MshStructure Nicosia Haspolat via mersin 10	Project				Job Ref.	
	Calc. by Asst. Prof. Dr. Shihab Ibrahim (PhD, M.ACI, Aff.M.ASCE)				Sheet no./rev. 1	
	Section S	Date 09-Jun-25	Chk'd by	Date	App'd by	Date

RC STAIR DESIGN

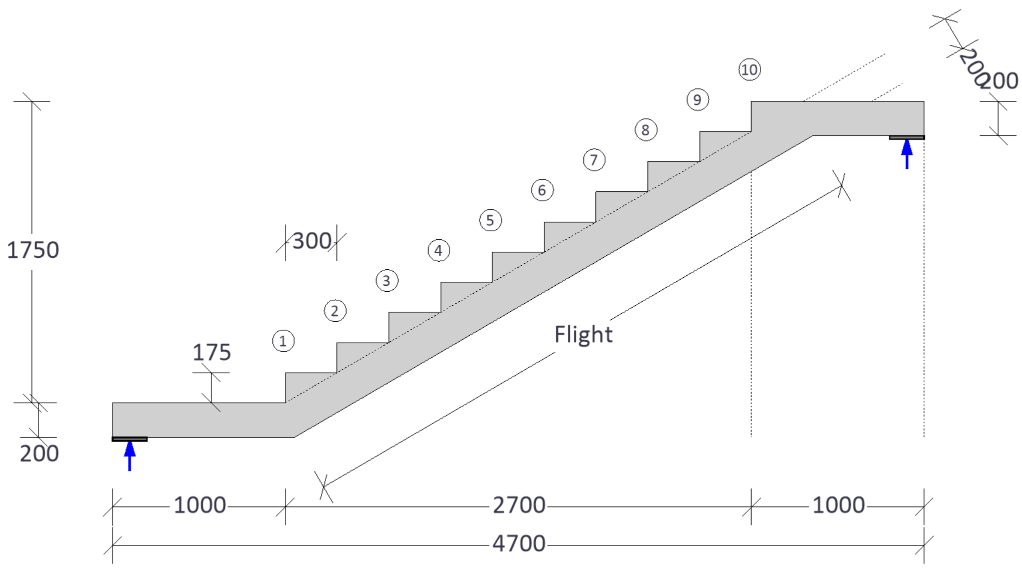
In accordance with ACI318-19(22)

Design summary

Overall design status PASS

Overall design utilization 0.804

Description	Unit	Provided	Required	Utilization	Result
Bottom long reinf. - mid span	mm^2	887	360	0.406	PASS
Top long reinf. - upper land.	mm^2	887	374	0.421	PASS
Top long reinf. - lower land.	mm^2	887	374	0.421	PASS
Bottom trans reinf. - mid span	mm^2/m	845	360	0.426	PASS
Top trans reinf. - upper land.	mm^2/m	845	360	0.426	PASS
Top trans reinf. - lower land.	mm^2/m	845	360	0.426	PASS
Shear resist. at up support	kN	66.5	32.3	0.486	PASS
Shear resist. at low support	kN	66.5	32.3	0.486	PASS
Minimum thickness of waist	mm	200	161	0.804	PASS



Stair geometry

Number of risers N_{steps} = **10**

Going G = **300** mm

Rise R = **175** mm

Waist h_{waist} = **200** mm

Breadth b = **1000** mm

Length of the tread span $L_{mid} = (N_{steps} - 1) \times G$ = **2700** mm

Overall height of stairs $h_{stairs} = N_{steps} \times R$ = **1750** mm

Angle of stairs α_{stairs} = atan (R / G) = **30.26** °

Upper landing - Interior support

Length of the upper landing L_{up} = **1000** mm

Depth of the upper landing h_{up} = **200** mm

Width of the supporting element	w_{up} = **200** mm

Lower landing - Interior support

Length of the lower landing	L_{low} = **1000** mm
Depth of the lower landing	h_{low} = **200** mm
Width of the supporting element	w_{low} = **200** mm

Span details

Overall length	$L_{total} = L_{low} + L_{mid} + L_{up}$ = **4700** mm
Clear distance between the supports faces	$L_n = L_{total} - w_{up} - w_{low}$ = **4300** mm
Distance between support centers	$L_{span} = L_{total} - (w_{up} + w_{low}) / 2$ = **4500** mm

