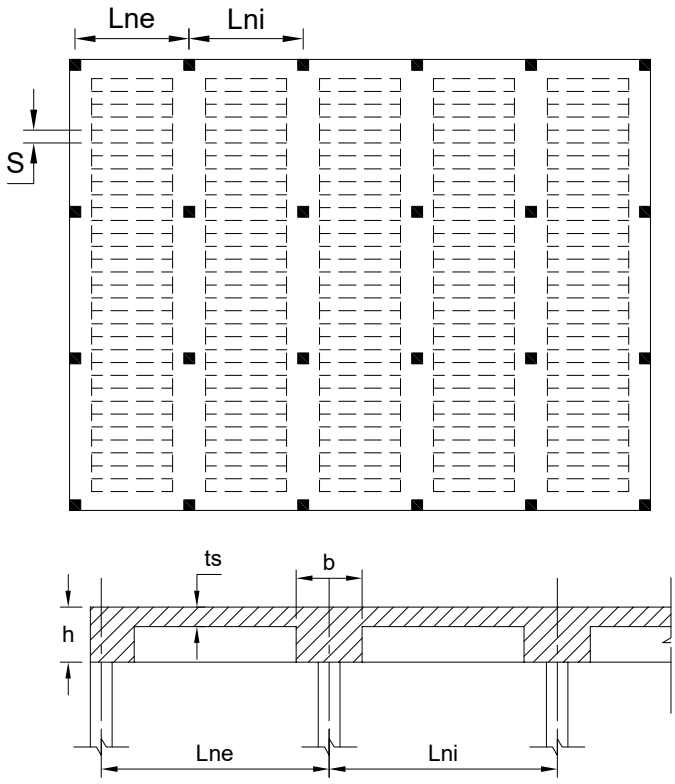
Design of One Way Joist as per ACI 318-11 Chapters 9 & 11



System

Width of Beam, b=		30.0 in
Width of Joist, b_j=		6.0 in
Spacing between Joists, s=		36.0 in
Slab Thickness, t_s=		3.5 in
Exterior Joist Span, L_{ne}=		27.5 ft
Interior Joist Span, L_{ni}=		27.0 ft
Concrete Cover, co=		1.25 in

Load

Dead Load, DL=			130 psf
Live Load, LL=			60 psf
Ultimate Load, w_u=	$\frac{1.2*DL+1.6*LL}{1000}*\frac{s}{12}$	=	0.756 kip/ft

Material Properties

Concrete Strength, f'_c=		4000 psi
Yield Strength of Reinforcement, f_y=		60000 psi
Tension Strength Reduction Factor (According to Cl.9.3.2 of ACI318), Φ=		0.90
Modification Factor for Lightweight Concrete, λ=		1.00
Factor for Rectangular Compressive Stress Block (According to Cl.10.2.7.3),		
β_1= IF(f'_c≤4000;0.85;IF(f'_c≥8000;0.65;1.05-0.00005*f'_c))	=	0.85

Moment Distribution for Joist

1. End Span

Edge Negative Moment for Exterior Joist, $M_{nee}=\frac{w_u * L_{ne}^2}{24}$ = 23.8 kip*ft

Positive Moment for Exterior Joist, $M_{pe}=\frac{w_u * L_{ne}^2}{14}$ = 40.8 kip*ft

Negative Moment for Exterior Joist, $M_{ne}=\frac{w_u * ((L_{ne}+L_{ni})/2)^2}{10}$ = 56.1 kip*ft

2. Interior Spans

Negative Moment for Interior Joist, $M_{ni}=\frac{w_u * L_{ni}^2}{11}$ = 50.1 kip*ft

Positive Moment for Interior Joist , $M_{pi}=\frac{w_u * L_{ni}^2}{16}$ = 34.4 kip*ft

3. Maximum Moment

M_{max}= $MAX(M_{nee}; M_{pe}; M_{ne}; M_{ni}; M_{pi})$ = 56.1 kip*ft

Calculation of Required Depth for Joist

ρ_t = $0.319 * f'_c * \beta_1 / f_y$ =0.01808

For Reasonable Deflection Control, choose a Reinforcement Ratio (ρ) equal to about one-half (ρ_t)

Reinforcement Ratio, ρ= $\rho_t / 2$ =0.00904

ω= $\rho * \frac{f_y}{f'_c}$ =0.13560

Required Depth, d= $\sqrt{\frac{M_{max} * 12000}{\Phi * bj * f'c * \omega * (1 - 0.59 * \omega)}}$ = 15.8 in

