

# اول فصل

## Site Investigation

### د ساحی تیست کول (تحقیقات)

Site Investigation



د معیاری ساختمان لپاره  
بڼه ساحه ټاکنه ضروره دی



Ketabton.com

?

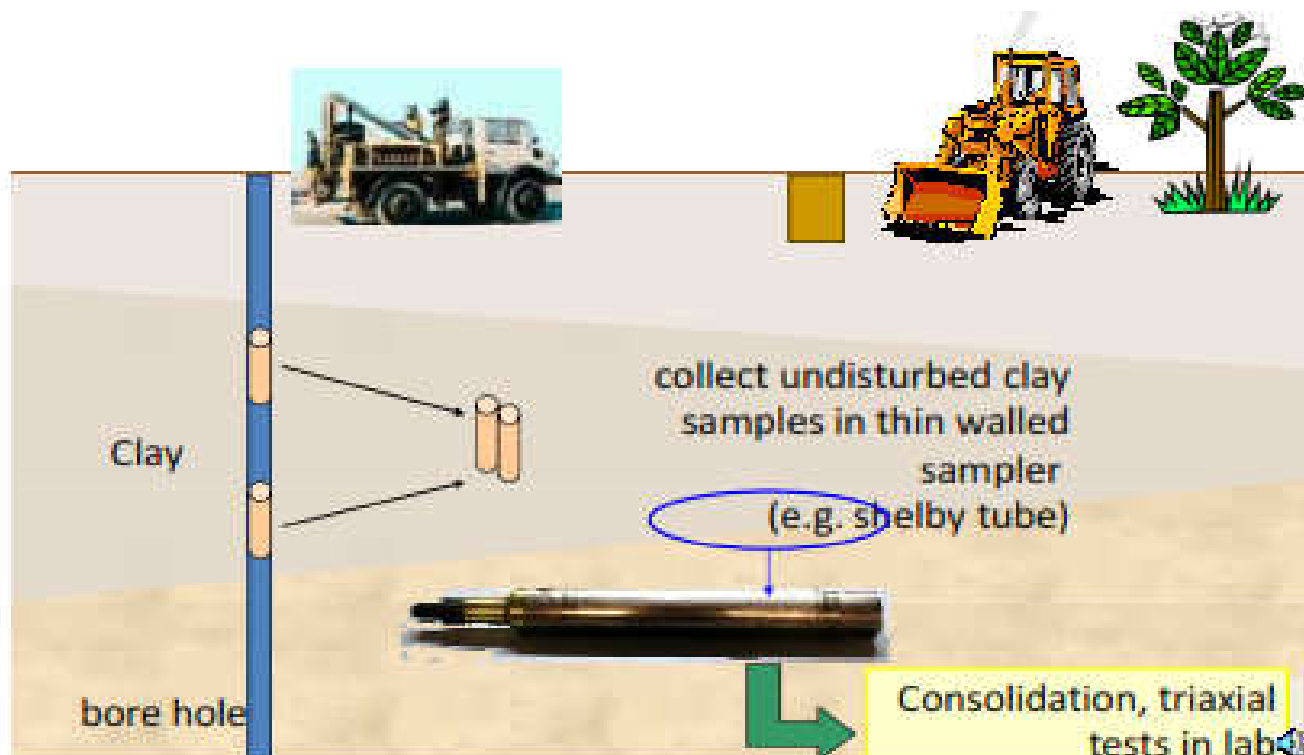
What is the soil problem ??

e.g., reactive clays, soft soils, sink holes, etc.

د خاورو مشکلات څه دی ???

فعالی خاوری ، نرمی خاوری او د ځمکې  
لاندي غارونه

## د ساحی ٹیسټول (تحقیقاتو) تکلاری



❖ مقدماتی (لمرنی) کتنه د ساحه نه

❖ د ساحی تحقیقات

❖ د ساحی په بارکی معلومات

❖ د موادو په لابراتوار کی ٹیسټ کول

❖ د جیوتکنیکل تحلیل او تفسیر

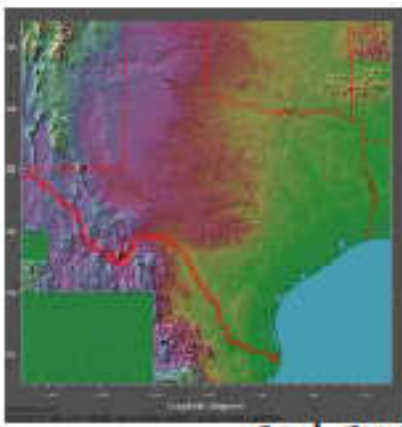
## ❖ د ساحی معلوماتو رپورټ جوړول

### ❖ مقدماتی (لمړنی) کتنه د ساحه نه



- a. ساحی ته لاسرسیه
- b. توپوگرافی
- c. جیولوجی معلومات
- d. د همسایه ګانو سره توافق
- e. د ترافیک کنترول
- f. د ساحه آبرو
- g. دغه ځمکې کوم بڼه والی لری
- h. د ساحه شیب (همواری)
- i. آوبه

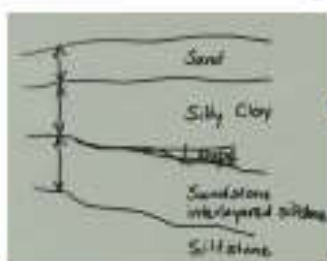
### ❖ د ساحی تحقیقات



- a. د ساحه توسعه پلان
- b. د ساحه ماسترپلان
- c. د محلی سایت نقشی
- d. د توپوگرافی نقشی
- e. د ستلاپت عکسونه (نقشه)
- f. د جیولوجیکی نقشه
- g. د ځمکې لاندی د ټیسټونو (تحقیقاتو) رپورټ

## ❖ د ځمکې لاندې تحقیقاتونه مطلب څه شي دی

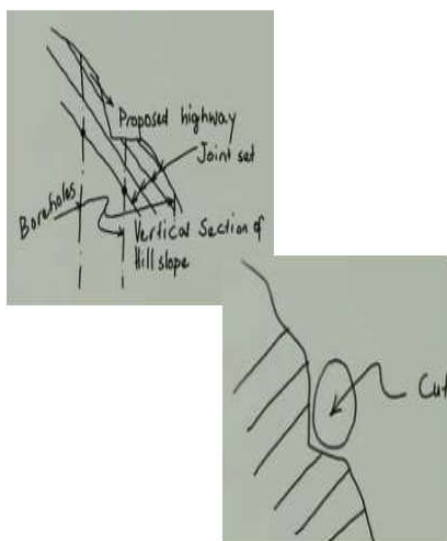
- a. د ځمکې قشرونه معلومول او مشخص کول دی
- b. د هر قشر تشریح او مشخصات معلومول
- c. د تراکم ، د هوا خلاوی، کثافت او نور مقدار معلومول
- d. د ځمکې عوارض پیدا کول لکه ، درزونه ، خلاوی ، ضیف قشرونه او نور
- e. د ساده او عالی آزمایشتو (تیسټونه)
- f. د هیدروژنولوژیکی شرایطو ارزیابی



## ❖ د بورنو (Bores) تعداد او عمق

تر نن پوری کوم معین تعداد او معین عمق په کوم سټنډرډ که نشته ،

۱- معمولاً تعداد د بورنو په لاندې لاملونو پور تړلی دی



a. د خاوره تغیرات

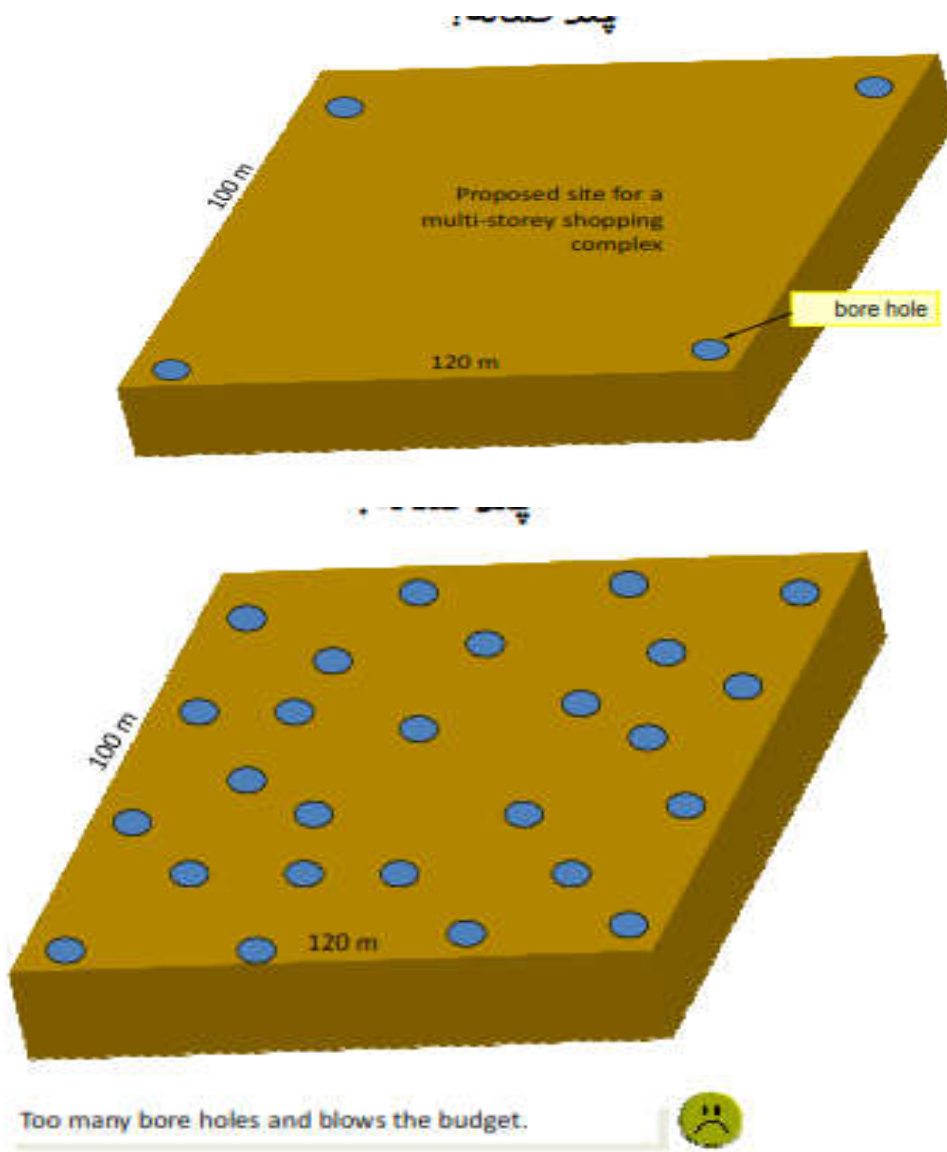
b. د بار زیاتوالی

c. د ساختمان مهم والی او حیاتی

## ۲- د تیرو تجروبو پر بنیاد

a. نرمی خاورو لپاره ۳۰ نه تر ۶۰ مترو

b. په سختو خاورو که امکان لری تر ۱۵۰ مترو پوری ورسیری



## په بعضی کتابونو که د لاندی جدولونو څخه استفادی کیری

| Subsurface Conditions       | Structure Footprint Area for Each<br>Exploratory Boring |                    |
|-----------------------------|---|--------------------|
|                             | (m <sup>2</sup> )                                       | (ft <sup>2</sup> ) |
| Poor quality and/or erratic | 100–300   | 1,000–3,000        |
| Average                     | 200–400   | 2,000–4,000        |
| High quality and uniform    | 300–1,000   | 3,000–10,000       |

| Subsurface Conditions | Minimum Depth of Borings<br>( <i>S</i> = number of stories;<br><i>D</i> = anticipated depth of foundation) |                  |
|-----------------------|--|------------------|
|                       | (m)  | (ft)             |
| Poor                  | $6 S^{0.7} + D$  | $20 S^{0.7} + D$ |
| Average               | $5 S^{0.7} + D$  | $15 S^{0.7} + D$ |
| Good                  | $3 S^{0.7} + D$  | $10 S^{0.7} + D$ |



| <b>Areas of investigation</b>                         | <b>Boring layout</b>  |
|---|---|
| New site of wide extent                               | Space preliminary borings 60 to 150 m (200 to 500 ft) apart so that area between any four borings includes approximately 10 percent of total area. In detailed exploration, add borings to establish geological sections at the most useful orientations. |
| Development of site on soft compressible soil         | Space borings 30 to 60 m (100 to 200 ft) at possible building locations. Add intermediate borings when building site is determined.   |
| Large structure with separate closely spaced footings | Space borings approximately 15 m (50 ft) in both directions, including borings at possible exterior foundation walls, at machinery or elevator pits, and to establish geologic sections at the most useful orientations.                                  |

|  |   |
|--|---|
| Low-load warehouse building of large area      | Minimum of four borings at corners plus intermediate borings at interior foundations sufficient to define subsoil profile.  |
| Isolated rigid foundation                      | For foundation 230 to 930 m <sup>2</sup> (2500 to 10,000 ft <sup>2</sup> ) in area, minimum of three borings around perimeter. Add interior borings, depending on initial results.  |
| Isolated rigid foundation                      | For foundation less than 230 m <sup>2</sup> (2500 ft <sup>2</sup> ) in area, minimum of two borings at opposite corners. Add more for erratic conditions.   |
| Major waterfront structures, such as dry docks | If definite site is established, space borings generally not farther than 15 m (50 ft), adding intermediate borings at critical locations, such as deep pump well, gate seat, tunnel, or culverts.  |
| Long bulkhead or wharf wall                    | Preliminary borings on line of wall at 60-m (200-ft) spacing. Add intermediate borings to decrease spacing to 15 m (50 ft). Place certain intermediate borings inboard and outboard of wall line to determine materials in scour zone at toe and in active wedge behind wall. |
| Cut stability, deep cuts, and high embankments | Provide three to five borings on line in the critical direction to provide geological section for analysis. Number of geologic sections depends on extent of stability problem. For an active slide, place at least one boring upslope of sliding area.                       |
| Dams and water-retention structures            | Space preliminary borings approximately 60 m (200 ft) over foundation area. Decrease spacing on centerline to 30 m (100 ft) by intermediate borings. Include borings at location of cutoff, critical spots in abutment, spillway, and outlet works.                           |
| <b>Source:</b> From NAVFAC DM-7.1, 1982.       |   |

| Areas of Investigation   | Recommended Boring Depth  |
|--|---|
| Bridge Foundations*<br>Highway Bridges   |   |
| 1. Spread Footings   | <p>For isolated footings of breadth <math>L_f</math> and width <math>\leq 2B_f</math>, where <math>L_f \leq 2B_f</math>, borings shall extend a minimum of two footing widths below the bearing level.</p> <p>For isolated footings where <math>L_f \geq 5B_f</math>, borings shall extend a minimum of four footing widths below the bearing level.</p> <p>For <math>2B_f \leq L_f \leq 5B_f</math>, minimum boring length shall be determined by linear interpolation between depths of <math>2B_f</math> and <math>5B_f</math> below the bearing level.</p>  |
| 2. Deep Foundations  | <p>In soil, borings shall extend below the anticipated pile or shaft tip elevation a minimum of 6 m, or a minimum of two times the maximum pile group dimension, whichever is deeper.</p> <p>For piles bearing on rock, a minimum of 3 m of rock core shall be obtained at each boring location to verify that the boring has not terminated on a boulder.</p> <p>For shafts supported on or extending into rock, a minimum of 3 m of rock core, or a length of rock core equal to at least three times the shaft diameter for isolated shafts or two times the maximum shaft group dimension, whichever is greater, shall be extended below the anticipated shaft tip elevation to determine the physical characteristics of rock within the zone of foundation influence.</p> |
| Retaining Walls  | <p>Extend borings to depth below final ground line between 0.75 and 1.5 times the height of the wall. Where stratification indicates possible deep stability or settlement problem, borings should extend to hard stratum.</p> <p>For deep foundations use criteria presented above for bridge foundations.</p>   |
| Roadways   | Extend borings a minimum of 2 m below the proposed subgrade level.  |
| Cuts   | Borings should extend a minimum of 5 m below the anticipated depth of the cut at the ditch line. Borings depths should be increased in locations where base stability is a concern due to the presence of soft soils, or in locations where the base of the cut is below groundwater level to determine the depth of the underlying pervious strata.  |
| Embankments  | Extend borings a minimum depth equal to twice the embankment height unless a hard stratum is encountered above this depth. Where soft strata are encountered which may present stability or settlement concerns the borings should extend to hard material.   |
| Culverts   | Use criteria presented above for embankments.   |
| *Note: Taken from AASHTO Standard Specifications for Design of Highway Bridges |   |



| <i>Geotechnical Features</i> | <i>Boring Layout</i>  |
|------------------------------|---|
| Bridge Foundations           | <p>For piers or abutments over 30 m wide, provide a minimum of two borings.</p> <p>For piers or abutments less than 30 m wide, provide a minimum of one boring.</p> <p>Additional borings should be provided in areas of erratic subsurface conditions.</p>   |
| Retaining Walls              | <p>A minimum of one boring should be performed for each retaining wall. For retaining walls more than 30 m in length, the spacing between borings should be no greater than 60 m. Additional borings inboard and outboard of the wall line to define conditions at the toe of the wall and in the zone behind the wall to estimate lateral loads and anchorage capacities should be considered.</p>   |
| Roadways                     | <p>The spacing of borings along the roadway alignment generally should not exceed 60 m. The spacing and location of the borings should be selected considering the geologic complexity and soil/rock strata continuity within the project area, with the objective of defining the vertical and horizontal boundaries of distinct soil and rock units within the project limits.</p>  |
| Cuts                         | <p>A minimum of one boring should be performed for each cut slope. For cuts more than 60 m in length, the spacing between borings along the length of the cut should generally be between 60 and 120 m.</p> <p>At critical locations and high cuts, provide a minimum of three borings in the transverse direction to define the existing geological conditions for stability analyses. For an active slide, place at least one boring upslope of the sliding area.</p> |
| Embankments                  | <p>Use criteria presented above for Cuts.</p>   |
| Culverts                     | <p>A minimum of one boring at each major culvert. Additional borings should be provided for long culverts or in areas of erratic subsurface conditions.</p>   |

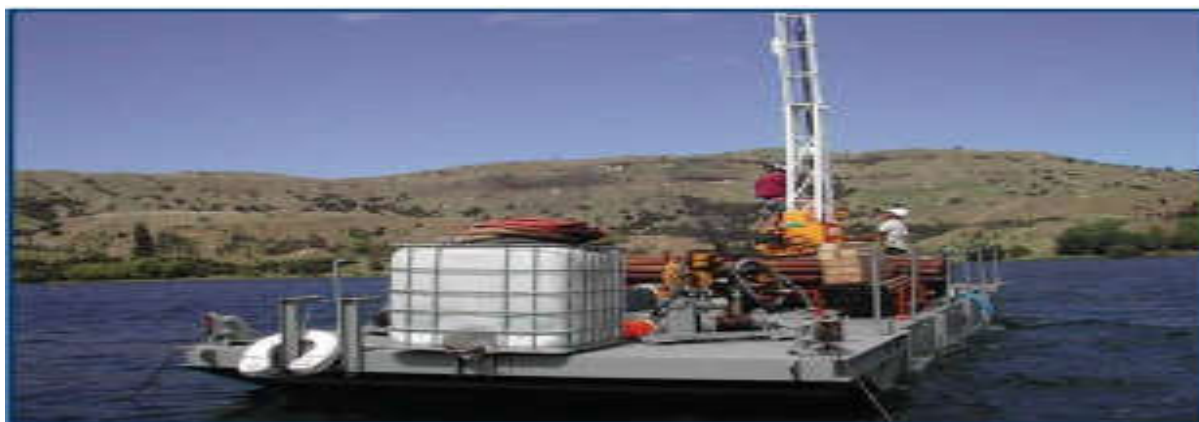
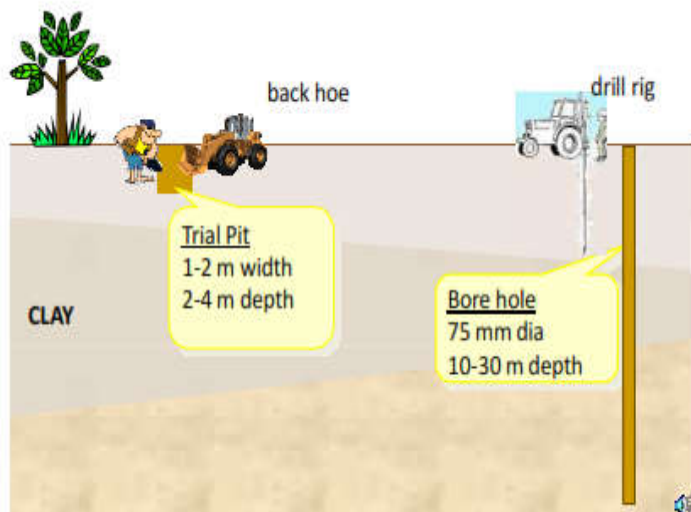
\*Also see *FHWA Geotechnical Checklist and Guidelines*; FHWA-ED-88-053

| Geotechnical Feature                         | Minimum Number of Borings   | Minimum Depth of Borings  |
|--|---|---|
| Structure foundation                         | One per substructure unit for width $\leq 30$ m<br><br>Two per substructure unit for width $> 30$ m   | Advance borings: (1) through unsuitable foundation soils (e.g., peat, highly organic soils, soft fine-grained soils) into competent material of suitable bearing capacity; (2) to a depth where stress increases due to estimated footing load is less than 10% of the existing effective soil overburden stress; or (3) a minimum of 3 m into bedrock if bedrock is encountered at shallower depth |
| Retaining walls                              | Borings alternatively spaced every 30 to 60 m in front of and behind wall   | Extend borings to depth of two times wall height or a minimum of 3 m into bedrock   |
| Culverts                                     | Two borings depending on length   | See structure foundations   |
| Bridge approach embankments over soft ground | For approach embankments placed over soft ground, one boring at each embankment to determine problems associated with stability and settlement of the embankment (note: borings for approach embankments are usually located at proposed abutment locations to serve a dual function)                           | See structure foundations<br><br>Additional shallow explorations at approach embankment locations are an economical means to determine depth of unsuitable surface soils  |
| Cuts and embankments                         | Borings typically spaced every 60 (erratic conditions) to 150 m (uniform conditions) with at least one boring taken in each separate landform.<br>For high cuts and fills, two borings along a straight line perpendicular to centerline or planned slope face to establish geologic cross section for analysis | Cut: (1) in stable materials, extend borings a minimum of 3 to 5 m below cut grade<br>(2) in weak soils, extend borings below cut grade to firm materials, or to the depth of cut below grade whichever occurs first<br><br>Embankment: extend borings to firm material or to depth of twice the embankment height  |

Source: Modified after FHWA, 1993, Soils and Foundations, Workshop Manual, 2nd ed., FHWA HI-88-009, National Highway Institute, NHI Course No. 13212, Revised, July.

