Tutorial 4
Mat Foundation (Solution)

1. The 20m * 30m size mat is constructed at 3.5m depth having basement for underground parking. The site consists of highly compressible saturated clay having cohesion of 30kN/m^2. If the mat carries the total load of 57000KN. Calculate the Factor of Safety.

Solution:

Given: B = 20m.

L = 30m.

D_f = 3.5m.

C = 30 kN/m^2.

Q = 57000 kN.

Taking γ = 18 kN/m^3.

$$F = \frac{CN_c}{Q/A - \gamma D_f} = \frac{C \times 5\left[1 + 0.2\frac{D_f}{B}\right]\left[1 + 0.2\frac{B}{L}\right]}{Q/A - \gamma D_f}$$

$$= \frac{5 \times 30 \times \left[1 + 0.2 \times \frac{3.5}{20}\right]\left[1 + 0.2 \times \frac{20}{30}\right]}{\frac{57000}{20 \times 30} - (18 \times 3.5)}$$

$$= 5.498$$

∴ The required FOS is 5.498.

2. A mat foundation of size 8m * 10m is resting at a depth of 5m. The foundation is on a saturated cohesive soil having undrained cohesion of 50 kPa. The soil has a unit weight of 19 kN/m³. Find the net safe bearing capacity using Skempton's Method.

Solution;

$B = 8m$.

$L = 10m$.

$D_f = 5m$.

$C_u = 50kPa = 50kN/m^2$.

we have;

$q_{nu} = C_u N_c$.

or, $q_{nu} = C_u N_c = 50 \times 5 \left[1 + 0.2 \times \frac{5}{8}\right] \left[1 + 0.2 \times \frac{8}{10}\right]$.

$= 326.25 kN/m^2$.

$q_{ns} = \frac{q_{nu}}{FOS}$.

$= \frac{326.25}{FOS}$.

Taking FOS as 3.

$q_{ns} = \frac{326.25}{3}$.

$= 108.75 kN/m^2$.

∴ The req^d. net safe bearing capacity is $108.75 kN/m^2$.

3. A raft foundation is 20m*30m. The raft is constructed over a soft clay having $c_u = 10\ kN/m^2$ and $\gamma = 19kN/m3$. If the live load and dead load on the raft are 100 MN. Find the depth of foundation given that, the foundation is fully compensated. Also determine the depth of foundation for a Factor of Safety of 3.

Solution;

Given, B = 20m.

L = 30m.

$C_u = 10\ kN/m^2$

$\gamma = 19\ kN/m^3$.

Given that total load $Q = 100 \times 10^6\ N = 100 \times 10^3\ kN$.

FOS = 3.

Now;

for fully compensated foundation;

$$\frac{Q}{A} = \gamma D_f.$$

$$\text{or, } \frac{100 \times 10^3}{20 \times 30} = 19 \times D_f.$$

$$\therefore D_f = 8.77m.$$

Calculation of depth of foundation for FOS = 3.

we have;

$$F = \frac{5c\left[1 + 0.2\frac{D_f}{B}\right]\left[1 + 0.2\frac{B}{L}\right]}{\frac{Q}{A} - \gamma D_f}.$$

$$\text{or, } 3 = \frac{5 \times 10 \times \left[1 + 0.2 \times \frac{D_f}{20}\right]\left[1 + 0.2 \times \frac{20}{30}\right]}{\frac{100 \times 10^3}{600} - 19 \times D_f}.$$

on solving, we get;

$$D_f = 7.70m.$$

4. A mat 18m * 22m in plan has its base 3 m below the surface of deposit of clay with a unit weight of 20 kN/m^3. The unconfined compressive strength of clay is 75 KN/m^2. The FOS against bearing capacity failure must be 3. Determine the total weight of building in the foundation that the raft can safely support.

Solution;

Given;
$B \times L = 18m \times 22m$.
$D_f = 3m$.
$\gamma = 20 kN/m^3$.
$q_u = 75 kN/m^2$.
$C_u = q_u/2 = 37.5 kN/m^2$.
$FOS = 3$.

Now;
we have; $q_{nu} = C_u N_c$.

$= C_u \times 5 \times \left[1 + 0.2 \frac{D_f}{B}\right] \left[1 + 0.2 \frac{B}{L}\right]$.

