Composite Section Stresses

Description	Composite Section Stress
References	PCI Design Handbook, 8th Edition
Design File	Heavy IT Beam

Eriksson software

Geometry

Height of precast section	$h_{pre} := 32 \ \text{in}$
Width of stem	$w_{stem} := 24 \ \text{in}$
Thickness of ledge	$t_{ledge} := 12 \ \text{in}$
Width of ledge	$w_{ledge} := 8 \ \text{in}$
Gross Cross Section Area	$A_g := 960 \ \text{in}^2$
Composite Cross Section Area	$A_c := 1124 \ \text{in}^2$
Area of Topping	$t_{top} := 2.75 \ \text{in}$
Centroid Location of the Gross Cross Section Measured from Bottom	$cg_{gb} := 14 \ \text{in}$
Centroid Location of the Gross Cross Section Measured from Top	$cg_{gt} := h_{pre} - cg_{gb} = 18 \ \text{in}$
Centroid Location of the Composition Section Measured from Bottom	$cg_{cb} := 16.659 \ \text{in}$
Centroid Location of the Composite Section Measured from Top	$cg_{ct} := \left(h_{pre} + t_{top} \right) - cg_{cb} = 18.091 \ \text{in}$
Height of the member	$h := 32 \ \text{in}$
Gross Section Moment of Inertia	$I_{zz.g} := 83200 \ \text{in}^4$
Composite Section Moment of Inertia	$I_{zz.c} := 132753.7 \ \text{in}^4$

Material Properties

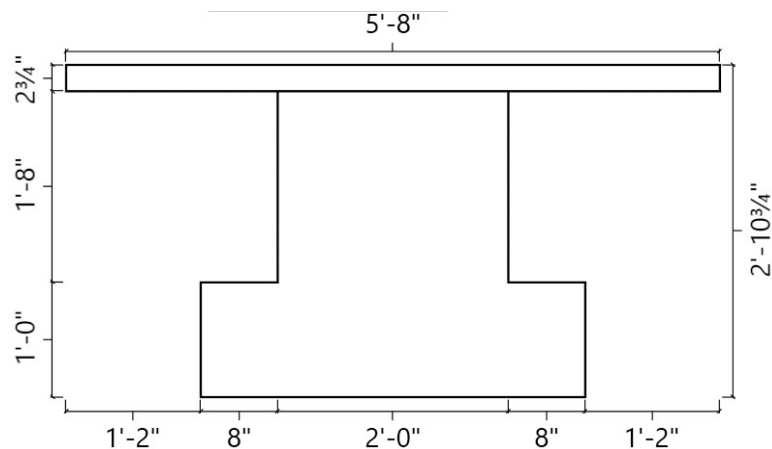|	
Initial Elast Modulus	$E_{ci} := 3586 \ \text{ksi}$
30-Day Elastic Modulus	$E_{cf} := 4695 \ \text{ksi}$
Relative Humidity	$R_h := 70$

Figure 1: Concrete Geometry of Composite Precast IT Beam

Prestress Properties

Number of strand in rows 1-4	$num_{row1} := 16$
	$num_{row2} := 14$

$$num_{row3} := 2$$

$$num_{row4} := 2$$

Centroid of strand in rows 1-4 measured from the bottom

$$cg_{row1} := 3 \text{ in}$$

$$cg_{row2} := 5 \text{ in}$$

$$cg_{row3} := 10 \text{ in}$$

$$cg_{row4} := 30 \text{ in}$$

Area of individual strand

$$A_{strand} := 0.167 \text{ in}^2$$

Strand elastic modulus

$$E_{ps} := 29000 \text{ ksi}$$

Strand ultimate Stress

$$f_{pu} := 270 \text{ ksi}$$

Initial strand stress

$$f_{pi} := 0.75 \cdot f_{pu} = 202.5 \text{ ksi}$$

Total area of strand

$$A_{ps} := A_{strand} \cdot \left(num_{row1} + num_{row2} + num_{row3} + num_{row4} \right) = 5.678 \text{ in}^2$$