## د نمونه راخستلو لاری

- a. لاس خورلی نمونه
- b. لاس نه خورلی نمونه



## اس پی ٹی

### Standard Penetration Test (SPT)



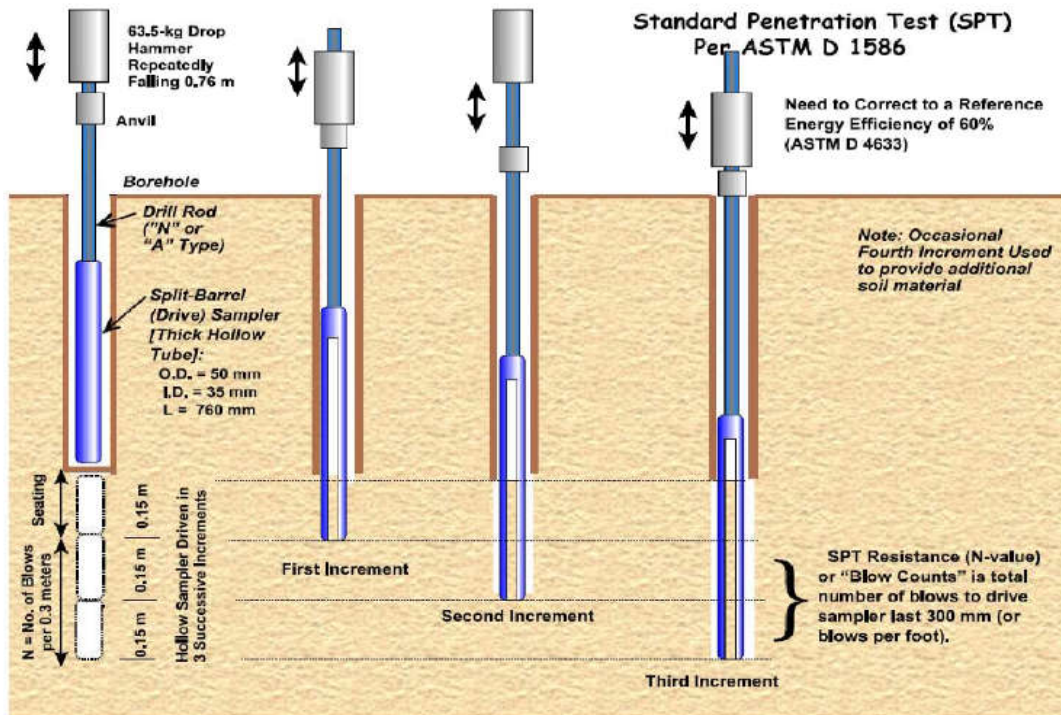
- a. پھ دی ازمایشت که یو اله چه د غوچیونکی میله په سر وصل دی په خُمکې که داخلیری اود هر قشر مقاومت او اندازگیری کوی
- b. دغه مقاومت نظر د جیوتکنیکل پارمٹرو پوری تړل دی لکه د اصطکاک زاویه ، د خاوری سختی او نور
- c. د ازمایشت ۸۰٪ د تعداد د دیزاین لپاره پکار کیری



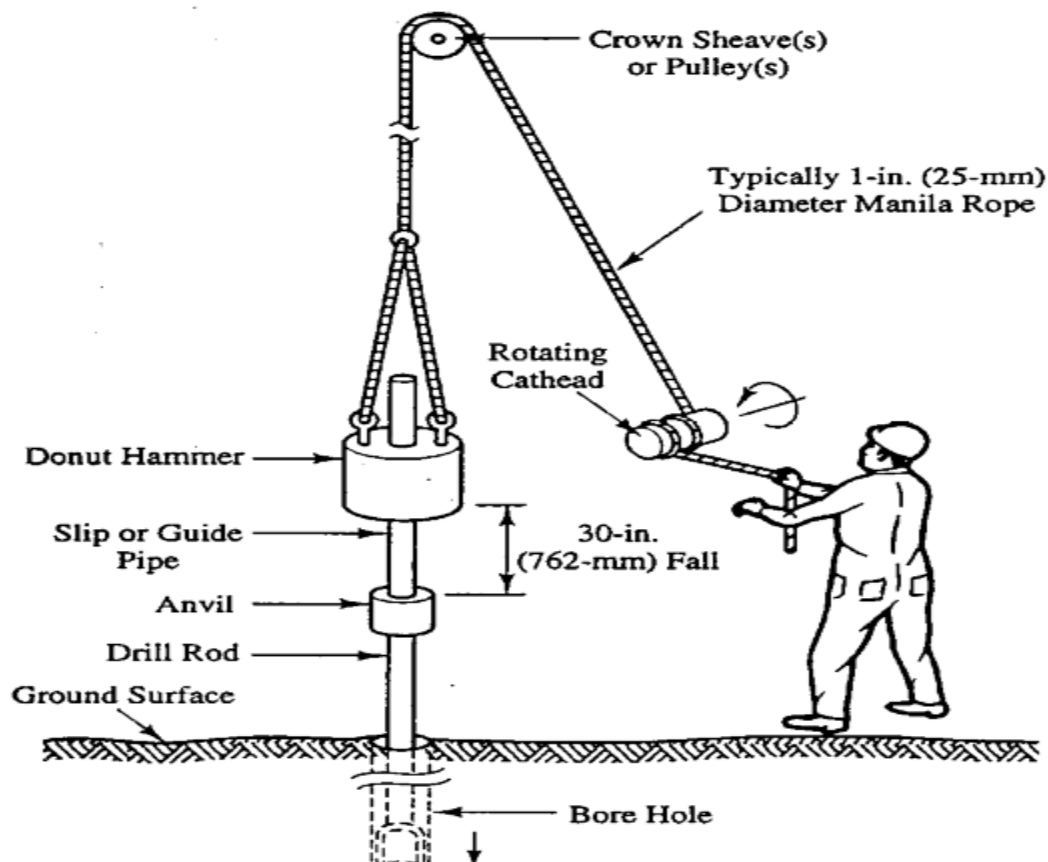
## SPT وسایل

- a. چکش ۶۳,۵ کیلوگرام
- b. د چکش سقوط ارتفاع ۷۶ سانتی متر
- c. د نمونہ راخستلو اندازہ ۴۵ سانتی متر
- d. د صرباتو تعداد د ہر ۱۵ سانتی متر نفوذ (داخلیدلو) لپارہ یادداشت شی

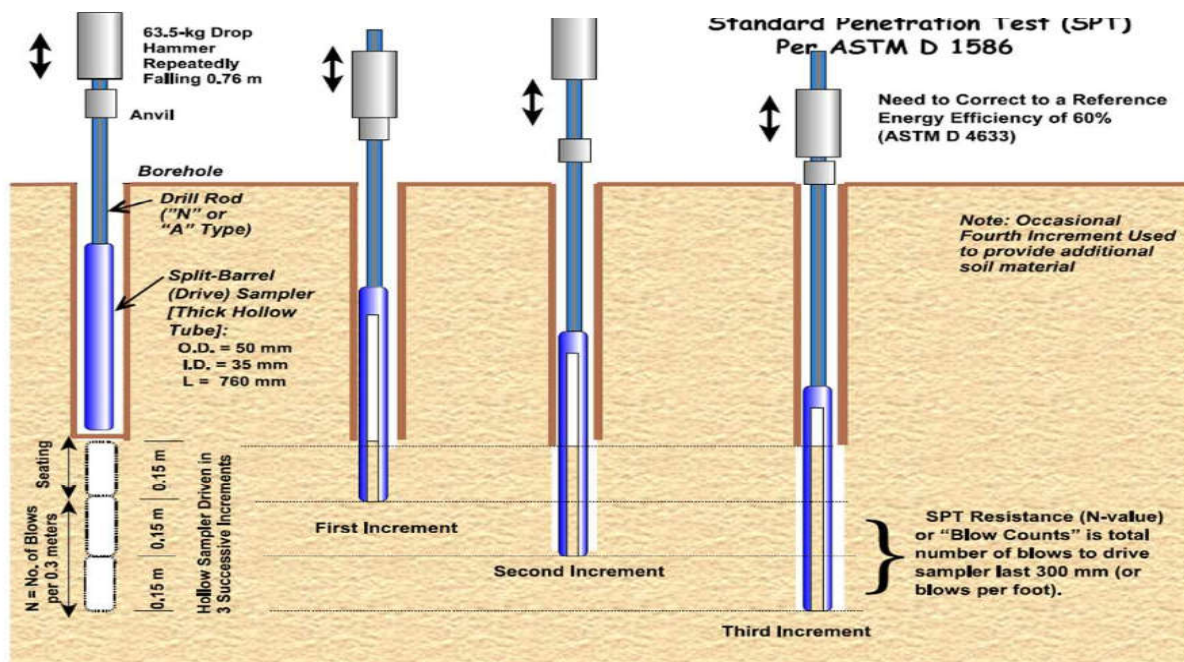
## SPT Hammer







- Obtain
- Simple
- Suitable
- Can be
- Available



## Standard Split Spoon Sampler



## د SPT خخه کوم موارد (ارقام) لاسته راوړه شوی؟

a.  $D_r$  (نسبتی تراکم) لاسته راوړو

b. تعیین  $\phi$

c.  $C$  تعیین

d. خاورو نوعیت او خواص

e. برشی امواجو سرعت

| Soil Type | $D_r$ | $\Psi$ | $K_0$ | OCR | $S_t$ | $s_u$ | $\phi$ | E,G | M | $G_0$ | k | $c_H$ |
|-----------|-------|--------|-------|-----|-------|-------|--------|-----|---|-------|---|-------|
| Sand      | 3-4   | 4      |       | 5   |       |       | 3-4    | 4-5 |   | 4-5   |   |       |
| Clay      |       | 5      | 5     | 4   | 5     | 3-4   | 5      | 4-5 | 5 | 4-5   | 5 | 5     |

1 = high; 2 = high to moderate; 3 = moderate; 4 = moderate to low; 5 = low;  
Blank = no applicability

Where:

$D_r$  Relative density

$\Psi$  State Parameter

E, G Young's and Shear moduli

OCR Over consolidation ratio

$s_u$  Undrained shear strength

$c_H$  Coefficient of consolidation

$\phi$  Friction angle

$K_0$  In-situ stress ratio

$G_0$  Small strain shear moduli

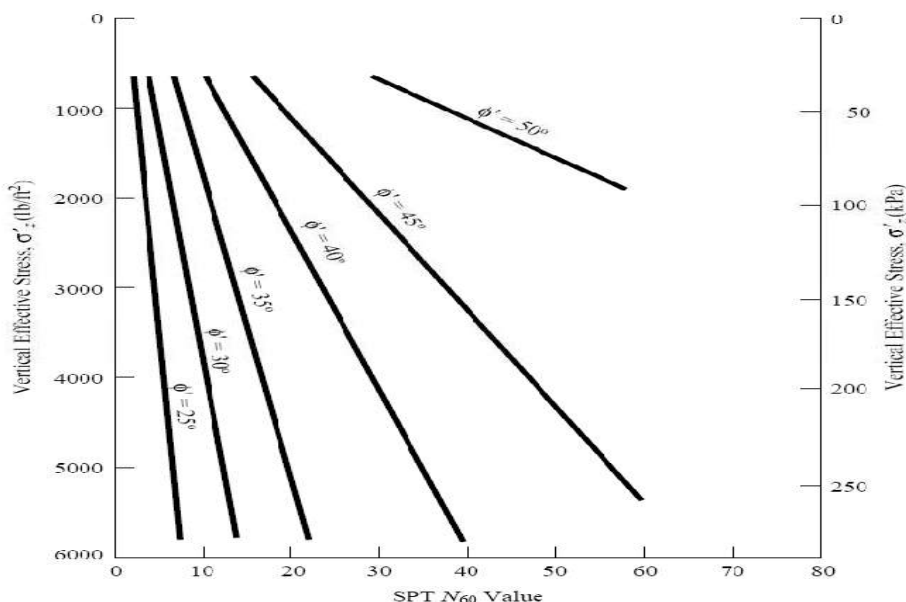
M (or  $m_v$ ) Compressibility

$S_t$  Sensitivity

k Permeability

| Type of Soil       | Pile Design | Bearing Capacity | Settlement | Compaction Control | Liquefaction |
|--------------------|-------------|------------------|------------|--------------------|--------------|
| Sand               | 2-3         | 1-2              | 2-3        | 2-3                | 1-2          |
| Clay               | 3-4         | 3-4              | 4-5        | 4-5                | 1-2          |
| Intermediate Soils | 3-4         | 2-3              | 3-4        | 4-5                | 1-2          |

Reliability rating: 1 = High; 2 = High to moderate; 3 = Moderate; 4 = Moderate to low; 5 = low



Schmertman(1975) :

$$\phi' = \tan^{-1} \left[ \frac{N_{60}}{12.2 + 20.3 \left( \frac{\sigma'_0}{P_a} \right)} \right]^{0.34}$$

$\sigma'_0$  = effective overburden stress

$P_a$  = atmospheric pressure in the same unit as  $\sigma'_0$

( $\approx 100 \text{ kN/m}^2$  or  $2000 \text{ lb/ft}^2$ )

Peck, Hanson and Thornburn (1974):

$$\phi'(\text{deg}) = 27.1 + 0.3(N_{60})_{\text{cor}} - 0.00054[(N_{60})_{\text{cor}}]^2$$

Hatanaka and Uchida (1996):

$$\phi' = \sqrt{20(N_{60})_{\text{cor}}} + 20$$

Stroud (1974):  $s_u = KN_{60}$

$s_u$  = Undrained shear strength of clay

K=Constant=3.5-6.5 kN/m<sup>2</sup> (0.507 – 0.942 lb/in<sup>2</sup>) average 4.4 kN/m<sup>2</sup>

Hara et al. (1971):  $c_u \text{ (kN/m}^2\text{)} = 29N_{60}^{0.5}$

Mayne and Kemper (1988):  $OCR = 0.193 \left( \frac{N_{60}}{\sigma'_v} \right)^{0.5}$

$\sigma'_v$  = effective vertical stress in MN/m<sup>2</sup>

**TABLE 7.4 Correlation of  $N$ ,  $N_{60}$ ,  $\gamma$ ,  $D_r$ , and  $\phi'$  for Coarse-Grained Soils**

| $N$   | $N_{60}$ | Compactness | $\gamma$ (kN/m <sup>3</sup> ) | $D_r$ (%) | $\phi'$ (degrees) |
|-------|----------|-------------|-------------------------------|-----------|-------------------|
| 0-4   | 0-3      | Very loose  | 11-13                         | 0-20      | 26-28             |
| 4-10  | 3-9      | Loose       | 14-16                         | 20-40     | 29-34             |
| 10-30 | 9-25     | Medium      | 17-19                         | 40-70     | 35-40*            |
| 30-50 | 25-45    | Dense       | 20-21                         | 70-85     | 38-45*            |
| >50   | >45      | Very dense  | >21                           | >85       | >45*              |

\*These values correspond to  $\phi'_{cr}$

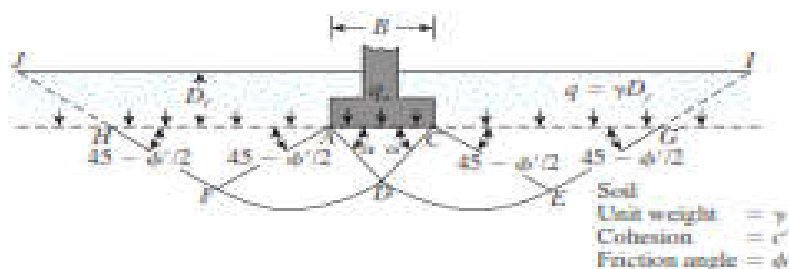
**TABLE 7.5 Correlation of  $N_{60}$  and  $s_u$  for Saturated Fine-Grained Soils**

| $N_{60}$ | Description     | $s_u$ (kPa) |
|----------|-----------------|-------------|
| 0-2      | Very soft       | <10         |
| 3-5      | Soft            | 10-25       |
| 6-9      | Medium          | 25-50       |
| 10-15    | Stiff           | 50-100      |
| 15-30    | Very stiff      | 100-200     |
| >30      | Extremely stiff | >200        |

## SPT Correlations in Granular Soils

| $(N)_{60}$ | $D_r$ (%) | consistency |
|------------|-----------|-------------|
| 0-4        | 0-15      | very loose  |
| 4-10       | 15-35     | loose       |
| 10-30      | 35-65     | medium      |
| 30-50      | 65-85     | dense       |
| >50        | 85-100    | very dense  |

not corrected for overburden





**Table 3.1** Terzaghi's Bearing Capacity Factors—Eqs. (3.4), (3.5), and (3.6) a From Kumbhojkar (1993)

| $\phi'$ | $N_c$ | $N_q$ | $N_{\gamma}^a$ | $\phi'$ | $N_c$  | $N_q$  | $N_{\gamma}^a$ |
|---------|-------|-------|----------------|---------|--------|--------|----------------|
| 0       | 5.70  | 1.00  | 0.00           | 26      | 27.09  | 14.21  | 9.84           |
| 1       | 6.00  | 1.10  | 0.01           | 27      | 29.24  | 15.90  | 11.60          |
| 2       | 6.30  | 1.22  | 0.04           | 28      | 31.61  | 17.81  | 13.70          |
| 3       | 6.62  | 1.35  | 0.06           | 29      | 34.24  | 19.98  | 16.18          |
| 4       | 6.97  | 1.49  | 0.10           | 30      | 37.16  | 22.46  | 19.13          |
| 5       | 7.34  | 1.64  | 0.14           | 31      | 40.41  | 25.28  | 22.65          |
| 6       | 7.73  | 1.81  | 0.20           | 32      | 44.04  | 28.52  | 26.87          |
| 7       | 8.15  | 2.00  | 0.27           | 33      | 48.09  | 32.23  | 31.94          |
| 8       | 8.60  | 2.21  | 0.35           | 34      | 52.64  | 36.50  | 38.04          |
| 9       | 9.09  | 2.44  | 0.44           | 35      | 57.75  | 41.44  | 45.41          |
| 10      | 9.61  | 2.69  | 0.56           | 36      | 63.53  | 47.16  | 54.36          |
| 11      | 10.16 | 2.98  | 0.69           | 37      | 70.01  | 53.80  | 65.27          |
| 12      | 10.76 | 3.29  | 0.85           | 38      | 77.50  | 61.55  | 78.61          |
| 13      | 11.41 | 3.63  | 1.04           | 39      | 85.97  | 70.61  | 95.03          |
| 14      | 12.11 | 4.02  | 1.26           | 40      | 95.66  | 81.27  | 115.31         |
| 15      | 12.86 | 4.45  | 1.52           | 41      | 106.81 | 93.85  | 140.51         |
| 16      | 13.68 | 4.92  | 1.82           | 42      | 119.67 | 108.75 | 171.99         |
| 17      | 14.60 | 5.45  | 2.18           | 43      | 134.58 | 126.50 | 211.56         |
| 18      | 15.62 | 6.04  | 2.59           | 44      | 151.95 | 147.74 | 261.60         |
| 19      | 16.56 | 6.70  | 3.07           | 45      | 172.28 | 173.28 | 325.34         |
| 20      | 17.69 | 7.44  | 3.64           | 46      | 196.22 | 204.19 | 407.11         |
| 21      | 18.92 | 8.26  | 4.31           | 47      | 224.55 | 241.80 | 512.84         |
| 22      | 20.27 | 9.19  | 5.09           | 48      | 258.28 | 287.85 | 650.67         |
| 23      | 21.75 | 10.23 | 6.00           | 49      | 298.71 | 344.63 | 831.99         |
| 24      | 23.36 | 11.40 | 7.08           | 50      | 347.50 | 415.14 | 1072.80        |
| 25      | 25.13 | 12.72 | 8.34           |         |        |        |                |

\*From Kumbhojkar (1993)

Table 3.2 Terzaghi's Modified Bearing Capacity Factors  $N_c$ ,  $N_q$ , and  $N_{\gamma}$ 

| $\phi'$ | $N_c$ | $N_q$ | $N_{\gamma}$ | $\phi'$ | $N_c$ | $N_q$ | $N_{\gamma}$ |
|---------|-------|-------|--------------|---------|-------|-------|--------------|
| 0       | 5.70  | 1.00  | 0.00         | 26      | 15.53 | 6.05  | 2.59         |
| 1       | 5.90  | 1.07  | 0.005        | 27      | 16.30 | 6.54  | 2.88         |
| 2       | 6.10  | 1.14  | 0.02         | 28      | 17.13 | 7.07  | 3.29         |
| 3       | 6.30  | 1.22  | 0.04         | 29      | 18.03 | 7.66  | 3.76         |
| 4       | 6.51  | 1.30  | 0.055        | 30      | 18.99 | 8.31  | 4.39         |
| 5       | 6.74  | 1.39  | 0.074        | 31      | 20.03 | 9.03  | 4.83         |
| 6       | 6.97  | 1.49  | 0.10         | 32      | 21.16 | 9.82  | 5.51         |
| 7       | 7.22  | 1.59  | 0.128        | 33      | 22.39 | 10.69 | 6.32         |
| 8       | 7.47  | 1.70  | 0.16         | 34      | 23.72 | 11.67 | 7.22         |
| 9       | 7.74  | 1.82  | 0.20         | 35      | 25.18 | 12.75 | 8.35         |
| 10      | 8.02  | 1.94  | 0.24         | 36      | 26.77 | 13.97 | 9.41         |
| 11      | 8.32  | 2.08  | 0.30         | 37      | 28.51 | 15.32 | 10.90        |
| 12      | 8.63  | 2.22  | 0.35         | 38      | 30.43 | 16.85 | 12.75        |
| 13      | 8.96  | 2.38  | 0.42         | 39      | 32.53 | 18.56 | 14.71        |
| 14      | 9.31  | 2.55  | 0.48         | 40      | 34.87 | 20.50 | 17.22        |
| 15      | 9.67  | 2.73  | 0.57         | 41      | 37.45 | 22.70 | 19.75        |
| 16      | 10.06 | 2.92  | 0.67         | 42      | 40.33 | 25.21 | 22.50        |
| 17      | 10.47 | 3.13  | 0.76         | 43      | 43.54 | 28.06 | 26.25        |
| 18      | 10.90 | 3.36  | 0.88         | 44      | 47.13 | 31.34 | 30.40        |
| 19      | 11.36 | 3.61  | 1.03         | 45      | 51.17 | 35.11 | 36.00        |
| 20      | 11.85 | 3.88  | 1.12         | 46      | 55.73 | 39.48 | 41.70        |
| 21      | 12.37 | 4.17  | 1.35         | 47      | 60.91 | 44.45 | 49.30        |
| 22      | 12.92 | 4.48  | 1.55         | 48      | 66.80 | 50.46 | 59.25        |
| 23      | 13.51 | 4.82  | 1.74         | 49      | 73.55 | 57.41 | 71.45        |
| 24      | 14.14 | 5.20  | 1.97         | 50      | 81.31 | 65.60 | 85.75        |
| 25      | 14.80 | 5.60  | 2.25         |         |       |       |              |

که د دغه ساحه تحقیقات په وخت شوی وایی!!!!



