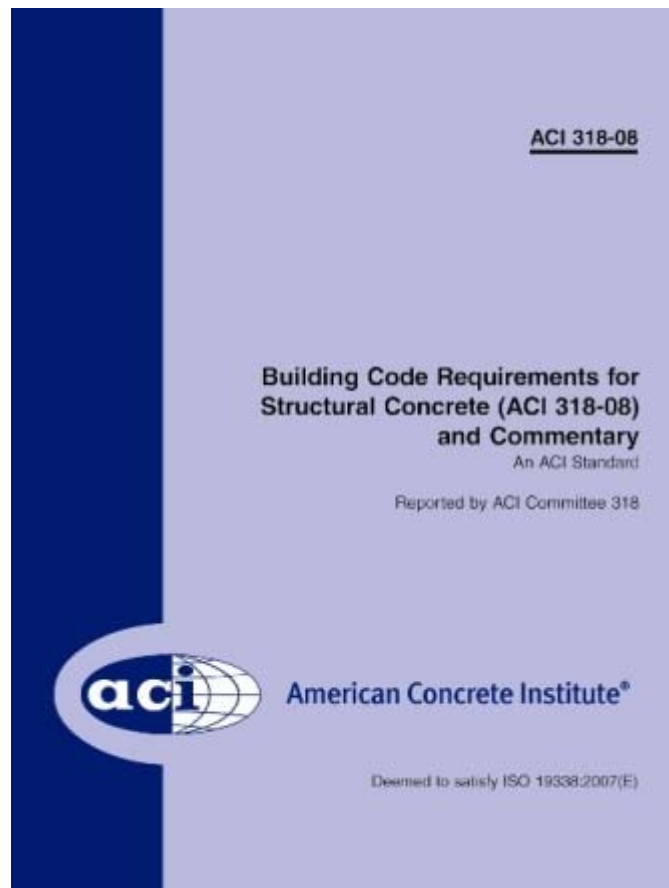


Lecture 2 – Introduction to ACI 318-08

The American Concrete Institute (ACI) is the governing agency for all concrete construction in the U.S. It was established in 1904 to serve and represent user interests in the field of concrete. The ACI publishes many different standards, but the most commonly referenced standard used by architects and engineers is the ACI 318 “Building Code Requirements for Structural Concrete.” It is updated every 3 years and the latest version is ACI 318-08 updated in 2008.

Almost all Building Codes, including the IBC, refer to ACI 318 as the basis for structural design of concrete members.



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Analysis and Design – General Considerations

Design Basis:

Similar to the LRFD method in steel, concrete is designed on the basis of “Ultimate” loading. This is often referred to as “Strength” design. Factors are applied to service loads in accordance with ACI 318 Section 9.2. These factored loads are used to determine maximum factored moments, shears and other effects which are then compared to the strength of the member. Strength of member is reduced by a strength reduction factor.

$$\text{Factored Load Effects} < (\phi)\text{Member Strength}$$

Load Factors:

- 1) $1.4(D + F)$
- 2) $1.2(D + F + T) + 1.6(L + H) + 0.5(L_r \text{ or } S \text{ or } R)$
- 3) $1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (1.0L \text{ or } 0.8W)$
- 4) $1.2D + 1.6W + 1.0L + 0.5(L_r \text{ or } S \text{ or } R)$
- 5) $1.2D + 1.0E + 1.0L + 0.2S$
- 6) $0.9D + 1.6W + 1.6H$
- 7) $0.9D + 1.0E + 1.6H$

where: D = service dead loads

L = service live load

L_r = service roof live load

S = snow loads

W = wind loads

R = rainwater loads

E = earthquake loads

F = fluid loads

H = soil loads

T = Temperature, creep, settlement, shrinkage loads

Strength Reduction Factors, ϕ		
Member Type:		ϕ
Tension member		0.90
Compression member	Spiral reinforced	0.75
	Tied reinforced	0.65
Flexural members (beams)		0.85
Shear and torsion		0.75
Bearing		0.65

Example 1

GIVEN: The interior column of a 2-story concrete-framed building has the following applied service loads to the 1200 ft² tributary area as shown:

