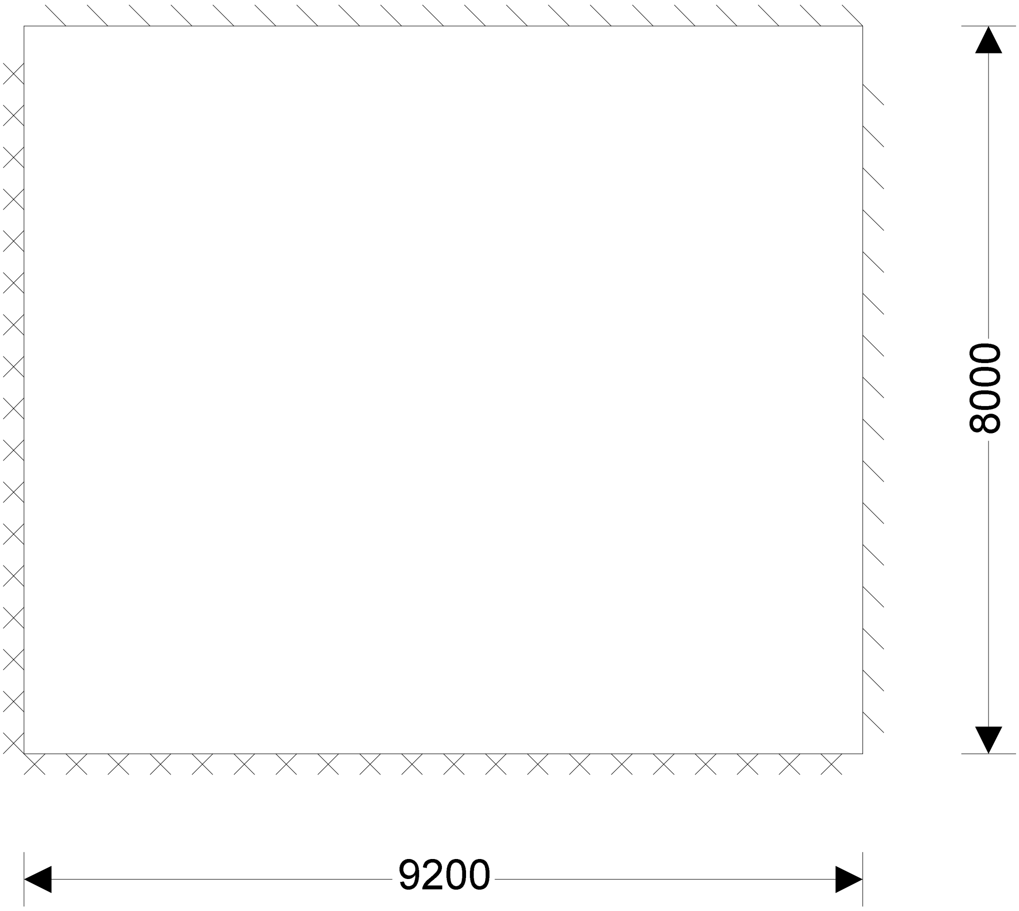
RC SLAB DESIGN

In accordance with EN1992-1-1:2004 incorporating corrigendum January 2008 and the recommended values



Slab definition

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Type of slab; **Two way spanning with restrained edges**

Overall slab depth; h = **225** mm

Shorter effective span of panel; l_x = **8000** mm

Longer effective span of panel; l_y = **9200** mm

Support conditions;	**Two adjacent edges discontinuous**
Top outer layer of reinforcement;	**Short span direction**
Bottom outer layer of reinforcement;	**Short span direction**

Loading

Characteristic permanent action;	G_k = **6.0** kN/m^2
Characteristic variable action;	Q_k = **5.0** kN/m^2
Partial factor for permanent action;	γ_G = **1.35**
Partial factor for variable action;	γ_Q = **1.50**
Quasi-permanent value of variable action;	ψ_2 = **0.30**
Design ultimate load;	$q = \gamma_G \times G_k + \gamma_Q \times Q_k$ = **15.6** kN/m^2
Quasi-permanent load;	$q_{SLS} = 1.0 \times G_k + \psi_2 \times Q_k$ = **7.5** kN/m^2

