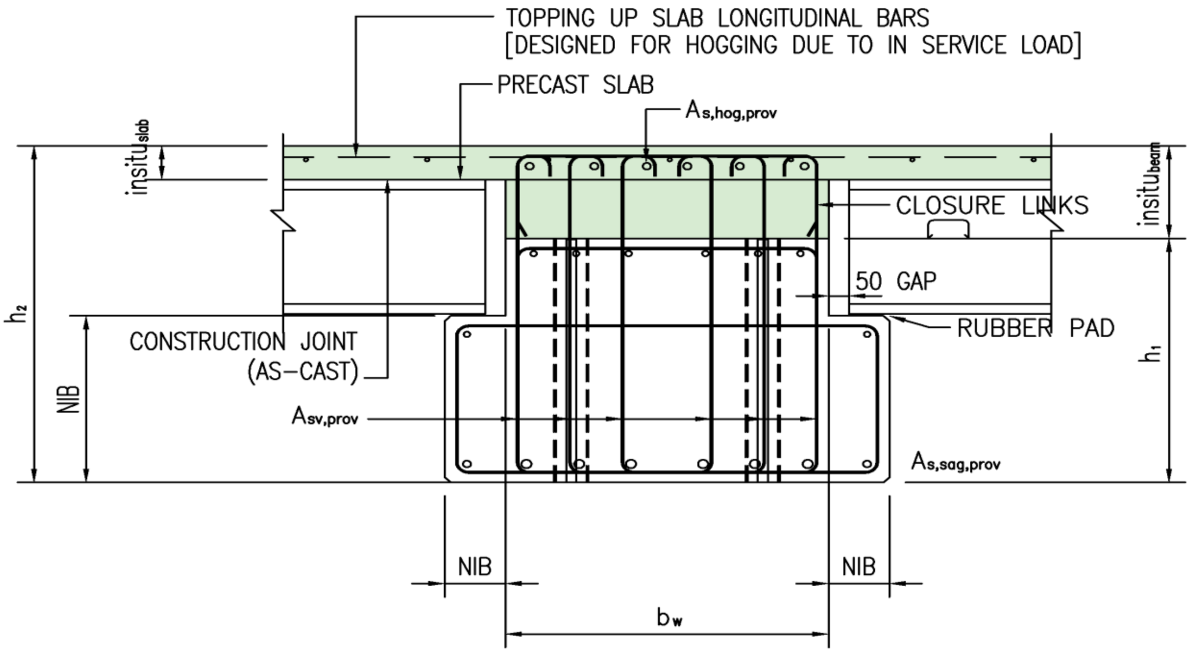
| | | | | |
|---|---|---|---|---|
| **CONSULTING ENGINEERS** | Engineering Calculation Sheet<br>Consulting Engineers | Job No.<br>jXXX | Sheet No.<br>1 | Rev. |
| | | Member/Location | | |
| Job Title | Structure, Member Design - Precast Concrete Frame, Be | Drg. Ref. | | |
| Structure, Member Design - PC Frame, Beam and Slab | | Made by XX | Date 4/7/2026 | Chd. |

| | | | | |
|---|---|---|---|---|
| | | | | BS8110 |
| **Material Properties** | | | | |
| Characteristic strength of concrete, $f_{cu}$ / $f_c$' ($f_{cu}$ ≤ 75 or 105N/mm$^2$; | 55 | 45 | N/mm$^2$ | **OK** |
| Yield strength of longitudinal steel, $f_y$ | | 460 | N/mm$^2$ | |
| Yield strength of shear link steel, $f_{yv}$ | | 460 | N/mm$^2$ | |
| Type of concrete and density, $\rho_c$ | Normal Weight 25kN/m3 | 25 | kN/m$^3$ | |
| **Section Dimensions and Reinforcement [Stage 1: Precast Simply-Supported]** | | | | |
| Slab insitu depth, $insitu_{slab}$ | | 100 | mm | |
| Beam (precast) width, $b_{w1} = b_w$ | | 500 | mm | |
| Beam (precast) depth, $h_1$ | | 700 | mm | |
| Cover, $cover_{bot1}$ (usually 35 (C35) or 30 (C40) internal; 40 external) | | 25 | mm | |
| Sag steel reinforcement diameter, $\phi_{t1}$ | | 32 | mm | |
| Sag steel reinforcement number, $n_{t1}$ | | 8 | | |
| Sag steel area provided, $A_{s,sag,prov} = n_{t1}.\pi.\phi_{t1}^2/4$ | | **6434** | mm$^2$ | |
| Number of layers of sag steel, $n_{layers,sag1}$ | | 2 | layer(s) | |
| Spacer for sag steel, $s_{r,sag1}$ (≥ MAX ($\phi_{t1}$, 25mm)) | | 32 | mm | **OK** |
| 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$^2$ | |
| Pitch of shear links, S | | 100 | mm | |
| Eff. depth to sag steel, $d_{sag1} = h_1 - cover_{bot1} - \phi_{link} - [\phi_{t1}+(n_{layers,sag1}-1)(\phi_{t1}+s_{r,sag}$ | | 617 | mm | |
| **Section Dimensions [Stage 2: Insitu]** | | | | |
| Beam (composite) width, $b_{w2} = b_w$ | | 500 | mm | |
| Beam insitu depth, $insitu_{beam}$ | | 300 | mm | |
| Beam (composite) depth, $h_2 = h_1 + insitu_{beam}$ | | 1000 | mm | |
| Cover, $cover_{top2}$ (usually 35 (C35) or 30 (C40) internal; 40 external) | | 25 | mm | |
| Add cover to hog steel (due to transverse steel layer(s)), $cover_{add,t}$ | | 12 | mm | |
| Hog steel reinforcement diameter, $\phi_{t2}$ | | 32 | mm | |
| Hog steel reinforcement number, $n_{t2}$ | | 8 | | |
| Hog steel area provided, $A_{s,hog,prov} = n_{t2}.\pi.\phi_{t2}^2/4$ | | **6434** | mm$^2$ | |
| Number of layers of hog steel, $n_{layers,hog2}$ | | 2 | layer(s) | |
| Spacer for hog steel, $s_{r,hog2}$ (≥ MAX ($\phi_{t2}$, 25mm)) | | 32 | mm | **OK** |
| Eff. depth to sag steel, $d_{sag2} = h_2 - cover_{bot1} - \phi_{link} - [\phi_{t1}+(n_{layers,sag1}-1)(\phi_{t1}+s_{r,sag}$ | | 917 | mm | |
| Eff. depth to hog steel, $d_{hog2} = h_2 - cover_{top2} - MAX(\phi_{link}, cover_{add,t}) - [\phi_{t2}+(n_{laye}$ | | 915 | mm | |

