EXAMPLE Indian IS 456-2000 Wall-001

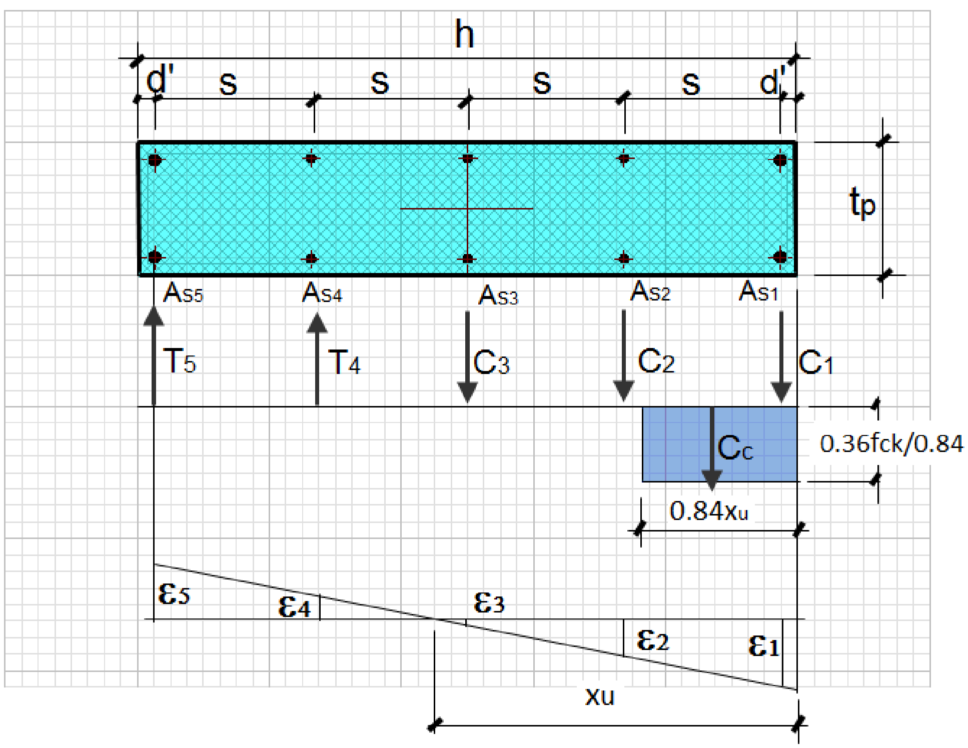
P-M INTERACTION CHECK FOR A WALL

EXAMPLE DESCRIPTION

The Demand/Capacity ratio for a given axial load and moment are tested in this example.

A reinforced concrete wall is subjected factored axial load P_u = 3146 kN and moments M_{uy} = 1875 kN-m. This wall is reinforced with two 30M bars at each end and 15M bars at 350 mm on center of each face. The total area of reinforcement is 4000 mm^2. The design capacity ratio is checked by hand calculations and the results are compared with ETABS program results.

GEOMETRY, PROPERTIES AND LOADING



Material Properties		Section Properties		Design Properties
E =	25000 MPa	tb =	300 mm	f'_c = 30 MPa
v =	0.2	h =	1500 mm	f_y = 460 MPa
		d' =	50 mm	
		s =	350 mm	
		As1= As5 = 2-30M (1400 mm^2)		
		As2, As3, As4 = 2-15M (400 mm^2)		

TECHNICAL FEATURES OF ETABS TESTED

- Concrete wall flexural demand/capacity ratio

RESULTS COMPARISON

Independent results are hand calculated and compared with ETABS design check.

Output Parameter	ETABS	Independent	Percent Difference
Wall Demand/Capacity Ratio	1.035	1.00	3.50%

COMPUTER FILE: INDIAN IS 456-2000 WALL-001

CONCLUSION

The ETABS results show an acceptable match with the independent results.

HAND CALCULATION

Wall Strength Determined as follows:

F'_c = 30MPa $\quad f_y$ = 460 MPa
b = 300mm $\quad h$ = 1500 mm

1) A value of e = 596 mm was determined using $e = M_u / P_u$ where M_u and P_u were taken from the ETABS test model PMM interaction diagram for the pier, P1. Values for M_u and P_u were taken near the balanced condition and large enough to produce a flexural D/C ratio very close to or equal to one. The depth to the neutral axis, c, was determined by iteration using an excel spreadsheet so that equations 1 and 2 below were equal.

