | OK                |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |
| Add. longitudinal steel (for shear), $A_{s,s} = 0.5V_{d,crit.} \cot\theta / (0.87f_y)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                    |                                                       |       | 2329             | mm <sup>2</sup>     | NOT OK            |                               |                           |       |    |    |    |    |                     |      |            |      |      |      |      |     |     |     |     |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |     |       |       |       |       |       |       |       |       |       |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                |                                                          |                                  |                  |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|----------------------------------------------------------|----------------------------------|------------------|---------------------|---------------------|-------|--|--|-----------------------------|----------------------------------------------------------------------------------------|-----|--------------------------------------------|-----|-------------------------------|-----|
| <div>CONSULTING ENGINEERS</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                | Engineering Calculation Sheet<br>Consulting Engineers    |                                  | Job No.<br>jXXX  | Sheet No.<br>19     | Rev.                |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                |                                                          |                                  | Member/Location  |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Job Title                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Member Design - Reinforced Concrete Beam BS8110,                                               |                                                          |                                  | Drg. Ref.        |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Member Design - RC Beam                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                |                                                          |                                  | Made by          | XX                  | Date<br>24/10/2026  |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                |                                                          |                                  | Chd.             | ACI318              |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Shear Rectangular Beam (ACI318)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                |                                                          |                                  |                  |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Note that this design check is performed for both rectangular and flanged sections, adopting rectangular section equations in the case of flanged sections;                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                |                                                          |                                  |                  |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Note that d is the effective depth to the tension reinforcement irrespective of whether the section is sagging at midspans or hogging at supports. It follows then, for midspans, tension steel is the bottom steel whilst for supports, tension steel is the top steel;                                                                                                                                                                                                                                                                                                                                |                                                                                                |                                                          |                                  |                  |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Ultimate shear stress, $v_{ult} = V_d/b_wd$ ( $< \phi(0.66+0.17\lambda)\sqrt{f'_c}$ , $f'_c \leq 70\text{N/mm}^2$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                |                                                          |                                  | 2.55             | N/mm <sup>2</sup>   | cl.22.5.5.1         |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Ultimate shear strength, $\phi(0.66+0.17\lambda)\sqrt{f'_c}$ , $f'_c \leq 70\text{N/mm}^2$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                |                                                          |                                  | 3.29             | N/mm <sup>2</sup>   | cl.22.5.5.1         |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Ultimate shear stress utilisation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                |                                                          |                                  | 77%              |                     | OK                  |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Design shear stress, $v_d = V_{d,crit.}/b_wd$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                |                                                          |                                  | Full shear $V_d$ | 2.55                | N/mm <sup>2</sup>   |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Enhanced shear strength, $d/a_v.v_c$ ( $< \phi(0.66+0.17\lambda)\sqrt{f'_c}$ , $f'_c \leq 70\text{N/mm}^2$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                |                                                          |                                  | x 1.00           | 0.74                | N/mm <sup>2</sup>   |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Distance, $a_v$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                |                                                          |                                  | 2.00d            | 917                 | mm                  |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| (Shear capacity enhancement by calculating $v_d$ within d of support and comparing against enhanced $v_c$ within d of the support employed instead of calculating $v_d$ at d from support and comparing against unenhanced $v_c$ as clause 9.4.3.2 ACI318;)                                                                                                                                                                                                                                                                                                                                             |                                                                                                |                                                          |                                  |                  |                     | Note                |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Area of tension steel reinforcement provided, $A_{s,prov}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                |                                                          |                                  | 6434             | mm <sup>2</sup>     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| $\rho_w = 100A_{s,prov}/b_wd$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                |                                                          |                                  | 1.40             | %                   |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| 2.2(2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | $v_c = \phi V_d/b_wd$                                                                          |                                                          | Note $f'_c \leq 70\text{N/mm}^2$ | Detailed         | 0.74                | N/mm <sup>2</sup>   |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                | <div><math>V_c = 0.17\lambda\sqrt{f'_c}b_wd</math></div> | [Simplified] $\phi V_c =$        | 309              | kN                  | 5.5.1, cl.22        |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| 2.2(2)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | where $\lambda = \{1.00 \text{ NWC}, 0.75 \text{ LWC}\}$                                       |                                                          | Normal weight                    |                  |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| <div>Table 22.5.5.1—Detailed method for calculating <math>V_c</math></div> <table><tr><td colspan="2"><math>V_c</math></td><td></td></tr><tr><td rowspan="3">Least of (a), (b), and (c):</td><td><math>\left(0.16\lambda\sqrt{f'_c} + 17\rho_w \frac{V_u d}{M_u}\right)b_w d</math> <sup>(1)</sup></td><td>(a)</td></tr><tr><td><math>(0.16\lambda\sqrt{f'_c} + 17\rho_w)b_w d</math></td><td>(b)</td></tr><tr><td><math>0.29\lambda\sqrt{f'_c}b_w d</math></td><td>(c)</td></tr></table> <p><sup>(1)</sup> <math>M_u</math> occurs simultaneously with <math>V_u</math> at the section considered.</p> |                                                                                                |                                                          |                                  |                  |                     |                     | $V_c$ |  |  | Least of (a), (b), and (c): | $\left(0.16\lambda\sqrt{f'_c} + 17\rho_w \frac{V_u d}{M_u}\right)b_w d$ <sup>(1)</sup> | (a) | $(0.16\lambda\sqrt{f'_c} + 17\rho_w)b_w d$ | (b) | $0.29\lambda\sqrt{f'_c}b_w d$ | (c) |
| $V_c$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                |                                                          |                                  |                  |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Least of (a), (b), and (c):                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | $\left(0.16\lambda\sqrt{f'_c} + 17\rho_w \frac{V_u d}{M_u}\right)b_w d$ <sup>(1)</sup>         | (a)                                                      |                                  |                  |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | $(0.16\lambda\sqrt{f'_c} + 17\rho_w)b_w d$                                                     | (b)                                                      |                                  |                  |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | $0.29\lambda\sqrt{f'_c}b_w d$                                                                  | (c)                                                      |                                  |                  |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| where $\lambda = \{1.00 \text{ NWC}, 0.75 \text{ LWC}\}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                |                                                          |                                  | Normal weight    |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Strength reduction factor for shear, $\phi = 0.75$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                |                                                          |                                  | 0.75             |                     | cl.21.2             |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Minimum shear strength, $v_r = \text{MAX} (0.35, 0.062\sqrt{f'_c})$ , $f'_c \leq 70\text{N/mm}^2$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                |                                                          |                                  | 0.35             | N/mm <sup>2</sup>   | 5.2.2, cl.22        |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Check $v_d < 0.5.d/a_v.v_c$ for no links (minor elements)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                |                                                          |                                  | INVALID          | 0.37                | cl.9.6.3.1          |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| 2.2(6)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Concrete shear capacity $d/a_v.v_c.(b_wd)$                                                     |                                                          |                                  | 339              | kN                  | 5.5.1, cl.9.        |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Check $0.0 < v_d < \phi v_r + d/a_v.v_c$ for nominal links                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                |                                                          |                                  | 0.00             | N/A                 | 1.00                |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| 2.2(3)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | $(A_{sv}/S)_{nom} > v_r.b_w/f_{yv}$ , $f_{yv} \leq 420\text{N/mm}^2$ i.e. $(A_{sv}/S)_{nom} >$ |                                                          |                                  | 0.42             | mm <sup>2</sup> /mm | 5.10.5, cl.2        |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| cl.3.2.2(3) $V_{cap,nom} = (\phi d/a_v.v_r + d/a_v.v_c).(b_wd)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                |                                                          |                                  |                  | 459                 | kN                  |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Check $v_d > \phi v_r + d/a_v.v_c$ for design links                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                |                                                          |                                  | 1.00             | VALID               | 3.29                |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| cl.3.2.2(3) $A_{sv}/S > b_w(v_d - d/a_v.v_c)/(\phi f_{yv})/(d/a_v)$ , $f_{yv} \leq 420\text{N/mm}^2$ i.e. $A_{sv}/S >$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                |                                                          |                                  |                  | 2.88                | mm <sup>2</sup> /mm |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| cl.3.2.2(3) $V_{cap} = \phi d/a_v.(A_{sv,prov}/S + A_{sv,prov,t}/S_t).f_{yv}.d + d/a_v.v_c.(b_wd)$ , $f_{yv} \leq 420\text{N}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                |                                                          |                                  |                  | 1246                | kN                  |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| 2.3(8)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                |                                                          |                                  |                  |                     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Area prov. by all shear and torsion links in section, $A_{sv,prov} + A_{sv,prov,t}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                |                                                          |                                  | 314              | mm <sup>2</sup>     |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Tried $A_{sv,prov}/S + A_{sv,prov,t}/S_t$ value                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                |                                                          |                                  | 3.14             | mm <sup>2</sup> /mm |                     |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |
| Design shear resistance utilisation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                |                                                          |                                  | 94%              |                     | OK                  |       |  |  |                             |                                                                                        |     |                                            |     |                               |     |

[illegible]

[illegible]