نو نن به د پیزا مانی داسی نه وایی

## دوهم فصل

### تهداب (Foundation)

تهداب د ساختمان هغه برخه ده چې پر ساختمان وارد شوی بار د خاورې هغه برخې ته لیردوي چې تهداب پرې پروت دی ، په دې کې د ځمکې د لیول له سطحې څخه لاندې برخې (Sub structure) او هغه اضافي برخې چې د ساختمان په شمول وزنونه لاندې خاورې ته لیردوي شاملې دي ،

او Sub Structure د تهاداب هغه برخه ده چې د ځمکې د لیول له سطحې د ساختمان د پورته برخې (Super structure) لپاره بنیاد یا قاعدې دنده تر سره کوي.

#### زیات د استفاده وړ اصطلاحات د تهاداب ډیزاین کې

1:- تهاداب (Foundation) - تهاداب د ساختمان هغه برخه ده چې پر ساختمان وارد شوی بار د خاورې هغه برخې ته لیردوي او د اساس په نوم هم یادېږي.

2:- سپل (Footing) - سپل عبارت د تهاداب له یو برخې څخه دی چې د ځمکې سر مستقیم په تماس کې دی

3:- د تهاداب خاوره (Foundation Soil) - عبارت د ځمکې خارجي سطح څخه دی چې په تهاداب وارد شوی بار احجار یا لاندې سطح ته انتقالوي.

4:- د خاورې برداشت قابلیت (د خاوره د زغم قوی) (Soil Bearing Capacity) - عبارت له هغه زغمونکې توان (توان تحمل پذیري) څخه دی چې خاورې یا احجار یې د قوی په مقابل کې لری

ترتیب کوونکی:- انجینر عبدالحمید (رسولی)  
مضمون: د تھداب دیزاین

6:- مجموعی شدت د فشار (Gross Pressure intensity)- عبارت له مجموعی فشار په تھداب

یا سپل باندی په شمول د ټولو وزنونو لکه د سپل وزن ، د پرکاری خاوری وزن او داسی نور

7:- خالص شدت د فشار (Net Pressure intensity)- عبارت له مجموعی شدت د فشار بیدون

دی اضافی خاورونه لکه

$$q_n = q - \gamma * D_f$$

q-مجموعی شدت د فشار

$\gamma$ -د خاوری حجم وزن

$D_f$ - د تھدات عمق (ژوروالی)

8:- نهایی د خاوری برداشت قابلیت (Ultimate Bearing Capacity)-نهایی برداشت قابلیت

عبارت له هغه اصغری مجموعی فشار په تھداب باندی دی چی خاوری برش ونکړی دی ، او  
نشست هم د مجازی حد څخه زیات نشی .

9:-مصوون خالص د خاوری برداشت قابلیت (Net Safe Bearing Capacity)- عبارت د نهایی

د خاوری برداشت قابلیت تقسیم پر یو د مصوونیت فکتور (Factor of Safety) باندی لکه :

$$q_{ns} = q_{ult} / SF$$

10:- مجازی فشار قابل د تحمل (زغم) (Allowable Bearing Pressure)-عبارت له خالص بار

شدت چه نه د خاوری برش باعث شی او نه د مجازی نشست له حد زیات شی .

# Bearing Capacity Analyses for foundation

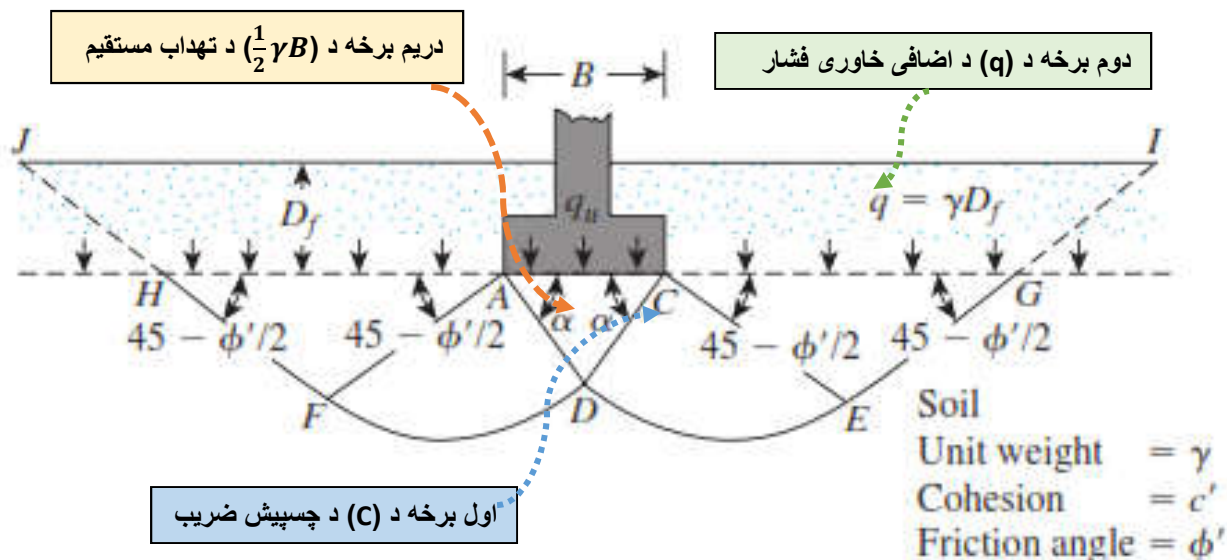
## تحليل برداشت قابليت د تھداب لپاره

ویسیک (Vesic 1940-1973) د پنځلس نه زیاتی معادلی (تیوری) دخاوری برداشت قابليت ته ترتیب کړی مکر یو معادلی (تیوری) هم نن سبا قابل د استفادی نه دی ، په همدی وختونو که ( 1943 ) پراندیل (Prandtl) په یو معادله (تیوری) کار شروع کړی مکر تکمیل وایی ونشو ، ترزاغی (Terzaghi) د پراندیل معادلی ته انکشاف ورکړ او یو معادلی د خاوری برداشت قابليت لپاره ترتیب کړل چه تر نن پور قابل د استفادی ده ، او دغه معادله (تیور) د ترزاغی معادله په نوم یادیری ، او د کم عمق تھدابونو لپاره کارول کیری ، یعنی  $H \leq B$  ، H-د تھداب ارتفاع او B- د تھداب عرض دی ، د ترزاغی معادله (تیوری) ته نور پوهانو لکه مایراوف ، هانسن او وزیک انکشاف او یا همدا شان معادله ترتیب کړی خو نن سبا د مایراوف معادله کوم چي د ترزاغی معادله ته یی د عمق ، شکل او د قوی زاویه په نظر که نیول دی ډیر زیات د استفادی وړ دی ، او دغه معادله د عمومی (ترزاغی-مایراوف) معادلی په نوم یادیری.



**1:- د ترزاغی (Terzaghi) معادلی (تیوری)**

د ترزاغی تیوری د لاندی شکل نه تشکیل شوی دی ، ترزاغی تہداب په دری برخو ویشل دی



او په نتیجه که لاندنی معادله تشکیل شوی

$$q = C + q + \frac{1}{2}\gamma B$$

په دغه معادله کی بعض مشکلات ولیدل شول ، لکه د برداشت قابلیت کم خودل ، د مسطیل ، مربع او دایروی شکل په نظر نه نیول او داسی نور ، بنا ترزاغی پسی له ډیرو تحقیقاتو یو د  $(N)$  ضریب د دریو برخو لپاره په جدول کی ترتیب کړی چه نظر د اصطحاکاک زاویه ( ) ته دی او معادلی په لاندی شکل شوی

د مستطیل او مسلسل تہدابونو لپاره

$$q_u = c'N_c + qN_q + \frac{1}{2}\gamma BN_\gamma \quad (\text{continuous or strip foundation}) \quad (3.3)$$

د مربعی تہدابونو لپاره

$$q_u = 1.3c'N_c + qN_q + 0.4\gamma BN_\gamma \quad (\text{square foundation}) \quad (3.7)$$

د دایروی تہدابونو لپاره

$$q_u = 1.3c'N_c + qN_q + 0.3\gamma BN_\gamma \quad (\text{circular foundation}) \quad (3.8)$$

نوت: لاندنی جدول صرف د ترزاغی معادلو لپاره استعمالیری او د یادونی وړ دی چه د اصطحاکاک زاو زیه ( ) او د چسپیش ضریب (C) په ساختمانی لابراتوارنو کی د یو خاص ماشین الاتو په واسطه پیدای کیری او د جیوتکنیکل رپورت په واسطه د انجینرانو ته ورکول کیری.

### 3.3 Terzaghi's Bearing Capacity Theory 139

**Table 3.1** Terzaghi's Bearing Capacity Factors—Eqs. (3.4), (3.5), and (3.6) a From Kumbhojkar (1993)

| $\phi'$ | $N_c$ | $N_q$ | $N_\gamma^a$ | $\phi'$ | $N_c$  | $N_q$  | $N_\gamma^a$ |
|---------|-------|-------|--------------|---------|--------|--------|--------------|
| 0       | 5.70  | 1.00  | 0.00         | 26      | 27.09  | 14.21  | 9.84         |
| 1       | 6.00  | 1.10  | 0.01         | 27      | 29.24  | 15.90  | 11.60        |
| 2       | 6.30  | 1.22  | 0.04         | 28      | 31.61  | 17.81  | 13.70        |
| 3       | 6.62  | 1.35  | 0.06         | 29      | 34.24  | 19.98  | 16.18        |
| 4       | 6.97  | 1.49  | 0.10         | 30      | 37.16  | 22.46  | 19.13        |
| 5       | 7.34  | 1.64  | 0.14         | 31      | 40.41  | 25.28  | 22.65        |
| 6       | 7.73  | 1.81  | 0.20         | 32      | 44.04  | 28.52  | 26.87        |
| 7       | 8.15  | 2.00  | 0.27         | 33      | 48.09  | 32.23  | 31.94        |
| 8       | 8.60  | 2.21  | 0.35         | 34      | 52.64  | 36.50  | 38.04        |
| 9       | 9.09  | 2.44  | 0.44         | 35      | 57.75  | 41.44  | 45.41        |
| 10      | 9.61  | 2.69  | 0.56         | 36      | 63.53  | 47.16  | 54.36        |
| 11      | 10.16 | 2.98  | 0.69         | 37      | 70.01  | 53.80  | 65.27        |
| 12      | 10.76 | 3.29  | 0.85         | 38      | 77.50  | 61.55  | 78.61        |
| 13      | 11.41 | 3.63  | 1.04         | 39      | 85.97  | 70.61  | 95.03        |
| 14      | 12.11 | 4.02  | 1.26         | 40      | 95.66  | 81.27  | 115.31       |
| 15      | 12.86 | 4.45  | 1.52         | 41      | 106.81 | 93.85  | 140.51       |
| 16      | 13.68 | 4.92  | 1.82         | 42      | 119.67 | 108.75 | 171.99       |
| 17      | 14.60 | 5.45  | 2.18         | 43      | 134.58 | 126.50 | 211.56       |
| 18      | 15.12 | 6.04  | 2.59         | 44      | 151.95 | 147.74 | 261.60       |
| 19      | 16.56 | 6.70  | 3.07         | 45      | 172.28 | 173.28 | 325.34       |
| 20      | 17.69 | 7.44  | 3.64         | 46      | 196.22 | 204.19 | 407.11       |
| 21      | 18.92 | 8.26  | 4.31         | 47      | 224.55 | 241.80 | 512.84       |
| 22      | 20.27 | 9.19  | 5.09         | 48      | 258.28 | 287.85 | 650.67       |
| 23      | 21.75 | 10.23 | 6.00         | 49      | 298.71 | 344.63 | 831.99       |
| 24      | 23.36 | 11.40 | 7.08         | 50      | 347.50 | 415.14 | 1072.80      |
| 25      | 25.13 | 12.72 | 8.34         |         |        |        |              |

<sup>a</sup>From Kumbhojkar (1993)

مثال : - يو مربع شكل تهاداب چې  $2m \times 2m$  ابعاد لري په پلان كې لرو او د ساحه جيوټكنيكل رپورټ له مخ لرو

د اصطحكاك زاويه  $\phi = 25^\circ$  د خاوري في واحد حجم وزن  $\gamma = 16.5 \frac{KN}{m^3}$

د خاوري چسپش ضريب  $C = 20 \frac{KN}{m^2}$  د مصوونيت ضريب  $SF=3$

د تهاداب عمق  $D_f=1.5m$

په تهاداب باندې دخاوري مجازي فشار ( $q_{all}$ ) او په تهاداب باندې د خاوري لخوا مجموعي قوي ( $Q$ ) پيدا كړي .

حل:  $q_u = 1.3c'N_c + qN_q + 0.4\gamma BN_\gamma$

كله چې د اصطحكاك زاويه  $\phi = 25^\circ$  وي د ترزاغي له جدول لرو

**Table 3.1** Terzaghi's Bearing Capacity Factors—Eqs. (3.4), (3.5), and (3.6) a From Kumbhojkar (1993)

| $\phi'$ | $N_c$ | $N_q$ | $N_\gamma^a$ | $\phi'$ | $N_c$  | $N_q$  | $N_\gamma^a$ |
|---------|-------|-------|--------------|---------|--------|--------|--------------|
| 20      | 17.69 | 7.44  | 3.64         | 46      | 196.22 | 204.19 | 407.11       |
| 21      | 18.92 | 8.26  | 4.31         | 47      | 224.55 | 241.80 | 512.84       |
| 22      | 20.27 | 9.19  | 5.09         | 48      | 258.28 | 287.85 | 650.67       |
| 23      | 21.75 | 10.23 | 6.00         | 49      | 298.71 | 344.63 | 831.99       |
| 24      | 23.36 | 11.40 | 7.08         | 50      | 347.50 | 415.14 | 1072.80      |
| 25      | 25.13 | 12.72 | 8.34         |         |        |        |              |

$$N_c=25.13$$

$$C' = 20 \frac{KN}{m^2}$$

$$\gamma = 16.5 \frac{kg}{m^3}$$

$$N_q=12.72$$

$$SF=3$$

$$q_u = 1.3c'N_c + qN_q + 0.4\gamma BN_\gamma$$

$$N_\gamma=8.34$$

$$D_f=1.5m$$

$$q_u = (1.3)(20)(25.13) + (1.5 \times 16.5)(12.72) + (0.4)(16.5)(2)(8.34)$$

$$= 653.38 + 314.82 + 110.09 = 1078.29 \text{ kN/m}^2$$

د مجازی فشار د پیدا کولو لپاره لرو

$$q_{all} = \frac{q_u}{SF} = \frac{1078.29}{3} \approx 359.5 \frac{KN}{m^2}$$

د مجموعی قوی لپاره لرو

$$Q_{all} = q_{all} \times B^2 = 359.5 \times 2^2 \approx 1438KN$$

2:- د مایراوف - ترزاغی معادله (عمومی معادله) د خاوری برداشت قابلیت لپاره

د ترزاغی معادلی ته مایراوف انکشاف ورکړی ، مایراوف د تھداب د شکل ، عمق ضرایب په معادله کی اضاف کړل . چې تیوری او معادلی د ترزاغی په شان دی نو نوی معادله به په لاندی ډول وی

$$q_u = c' N_c F_{cs} F_{cd} F_{ci} + q N_q F_{qs} F_{qd} F_{qi} + \frac{1}{2} \gamma B N_\gamma F_{\gamma s} F_{\gamma d} F_{\gamma i} \quad (3.19)$$

In this equation:

$c'$  = cohesion

$q$  = effective stress at the level of the bottom of the foundation

$\gamma$  = unit weight of soil

$B$  = width of foundation (= diameter for a circular foundation)

$F_{cs}, F_{qs}, F_{\gamma s}$  = shape factors      تھداب د شکل ضریب

$F_{cd}, F_{qd}, F_{\gamma d}$  = depth factors      تھداب د عمق ضریب

$F_{ci}, F_{qi}, F_{\gamma i}$  = load inclination factors

$N_c, N_q, N_\gamma$  = bearing capacity factors

د قوی د عمل زاویه ضریب

د برداشت قابلیت ضریب

د پورتنی معادلی د تهاداب شکل ، د تهاداب عمق او د قوی د عمل زاویه ضرایب د لاندنی روابطو په اساس سر لاسته راخی.

Shape

$$F_{cs} = 1 + \left(\frac{B}{L}\right)\left(\frac{N_q}{N_c}\right)$$

1: د شکل ضرایب

$$F_{qs} = 1 + \left(\frac{B}{L}\right) \tan \phi'$$

$$F_{\gamma s} = 1 - 0.4 \left(\frac{B}{L}\right)$$

2:- د عمق ضرایب څلور حالت لری چې په لاندی ډول دی

For  $\phi = 0$ :

$$\frac{D_f}{B} \leq 1$$

$$F_{cd} = 1 + 0.4 \left(\frac{D_f}{B}\right)$$

$$F_{qd} = 1$$

$$F_{\gamma d} = 1$$

اول حالت : د تهاداب عمق ( $D_f$ ) پر د تهاداب عرض ( $B$ ) کوچنی یا مساوی د 1 سره وی او د اصطحاکاک زاویه مساوی د صفر سره وی

For  $\phi' > 0$ :

$$\frac{D_f}{B} \leq 1$$

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan \phi'}$$

$$F_{qd} = 1 + 2 \tan \phi' (1 - \sin \phi')^2 \left(\frac{D_f}{B}\right)$$

$$F_{\gamma d} = 1$$

دوهم حالت : د تهاداب عمق ( $D_f$ ) پر د تهاداب عرض ( $B$ ) کوچنی یا مساوی د 1 سره وی او د اصطحاکاک زاویه له صفر څخه زیات وی



$$\text{For } \phi = 0: \quad \frac{D_f}{B} > 1$$

$$F_{cd} = 1 + 0.4 \underbrace{\tan^{-1}\left(\frac{D_f}{B}\right)}_{\text{radians}}$$

$$F_{qd} = 1$$

$$F_{\gamma d} = 1$$

دریم حالت : د تھداب عمق ( $D_f$ ) پر د تھداب عرض ( $B$ ) لوی د 1 وی او د اصطحکاک زاویه له صفر سره مساوی وی

$$\text{For } \phi' > 0: \quad \frac{D_f}{B} > 1$$

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan \phi'}$$

$$F_{qd} = 1 + 2 \tan \phi' (1 - \sin \phi')^2 \underbrace{\tan^{-1}\left(\frac{D_f}{B}\right)}_{\text{radians}}$$

$$F_{\gamma d} = 1$$

دریم حالت : د تھداب عمق ( $D_f$ ) پر د تھداب عرض ( $B$ ) لوی د 1 وی او د اصطحکاک زاویه له صفر سره مساوی وی

3:- قوی په زاویه ضرایب

نوټ: که قوی په تھداب باندي عمود وی نو ضرایب به مساوی د 1 سره وی

$$\text{Inclination} \quad F_{ci} = F_{qi} = \left(1 - \frac{\beta^\circ}{90^\circ}\right)^2$$

$$F_{\gamma i} = \left(1 - \frac{\beta}{\phi'}\right)$$

$\beta$  = inclination of the load on the foundation with respect to the vertical

مثال : - يو مربع شكل تهاداب چې  $2m \times 2m$  ابعاد لري په پلان كې لرو او د ساحه جيو تكنيكل رپورټ له مخ لروى

د اصطحكاك زاويه  $\phi = 25^\circ$  د خاورى في واحد حجم وزن  $\gamma = 16.5 \frac{KN}{m^3}$

د خاورى چسپيش ضريب  $C = 20 \frac{KN}{m^2}$  د مصوونيت ضريب  $SF=3$

د تهاداب عمق  $D_f=1.5m$

په تهاداب باندې دخاورى مجازى فشار ( $q_{all}$ ) او په تهاداب باندې د خاورى لخوا مجموعى قوى ( $Q$ ) پيدا كړى .