Roof live load = 20 PSF

Snow load = 45 PSF

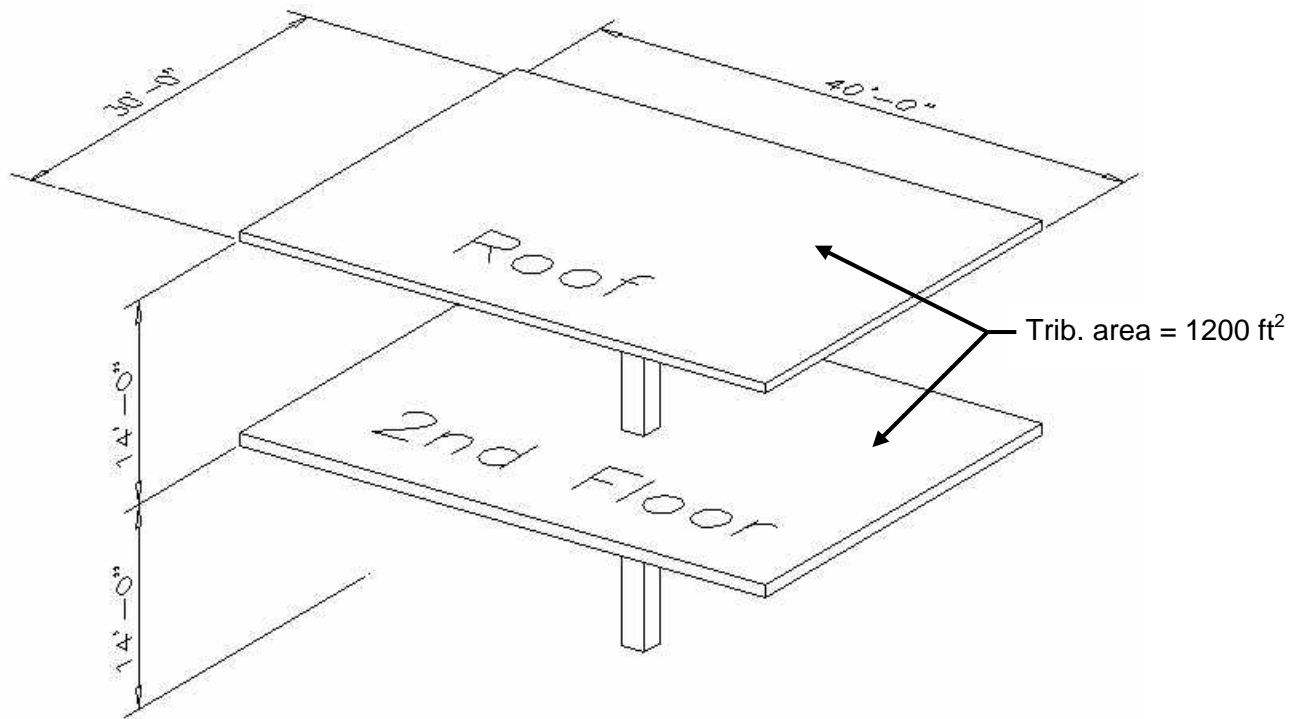
Roof superimposed dead load (not including 8" thick slab) = 16 PSF

Roof wind uplift = -8 PSF

Floor live load = 100 PSF

Floor superimposed dead load (not including 10" thick slab) = 42 PSF

REQUIRED: Determine the maximum factored load, P_u , at the bottom of the 20" x 20" square column.



Step 1 – Determine the total service loads on the roof:

- a) Service roof live load, $L_r = \text{Trib. area}(\text{Roof PSF})$
 $= 1200 \text{ ft}^2(20 \text{ PSF})$
 $= 24,000 \text{ lbs.}$
 $= 24.0 \text{ KIPS}$
- b) Service snow load, $S = \text{Trib. area}(\text{Floor PSF})$
 $= 1200 \text{ ft}^2(45 \text{ PSF})$
 $= 54,000 \text{ lbs.}$
 $= 54.0 \text{ KIPS}$
- c) Service wind uplift load, $W = 1200 \text{ ft}^2(-8 \text{ PSF})$
 $= -9,600 \text{ lbs.}$
 $= -9.6 \text{ KIPS}$
- d) Service roof dead load, $D_{\text{roof}} = (\text{Superimposed loads}) + (\text{slab wt.})$
 $= 1200 \text{ ft}^2(16 \text{ PSF}) + 1200 \text{ ft}^2\left(\frac{8''}{12}(150 \text{ PCF})\right)$