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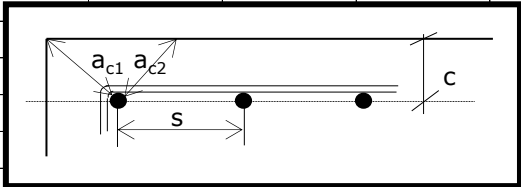
|                                                                                                                                                                              |                                                  |                                                       |  |  |  |                 |           |      |            |      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-------------------------------------------------------|--|--|--|-----------------|-----------|------|------------|------|
| CONSULTING ENGINEERS                                                                                                                                                         |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |  |  |  | Job No.         | Sheet No. | Rev. |            |      |
|                                                                                                                                                                              |                                                  |                                                       |  |  |  | jXXX            | 23        |      |            |      |
|                                                                                                                                                                              |                                                  |                                                       |  |  |  | Member/Location |           |      |            |      |
| Job Title                                                                                                                                                                    | Member Design - Reinforced Concrete Beam BS8110, |                                                       |  |  |  | Drg. Ref.       |           |      |            |      |
| Member Design - RC Beam                                                                                                                                                      |                                                  |                                                       |  |  |  | Made by         | XX        | Date | 24/10/2026 | Chd. |
| Detailing Requirements Rectangular or Flanged Beam                                                                                                                           |                                                  |                                                       |  |  |  |                 |           |      |            |      |
| All detailing requirements met ?                                                                                                                                             |                                                  |                                                       |  |  |  | OK              |           |      |            |      |
| Min tension steel reinforcement diameter, $\phi_t$ ( $\geq 12\text{mm}$ )                                                                                                    |                                                  |                                                       |  |  |  | 32              | mm        | OK   |            |      |
| Min tension steel reinforcement pitch ( $b_w - 2 \cdot \text{cover} - 2 \cdot \text{MAX}(\phi_{\text{link}}, \phi_{\text{link},t}) - \phi_t$ ) / ( $n_t/n$ )                 |                                                  |                                                       |  |  |  | 133             | mm        | OK   |            |      |
| Max tension steel reinforcement pitch ( $b_w - 2 \cdot \text{cover} - 2 \cdot \text{MAX}(\phi_{\text{link}}, \phi_{\text{link},t}) - \phi_t$ ) / ( $n_t/r$ )                 |                                                  |                                                       |  |  |  | 133             | mm        | OK   |            |      |
| Note that max pitch assumes no moment redistribution in beam, if less than 20% moment redistribution then pitch to be less than 175mm for G250 and less than 150mm for G460; |                                                  |                                                       |  |  |  |                 |           |      |            |      |
| Min compression steel reinforcement diameter, $\phi_c$ ( $\geq 12\text{mm}$ )                                                                                                |                                                  |                                                       |  |  |  | N/A             | mm        | N/A  |            |      |
| Min compression steel reinforcement pitch ( $b_w$ or $b - 2 \cdot \text{cover} - 2 \cdot \text{MAX}(\phi_{\text{link}}, \phi_{\text{link},t})$ )                             |                                                  |                                                       |  |  |  | N/A             | mm        | N/A  |            |      |
| Max compression steel reinforcement pitch ( $b_w$ or $b - 2 \cdot \text{cover} - 2 \cdot \text{MAX}(\phi_{\text{link}}, \phi_{\text{link},t})$ )                             |                                                  |                                                       |  |  |  | N/A             | mm        | N/A  |            |      |
| Min shear link diameter, $\phi_{\text{link}}$ ( $\geq 6\text{mm}$ , $\geq \phi_c/4$ )                                                                                        |                                                  |                                                       |  |  |  | 10              | mm        | OK   |            |      |
| Min torsion link diameter, $\phi_{\text{link},t}$ ( $\geq 6\text{mm}$ , $\geq \phi_c/4$ )                                                                                    |                                                  |                                                       |  |  |  | N/A             | mm        | N/A  |            |      |
| Shear link pitch, $S$ ( $\leq 0.75d$ , $\leq 12\phi_c$ , $\leq 300\text{mm}$ , $\geq \text{MAX}(100\text{mm}, 50 + 12 \cdot \phi_c)$ )                                       |                                                  |                                                       |  |  |  | 100             | mm        | OK   |            |      |
| Torsion link pitch, $S_t$ ( $\leq 0.75d$ , $\leq 12\phi_c$ , $\leq 300\text{mm}$ , $\geq \text{MAX}(100\text{mm}, 50 + 12 \cdot \phi_c)$ )                                   |                                                  |                                                       |  |  |  | N/A             | mm        | N/A  |            |      |
| $A_{sv,prov} / (b_w \cdot S) + A_{sv,prov,t} / (b_w \cdot S_t)$ ( $> 0.10\%$ G460; $> 0.17\%$ G250)                                                                          |                                                  |                                                       |  |  |  | 0.63            | %         | OK   |            |      |
| $A_{sv,prov} / (b_w \cdot S) + A_{sv,prov,t} / (b_w \cdot S_t)$ ( $< 4.00\%$ )                                                                                               |                                                  |                                                       |  |  |  | 0.63            | %         | OK   |            |      |
| Note require an overall enclosing link; Note require additional restraining links for each alternate longitudinal                                                            |                                                  |                                                       |  |  |  |                 |           |      |            |      |
|                                                                                                                                                                              |                                                  |                                                       |  |  |  |                 |           |      |            |      |
| A pattern which overlaps links as shown below should not be used.                                                                                                            |                                                  |                                                       |  |  |  |                 |           |      |            |      |
|                                                                                                                                                                              |                                                  |                                                       |  |  |  |                 |           |      |            |      |
| 5.3.1,                                                                                                                                                                       |                                                  |                                                       |  |  |  |                 |           |      |            |      |
| Open links may be used for beam and slab construction using 'L' hooks where the width of rib is 450mm or more. In such circumstance a top locking link is also used.         |                                                  |                                                       |  |  |  |                 |           |      |            |      |
|                                                                                                                                                                              |                                                  |                                                       |  |  |  |                 |           |      |            |      |
| Where links are used for torsion the bar shape 99 should be used to describe the shape shown below.                                                                          |                                                  |                                                       |  |  |  |                 |           |      |            |      |
|                                                                                                                                                                              |                                                  |                                                       |  |  |  |                 |           |      |            |      |
| Note lacer bars of 16mm are required at the sides of beams more than 750mm deep at 250mm pitch;                                                                              |                                                  |                                                       |  |  |  |                 |           |      |            |      |



[illegible]

| CONSULTING<br>ENGINEERS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |                                         |  |  | Job No.         | Sheet No. |        | Rev.       |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-------------------------------------------------------|-----------------------------------------|--|--|-----------------|-----------|--------|------------|----------|-------------------|---|----------------------------------------|-----------------------------------------|-----------------------------------------------------------------------|-----|----|----|---------------------------------------------------------------------------------------------------------------|-----|----|----|-----------------------------------------------------------|-----|----|----|----------------------------------------------------------------------------|-----|----|----|------------|-----|---|---|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |                                         |  |  | jXXX            | 26        |        |            |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |                                         |  |  | Member/Location |           |        |            |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Job Title                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Member Design - Reinforced Concrete Beam BS8110, |                                                       |                                         |  |  | Drg. Ref.       |           |        |            |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Member Design - RC Beam                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                  |                                                       |                                         |  |  | Made by         | XX        | Date   | 24/10/2026 | Chd.     |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |                                         |  |  |                 |           |        |            | EC2      |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Span, L                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                  |                                                       |                                         |  |  |                 |           | 10.000 | m          |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Span, L / eff. depth ratio, d                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                  |                                                       |                                         |  |  |                 |           | 10.9   |            |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Basic span / eff. depth ratio criteria, {L/d_eff}_basic = f{K, rho_req, rho_req', f_ck}                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                  |                                                       |                                         |  |  |                 |           | 21.7   |            | cl.7.4.2 |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| <div><math display="block">\frac{l}{d} = K \left[ 11 + 15 \sqrt{f_{ck}} \frac{\rho_0}{\rho} + 3,2 \sqrt{f_{ck}} \left( \frac{\rho_0}{\rho} - 1 \right)^{3/2} \right] \quad \text{if } \rho \leq \rho_0</math><math display="block">\frac{l}{d} = K \left[ 11 + 15 \sqrt{f_{ck}} \frac{\rho_0}{\rho - \rho'} + \frac{1}{12} \sqrt{f_{ck}} \sqrt{\frac{\rho'}{\rho_0}} \right] \quad \text{if } \rho &gt; \rho_0</math></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                  |                                                       |                                         |  |  |                 |           |        |            |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Multiplier F_{1,rect or flanged}                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                  |                                                       |                                         |  |  |                 |           | 1.00   |            | cl.7.4.2 |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Multiplier F_{2,L>7m}                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                  |                                                       |                                         |  |  | Include         |           | 0.70   |            | cl.7.4.2 |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Modification factor for tension F_3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                  |                                                       |                                         |  |  |                 |           |        |            | cl.7.4.2 |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| rho_req = 100A_s/(b_w or b).d                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                  |                                                       |                                         |  |  |                 |           | 1.21   | %          | cl.7.4.2 |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| sigma_s = 310.(f_y/500).[A_s/A_{s,prov}]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                  |                                                       |                                         |  |  |                 |           | 268    | N/mm^2     | cl.7.4.2 |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Modification 310 / sigma_s = 500 /(f_{yk} A_{s,req} / A_{s,prov})                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |                                         |  |  | ≤ 1.5           |           | 1.16   |            | cl.7.4.2 |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| rho_req' = 100A_s'/(b_w or b).d                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |                                         |  |  |                 |           | N/A    | %          | cl.7.4.2 |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Modified span / eff. depth ratio criteria = F_1.F_2.F_3.{L/d_eff}_basic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                  |                                                       |                                         |  |  |                 |           | 17.6   |            |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Deflection utilisation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  |                                                       |                                         |  |  |                 |           | 62%    |            | OK       |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| <div>Table 7.4N: Basic ratios of span/effective depth for reinforced concrete members without axial compression</div> <table><thead><tr><th>Structural System</th><th>K</th><th>Concrete highly stressed<br/>rho = 1,5%</th><th>Concrete lightly stressed<br/>rho = 0,5%</th></tr></thead><tbody><tr><td>Simply supported beam, one- or two-way spanning simply supported slab</td><td>1,0</td><td>14</td><td>20</td></tr><tr><td>End span of continuous beam or one-way continuous slab or two-way spanning slab continuous over one long side</td><td>1,3</td><td>18</td><td>26</td></tr><tr><td>Interior span of beam or one-way or two-way spanning slab</td><td>1,5</td><td>20</td><td>30</td></tr><tr><td>Slab supported on columns without beams (flat slab) (based on longer span)</td><td>1,2</td><td>17</td><td>24</td></tr><tr><td>Cantilever</td><td>0,4</td><td>6</td><td>8</td></tr></tbody></table> <div><p><b>Note 1:</b> The values given have been chosen to be generally conservative and calculation may frequently show that thinner members are possible.</p><p><b>Note 2:</b> For 2-way spanning slabs, the check should be carried out on the basis of the shorter span. For flat slabs the longer span should be taken.</p><p><b>Note 3:</b> The limits given for flat slabs correspond to a less severe limitation than a mid-span deflection of span/250 relative to the columns. Experience has shown this to be satisfactory.</p></div> |                                                  |                                                       |                                         |  |  |                 |           |        |            |          | Structural System | K | Concrete highly stressed<br>rho = 1,5% | Concrete lightly stressed<br>rho = 0,5% | Simply supported beam, one- or two-way spanning simply supported slab | 1,0 | 14 | 20 | End span of continuous beam or one-way continuous slab or two-way spanning slab continuous over one long side | 1,3 | 18 | 26 | Interior span of beam or one-way or two-way spanning slab | 1,5 | 20 | 30 | Slab supported on columns without beams (flat slab) (based on longer span) | 1,2 | 17 | 24 | Cantilever | 0,4 | 6 | 8 |
| Structural System                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | K                                                | Concrete highly stressed<br>rho = 1,5%                | Concrete lightly stressed<br>rho = 0,5% |  |  |                 |           |        |            |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Simply supported beam, one- or two-way spanning simply supported slab                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1,0                                              | 14                                                    | 20                                      |  |  |                 |           |        |            |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| End span of continuous beam or one-way continuous slab or two-way spanning slab continuous over one long side                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1,3                                              | 18                                                    | 26                                      |  |  |                 |           |        |            |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Interior span of beam or one-way or two-way spanning slab                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 1,5                                              | 20                                                    | 30                                      |  |  |                 |           |        |            |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Slab supported on columns without beams (flat slab) (based on longer span)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1,2                                              | 17                                                    | 24                                      |  |  |                 |           |        |            |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |
| Cantilever                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0,4                                              | 6                                                     | 8                                       |  |  |                 |           |        |            |          |                   |   |                                        |                                         |                                                                       |     |    |    |                                                                                                               |     |    |    |                                                           |     |    |    |                                                                            |     |    |    |            |     |   |   |