$$q_u = c' N_c F_{cs} F_{cd} F_{ci} + q N_q F_{qs} F_{qd} F_{qt} + \frac{1}{2} \gamma B N_\gamma F_{\gamma s} F_{\gamma d} F_{\gamma t} \quad \text{حل:}$$

كله چې د اصطحكاك زاويه  $\phi = 25^\circ$  وي د عمومى جدول نه لروى

Table 3.3 Bearing Capacity Factors

| $\phi'$ | $N_c$ | $N_q$ | $N_\gamma$ | $\phi'$ | $N_c$  | $N_q$  | $N_\gamma$ |
|---------|-------|-------|------------|---------|--------|--------|------------|
| 20      | 14.83 | 6.40  | 5.39       | 46      | 152.10 | 158.51 | 330.35     |
| 21      | 15.82 | 7.07  | 6.20       | 47      | 173.64 | 187.21 | 403.67     |
| 22      | 16.88 | 7.82  | 7.13       | 48      | 199.26 | 222.31 | 496.01     |
| 23      | 18.05 | 8.66  | 8.20       | 49      | 229.93 | 265.51 | 613.16     |
| 24      | 19.32 | 9.60  | 9.44       | 50      | 266.89 | 319.07 | 762.89     |
| 25      | 20.72 | 10.66 | 10.88      |         |        |        |            |

$$N_c=20.72, N_q=10.66, N_\gamma=10.88$$

قوى عمودى دى نو د قوى زاويه ضرايب به مساوى د 1 سره وي

او د تهاداب عمق او د تهاداب شكل ضرايب  $F_{ci} = F_{qi} = F_{\gamma i} = 1$  Since the load is vertical

1: اول باید  $\frac{D_f}{B}$  چک کرو

$$\frac{D_f}{B} = \frac{1.5}{2} = 0.75 < 1$$

نوٹ: تہداب شرایط د دوہم حالت لری نو لرو

1: د تہداب د شکل ضرایب

$$F_{cs} = 1 + \left(\frac{B}{L}\right)\left(\frac{N_q}{N_c}\right) = 1 + \left(\frac{2}{2}\right)\left(\frac{10.66}{20.72}\right) = 1.514$$

$$F_{qs} = 1 + \left(\frac{B}{L}\right) \tan\phi' = 1 + \left(\frac{2}{2}\right) \tan 25 = 1.466$$

$$F_{\gamma s} = 1 - 0.4\left(\frac{B}{L}\right) = 1 - 0.4\left(\frac{2}{2}\right) = 0.6$$

1: د تہداب د عمق ضرایب

$$F_{qd} = 1 + 2 \tan\phi' (1 - \sin\phi')^2 \left(\frac{D_f}{B}\right) = 1 + (2) (\tan 25) (1 - \sin 25)^2 \left(\frac{1.5}{2}\right) = 1.233$$

$$F_{cd} = F_{qd} - \frac{1 - F_{qd}}{N_c \tan\phi'} = 1.233 - \left[ \frac{1 - 1.233}{(20.72) (\tan 25)} \right] = 1.257$$

$$F_{\gamma d} = 1$$

ضرایب پیدا شول اوس یی پہ لاندی عمومی معادلہ کی وضع کوی

$$q_u = c' N_c F_{cs} F_{cd} F_{ci} + q N_q F_{qs} F_{qd} F_{qt} + \frac{1}{2} \gamma B N_\gamma F_{\gamma s} F_{\gamma d} F_{\gamma t}$$

$$q_u = (20)(20.72)(1.514)(1.257)(1) + (1.5 \times 16.5)(10.66)(1.466)(1.233)(1)$$

$$+ \frac{1}{2}(16.5)(2)(10.88)(0.6)(1)(1) = 788.6 + 476.9 + 107.7 = 1373.2 \text{ kN/m}^2$$

$$q_{\text{all}} = \frac{q_u}{\text{FS}} = \frac{1373.2}{3} = 457.7 \text{ kN/m}^2$$

$$Q = (457.7)(2 \times 2) = \mathbf{1830.8 \text{ kN}}$$

## درېم فصل Design of footing

### د تهاداب ډيزاين

تهداب د ساختمان يو خاص او اساس برخه دی چه د لاندنی موخي لپاره استفاده کیری

د تهاداب موخي (مقاصد)

- 1:- د تهاداب موخه داده چي د ساختمان بار په يو پراخه سيمه باندي وويشل شي تر څو بار په يوه نقطه باندي عمل ونکړی ، يعنی په خاوری د زيات بار له واریدو څخه وژغوري.
- 2:- د تهاداب دويمه موخه داده چي د ساختمان بار په مساوي شکل وويشل شي او د غير منظمي کهناستنی(نشست) مخنيوي وکړي.
- 3:-تهداب د ساختمان لپاره د ليول سطحه برابروي
- 4:-په ځمکه کي د تهاداب په ننوتولو سره ساختمان ټيکاو(ثبات) اخلي او له تاويدو څخه يي مخنيوی کیری.

## د تهاداب ډولونه

تهداب په عمومي ډول په دو برخه وويشل شوی دی.

1 :- ژور تهادابونه

2:- سطحي تهادابونه

1:- ژور تهادابونه

کله چي تهاداب د ساختمان د Super Structure له ټولو څخه بنسکتی نقطې څخه لاندي واقع شي ژور تهاداب بلل کيري ، Pile , pier , well د ژور تهادابونو په ډله کي راځي

2:- سطحي تهادابونه



ترتيب كونيكي:- انجينر عبدالحميد (رسولي)  
مضمون: د تهاداب ډيزاين

كله چي تهاداب د څخه وروسته متصل واقع شي د سطحي تهادابونو په نوم ياديږي سطحي تهادابونه لاندې ډولونه لري.

1:- غزیدلی یا جداگانه تهادابونه (Spread/single Footing)

2:- مرکب یا مسلسل تهادابونه (Combined/Continuous Footing)

3:- فرشی تهادابونه (Raft/Mat Footing)

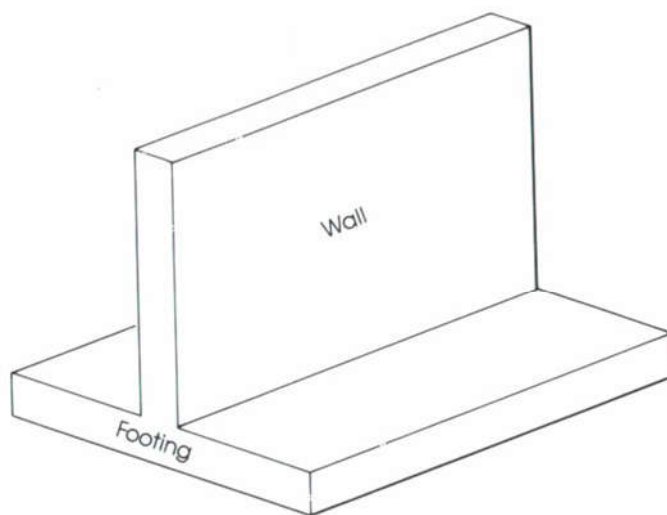
## د شکل له مخي تهادابونه

- 1:- مسلسل یا دیوالي تهادابونه 2:- مربعوي تهادابونه 3:- مایل مربعوي تهادابونه
- 4:- پته يي مربعوي تهادابونه 5:- مستطیل شکله تهادابونه 6:- مایل مستطیل شکله تهادابونه

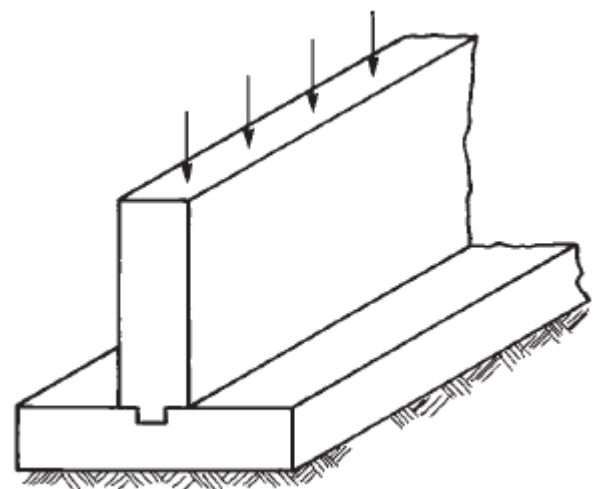
### 1:- دیوالي تهادابونه

دیوالي تهادابونه د ساختمان بار برداری یوالونو او غیر بار برداری دیوالونو لپاره استفادی کيږی. او همچنان د استنادی دیوالونو لپاره هم کارول کيږی.

**Wall footings** are used to support structural walls that carry loads for other floors or to support nonstructural walls.



Wall footing.

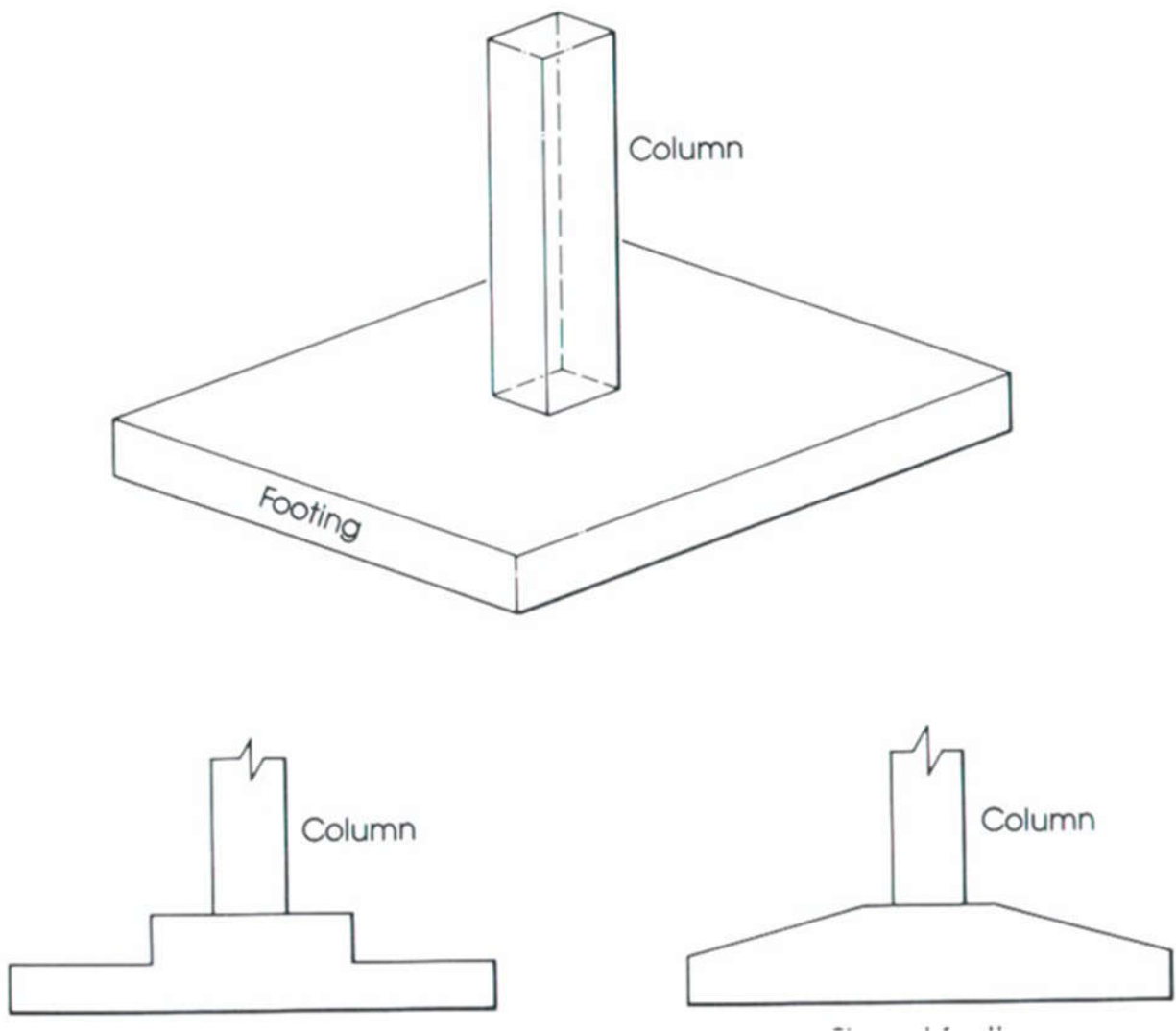


(a) Strip or wall footing.

## 2:- جداگاني تهادابونه

جداگانه تهادابونه د هر کالم (پايه) لپاره يو تهاداب استعمالیږي، او يا د پایو تر منځی فاصله چې زیاتی وی استفادی کیری او تر ټول اقتصادي ترین تهادابونه دی چه نن سبا ډیر زیات کاروال کیری.

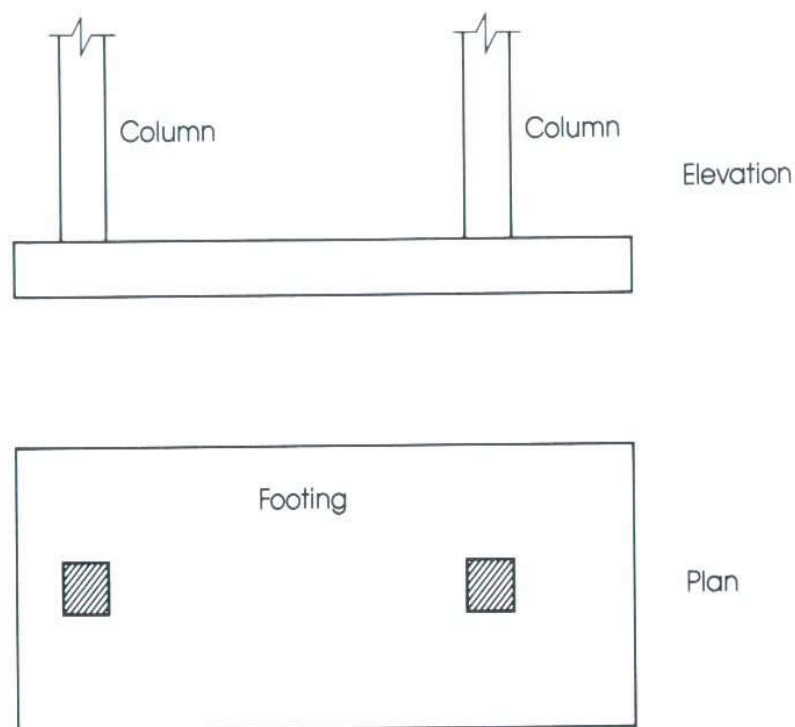
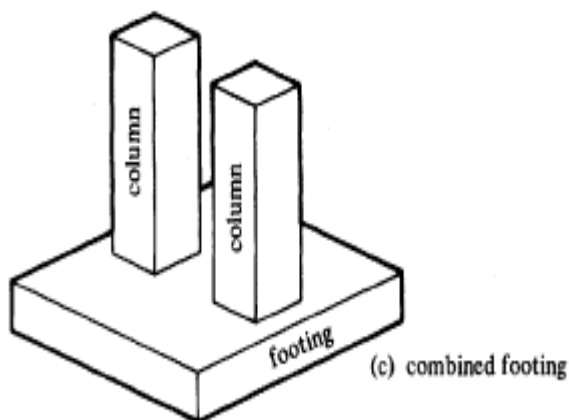
**Isolated or single footings** are used to support single columns. This is one of the most economical types of footings and is used when columns are spaced at relatively long distances



### 3:- مرکب تهادابونه

مرکب تهادابونه معمولا د دوه کالمونه، یا درې ستنې چې په یو قطار کې وي. او همچنان مرکب تهادابونه هغه وخت کارول کېږي کله چې دوه تهادابونه ډیر نږدې وي یا کله چې یو کالم د ملکیت په اخیرکړبني ته نږدې وي

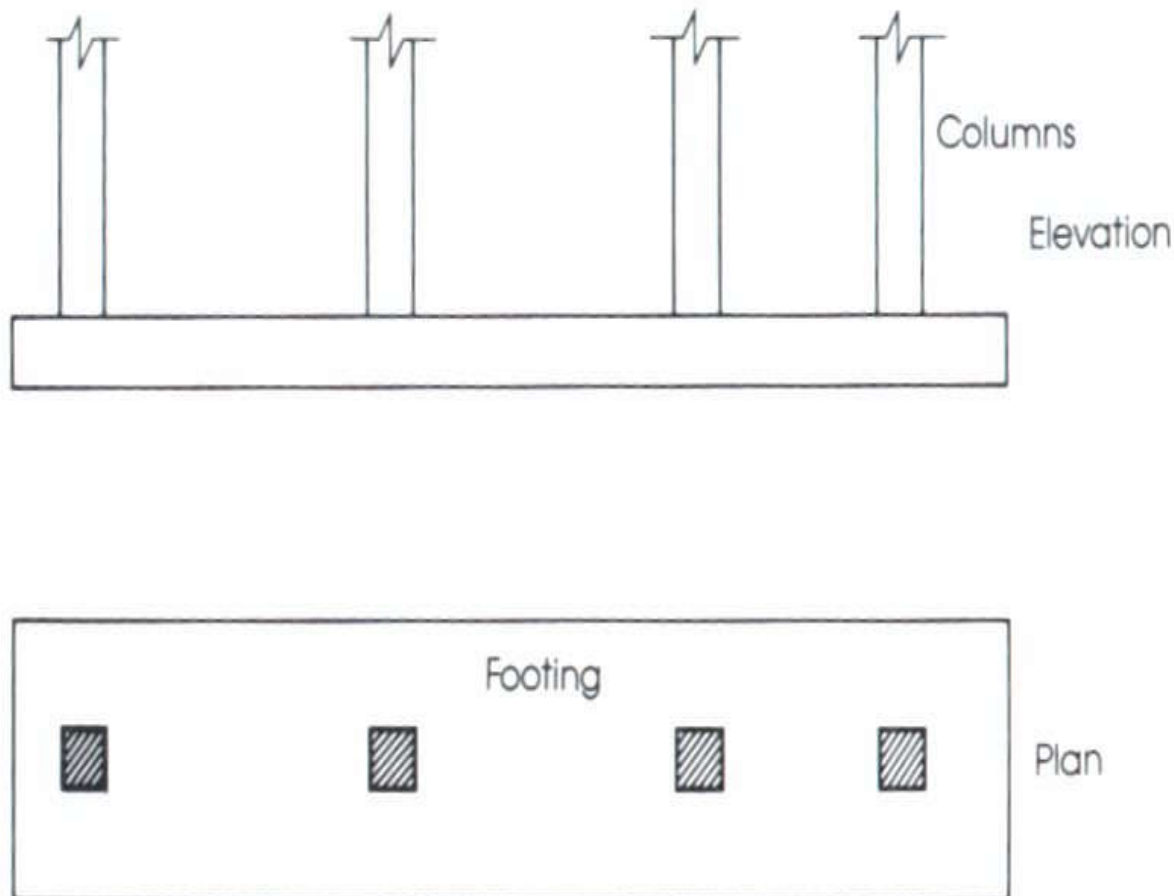
**Combined footings** usually support two columns, or three columns in a row. Combined footings are used when two columns are so close that single footings cannot be used or when one column is located at or near a property line.



## 4:- مسلسل تھدابونہ

مسلسل تھدابونہ د دریو یا زیات تر دریو پایو لپارہ استفادی کیری ، مسلسل تھدابونہ د یو وایہ  
تولو پایو لاندی پہ معین عرض سرہ استمعالییری

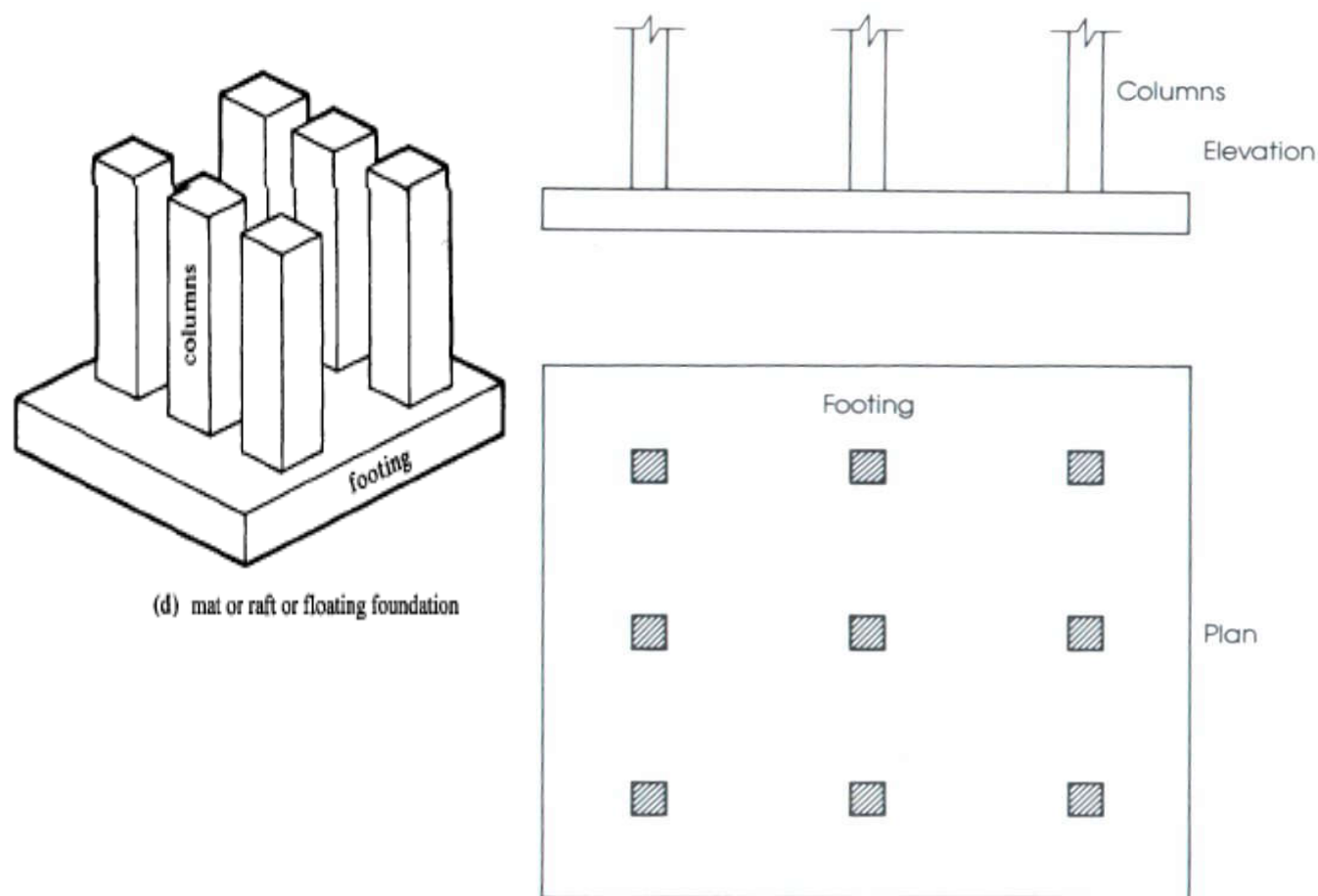
**Continuous footings** support a row of three or more columns. They have limited width and continue under all columns.