Concrete details

Compressive strength of concrete	f'_c = **21** MPa
Density of reinforced concrete	w_c = **23** kN/m^3
Concrete type	Normal weight
Modulus of elasticity of concrete (cl.19.2.2.1)	$E = (w_c / g_{acc})^{1.5} \times 0.043(m^3/kg)^{1.5} \times (f'_c \times 1MPa)^{0.5}$ = **22381** MPa
Strength reduction factor for shear	ϕ_s = **0.75**

Reinforcement details

Yield strength of reinforcement	f_y = **420** MPa
Compression-controlled strain limit (cl.21.2.2.1)	$\varepsilon_{ty} = f_y / E_s$ = **0.00210**

Nominal cover to reinforcement

Cover to reinforcement	c_{nom} = **25** mm

Loading details

Self weight slab	$F_{self,slab} = h_{waist} / \cos(\alpha_{stairs}) \times (w_c) \times b$ = **5.3** kN/m
Self weight steps	$F_{self,steps} = R / 2 \times (w_c) \times b$ = **2.0** kN/m
Average self weight	$F_{self,aver} = F_{self,slab} + F_{self,steps}$ = **7.3** kN/m
Loading from finishes	F_{fin} = **1.2** kN/m^2
Live load	F_L = **3.0** kN/m^2
Dead load factor	γ_D = **1.20**
Live load factor	γ_L = **1.60**
Design load	$F_{total} = \gamma_D \times (F_{self,aver} + F_{fin} \times b) + \gamma_L \times F_L \times b$ = **15.0** kN /m

Midspan design

Bending moment coefficient	α_{mid} = **0.042**
Factored bending moment at section	$M_u = abs(\alpha_{mid}) \times F_{total} \times L_n^2$ = **11.59** kNm
Effective depth to tension reinforcement	$d = h_{waist} - c_{nom} - \phi / 2$ = **168.7** mm
Tension reinforcement provided	7 x 12.7 mm ϕ bars
Area of tension reinforcement provided	$A_{s,prov}$ = **887** mm^2
Gross area of section	$A_g = b \times h_{waist}$ = **200000** mm^2
Minimum area of reinforcement (cl.7.6.1.1)	$A_{s,min} = 0.0018 \times A_g$ = **360** mm^2

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

Stress block depth factor (cl.22.2.2.4.3)	$\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 28MPa) / 7\ MPa, 0.65), 0.85)$ = **0.85**
Depth of equivalent rectangular stress block	$a = A_{s,prov} \times f_y / (0.85 \times f'_c \times b)$ = **21** mm
Depth to neutral axis	$c = a / \beta_1$ = **25** mm
Net tensile strain in extreme tension fibers	$\varepsilon_t = 0.003 \times (d - c) / \max(c, 0.1\ mm)$ = **0.01761**

Net tensile strain in tension controlled zone

Strength reduction factor (cl.21.2.1) $\phi_f = \min(\max(0.65 + 0.25 \times (\varepsilon_t - \varepsilon_{ty}) / (0.003), 0.65), 0.9) =$ **0.90**

Nominal moment strength $M_n = A_{s,prov} \times f_y \times (d - a / 2) =$ **58.9** kNm

Design moment strength $\phi M_n = M_n \times \phi_f =$ **53.0** kNm

PASS - Required moment strength is less than design moment strength

Area of transverse reinforcement required $A_{s,req,t} = 0.0018 \times h_{waist} =$ **360** mm²/m

Transverse reinforcement provided 13 mm ϕ bars @ 150 mm c/c

Area of transverse reinforcement provided $A_{s,prov,t} =$ **845** mm²/m

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

Flexural cracking

Steel stress (cl.24.3.2) $f_s = 2 \times f_y / 3 =$ **280** N/mm²

Max allowable spacing (cl.7.7.2.4 and T.24.3.2) $s_{max} = \min(3 \times h_{waist}, 18in, 380mm \times (280MPa / f_s) - 2.5 \times c_{nom}, 300mm \times (280MPa / f_s)) =$ **300** mm