[illegible]

|                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |  |                 |           |      |            |                   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-------------------------------------------------------|--|-----------------|-----------|------|------------|-------------------|
| CONSULTING<br>ENGINEERS                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |  | Job No.         | Sheet No. | Rev. |            |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |  | jXXX            | 28        |      |            |                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |  | Member/Location |           |      |            |                   |
| Job Title                                                                                                                                                                                                                                                                                                                                                                                                                             | Member Design - Reinforced Concrete Beam BS8110, |                                                       |  | Drg. Ref.       |           |      |            |                   |
| Member Design - RC Beam                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  |                                                       |  | Made by         | XX        | Date | 24/10/2026 | Chd.              |
|                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |  |                 |           |      |            | BS8110            |
| Crack Width Estimation Rectangular Beam                                                                                                                                                                                                                                                                                                                                                                                               |                                                  |                                                       |  |                 |           |      |            |                   |
| Note that this design check is performed for both rectangular and flanged sections, adopting rectangular section equations in the case of flanged sections;                                                                                                                                                                                                                                                                           |                                                  |                                                       |  |                 |           |      |            |                   |
| Maximum crack width criteria, Standard concrete BS8110 (0.30mm)                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |  | ▼               |           | 0.30 |            | mm                |
| Load factor, LF = 1.4 conservatively                                                                                                                                                                                                                                                                                                                                                                                                  |                                                  |                                                       |  |                 |           | 1.4  |            |                   |
| SLS bending moment, $M_{sls} = M / LF$                                                                                                                                                                                                                                                                                                                                                                                                |                                                  |                                                       |  |                 |           | 1321 |            | kNm               |
| SLS axial force (tension +ve and compression -ve), $F_{sls} = -F / LF$                                                                                                                                                                                                                                                                                                                                                                |                                                  |                                                       |  |                 |           | 0    |            | kN                |
| Uncracked elastic modulus, $E_{uncracked} = 20+0.2f_{cu}$                                                                                                                                                                                                                                                                                                                                                                             |                                                  |                                                       |  |                 |           | 27   |            | GPa               |
| Cracked elastic modulus, $E_{cracked} = E_{uncracked} / 2$                                                                                                                                                                                                                                                                                                                                                                            |                                                  |                                                       |  |                 |           | 14   |            | GPa               |
| Steel elastic modulus, $E_s$                                                                                                                                                                                                                                                                                                                                                                                                          |                                                  |                                                       |  |                 |           | 200  |            | GPa               |
| Modulus ratio, $\alpha_e = E_s / E_{cracked}$                                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                                       |  |                 |           | 14.8 |            |                   |
| Reinforcement ratio, $\rho_w = A_{s,prov}/b_w d$                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |  |                 |           | 0.01 |            |                   |
| Factor, $\alpha_e \cdot \rho_w$                                                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |  |                 |           | 0.21 |            |                   |
| Depth of neutral axis, $x = \alpha_e \cdot \rho_w \cdot [(1+2/(\alpha_e \rho_w))^{1/2} - 1] \cdot d$                                                                                                                                                                                                                                                                                                                                  |                                                  |                                                       |  |                 |           | 431  |            | mm                |
| Lever arm, $z = d - x/3$                                                                                                                                                                                                                                                                                                                                                                                                              |                                                  |                                                       |  |                 |           | 773  |            | mm                |
| Steel tensile service stress (flexural), $f_{s1} = M_{sls}/z / A_{s,prov}$                                                                                                                                                                                                                                                                                                                                                            |                                                  |                                                       |  |                 |           | 265  |            | N/mm <sup>2</sup> |
| Steel tensile (tensile +ve and compressive -ve) service stress (axial), $f_{s2}$                                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |  |                 |           | 0    |            | N/mm <sup>2</sup> |
| Note if $F_{sls} > 0$ , $f_{s2} = F_{sls}/(A_{s,prov} + A_{s,prov}')$ ,                                                                                                                                                                                                                                                                                                                                                               |                                                  |                                                       |  |                 |           |      |            |                   |
| else $f_{s2} = \alpha_e \cdot (A_{s,prov} + A_{s,prov}')/[ \alpha_e \cdot (A_{s,prov} + A_{s,prov}') + (b_w \cdot h - A_{s,prov} - A_{s,prov}') ] \cdot F_{sls}/(A_{s,prov} + A_{s,prov}')$ ;                                                                                                                                                                                                                                         |                                                  |                                                       |  |                 |           |      |            |                   |
| Steel tensile service stress utilisation, $(f_{s1} + f_{s2}) / (0.8f_y) < 1.00$                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |  |                 |           | 66%  |            | OK                |
| Concrete compressive service stress (flexural and axial), $f_c$                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |  |                 |           | 16   |            | N/mm <sup>2</sup> |
| Note if $F_{sls} > 0$ , $f_c = 2(M_{sls}/z)/(b_w x)$ , else $f_c = 2(M_{sls}/z)/(b_w x) + (b_w \cdot h - A_{s,prov} - A_{s,prov}')/[ \alpha_e \cdot (A_{s,prov} + A_{s,prov}') + (b_w \cdot h - A_{s,prov} - A_{s,prov}') ] \cdot ABS(F_{sls})/(b_w \cdot h - A_{s,prov} - A_{s,prov}')$ ;                                                                                                                                            |                                                  |                                                       |  |                 |           |      |            |                   |
| Concrete compressive service stress utilisation, $f_c / (0.45f_{cu}) < 1.00$                                                                                                                                                                                                                                                                                                                                                          |                                                  |                                                       |  |                 |           | 101% |            | NOT OK            |
| Strain at tension face, $\epsilon_1 = (h-x)/(d-x) \cdot (f_{s1} + f_{s2})/E_s$                                                                                                                                                                                                                                                                                                                                                        |                                                  |                                                       |  |                 |           | 1.55 |            | x10 <sup>-3</sup> |
| Strain stiffening, $\epsilon_2 = b_w(h-x)^2/[3E_s A_{s,prov}(d-x)]$                                                                                                                                                                                                                                                                                                                                                                   |                                                  |                                                       |  |                 |           | 0.09 |            | x10 <sup>-3</sup> |
| Mean strain, $\epsilon_m = \epsilon_1 - \epsilon_2$                                                                                                                                                                                                                                                                                                                                                                                   |                                                  |                                                       |  |                 |           | 1.47 |            | x10 <sup>-3</sup> |
| Distance to face of extreme rebar, $c_f = \text{cover} + \text{MAX}(\phi_{link}, \phi_{link,t})$                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |  |                 |           | 35   |            | mm                |
| Distance to centroid of extreme rebar, $c = c_f + \phi_t/2$                                                                                                                                                                                                                                                                                                                                                                           |                                                  |                                                       |  |                 |           | 51   |            | mm                |
| Distance, $s = (b_w - 2 \cdot \text{cover} - 2 \cdot \text{MAX}(\phi_{link}, \phi_{link,t}) - \phi_t)/(n_t/n_{layers,tens} - 1)$                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |  |                 |           | 133  |            | mm                |
| Distance, $a_{c1} = [c^2 + c^2]^{1/2} - \phi_t/2$                                                                                                                                                                                                                                                                                                                                                                                     |                                                  |                                                       |  |                 |           | 56   |            | mm                |
| Distance, $a_{c2} = [c^2 + (s/2)^2]^{1/2} - \phi_t/2$                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  |                 |           | 68   |            | mm                |
| Distance, $a_{cr} = \text{MAX}(a_{c1}, a_{c2})$                                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |  |                 |           | 68   |            | mm                |
| Note $a_{c1}$ is not applicable for continuous width sections, i.e. slabs or walls;                                                                                                                                                                                                                                                                                                                                                   |                                                  |                                                       |  |                 |           |      |            |                   |
|                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |  |                 |           |      |            |                   |
| Maximum crack width, $w_{max} = 3a_{cr}\epsilon_m/[1+2 \cdot (a_{cr}-c_f)/(h-x)]$                                                                                                                                                                                                                                                                                                                                                     |                                                  |                                                       |  |                 |           | 0.27 |            | mm                |
| Maximum crack width utilisation, $w_{max} / w_{allow} < 1.00$                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                                       |  |                 |           | 89%  |            | OK                |
| Note for a particular section and force / moment, crack widths can be reduced by increasing steel area, reducing spacing between rebars and reducing concrete cover (limited to durability requirements). The employment of smaller diameter bars at closer centres is thus preferable to larger diameter bars at further centres. There should be a provision for longitudinal steels at the side faces of beams of moderate depths; |                                                  |                                                       |  |                 |           |      |            |                   |
| Crack width utilisation                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  |                                                       |  |                 |           | 101% |            | NOT OK            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |  |  |  |                 |                    |              |            |      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-------------------------------------------------------|--|--|--|-----------------|--------------------|--------------|------------|------|
| CONSULTING<br>ENGINEERS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |  |  |  | Job No.         | Sheet No.          |              | Rev.       |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |  |  |  | jXXX            | 29                 |              |            |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |  |  |  | Member/Location |                    |              |            |      |
| Job Title                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Member Design - Reinforced Concrete Beam BS8110, |                                                       |  |  |  | Drg. Ref.       |                    |              |            |      |
| Member Design - RC Beam                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  |                                                       |  |  |  | Made by         | XX                 | Date         | 24/10/2026 | Chd. |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |  |  |  | EC2             |                    |              |            |      |
| Longitudinal Shear Between Web and Flange Rectangular or Flanged Beam (EC2)                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                  |                                                       |  |  |  |                 |                    |              |            |      |
| Note that this check is performed for both rectangular and flanged section designs, although theoretically only applicable in the latter case;                                                                                                                                                                                                                                                                                                                                                                     |                                                  |                                                       |  |  |  |                 |                    |              |            |      |
| Longitudinal shear stress, $K_S \cdot V_{Ed}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |  |  |  | 1.61            | N/mm <sup>2</sup>  |              |            |      |
| Longitudinal shear stress, $v_{Ed} = \Delta F_d / (h_f \cdot \Delta x)$                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  |                                                       |  |  |  | 1.21            | N/mm <sup>2</sup>  | cl.6.2.4     |            |      |
| Change of normal force in flange half over $\Delta x$ , $\Delta F_d = K_B \cdot (M^* - 0) / z$                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                  |                                                       |  |  |  | 605             | kN                 |              |            |      |
| Note conservatively factor, $K_B = 0.5(b_{eff} - b_w) / b_{eff}$ employed even if neutral axis within web;                                                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                                       |  |  |  |                 |                    |              |            |      |
| Lever arm, $z$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                  |                                                       |  |  |  | 0.765           | m                  |              |            |      |
| Note if neutral axis within web, for simplicity, $z = d - h_f / 2$ ;                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  |                                                       |  |  |  |                 |                    |              |            |      |
| Thickness of the flange at the junctions, $h_f$                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |  |  |  | 200             | mm                 |              |            |      |
| Length under consideration, $\Delta x$                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                  |                                                       |  |  |  | 2500            | mm                 |              |            |      |
| Note the maximum value that may be assumed for $\Delta x$ is half the distance between the section where the moment is 0 and the section where the moment is maximum. However, since $\Delta F_d$ is also calculated over $\Delta x$ based on a variation of moment of $\sim M/2 - 0$ say, it is deemed acceptable to use for $\Delta x$ the full distance between the section where the moment is 0 and the section where the moment is maximum based on a variation of moment of $M - 0$ and factored by $K_S$ . |                                                  |                                                       |  |  |  |                 |                    |              |            |      |
| Shear stress distribution factor, $K_S$                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  |                                                       |  |  |  | 1.33            |                    |              |            |      |
| For UDLs, $K_S$ may be taken as 2.00 for simply supported beams, 1.33 for continuous beams and 2.00 for cantilever beams;                                                                                                                                                                                                                                                                                                                                                                                          |                                                  |                                                       |  |  |  |                 |                    |              |            |      |
| Effective width, $b_{eff} = \text{MIN}(b_w + \text{function (span, section, structure)})$                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                  |                                                       |  |  |  | 1000            | mm                 |              |            |      |
| Note for rectangular sections, $b_{eff}$ equivalent to that of T-sections assumed;                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  |  |  |                 |                    |              |            |      |
| Width (rectangular) or web width (flanged), $b_w$                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                  |                                                       |  |  |  | 500             | mm                 |              |            |      |
| Longitudinal shear stress limit to prevent crushing, $v_{cd} \sin \theta_f \cos \theta_f$                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                  |                                                       |  |  |  | 4.97            | N/mm <sup>2</sup>  | cl.6.2.4     |            |      |
| Design compressive strength, $f_{cd}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                  |                                                       |  |  |  | 19              | N/mm <sup>2</sup>  |              |            |      |
| $f_{cd} = \alpha_{cc} f_{ck} / \gamma_c$ with $\alpha_{cc} = 1.0$ , $\gamma_c = 1.5$                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  |                                                       |  |  |  | cl.3.1.6        |                    |              |            |      |
| Strength reduction factor for concrete cracked in shear, $v$                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |  |  |  | 0.533           |                    |              |            |      |
| $v = 0.6 \left[ 1 - \frac{f_{ck}}{250} \right]$                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |  |  |  | cl.6.2.2        |                    |              |            |      |
| Longitudinal shear stress limit to prevent crushing utilisation, $(K_S \cdot v_{Ed}) / (v_{cd} \sin \theta_f \cos \theta_f)$                                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                                                       |  |  |  | 32%             | OK                 |              |            |      |
| Longitudinal shear stress limit for no transverse reinforcement, $0.4 f_{ctd}$                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                  |                                                       |  |  |  | 0.52            | N/mm <sup>2</sup>  | cl.6.2.4     |            |      |
| Design tensile strength, $f_{ctd}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  |  |  | 1.29            | N/mm <sup>2</sup>  |              |            |      |
| $f_{ctd} = \alpha_{ct} f_{ctk,0.05} / \gamma_c$ with $\alpha_{ct} = 1.0$ , $\gamma_c = 1.5$                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                  |                                                       |  |  |  | cl.3.1.6        |                    |              |            |      |
| $f_{ctk,0.05} = 0.7 \times f_{ctm}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                  |                                                       |  |  |  | 1.94            | N/mm <sup>2</sup>  | T.3.1        |            |      |
| $f_{ctm} = 0.30 \times f_{ck}^{(2/3)} \leq C50/60$ $f_{ctm} = 2.12 \cdot \ln(1 + (f_{cm}/10)) > C50/60$                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  |                                                       |  |  |  | 2.77            | N/mm <sup>2</sup>  | T.3.1        |            |      |
| $f_{cm} = f_{ck} + 8 \text{ (MPa)}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                  |                                                       |  |  |  | 36              | N/mm <sup>2</sup>  | T.3.1        |            |      |
| Characteristic cylinder strength of concrete, $f_{ck}$                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                  |                                                       |  |  |  | 28              | N/mm <sup>2</sup>  | T.3.1        |            |      |
| Characteristic cube strength of concrete, $f_{cu}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  |  |  | 35              | N/mm <sup>2</sup>  | T.3.1        |            |      |
| Longitudinal shear stress limit for no transverse reinforcement utilisation, $(K_S \cdot v_{Ed}) / (v_{cd} \sin \theta_f \cos \theta_f)$                                                                                                                                                                                                                                                                                                                                                                           |                                                  |                                                       |  |  |  | 311%            | NOT OK             |              |            |      |
| Required design transverse reinforcement per unit length, $A_{sf}/s_f >$                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                  |                                                       |  |  |  | 740             | mm <sup>2</sup> /m |              |            |      |
| $(A_{sf} f_{yd} / s_f) \geq v_{Ed} \cdot h_f / \cot \theta_f$                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |  |  |  |                 |                    |              |            |      |
| Note area of transverse steel to be provided should be the greater of $1.0 A_{sf}/s_f$ and $0.5 A_{sf}/s_f + \text{area required for slab bending}$ ; Note $K_S$ factored onto $v_{Ed}$ herein;                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |  |  |  |                 |                    |              |            |      |
| Design yield strength of reinforcement, $f_{yd} = f_y / \gamma_s$ , $\gamma_s = 1.15$ , $f_y \leq 60$                                                                                                                                                                                                                                                                                                                                                                                                              |                                                  |                                                       |  |  |  | 435             | N/mm <sup>2</sup>  | .2.4, cl.3.2 |            |      |
| Thickness of the flange at the junctions, $h_f$                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  |                                                       |  |  |  | 200             | mm                 |              |            |      |
| Angle, $\theta_f$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                  |                                                       |  |  |  | 45.0            | degrees            |              |            |      |
| $1.0 \leq \cot \theta_f \leq 2.0$ for compression flanges ( $45^\circ \geq \theta_f \geq 26.5^\circ$ )<br>$1.0 \leq \cot \theta_f \leq 1.25$ for tension flanges ( $45^\circ \geq \theta_f \geq 38.6^\circ$ )                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |  |  |  | cl.6.2.4        |                    |              |            |      |
| Provided transverse reinforcement per unit length, $A_e$                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                  |                                                       |  |  |  | 785             | mm <sup>2</sup> /m |              |            |      |
| Required design transverse reinforcement per unit length utilisation, $(A_{sf}/s_f) /$                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                  |                                                       |  |  |  | 94%             | OK                 |              |            |      |