## 5:- فرشی تہدابونہ

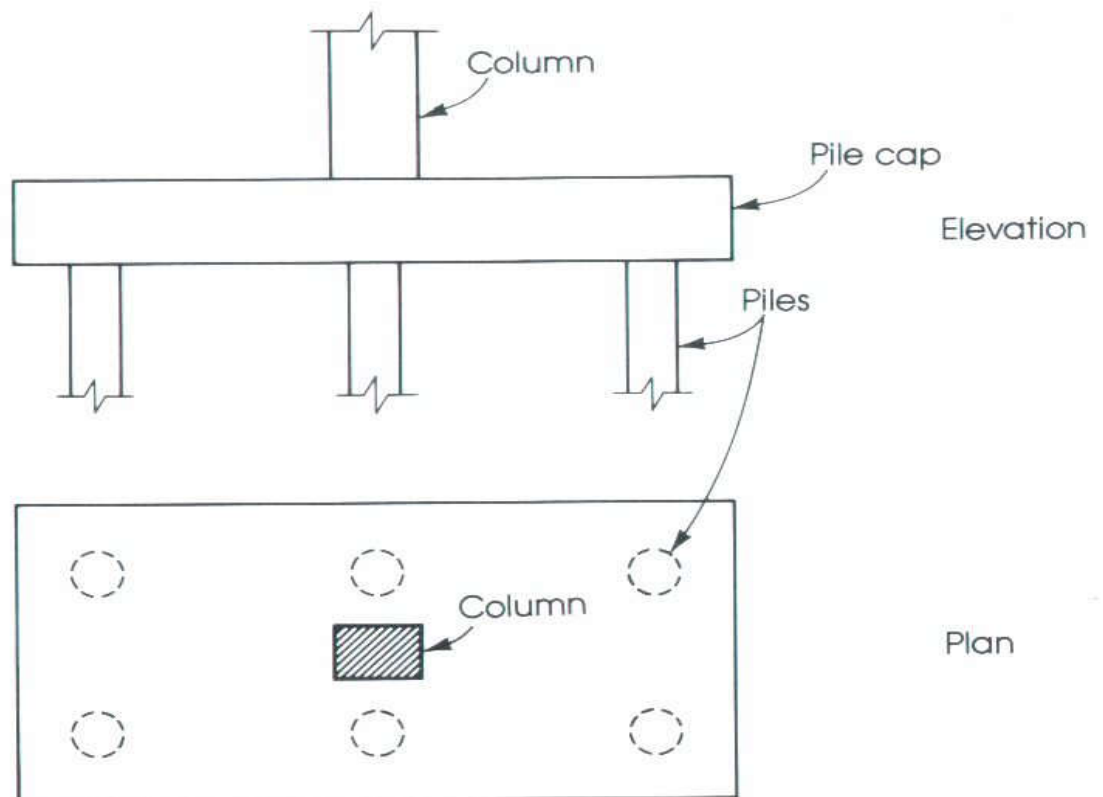
فرشی تہداب د ساختمان ٹولو پایو لاندی پہ شکل د فرش استمعالییری ، دغہ تہداب پہ ہغہ وخت کی استفادی کیری چہ د خاوری برداشت قابلیت ڈیر کمزوری وی یعنی جداگانی تہدابونو مساحت یو د بل سر تکر کوی

**Rafted or mat foundation** consists of one footing usually placed under the entire building area. They are used, when soil bearing capacity is low, column loads are heavy single footings cannot be used

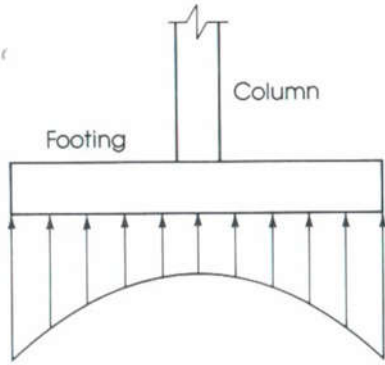




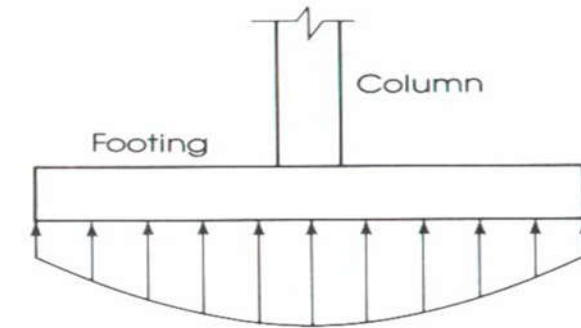
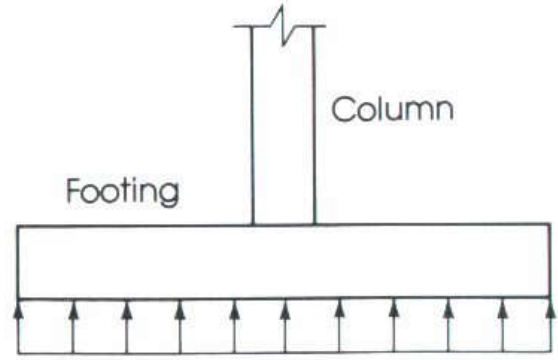
***Pile caps*** are thick slabs used to tie a group of piles together to support and transmit column loads to the piles.



## د تھداب لاندی د خاوری عکس العمل نظر د خاوری خواص ته



*Soil pressure distribution in cohesive soil.*



*Soil pressure distribution in cohesionless soil.*

مثال:- دپایي لاندی تھداب ڈیزاین کری چه د پایي ابعاد 18\*18in دی او د پایي لخوا نهایی بار  
خالص بار  $P_u=300.54\text{Kip}$  ، عمل کری وی ، او همچنان د خاوری  
برداشت قابلیت  $q_a=2.204\text{kip}/\text{ft}^2$  وی ، او د پکونکو خاورو حجمی وزن  $=0.1\text{Klb}/\text{ft}^3$   
او د کانکریٹو حجمی وزن  $\gamma_{fill}=0.15\text{kip}/\text{ft}^3$  وی ، نظر جیوتکنیکل راپورته د تھداب  
ارتفاع 18in وی ، نوموړی تھداب د حُمکی له سطحه څخه په 5ft کی لاندی قرار لری ، دا  
چی د کانکریٹو فشاری مقاومت  $f_c=3\text{ksi}$  وی او د فولادی سخانو کشش مقاومت  $f_y=40\text{ksi}$   
وی

حل:-

راکړ شوی ارقام (Given Data)

$$\begin{aligned} P_u &= 300.54\text{Kip} & f_c &= 3\text{ksi} \\ P &= 235.64\text{Kip} & f_y &= 40\text{ksi} \\ q_a &= 2.204\text{kip}/\text{ft}^2 & D_f &= 5\text{ft} \\ \gamma_{fill} &= 0.1\text{kip}/\text{ft}^3 & h &= 18\text{in} \\ \gamma_c &= 0.15\text{kip}/\text{ft}^3 & \text{Column size} &= 18*18\text{in} \end{aligned}$$

Step-1

د خاوری خالص فشار

$$\begin{aligned} q_e &= q_a - w_s \\ w_s &= \gamma_{fill}(D_f - h) + \gamma_c * h = 0.1(5 - 1.5) + 0.15 * 0.15 \\ w_s &= 0.575 \\ q_e &= q_a - w_s = 2.204 - 0.575 = 1.629\text{kip}/\text{ft}^2 \end{aligned}$$

$$A = \frac{p}{q_e} = \frac{235.64}{1.624} = 144.63 ft^2 \approx 144 ft^2$$

که چیری مربع شکل تھداب وی نو لروی

$$B = L \text{ and } B \times B \text{ so } B^2 = 144 ft^2 \Rightarrow \sqrt{B} = \sqrt{144}$$

$$B = 12 ft$$

Step-2

په دوهم مرحله کی دو طرفه برش په لاس راوری (Two way shear or punching shear)

$$V_u = P_u - q_a (l_c + d_{average}) * (b_c + d_{average})$$

$$q_a = \frac{P_u}{A} = \frac{300.54}{144} = 2.087 \frac{kip}{ft^2}$$

$$d_{average} = h - 3 - \text{one bar dia}$$

if we use #8 so  $d_{average} = 14 in$

$$V_u = 300.54 - 2.087 \left( 1.5 + \frac{14}{12} \right) \left( 1.5 + \frac{14}{12} \right) = 285.69 kip$$

اوس مقاومه عرضانی قوه په لاس راوری چي عبارت دی له

$$\phi V_c = 0.75 \cdot 4 \cdot \sqrt{f_c} \cdot b_0 \cdot d_{average}$$

$$b_0 = 2(l_c + b_c + 2d) \text{ or } 4(b_c + d_{average}) = 4 \left( 1.5 + \frac{14}{12} \right) = 10.67 ft = 128 in$$

$$\phi V_c = 0.75 \cdot 4 \cdot \sqrt{3000} \cdot 128 \cdot 14 = \frac{294455.64}{1000} = 294.45 kip$$

خرنگه چي زمونږ  $V_u < \phi V_c$  زیات دی نو  $d$  درست انتخاب شوی یا د تھداب ارتفاع (h) صحیح دی

اوس یو طرفہ (یو لوریزہ) اعظمی عرضانی قوہ پہ لاس راورو

1:- د لوری سرہ اعظمی عرضانی قوہ پہ لاس راورو

$$V_{u-B} = q_a \left( \frac{l}{2} d_{average} \right) B = 2.087 \left( \frac{5}{2} \frac{1.5}{12} \right) 12 = 14.609 \text{kip}$$

اوس د لوری سرہ موازہ مقاومہ عرضانی قوہ پہ لاس راورو

$$\phi V_c = 0.75 \cdot 2 \cdot \sqrt{f_c} \cdot B \cdot d_{average}$$

$$\phi V_c = 0.75 \cdot 4 \cdot \sqrt{3000} \cdot 144 \cdot 14 = \frac{331262.6}{1000} = 331.263 \text{kip}$$

خرنگہ چي L او B لوری سرہ مساوی دی یعنی تھداب مربع شکل دی نو د بل لوری محاسبہ نہ صرف نظر کیوی.

Step-3

اوس مومنت پہ لاس راورو

$$M_{u-B} = q_a \left( \frac{(L \cdot l_c)}{8} \right) B = 2.087 \left( \frac{(5 \cdot 1.5)}{8} \right) 12 = 38.34 \text{kip ft}$$

$$M_{u-B} = 480.18 \text{kip in}$$

$$M_{u-h} = \frac{M_{u-B}}{\phi} = \frac{480.18 \text{kip in}}{0.9} = 511.315 \text{kip in}$$

$$R_{h-B} = \frac{M_{h-B}}{B \cdot d_{average}^2} = \frac{511.315 \text{kip in}}{12 \cdot 12 \cdot 14^2} = 18.11 \text{PSI}$$

$$\rho_B = 0.85 \frac{f_c}{f_y} \left[ 1 + \sqrt{\left( 1 + \frac{2R_h}{0.85f_c} \right)} \right] = 0.85 \frac{3}{40} \left[ 1 + \sqrt{\left( 1 + \frac{2 \cdot 18.11}{0.85 \cdot 3000} \right)} \right]$$



$$\rho_B = 0.000454$$

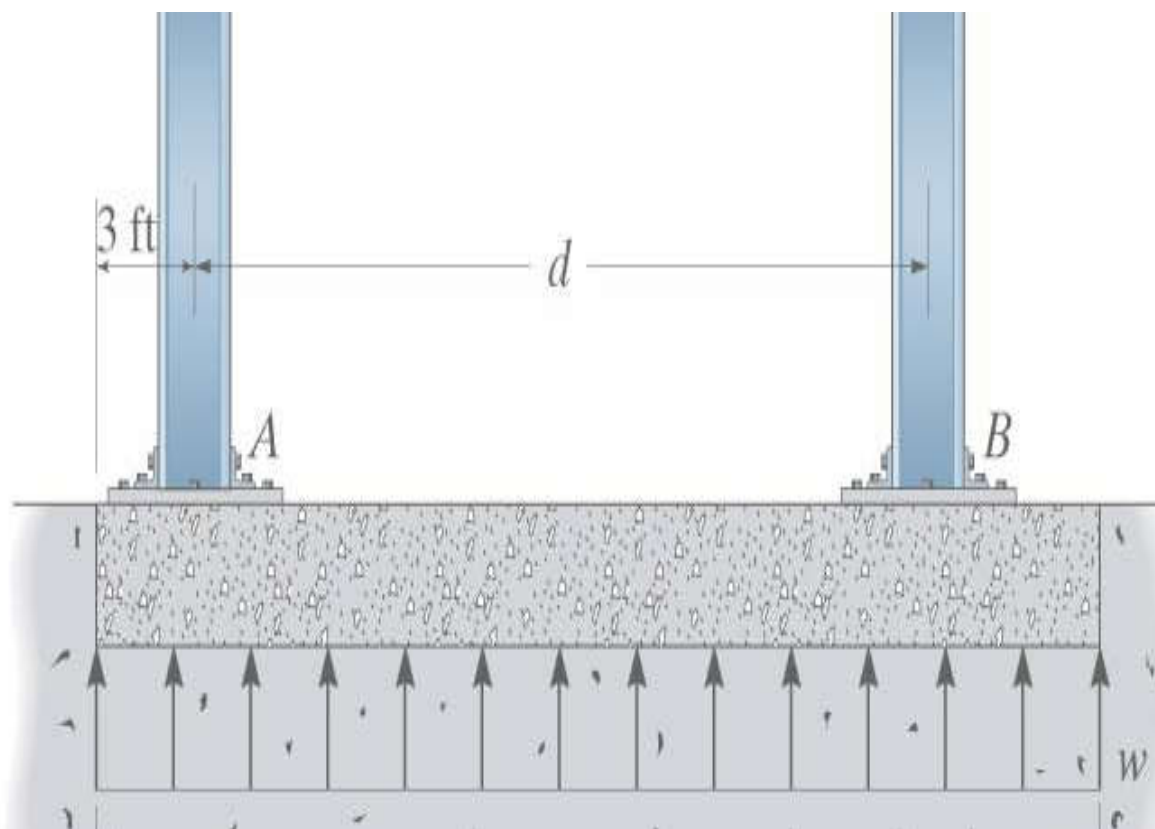
چون رو  $\rho_B < \rho_{min}$  لوی دی بنا  $\rho_{min}$  استفادی کوی

$$A_{S_{min}} = \rho_{min} B d_{average} = 0.002 \quad 12 \quad 12 \quad 14 = 4.032 in^2$$

# Footing Design

## Part II

### *Combined footing*



## مرکب تهادابونه

### مرکب تهادابونه د لاندي اړتياو له مخي ټاکل کيږي

1. کله چې دو پایي دومره نژدی وی چې د دو تهادابونو مساحت یو د بل سره ټکری وکړی
2. کله چې د یوی دوانی بانندی پایي داسی وی چې د بل چاه تعمیر ته ډیر نژدی وی
3. کله چې د تهاداب د خاوری برداشت قوه کمزوری وی

### د مرکب تهادابونو ډولونه

- مستطیلی تهادابونه
- ذونقه یی تهادابونه
- کنسولی تهادابونه
- پته یی تهادابونه

د مستطیلی مرکب تهاداب د ډیزاين لپاره لاندي ټکي په پام کي ونيول شي

په پایه باندي وارد شوی مجموعی بار معلومول ❖

د تهاداب تقریبی مساحت ټاکل ❖

د تهاداب د ابعادو ټاکل او د هغی له مخي د خاوری فشار پیدا کول ❖

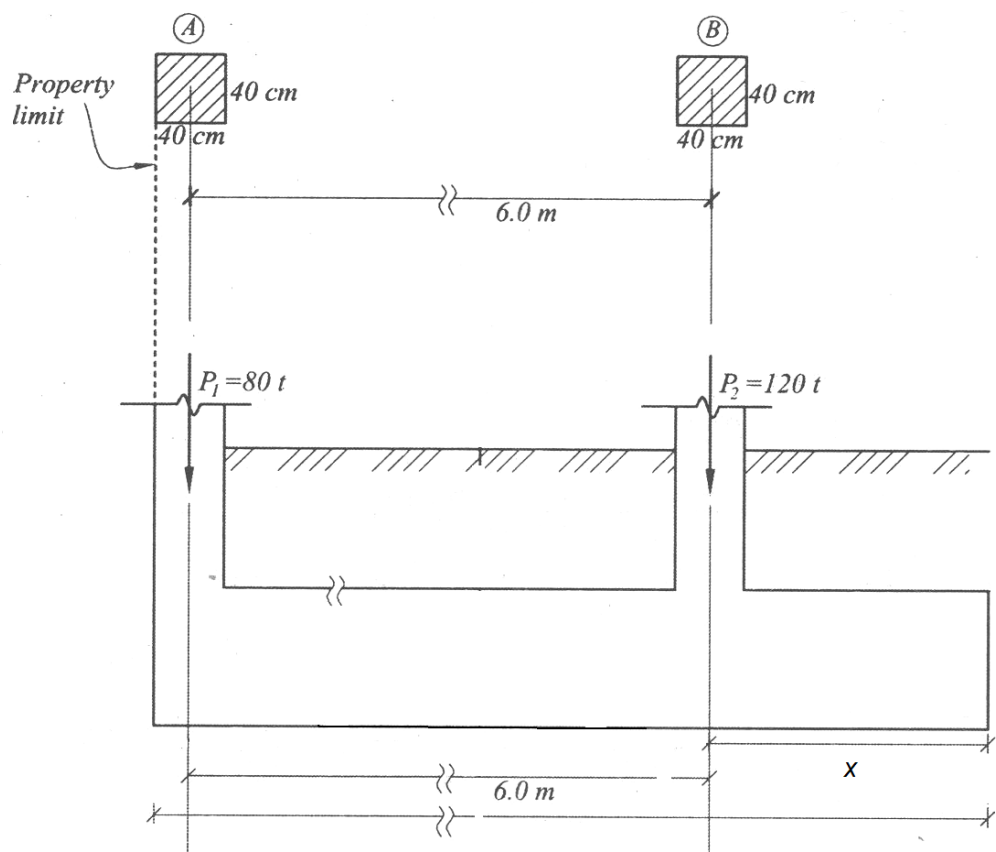
په مختلفو مقطعو کی د عرضی قوي پیدا کول ❖

مومنټ پیدا کول ❖

مثال: د  $C_A$  او  $C_B$  پایو لپاره مرکب تهاداب ډیزاین کړی چې د پایو د مرکز نه تر مرکز فاصله او  $6\text{m}$  ،  $40 \times 40\text{cm}$  ابعاد لری چې په ترتیب سره  $800\text{KN}$  په  $C_A$  باند او  $120\text{KN}$  په  $C_B$  باندی او د خاوری د برداشت قابلیت  $q_a = 200\text{Kpa}$  ، او د کانکریتو فشار مقاومت  $200 = f_c \text{ N/mm}^2$  ، او د سیخانو کشش مقاومت  $f_y = 420 \text{ N/mm}^2$  چی په لاندی شکل که خودل شوی

