

Worked Examples to Eurocode 2

25 February 2010
Amended 18 January 2012

Revisions required to **Worked Examples to Eurocode 2**
due to Amendment 1 to NA to BS EN 1992-1-1:2004 dated Dec 2009.

Amended 18/1/2012 to illustrate 40K limit on l/d according to Table NA.5 Note 6

Page	Where	Old text	Revised text
37/38	3.1.6	<p>Allowable $l/d = N \times K \times F1 \times F2 \times F3$ where $N = 25.6$ ($\rho = 0.41\%$, $f_{ck} = 30$) $K = 1.0$ (simply supported) $F1 = 1.0$ ($b_{eff}/b_w = 1.0$) $F2 = 1.0$ (span < 7.0 m) $F3 = 310/\sigma_s \leq 1.5$ where $\sigma_s = \sigma_{sn} (A_{s,req}/A_{s,prov}) 1/\delta$ where $\sigma_{sn} \approx 242$ MPa (From Concise Figure 15.3 and $g_k/q_k = 1.79$, $\psi_2 = 0.3$, $\gamma_g = 1.25$) $\delta =$ redistribution ratio = 1.0 $\therefore \sigma_s \approx 242 \times 594/645 = 222$ $\therefore F3 = 310/222 = 1.40$ \therefore Allowable $l/d = 25.6 \times 1.40 = 35.8$ Actual $l/d = 4800/144 = 33.3$ \therefore <u>OK</u> Use H12 @ 175 B1 (645 mm²/m)</p>	<p>Allowable $l/d = N \times K \times F1 \times F2 \times F3$ where $N = 25.6$ ($\rho = 0.41\%$, $f_{ck} = 30$) $K = 1.0$ (simply supported) $F1 = 1.0$ ($b_{eff}/b_w = 1.0$) $F2 = 1.0$ (span < 7.0 m) $F3 = A_{s,prov}/A_{s,req} \leq 1.50$ $= 645/594 = 1.09$ \therefore Allowable $l/d = 25.6 \times 1.09 = 27.9$ Actual $l/d = 4800/144 = 33.3$ \therefore <u>no good</u> Try $33.3/27.9 \times 654 = 784$ mm²/m i.e. H12@140 (807 mm²/m) $F3 = 807/594 = 1.36$ \therefore Allowable $l/d = 25.6 \times 1.36 = 34.8$ (which is < 40K = 40) [Table NA.5 Note 6] i.e. > 33.3 \therefore <u>OK</u> Use H12 @ 140 B1 (807 mm²/m)</p>
38	3.1.7	<p>By inspection, OK However, if considered critical: $V = 29.5$ kN/m as before $V_{Ed} = 29.5 - 0.14 \times 12.3 = 27.8$ kN/m $V_{Ed} = 27.8 \times 10^3/144 \times 10^3 = 0.19$ MPa $V_{Rd,c} = 0.53$ MPa</p>	<p>By inspection, OK However, if considered critical: $V = 29.5$ kN/m as before $V_{Ed} = 29.5 - 0.14 \times 12.3 = 27.8$ kN/m $V_{Ed} = 27.8 \times 10^3/144 \times 10^3 = 0.19$ MPa $\rho = 804/1000 \times 144 = 0.56\%$ say 50% curtailed use 0.28% $V_{Rd,c} = 0.54$ MPa</p>

42	3.2.6	$F3 = 310/\sigma_s \leq 1.5$ <p>where</p> $\sigma_s = (f_{yk}/\gamma_s) (A_{s,req}/A_{s,prov}) \text{ (GLS loads/ULS loads) } (1/\delta)$ $= f_{yd} \times (A_{s,req}/A_{s,prov}) \times (g_k + \psi_2 q_k)/(\gamma_G g_k + \gamma_Q q_k) (1/\delta)$ $= (500/1.15) \times (639/645) \times [(5.9 + 0.3 \times 3.3)/12.3] \times 1.08^1$ $= 434.8 \times 0.99 \times 0.56 \times 1.08 = 260 \text{ MPa}$ $F3 = 310/260 = 1.19$ <p>Note: $A_{s,prov}/A_{s,req} \leq 1.50$</p> $\text{Allowable } l/d = N \times K \times F1 \times F2 \times F3$ $= 23.5 \times 1.3 \times 1.0 \times 1.19 = 36.4$ <p>Max. span = 36.4 × 144 = 5675 mm, i.e. < 5795 mm</p> <p>\therefore No good</p> <p>Try H12 @ 150 B1 (754 mm²/m)</p> $\sigma_s = 434.8 \times 639/754 \times 0.56 \times 1.08 = 223$ $F3 = 310/223 = 1.39$ $\text{Allowable } l/d = 23.5 \times 1.3 \times 1.0 \times 1.39 = 42.5$ <p>Max. span = 42.5 × 144 = 6120 mm, i.e. > 5795 mm <u>OK</u></p> <p>\therefore H12 @ 150 B1 (754 mm²/m) <u>OK</u></p>	$F3 = A_{s,prov}/A_{s,req} \leq 1.50$ $= 645/639 = 1.01$ $\text{Allowable } l/d = N \times K \times F1 \times F2 \times F3$ $= 23.5 \times 1.3 \times 1.0 \times 1.01 = 30.8$ <p>Max. span = 30.8 × 144 = 4435 mm, i.e. < 5795 mm</p> <p>\therefore No good</p> <p>Try H12 @ 125 B1 (904 mm²/m)</p> $F3 = 904/639 = 1.41$ $\text{Allowable } l/d = 23.5 \times 1.3 \times 1.0 \times 1.41 = 43.1$ <p>Max. span = 43.1 × 144 = 6206 mm, i.e. > 5795 mm <u>OK</u></p> <p>\therefore H12 @ 125 B1 (904 mm²/m) <u>OK</u></p>
43	3.2.7	$F3 = 310/\sigma_s \leq 1.5$ <p>where</p> $\sigma_s = f_{yd} \times (A_{s,req}/A_{s,prov}) \times (g_k + \psi_2 q_k)/(\gamma_G g_k + \gamma_Q q_k) (1/\delta)$ $= (500/1.15) \times (465/502) \times [(5.9 + 0.3 \times 3.3)/12.3] \times 1.03$ $= 434.8 \times 0.93 \times 0.56 \times 1.03 = 233 \text{ MPa}$ $F3 = 310/233 = 1.33$ $\text{Allowable } l/d = N \times K \times F1 \times F2 \times F3$ $= 35.8 \times 1.5 \times 1.0 \times 1.33 = 71.4$ <p>Max. span = 71.4 × 144 = 10280 mm i.e. > 5795 mm <u>OK</u></p>	$F3 = A_{s,prov}/A_{s,req} \leq 1.5$ $= 502/465 = 1.08$ $\text{Allowable } l/d = N \times K \times F1 \times F2 \times F3$ $= 35.8 \times 1.5 \times 1.0 \times 1.08 = 58.0$ <p>(which is < 40K = 40 × 1.5 = 60)</p> <p>[Table NA.5 Note 6]</p> <p>Max. span = 58.0 × 144 = 8352 mm i.e. > 5795 mm <u>OK</u></p>
44	3.2.9	In Figure 3.4 H12@150	In Figure 3.4 H12@125
46	3.2.10a)	Crack control As slab < 200 mm, measures to control cracking are unnecessary.	Crack control As slab < 200 mm, measures to control cracking are unnecessary.