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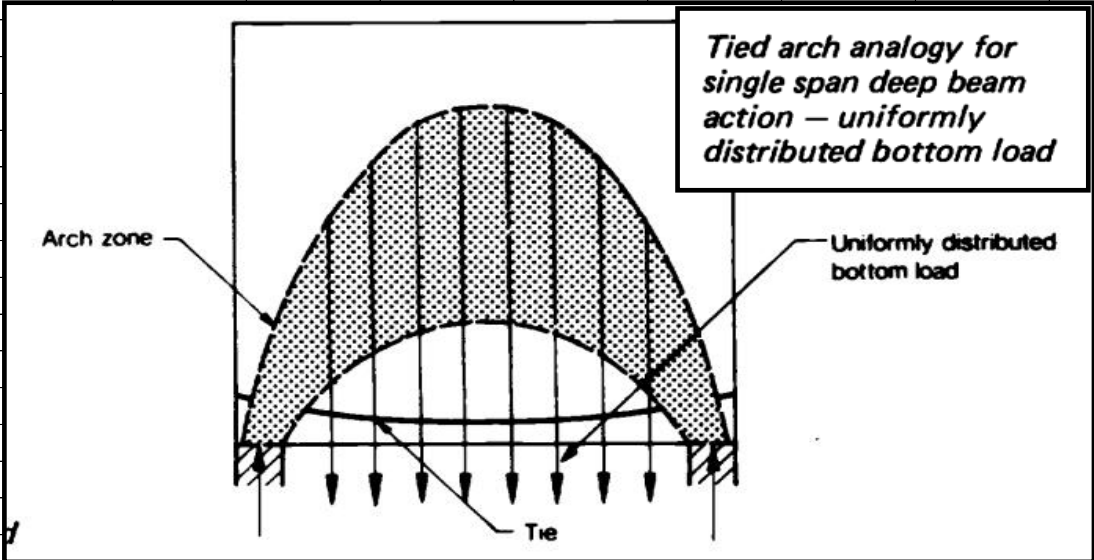
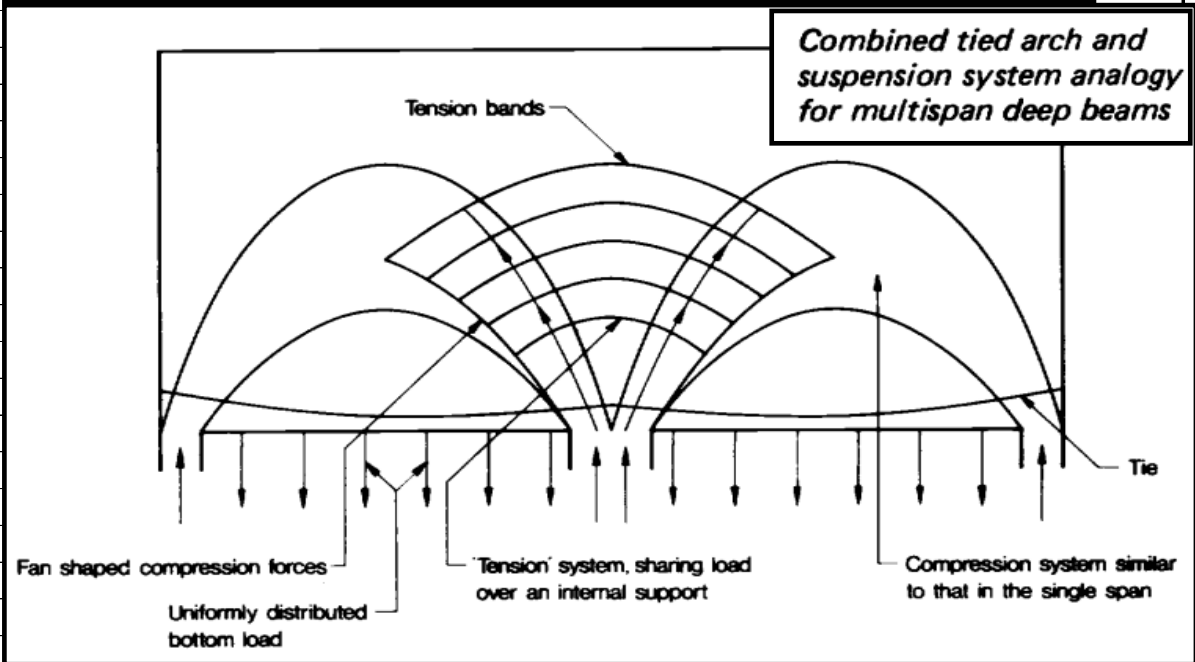
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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------|--|--|--|-----------------|-----------|-------------------|------------|
| CONSULTING<br>ENGINEERS                                                                                                                                                                                                                                                                                                                           |                                                             | Engineering Calculation Sheet<br>Consulting Engineers |  |  |  | Job No.         | Sheet No. |                   | Rev.       |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  | jXXX            | 36        |                   |            |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  | Member/Location |           |                   |            |
| Job Title                                                                                                                                                                                                                                                                                                                                         | Member Design - Reinforced Concrete Beam BS8110,            |                                                       |  |  |  | Drg. Ref.       |           |                   |            |
| Member Design - RC Beam                                                                                                                                                                                                                                                                                                                           |                                                             |                                                       |  |  |  | Made by         | XX        | Date              | 24/10/2026 |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   | Chd.       |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   | BS8110     |
| Deep Beam Bending                                                                                                                                                                                                                                                                                                                                 |                                                             |                                                       |  |  |  |                 |           |                   | CIRIA      |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   | Guide 2    |
| Design bending moment, M                                                                                                                                                                                                                                                                                                                          |                                                             |                                                       |  |  |  |                 | N/A       | kNm               |            |
| Note the ultimate bending moment limit is $0.12f_{cu}b_w h^2$ ;                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   | cl.2.4.1   |
| Ultimate bending moment utilisation                                                                                                                                                                                                                                                                                                               |                                                             |                                                       |  |  |  |                 | N/A       |                   | N/A        |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   |            |
| Tension steel (deep beam), $A_{s,db} = M / [0.95f_y z]$ , $f_y \leq 460 \text{ N/mm}^2$                                                                                                                                                                                                                                                           |                                                             |                                                       |  |  |  |                 | N/A       | mm <sup>2</sup>   | cl.2.4.1   |
| Lever arm at which the tension steel (deep beam) acts, z                                                                                                                                                                                                                                                                                          |                                                             |                                                       |  |  |  |                 | N/A       | mm                | cl.2.4.1   |
|                                                                                                                                                                                                                                                                                                                                                   | Simply supported, $z = 0.2 \times \text{span}_{lim} + 0.4h$ |                                                       |  |  |  |                 | N/A       | mm                | cl.2.4.1   |
| LF                                                                                                                                                                                                                                                                                                                                                | Continuous, $z = 0.2 \times \text{span}_{lim} + 0.3h$       |                                                       |  |  |  |                 | N/A       | mm                | cl.2.4.1   |
|                                                                                                                                                                                                                                                                                                                                                   | Cantilever, $z = 0.4 \times \text{span}_{lim} + 0.4h$       |                                                       |  |  |  |                 | N/A       | mm                | SELF       |
| Tension steel zone depth, $T_{zone}$ (sag s/s, sag cont, hog cant)                                                                                                                                                                                                                                                                                |                                                             |                                                       |  |  |  |                 | N/A       | mm                | cl.2.4.1   |
| Tension steel zone depth, $T_{zone}$ (hog cont) upper band                                                                                                                                                                                                                                                                                        |                                                             |                                                       |  |  |  | N/A             | N/A       | mm                | cl.2.4.1   |
| Tension steel zone depth, $T_{zone}$ (hog cont) lower band                                                                                                                                                                                                                                                                                        |                                                             |                                                       |  |  |  | N/A             | N/A       | mm                | cl.2.4.1   |
| Note $A_{s,db}$ to be distributed over depth of $T_{zone}$ from tension face;                                                                                                                                                                                                                                                                     |                                                             |                                                       |  |  |  |                 |           |                   | cl.2.4.1   |
| Note $T_{zone} = 0.2h$ s/s sag, cont sag and cant hog;                                                                                                                                                                                                                                                                                            |                                                             |                                                       |  |  |  |                 |           |                   | cl.2.4.1   |
| Note $T_{zone} = 0.2h$ cont hog upper band $0.5(\text{span}_{lim}/h-1)A_{s,db}$ , $0.2h-0.8h$ cont hog lower band remainder;                                                                                                                                                                                                                      |                                                             |                                                       |  |  |  |                 |           |                   |            |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   |            |
| Tension steel area provided (deep beam)                                                                                                                                                                                                                                                                                                           |                                                             |                                                       |  |  |  |                 | N/A       | mm <sup>2</sup>   |            |
| Tension steel area provided (deep beam) utilisation                                                                                                                                                                                                                                                                                               |                                                             |                                                       |  |  |  |                 | N/A       |                   | N/A        |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   |            |
| Deep Beam Shear                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   | CIRIA      |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   | Guide 2    |
| Design shear force, $V_d$                                                                                                                                                                                                                                                                                                                         |                                                             |                                                       |  |  |  |                 | N/A       | kN                |            |
| Note the ultimate shear force limit is $\min\{b_w \cdot h \cdot v_u, 2b_w \cdot h^2 v_c k_s / x_e\}$ where $v_u$ is the ultimate concrete shear strength from CP 110 T.6 and T.26 replaced by $\min\{0.8f_{cu}^{0.5}, \{5.0, 7.0\} \text{ N/mm}^2\}$ and $v_c$ is the design concrete shear strength from CP 110 T.5 and T.25 replaced by $v_c$ ; |                                                             |                                                       |  |  |  |                 |           |                   | cl.2.4.2   |
| Factor, $k_s = 1.0$ for $h/b_w < 4$ , else $0.6$                                                                                                                                                                                                                                                                                                  |                                                             |                                                       |  |  |  |                 | N/A       |                   | cl.2.4.2   |
| Ultimate shear force utilisation                                                                                                                                                                                                                                                                                                                  |                                                             |                                                       |  |  |  |                 | N/A       |                   | N/A        |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   |            |
| Area of tension steel reinforcement provided, $A_{s,prov}$                                                                                                                                                                                                                                                                                        |                                                             |                                                       |  |  |  |                 | N/A       | mm <sup>2</sup>   |            |
| Clear distance from edge of load to face of support, $x_e$                                                                                                                                                                                                                                                                                        |                                                             |                                                       |  |  |  | DL @ mid 0.625h |           | N/A               | mm         |
| Note for UDLs, concentrate total UDL at $\{\text{span}/4 \text{ s/s and cont, span}/2 \text{ cant}\}$ from the support(s);                                                                                                                                                                                                                        |                                                             |                                                       |  |  |  |                 |           |                   | cl.2.4.2   |
| Ratio $x_e/h$                                                                                                                                                                                                                                                                                                                                     |                                                             |                                                       |  |  |  |                 | N/A       |                   | N/A        |
| Note ensure $x_e/h$ is not greatly outside range of $0.23$ to $0.70$ ;                                                                                                                                                                                                                                                                            |                                                             |                                                       |  |  |  |                 |           |                   | cl.3.4.2   |
| Angle between horizontal bar and critical diagonal crack, $\theta = \tan^{-1} (h/x_e)$                                                                                                                                                                                                                                                            |                                                             |                                                       |  |  |  |                 | N/A       | degrees           | cl.2.4.2   |
| Empirical coefficient, $\lambda_1 = \{0.44 \text{ NWC, } 0.32 \text{ LWC}\}$                                                                                                                                                                                                                                                                      |                                                             |                                                       |  |  |  |                 | N/A       |                   | cl.3.4.2   |
| Empirical coefficient, $\lambda_2 = \{0.85 \text{ plain round bars, } 1.95 \text{ deformed bars}\}$                                                                                                                                                                                                                                               |                                                             |                                                       |  |  |  |                 | N/A       | N/mm <sup>2</sup> | cl.3.4.2   |
| Number of rows of horizontal shear links in a vertical cross-section, n                                                                                                                                                                                                                                                                           |                                                             |                                                       |  |  |  |                 | N/A       |                   |            |
| Note the no. of rows of horizontal shear links reduced to account for $T_{zone}$ , i.e. $(h - T_{zone})/S_h$ ;                                                                                                                                                                                                                                    |                                                             |                                                       |  |  |  |                 |           |                   |            |
| Design horizontal links shear capacity, $V_r = 100\lambda_2 \Sigma A_{sv,prov,h} \cdot \gamma_r \cdot \sin^2 \theta / h$                                                                                                                                                                                                                          |                                                             |                                                       |  |  |  |                 | N/A       | kN                | cl.3.4.2   |
| Note the summation of the depths at which the horizontal shear links intersect the diagonal crack, $\Sigma \gamma_r$ is calculated as $S_h \cdot n \cdot (n+1)/2$ where n is the number of rows of horizontal shear links;                                                                                                                        |                                                             |                                                       |  |  |  |                 |           |                   |            |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   |            |
| Check $V_d < 1.0V$ for no horizontal links (minor elements)                                                                                                                                                                                                                                                                                       |                                                             |                                                       |  |  |  |                 | N/A       |                   | cl.3.4.2   |
| Concrete shear capacity, $V (\leq 1.3\lambda_1 \sqrt{f_{cu}} \cdot b_w \cdot h)$                                                                                                                                                                                                                                                                  |                                                             |                                                       |  |  |  |                 | N/A       | kN                | cl.3.4.2   |
| Note $V = \text{MAX}[0, \lambda_1 \cdot (h - 0.35x_e) \cdot \sqrt{f_{cu}} \cdot b_w] + 100\lambda_2 \cdot A_{s,prov} \cdot d \cdot \sin^2 \theta / h$ ;                                                                                                                                                                                           |                                                             |                                                       |  |  |  |                 |           |                   | cl.3.4.2   |
| Note require $[100\lambda_2 \cdot A_{s,prov} \cdot d \cdot \sin^2 \theta / h] / V \geq 0.20$ ;                                                                                                                                                                                                                                                    |                                                             |                                                       |  |  |  |                 | N/A       |                   | N/A        |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   |            |
| Check $V_d > 0.0$ for design horizontal links                                                                                                                                                                                                                                                                                                     |                                                             |                                                       |  |  |  |                 | N/A       |                   | cl.3.4.2   |
| Concrete and design horizontal links shear capacity $V_r + V (\leq \lambda_1 \cdot \sqrt{f_{cu}} \cdot b_w \cdot h)$                                                                                                                                                                                                                              |                                                             |                                                       |  |  |  |                 | N/A       | kN                | cl.3.4.2   |
| Note $v_{max} = 1.3 \sqrt{f_{cu}}$ ;                                                                                                                                                                                                                                                                                                              |                                                             |                                                       |  |  |  |                 |           |                   | T.5        |
| Note require $[V_r + 100\lambda_2 \cdot A_{s,prov} \cdot d \cdot \sin^2 \theta / h] / [V_r + V] \geq 0.20$ ;                                                                                                                                                                                                                                      |                                                             |                                                       |  |  |  |                 | N/A       |                   | N/A        |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   |            |
| Design shear resistance (deep beam) utilisation                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 | N/A       |                   | N/A        |
|                                                                                                                                                                                                                                                                                                                                                   |                                                             |                                                       |  |  |  |                 |           |                   |            |