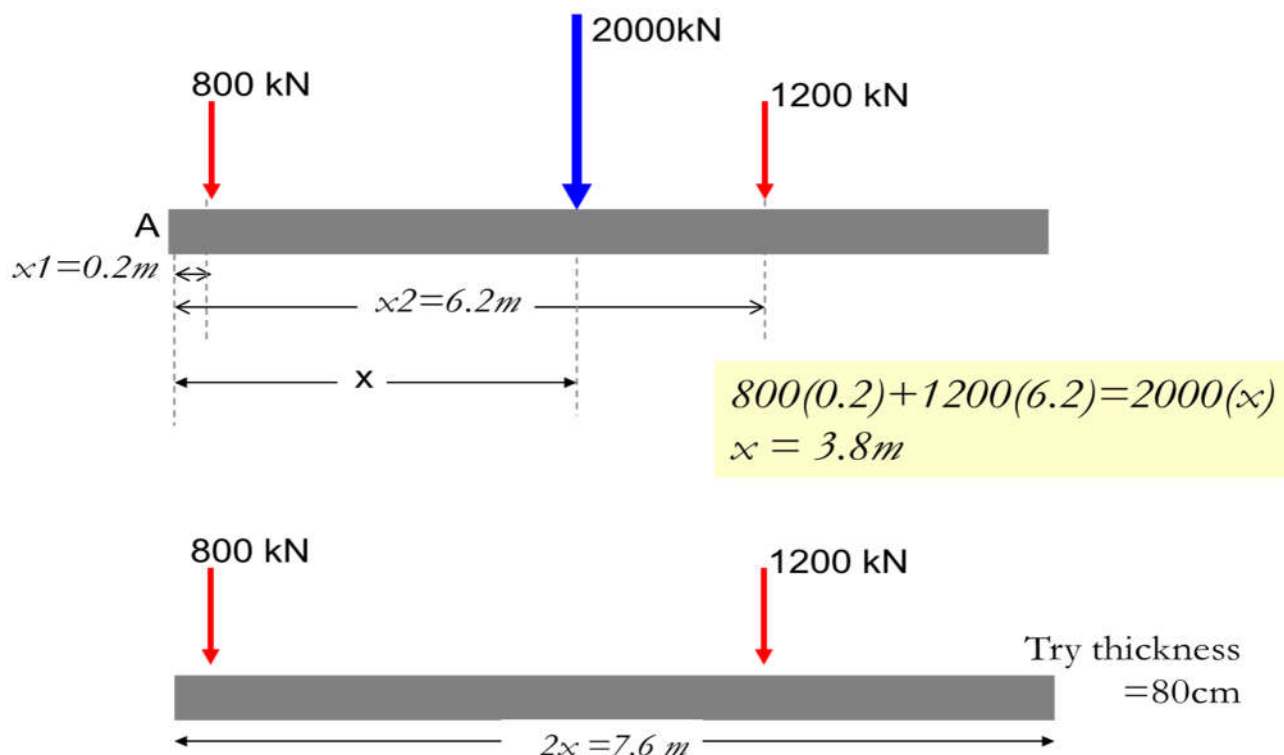
## Design a combined footing As shown

$$q_{all(net)} = 20\text{t} / \text{m}^2 = 200\text{kPa} \quad f'_c = 25 \text{ N/mm}^2 \quad f_y = 420 \text{ N/mm}^2$$



## Dimension calculation د مجموعی قوه فاصله پیدا کوی

### The base dimension to get uniform distributed load



## Area required

$$q_{all(net)} = 20\text{ t} / \text{m}^2 = 200\text{ kPa},$$

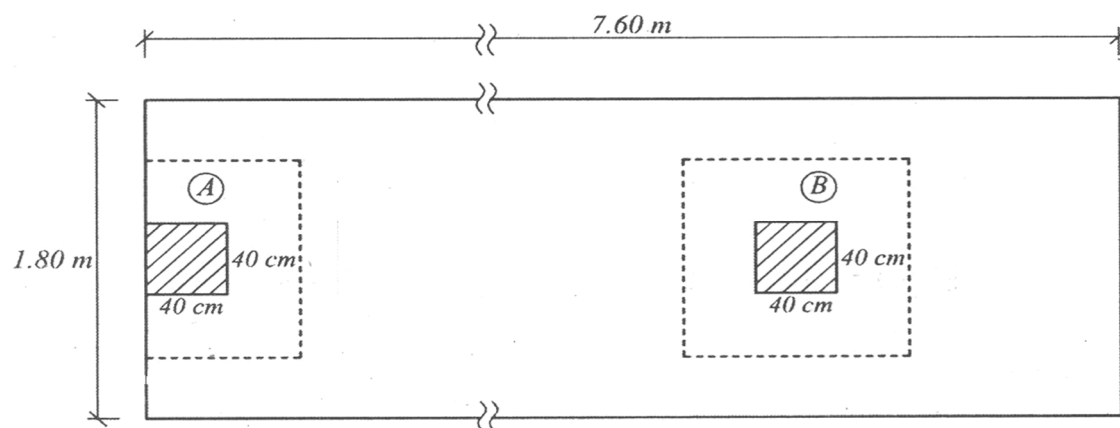
$$P_u = 1.3(P_s) = 1.3(2000) = 2600\text{ kN}$$

$$A_g = \frac{P_s}{q_{all(net)}} = \frac{2000 \times 10^3}{200 \times 10^3} = 10\text{ m}^2 \approx 7.6 * 1.8$$

$$q_u = \frac{P_u}{A} = \frac{(2600) \times 10^3}{7.6 * 1.8} = 190 \times 10^3\text{ Pa} = 190\text{ kPa}$$

## د دو طرفه برش پیدا کول Check for punching Shear

توت: فرض کوی چي  $d = 730 \text{ mm}$



### Column A

$$b_o = 2(765) + 1130 = 2260 \text{ mm}$$

$$\phi V_c = \phi \frac{\sqrt{f'_c}}{3} b_o d = 0.75 \times \frac{\sqrt{25}}{3} \times 730 \times 2260 / 1000 = 2062.3 \text{ kN}$$

$$\phi V_c = \phi \left( 2 + \frac{\alpha_s d}{b} \right) \frac{\sqrt{f'_c}}{12} b_o d = 0.75 \left( 2 + \frac{30 \times 730}{2260} \right) \times \frac{\sqrt{25}}{12} \times 730 \times 2260 / 1000 = 6027 \text{ kN}$$

$$V_u = 800(1.3) - 1.13 \times 0.765 \times 190 = 875.8 \text{ kN} < \phi V_c \quad \text{oK}$$

### Column B

$$b_o = 4[(730 + 400)] = 4520 \text{ mm}$$

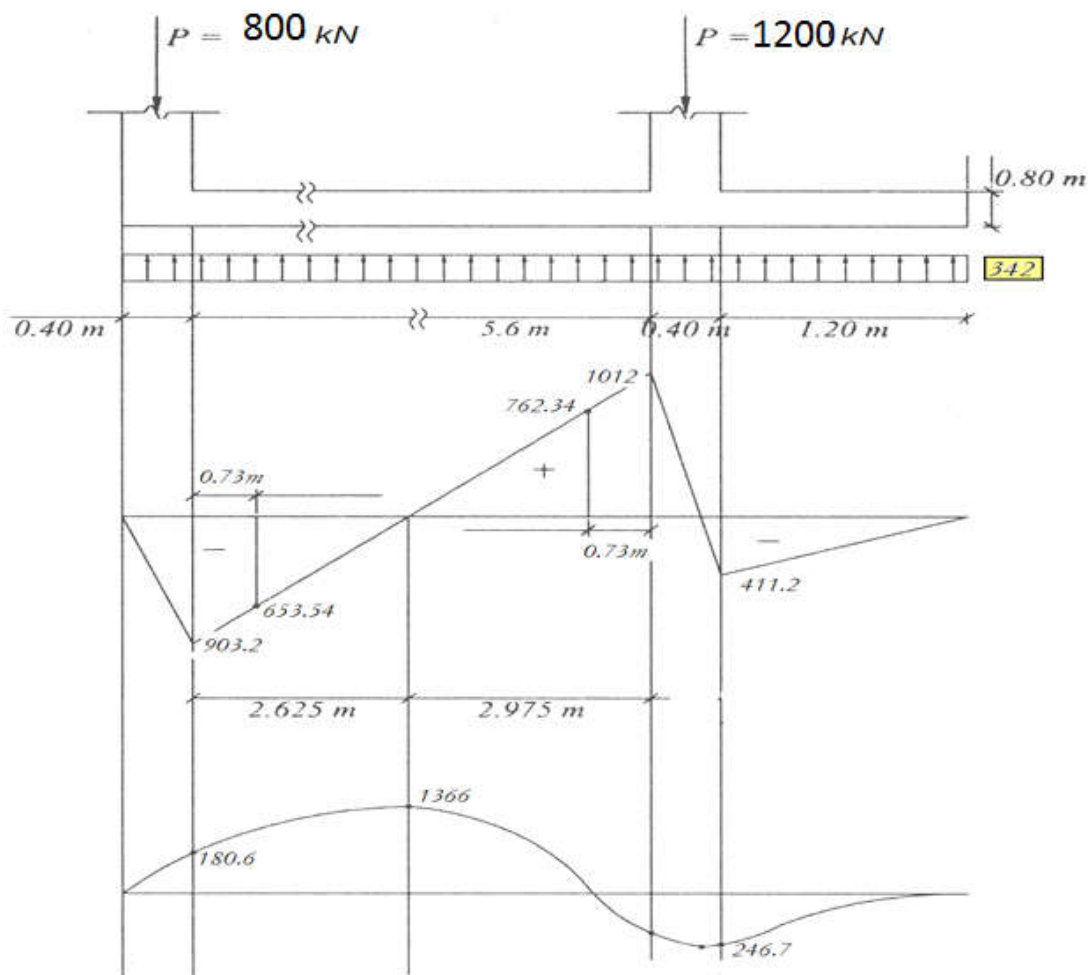
$$\phi V_c = \phi \frac{\sqrt{f'_c}}{3} b_o d = 0.75 \times \frac{\sqrt{25}}{3} \times 730 \times 4520 / 1000 = 4124.4 \text{ kN}$$

$$\phi V_c = \phi \left( 2 + \frac{\alpha_s d}{b} \right) \frac{\sqrt{f'_c}}{12} b_o d = 0.75 \left( 2 + \frac{40 \times 730}{4520} \right) \times \frac{\sqrt{25}}{12} \times 730 \times 4520 / 1000 = 13322.5 \text{ kN}$$

$$V_u = 1200(1.3) - 1.13 \times 1.13 \times 190 = 1317.4 \text{ kN} < \phi V_c \quad \text{oK}$$

## Draw S.F.D & B.M.D

د خاوری فشار *Stress under footing*  
 $= 190 * 1.8 = 342 \text{ kN/m}$





## Check for beam shear

$$b = 1800\text{mm}, d = 730\text{mm}$$

$$\phi V_C = 0.75 \times \frac{\sqrt{25}}{6} \times 730 \times 1800 / 1000 = 821.25\text{kN}$$

$$\text{Max.} \rightarrow V_U \text{ at } \underline{d} \text{ from column face} = 762.34\text{kN}$$

$$V_U < \phi V_C$$

## مومنت پہ طولی سیکشن کی Bending moment Long direction

$$-ve M = 1366\text{kN.m}$$

$$b = 1800\text{mm}, d = 730\text{mm}$$

$$\rho = 0.85 * \frac{25}{420} \left[ 1 - \sqrt{1 - \frac{2 \times 10^6 * 1366}{0.9(0.85)25 * 730^2 * 1800}} \right] = 0.0039$$

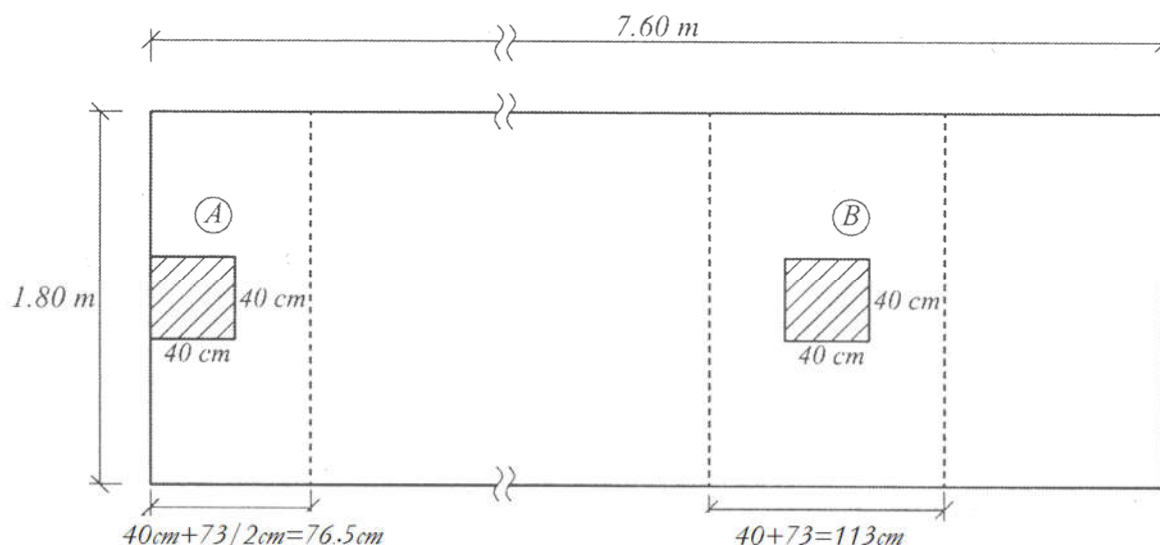
$$A_S = 0.0039 \times 730 \times 1000 = 2847\text{mm}^2 = 28.5\text{cm}^2 \text{ use } 9\phi 20 / m \text{ Top}$$

$$+ve M = 246.7\text{kN.m}$$

$$b = 1800\text{mm}, d = 730\text{mm}$$

$$\rho = 0.85 * \frac{25}{420} \left[ 1 - \sqrt{1 - \frac{2 \times 10^6 * 246.7}{0.9(0.85)25 * 730^2 * 1800}} \right] = 0.0007 < \rho_{\min}$$

$$A_{S\min} = 0.0018 \times 800 \times 1000 = 1440\text{mm}^2 = 14.4\text{cm}^2 \text{ use } 7\phi 16 / m \text{ Bottom}$$

**مومنٹ پہ عرضی سیکشن کی Bending moment Short direction****Under Column A**

$$M = \frac{1040}{(1.8 * 0.765)} \times \frac{0.765}{2} \left( \frac{1.8 - 0.4}{2} \right)^2 = 141.6$$

$$b = 765 \text{ mm}, d = 730 \text{ mm}$$

$$\rho = 0.85 * \frac{25}{420} \left[ 1 - \sqrt{1 - \frac{2 \times 10^6 * 141.6}{0.9(0.85)25 * 730^2 * 765}} \right] < \rho_{\min}$$

$$A_{S \min} = 0.0018 \times 800 \times 765 = 1101.6 \text{ mm}^2 = 11 \text{ cm}^2 \quad \text{use } 7\phi 14 / m$$

**Under Column B**

$$M = \frac{1560}{(1.8 * 1.13)} \times \frac{1.13}{2} \left( \frac{1.8 - 0.4}{2} \right)^2 = 212.33$$

$$b = 1130 \text{ mm}, d = 730 \text{ mm}$$

$$\rho = 0.85 * \frac{25}{420} \left[ 1 - \sqrt{1 - \frac{2 \times 10^6 * 212.33}{0.9(0.85)25 * 730^2 * 1130}} \right] < \rho_{\min}$$

$$A_{S \min} = 0.0018 \times 800 \times 765 = 1101.6 \text{ mm}^2 = 11 \text{ cm}^2 \quad \text{use } 7\phi 14 / m$$

### Shrinkage Reinforcement in short direction

$$A_{S_{\min}} = 0.0018 \times 800 \times 765 = 1101.6 \text{ mm}^2 = 11 \text{ cm}^2 \quad \text{use } 7\phi 14 / \text{m}$$

### Under Column B

$$M = \frac{1560}{(1.8 * 1.13)} \times \frac{1.13}{2} \left( \frac{1.8 - 0.4}{2} \right)^2 = 212.33$$

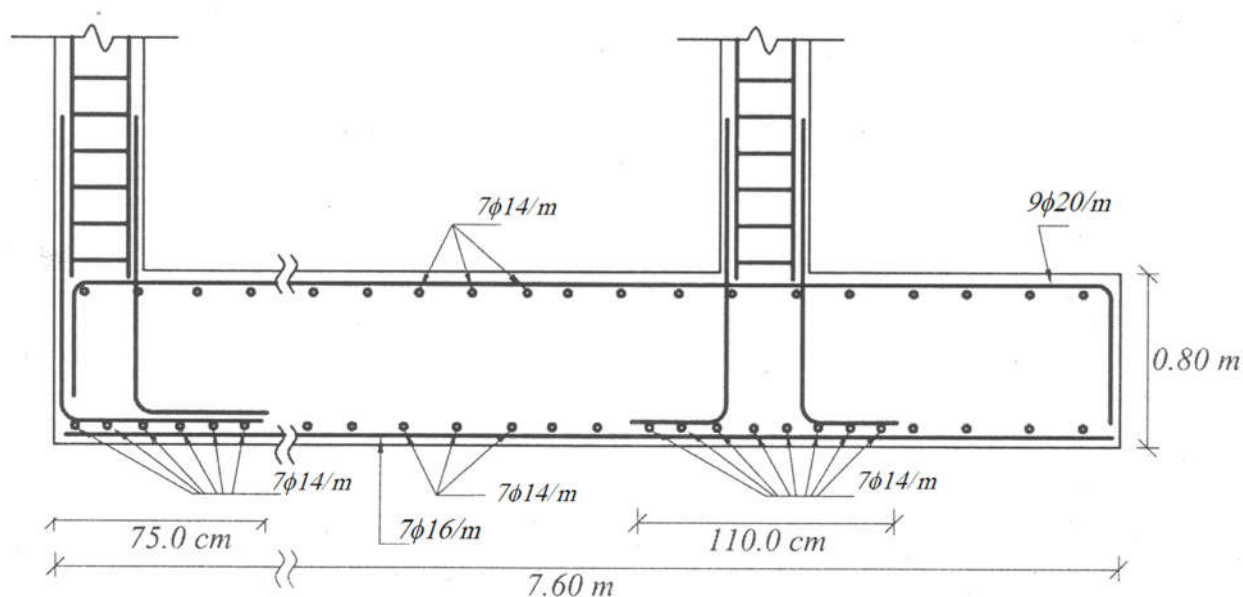
$$b = 1130 \text{ mm}, d = 730 \text{ mm}$$

$$\rho = 0.85 * \frac{25}{420} \left[ 1 - \sqrt{1 - \frac{2 \times 10^6 * 212.33}{0.9(0.85)25 * 730^2 * 1130}} \right] < \rho_{\min}$$

$$A_{S_{\min}} = 0.0018 \times 800 \times 765 = 1101.6 \text{ mm}^2 = 11 \text{ cm}^2 \quad \text{use } 7\phi 14 / \text{m}$$

### Shrinkage Reinforcement in short direction

$$A_{S_{\min}} = 0.0018 \times 800 \times 765 = 1101.6 \text{ mm}^2 = 11 \text{ cm}^2 \quad \text{use } 7\phi 14 / \text{m}$$



## Footing Design Part III

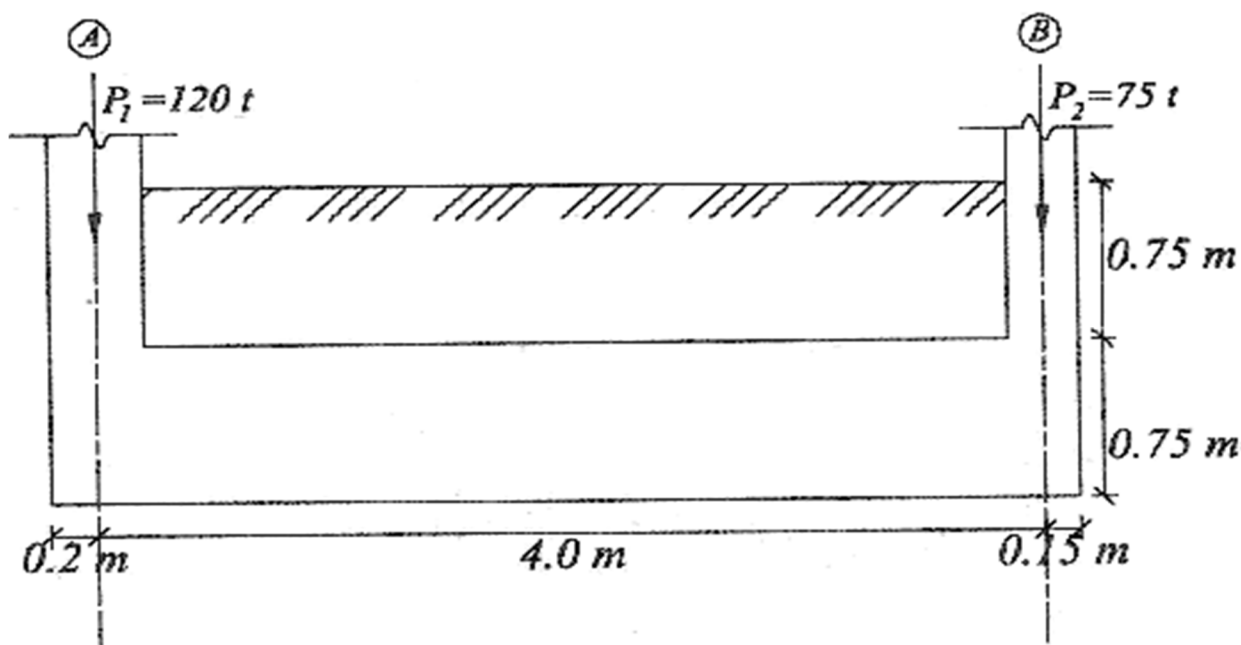
نوٹ: پہ لاندنیو ٲولو مثالونو کہ پورتنی تکلار استفادی کیری