| CONSULTING ENGINEERS | Engineering Calculation Sheet<br>Consulting Engineers | Job No.<br>jXXX | Sheet No.<br>2 | Rev. |
|---|---|---|---|---|
| | | Member/Location | | |
| Job Title | Structure, Member Design - Precast Concrete Frame, Be | Drg. Ref. | | |
| Structure, Member Design - PC Frame, Beam and Slab | | Made by XX | Date 4/7/2026 | Chd. |

BS8110

**Detailing Instructions**



PRECAST BEAM SECTION

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| cover = | 25 mm | 25 mm | | $b_w$ = | 500 mm | | $insitu_{slab}$ = | 100 mm | |
| | $f_{cu}$ = | 55 | | $h_1$ = | 700 mm | | $insitu_{beam}$ = | 300 mm | |
| | $f_y$ = | 460 | | $h_2$ = | 1000 mm | | $nib_b$ = | 0 mm | |
| | $f_{yv}$ = | 460 | | | | | $nib_h$ = | 0 mm | |
| | $A_{s,sag,prov}$ = | 8 no. | 32 | rebar in | 2 | layers @ | 32 mm | spacer | 1.3% |
| | $A_{s,hog,prov}$ = | 8 no. | 32 | rebar in | 2 | layers @ | 32 mm | spacer | 1.3% |
| | $A_{sv,prov}$ = | 4 no. | 10 | shear link | legs | @ | 100 mm | pitch | |

stage 2 support conditions = **Continuous Internal Span**

precast concrete beam total weight for erection = **8.750** tonnes

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | strand short-term losses = | | 5.0 | % |
| | | | | strand long-term losses = | | 15.0 | % |
| | | | | strand breaking load = | | 260.4 | kN |
| | | | | strand jacking percentage = | | 75.0 | % |
| strands = | 0 | 0 | 0 | 0 | 0 | 0 | strands |
| $P_{st}$ = | 0 | 0 | 0 | 0 | 0 | **0** | kN |
| $-P_{st}/A_1$ = | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | $N/mm^2$ |
| $P_{lt}$ = | 0 | 0 | 0 | 0 | 0 | **0** | kN |
| $-P_{lt}/A_1$ = | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | $N/mm^2$ |
| $_{strands,1,b}$ (from bot.) = | 50 | 100 | 150 | 200 | 650 | **N/A** | mm |
| eccentricity, $e_s$ = | -300 | -250 | -200 | -150 | 300 | **N/A** | mm |
| $M_{PT,st} = \Sigma P_{st}.e_s$ = | 0 | 0 | 0 | 0 | 0 | **0** | kNm |
| $M_{PT,lt} = \Sigma P_{lt}.e_s$ = | 0 | 0 | 0 | 0 | 0 | **0** | kNm |

| CONSULTING ENGINEERS | Engineering Calculation Sheet<br>Consulting Engineers | Job No. | Sheet No. | | Rev. |
|---|---|---|---|---|---|
| | | jXXX | 3 | | |
| | | Member/Location | | | |
| Job Title | Structure, Member Design - Precast Concrete Frame, Be | Drg. Ref. | | | |
| Structure, Member Design - PC Frame, Beam and Slab | | Made by XX | Date 4/7/2026 | | Chd. |