2) From the equation of equilibrium:

$$P_n = C_c + C_s - T$$

where

$$C_c = \frac{0.36}{0.84} f_{\mathrm{ck}} ab = 0.4286 \bullet 30 \bullet 300a = 3857a, \text{ where } a = 0.84 x_u$$

$$C_s = \frac{A'_{s1}}{\gamma_s}\left(f_{s1} - 0.4286 f'_c\right) + \frac{A'_{s2}}{\gamma_s}\left(f_{s2} - 0.4286 f'_c\right) + \frac{A'_{s3}}{\gamma_s}\left(f_{s3} - 0.4286 f'_c\right)$$

$$T = \frac{A_{s4}}{\gamma_s} f_{s4} + \frac{A_{s5}}{\gamma_s} f_{s5}$$

$$P_{n1} = 3857a + \frac{A'_{s1}}{\gamma_s}\left(f_{s1} - 0.4286 f'_c\right) + \frac{A'_{s2}}{\gamma_s}\left(f_{s2} - 0.4286 f'_c\right) + \frac{A'_{s3}}{\gamma_s}\left(f_{s3} - 0.4286 f'_c\right) - \frac{A_{s4}}{\gamma_s} f_{s4} + \frac{A_{s5}}{\gamma_s} f_{s5} \qquad \text{(Eqn. 1)}$$

3) Taking moments about A_{s5}:

$$P_{n2} = \frac{1}{e'}\left[C_c\left(d - \frac{a}{2}\right) + C_{s1}\left(d - d'\right) + C_{s2}\left(d - d' - s\right) + C_{s3}\left(2s\right) - T_{s4}\left(s\right)\right] \qquad \text{(Eqn. 2)}$$

where $C_{s1} = \frac{A_{s1}}{\gamma_s}\left(f_{s1} - 0.4286 f_c' \right)$; $C_{s2} = \frac{A_{s2}}{\gamma_s}\left(f_{s2} - 0.4286 f_c' \right)$;
$C_{s3} = \frac{A_{s3}}{\gamma_s}\left(f_{s3} - 0.4286 f_c' \right)$; $T_{s4} = \frac{A_{s4}}{\gamma_s}\left(f_{s4} \right)$ and the bar strains and stresses are determined below.

The plastic centroid is at the center of the section and d'' = 700 mm

$$e' = e + d'' = 596 + 700 = 1296 \text{ mm.}$$

4) Using c = 917.3 mm (from iteration)

$$a = \beta_1 c = 0.84 \bullet 917.3 = 770.5 \text{ mm}$$

5) Assuming the extreme fiber strain equals 0.0035 and c = 917.3 mm, the steel stresses and strains can be calculated. When the bar strain exceeds the yield strain, then $f_s = f_y$:

$$\varepsilon_{s1} = \left(\frac{c - d'}{c}\right)0.0035 = 0.00331; \; f_s = \varepsilon_s E \le F_y; \quad f_{s1} = 460 \text{ MPa}$$

$$\varepsilon_{s2} = \left(\frac{c - s - d'}{c}\right)0.0035 = 0.00197 \qquad f_{s2} = 394.8 \text{ MPa}$$

$$\varepsilon_{s3} = \left(\frac{c - 2s - d'}{c}\right)0.0035 = 0.00064 \qquad f_{s3} = 127.7 \text{ MPa}$$

$$\varepsilon_{s4} = \left(\frac{d - c - s}{d - c}\right)\varepsilon_{s5} = 0.00070 \qquad f_{s4} = 139.4 \text{ MPa}$$

$$\varepsilon_{s5} = \left(\frac{d - c}{c}\right)0.0035 = 0.00203 \qquad f_{s5} = 406.5 \text{ MPa}$$

Substituting in Eqn. 1 and 2 and iterating the value of the neutral axis depth until the two equations are equal give

$$P_{n1} = 3146 \text{ kN}$$
$$P_{n2} = 3146 \text{ kN}$$

$$M_n = P_n e = 3146(596)/1000 = 1875 \text{ kN-m}$$