¹ The use of Table 15.2 from Concise Eurocode 2 implies certain amounts of redistribution, which are defined in Concise Eurocode 2 Table 15.14.

		<p>However, as a check on end span: Loading is the main cause of cracking, \therefore use Table 7.2N or Table 7.3N for $w_{max} = 0.4$ mm and $\sigma = 241$ MPa (see deflection check). Max. bar size = 20 mm or max. spacing = 250 mm \therefore H12 @ 150 B1 OK.</p>	<p>However, as a check on end span: Loading is the main cause of cracking, \therefore use Table 7.2N or Table 7.3N for $w_{max} = 0.4$ mm and $\sigma = 241$ MPa (see deflection check). Max. bar size = 20 mm or max. spacing = 250 mm \therefore H12 @ 125 B1 OK</p>
		<p>End supports: effects of partial fixity Try H12 @ 450 (251 mm²/m) U-bars at supports</p>	<p>End supports: effects of partial fixity Try H12 @ 500 (226 mm²/m) U-bars at supports</p>
46	3.2.10b)	<p>End span, bottom reinforcement Try H12 @ 300 (376 mm²/m) at supports</p>	<p>End span, bottom reinforcement Try H12 @ 250 (452 mm²/m) at supports</p>
49	3.2.10b) iii	<p>Support B bottom steel at support For convenience use H12 @ 300 B1 (376 mm²/m)</p>	<p>Support B bottom steel at support For convenience use H12 @ 250 B1 (452 mm²/m)</p>
51	3.2.11	Figure 3.6	See A below
57/58	3.3.5b)	<p>Span A-B: Deflection $F3 = 310/\sigma_s \leq 1.5$ where $\sigma_s = (f_{yk}/\gamma_s) (A_{s,req}/A_{s,prov})$ (SLS loads/ULS loads) (1/δ) $= 434.8(523/628) [(4.30 + 0.3 \times 5.0)/13.38] (65.3/61.7^{\#})$ $= 434.8 \times 0.83 \times 0.43 \times 1.06$ $= 164$ MPa $F3 = 310/\sigma_s$ $= 310/164 = 1.89^{\#}$ but ≤ 1.50 therefore say 1.50 \therefore Permissible $l/d = 22.8 \times 1.3 \times 0.8 \times 0.93 \times 1.50 = 33.0$ Actual $l/d = 7500/257 = 29.2$ \therefore OK Use 2 no. H20/rib (628 mm²/rib)</p>	<p>Span A-B: Deflection $F3 = 310/\sigma_s \leq 1.5$ where $\sigma_s = (f_{yk}/\gamma_s) (A_{s,req}/A_{s,prov})$ (SLS loads/ULS loads) (1/δ) $= 434.8(523/628) [(4.30 + 5.0)/13.38] (65.3/61.7^{\#})$ $= 434.8 \times 0.83 \times 0.70 \times 1.06$ $= 267$ MPa $F3 = 310/\sigma_s$ $= 310/267 = 1.16$ \therefore Permissible $l/d = 22.8 \times 1.3 \times 0.8 \times 0.93 \times 1.16 = 25.6$ Actual $l/d = 7500/257 = 29.2$ \therefore no good Try 1H25 + 1H20/rib (805 mm²/rib) $d = 254$ mm; $K = 0.028$; $z = 241$ mm $A_{s,req} = 529$ mm² $\therefore \sigma_s = 434.8(529/805) [(4.30 + 5.0)/13.38] (65.3/61.7^{\#})$ $= 434.8 \times 0.66 \times 0.70 \times 1.06$ $= 213$ MPa $F3 = 310/213 = 1.45$ Permissible l/d $= 22.8 \times 1.3 \times 0.8 \times 0.93 \times 1.45$ $= 32.0$ Actual $l/d = 7500/254 = 29.5$ \therefore OK Use 1H25 + 1H20/rib (805 mm²/rib)</p>