*BS8110*

**Utilisation Summary**

| Item | UT | Remark |
|---|---|---|
| Precast beam sag section ductility | N/A | OK |
| Precast beam sag steel area provided | 41% | OK |
| Precast beam ultimate shear stress | 17% | OK |
| Precast beam design shear links area | 15% | OK |
| Precast beam design shear resistance | 22% | OK |
| Precast beam deflection | 66% | OK |
| Precast beam deflection (first principles) | 28% | OK |
| Composite beam sag section ductility | N/A | OK |
| Composite beam sag steel area provided | 89% | OK |
| Composite beam hog section ductility | N/A | OK |
| Composite beam hog steel area provided | 75% | OK |
| Composite beam ultimate shear stress | 40% | OK |
| Composite beam design shear links area | 40% | OK |
| Composite beam design shear resistance | 71% | OK |
| Composite beam deflection | 53% | OK |
| Composite beam deflection (first principles) | 42% | OK |
| Precast and composite beam miscellaneous checks | N/A | OK |

| | | |
|---|---|---|
| Stage 1 beam bottom section modulus, $Z_{b1}$ | 4083 | $x10^4$ $mm^3$ |
| Stage 2 beam bottom section modulus, $Z_{b2}$ | 10684 | $x10^4$ $mm^3$ |

BS8110

**Loading and Structural Analysis [Stage 1: Precast Simply-Supported]**

| | | |
|---|---|---|
| British or Eurocode loading combination factors | British | |
| Beam span, $L_1$ | 10.000 | m |
| Tributary width (inc. precast slab clear span), $t_{w1}$ | 5.000 | m |
| Dead load of inc. precast slab (pressure load), $DL_{slab}$ | 2.50 | kPa |
| Dead load of inc. precast slab insitu topping (pressure load), $DL_{top}$ | 2.50 | kPa |
| *Note DL of inc. precast slab insitu topping (pressure load), $DL_{top} = insitu_{slab} \cdot \rho_c$* | | |
| SLS slab loading (pressure load), $SLS_{slab1} = DL_{slab} + DL_{top}$ | 5.00 | kPa |
| Dead load of precast and wet beam (line load), $DL_{beam} = b_{w1}.(\%h_1+insitu_{beam})$ | 12.5 | kN/m |
| Dead load of precast beam nibs (line load), $DL_{nib} = 2.nib_w.nib_h.\rho_c$ | 0.0 | kN/m |
| Dead load of precast beam incl. nibs (line load), $DL_{precastbeam}$ 100% | 8.8 | kN/m |
| *Note DL of precast beam incl. nibs (line load), $DL_{precastbeam} = b_{w1}.h_1.\rho_c+DL_{nib}$* | | |
| Dead load of inc. precast slab and topping concrete (line load), $DL_{precastslab+toppi}$ | 28.8 | kN/m |
| *Note DL of inc. precast slab and topping concrete (line load), $DL_{precastslab+topping} = b_{w1}.insitu_{beam}.\rho_c + SLS_{slab1}.$* | | |
| ULS beam loading (line load), $\omega_{ULS1}$ | 52.5 | kN/m |
| *Note $\omega_{ULS1} = (1.35\text{-}1.4)SLS_{slab1}.t_{w1}+(1.35\text{-}1.4)DL_{beam}+(1.35\text{-}1.4)DL_{nib}$* | | |
| Beam unpropped or propped ? | Unpropped | |
| Beam ULS sag bending moment, $M_{1,sag}$ | 656 | kNm |
| *Note $M_{1,sag} = 0.125.\omega_{ULS1}.L_1^2$ (if unpropped only)* | | |
| Beam SLS sag bending moment, $M_{1,sag,SLS}$ | 469 | kNm |
| *Note $M_{1,sag,SLS}$ calculated as per $M_{1,sag}$ but without load combination factors, plus the addition of $M_{PT,lt}$.* | | |
| Beam bottom SLS stress at end of stage 1 (comp. -ve), $\sigma_{b1,SLS}$ | 11.48 | $N/mm^2$ |
| *Note $\sigma_{b1,SLS} = -\Sigma P_{lt}/A_1 + M_{1,sag,SLS}/Z_{b1}$* | | |
| *Note beam bottom stress at end of stage 1 results from prestressing, DL of precast beam including nibs and dead load of precast slab and topping concrete.* | | |
| Beam ULS shear force, $V_1 = 0.5.\omega_{ULS1}.L_1$ (if unpropped only) | 263 | kN |

| CONSULTING ENGINEERS | Engineering Calculation Sheet<br>Consulting Engineers | Job No. | Sheet No. | Rev. |
|---|---|---|---|---|
| | | jXXX | 4 | |
| | | Member/Location | | |
| Job Title | Structure, Member Design - Precast Concrete Frame, Be | Drg. Ref. | | |
| Structure, Member Design - PC Frame, Beam and Slab | | Made by XX | Date 4/7/2026 | Chd. |

BS8110

**Loading and Structural Analysis [Stage 2: Insitu]**

| | | | |
|---|---|---|---|
| British or Eurocode loading combination factors | British | | |
| Beam span, $L_2$ | | 10.000 | m |
| Tributary width (grid to grid), $t_{w2}$ | | 5.000 | m |
| Superimposed dead load on slab (pressure load), $SDL_{slab}$ | | 15.00 | kPa |
| Superimposed dead load on beam (line load), $SDL_{beam}$ | | 0.0 | kN/m |
| Superimposed dead load on beam (midspan point load), $SDL_{point}$ | | 0.0 | kN |
| Live load on slab (pressure load), $LL_{slab}$ [with pattern loading] | | 10.00 | kPa |
| Superimposed dead and live load on beam (line load), $[SDL_{slab} + LL_{slab}].t_{w2}$ + $ | | 125.0 | kN/m |
| ULS beam loading (line load), $\omega_{ULS2}$ | | 185.0 | kN/m |