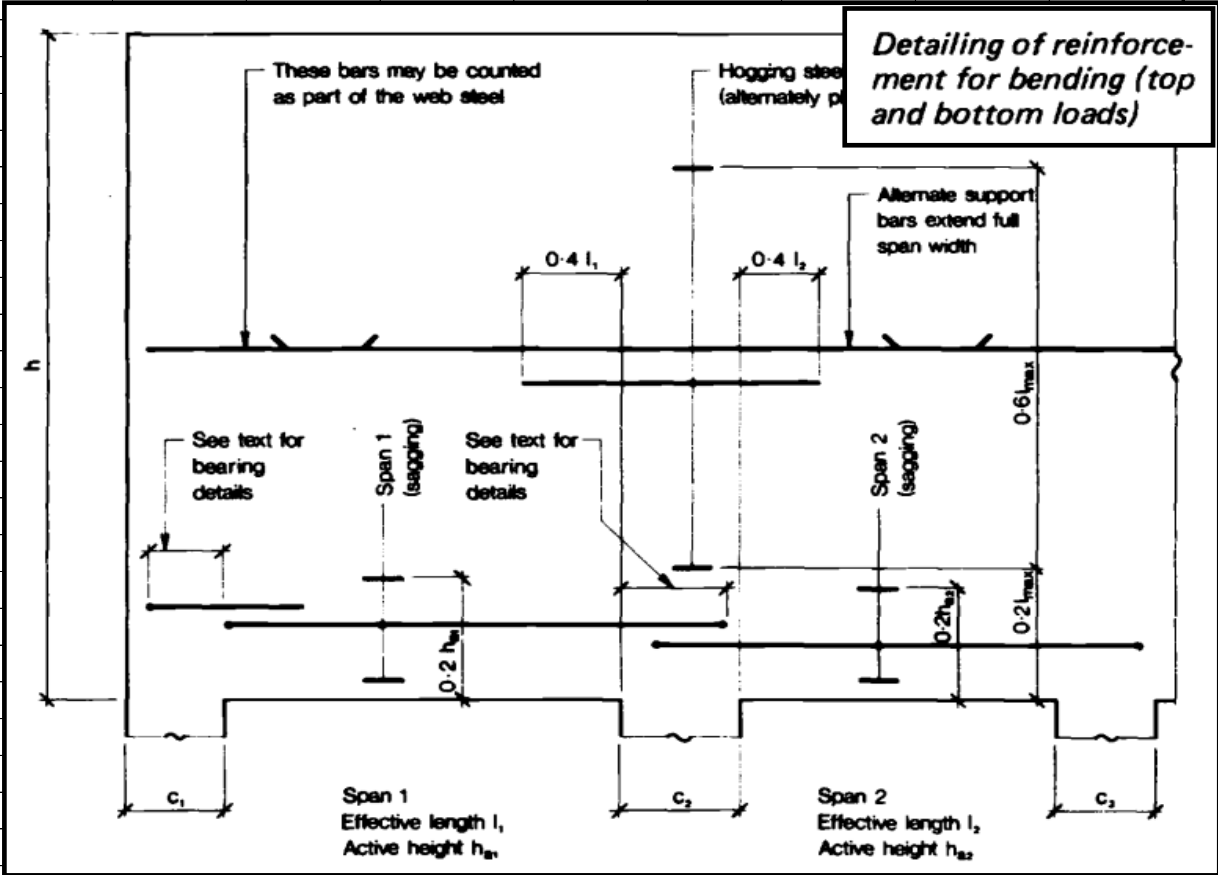
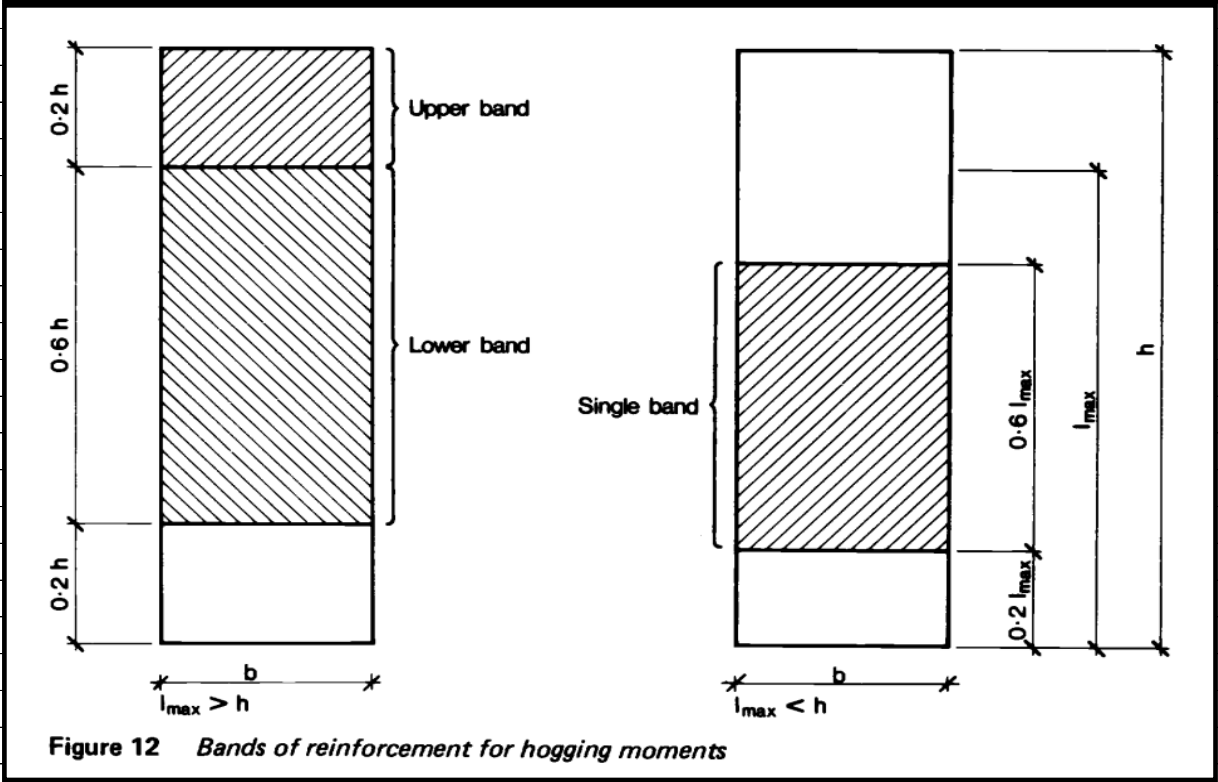
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|-------------------------|-------------------------------------------------------|-----------------|-----------|------------|
| CONSULTING<br>ENGINEERS | Engineering Calculation Sheet<br>Consulting Engineers | Job No.         | Sheet No. | Rev.       |
|                         |                                                       | jXXX            | 37        |            |
|                         |                                                       | Member/Location |           |            |
| Job Title               | Member Design - Reinforced Concrete Beam BS8110,      | Drg. Ref.       |           |            |
| Member Design - RC Beam |                                                       | Made by         | XX        | Date       |
|                         |                                                       |                 |           | 24/10/2026 |
|                         |                                                       |                 |           | Chd.       |