61	3.3.6b)	<p>Span B–C – : Deflection</p> $F3 = 310/\sigma_s \leq 1.5$ <p>where</p> $\sigma_s = (f_{yk}/\gamma_s) (A_{s,req}/A_{s,prov}) \text{ (SLS loads/ULS loads) } (1/\delta)$ $= 434.8 \times (474/628) [(4.30 + 0.3 \times 5.0)/13.38] (61.1/55.9)$ $= 434.8 \times 0.75 \times 0.43 \times 1.09$ $= 153 \text{ MPa}$ $F3 = 310/\sigma_s$ $= 310/153 = 2.03, \text{ say } = 1.50^2$ $\therefore \text{ Permissible } l/d = 26.8 \times 1.5 \times 0.8 \times 0.77 \times 1.50 = 37.1$ $\text{Actual } l/d = 9000/257 = 35 \quad \therefore \text{ OK}$ <p style="text-align: center;"><i>∴ Use 2 H20/rib (628 mm²/rib)</i></p>	<p>Span B–C – : Deflection</p> $F3 = 310/\sigma_s \leq 1.5$ <p>where</p> $\sigma_s = (f_{yk}/\gamma_s) (A_{s,req}/A_{s,prov}) \text{ (SLS loads/ULS loads) } (1/\delta)$ $= 434.8 \times (474/628) [(4.30 + 5.0)/13.38] (61.1/55.9)$ $= 434.8 \times 0.75 \times 0.70 \times 1.09$ $= 249 \text{ MPa}$ $F3 = 310/\sigma_s$ $= 310/249 = 1.24$ $\therefore \text{ Permissible } l/d = 26.8 \times 1.5 \times 0.8 \times 0.77 \times 1.24 = 30.7$ $\text{Actual } l/d = 9000/257 = 35 \quad \therefore \text{ no good}$ <p style="text-align: center;"><i>Try 1H25 + 1H20/rib (805 mm²/rib)</i></p> <p style="text-align: center;"><i>d = 254 mm; K = 0.025;</i></p> <p style="text-align: center;"><i>z = 241 mm A_{s,req} = 480 mm²</i></p> $\therefore \sigma_s = 434.8(480/805) [(4.30 + 5.0)/13.38] (61.1/55.9)$ $= 434.8 \times 0.60 \times 0.70 \times 1.09$ $= 199 \text{ MPa}$ $F3 = 310/199 = 1.56 \text{ but } \leq 1.50$ <p><i>Permissible l/d</i></p> $= 26.8 \times 1.5 \times 0.8 \times 0.77 \times 1.50$ $= 37.1$ $\text{Actual } l/d = 9000/254 = 35.4 \quad \therefore \text{ OK}$ <p style="text-align: center;"><i>Use 1H25 + 1H20/rib (805 mm²/rib)</i></p>
65	3.3.10	Figure 3.15	See B below
69	3.3.10b) viii	<p>Support B (and C): bottom steel curtailment BA and BC To suit prefabrication 2 no. H20/rib will be curtailed at solid/rib interface, 1000 mm from B_A (B towards A) and B_C.</p>	<p>Support B (and C): bottom steel curtailment BA and BC To suit prefabrication 1 H20 + 1H25 /rib will be curtailed at solid/rib interface, 1000 mm from B_A (B towards A) and B_C.</p>
69	3.3.10c)	<p>Laps</p> <p>At A_B, check lap 1 no. H20 B to 2 no. H20 B in rib full tension lap:</p> $l_o = \alpha_1 \alpha_6 l_{b,req,d} > l_{o,min}$ <p>where</p> $\alpha_1 = 1.0 \text{ (} c_d = 45 \text{ mm, i.e. } < 3\varphi \text{)}$ $\alpha_6 = 1.5 \text{ (as } > 50\% \text{ being lapped)}$ $l_{b,req,d} = (\varphi/4) (\sigma_{sd}/f_{bd})$ <p>where</p> $\varphi = 20$ $\sigma_{sd} = 434.8$ $f_{bd} = 3.0 \text{ MPa as before}$	<p>Laps</p> <p>At A_B, check lap 1 no. H20 B to 1 H20 B + 1H25 B in rib full tension lap:</p> $l_o = \alpha_1 \alpha_6 l_{b,req,d} > l_{o,min}$ <p>where</p> $\alpha_1 = 1.0 \text{ (} c_d = 45 \text{ mm, i.e. } < 3\varphi \text{)}$ $\alpha_6 = 1.5 \text{ (as } > 50\% \text{ being lapped)}$ $l_{b,req,d} = (\varphi/4) (\sigma_{sd}/f_{bd})$ <p>where</p> $\varphi = 20$ $\sigma_{sd} = 434.8 \text{ (bar assumed to be fully stressed)}$ $f_{bd} = 3.0 \text{ MPa as before}$
65	3.3.10d)	Figure 3.17	See C below
74	3.4.5b)	$F3 = 310/\sigma_s \leq 1.5$ <p>where</p>	$F3 = 310/\sigma_s \leq 1.5$ <p>where</p>

² Both $A_{s,prov}/A_{s,req}$ and any adjustment to N obtained from Expression (7.16a) or Expression (7.16b) is restricted to 1.5 by Note 5 to Table NA.5 in the UK NA.