*Note* $\omega_{ULS2} = ((1.35\text{-}1.4)SDL_{slab}+(1.5\text{-}1.6)LL_{slab}).t_{w2}+(1.35\text{-}1.4)SDL_{beam}$

| | | | |
|---|---|---|---|
| Beam ULS sag bending moment, $M_{2,sag}$ | Continuous Internal Span | 1171 | kNm |

*Note* $M_{2,sag} = k_{DL|SDL,sag}\,.\,\omega_{ULS1}.L_2^{\,2}$ *(if propped only)* $+\ k_{DL|SDL,sag}.(1.35\text{-}1.4).[SDL_{slab}.t_{w2}+SDL_{beam}].L_2^{\,2}$
$+\ k_{SDL,p,sag}.(1.35\text{-}1.4).[SDL_{point}].L_2\ +\ k_{LL,sag}.(1.5\text{-}1.6).[LL_{slab}.t_{w2}].L_2^{\,2}$

| | $k_{DL\|SDL,sag}$ | $k_{SDL,p,sag}$ | $k_{LL,sag}$ |
|---|---|---|---|
| *Continuous Internal Span* | *0.046* | *0.125* | *0.086* |
| *Continuous End Span* | *0.078* | *0.170* | *0.100* |
| *Simply-Supported* | *0.125* | *0.250* | *0.125* |

| | | | |
|---|---|---|---|
| Beam SLS sag bending moment, $M_{2,sag,SLS}$ | 775 | kNm | |

*Note* $M_{2,sag,SLS}$ *calculated as per* $M_{2,sag}$ *but without load combination factors.*

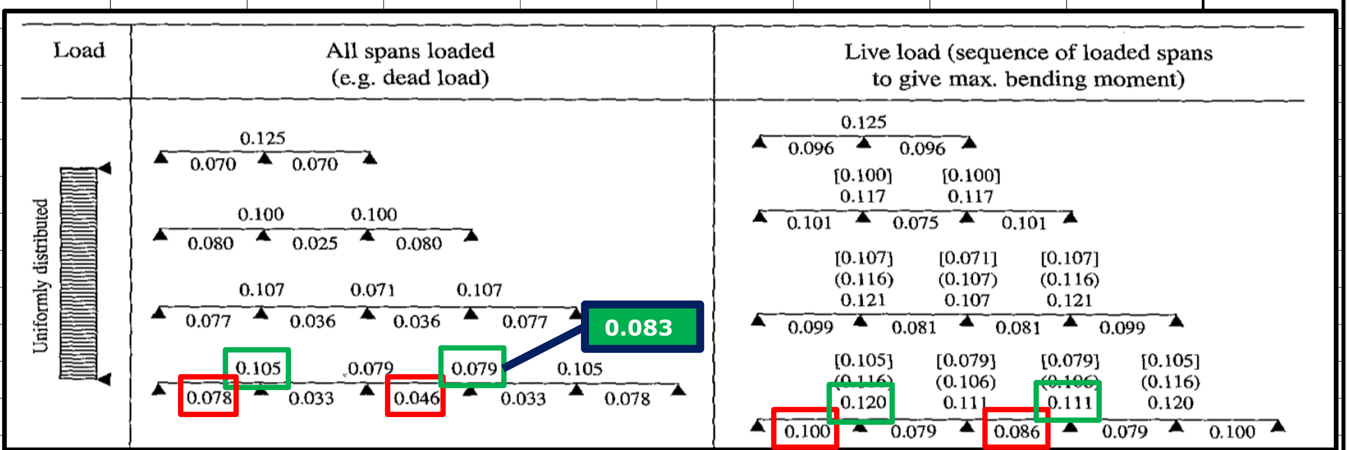
| | | | |
|---|---|---|---|
| Beam bottom SLS stress stage 2 loading (comp. -ve), $\sigma_{b2,SLS}$ | 7.25 | $N/mm^2$ | |

*Note* $\sigma_{b2,SLS} = M_{2,sag,SLS}/Z_{b2}$

| | | | |
|---|---|---|---|
| Beam bottom SLS stress at end of stage 2 (comp. -ve), $\sigma_{b1,SLS} + \sigma_{b2,SLS}$ | 18.73 | $N/mm^2$ | N/A |
| Beam total ULS sag bending moment, $M_{1,sag} + M_{2,sag}$ | 1827 | kNm | |
| Beam ULS hog bending moment, $M_{2,hog}$ — Continuous Internal Span | 1760 | kNm | |