$= 37.5 \times 5 \left[1 + 0.2 \times \frac{3}{18}\right] \left[1 + 0.2 \times \frac{18}{22}\right]$.

$= 225.45 kN/m^2$.

we have; $FOS = \frac{q_{nu}}{Q/A - \gamma D_f}$.

or, $FOS = \frac{225.45}{\frac{Q}{18 \times 22} - (20 \times 3)}$

$\therefore Q = 53519.40 kN$.

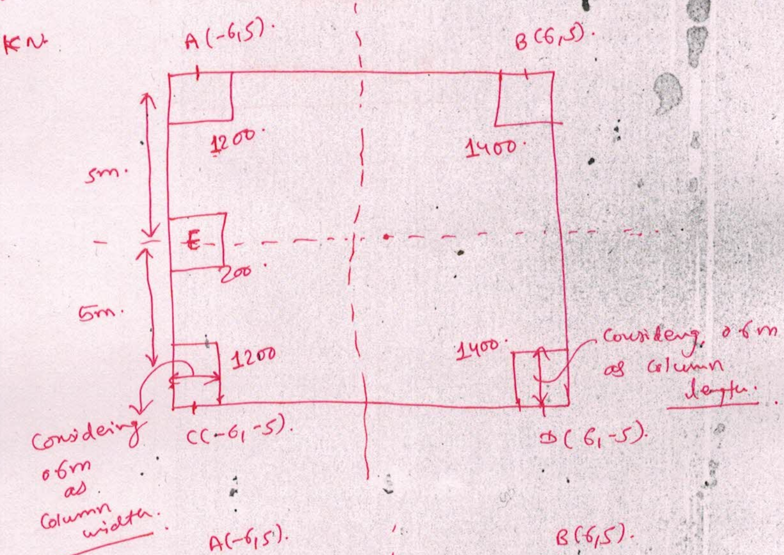
$\therefore$ The total weight of building in the foundation that the raft can safely support is 53519.40kN.

5. A rectangular mat foundation of 10m*12m is designed to support four main columns located at the corners of the mat. The coordinates of the centroids of the columns (with respect to the centroid of the mat) and the designated loads are as follows:

Columns	Coordinates (m,m)	Load (kN)
A	(-6,5)	1200
B	(6,5)	1400
C	(-6,-5)	1200
D	(6,-5)	1400

The fifth column is located in the middle between the columns A and C carries a load of 200kN. Using conventional method, determine average soil pressure between A and B.

Solution;



$Q = 1200 + 1400 + 1200 + 1400 + 200 = 5400\ kN$

$Area = 12.6 \times 10.6 = 133.56\ m^2$

Taking moment about face AC.

$Q \times \bar{x} = [1200 + 200 + 1200] \times 0.3 + [1400 + 1400] \times 12.3$

or, $5400 \times \bar{x} = 35220$

$\therefore \bar{x} = 6.522\ m$

$e_x = \frac{L}{2} - \bar{x}$

$= \frac{12.6}{2} - 6.522 = -0.222m$

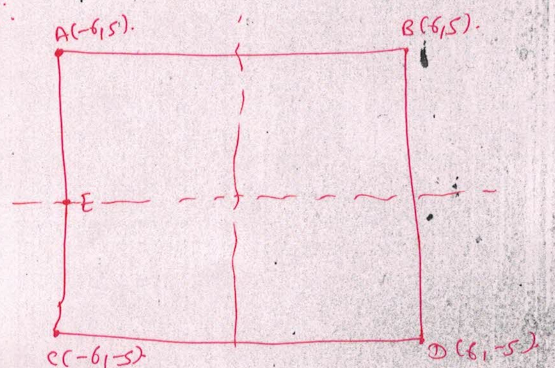
Taking moment about face CD,

$Q \times \bar{y} = [1200 + 1400] \times 0.3 + (200 \times 5.3) + [1200 + 1400] \times 10.3$

or, $5400 \times \bar{y} = 28620$

$\therefore \bar{y} = 5.30m$

$e_y = \frac{B}{2} - \bar{y} = \frac{10.6}{2} - \bar{y} = 0\ m$



(Try yourself without considering column thickness and total length and breadth as 12m and 10m respectively.)