		$\sigma_s = \sigma_{sn} (A_{s,req} / A_{s,prov}) / \delta$ <p>where</p> $\sigma_{sn} = (500/1.15) \times (8.5 + 0.3 \times 4.0) / 16.6 = 254 \text{ MPa}$ <p>(or $\approx 253 \text{ MPa}$ (From Concise Figure 15.3 for $G_k/Q_k = 2.1$, $\psi_2 = 0.3$ and $\gamma_g = 1.25$)</p> $\delta = \text{redistribution ratio} = 1.03$ $\therefore \sigma_s \approx 253 \times (1324/1570)/1.03 = 207$ $\therefore F3 = 310/207 = 1.50$ $\therefore \text{Allowable } l/d = 20.3 \times 1.2 \times 1.50 = 36.5$ <p>Actual $l/d = 9500/260 = 36.5 \therefore \text{OK}$ <u>Use H20 @ 200 B1 (1570)</u></p>	$\sigma_s = \sigma_{sn} (A_{s,req} / A_{s,prov}) / \delta$ <p>where</p> $\sigma_{sn} = (500/1.15) \times (8.5 + 4.0) / 16.6 = 327 \text{ MPa}$ $\delta = \text{redistribution ratio} = 1.03$ $\therefore \sigma_s \approx 327 \times (1324/1570)/1.03 = 267$ $\therefore F3 = 310/267 = 1.16$ $\therefore \text{Allowable } l/d = 20.3 \times 1.2 \times 1.16 = 28.2$ <p>Actual $l/d = 9500/260 = 36.5 \therefore \text{no good}$ <u>Try H16 @ 100 (2010 mm²/m) and</u> $F3 = A_{s,prov} / A_{s,req} \leq 1.50$ $= 2010 / 1340 = 1.50 \leq 1.50$ $\therefore \text{Allowable } l/d = 20.3 \times 1.2 \times 1.50 = 36.5$ <p>Actual $l/d = 36.5 \therefore \text{OK}$ <u>Use H16 @ 100 B1 (2093 mm²/m)</u></p> </p>
78	3.4.7b)	<p>Allowable $l/d = N \times K \times F1 \times F2 \times F3$ where</p> $N = 26.2 \quad (\rho = 0.40\%, f_{ck} = 30)$ $K = 1.2 \quad (\text{flat slab})$ $F1 = 1.0 \quad (b_{eff}/b_w = 1.0)$ $F2 = 1.0 \quad (\text{no brittle partitions})$ $F3 = 310/\sigma_s$ <p>where</p> $\sigma_s = \sigma_{sn} (A_{s,req} / A_{s,prov}) / \delta$ <p>where</p> $\sigma_{sn} \approx 283 \text{ MPa (from Concise Figure 15.3 and } G_k/Q_k = 3.6, \psi_2 = 0.3, \gamma_g = 1.25)$ $\delta = \text{redistribution ratio} = 1.08$ $\therefore \sigma_s \approx 283 \times (959/1005)/1.08 = 250$ $\therefore F3 = 310/250 = 1.24$ $\therefore \text{Allowable } l/d = 26.2 \times 1.2 \times 1.24 = 39.0$ <p>Actual $l/d = 5900/240 = 24.5 \therefore \text{OK}$ <u>Use H16 @ 200 B2 (1005 mm²/m)</u></p>	<p>Allowable $l/d = N \times K \times F1 \times F2 \times F3$ where</p> $N = 26.2 \quad (\rho = 0.40\%, f_{ck} = 30)$ $K = 1.2 \quad (\text{flat slab})$ $F1 = 1.0 \quad (b_{eff}/b_w = 1.0)$ $F2 = 1.0 \quad (\text{no brittle partitions})$ $F3 = A_{s,prov} / A_{s,req} \leq 1.50$ $= 1005 / 959 = 1.05 \leq 1.50$ $\therefore \text{Allowable } l/d = 26.2 \times 1.2 \times 1.05 = 33.0$ <p>Actual $l/d = 5900/240 = 24.5 \therefore \text{OK}$ <u>Use H16 @ 200 B2 (1005 mm²/m)</u></p>
90	3.4.13	Spans 1–2 and 2–3: Column strip and middle strip: H20 @ 200 B	Spans 1–2 and 2–3: Column strip and middle strip: H16 @ 100 B1
92	3.4.13	Figure 3.26	See D below
112	4.2.6	$F3 = 310/\sigma_s \leq 1.5$ <p>where</p> $\sigma_s \text{ in simple situations} = (f_{yk} / \gamma_s) (A_{s,req} / A_{s,prov}) \text{ (SLS loads/ULS loads) } (1/\delta).$ <p>However in this case separate analysis at SLS would be required to determine σ_s. Therefore as a simplification use the conservative assumption:</p> $310/\sigma_s = (500/f_{yk}) (A_{s,req} / A_{s,prov})$ $= (500/500) \times (4824/4158) = 1.16$	$F3 = A_{s,prov} / A_{s,req} \leq 1.50$ $= 4824/4158 = 1.16$

