

Project				Job no.	
Calcs for				Start page no./Revision 1	
Calcs by K	Calcs date 14.03.2019	Checked by	Checked date	Approved by	Approved date

RC MEMBER DESIGN

In accordance with EN1992-1-1:2004 incorporating Corrigenda January 2008 and the UK national annex

Tedds calculation version 3.2.00

Concrete details - Table 3.1. Strength and deformation characteristics for concrete

Concrete strength class	C30/37
Aggregate type	Quartzite
Aggregate adjustment factor - cl.3.1.3(2)	AAF = 1.0
Characteristic compressive cylinder strength	$f_{ck} = 30 \text{ N/mm}^2$
Mean value of compressive cylinder strength	$f_{cm} = f_{ck} + 8 \text{ N/mm}^2 = 38 \text{ N/mm}^2$
Mean value of axial tensile strength	$f_{ctm} = 0.3 \text{ N/mm}^2 \times (f_{cm} / 1 \text{ N/mm}^2)^{2/3} = 2.9 \text{ N/mm}^2$
Secant modulus of elasticity of concrete	$E_{cm} = 22 \text{ kN/mm}^2 \times [f_{cm} / 10 \text{ N/mm}^2]^{0.3} \times \text{AAF} = 32837 \text{ N/mm}^2$
Ultimate strain - Table 3.1	$\epsilon_{cu2} = 0.0035$
Shortening strain - Table 3.1	$\epsilon_{cu3} = 0.0035$
Effective compression zone height factor	$\lambda = 0.80$
Effective strength factor	$\eta = 1.00$
Coefficient k_1	$k_1 = 0.40$
Coefficient k_2	$k_2 = 1.0 \times (0.6 + 0.0014 / \epsilon_{cu2}) = 1.00$
Coefficient k_3	$k_3 = 0.40$
Coefficient k_4	$k_4 = 1.0 \times (0.6 + 0.0014 / \epsilon_{cu2}) = 1.00$
Partial factor for concrete - Table 2.1N	$\gamma_C = 1.50$
Compressive strength coefficient - cl.3.1.6(1)	$\alpha_{cc} = 0.85$
Design compressive concrete strength - exp.3.15	$f_{cd} = \alpha_{cc} \times f_{ck} / \gamma_C = 17.0 \text{ N/mm}^2$
Compressive strength coefficient - cl.3.1.6(1)	$\alpha_{ccw} = 1.00$
Design compressive concrete strength - exp.3.15	$f_{cwd} = \alpha_{ccw} \times f_{ck} / \gamma_C = 20.0 \text{ N/mm}^2$
Maximum aggregate size	$h_{agg} = 20 \text{ mm}$
Monolithic simple support moment factor	$\beta_1 = 0.25$

Reinforcement details

Characteristic yield strength of reinforcement	$f_{yk} = 500 \text{ N/mm}^2$
Partial factor for reinforcing steel - Table 2.1N	$\gamma_S = 1.15$
Design yield strength of reinforcement	$f_{yd} = f_{yk} / \gamma_S = 435 \text{ N/mm}^2$

Nominal cover to reinforcement

Nominal cover to top reinforcement	$c_{nom_t} = 30 \text{ mm}$
Nominal cover to bottom reinforcement	$c_{nom_b} = 30 \text{ mm}$
Nominal cover to side reinforcement	$c_{nom_s} = 30 \text{ mm}$

Fire resistance

Standard fire resistance period	$R = 120 \text{ min}$
Number of sides exposed to fire	3
Minimum width of beam - EN1992-1-2 Table 5.5	$b_{min} = 200 \text{ mm}$

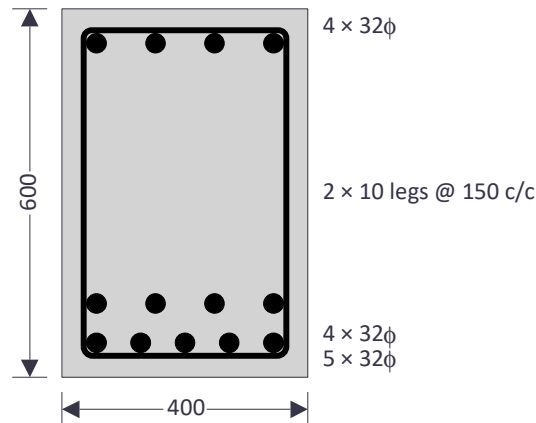
Section 1 - Multiple layers

Rectangular section details

Section width	$b = 400 \text{ mm}$
Section depth	$h = 600 \text{ mm}$

PASS - Minimum dimensions for fire resistance met

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Positive moment - section 6.1