Concrete properties

Concrete strength class;	C25/30
Characteristic cylinder strength;	f_{ck} = **25** N/mm^2
Partial factor (Table 2.1N);	γ_C = **1.50**
Compressive strength factor (cl. 3.1.6);	α_{cc} = **1.00**
Design compressive strength (cl. 3.1.6);	f_{cd} = **16.7** N/mm^2
Mean axial tensile strength (Table 3.1);	$f_{ctm} = 0.30\text{ N/mm}^2 \times (f_{ck} / 1\text{ N/mm}^2)^{2/3}$ = **2.6** N/mm^2
Maximum aggregate size;	d_g = **20** mm

Reinforcement properties

Characteristic yield strength;	f_{yk} = **500** N/mm^2
Partial factor (Table 2.1N);	γ_S = **1.15**
Design yield strength (fig. 3.8);	$f_{yd} = f_{yk} / \gamma_S$ = **434.8** N/mm^2

Concrete cover to reinforcement

Nominal cover to outer top reinforcement;	c_{nom_t} = **30** mm
Nominal cover to outer bottom reinforcement;	c_{nom_b} = **30** mm
Fire resistance period to top of slab;	R_{top} = **60** min
Fire resistance period to bottom of slab;	R_{btm} = **60** min
Axia distance to top reinft (Table 5.8);	a_{fi_t} = **10** mm
Axia distance to bottom reinft (Table 5.8);	a_{fi_b} = **10** mm
Min. top cover requirement with regard to bond;	c_{min,b_t} = **16** mm
Min. btm cover requirement with regard to bond;	c_{min,b_b} = **16** mm
Reinforcement fabrication;	**Not subject to QA system**
Cover allowance for deviation;	Δc_{dev} = **10** mm
Min. required nominal cover to top reinft;	$c_{nom\_t\_min}$ = **26.0** mm
Min. required nominal cover to bottom reinft;	$c_{nom\_b\_min}$ = **26.0** mm

PASS - There is sufficient cover to the top reinforcement

PASS - There is sufficient cover to the bottom reinforcement

Reinforcement design at midspan in short span direction (cl.6.1)

Bending moment coefficient; β_{sx_p} = **0.0445**

Design bending moment; $M_{x\_p} = \beta_{sx\_p} \times q \times l_x^2$ = **44.4** kNm/m

Reinforcement provided; 16 mm dia. bars at 200 mm centres

Area provided; A_{sx_p} = 1005 mm²/m

Effective depth to tension reinforcement; $d_{x\_p} = h - c_{nom\_b} - \phi_{x\_p} / 2$ = **187.0** mm

K factor; $K = M_{x\_p} / (b \times d_{x\_p}^2 \times f_{ck})$ = **0.051**

Redistribution ratio; δ = 1.0

K' factor; $K' = 0.598 \times \delta - 0.18 \times \delta^2 - 0.21$ = **0.208**

K < K' - Compression reinforcement is not required

Lever arm; $z = \min(0.95 \times d_{x\_p}, d_{x\_p}/2 \times (1 + (1 - 3.53 \times K)^{0.5}))$ =
177.7 mm

Area of reinforcement required for bending; $A_{sx\_p\_m} = M_{x\_p} / (f_{yd} \times z)$ = **575** mm²/m

Minimum area of reinforcement required; $A_{sx\_p\_min} = \max(0.26 \times (f_{ctm}/f_{yk}) \times b \times d_{x\_p},$
$0.0013 \times b \times d_{x\_p})$ = **249** mm²/m

Area of reinforcement required; $A_{sx\_p\_req} = \max(A_{sx\_p\_m}, A_{sx\_p\_min})$ = **575** mm²/m

PASS - Area of reinforcement provided exceeds area required

Check reinforcement spacing

Reinforcement service stress; $\sigma_{sx\_p} = (f_{yk} / \gamma_S) \times \min((A_{sx\_p\_m}/A_{sx\_p}), 1.0) \times q_{SLS} / q$
= **119.6** N/mm²

Maximum allowable spacing (Table 7.3N); $s_{max\_x\_p}$ = **300** mm

Actual bar spacing; s_{x_p} = **200** mm

PASS - The reinforcement spacing is acceptable

Reinforcement design at midspan in long span direction (cl.6.1)

Bending moment coefficient; β_{sy_p} = **0.0340**

Design bending moment; $M_{y\_p} = \beta_{sy\_p} \times q \times l_x^2$ = **33.9** kNm/m

Reinforcement provided; 16 mm dia. bars at 250 mm centres

Area provided; A_{sy_p} = 804 mm²/m

Effective depth to tension reinforcement; $d_{y\_p} = h - c_{nom\_b} - \phi_{x\_p} - \phi_{y\_p} / 2$ = **171.0** mm