123	4.3.5b)	$F3 = 310/\sigma_s \leq 1.5$ where $\sigma_s = (f_{yk}/\gamma_s)(A_{s,req}/A_{s,prov})(SLS\ loads/ULS\ loads)(1/\delta)$ $= 434.8 \times (5835/5892) [(47.8 + 0.3 \times 45.8)/(1.25 \times 47.8 + 1.5 \times 45.8)] \times (1/0.945)$ $= 434.8 \times 0.99 \times 0.48 \times 1.06$ $= 219\text{ MPa}$	$F3 = A_{s,prov}/A_{s,req} \leq 1.50$ $= 5892/5835 = 1.01$
124	4.3.5b)	$F3 = 310/\sigma_s \leq 1.5$ $= 310/219 = 1.41$ \therefore Permissible $l/d = 17.8 \times 13 \times 0.90 \times 0.95 \times 1.41 = 27.9$ Actual $l/d = 7500/252 = 29.8 \therefore$ no good Try 13 no. H25 B (6383 mm ²) $F3 = 310/\sigma_s$ $= 310/219 \times 13/12 = 1.53^3 = \text{say } 1.50$ \therefore Permissible $l/d = 17.8 \times 13 \times 0.90 \times 0.95 \times 1.50 = 29.7$ Actual $l_{eff}/d = 7400/252 = 29.8$ Say OK Use 13 no. H25 B (6383 mm ²)	\therefore Permissible $l/d = 17.8 \times 13 \times 0.90 \times 0.95 \times 1.01 = 20.0$ Actual $l/d = 7500/252 = 29.8 \therefore$ no good Try 12 no. H32 B (9648 mm ²) $F3 = A_{s,prov}/A_{s,req} \leq 1.50$ $= 9648/5835 = 1.65^4 = \text{say } 1.50$ \therefore Permissible $l/d = 17.8 \times 13 \times 0.90 \times 0.95 \times 1.50 = 29.7$ Actual $l_{eff}/d = 7400/252 = 29.8$ Say OK Use 13 no. H25 B (6383 mm ²)
124	4.3.6	Figure 4.20	See E below
127	4.3.7d)	$F3 = 310/\sigma_s \leq 1.5$ where $\sigma_s = (f_{yk}/\gamma_s)(A_{s,req}/A_{s,prov})(SLS\ loads/ULS\ loads)(1/\delta)$ $= 434.8 \times (3783/3828) [(47.8 + 0.3 \times 45.8)/(1.25 \times 47.8 + 1.5 \times 45.8)] \times (1/0.908)$ $= 434.8 \times 0.99 \times 0.48 \times 1.10$ $= 227\text{ MPa}$ $F3 = 310/\sigma_s$ $= 310/227 = 1.37$ \therefore Permissible $l/d = 44.7 \times 1.37 \times 0.88 \times 0.95 \times 1.37 = 70.1$ Actual $l/d = 7500/252 = 29.8 \therefore$ OK Use 8 no. H25 B (3928 mm ²)	$F3 = A_{s,prov}/A_{s,req} \leq 1.50$ $= 3828/3783 = 1.01$ \therefore Permissible l/d $= 44.7 \times 1.50 \times 0.88 \times 0.95 \times 1.01 = 56.6$ (which is $< 40K = 40 \times 1.5 = 60$) [Table NA.5 Note 6] Actual $l/d = 7500/252 = 29.8 \therefore$ OK Use 8 no. H25 B (3928 mm ²)
133	4.3.10	Figures 4.22 and 4.23	See F below
146	5.3	Figure 5.6 300 mm flat slabs All columns 400 mm s_{\perp}	300 mm flat slabs All columns 500 mm s_{\perp}
153	5.3.8	Changes re s_{\perp} d	
183	Refer-ences	1a National Annex to Eurocode 2- Part 1-1. BSI 2005	1a National Annex to Eurocode 2- Part 1-1. Incorporating Amendment No.1 BSI 2009
183	Refer-ences	5 R S NARAYANAN & C H GOODCHILD. The Concrete Centre. Concise Eurocode 2, CCIP-005. TCC 2006	5 R S NARAYANAN & C H GOODCHILD. The Concrete Centre. Concise Eurocode 2, CCIP-005. TCC 2006 As Amended

³ Both $A_{s,prov}/A_{s,req}$ and any adjustment to N obtained from Expression (7.16a) or Expression (7.16b) is restricted to 1.5 by Note 5 to Table NA.5 in the UK NA.

⁴ Both $A_{s,prov}/A_{s,req}$ and any adjustment to N obtained from Expression (7.16a) or Expression (7.16b) is restricted to 1.5 by Note 5 to Table NA.5 in the UK NA.

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190	B1.1	Delete existing text. See G below	<p>New text:</p> <p>According to Note 5 of Table NA.5 the NA to BS EN 1992-1-1^[1a] the modification factor for service stress used with the l/d method of checking the SLS state of deformation (designated factor F3 in TCC publications) may be determined as either</p> <ul style="list-style-type: none"> • $310/\sigma_s$ using characteristic load combinations to determine the service stress, σ_s <p>or</p> <ul style="list-style-type: none"> • $(500/f_{yk})(A_{s,prov} / A_{s,req})$ <p>In either case the modification factor is restricted to a maximum of 1.50. In the UK</p> <p>$f_{yk} = 500$ MPa.</p> <p>Assuming σ_s is proportional to σ_u, and using characteristic load combinations to determine σ_s produces values of $310/\sigma_s = 1.00 +3\% - 6\%$. and so is not as attractive to using $A_{s,prov} / A_{s,req}$.</p> <p>The use of $F3 = A_{s,prov} / A_{s,req} \leq 1.5$ is therefore advocated in checking deformation using the l/d method.</p>
190	B1.2	See H below	
191	B1.4	See J below	
191	B1.5	See K below	
201	C7	See L below	
204	C8	See M below	