Design bending moment

$$M = M_{pos_s1} = 1200.0 \text{ kNm}$$

Effective depth of tension reinforcement

$$d = 516 \text{ mm}$$

Redistribution ratio

$$\delta = \min(\delta_{pos_s1}, 1) = 1.000$$

$$K = M / (b \times d^2 \times f_{ck}) = 0.376$$

$$K' = (2 \times \eta \times \alpha_{cc} / \gamma_c) \times (1 - \lambda \times (\delta - k_1) / (2 \times k_2)) \times (\lambda \times (\delta - k_1) / (2 \times k_2)) = 0.207$$

K > K' - Compression reinforcement is required

Lever arm

$$z = 0.5 \times d \times [1 + (1 - 2 \times K' / (\eta \times \alpha_{cc} / \gamma_c))^{0.5}] = 392 \text{ mm}$$

Depth of neutral axis

$$x = d \times (\delta - k_1) / k_2 = 309 \text{ mm}$$

Effective depth of compression reinforcement

$$d_2 = 56 \text{ mm}$$

$$f_{sc} = \min(E_s \times \epsilon_{cu3} \times (x - d_2) / x, f_{yd}) = 435 \text{ N/mm}^2$$

Area of compression reinforcement required

$$A_{s2,req} = (K - K') \times f_{ck} \times b \times d^2 / (f_{sc} \times (d - d_2)) = 2706 \text{ mm}^2$$

Compression reinforcement provided

$$4 \times 32\phi$$

Area of compression reinforcement provided

$$A_{s2,prov} = 3217 \text{ mm}^2$$

Maximum area of reinforcement - cl.9.2.1.1(3)

$$A_{s,max} = 0.04 \times b \times h = 9600 \text{ mm}^2$$

PASS - Area of reinforcement provided is greater than area of reinforcement required

Area of tension reinforcement required

$$A_{s,req} = K' \times f_{ck} \times b \times d^2 / (f_{yd} \times z) + A_{s2,req} \times f_{sc} / f_{yd} = 6576 \text{ mm}^2$$

Tension reinforcement provided

$$\text{Layer 1 - } 5 \times 32\phi, \text{ Spacing - } 32\text{mm, Layer 2 - } 4 \times 32\phi$$

Area of tension reinforcement provided

$$A_{s,prov} = 7238 \text{ mm}^2$$

Minimum area of reinforcement - exp.9.1N

$$A_{s,min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times b \times d = 311 \text{ mm}^2$$

PASS - Area of reinforcement provided is greater than area of reinforcement required

Crack control - Section 7.3

Maximum crack width

$$w_k = 0.3 \text{ mm}$$

Design value modulus of elasticity reinf - 3.2.7(4)

$$E_s = 200000 \text{ N/mm}^2$$

Mean value of concrete tensile strength

$$f_{ct,eff} = f_{ctm} = 2.9 \text{ N/mm}^2$$

Stress distribution coefficient

$$k_c = 0.4$$

Non-uniform self-equilibrating stress coefficient

$$k = \min(\max(1 + (300 \text{ mm} - \min(h, b)) \times 0.35 / 500 \text{ mm}, 0.65), 1) = 0.93$$

Actual tension bar spacing

$$s_{bar} = (b - (2 \times (c_{nom_s} + \phi_{s1_v}) + \phi_{s1_b_L1} \times N_{s1_b_L1})) / (N_{s1_b_L1} - 1) + \phi_{s1_b_L1} = 72 \text{ mm}$$

Maximum stress permitted - Table 7.3N

$$\sigma_s = 342 \text{ N/mm}^2$$

Steel to concrete modulus of elast. ratio

$$\alpha_{cr} = E_s / E_{cm} = 6.09$$

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Distance of the Elastic NA from bottom of beam $y = (b \times h^2 / 2 + A_{s,prov} \times (\alpha_{cr} - 1) \times (h - d)) / (b \times h + A_{s,prov} \times (\alpha_{cr} - 1)) = 271 \text{ mm}$

Area of concrete in the tensile zone $A_{ct} = b \times y = 108524 \text{ mm}^2$

Minimum area of reinforcement required - exp.7.1 $A_{sc,min} = k_c \times k \times f_{ct,eff} \times A_{ct} / \sigma_s = 342 \text{ mm}^2$