Centroid of strand

$$cg_{st} := \frac{num_{row1} \cdot cg_{row1} + num_{row2} \cdot cg_{row2} + num_{row3} \cdot cg_{row3} + num_{row4} \cdot cg_{row4}}{num_{row1} + num_{row2} + num_{row3} + num_{row4}} = 5.824 \text{ in}$$
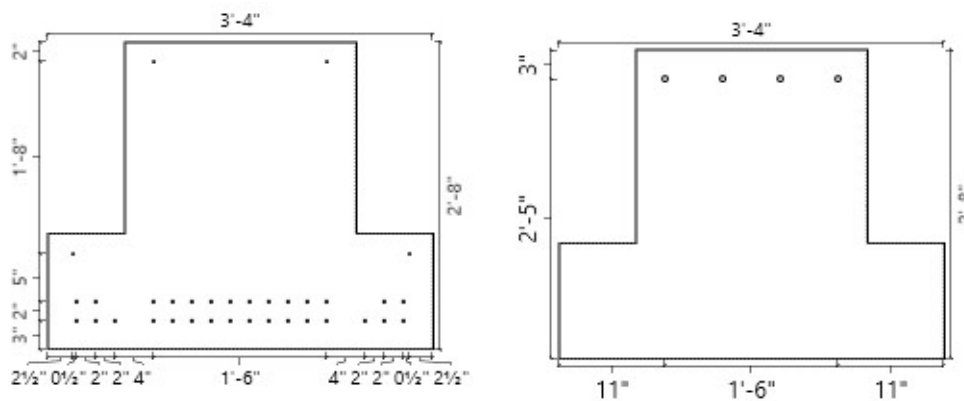

Figure 2: Reinforcement Locations of Strand (Left) and Rebar (Right)

Loading

Moment due to self weight

$$M_{SW} := 249.389 \text{ kip ft}$$

Moment due to non-composite dead load

$$M_{Dnc} := 498.778 \text{ kip ft}$$

Moment due to topping weight

$$M_{Dt} := 48.5789 \text{ kip ft}$$

Moment due to composite dead load

$$M_{Dc} := 997.556 \text{ kip ft}$$

Moment due to live load

$$M_{LL} := 748.167 \text{ kip ft}$$

Stresses from non composite loads

Strand eccentricity

$$e := cg_{gb} - cg_{st} = 8.1765 \text{ in}$$

Total moment on the non composite section

$$M_{nc} := M_{SW} + M_{Dnc} + M_{Dt} = 796.7459 \text{ kip ft}$$

Percent loss

$$Loss := 8.4828 \text{ \%}$$

Prestressing force

$$P_i := A_{ps} \cdot f_{pi} \cdot \left(1 - Loss \right) = 1052.2602 \text{ kip}$$

Prestressing moment

$$M_i := P_i \cdot e = 716.9812 \text{ kip ft}$$

Stress at bottom of precast from non composite loading

$$f_{nbp} := \frac{P_i}{A_g} + \frac{\left(M_i - M_{nc}\right) \cdot cg_{gb}}{I_{zz.g}} = 935.041 \; psi$$

Stress at top of precast from non composite loading

$$f_{ntp} := \frac{P_i}{A_g} + \frac{\left(M_{nc} - M_i\right) \cdot cg_{gt}}{I_{zz.g}} = 1303.186 \; psi$$

Stresses from composite loads

Total moment on the composite section

$$M_c := M_{Dc} + M_{LL} = 1745.723 \; kip \; ft$$

Stress due to composite loading at bottom of precast

$$f_{cbp} := -\frac{M_c \cdot cg_{cb}}{I_{zz.c}} = -2628.808 \; psi$$

Stress due to composite loading at top of precast

$$f_{ctp} := \frac{M_c \cdot \left(h_{pre} - cg_{cb}\right)}{I_{zz.c}} = 2420.8262 \; psi$$

Stress at bottom of topping

$$f_{tb} := \frac{M_c \cdot \left(h_{pre} - cg_{cb}\right)}{I_{zz.c}} = 2420.826 \; psi$$

Stress at top of topping

$$f_{tt} := \frac{M_c \cdot cg_{ct}}{I_{zz.c}} = 2854.779 \; psi$$

Stresses from all loads

$$f_{pb} := f_{nbp} + f_{cbp} = -1693.767 \; psi$$

Stress at bottom of precast

Stress at top of precast

$$f_{pt} := f_{ntp} + f_{ctp} = 3724.012 \; psi$$