A Amends to p 51 Figure 3.7

3.2.11 Summary of reinforcement details

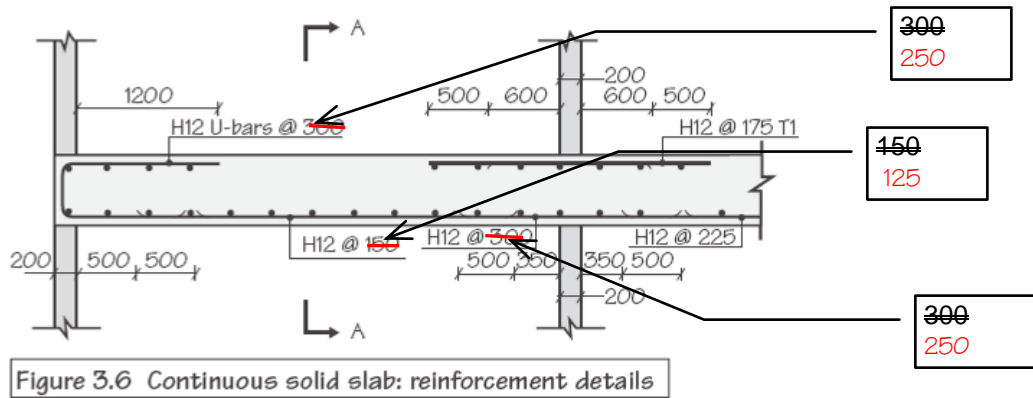


Figure 3.6 Continuous solid slab: reinforcement details

B Amends to p 65 Figure 3.15

3.3.10 Summary of design

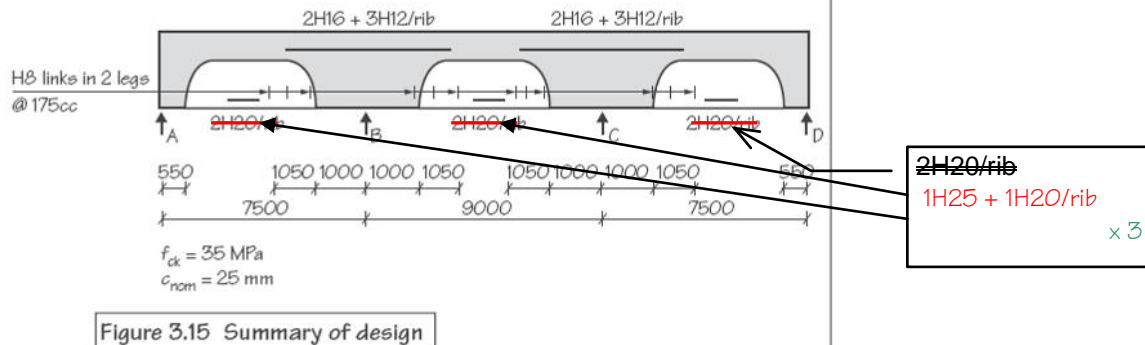
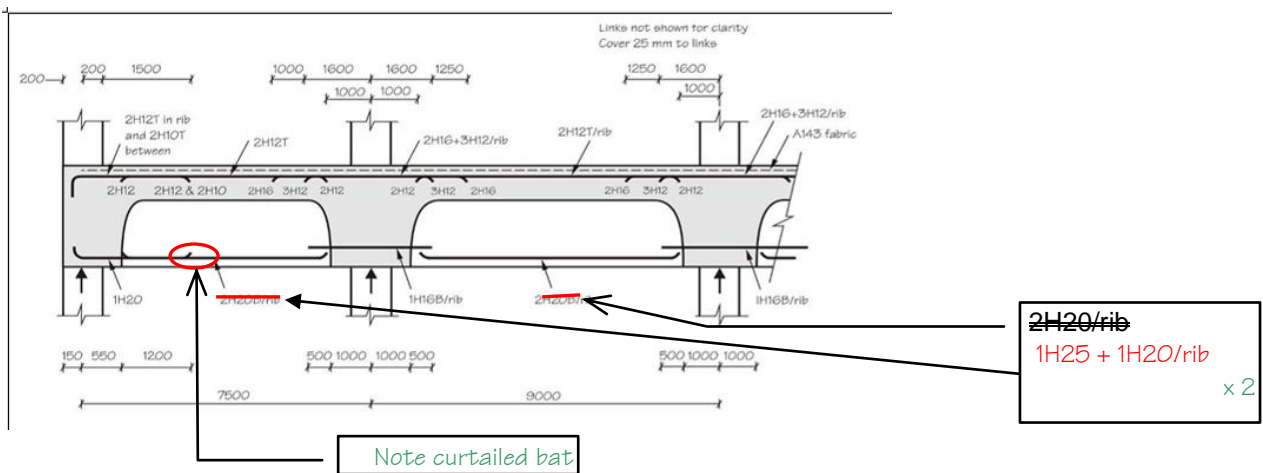