*Note* $M_{2,hog} = k_{DL|SDL,hog}\,.\,\omega_{ULS1}.L_2^{\,2}$ *(if propped only)* $+\ k_{DL|SDL,hog}.(1.35\text{-}1.4).[SDL_{slab}.t_{w2}+SDL_{beam}].L_2^{\,2}$
$+\ k_{SDL,p,hog}.(1.35\text{-}1.4).[SDL_{point}].L_2\ +\ k_{LL,hog}.(1.5\text{-}1.6).[LL_{slab}.t_{w2}].L_2^{\,2}$

| | $k_{DL\|SDL,hog}$ | $k_{SDL,p,hog}$ | $k_{LL,hog}$ |
|---|---|---|---|
| *Continuous Internal Span* | *0.083* | *0.125* | *0.111* |
| *Continuous End Span* | *0.105* | *0.161* | *0.120* |
| *Simply-Supported* | *0.040* | *0.040* | *0.040* |




| | | | |
|---|---|---|---|
| Beam ULS shear force, $V_2$ | 925 | kN | |

*Note* $V_2 = (0.5\text{-}0.6).\,\omega_{ULS1}.L_2$ *(if propped only)* $+ (0.5\text{-}0.6).\,\omega_{ULS2}.L_2+(0.5\text{-}0.6).((1.35\text{-}1.4)SDL_{point})$

| | | | | | | |
|---|---|---|---|---|---|---|
| **CONSULTING ENGINEERS** | Engineering Calculation Sheet<br>Consulting Engineers | | Job No. | Sheet No. | | Rev. |
| | | | jXXX | 5 | | |
| | | | Member/Location | | | |
| Job Title | Structure, Member Design - Precast Concrete Frame, B | | Drg. Ref. | | | |
| Structure, Member Design - PC Frame, Beam and Slab | | | Made by XX | Date | 4/7/2026 | Chd. |

| | | | | |
|---|---|---|---|---|
| | | | | BS8110 |
| **Structural Design [Stage 1: Precast Simply-Supported]** | | | | |
| **Bending Design** | | | | |
| Stress coefficient, $M_{1,sag}/(b_{w1}+2.nib_b)d_{sag1}^2$ | | 3.4 | $N/mm^2$ | |
| Stress coefficient, $K_{sag1} = M_{1,sag}/(b_{w1}+2.nib_b)d_{sag1}^2 f_{cu}$ | | 0.063 | | OK |
| Lever arm, $z_{sag1} = d_{sag1}.[0.5+(0.25-K_{sag1}/0.9)^{0.5}] \le 0.95d_{sag1}$ | | 571 | mm | |
| Area of req. sag steel, $A_{s,sag1} = M_{1,sag} / (0.95f_y.z_{sag1})$ | | 2632 | $mm^2$ | |
| Sag steel area provided, $A_{s,sag,prov}$ | | 6434 | $mm^2$ | |
| Sag steel area provided utilisation, $A_{s,sag1} / A_{s,sag,prov}$ | | 41% | | OK |
| **Shear Design** | | | | |
| Ultimate shear stress, $v_{ult1} = V_1/b_{w1}d_{sag1}$ (< $0.8f_{cu}^{0.5}$ & $5.0N/mm^2$) | | 0.85 | $N/mm^2$ | |
| Ultimate shear stress utilisation, $v_{ult1}$ / ($0.8f_{cu}^{0.5}$ & $5.0N/mm^2$) | | 17% | | OK |
| Design shear stress, $v_{d1} = V_1/b_{w1}d_{sag1}$ | | 0.85 | $N/mm^2$ | |
| Enhanced shear strength, $2d_{sag1}/a_v.v_c$ (< $0.8f_{cu}^{0.5}$ & $5.0N/mm^2$) | *x 1.00* | 1.05 | $N/mm^2$ | |
| Distance, $a_v$ | 2.00d | 1234 | 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;)* | | | | |
| Sag steel area provided, $A_{s,sag,prov}$ | | 6434 | $mm^2$ | |
| $\rho_w = 100A_{s,sag,prov}/b_{w1}d_{sag1}$ | | 2.09 | % | |
| $v_c = (0.79/1.25)(\rho_w f_{cu}/25)^{1/3}(400/d_{sag1})^{1/4}$; $\rho_w$<3; $f_{cu}$<80; $(400/d_{sag}$ | | 1.05 | $N/mm^2$ | |
| Provide shear links $(A_{sv}/S)_1 > b_{w1}MAX[0.4,(v_{d1}-2d_{sag1}/a_v.v_c)]/(0.95f_{yv})$ i.e. $(A_{sv}$ | | 0.46 | $mm^2/mm$ | |
| Area provided by all shear links in a cross-section, $A_{sv,prov}/S$ | | 3.14 | $mm^2/mm$ | |
| Concrete and design links shear capacity, $V_{cap1} = (A_{sv,prov}/S).(0.95f_{yv}).d_{sag1}$ + 2 | | 1171 | kN | |
| Design shear links area utilisation, $(A_{sv}/S)_1 / (A_{sv,prov}/S)$ | | 15% | | OK |
| Design shear resistance utilisation, $V_1 / V_{cap1}$ | | 22% | | OK |
| **Deflection Design** | | | | |
| Span | | 10.000 | m | |
| Span / effective depth ratio | | 16.2 | | |
| Basic span / effective depth ratio criteria | | 20.0 | | |
| Multiplier $C_{1,rect\ or\ flanged}$ | | 1.00 | | cl.3.4.6.3 |
| Multiplier $C_{1,span\ more\ or\ less\ than\ 10m}$ | Include | 1.00 | | cl.3.4.6.4 |
| Modification factor for tension $C_2$ $\quad 0.55 + \frac{(477-f_s)}{120\left(0.9+\frac{M}{bd^2}\right)} \le 2.0$ | | 1.22 | | T.3.10 |
| $(M_{1,sag}+M_{PT,lt})/(b_{w1}+2.nib_b).d_{sag1}^2$ | | 3.45 | $N/mm^2$ | cl.3.4.6.2 |
| $f_s = \frac{2f_y A_{s\ req}}{3A_{s\ prov}} \times \frac{1}{\beta_b}$ | | 125 | $N/mm^2$ | |
| Modified span / effective depth ratio criteria | | 24.5 | | |
| Deflection utilisation | | 66% | | OK |