 $= 19,200 \text{ lbs.} + 120,000 \text{ lbs.}$
 $= 139,200 \text{ lbs.}$
 $= 139.2 \text{ KIPS}$

Step 2 – Determine the total service loads on the 2nd floor:

- a) Service floor live load, $L = 1200 \text{ ft}^2(100 \text{ PSF})$
 $= 120,000 \text{ lbs.}$
 $= 120.0 \text{ KIPS}$
- b) Service floor dead load, $D_{\text{floor}} = (\text{Superimposed loads}) + (\text{slab wt.})$
 $= 1200 \text{ ft}^2(42 \text{ PSF}) + 1200 \text{ ft}^2\left(\frac{10''}{12}(150 \text{ PCF})\right)$

 $= 50,400 \text{ lbs.} + 150,000 \text{ lbs.}$
 $= 200,400 \text{ lbs.}$
 $= 200.4 \text{ KIPS}$

Step 3 – Determine the total service dead load of the concrete column:

$$\begin{aligned} \text{Column dead load, } D_{\text{column}} &= \left(\frac{20''}{12}\right)\left(\frac{20''}{12}\right)(28 \text{ ft})(150 \text{ lb} / \text{ft}^3) \\ &= 11,667 \text{ lbs.} \\ &= 11.7 \text{ KIPS} \end{aligned}$$

Step 4 – Sum all service dead loads together:

$$\begin{aligned}\text{Total service dead load, } D &= D_{\text{roof}} + D_{\text{floor}} + D_{\text{column}} \\ &= 139.2 \text{ KIPS} + 200.4 \text{ KIPS} + 11.7 \text{ KIPS} \\ &= 351.3 \text{ KIPS}\end{aligned}$$

Step 5 – Check all 7 load factors, select “worst” case:

1) $1.4(D + F)$
 $1.4(351.3) = \mathbf{491.8 \text{ KIPS}}$

2) $1.2(D + F + T) + 1.6(L + H) + 0.5(L_r \text{ or } S \text{ or } R)$
 $1.2(351.3) + 1.6(120.0) + 0.5(54.0) = \mathbf{640.6 \text{ KIPS}} \leftarrow \text{USE}$

3) $1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (1.0L \text{ or } 0.8W)$ Wind uplift ignored – pos. loads only
 $1.2(351.3) + 1.6(54.0) + (1.0(120.0)) = \mathbf{628.0 \text{ KIPS}}$

4) $1.2D + 1.6W + 1.0L + 0.5(L_r \text{ or } S \text{ or } R)$
 $1.2(351.3) + 1.0(120.0) + 0.5(54) = \mathbf{568.6 \text{ KIPS}}$

5) $1.2D + 1.0E + 1.0L + 0.2S$
 $1.2(351.3) + 1.0(120) + 0.2(54.0) = \mathbf{552.4 \text{ KIPS}}$