PASS - Area of tension reinforcement provided exceeds minimum required for crack control

Quasi-permanent moment $M_{QP} = M_{pos_QP_s1} = 0.0 \text{ kNm}$

Permanent load ratio $R_{PL} = M_{QP} / M = 0.00$

Service stress in reinforcement $\sigma_{sr} = f_{yd} \times A_{s,req} / A_{s,prov} \times R_{PL} = 0 \text{ N/mm}^2$

Maximum bar spacing - Tables 7.3N $s_{bar,max} = 300 \text{ mm}$

PASS - Maximum bar spacing exceeds actual bar spacing for crack control

Minimum bar spacing (Section 8.2)

Top bar spacing $s_{top} = (b - (2 \times (c_{nom_s} + \phi_{s1_v}) + \phi_{s1_t_L1} \times N_{s1_t_L1})) / (N_{s1_t_L1} - 1) = 64.0 \text{ mm}$

Minimum allowable top bar spacing $s_{top,min} = \max(\phi_{s1_t_L1} \times k_{s1}, h_{agg} + k_{s2}, 20 \text{ mm}) = 32.0 \text{ mm}$

PASS - Actual bar spacing exceeds minimum allowable

Bottom bar spacing $s_{bot} = (b - (2 \times (c_{nom_s} + \phi_{s1_v}) + \phi_{s1_b_L1} \times N_{s1_b_L1})) / (N_{s1_b_L1} - 1) = 40.0 \text{ mm}$

Minimum allowable bottom bar spacing $s_{bot,min} = \max(\phi_{s1_b_L1} \times k_{s1}, h_{agg} + k_{s2}, 20 \text{ mm}) = 32.0 \text{ mm}$

PASS - Actual bar spacing exceeds minimum allowable

Section in shear (section 6.2)

Angle of comp. shear strut for maximum shear $\theta_{max} = 45 \text{ deg}$

Strength reduction factor - cl.6.2.3(3) $v_1 = 0.6 \times (1 - f_{ck} / 250 \text{ N/mm}^2) = 0.528$

Compression chord coefficient - cl.6.2.3(3) $\alpha_{cw} = 1.00$

Minimum area of shear reinforcement - exp.9.5N $A_{sv,min} = 0.08 \text{ N/mm}^2 \times b \times (f_{ck} / 1 \text{ N/mm}^2)^{0.5} / f_{yk} = 351 \text{ mm}^2/\text{m}$

Design shear force at support $V_{Ed,max} = V_{Ed,max_s1} = 300 \text{ kN}$

Min lever arm in shear zone $z = 392 \text{ mm}$

Maximum design shear resistance - exp.6.9 $V_{Rd,max} = \alpha_{cw} \times b \times z \times v_1 \times f_{cwd} / (\cot(\theta_{max}) + \tan(\theta_{max})) = 828 \text{ kN}$

PASS - Design shear force at support is less than maximum design shear resistance

Design shear force $V_{Ed} = 300 \text{ kN}$

Design shear stress $v_{Ed} = V_{Ed} / (b \times z) = 1.914 \text{ N/mm}^2$

Angle of concrete compression strut - cl.6.2.3 $\theta = \min(\max(0.5 \times \text{Asin}(\min(2 \times v_{Ed} / (\alpha_{cw} \times f_{cwd} \times v_1), 1))), 21.8 \text{ deg}), 45 \text{ deg}) = 21.8 \text{ deg}$

Area of shear reinforcement required - exp.6.8 $A_{sv,des} = V_{Ed} \times b / (f_{yd} \times \cot(\theta)) = 704 \text{ mm}^2/\text{m}$

Area of shear reinforcement required $A_{sv,req} = \max(A_{sv,min}, A_{sv,des}) = 704 \text{ mm}^2/\text{m}$

Shear reinforcement provided $2 \times 10 \text{ legs @ } 150 \text{ c/c}$

Area of shear reinforcement provided $A_{sv,prov} = 1047 \text{ mm}^2/\text{m}$

PASS - Area of shear reinforcement provided exceeds minimum required

Maximum longitudinal spacing - exp.9.6N $s_{vl,max} = 0.75 \times d = 387 \text{ mm}$

PASS - Longitudinal spacing of shear reinforcement provided is less than maximum