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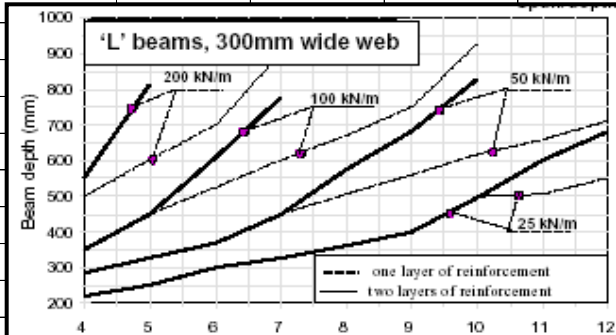
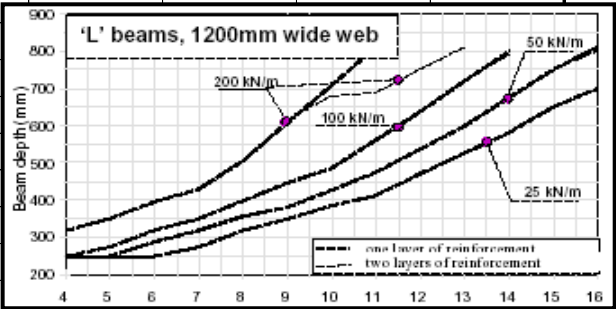
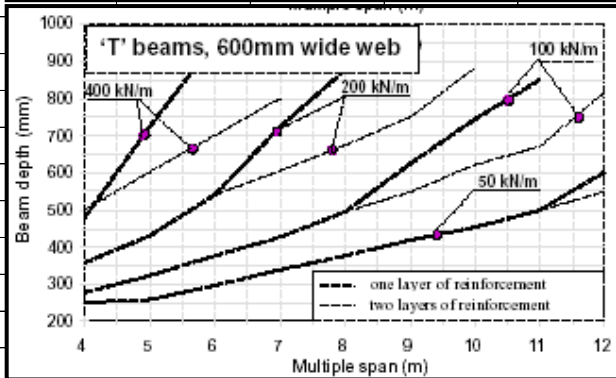
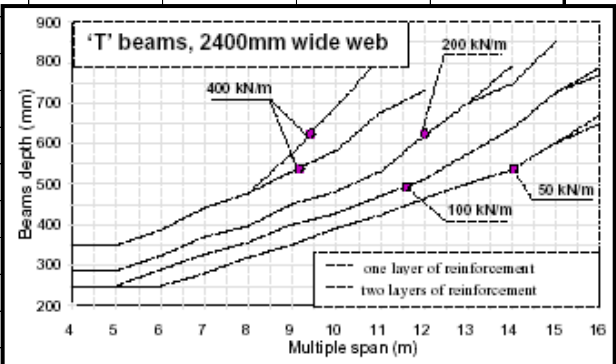
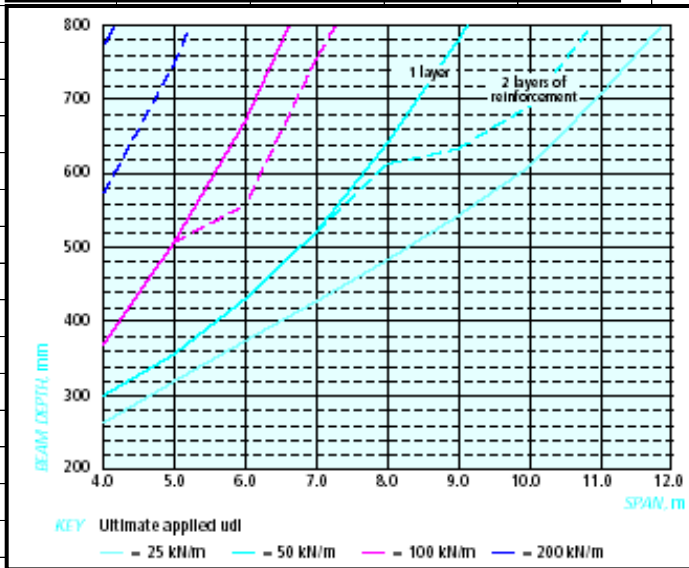
Detailing Instructions (Deep Beam)



