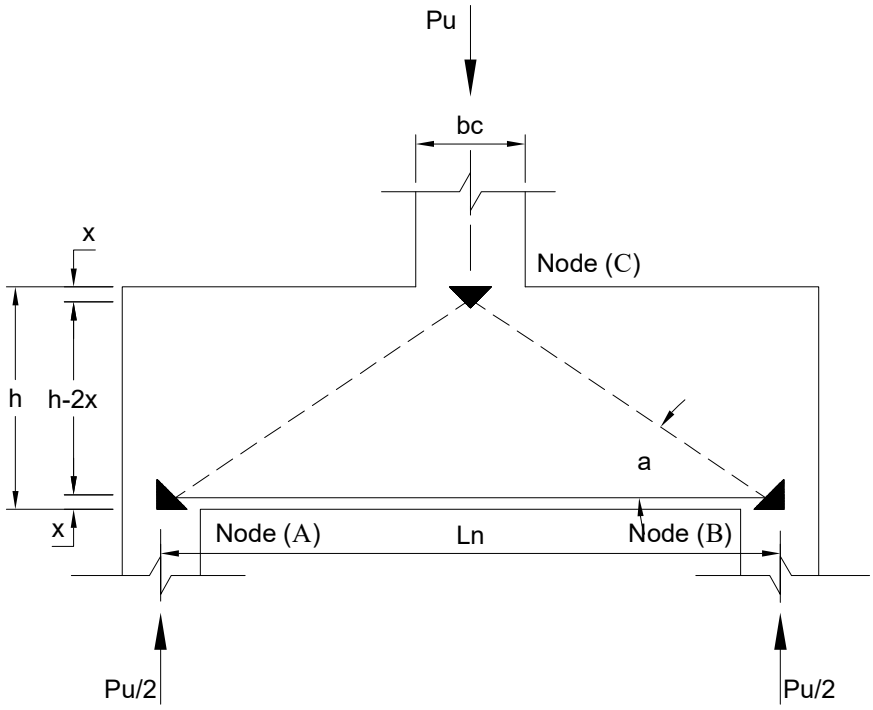
Design of Simple Span Deep Beam by the Strut-and-Tie Model as per ACI318 Appendix A



System

Width of Deep Beam, b=			7.0 in
Height of Deep Beam, h=			60.0 in
Concrete Cover, co=			1.25 in
Depth of Deep Beam, d=	h - co	=	58.75 in
End Distance of Truss Model, x=			5.0 in
Span of Deep Beam, L_n=			13.3 ft
Column Width, b_c=			20.0 in

Load

Dead Load for Column, P_D=			173.35 kips
Live Load for Column, P_L=			270.0 kips
Service Load for Column, P=	$1.0*P_D + 1.0*P_L$	=	443.4 kips
Ultimate Load for Column, P_u=	$1.2*P_D + 1.6*P_L$	=	640.0 kips

Material Properties

Concrete Strength, f'_c=		4000 psi
Yield Strength of Reinforcement, f_y=		60000 psi
Strength Reduction Factor (According to Cl.9.3.2 of ACI318), Φ=		0.75
Modification Factor for Lightweight Concrete, λ=		1.00
Friction Factor (According to Cl.11.6.4.3 of ACI318), μ= 1.4* λ	=	1.40

Check Deep Beam Requirments

Check on Height of Deep Beam Requirements (According to Cl.11.7.1 of ACI318),

R = IF(12*Ln/h<4; "Deep Beam Design"; "Normal Beam Design") = Deep Beam Design

Estimation of Truss Model

Length of Diagonal Strut, L1= $\sqrt{\left(\frac{L_n*12}{2}\right)^2+(h-2*x)^2}$ = 94.17 in

The Force in Diagonal Strut, Fs= $\frac{P_u}{2}*\frac{L1}{h-2*x}$ = 602.69 kips

The Force in Horizontal Tie, Ft= $\frac{P_u}{2}*\frac{0.5*L_n*12}{h-2*x}$ = 510.72 kips

Angle Between Diagonal Strut and Horizontal Tie, α= $\operatorname{atan}\left(\frac{h-2*x}{0.5*L_n*12}\right)$ = 32.07 °

Check Validity (According to Cl.A.2.5 of ACI318)= IF(α>25; "Valid"; "Invalid") = Valid