we have;

$$q = \frac{Q}{A} \pm \frac{Q \times e_x}{I_{yy}} \times x \pm \frac{Q \times e_y}{I_{xx}} \times y$$

$$= \frac{5400}{133.56} + \frac{5400 \times (-0.222) \times x}{I_{yy}} + 0$$

Calculation of I_{yy}.

$$I_{yy} = \frac{10.6 \times 12.6^3}{12}$$

$$= 1767 m^4.$$

Now,

$$q = 40.43 + (-0.6784x).$$

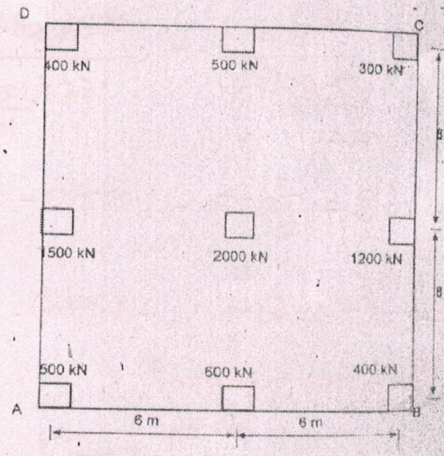
$$= 40.43 - 0.6784x.$$

for avg. soil pressure between A and B, we have;

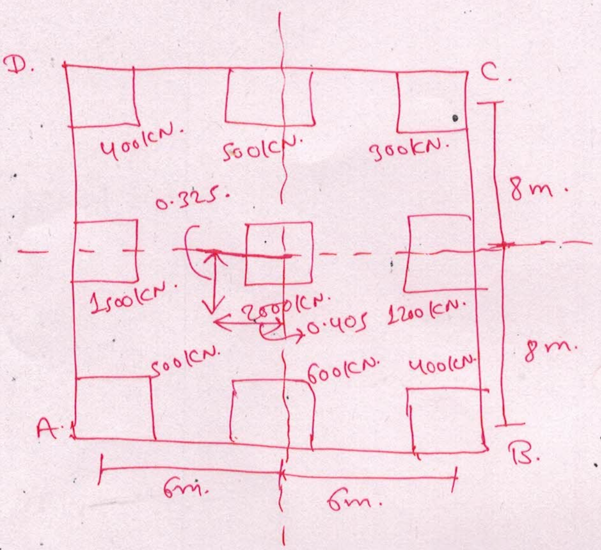
coordinate as (0,5).

$q = 40.43$ kN.

6. The plan of a mat foundation with 9 columns is shown in the figure below. Assuming that the mat is rigid, determine the soil pressure distribution at points A, B, C and D. All the columns are of the size 0.6m * 0.6m.



Solution:



Total load = 400+1500+500+600+2000+500+300+400+1200.

= 7400 kN.

Taking the moment about the face AD.

$$\bar{x} = \frac{[400+1500+500]\times 0.3 + [500+2000+600]\times 6.3 + [300+1200+400]\times 12.3}{7400}$$

= 5.89m.

$$e_x = \frac{12.6}{2} - 5.89 = 0.405\,m.$$

Taking the moment about the face AB.

$$\bar{y} = \frac{[500+600+400]\times 0.3 + [1500+2000+1200]\times 8.3 + (400+500+300)\times 16.3}{7400}$$

= 7.975m.

$$e_y = \frac{16.6}{2} - 7.975 = 0.325\,m.$$

Calculation of Pressure;

$$q = \frac{Q}{A} \pm \frac{Q \times e_x}{I_{yy}} \cdot x \pm \frac{Q e_y \times y}{I_{xx}}$$

$$\text{or, } q = \frac{7400}{12.6 \times 16.6} - \frac{7400 \times 0.405 \times x}{\frac{16.6 \times 12.6^3}{12}} - \frac{7400 \times 0.325 \times y}{\frac{16.6^3 \times 12.6}{12}}$$

$$\therefore q = 35.37 - 1.083x - 0.500y.$$

At A. $(x = -6.3m, y = -8.3m)$.

$q_A = 46.34 kN/m^2$.

At B. $(x = 6.3m, y = -8.3m)$

$q_B = 32.69 kN/m^2$.

At C. $(x = +6.3m, y = 8.3m)$.

$q_C = 24.397 kN/m^2$.

At D. $(x = -6.3m, y = 8.3m)$.

$q_D = 38.04 kN/m^2$.