|                         |                                                  |                                                       |  |  |  |                 |           |      |            |        |
|-------------------------|--------------------------------------------------|-------------------------------------------------------|--|--|--|-----------------|-----------|------|------------|--------|
| CONSULTING<br>ENGINEERS |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |  |  |  | Job No.         | Sheet No. |      | Rev.       |        |
|                         |                                                  |                                                       |  |  |  | jXXX            | 38        |      |            |        |
|                         |                                                  |                                                       |  |  |  | Member/Location |           |      |            |        |
| Job Title               | Member Design - Reinforced Concrete Beam BS8110, |                                                       |  |  |  | Drg. Ref.       |           |      |            |        |
| Member Design - RC Beam |                                                  |                                                       |  |  |  | Made by         | XX        | Date | 24/10/2026 | Chd.   |
|                         |                                                  |                                                       |  |  |  |                 |           |      |            | BS8110 |
|                         |                                                  |                                                       |  |  |  |                 |           |      |            |        |
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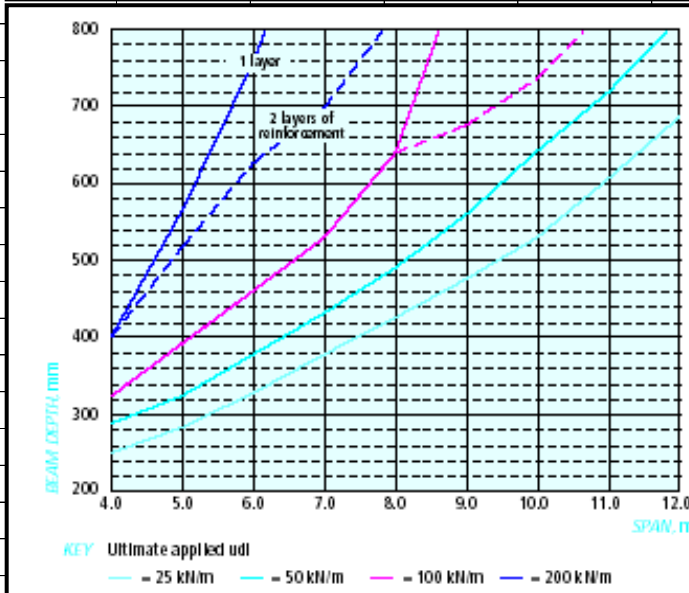


Scheme Design



Rectangular beams  
300 mm  
wide

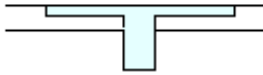
single span

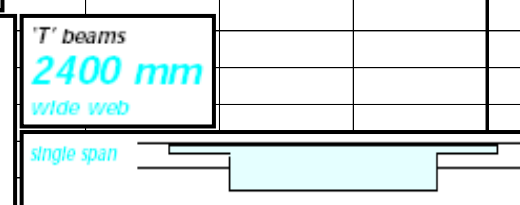


Rectangular beams  
600 mm  
wide

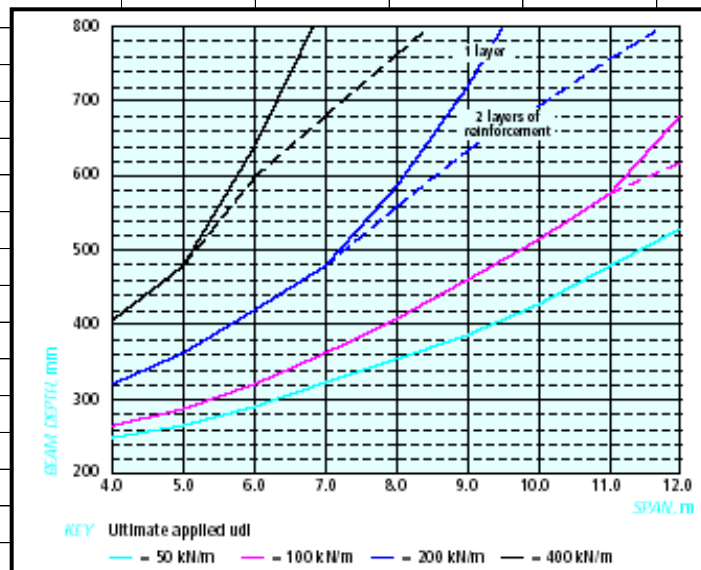
single span





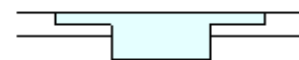
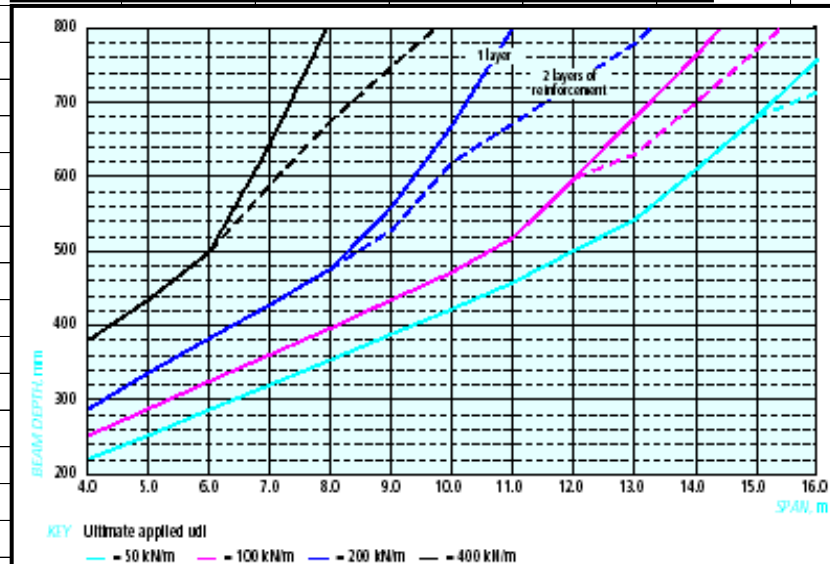


|                         |                                                  |                                                       |  |  |  |                 |           |      |            |        |  |  |  |  |  |  |  |  |  |
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| CONSULTING<br>ENGINEERS |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |  |  |  | Job No.         | Sheet No. | Rev. |            |        |  |  |  |  |  |  |  |  |  |
|                         |                                                  |                                                       |  |  |  | jXXX            | 42        |      |            |        |  |  |  |  |  |  |  |  |  |
|                         |                                                  |                                                       |  |  |  | Member/Location |           |      |            |        |  |  |  |  |  |  |  |  |  |
| Job Title               | Member Design - Reinforced Concrete Beam BS8110, |                                                       |  |  |  | Drg. Ref.       |           |      |            |        |  |  |  |  |  |  |  |  |  |
| Member Design - RC Beam |                                                  |                                                       |  |  |  | Made by         | XX        | Date | 24/10/2026 | Chd.   |  |  |  |  |  |  |  |  |  |
|                         |                                                  |                                                       |  |  |  |                 |           |      |            | BS8110 |  |  |  |  |  |  |  |  |  |
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| </                      |                                                  |                                                       |  |  |  |                 |           |      |            |        |  |  |  |  |  |  |  |  |  |