Actual tensile bar spacing provided $s =$ **156.2** mm

PASS - spacing of longitudinal reinforcement less than maximum allowable

Minimum spacing

Actual clear spacing $s_{clear} = (b - 2 \times c_{nom} - \phi \times N) / (N - 1) =$ **144** mm

Min allowable spacing (cl.25.2.1) $s_{min} = \max(25mm, \phi) =$ **25** mm

PASS - clear spacing of reinforcement greater than minimum allowable

Control of deflections (Section 24.2)

Concrete density factor $K_w =$ **1.00**

Reinforcement yield strength factor $K_f = 0.4 + f_y / 700 \text{ MPa} =$ **1.00**

Minimum thickness of beam (Table 7.3.1.1) $h_{min} = L_{span} / 28 \times K_w \times K_f =$ **161** mm

PASS - Thickness of waist exceeds minimum depth of slab required

Upper landing support design

Bending moment coefficient $\alpha_{up} =$ **-0.083**

Factored bending moment at section $M_u = abs(\alpha_{up}) \times F_{total} \times L_n^2 =$ **23.18** kNm

Effective depth to tension reinforcement $d = h_{up} - c_{nom} - \phi / 2 =$ **168.7** mm

Tension reinforcement provided 7 x 12.7 mm ϕ bars

Area of tension reinforcement provided $A_{s,prov} =$ **887** mm²

Gross area of section $A_g = b \times h_{up} =$ **200000** mm²

Minimum area of reinforcement (cl.7.6.1.1) $A_{s,min} = 0.0018 \times A_g =$ **360** mm²

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

Stress block depth factor (cl.22.2.2.4.3) $\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 28MPa) / 7 \text{ MPa}, 0.65), 0.85) =$ **0.85**

Depth of equivalent rectangular stress block $a = A_{s,prov} \times f_y / (0.85 \times f'_c \times b) =$ **21** mm

Depth to neutral axis $c = a / \beta_1 =$ **25** mm

Net tensile strain in extreme tension fibers $\varepsilon_t = 0.003 \times (d - c) / \max(c, 0.1 \text{ mm}) =$ **0.01761**

Net tensile strain in tension controlled zone

Strength reduction factor (cl.21.2.1) $\phi_f = \min(\max(0.65 + 0.25 \times (\varepsilon_t - \varepsilon_{ty}) / (0.003), 0.65), 0.9) =$ **0.90**

Nominal moment strength $M_n = A_{s,prov} \times f_y \times (d - a / 2) =$ **58.9** kNm

Design moment strength $\phi M_n = M_n \times \phi_f =$ **53.0** kNm

PASS - Required moment strength is less than design moment strength

Area of transverse reinforcement required — $A_{s,req,t} = 0.0018 \times h_{up} = \mathbf{360}$ mm²/m

Transverse reinforcement provided — 13 mm ϕ bars @ 150 mm c/c

Area of transverse reinforcement provided — $A_{s,prov,t} = \mathbf{845}$ mm²/m

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

Flexural cracking

Steel stress (cl.24.3.2) — $f_s = 2 \times f_y / 3 = \mathbf{280}$ N/mm²

Max allowable spacing (cl.7.7.2.4 and T.24.3.2) — $s_{max} = \min(3 \times h_{up}, 18\text{in}, 380\text{mm} \times (280\text{MPa} / f_s) - 2.5 \times c_{nom}, 300\text{mm} \times (280\text{MPa} / f_s)) = \mathbf{300}$ mm

Actual tensile bar spacing provided — $s = \mathbf{156.2}$ mm

PASS - spacing of longitudinal reinforcement less than maximum allowable

Minimum spacing

Actual clear spacing — $s_{clear} = (b - 2 \times c_{nom} - \phi \times N) / (N - 1) = \mathbf{144}$ mm

Min allowable spacing (cl.25.2.1) — $s_{min} = \max(25\text{mm}, \phi) = \mathbf{25}$ mm

PASS - clear spacing of reinforcement greater than minimum allowable

Check for shear based on concrete alone

Shear coefficient — $\beta_{up} = \mathbf{0.5}$

Required shear strength — $V_u = \beta_{up} \times F_{total} \times L_n = \mathbf{32.3}$ kN