K factor; $K = M_{y\_p} / (b \times d_{y\_p}^2 \times f_{ck})$ = **0.046**

Redistribution ratio; δ = 1.0

K' factor; $K' = 0.598 \times \delta - 0.18 \times \delta^2 - 0.21$ = **0.208**

K < K' - Compression reinforcement is not required

Lever arm; $z = \min(0.95 \times d_{y\_p}, d_{y\_p}/2 \times (1 + (1 - 3.53 \times K)^{0.5}))$ =
162.5 mm

Area of reinforcement required for bending; $A_{sy\_p\_m} = M_{y\_p} / (f_{yd} \times z)$ = **481** mm²/m

Minimum area of reinforcement required; $A_{sy\_p\_min} = \max(0.26 \times (f_{ctm}/f_{yk}) \times b \times d_{y\_p},$
$0.0013 \times b \times d_{y\_p})$ = **228** mm²/m

Area of reinforcement required; $A_{sy\_p\_req} = \max(A_{sy\_p\_m}, A_{sy\_p\_min})$ = **481** mm²/m

PASS - Area of reinforcement provided exceeds area required

Check reinforcement spacing

Reinforcement service stress; $\sigma_{sy\_p} = (f_{yk} / \gamma_S) \times \min((A_{sy\_p\_m}/A_{sy\_p}), 1.0) \times q_{SLS} / q$ = **124.9** N/mm^2

Maximum allowable spacing (Table 7.3N); $s_{max\_y\_p}$ = **300** mm

Actual bar spacing; s_{y_p} = **250** mm

PASS - The reinforcement spacing is acceptable

Reinforcement design at continuous support in short span direction (cl.6.1)

Bending moment coefficient; β_{sx_n} = **0.0595**

Design bending moment; $M_{x\_n} = \beta_{sx\_n} \times q \times l_x^2$ = **59.4** kNm/m

Reinforcement provided; 16 mm dia. bars at 200 mm centres

Area provided; A_{sx_n} = 1005 mm^2/m

Effective depth to tension reinforcement; $d_{x\_n} = h - c_{nom\_t} - \phi_{x\_n} / 2$ = **187.0** mm

K factor; $K = M_{x\_n} / (b \times d_{x\_n}^2 \times f_{ck})$ = **0.068**

Redistribution ratio; δ = 1.0

K' factor; $K' = 0.598 \times \delta - 0.18 \times \delta^2 - 0.21$ = **0.208**

K < K' - Compression reinforcement is not required

Lever arm; $z = \min(0.95 \times d_{x\_n}, d_{x\_n}/2 \times (1 + (1 - 3.53 \times K)^{0.5}))$ = **175.0** mm

Area of reinforcement required for bending; $A_{sx\_n\_m} = M_{x\_n} / (f_{yd} \times z)$ = **781** mm^2/m

Minimum area of reinforcement required; $A_{sx\_n\_min} = \max(0.26 \times (f_{ctm}/f_{yk}) \times b \times d_{x\_n}, 0.0013 \times b \times d_{x\_n})$ = **249** mm^2/m

Area of reinforcement required; $A_{sx\_n\_req} = \max(A_{sx\_n\_m}, A_{sx\_n\_min})$ = **781** mm^2/m

PASS - Area of reinforcement provided exceeds area required

Check reinforcement spacing

Reinforcement service stress; $\sigma_{sx\_n} = (f_{yk} / \gamma_S) \times \min((A_{sx\_n\_m}/A_{sx\_n}), 1.0) \times q_{SLS} / q$ = **162.3** N/mm^2

Maximum allowable spacing (Table 7.3N); $s_{max\_x\_n}$ = **297** mm

Actual bar spacing; s_{x_n} = **200** mm

PASS - The reinforcement spacing is acceptable

Reinforcement design at continuous support in long span direction (cl.6.1)

Bending moment coefficient; β_{sy_n} = **0.0450**

Design bending moment; $M_{y\_n} = \beta_{sy\_n} \times q \times l_x^2$ = **44.9** kNm/m

Reinforcement provided; 16 mm dia. bars at 200 mm centres

Area provided; A_{sy_n} = 1005 mm^2/m

Effective depth to tension reinforcement; $d_{y\_n} = h - c_{nom\_t} - \phi_{x\_n} - \phi_{y\_n} / 2$ = **171.0** mm

K factor; $K = M_{y\_n} / (b \times d_{y\_n}^2 \times f_{ck})$ = **0.061**

Redistribution ratio; δ = 1.0

K' factor; $K' = 0.598 \times \delta - 0.18 \times \delta^2 - 0.21$ = **0.208**

K < K' - Compression reinforcement is not required

Lever arm; $z = \min(0.95 \times d_{y\_n}, d_{y\_n}/2 \times (1 + (1 - 3.53 \times K)^{0.5})) =$ **161.2** mm