BS8110

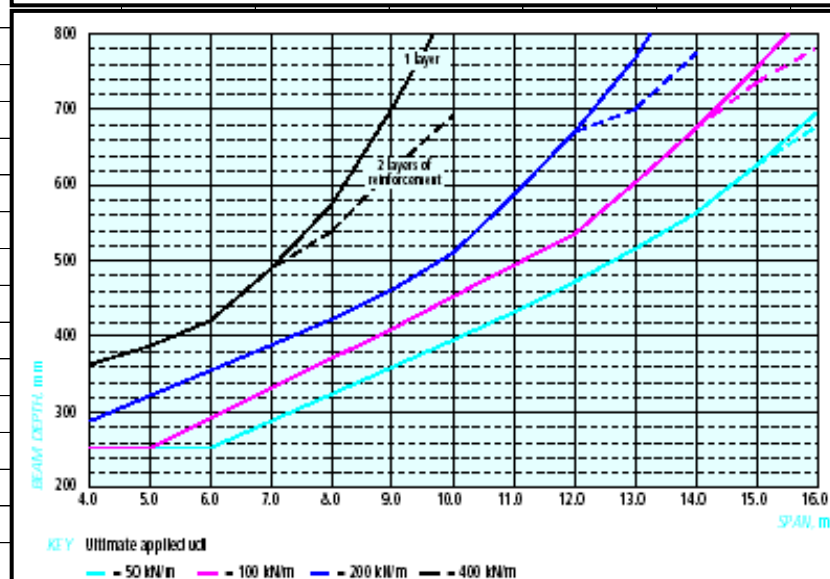
'T' beams  
**900 mm**  
wide web

*multiple span*



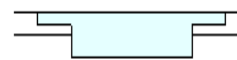
T' beams  
1200 mm  
wide web

*multiple span*



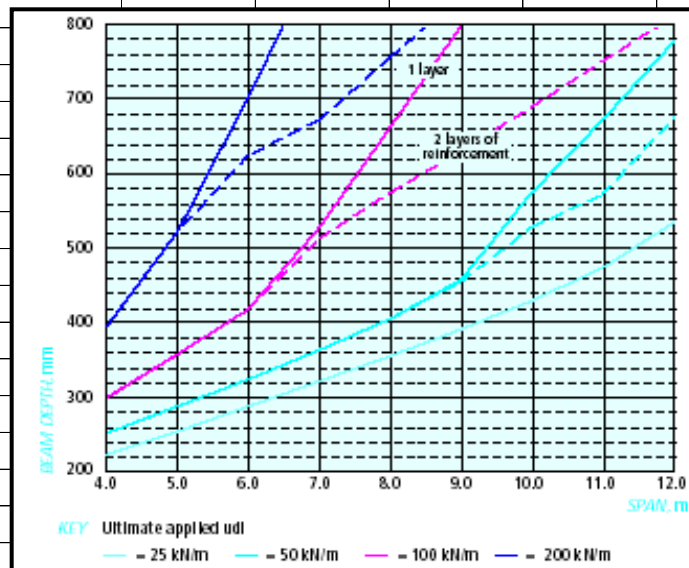
'T' beams  
**1800 mm**  
wide web

*multiple span*



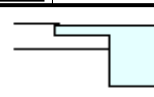
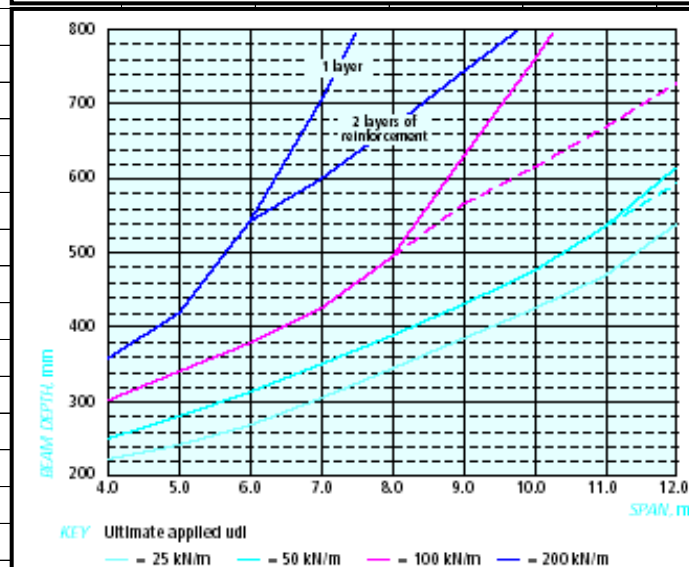
|                         |                                                  |                                                       |  |  |  |                 |           |      |            |        |  |  |  |  |  |  |  |  |  |  |
|-------------------------|--------------------------------------------------|-------------------------------------------------------|--|--|--|-----------------|-----------|------|------------|--------|--|--|--|--|--|--|--|--|--|--|
| CONSULTING ENGINEERS    |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |  |  |  | Job No.         | Sheet No. | Rev. |            |        |  |  |  |  |  |  |  |  |  |  |
|                         |                                                  |                                                       |  |  |  | jXXX            | 44        |      |            |        |  |  |  |  |  |  |  |  |  |  |
|                         |                                                  |                                                       |  |  |  | Member/Location |           |      |            |        |  |  |  |  |  |  |  |  |  |  |
| Job Title               | Member Design - Reinforced Concrete Beam BS8110, |                                                       |  |  |  | Drg. Ref.       |           |      |            |        |  |  |  |  |  |  |  |  |  |  |
| Member Design - RC Beam |                                                  |                                                       |  |  |  | Made by         | XX        | Date | 24/10/2026 | Chd.   |  |  |  |  |  |  |  |  |  |  |
|                         |                                                  |                                                       |  |  |  |                 |           |      |            | BS8110 |  |  |  |  |  |  |  |  |  |  |
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| CONSULTING ENGINEERS    |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |  |  |  | Job No.         | Sheet No. | Rev. |            |        |  |  |  |  |  |  |  |  |  |
|                         |                                                  |                                                       |  |  |  | jXXX            | 45        |      |            |        |  |  |  |  |  |  |  |  |  |
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| Job Title               | Member Design - Reinforced Concrete Beam BS8110, |                                                       |  |  |  | Drg. Ref.       |           |      |            |        |  |  |  |  |  |  |  |  |  |
| Member Design - RC Beam |                                                  |                                                       |  |  |  | Made by         | XX        | Date | 24/10/2026 | Chd.   |  |  |  |  |  |  |  |  |  |
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BS8110

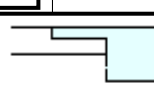
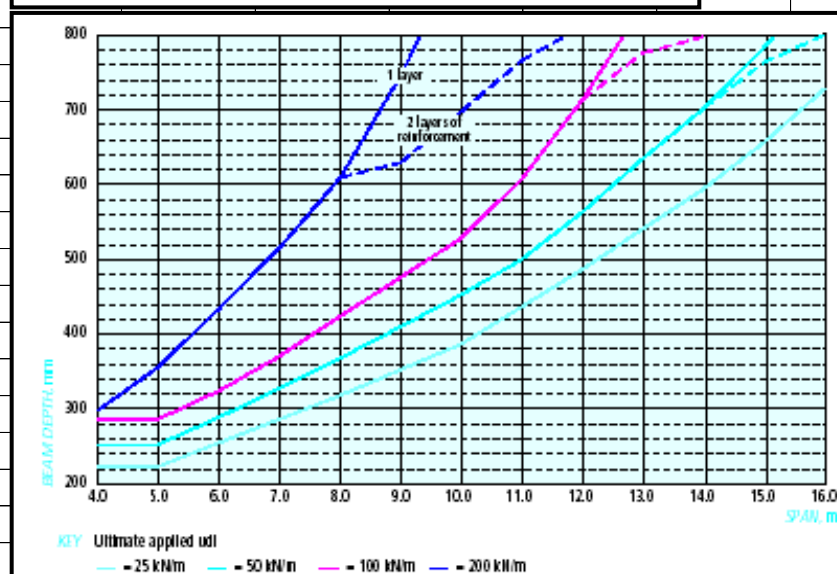
**Inverted 'L' beams**  
**450 mm**  
wide web

*multiple span*



*Inverted 'L' beams*  
**600 mm**  
*wide web*

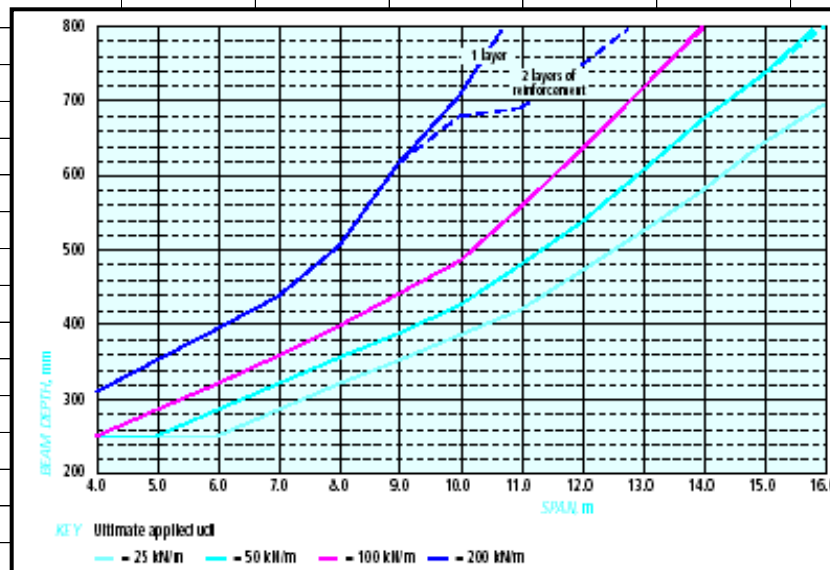
multiple span



*Inverted 'L' beams*  
**900 mm**  
*wide web*

multiple span



BS8110

*Inverted 'L' beams*  
**1200 mm**  
*wide web*

*multiple span*

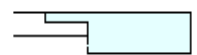


Table 3.1 — Allowable steel stresses in direct or flexural tension for serviceability limit states

| Design crack width | Allowable stress        |                            |
|--------------------|-------------------------|----------------------------|
|                    | Plain bars <sup>a</sup> | Deformed bars <sup>b</sup> |
| mm                 | N/mm <sup>2</sup>       | N/mm <sup>2</sup>          |
| 0.1                | 85                      | 100                        |
| 0.2                | 115                     | 130                        |

<sup>b</sup> Deformed grade 460 bars complying with BS 4449 or BS 4461 and high-yield wire fabric complying with BS 4483 having a guaranteed yield or proof stress and guaranteed weld strength.

*Note optional method of limiting allowable steel stress to full crack width calculation method;*

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                  |                                                       |  |       |                            |                 |           |       |            |        |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|-------------------------------------------------------|--|-------|----------------------------|-----------------|-----------|-------|------------|--------|--|
| CONSULTING ENGINEERS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                  | Engineering Calculation Sheet<br>Consulting Engineers |  |       |                            | Job No.         | Sheet No. |       | Rev.       |        |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                  |                                                       |  |       |                            | jXXX            | 48        |       |            |        |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                  |                                                       |  |       |                            | Member/Location |           |       |            |        |  |
| Job Title                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Member Design - Reinforced Concrete Beam BS8110, |                                                       |  |       |                            | Drg. Ref.       |           |       |            |        |  |
| Member Design - RC Beam                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                  |                                                       |  |       |                            | Made by         | XX        | Date  | 24/10/2026 | Chd.   |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                  |                                                       |  |       |                            |                 |           |       |            | BS8110 |  |
| Typical Initial Span / Effective Depth Ratios                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                  |                                                       |  |       |                            |                 |           |       |            |        |  |
| Span-to-depth ratios for beams                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  |       |                            |                 |           |       |            |        |  |
| Condition                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  |                                                       |  |       | Span-to-depth ratio        |                 |           |       |            |        |  |
| Simply supported                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  |                                                       |  |       | 15                         |                 |           |       |            |        |  |
| End-bay                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                  |                                                       |  |       | 17                         |                 |           |       |            |        |  |
| Cantilever                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                  |                                                       |  |       | 6                          |                 |           |       |            |        |  |
| Transfer beams                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  |       |                            |                 |           |       |            |        |  |
| <p>The experienced engineer will understand that it is not advisable to determine the section size merely by using span-to-depth tables – careful consideration is needed. Shear strength is often the governing criteria for a reinforced concrete transfer beam. From BS 8110, <math>v = V/bd</math>. In no case should <math>v</math> exceed <math>0.8\sqrt{f_{cu}}</math> or <math>5 \text{ N/mm}^2</math> (whichever is smaller). If the section is not to become congested with shear reinforcement it is advisable to limit <math>v</math> to <math>2 \text{ N/mm}^2</math>. However, it may be necessary to increase this to <math>4 \text{ N/mm}^2</math>. If we assume a well proportioned beam has a width, <math>b</math>, which is half it's depth, then we rearrange the expression above so that:</p> $d = \sqrt{V}$ <p>where <math>V</math> is in newtons (N) for shear stress of <math>2 \text{ N/mm}^2</math></p> $d = \sqrt{(V/2)}$ <p>for shear stress of <math>4 \text{ N/mm}^2</math></p> <p>The headroom under the beam should be checked and consideration given to the connection into the column. Deflection and flexural strength should also be considered because they may govern the design.</p> |                                                  |                                                       |  |       |                            |                 |           |       |            |        |  |
| Table 5: Span/depth ratios for insitu concrete beams (from Reynolds's Reinforced Concrete Designer's Handbook)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                  |                                                       |  |       |                            |                 |           |       |            |        |  |
| Beam span condition                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  | Ultimate line load 25 kN/m                            |  |       | Ultimate line load 50 kN/m |                 |           | Ultim |            |        |  |
| Simply supported                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                  | 18                                                    |  |       | 14                         |                 |           |       |            |        |  |
| Continuous                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                  | 22                                                    |  |       | 17                         |                 |           |       |            |        |  |
| Cantilever                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                  | 9                                                     |  |       | 7                          |                 |           |       |            |        |  |
| Table 6: Estimated depths of insitu concrete single span T-beams (600mm wide)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                  |                                                       |  |       |                            |                 |           |       |            |        |  |
| Span                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                  | 4m                                                    |  | 5m    |                            | 6m              |           | 7m    |            | 8m     |  |
| 50 kN/m UDL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  | 250mm                                                 |  | 300mm |                            | 350mm           |           | 400mm |            | 500mm  |  |
| 100 kN/m UDL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                  | 275mm                                                 |  | 325mm |                            | 400mm           |           | 450mm |            | 575mm  |  |
| 200 kN/m UDL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                  | 325mm                                                 |  | 375mm |                            | 450mm           |           | 525mm |            | 650mm  |  |
| Table 7: Estimated depths of insitu concrete single span band-beams (2400mm wide)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                  |                                                       |  |       |                            |                 |           |       |            |        |  |
| Span                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                  | 6m                                                    |  | 7m    |                            | 8m              |           | 9m    |            | 10m    |  |
| 50 kN/m UDL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                  | 250mm                                                 |  | 300mm |                            | 350mm           |           | 400mm |            | 475mm  |  |
| 100 kN/m UDL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                  | 300mm                                                 |  | 350mm |                            | 425mm           |           | 500mm |            | 575mm  |  |
| 200 kN/m UDL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                  | 350mm                                                 |  | 400mm |                            | 475mm           |           | 575mm |            | 675mm  |  |

[illegible]