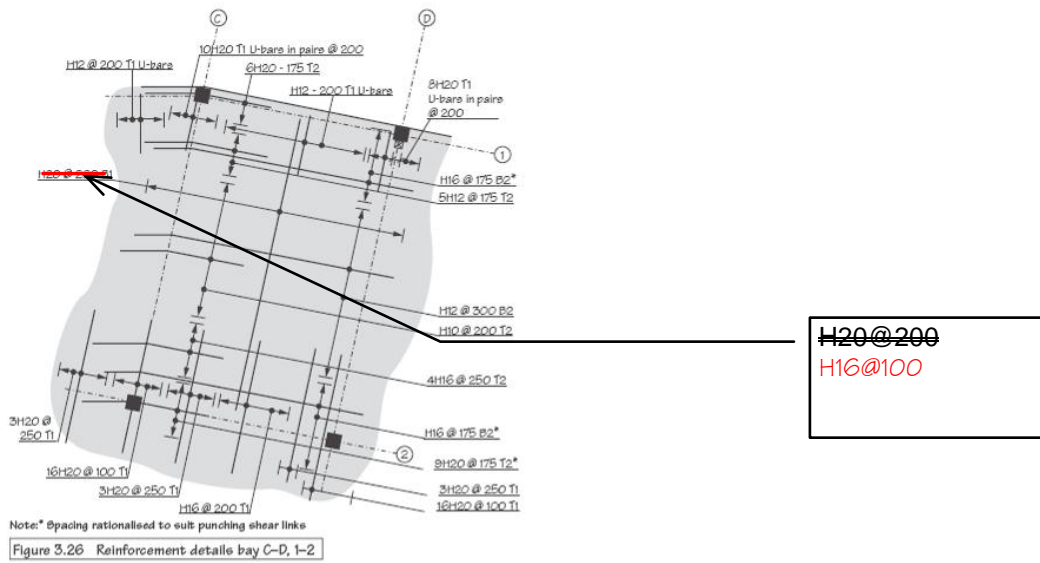
Figure 3.15 Summary of design

C Amends to p 70 Figure 3.17

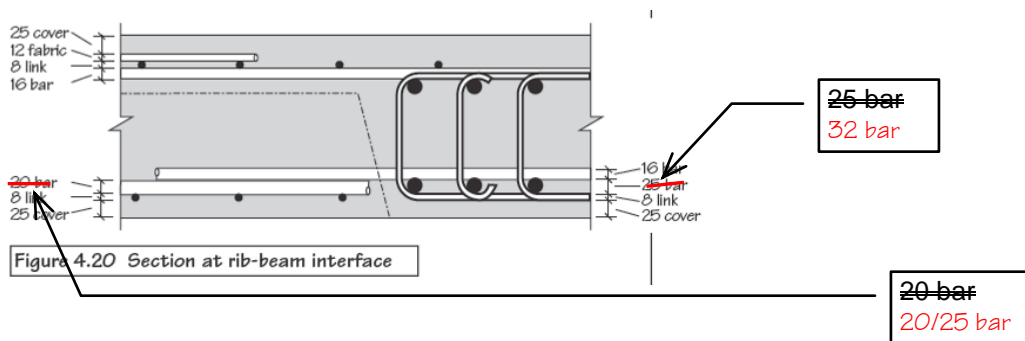


Note curtailed bar

D Amends to p 92 Figure 3.26

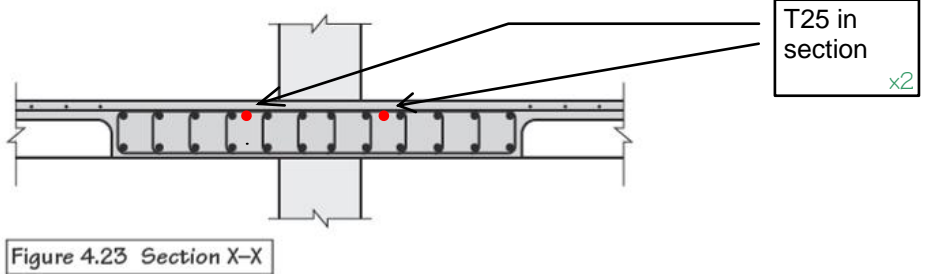
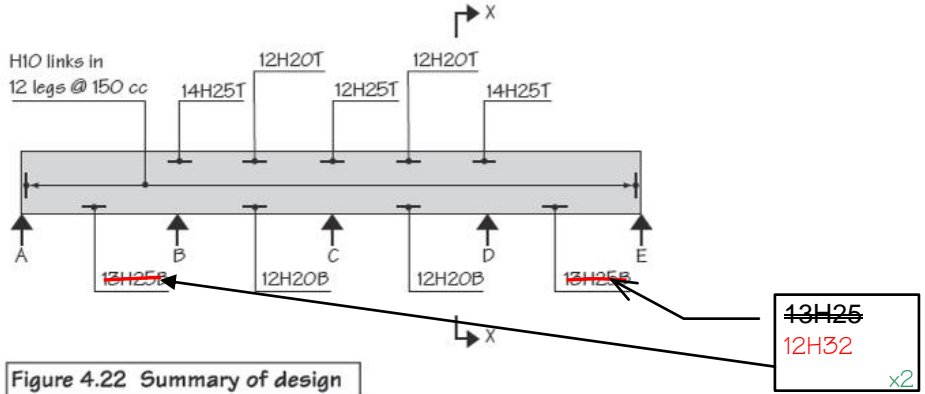


E Amends to p 124 Figure 4.20



F Amends to p133 Figures 4.22 and 4.23

4.3.11 Summary of design



G Amends to p190 B1.1

B1.1 TCC method^[5,19]

The in-service stress of reinforcement, σ_s , is used to determine a factor, $310/\sigma_s$, which is used to modify the basic span:effective depth ratio as allowed in Cl. 7.4.2(2) of Eurocode 2^[1] and moderated by the National Annex^[2a]. This method, highlighted as factor F3 in *Concrete Eurocode 2*^[5], is intended to be used in hand calculations to derive (conservative) values of σ_s from available ULS moments. In accordance with Note 5 of Table NA.5 of the UK NA^[2a], the ratio for $A_{s,prov}/A_{s,req}$ is restricted to 1.5. In effect this limits the factor $310/\sigma_s$ to 1.5.

where²

$$\sigma_s = (f_{yk}/\gamma_s) (w_{qp}/w_{ult}) (A_{s,req}/A_{s,prov}) / \delta \leq 310/1.5$$

where

- f_{yk} = characteristic strength of reinforcement = 500 MPa
- γ_s = partial factor for reinforcement = 1.15
- w_{qp} = quasi-permanent load (UDL assumed)
- w_{perm} = ultimate load (UDL assumed)
- $A_{s,req}$ = area of reinforcement required
- $A_{s,prov}$ = area of reinforcement provided
- δ = redistribution ratio

NewText

According to Note 5 of Table NA.5 the NA to BS EN 1992-1-1^[1a] the modification factor for service stress used with the l/d method of checking the SLS state of deformation (designated factor F3 in TCC publications) may be determined as either

- $310/\sigma_s$ using characteristic load combinations to determine the service stress, σ_s

or

- $(500/f_{yk})(A_{s,prov}/A_{s,req})$

In either case the modification factor is restricted to a maximum of 1.50. In the UK

$f_{yk} = 500$ MPa.

Assuming σ_s is simply proportional to the ultimate stress, σ_u , produces values of $310/\sigma_s = 1.00 \pm 5\%$ and so for hand calculations is not as attractive as using $A_{s,prov}/A_{s,req}$.

The use of $F3 = A_{s,prov}/A_{s,req} \leq 1.5$ is therefore advocated in checking deformation using the l/d method by hand.

H Amends to p190 B1.2

B1.2 RC Spreadsheets method^[28]

The RC spreadsheets TCCxx.xls^[28] use the span:depth method of checking deformation but use an accurate method for determining σ_s (see B3.2 below), which ~~again~~ is used to determine the moderating factor = $310/\sigma_s$. ~~Again, in accordance with Note 5 of Table NA.5 of the UK NA^[2a], the ratio for $A_{s,prov}/A_{s,req}$ is restricted to 1.5, in effect this limits the factor $310/\sigma_s$ to 1.5.~~

Separate analyses using ~~quasi permanent loads~~ need to be carried out. For each span, an SLS neutral axis depth is determined, then σ_c and σ_s are derived for the ~~quasi permanent load conditions~~. The factor ~~σ_s~~ is used in accordance with Eurocode 2^[2] and the current National Annex^[2a] to modify the basic span:effective depth ratio.