Required Thickness, h_{req}= d + co = 17.1 in

h_{min}= $MAX(L_{ne}*12+b; L_{ni}*12+b;)/18.5$ = 19.5 in

Provided Thickness, h= $MAX(h_{req}; h_{min})$ = 19.5 in

Effective Depth of Joist, d_j= h-co = 18.25 in

Calculation of Required Reinforcement for Exterior Negative Moment of End Span (A_{sc1})

$R_{n1}=\frac{M_{nee} * 12000}{\Phi * b_j * d_j^2}$ = 159 psi

Reinforcement Ratio, $\rho_1=0.85 * \frac{f'_c}{f_y} * \left(1 - \sqrt{1 - 2 * \frac{R_{n1}}{0.85 * f'_c}}\right)$ = 0.0027

Area of Reinforcement, A_{s1}= $\rho_1 * b_j * d_j$ = 0.30 in^2

Minimum Area of Reinforcement (According to Cl.10.5 of ACI318),

A_{s_min1}=	$\frac{3*\sqrt{f'_c}*b_j*d_j}{f_y}$	=	0.35 in^2
A_{s_min2}=	$\frac{200*b_j*d_j}{f_y}$	=	0.36 in^2
A_{s_min}=	MAX(A_{s_min1} ; A_{s_min2})	=	0.36 in^2
Required Area of Reinforcement, A_{sc1}=	MAX(A_{s1}; A_{s_min})	=	0.36 in^2
Provided Reinforcement, Bar=	SEL("ACI/Bar"; Bar;)	=	No.3
Provided Reinforcement, A_{sb}=	TAB("ACI/Bar"; Asb; Bar=Bar)	=	0.11 in^2
Number of Bars, n=			4
Vertical Reinforcement, A_{sc1_Prov}=	A_{sb} * n	=	0.44 in^2
Check Validity=	IF($A_{sc1\_Prov} \geq A_{sc1}$; "Valid"; "Invalid")	=	Valid

Calculation of Required Reinforcement for Positive Moment of End Span (A_{sc2})

R_{n2}=	$\frac{M_{pe}*12000}{\Phi*b_j*d_j^2}$	=	272 psi
Reinforcement Ratio, ρ_2=	$0.85*\frac{f'_c}{f_y}*\left(1-\sqrt{1-2*\frac{R_{n2}}{0.85*f'_c}}\right)$	=	0.0047
Area of Reinforcement, A_{s2}=	ρ_2 * b_j * d_j	=	0.51 in^2

Minimum Area of Reinforcement (According to Cl.10.5 of ACI318),

A_{s_min1}=	$\frac{3*\sqrt{f'_c}*b_j*d_j}{f_y}$	=	0.35 in^2
A_{s_min2}=	$\frac{200*b_j*d_j}{f_y}$	=	0.36 in^2
A_{s_min}=	MAX(A_{s_min1} ; A_{s_min2})	=	0.36 in^2
Required Area of Reinforcement, A_{sc2}=	MAX(A_{s2}; A_{s_min})	=	0.51 in^2
Provided Reinforcement, Bar=	SEL("ACI/Bar"; Bar;)	=	No.5
Provided Reinforcement, A_{sb}=	TAB("ACI/Bar"; Asb; Bar=Bar)	=	0.31 in^2
Number of Bars, n=			2
Vertical Reinforcement, A_{sc2_Prov}=	A_{sb} * n	=	0.62 in^2
Check Validity=	IF($A_{sc2\_Prov} \geq A_{sc2}$; "Valid"; "Invalid")	=	Valid

Calculation of Required Reinforcement for Interior Negative Moment of End Span (A_{sc3})

R_{n3}=	$\frac{M_{ne}*12000}{\Phi*b_j*d_j^2}$	=	374 psi

Reinforcement Ratio, ρ_3=	$0.85*\frac{f'_c}{f_y}*\left(1-\sqrt{1-2*\frac{R_{n3}}{0.85*f'_c}}\right)$	=	0.0066
Area of Reinforcement, A_{s3}=	$\rho_3 * b_j * d_j$	=	0.72 in^2