| | | | | |
|---|---|---|---|---|
| **CONSULTING ENGINEERS** | Engineering Calculation Sheet<br>Consulting Engineers | Job No.<br>jXXX | Sheet No.<br>6 | Rev. |
| | | Member/Location | | |
| Job Title | Structure, Member Design - Precast Concrete Frame, B | Drg. Ref. | | |
| Structure, Member Design - PC Frame, Beam and Slab | | Made by XX | Date 4/7/2026 | Chd. |

| | | | | |
|---|---|---|---|---|
| | | | | BS8110 |
| **Structural Design [Stage 2: Insitu]** | | | | |
| **Bending Design** | | | | |
| Stress coefficient, $M_{2,sag}/(b_{w2}+2.nib_b)d_{sag2}^2$ | | 2.8 | $N/mm^2$ | |
| Stress coefficient, $M_{1,sag}/(b_{w1}+2.nib_b)d_{sag1}^2 + M_{2,sag}/(b_{w2}+2.nib_b)d_{sag2}^2$ | | 6.2 | $N/mm^2$ | |
| Stress coefficient, $K_{sag2} = M_{2,sag}/(b_{w2}+2.nib_b)d_{sag2}^2f_{cu}$ | | 0.051 | | OK |
| Lever arm, $z_{sag2} = d_{sag2}.[0.5+(0.25-K_{sag2}/0.9)^{0.5}] \le 0.95d_{sag2}$ | | 862 | mm | |
| Area of req. sag steel, $A_{s,sag2} = M_{2,sag} / (0.95f_y.z_{sag2})$ | | 3108 | $mm^2$ | |
| Sag steel area provided, $A_{s,sag,prov}$ | | 6434 | $mm^2$ | |
| Sag steel area provided utilisation, $[A_{s,sag1} + A_{s,sag2}] / A_{s,sag,prov}$ | | 89% | | OK |
| Stress coefficient, $M_{2,hog}/b_{w2}d_{hog2}^2$ | | 4.2 | $N/mm^2$ | |
| Stress coefficient, $K_{hog2} = M_{2,hog}/b_{w2}d_{hog2}^2f_{cu}$ | | 0.076 | | OK |
| Lever arm, $z_{hog2} = d_{hog2}.[0.5+(0.25-K_{hog2}/0.9)^{0.5}] \le 0.95d_{hog2}$ | | 829 | mm | |
| Area of req. hog steel, $A_{s,hog2} = M_{2,hog} / (0.95f_y.z_{hog2})$ | | 4855 | $mm^2$ | |
| Hog steel area provided, $A_{s,hog,prov}$ | | 6434 | $mm^2$ | |
| Hog steel area provided utilisation, $A_{s,hog2} / A_{s,hog,prov}$ | | 75% | | OK |
| **Shear Design** | | | | |
| Ultimate shear stress, $v_{ult2} = V_2/b_{w2}d_{hog2}$ (< $0.8f_{cu}^{0.5}$ & $5.0N/mm^2$) | | 2.02 | $N/mm^2$ | |
| Ultimate shear stress utilisation, $v_{ult2}$ / ($0.8f_{cu}^{0.5}$ & $5.0N/mm^2$) | | 40% | | OK |
| Design shear stress, $v_{d2} = V_2/b_{w2}d_{hog2}$ | | 2.02 | $N/mm^2$ | |
| Enhanced shear strength, $2d_{hog2}/a_v.v_c$ (< $0.8f_{cu}^{0.5}$ & $5.0N/mm^2$) | *x 1.00* | 0.92 | $N/mm^2$ | |
| Distance, $a_v$ | 2.00d | 1830 | 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;)* | | | | |
| Hog steel area provided, $A_{s,hog,prov}$ | | 6434 | $mm^2$ | |
| $\rho_w = 100A_{s,hog,prov}/b_{w2}d_{hog2}$ | | 1.41 | % | |
| $v_c = (0.79/1.25)(\rho_w f_{cu}/25)^{1/3}(400/d_{hog2})^{1/4}$; $\rho_w<3$; $f_{cu}<80$; $(400/d_{hog}$ | | 0.92 | $N/mm^2$ | |
| Provide shear links $(A_{sv}/S)_2 > b_{w2}MAX[0.4,(v_{d2}-2d_{hog2}/a_v.v_c)]/(0.95f_{yv})$ i.e. $(A_{sv}$ | | 1.26 | $mm^2/mm$ | |
| Area provided by all shear links in a cross-section, $A_{sv,prov}/S$ | | 3.14 | $mm^2/mm$ | |
| Concrete and design links shear capacity, $V_{cap2} = (A_{sv,prov}/S).(0.95f_{yv}).d_{hog2}$ + 2 | | 1678 | kN | |
| Design shear links area utilisation, $[(A_{sv}/S)_1 + (A_{sv}/S)_2] / (A_{sv,prov}/S)$ | | 40% | | OK |
| Design shear resistance utilisation, $[V_1 + V_2] / V_{cap2}$ | | 71% | | OK |
| **Deflection Design** | | | | |
| Span | | 10.000 | m | |
| Span / effective depth ratio | | 10.9 | | |
| Basic span / effective depth ratio criteria | Continuous Internal Span | 26.0 | | |
| Multiplier $C_{1,rect\ or\ flanged}$ | | 1.00 | | *cl.3.4.6.3* |
| Multiplier $C_{1,span\ more\ or\ less\ than\ 10m}$ | Include | 1.00 | | *cl.3.4.6.4* |
| Modification factor for tension $C_2$ | $0.55 + \frac{(477 - f_s)}{120\left(0.9 + \frac{M}{bd^2}\right)} \le 2.0$ | 0.79 | | *T.3.10* |
| $(M_{1,sag}+M_{PT,lt})/(b_{w1}+2.nib_b).d_{sag1}^2 + M_{2,sag}/(b_{w2}+2.nib_b)d_{sag2}^2$ | | 6.23 | $N/mm^2$ | *cl.3.4.6.2* |
| $f_s = \frac{2f_yA_{s\ req}}{3A_{s\ prov}} \times \frac{1}{\beta_b}$ | | 274 | $N/mm^2$ | |
| Modified span / effective depth ratio criteria | | 20.5 | | |
| Deflection utilisation | | 53% | | OK |