6) $0.9D + 1.6W + 1.6H$
 $0.9(351.3) = \mathbf{316.2 \text{ KIPS}}$

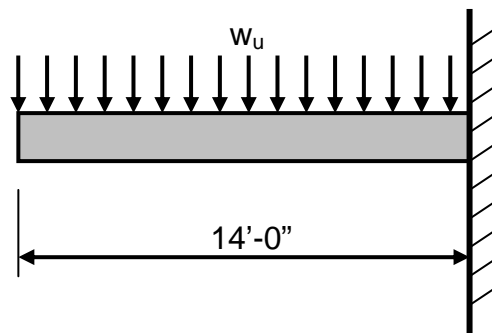
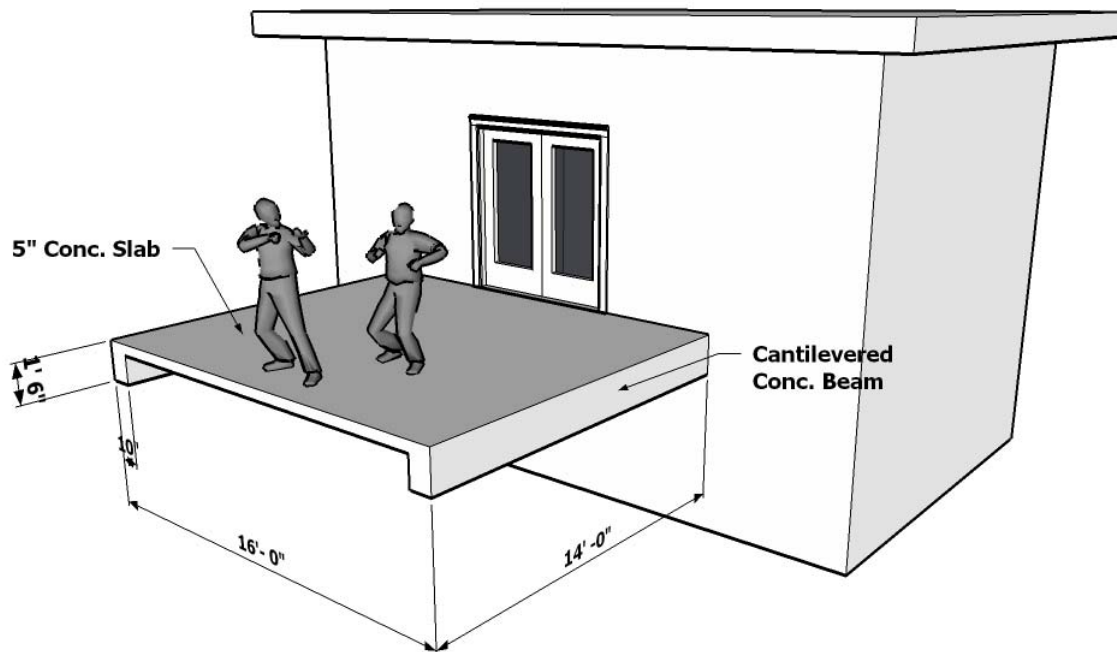
7) $0.9D + 1.0E + 1.6H$
 $0.9(351.3) = \mathbf{316.2 \text{ KIPS}}$

From above, $P_u = 640.6 \text{ KIPS}$

Example 2

GIVEN: The cantilevered floor balcony beam/slab as shown below. The service superimposed dead load (not including concrete) = 14 PSF and the superimposed service live load = 75 PSF.

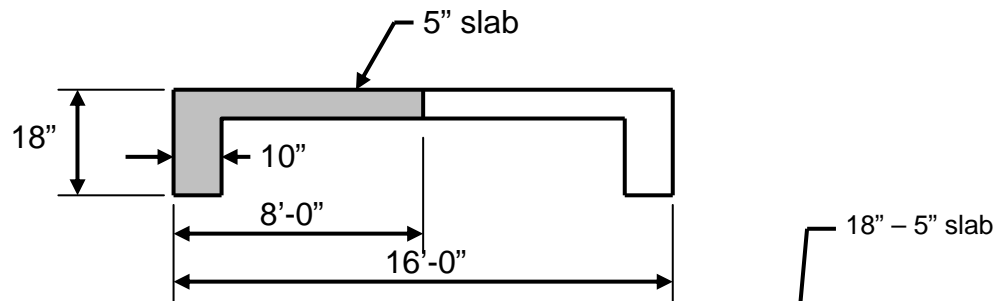
REQUIRED: Determine the maximum factored moment, M_u on the cantilevered beam.