Calculation of Effective Concrete Strength

(According to Cl.3.2.2(a) of ACI318) Factor of, β_s= 0.75

Effective Concrete Strength (According to Eq.A-3 of ACI 318),

f_{ce1}= $0.85 * \beta_s * f'_c$ = 2550 psi

Calculation of Effective Concrete Strength for Nodal Zones

For Nodal Zone C Bounded by Three Struts (C-C-C Nodal Zone)

(According to Cl.A.5.2.1 of ACI318) Factor of, β_n= 1.00

Effective Concrete Strength (According to Eq.A-3 of ACI 318),

f_{ce2}= $0.85 * \beta_n * f'_c$ = 3400 psi

For Nodal Zone A&B Bounded by Three Struts (C-C-T Nodal Zone)

(According to Cl.A.5.2.2 of ACI318) Factor of, β_n= 0.80

Effective Concrete Strength (According to Eq.A-3 of ACI 318),

f_{ce3}= $0.85 * \beta_n * f'_c$ = 2720 psi

Minimum Effective Concrete Strength, f_{ce}= MIN(f_{ce1}; f_{ce2}; f_{ce3};) = 2550 psi

Check Strength at Node C

The Length of The Horizontal Face of Nodal Zone C,

Lhc= $\frac{P_u*1000}{\Phi*b_c*f_{ce}}$ = 16.73 in

The Length of Other Faces of Nodal Zone C,

Lc= $Lhc*\frac{Fs}{P_u}$ = 15.75 in

Check Strength at Node A&B

The Length of The Horizontal Face of Nodal Zone A,

Lha= $\frac{Ft*1000}{\Phi*b_c*f_{ce}}$ = 13.35 in

Width of Node at Support A,

La= $\frac{0.5*P_u*1000}{\Phi*b_c*f_{ce}}$ = 8.37 in

Calculation VL. and HZ. Reinforcement to Resist Splitting Diagonal Struts

1. Vertical Reinforcement

Provided Reinforcement, Bar=	SEL("ACI/Bar"; Bar;)	=	No.4
Provided Reinforcement, A_{sbv}=	TAB("ACI/Bar"; Asb; Bar=Bar)	=	0.20 in^2
Number of Bars, n_v=			4
Vertical Reinforcement, A_{sv}=	$A_{sbv} * n_v$	=	0.80 in^2
Provided Spacing between Bars, s=			11.00 in

Vertical Reinforcement (According to Eq.A4 of ACI318),

VL= $\frac{A_{sv}}{b_c*s}*\sin(90-\alpha)$ =0.00308

2. Horizontal Reinforcement

Provided Reinforcement, Bar=	SEL("ACI/Bar"; Bar;)	=	No.5
Provided Reinforcement, A_{sbh}=	TAB("ACI/Bar"; Asb; Bar=Bar)	=	0.31 in^2
Number of Bars, n_h=			2
Vertical Reinforcement, A_{sh}=	$A_{sbh} * n_h$	=	0.62 in^2
Provided Spacing between Bars, s=			11.00 in

Horizontal Reinforcement (According to Eq.A4 of ACI318),

HZ= $\frac{A_{sh}}{b_c*s}*\sin(\alpha)$ =0.00150

Check Validity=	IF(VL+HZ>0.003; "Valid"; "Invalid")	=	Valid

Calculation of Tension Reinforcement for Tie Connecting Node A&B

Required Reinforcement Area, A_{sreq}=	$\frac{Ft*1000}{\Phi*fy}$	=	11.35 in^2
Provided Reinforcement, Bar=	SEL("ACI/Bar"; Bar;)	=	No.8
Provided Reinforcement, A_{sb}=	TAB("ACI/Bar"; Asb; Bar=Bar)	=	0.79 in^2
Number of Bars, n=			16
Total Provided Area, A_{sprov}=	$n*A_{sb}$	=	12.64 in^2
Check Validity=	IF(Asprov>Asreq; "Valid"; "Invalid")	=	Valid

Design Summary

Provided Vertical Reinforcement, A_{sv}=	A_{sv}	=	0.80 in^2
Provided Horizontal Reinforcement, A_{sh}=	A_{sh}	=	0.62 in^2
Provided Tension Reinforcement, A_{sprov}=	A_{sprov}	=	12.64 in^2