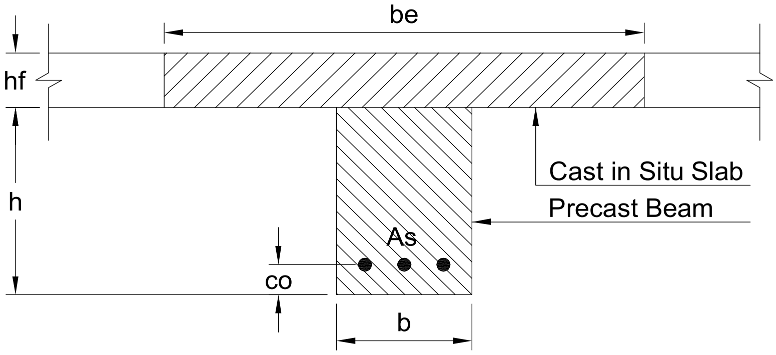
Calculation of Deflection of Shored Nonprestressed Simple Support Concrete Composite Section

As per ACI318-11 Chapter 9



System

Beam Span, L=			26.0 ft
Beam Spacing, S=			8.0 ft
Width of Precast Beam, b=			12.0 in
Depth of Precast Beam, h=			20.0 in
Thickness of Cast in Situ Slab, h_f=			4.0 in
Area of Tension Reinforcement for Precast Beam, A_s=			3.00 in^2
Concrete Cover for Precast Beam, co=			2.5 in
Effective Width of Slab, b_{e1}=	L*12 / 4	=	78.0 in
Effective Width of Slab, b_{e2}=	S*12	=	96.0 in
Effective Width of Slab, b_{e3}=	16*hf + b	=	76.0 in
Effective Width of Slab, b_e=	MIN(b_{e1}; b_{e2}; b_{e3})	=	76.0 in

Material Properties

Concrete Strength of Cast in Situ Slab, f'_{c1}=	3000 psi
Concrete Strength of Precast Beam, f'_{c2}=	4000 psi
Yield Strength of Reinforcement, f_y=	40000 psi
Modulus of Elasticity of Reinforcement, E_s=	29000000 psi
Modification Factor for Lightweight Concrete, λ=	1.00
Concrete Density, w_c=	150 psi

Load

Superimposed Dead Load, SDL=			10.00 psf
Live Load, LL=			75.00 psf
Dead Load per Unit Length for Slab, w_{d1}=	SDL*S + w_c*S*12*h_f/144	=	480.0 lb/ft
Dead Load per Unit Length for Beam, w_{d2}=	w_c*b*h/144	=	250.0 lb/ft
Live Load per Unit Length, w_l=	LL*S	=	600.0 lb/ft
Percentage of Sustained Live Load, Sus=			20 %

Bending Moment of Dead Load 1, M_{D1}= 1/1000 * w_{d1}*L^2/8 = 40.6 kip*ft

Bending Moment of Dead Load 2, M_{D2}= 1/1000 * w_{d2}*L^2/8 = 21.1 kip*ft

Bending Moment of Live Load, M_L= 1/1000 * w_l*L^2/8 = 50.7 kip*ft

Bending Moment of Sustained Load, M_{sus}= M_{D1} + M_{D2} + (Sus/100) * M_L = 71.8 kip*ft

Calculation of Modular Ratio

For Cast in Situ Slab:

Modulus of Elasticity of Concrete (According to Cl. 8.5.1 of ACI318),

E_{c1}= $w_c^{1.5} * 33 * \sqrt{f'_{c1}}$ = 3320561 psi

Modulus of rupture (According to Eq. 9-10 of ACI318), f_{r1}= $7.5 * \lambda * \sqrt{f'_{c1}}$ = 411 psi

For Precast Beam:

Modulus of Elasticity of Concrete (According to Cl. 8.5.1 of ACI318),

E_{c2}= $w_c^{1.5} * 33 * \sqrt{f'_{c2}}$ = 3834254 psi

Modulus of rupture (According to Eq. 9-10 of ACI318), f_{r2}= $7.5 * \lambda * \sqrt{f'_{c2}}$ = 474 psi