| CONSULTING ENGINEERS | Engineering Calculation Sheet Consulting Engineers | Job No. | Sheet No. | Rev. |
|---|---|---|---|---|
| | | jXXX | 7 | |
| | | Member/Location | | |
| Job Title | Structure, Member Design - Precast Concrete Frame, Be | Drg. Ref. | | |
| Structure, Member Design - PC Frame, Beam and Slab | | Made by XX | Date 4/7/2026 | Chd. |

*BS8110*

**Deflection Design Based on First Principles**

| | | | |
|---|---|---|---|
| Code of practice adopted for calculation of elastic modulus, E | BS8110 | | |
| Creep modulus factor, $C_{MF}$ | Storage Loading, CMF=1/[1+f=2.0] | | |
| Uncracked short-term, $E_{uncracked,28}$ | | 31.0 | GPa |
| Uncracked long-term (creep), $E_{uncracked,28,cp} = C_{MF} \cdot E_{uncracked,28}$ | | 10.3 | GPa |
| Cracked short-term, $E_{ck} = E_{uncracked,28} \cdot [0.5\text{-}1.0]$ | 0% Cracking | 31.0 | GPa |
| Cracked long-term (creep), $E_{ck,cp} = E_{uncracked,28,cp} \cdot [0.5\text{-}1.0]$ | | 10.3 | GPa |

**Structural Design [Stage 1: Precast Simply-Supported]**

| | | | | |
|---|---|---|---|---|
| Beam (precast) width, $b_{w1} = b_w$ | | 500 | mm | |
| Beam (precast) depth, $h_1$ | | 700 | mm | |
| Beam (precast) area, $A_1 = b_{w1}.h_1+2.nib_b.nib_h$ | | 3500 | $cm^2$ | |
| Beam (precast) centroid, $x_{c1} = (b_{w1}.h_1^2/2+2.nib_b.nib_h^2/2)/A_1$ | | 350 | mm | |
| Beam (precast) inertia, $I_1$ | | 1429 | $x10^3\ cm^4$ | |
| *Note* $I_1 = (b_{w1}.h_1^3+2.nib_b.nib_h^3)/12+b_{w1}.h_1.(x_{c1}-h_1/2)^2+2.nib_b.nib_h.(x_{c1}-nib_h/2)^2$ | | | | |
| Beam (precast) bottom section modulus, $Z_{b1} = I_1/x_{c1}$ | | 4083 | $x10^4\ mm^3$ | |
| Dead load of precast beam incl. nibs (line load), $DL_{precastbeam}$ | | 8.8 | kN/m | |
| *Note DL of precast beam incl. nibs (line load),* $DL_{precastbeam} = b_{w1}.h_1.\rho_c+DL_{nib}$ | | | | |
| SLS beam loading (line load), $\omega_{SLS1}$ | | 37.5 | kN/m | |
| *Note* $\omega_{SLS1} = SLS_{slab1}.t_{w1}+DL_{beam}+DL_{nib}$ | | | | |
| Beam (precast) transfer deflections, $\delta_{TLS}$ | | 2.6 | mm | |
| *Note* $\delta_{TLS} = 5.DL_{precastbeam}.L_1^4/[384E_{ck}.I_1]$ *(if unpropped only) +* $M_{PT,st}.L_1^2/[8E_{ck}.I_1]$ | | | | |
| Beam (precast) construction deflections, $\delta_1$ | Unpropped | 11.0 | mm | |
| *Note* $\delta_1 = 5\,\omega_{SLS1}.L_1^4/[384E_{ck}.I_1]$ *(if unpropped only) +* $M_{PT,st}.L_1^2/[8E_{ck}.I_1]$ | | | | |
| Beam (precast) transfer and construction deflections criteria, $L_1/250$ | | 40.0 | mm | |
| Beam (precast) transfer deflections utilisation, $\lvert\delta_{TLS}\rvert/[L_1/250]$ | | 6% | | OK |
| Beam (precast) construction deflections utilisation, $\lvert\delta_1\rvert/[L_1/250]$ | | 28% | | OK |