Area of reinforcement required for bending; $A_{sy\_n\_m} = M_{y\_n} / (f_{yd} \times z) =$ **641** mm^2/m

Minimum area of reinforcement required; $A_{sy\_n\_min} = \max(0.26 \times (f_{ctm}/f_{yk}) \times b \times d_{y\_n}, 0.0013 \times b \times d_{y\_n}) =$ **228** mm^2/m

Area of reinforcement required; $A_{sy\_n\_req} = \max(A_{sy\_n\_m}, A_{sy\_n\_min}) =$ **641** mm^2/m

PASS - Area of reinforcement provided exceeds area required

Check reinforcement spacing

Reinforcement service stress; $\sigma_{sy\_n} = (f_{yk} / \gamma_S) \times \min((A_{sy\_n\_m}/A_{sy\_n}), 1.0) \times q_{SLS} / q =$ **133.3** N/mm^2

Maximum allowable spacing (Table 7.3N); $s_{max\_y\_n} =$ **300** mm

Actual bar spacing; $s_{y\_n} =$ **200** mm

PASS - The reinforcement spacing is acceptable

Shear capacity check at short span continuous support

Shear force; $V_{x\_n} = q \times l_x / 2 + M_{x\_n} / l_x =$ **69.8** kN/m

Effective depth factor (cl. 6.2.2); $k = \min(2.0, 1 + (200 \text{ mm} / d_{x\_n})^{0.5}) =$ **2.000**

Reinforcement ratio; $\rho_l = \min(0.02, A_{sx\_n} / (b \times d_{x\_n})) =$ **0.0054**

Minimum shear resistance (Exp. 6.3N); $V_{Rd,c\_min} = 0.035 \text{ N/mm}^2 \times k^{1.5} \times (f_{ck} / 1 \text{ N/mm}^2)^{0.5} \times b \times d_{x\_n}$

$V_{Rd,c\_min} =$ **92.6** kN/m

Shear resistance (Exp. 6.2a); $V_{Rd,c\_x\_n} = \max(V_{Rd,c\_min}, (0.18 \text{ N/mm}^2 / \gamma_C) \times k \times (100 \times \rho_l \times (f_{ck} / 1 \text{ N/mm}^2))^{0.333} \times b \times d_{x\_n})$

$V_{Rd,c\_x\_n} =$ **106.6** kN/m

PASS - Shear capacity is adequate

Shear capacity check at long span continuous support

Shear force; $V_{y\_n} = q \times l_x / 2 + M_{y\_n} / l_y =$ **67.3** kN/m

Effective depth factor (cl. 6.2.2); $k = \min(2.0, 1 + (200 \text{ mm} / d_{y\_n})^{0.5}) =$ **2.000**

Reinforcement ratio; $\rho_l = \min(0.02, A_{sy\_n} / (b \times d_{y\_n})) =$ **0.0059**

Minimum shear resistance (Exp. 6.3N); $V_{Rd,c\_min} = 0.035 \text{ N/mm}^2 \times k^{1.5} \times (f_{ck} / 1 \text{ N/mm}^2)^{0.5} \times b \times d_{y\_n}$

$V_{Rd,c\_min} =$ **84.6** kN/m

Shear resistance (Exp. 6.2a); $V_{Rd,c\_y\_n} = \max(V_{Rd,c\_min}, (0.18 \text{ N/mm}^2 / \gamma_C) \times k \times (100 \times \rho_l \times (f_{ck} / 1 \text{ N/mm}^2))^{0.333} \times b \times d_{y\_n})$

$V_{Rd,c\_y\_n} =$ **100.4** kN/m

PASS - Shear capacity is adequate

Shear capacity check at short span discontinuous support

Shear force; $V_{x\_d} = q \times l_x / 2 =$;**62.4**; kN/m;

Reinforcement provided; **8 mm dia. bars at 200 mm centres**

Area provided; A_{sx_d} = **251** mm^2/m

Effective depth; $d_{x\_d} = h - c_{nom\_b} - \phi_{x\_d} / 2$ = ;**191.0**; mm

Effective depth factor; $k = \min(2.0, 1 + (200 \text{ mm} / d_{x\_d})^{0.5})$ = **2.000**

Reinforcement ratio; $\rho_l = \min(0.02, A_{sx\_d} / (b \times d_{x\_d}))$ = **0.0013**