n_c= E_{c2} / E_{c1} = 1.15

n_s= E_s / E_{c2} = 7.56

Width of Slab considering relative Concrete Strength, bs= be/n_c = 66.09 in

Calculation of Moment of Inertia for Cracked Section

For Precast Beam

Effective Depth of Section, d= 17.5 in

I_{g1}= b*h^3/12 = 8000 in^4

B= b/(n_s*A_s) = 0.53 1/in

kd= $\frac{\sqrt{2*d*B+1}-1}{B}$ = 6.5 in

I_{cr1}= $\frac{b*kd^3}{3} + n_s * A_s * (d - kd)^2$ = 3842.8 in^4

For Composite Section

Effective Depth of Section, d= (h+hf) - co = 21.5 in

h1 = h + hf = 24.0 in

bs1 = bs - b = 54.1 in

Distance from Centroidal Axis of Gross Section to Tension Face,

yt= $h1 - \frac{1}{2} * \frac{bs1*hf^2 + b*h1^2}{bs1*hf + b*h1}$ = 16.3 in

I_{g2}= $\frac{bs1*hf^3}{12} + \frac{b*h1^3}{12} + bs1*hf*\left(h + \frac{hf}{2} - yt\right)^2 + b*h1*\left(yt - \frac{h1}{2}\right)^2$ = 26468.49 in^4

B= $bs/(n_s*As)$ = 2.91 1/in

kd= $\frac{\sqrt{2*d*B+1}-1}{B}$ = 3.5 in

I_{cr2}= $\frac{bs*kd^3}{3}+n_s*As*(d-kd)^2$ = 8292.9 in^4

Ratio between Cracking & Gross Inertia, r= $\left(\frac{I_{g1}}{I_{g2}}+\frac{I_{cr1}}{I_{cr2}}\right)/2$ = 0.383

Cracking Moment (According to Eq. 9-9 of ACI318),

Cracking Moment for Beam Section, M_{cr1}= $\frac{f_{r2}*I_{g1}}{h/2*12000}$ = 31.60 kip*ft

Cracking Moment for Beam Section, M_{cr2}= $\frac{f_{r2}*I_{g2}}{yt*12000}$ = 64.14 kip*ft

Effective Moment of Inertia for Composite Section,

$I_{e1,2}$= $\left(\frac{M_{cr1}}{M_{D1}+M_{D2}}\right)^3*I_{g1}+\left(1-\left(\frac{M_{cr1}}{M_{D1}+M_{D2}}\right)^3\right)*I_{cr1}$ = 4401 in^4

$I_{ed,l}$= $\left(\frac{M_{cr2}}{M_{D1}+M_{D2}+M_L}\right)^3*I_{g2}+\left(1-\left(\frac{M_{cr2}}{M_{D1}+M_{D2}+M_L}\right)^3\right)*I_{cr2}$ = 11670 in^4

Check Validity= IF($I_{e1.2}$<I_{g1}; "Valid"; "Invalid") = Valid

Short Term Deflection

Short Term Deflection of composite section Due to Dead Load,

$\Delta_{i1,2}$= $\frac{5*(M_{D1}+M_{D2})*L^2*12^3}{48*E_{c2}*I_{g2}/1000}$ = 0.074 in

Deflection Due to Shrinkage

For Simple Span, Ksh= 0.125

ρ= $\frac{A_s*100}{b*d}$ = 1.16 %

(According to Fig.10-3 of PCA Note on ACI318), Ash= 0.789

Time Dependant Shrinkage Strain, ε_{sht}= $400*10^{-6}$ =0.00040

Deflection Due to Shrinkage, Δ_{sh}= $0.64*Ksh*Ash*\varepsilon_{sht}*L^2*12^2*r/h$ = 0.047 in

Deflection Due to Creep

For No Compression Reinforcement Factor of, k_r= 0.85

Average Creep Coefficient (According to Cl.2.3.4 of ACI435), Cu= 1.67

Deflection Due to Creep, Δ_{cp}= $Cu*\Delta_{i1,2}*k_r$ = 0.105 in

Deflection Due to Live Load

Deflection Due to Live Load , Δ_L= $\frac{5*(M_{D1}+M_{D2}+M_L)*L^2*12^3}{48*E_{c2}*I_{ed,l}/1000} - \Delta_{i1,2}$ = 0.232 in

Deflection Due to Creep Sustained Live Load, $\Delta_{cp,\,L}$= $Cu*\frac{Sus}{100}*\Delta_L*k_r$ = 0.066 in

Total Long Term Deflection

Total Deflection, Δ_u= $\Delta_{i1,2}*3.53+\Delta_{sh}+\Delta_{cp}+\Delta_L$ = 0.65 in

Calculation Summary

Total Deflection, Δ_u= $\Delta_{i1,2}*3.53+\Delta_{sh}+\Delta_{cp}+\Delta_L$ = 0.65 in