*Combined footing, strip footing, & Mat foundation*

### Example 2

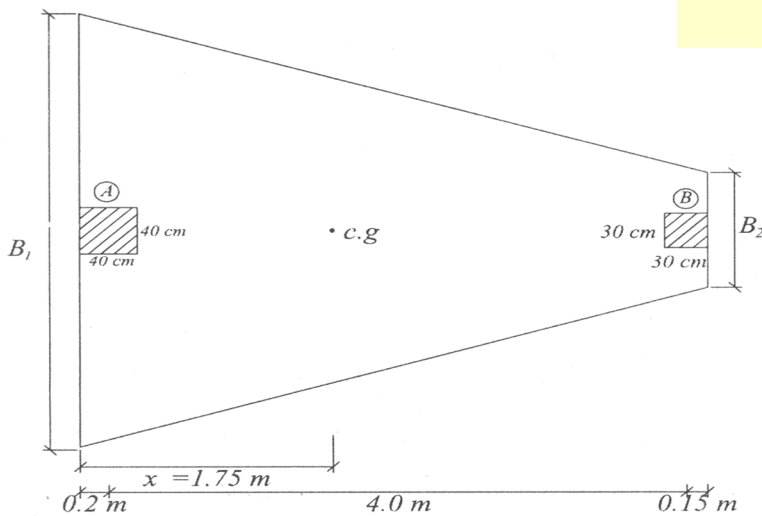
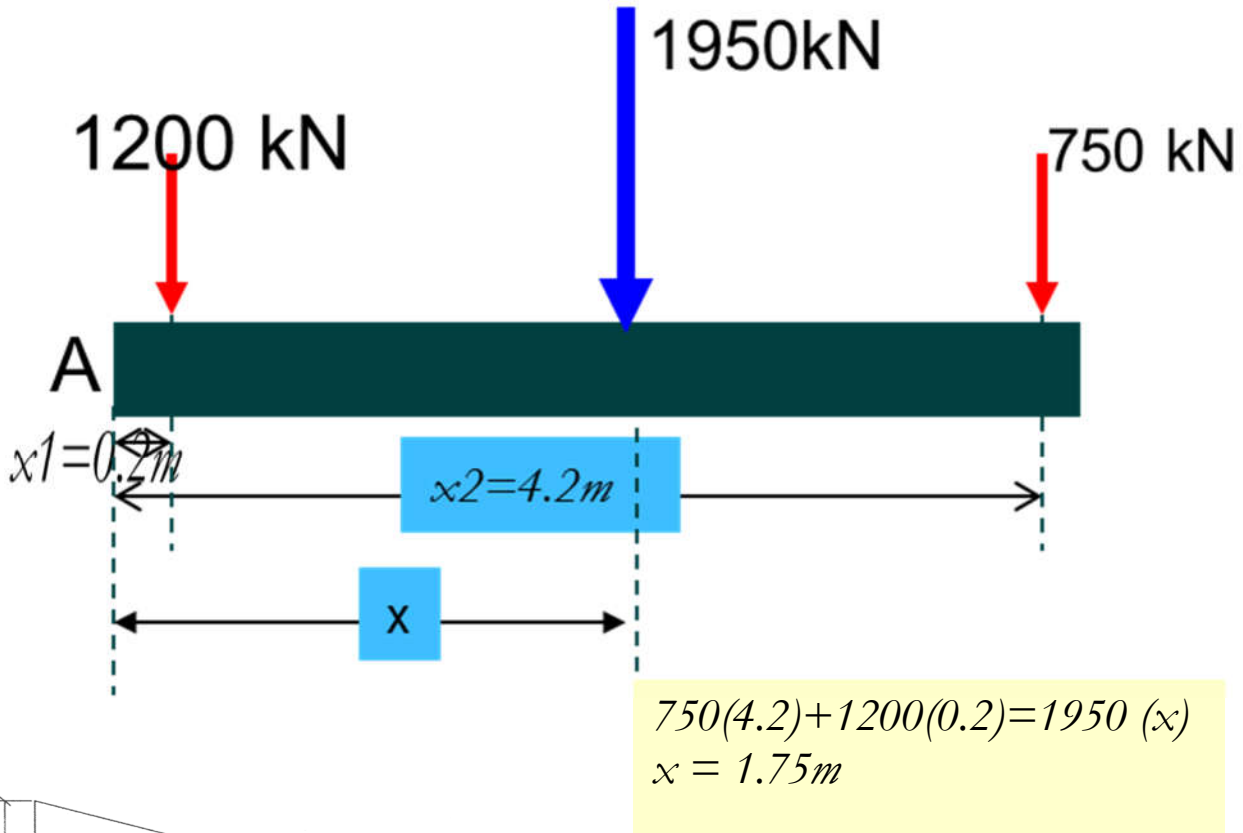
Design a combined footing As shown

$$q_{all(net)} = 18 t / m^2 = 180 kPa \quad f'_c = 25 N/mm^2 \quad f_y = 420 N/mm^2$$



## Dimension calculation

The base dimension to get uniform distributed load




$$x = \left( \frac{B_1 + 2B_2}{B_1 + B_2} \right) \frac{L}{3}$$

## Area required

$$q_{all (net)} = 20 t / m^2 = 200 kPa ,$$

$$A_g = \frac{P_s}{q_{all (net)}} = \frac{1950 \times 10^3}{180 \times 10^3} = 10.8 m^2$$




$$\left( \frac{B_1 + B_2}{2} \right) L = 10.8$$

$$\left( \frac{B_1 + B_2}{2} \right) 4.35 = 10.8$$

$$\left( \frac{B_1 + B_2}{2} \right) = 2.5$$

$$B_1 + B_2 = 5$$



$$x = \left( \frac{B_1 + 2B_2}{B_1 + B_2} \right) \frac{L}{3} = \left( \frac{5 + B_2}{5} \right) \frac{4.35}{3}$$

$$1.75 = 1.45 + 0.29 B_2$$

$$B_2 = 1 m$$

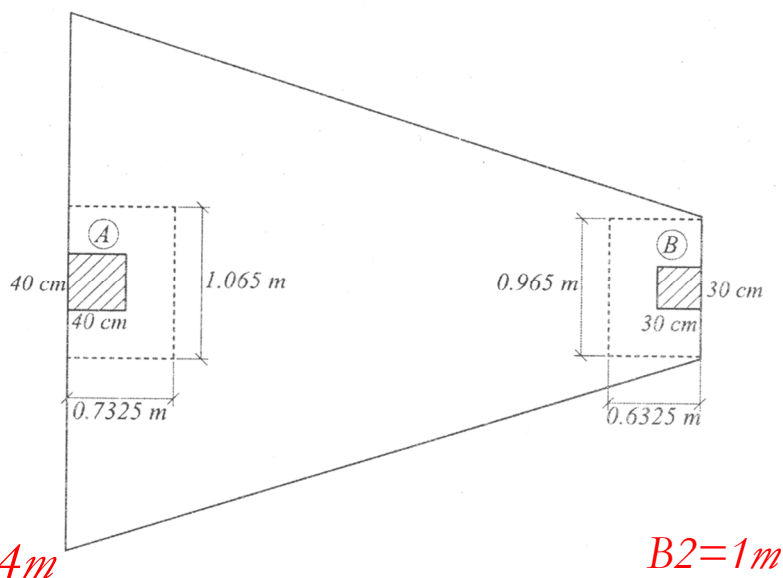
$$B_1 = 4 m$$

$$q_u = \frac{P_u}{A} = \frac{1.3(1950) \times 10^3}{10.8} = 235 \times 10^3 Pa = 235 kPa$$

## Check for punching Shear

$$h = 750 \text{ mm}$$

$$d = 732 \text{ mm}$$



### Column - A

$$b_o = 2(732) + 1065 = 2590 \text{ mm}$$

$$\phi V_c = \phi \frac{\sqrt{f'_c}}{3} b_o d = 0.75 \times \frac{\sqrt{25}}{3} \times 665 \times 2590 / 1000 = 2160.4 \text{ kN}$$

$$\phi V_c = \phi \left( 2 + \frac{\alpha_s d}{b} \right) \frac{\sqrt{f'_c}}{12} b_o d = 0.75 \left( 2 + \frac{30 \times 665}{2590} \right) \times \frac{\sqrt{25}}{12} \times 665 \times 2590 / 1000 = 5222 \text{ kN}$$

$$V_u = 1200(1.3) - 1.065 * 0.733 * 235 = 1376.6 \text{ kN} < \phi V_c \quad \text{oK}$$

### Column - B

$$b_o = 2(633) + 965 = 2231 \text{ mm}$$

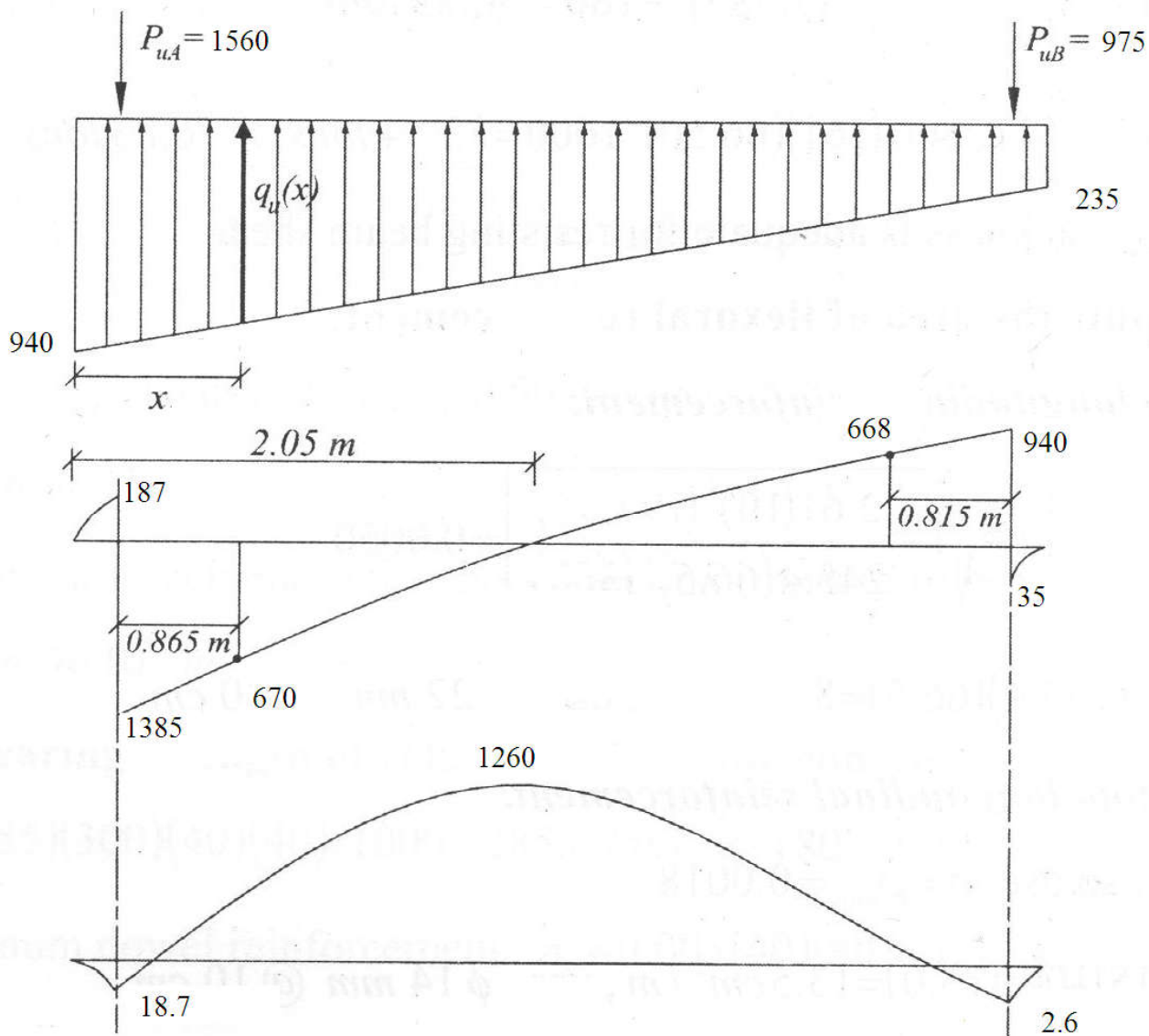
$$\phi V_c = \phi \frac{\sqrt{f'_c}}{3} b_o d = 0.75 \times \frac{\sqrt{25}}{3} \times 665 \times 2231 / 1000 = 1854.5 \text{ kN}$$

$$\phi V_c = \phi \left( 2 + \frac{\alpha_s d}{b} \right) \frac{\sqrt{f'_c}}{12} b_o d = 0.75 \left( 2 + \frac{30 \times 665}{2231} \right) \times \frac{\sqrt{25}}{12} \times 665 \times 2231 / 1000 = 5273 \text{ kN}$$

$$V_u = 800(1.3) - 0.965 * 0.633 * 235 = 896.5 \text{ kN} < \phi V_c \quad \text{oK}$$



## Draw S.F.D & B.M.D



## Empirical S.F.D & B.M.D

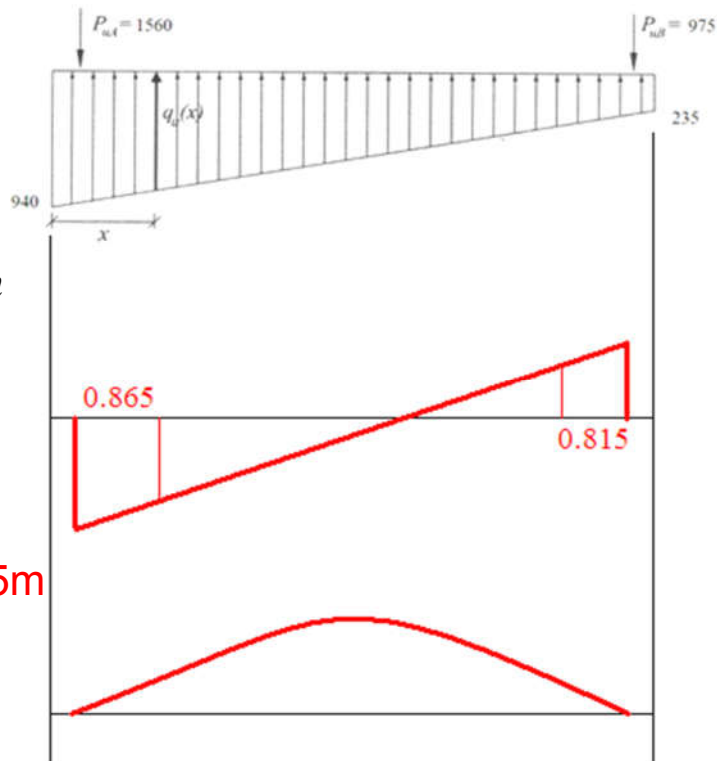
Convert trapezoidal load to rectangle

$$w_{ave} = 235 + \frac{2}{3}(940 - 235) = 705$$

$$-M_{max} = \frac{wl^2}{8} = \frac{705(3.65)^2}{8} = 1174 \text{ kN.m}$$

Clear distance between column

B in moment design = ave. width = 2.5m



Check for beam shear

$$d = 665 \text{ mm}$$

$$b = 1 + 2\left(\frac{x}{L}\right) \times y$$

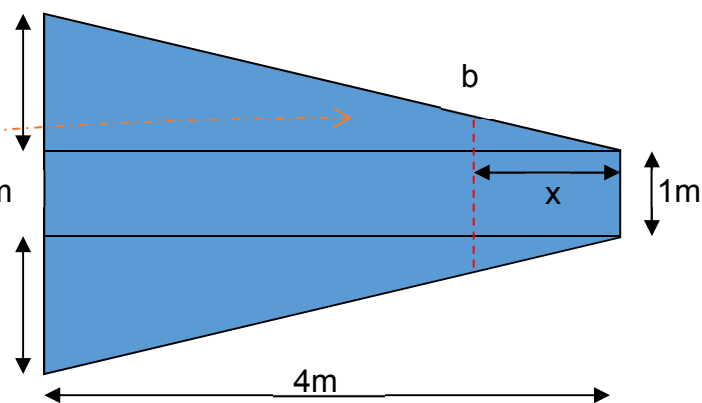
$$\text{at } x = 0.815 + 0.15$$

$$1 + 2\left(\frac{0.965}{4.35}\right) \times 1.5 = 1.7 \text{ m} = 1700 \text{ mm}$$

$$\phi V_C = 0.75 \times \frac{\sqrt{25}}{6} \times 665 \times 1700 / 1000 = 696 \text{ kN}$$

$$\text{Max.} \rightarrow V_U \text{ at } \underline{d} \text{ from column B face (the most critical)} = 668 \text{ kN}$$

$$V_U < \phi V_C$$



## Bending moment Long direction

$$b = 1 + 2\left(\frac{2.25}{4.35}\right) \times 1.5 = 2.60m = 2600 \quad \text{Top}$$

$$-ve M = 1260kN.m$$

$$d = 730mm$$

$$\rho = 0.85 * \frac{25}{420} \left[ 1 - \sqrt{1 - \frac{2 \times 10^6 * 1260}{0.9(0.85)25 * 665^2 * 2600}} \right] = 0.003$$

$$A_s = 0.003 \times 665 \times 1000 = 1995mm^2 = 20cm^2 \quad \text{use } 10\phi 16 / m \quad \text{Top}$$

### Bottom

$$A_{s_{min}} = 0.0018 \times 750 \times 1000 = 1350mm^2 = 13.5cm^2 \quad \text{use } 9\phi 14 / m \quad \text{Bottom}$$

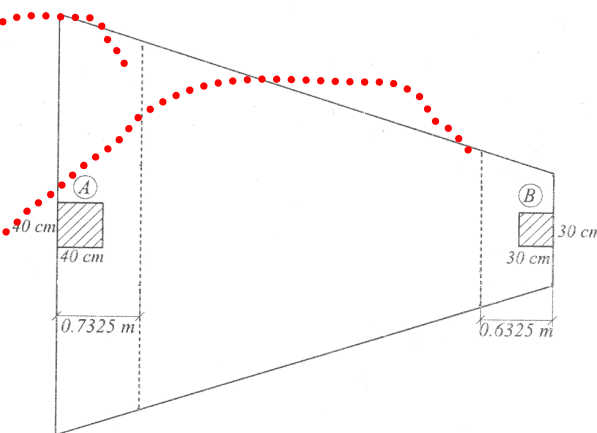
## Bending moment Short direction

### Under Column A

$$b' = 1 + 2\left(\frac{3.62}{4.35}\right) \times 1.5 = 3.5m = 3500mm$$

$$b = \frac{3.5 + 4}{2} m = 3.75m = 3750mm$$

$$b' = 1 + 2\left(\frac{0.633}{4.35}\right) \times 1.5 = 1.44m = 1440mm$$



$$M = \frac{1560}{(3.75 * 0.733)} \times \frac{0.733}{2} \left( \frac{3.75 - 0.4}{2} \right)^2 = 583.6$$

$$d = 665mm$$

$$\rho = 0.85 * \frac{25}{420} \left[ 1 - \sqrt{1 - \frac{2 \times 10^6 * 583.57}{0.9(0.85)25 * 665^2 * 733}} \right] = 0.005$$

$$A_s = 0.005 \times 665 \times 733 = 3325mm^2 = 33cm^2 \quad \text{use } 10\phi 20$$

## Under Column B

$$b = \frac{1.44 + 1}{2} m = 1.22 m = 1220 mm \quad \rho = 0.85 \times \frac{f_c}{f_y} \left[ 1 - \sqrt{1 - \frac{M}{0.9 \times 0.86 \times b \times d}} \right]$$

$$M = \frac{975}{(1.22 \times 0.633)} \times \frac{0.633}{2} \left( \frac{1.22 - 0.3}{2} \right)^2 = 84.6$$

$$b = 633 mm, d = 665 mm$$

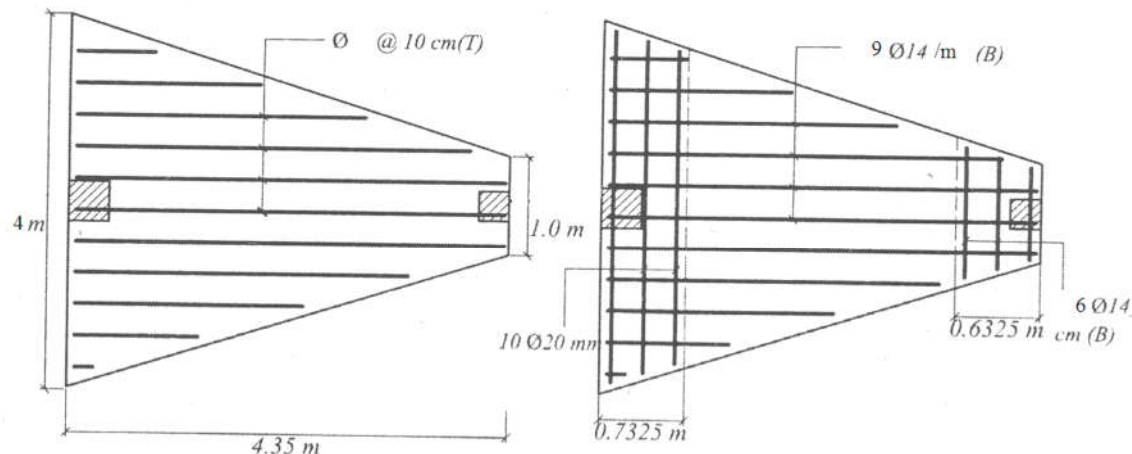
$$\rho = 0.85 * \frac{25}{420} \left[ 1 - \sqrt{1 - \frac{2 \times 10^6 * 84.6}{0.9(0.85)25 * 665^2 * 633}} \right] < \rho_{min}$$

$$A_{Smin} = 0.0018 \times 750 \times 633 = 854.6 mm^2 = 8.6 cm^2 \quad use 6 \phi 14$$

## Shrinkage Reinforcement in short direction

$$A_{Smin} = 0.0018 \times 1000 \times 750 = 1350 mm^2 = 13.5 cm^2 \quad use 9 \phi 14 / m$$