Side view of cantilevered beam

Step 1 – Determine service dead load, D acting on beam:

Since there are 2 beams, each supports ½ of the balcony:



$$\begin{aligned} \text{Weight of concrete (shaded area)} &= \frac{150lb}{ft^3} \left((8') \left(\frac{5''}{12} \right) + \left(\frac{10''}{12} \right) \left(\frac{13''}{12} \right) \right) \\ &= 635.4 \text{ PLF} \end{aligned}$$

$$\begin{aligned} \text{Superimposed dead load on beam} &= 8'(14 \text{ PSF}) \\ &= 112 \text{ PLF} \end{aligned}$$

$$\begin{aligned} \text{Total dead load acting on beam, D} &= 635.4 \text{ PLF} + 112 \text{ PLF} \\ &= 747.4 \text{ PLF} \end{aligned}$$

Step 2 – Determine service live load, L acting on beam:

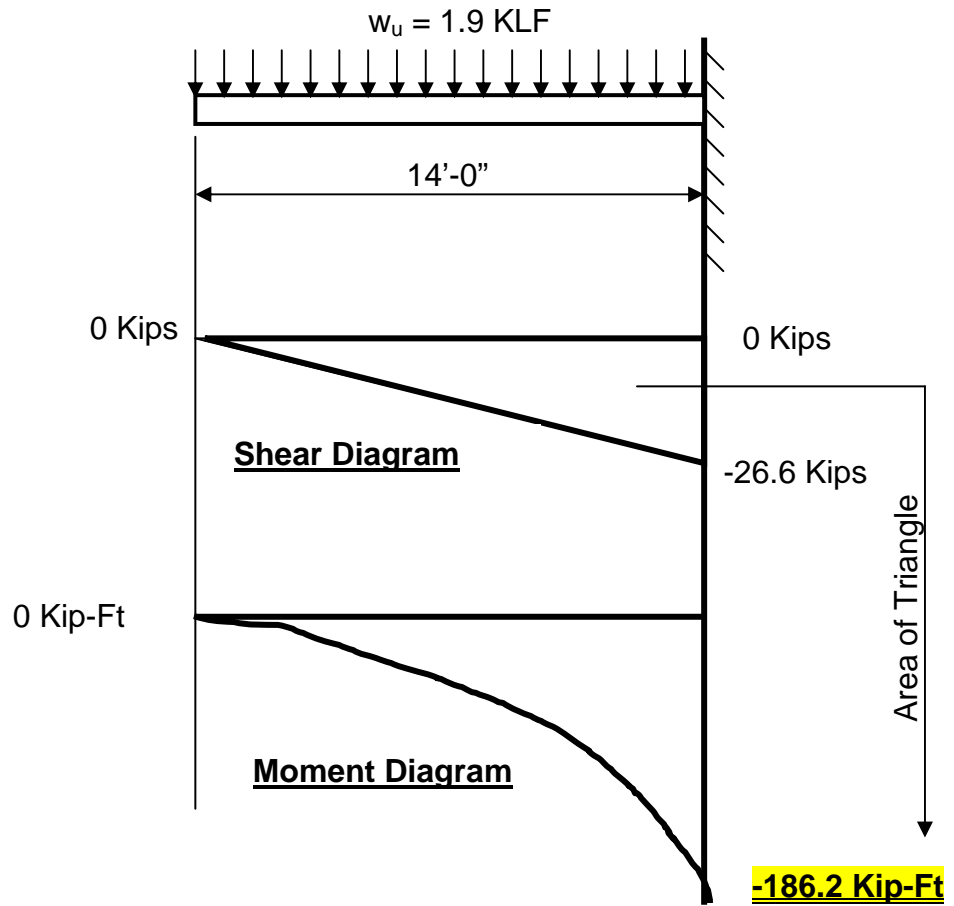
$$\begin{aligned} \text{Live load acting on beam} &= 8'(75 \text{ PSF}) \\ &= 600 \text{ PLF} \end{aligned}$$

Step 3 – Determine factored uniform load on beam, w_u:

By inspection, use load factor 1.2D + 1.6L

$$\begin{aligned} w_u &= 1.2(747.4 \text{ PLF}) + 1.6(600 \text{ PLF}) \\ &= 1857 \text{ PLF} \\ &= 1.9 \text{ KLF} \end{aligned}$$

Step 4 – Determine maximum factored moment on beam, M_u :



$$\begin{aligned} \text{For a cantilevered beam, } M_{\max} = M_u &= \frac{w_u L^2}{2} \\ &= \frac{(-1.9 \text{ KLF})(14'-0'')^2}{2} \end{aligned}$$

$$M_u = -186.2 \text{ KIP-FT}$$

NOTE: Negative sign indicates tension on TOP for cantilevers