Whilst this method gives a ~~more accurate and less conservative~~ assessment of σ_s , it is only suitable for computer spreadsheet applications. ~~See also Appendix B5.~~

In the analysis of slabs and beams, supports are usually assumed to be pinned. In reality supports have some continuity, especially at end supports. Usually, nominal top steel is assumed and provided in the top of spans and is used in the determination of section properties.

combination values of actions

combination values of actions taking account of SLS moments, compression reinforcement, $A_{s,prov}/A_{s,req}$ etc.

[1]

$310/\sigma_s$

[1a]

NewText
an accurate

J Amends to p191 B1.4

B1.4 Differing results

During 2008, it became increasingly apparent that there ~~are~~ inconsistencies between the results given by the rigorous calculation method and span:depth methods described in Eurocode 2. Using the rigorous method gives deflections that are greater than would be expected from the assumptions stated for L/d methods i.e. deflection limits of $L/250$ overall (see CL 7.4.1(4)) or $L/500$ after construction (see CL 7.4.1(5)). It is suspected that this disparity is the same as that experienced between span:depth and calculation methods in BS 8110: a disparity that was recognised as long ago as 1971^[33]. The rigorous method described above relies on many assumptions and is largely uncalibrated against real structures. As noted in TR58, there is an urgent need for data from actual structures so that methods may be calibrated. It should be noted that the rigorous analysis method observations were made using frequent loads where, in accordance with Eurocode 2, quasi-permanent loads are called for.

~~End spans are usually critical. With respect to the rigorous analysis method, it has been suggested that for end-spans, the TCC and RC-spreadsheet methods result in deflections close to the limits stated in Eurocode 2, provided that a nominal end-support restraining moment is present where none is assumed in analysis. Caution is therefore necessary in true pinned end-support situations but where some continuity exists, this disparity may be addressed by ensuring that appropriate amounts of reinforcement, in accordance with the Code and National Annex, are provided at end supports.~~

~~The NDP for CL 9.2.1.2(1) in the UK NA^[2a] to BS EN 1992-1-2 stipulates that 25% of end span moment should be used to determine end support reinforcement. This is usually accommodated by providing 25% of end span bottom steel as top steel at end supports. It is on this basis that the calculations in this publication are considered as being further substantiated.~~

were

Add new text
using the quasi permanent values of actions (see B.4)

New para

In the light of the above disparity and pending clarification, the UK NA was revised and published in December 2009 as detailed in B1.1 above.

K Amends to p191 B1.4

B1.5 Note regarding factor $310/\sigma_s$ (factor F3)

At the time of publication (December 2009) the authors were aware of a probable change to UK NA[2a] Table NA.5 which, in effect, would mean that the factor $310/\sigma_s$ ($F3$) = $A_{s,prov}/A_{s,req} \leq 1.5$, thus disallowing the accurate method outlined in Sections 3.1, 3.2, 3.3, 3.4, 4.3 and Appendices B1.1, B1.2 and C7.

New paras

Prior to the publication of the revised UK NA[1a] it was allowable to calculate the moderation factor using in l/d verifications of deformation ($F3$) by using quasi permanent loads.

Assuming σ_s due to quasi permanent actions is proportional to σ_u , the method as outlined in C8 may be used to determine σ_s in verifications of crack widths, etc.

L Amends to p201 C7

$F3$ = factor to account for service stress in tensile reinforcement = ~~$310/\sigma_s \leq 1.5$~~

Conservatively, if a service stress, σ_s , of 310 MPa is assumed for the designed area of reinforcement, $A_{s,req}$, then $F3 = A_{s,prov}/A_{s,req} \leq 1.5$.

More accurately,[‡] the serviceability stress, σ_s , may be estimated as follows:

$$\sigma_s = f_{yk}/\gamma_s [(C_k + \psi_2 Q_k)/(1.25C_k + 1.5Q_k)] [A_{s,req}/A_{s,prov}] (1/d)$$

or

$$\sigma_s = \sigma_{su} [A_{s,req}/A_{s,prov}] (1/d)$$

where

σ_{su} = the unmodified SLS steel stress, taking account of γ_M for reinforcement and of going from ultimate actions to serviceability actions

$$= 500/\gamma_s (C_k + \psi_2 Q_k)/(1.25C_k + 1.5Q_k)$$

σ_{su} may be estimated from Figure C3 as indicated by the blue arrow

$A_{s,req}/A_{s,prov}$ = area of steel required divided by area of steel provided.

$(1/d)$ = factor to 'un-redistribute' ULS moments so they may be used in this SLS verification (see Table C14)

New text:

either

- $310/\sigma_s$ using characteristic load combinations to determine the service stress, σ_s

or

- $(500/f_{yk})(A_{s,prov}/A_{s,req})$

In either case the modification factor is restricted to a maximum of 1.50.

Actual l/d = actual span divided by effective depth, d .

M Amends to p204 C8

C8 Control of cracking

Cracking may be controlled by restricting either maximum bar diameter or maximum bar spacing to the relevant diameters and spacings given in Table C15. The appropriate SLS stress in reinforcement, σ_s , may be determined as outlined for F3 in Section C7.

below

$$\sigma_s = f_{yk} / \gamma_s [(G_k + \psi_2 Q_k) / (1.25 G_k + 1.5 Q_k)] [A_{s,req} / A_{s,prov}] (1/d)$$

or

$$\sigma_s = \sigma_{su} [A_{s,req} / A_{s,prov}] (1/d)$$

where σ_{su} = the unmodified SLS steel stress, taking account of γ_M for reinforcement and of going from ultimate actions to serviceability actions
= $500 / \gamma_s (G_k + \psi_2 Q_k) / (1.25 G_k + 1.5 Q_k)$

σ_{su} may be estimated from Figure C3 as indicated by the blue arrow

$A_{s,req} / A_{s,prov}$ = area of steel required divided by area of steel provided.

$(1/d)$ = factor to 'un-redistribute' ULS moments so they may be used in this SLS verification (see Table C14)

New text ex p 201:

chg 25 Feb 2010