Minimum shear resistance; $V_{Rd,c\_min} = 0.035 \text{ N/mm}^2 \times k^{1.5} \times (f_{ck} / 1 \text{ N/mm}^2)^{0.5} \times b \times d_{x\_d}$

V_{Rd,c_min} = **94.5** kN/m

Shear resistance; $V_{Rd,c\_x\_d} = \max(V_{Rd,c\_min}, 0.18 \text{ N/mm}^2 / \gamma_C \times k \times (100 \times \rho_l \times (f_{ck}/1 \text{ N/mm}^2))^{0.333} \times b \times d_{x\_d})$

V_{Rd,c_x_d} = **94.5** kN/m

PASS - Shear capacity is adequate (0.660)

Shear capacity check at long span discontinuous support

Shear force; $V_{y\_d} = q \times l_x / 2$ = ;**62.4**; kN/m;

Reinforcement provided; **8 mm dia. bars at 250 mm centres**

Area provided; A_{sy_d} = **201** mm^2/m

Effective depth; $d_{y\_d} = h - c_{nom\_b} - \phi_{x\_p} - \phi_{y\_d} / 2$ = ;**175.0**; mm

Effective depth factor; $k = \min(2.0, 1 + (200 \text{ mm} / d_{y\_d})^{0.5})$ = **2.000**

Reinforcement ratio; $\rho_l = \min(0.02, A_{sy\_d} / (b \times d_{y\_d}))$ = **0.0011**

Minimum shear resistance; $V_{Rd,c\_min} = 0.035 \text{ N/mm}^2 \times k^{1.5} \times (f_{ck} / 1 \text{ N/mm}^2)^{0.5} \times b \times d_{y\_d}$

V_{Rd,c_min} = **86.6** kN/m

Shear resistance; $V_{Rd,c\_y\_d} = \max(V_{Rd,c\_min}, 0.18 \text{ N/mm}^2 / \gamma_C \times k \times (100 \times \rho_l \times (f_{ck}/1 \text{ N/mm}^2))^{0.333} \times b \times d_{y\_d})$

V_{Rd,c_y_d} = **86.6** kN/m

PASS - Shear capacity is adequate (0.720)

Basic span-to-depth deflection ratio check (cl. 7.4.2)

Reference reinforcement ratio; $\rho_0 = (f_{ck} / 1 \text{ N/mm}^2)^{0.5} / 1000$ = **0.0050**

Required tension reinforcement ratio; $\rho = \max(0.0035, A_{sx\_p\_req} / (b \times d_{x\_p}))$ = **0.0035**

Required compression reinforcement ratio; $\rho' = A_{scx\_p\_req} / (b \times d_{x\_p})$ = **0.0000**

Stuctural system factor (Table 7.4N); K_δ = **1.3**

Basic limit span-to-depth ratio; $ratio_{lim\_x\_bas} = K_\delta \times [11 + 1.5\times(f_{ck}/1 \text{ N/mm}^2)^{0.5}\times\rho_0/\rho + 3.2\times(f_{ck}/1 \text{ N/mm}^2)^{0.5}\times(\rho_0/\rho - 1)^{1.5}]$

(Exp. 7.16); $ratio_{lim\_x\_bas}$ = **34.06**

Mod span-to-depth ratio limit; $ratio_{lim\_x} = \min(40 \times K_\delta, \min(1.5, (500 \text{ N/mm}^2/f_{yk})\times(A_{sx\_p}/A_{sx\_p\_m})) \times ratio_{lim\_x\_bas})$ = **51.10**

Actual span-to-eff. depth ratio; $ratio_{act\_x} = l_x / d_{x\_p}$ = **42.78**

PASS - Actual span-to-effective depth ratio is acceptable

Reinforcement summary

Midspan in short span direction;	**16 mm dia. bars at 200 mm centres B1**
Midspan in long span direction;	**16 mm dia. bars at 250 mm centres B2**
Continuous support in short span direction;	**16 mm dia. bars at 200 mm centres T1**
Continuous support in long span direction;	**16 mm dia. bars at 200 mm centres T2**
Discontinuous support in short span direction;	**8 mm dia. bars at 200 mm centres B1**
Discontinuous support in long span direction;	**8 mm dia. bars at 250 mm centres B2**

Reinforcement sketch

The following sketch is indicative only. Note that additional reinforcement may be required in accordance with clauses 9.2.1.2, 9.2.1.4 and 9.2.1.5 of EN 1992-1-1:2004 to meet detailing rules.