Minimum Area of Reinforcement (According to Cl.10.5 of ACI318),

A_{s_min1}=	$\frac{3*\sqrt{f'_c}*b_j*d_j}{f_y}$	=	0.35 in^2
A_{s_min2}=	$\frac{200*b_j*d_j}{f_y}$	=	0.36 in^2
A_{s_min}=	$MAX(A_{s\_min1}; A_{s\_min2})$	=	0.36 in^2
Required Area of Reinforcement, A_{sc3}=	$MAX(A_{s3}; A_{s\_min})$	=	0.72 in^2
Provided Reinforcement, Bar=	SEL("ACI/Bar"; Bar;)	=	No.5
Provided Reinforcement, A_{sb}=	TAB("ACI/Bar"; Asb; Bar=Bar)	=	0.31 in^2
Number of Bars, n=			3
Vertical Reinforcement, A_{sc3_Prov}=	$A_{sb} * n$	=	0.93 in^2
Check Validity=	$IF(A_{sc3\_Prov} \geq A_{sc3}$; "Valid"; "Invalid")	=	Valid

Calculation of Required Reinforcement for Interior Negative Moment of Interior Span (A_{sc4})

R_{n4}=	$\frac{M_{ni}*12000}{\Phi*b_j*d_j^2}$	=	334 psi
Reinforcement Ratio, ρ_4=	$0.85*\frac{f'_c}{f_y}*\left(1-\sqrt{1-2*\frac{R_{n4}}{0.85*f'_c}}\right)$	=	0.0059
Area of Reinforcement, A_{s4}=	$\rho_4 * b_j * d_j$	=	0.65 in^2

Minimum Area of Reinforcement (According to Cl.10.5 of ACI318),

A_{s_min1}=	$\frac{3*\sqrt{f'_c}*b_j*d_j}{f_y}$	=	0.35 in^2
A_{s_min2}=	$\frac{200*b_j*d_j}{f_y}$	=	0.36 in^2
A_{s_min}=	$MAX(A_{s\_min1}; A_{s\_min2})$	=	0.36 in^2
Required Area of Reinforcement, A_{sc4}=	$MAX(A_{s4}; A_{s\_min})$	=	0.65 in^2
Provided Reinforcement, Bar=	SEL("ACI/Bar"; Bar;)	=	No.5
Provided Reinforcement, A_{sb}=	TAB("ACI/Bar"; Asb; Bar=Bar)	=	0.31 in^2
Number of Bars, n=			3
Vertical Reinforcement, A_{sc4_Prov}=	$A_{sb} * n$	=	0.93 in^2
Check Validity=	$IF(A_{sc4\_Prov} \geq A_{sc4}$; "Valid"; "Invalid")	=	Valid

Calculation of Required Reinforcement for Interior Positive Moment of Interior Span (A_{sc5})

R_{n5}=	$\frac{M_{pi} * 12000}{\Phi * b_j * d_j^2}$	=	230 psi
Reinforcement Ratio, ρ_5=	$0.85 * \frac{f'_c}{f_y} * \left(1 - \sqrt{1 - 2 * \frac{R_{n5}}{0.85 * f'_c}}\right)$	=	0.0040
Area of Reinforcement, A_{s5}=	$\rho_5 * b_j * d_j$	=	0.44 in^2

Minimum Area of Reinforcement (According to Cl.10.5 of ACI318),

A_{s_min1}=	$\frac{3 * \sqrt{f'_c} * b_j * d_j}{f_y}$	=	0.35 in^2
A_{s_min2}=	$\frac{200 * b_j * d_j}{f_y}$	=	0.36 in^2
A_{s_min}=	MAX(A_{s_min1} ; A_{s_min2})	=	0.36 in^2
Required Area of Reinforcement, A_{sc5}=	MAX(A_{s5}; A_{s_min})	=	0.44 in^2
Provided Reinforcement, Bar=	SEL("ACI/Bar"; Bar;)	=	No.5
Provided Reinforcement, A_{sb}=	TAB("ACI/Bar"; Asb; Bar=Bar)	=	0.31 in^2
Number of Bars, n=			2
Vertical Reinforcement, A_{sc5_Prov}=	$A_{sb} * n$	=	0.62 in^2
Check Validity=	IF($A_{sc5\_Prov} \geq A_{sc5}$; "Valid"; "Invalid")	=	Valid

Design Summary

Area of Reinforcement for Exterior Negative Moment of End Span:	A_{sc1_Prov}	=	0.44 in^2
Area of Reinforcement for Positive Moment of End Span:	A_{sc2_Prov}	=	0.62 in^2
Area of Reinforcement for Interior Negative Moment of End Span:	A_{sc3_Prov}	=	0.93 in^2
Area of Reinforcement for Interior Negative Moment of Interior Span:	A_{sc4_Prov}	=	0.93 in^2
Area of Reinforcement for Interior Positive Moment of Interior Span:	A_{sc5_Prov}	=	0.62 in^2