Concrete weight modification factor — $\lambda = \mathbf{1.00}$

Area of longitudinal steel — $A_{st} = A_{s,prov,l,up} = \mathbf{1.374}$ in²

Ratio of longitudinal reinforcement — $\rho_w = A_{st} / (b \times d) = \mathbf{0.005}$

Size effect factor (cl.22.5.5.1.3) — $\lambda_s = \min(\sqrt{(2 / (1 + 0.004 \times d / 1\text{mm}))}, 1.0) = \mathbf{1.00}$

Shear strength of concrete (Table 22.5.5.1) — $\phi V_c = \phi_s \times \min(0.66 \times \lambda_s \times \lambda \times (\rho_w)^{1/3}, 0.42 \times \lambda) \times \sqrt{(\min(f'_c, 70\text{MPa}) \times 1\text{MPa})} \times b \times d = \mathbf{66.5}$ kN

PASS - Design shear resistance exceeds applied shear

Lower landing support design

Bending moment coefficient — $\alpha_{low} = \mathbf{-0.083}$

Factored bending moment at section — $M_u = \text{abs}(\alpha_{low}) \times F_{total} \times L_n^2 = \mathbf{23.18}$ kNm

Effective depth to tension reinforcement — $d = h_{low} - c_{nom} - \phi / 2 = \mathbf{168.7}$ mm

Tension reinforcement provided — 7 x 12.7 mm ϕ bars

Area of tension reinforcement provided — $A_{s,prov} = \mathbf{887}$ mm²

Gross area of section — $A_g = b \times h_{low} = \mathbf{200000}$ mm²

Minimum area of reinforcement (cl.7.6.1.1) — $A_{s,min} = 0.0018 \times A_g = \mathbf{360}$ mm²

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

Stress block depth factor (cl.22.2.2.4.3) — $\beta_1 = \min(\max(0.85 - 0.05 \times (f'_c - 28\text{MPa}) / 7\text{ MPa}, 0.65), 0.85) = \mathbf{0.85}$

Depth of equivalent rectangular stress block — $a = A_{s,prov} \times f_y / (0.85 \times f'_c \times b) = \mathbf{21}$ mm

Depth to neutral axis — $c = a / \beta_1 = \mathbf{25}$ mm

Net tensile strain in extreme tension fibers — $\varepsilon_t = 0.003 \times (d - c) / \max(c, 0.1\text{ mm}) = \mathbf{0.01761}$

Net tensile strain in tension controlled zone

Strength reduction factor (cl.21.2.1) — $\phi_f = \min(\max(0.65 + 0.25 \times (\varepsilon_t - \varepsilon_{ty}) / (0.003), 0.65), 0.9) = \mathbf{0.90}$

Nominal moment strength — $M_n = A_{s,prov} \times f_y \times (d - a / 2) = \mathbf{58.9}$ kNm

Design moment strength — $\phi M_n = M_n \times \phi_f = \mathbf{53.0}$ kNm

PASS - Required moment strength is less than design moment strength

Area of transverse reinforcement required $A_{s,req,t} = 0.0018 \times h_{low} =$ **360** mm²/m

Transverse reinforcement provided 13 mm ϕ bars @ 150 mm c/c

Area of transverse reinforcement provided $A_{s,prov,t} =$ **845** mm²/m

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

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Check for shear based on concrete alone

Shear coefficient $\beta_{low} =$ **0.5**

Required shear strength $V_u = \beta_{low} \times F_{total} \times L_n =$ **32.3** kN

Concrete weight modification factor $\lambda =$ **1.00**

Area of longitudinal steel $A_{st} = A_{s,prov,l,low} =$ **1.374** in²

Ratio of longitudinal reinforcement $\rho_w = A_{st} / (b \times d) =$ **0.005**

Size effect factor (cl.22.5.5.1.3) $\lambda_s = \min(\sqrt{(2 / (1 + 0.004 \times d / 1mm))}, 1.0) =$ **1.00**

Shear strength of concrete (Table 22.5.5.1) $\phi V_c = \phi_s \times \min(0.66 \times \lambda_s \times \lambda \times (\rho_w)^{1/3}, 0.42 \times \lambda) \times \sqrt{(\min(f'_c, 70MPa) \times 1MPa)} \times b \times d =$ **66.5** kN

PASS - Design shear resistance exceeds applied shear