| | | | |
|---|---|---|---|
| CONSULTING ENGINEERS | Engineering Calculation Sheet<br>Consulting Engineers | Job No. jXXX | Sheet No. 8 | Rev. |
| | | Member/Location | | |
| Job Title | Structure, Member Design - Precast Concrete Frame, Be | Drg. Ref. | | |
| Structure, Member Design - PC Frame, Beam and Slab | | Made by XX | Date 4/7/2026 | Chd. |

| | | | |
|---|---|---|---|
| | | | BS8110 |
| **Deflection Design Based on First Principles** | | | |
| **Structural Design [Stage 2: Insitu]** | | | |
| Beam (composite) width, $b_{w2} = b_w$ | 500 | mm | |
| Beam (composite) depth, $h_2$ | 1000 | mm | |
| Beam (composite) flange eff. width, $b_{eff2} = b_{w2}+L_2/\{5.00\text{ s/s}, 7.14\text{ cont.}\} \le t_w$ | 1901 | mm | |
| Beam (composite) flange thickness, $h_f = \text{insitu}_{slab}$ | 100 | mm | |
| Beam (composite) area, $A_{eff2} = b_{w2}.h_2+(b_{eff2}-b_{w2}).h_f+2.nib_b.nib_h$ | 6401 | $cm^2$ | |
| Beam (composite) centroid, $x_{c2} = h_2-((b_{eff2}.h_f).(h_2-h_f/2)+b_{w2}.(h_2-h_f)^2/2+2.nib_b$ | 402 | mm | |
| Beam (composite) inertia, $I_2$ | 6394 | $x10^3\ cm^4$ | |
| *Note* $I_2 = (b_{eff2}.h_f^3+b_{w2}.(h_2-h_f)^3+2.nib_b.nib_h^3)/12+b_{eff2}.h_f.(x_{c2}-h_f/2)^2+b_{w2}.(h_2-h_f).((h_2-x_{c2})-(h_2-h_f$ | | | |
| Beam (composite) effect of composite and flanged section, $[I_2/I_1]$ | 4.47 | | |
| Beam (composite) bottom section modulus, $Z_{b2} = I_2/(h_2-x_{c2})$ | 10684 | $x10^4\ mm^3$ | |
| SLS beam loading (line load), $\omega_{SLS2}$ — Unpropped | 125.0 | kN/m | |
| *Note* $\omega_{SLS2} = \omega_{SLS1}$ *(if propped only)* + $(SDL_{slab}+LL_{slab}).t_{w2}+SDL_{beam}$ | | | |
| SLS beam loading (midspan point load), $P_{SLS2} = SDL_{point}$ | 0.0 | kN | |
| Beam (composite) incr. deflections, $\delta_2$ — Continuous Internal Span | 5.9 | mm | |
| *Note* $\delta_2 = \omega_{SLS1}.L_1^4/[384E_{ck,cp}.I_2]$ *(if unpropped only)* $- \omega_{SLS1}.L_1^4/[384E$ | *1.0* | mm | |
| $+ \omega_{SLS2}.L_1^4/[384E_{ck,cp}.I_2] + P_{SLS2}.L_2^3/[192E_{ck,cp}.I_2]$ *continuou* | *4.9* | mm | |
| *Note* $\delta_2 = \omega_{SLS1}.L_1^4/[185E_{ck,cp}.I_2]$ *(if unpropped only)* $- \omega_{SLS1}.L_1^4/[185E$ | *N/A* | mm | |
| $+ \omega_{SLS2}.L_1^4/[185E_{ck,cp}.I_2] + P_{SLS2}.L_2^3/[107E_{ck,cp}.I_2]$ *continuou* | *N/A* | mm | |
| *Note* $\delta_2 = 5\omega_{SLS1}.L_1^4/[384E_{ck,cp}.I_2]$ *(if unpropped only)* $- 5\omega_{SLS1}.L_1^4/[38$ | *N/A* | mm | |
| $+ 5\omega_{SLS2}.L_1^4/[384E_{ck,cp}.I_2] + P_{SLS2}.L_2^3/[48E_{ck,cp}.I_2]$ *simply-su* | *N/A* | mm | |
| Beam (composite) incr. deflections criteria, $MIN\{20mm, L_2/500\}$ | 20.0 | mm | |
| Beam (composite) incr. deflections utilisation, $\lvert\delta_2\rvert/MIN\{20mm, L_2/500\}$ | 30% | | OK |
| Beam (composite) total deflections utilisation, $\delta_1+\delta_2$ | 16.9 | mm | |
| Beam (composite) total deflections criteria, $L_2/250$ | 40.0 | mm | |
| Beam (composite) total deflections utilisation, $\lvert(\delta_1+\delta_2)\rvert/[L_2/250]$ | 42% | | OK |