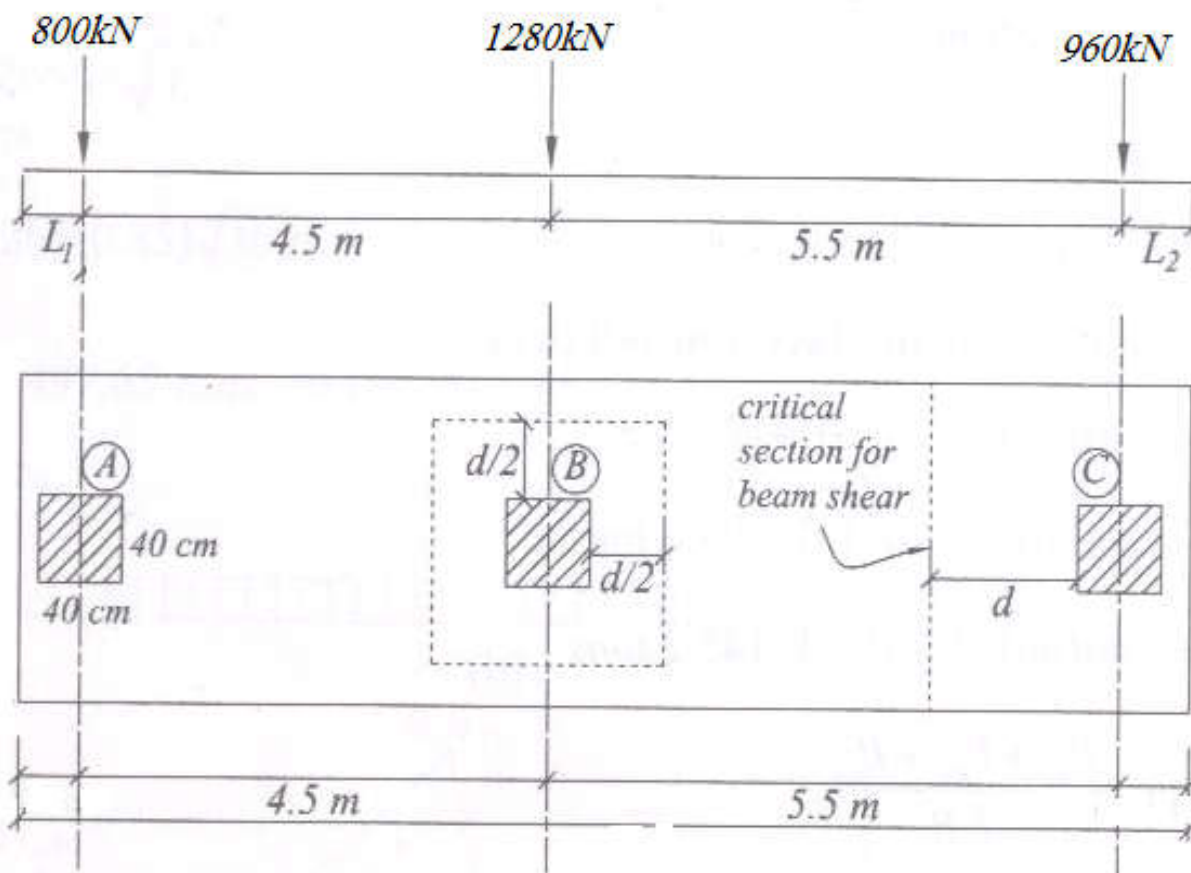
## Reinforcement details



## Example 3 (Strip footing)

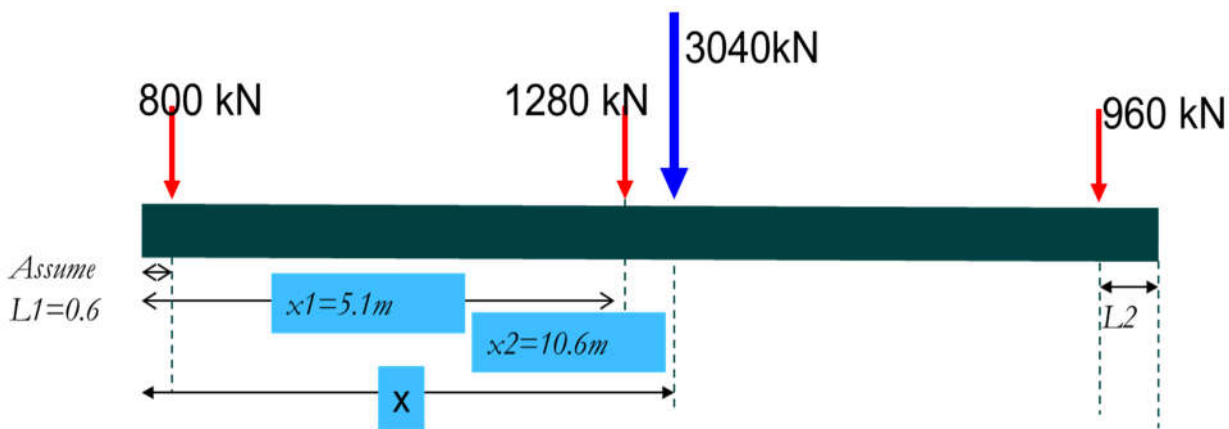
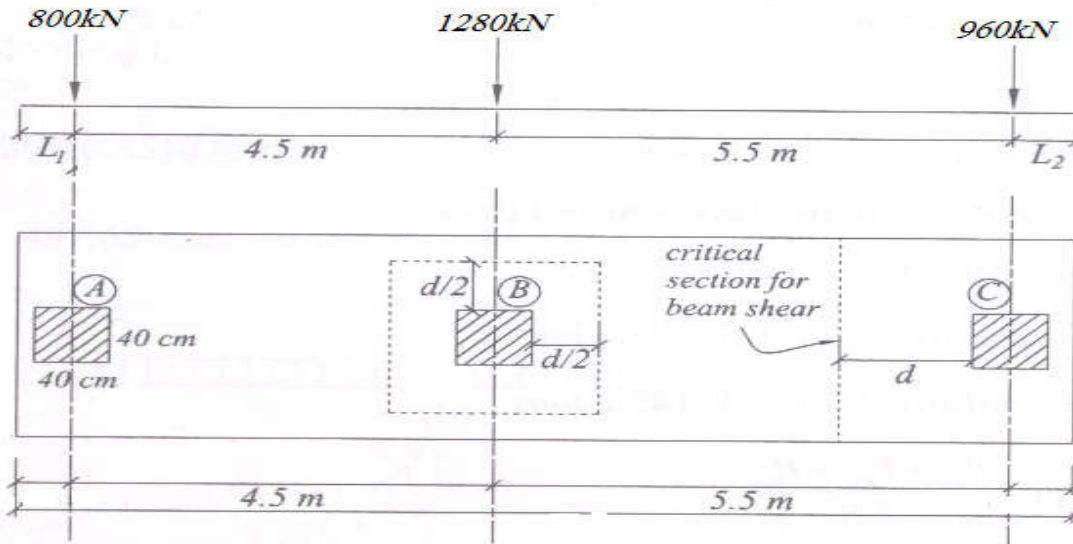
Design a combined or continue footing as shown

$$q_{all(net)} = 20t / m^2 = 200kPa \quad f'_c = 25 N/mm^2 \quad f_y = 420 N/mm^2$$



## Dimension calculation

The base dimension to get uniform distributed load



$$800(0.6) + 1280(5.1) + 960(10.6) = 3040(x)$$

$$x = 5.65 \text{ m},$$

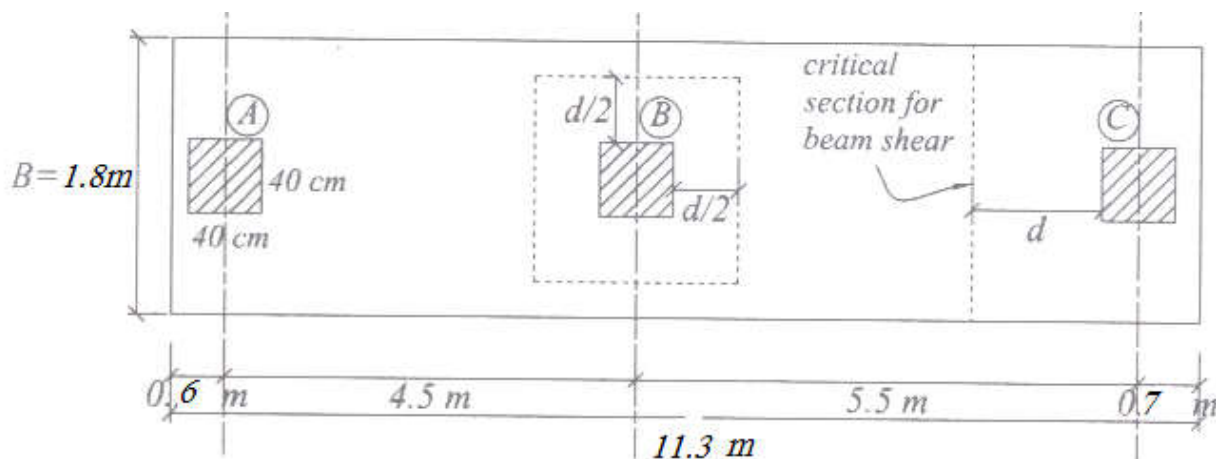
$$2(x) = 11.3 \text{ m}$$

$$L_2 = 11.3 - (10.6) = 0.7$$

$$q_{all(net)} = 18t / m^2 = 180kPa,$$

$$A_g = \frac{P_s}{q_{all(net)}} = \frac{3040 \times 10^3}{180 \times 10^3} = 16.9m^2 \approx 11.3m \times 1.8m$$

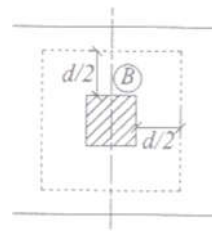
$$q_u = \frac{P_u}{A} = \frac{1.3(3040) \times 10^3}{11.3 \times 1.8} = 195 \times 10^3 Pa = 195kPa$$



## Check for punching Shear

$$h = 700 \text{ mm}$$

$$d = 630 \text{ mm}$$



## Column B

$$b_o = 4(630 + 400) = 4120 \text{ mm}$$

$$\phi V_c = \phi \frac{\sqrt{f'_c}}{3} b_o d = 0.75 \times \frac{\sqrt{25}}{3} \times 630 \times 4120 / 1000 = 3244.5 \text{ kN}$$

$$\phi V_c = \phi \left( 2 + \frac{\alpha_s d}{b} \right) \frac{\sqrt{f'_c}}{12} b_o d = 0.75 \left( 2 + \frac{40 \times 630}{4120} \right) \times \frac{\sqrt{25}}{12} \times 630 \times 4120 / 1000 = 6584 \text{ kN}$$

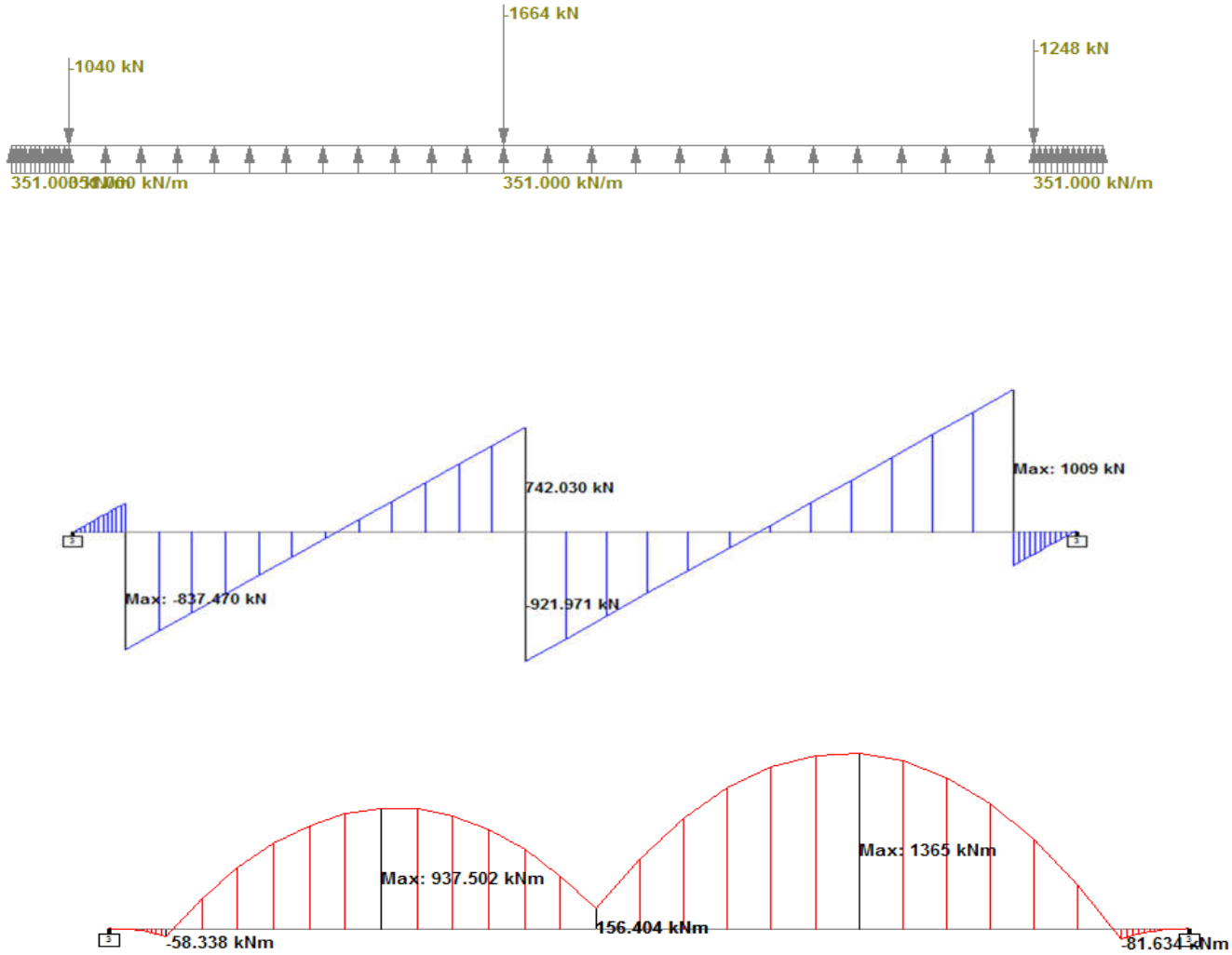
$$V_u = 1280(1.3) - 1.03^2 * 195 = 1457.1 \text{ kN} < \phi V_c \quad \text{oK}$$

You can check other columns



## Draw S.F.D & B.M.D

$$\text{Stress under footing} \\ = 195 * 1.8 = 351 \text{ kN/m}$$



**Check for beam shear**

$$b = 1800\text{mm}, d = 630\text{mm}$$

$$\phi V_C = 0.75 \times \frac{\sqrt{25}}{6} \times 630 \times 1800 / 1000 = 708.75\text{kN}$$

$$\text{Max} \rightarrow V_U \text{ at } \underline{d} \text{ from column face} \approx 0.7(1009) = 706.3\text{kN}$$

$$V_U < \phi V_C$$

**Bending moment Long direction**

$$-ve M = 1366\text{ kN.m}$$

$$b = 1800\text{ mm}, d = 730\text{ mm}$$

$$\rho = 0.85 \times \frac{f_c}{f_y} \left[ 1 - \sqrt{1 - \frac{M}{0.9 \times 0.86 \times b \times d}} \right]$$

$$\rho = 0.85 * \frac{25}{420} \left[ 1 - \sqrt{1 - \frac{2 \times 10^6 * 1365}{0.9(0.85)25 * 630^2 * 1800}} \right] = 0.0053$$

$$A_S = 0.0053 \times 630 \times 1000 = 3362\text{ mm}^2 = 33.6\text{ cm}^2 \quad \text{use } 9\phi 22 / m \quad \text{Top}$$

$$+ve M = 246.7\text{ kN.m}$$

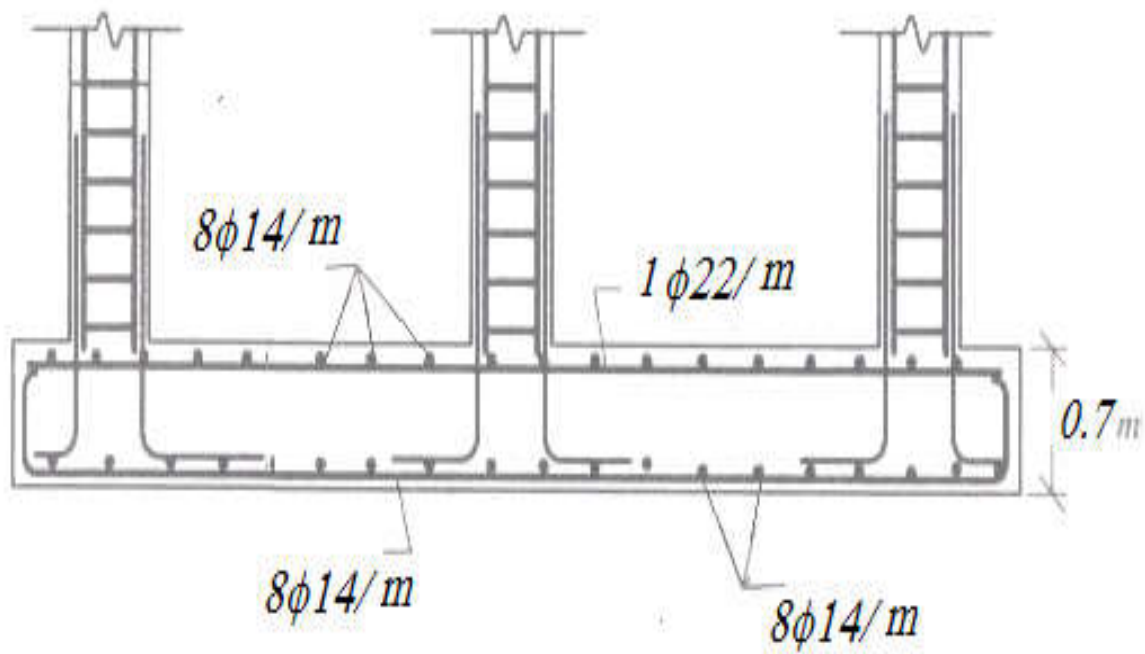
$$b = 1800\text{ mm}, d = 730\text{ mm}$$

$$\rho = 0.85 * \frac{25}{420} \left[ 1 - \sqrt{1 - \frac{2 \times 10^6 * 81}{0.9(0.85)25 * 730^2 * 1800}} \right] < \rho_{\min}$$

$$A_{S_{\min}} = 0.0018 \times 700 \times 1000 = 1260\text{ mm}^2 = 12.6\text{ cm}^2 \quad \text{use } 8\phi 14 / m \quad \text{Bottom}$$

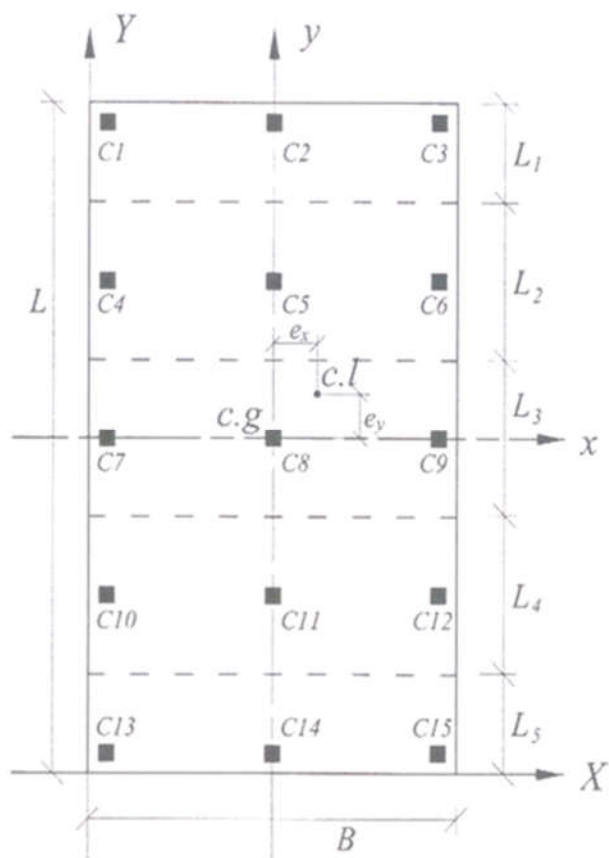
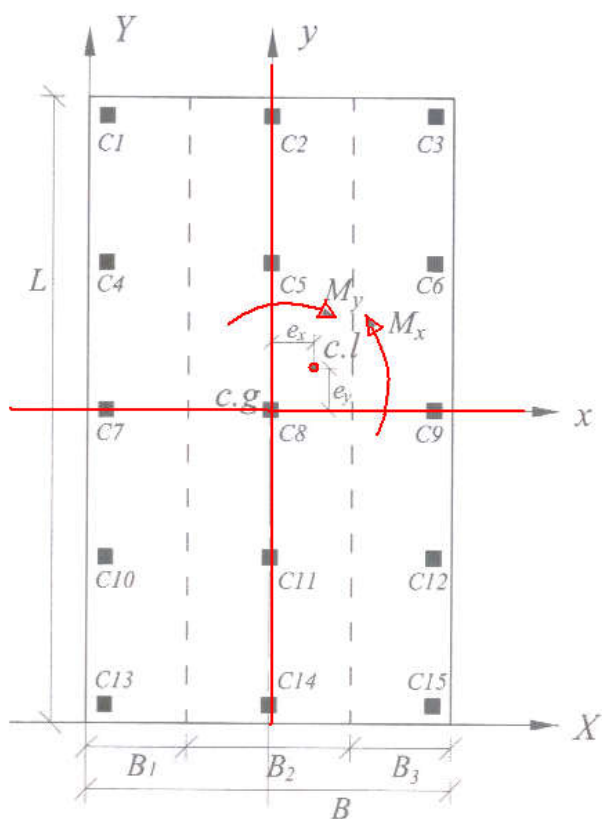
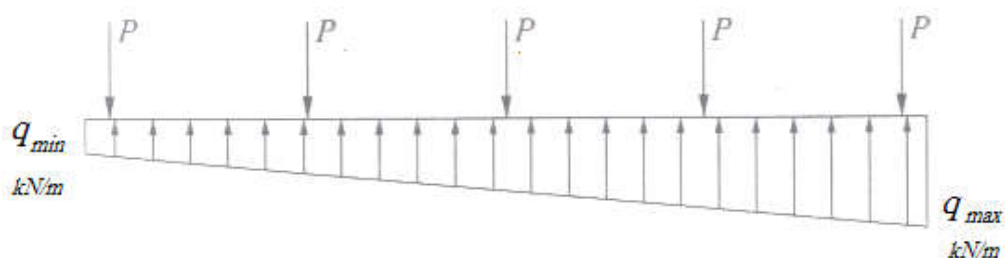
**Design Short direction as example 1 (lecture 11)**

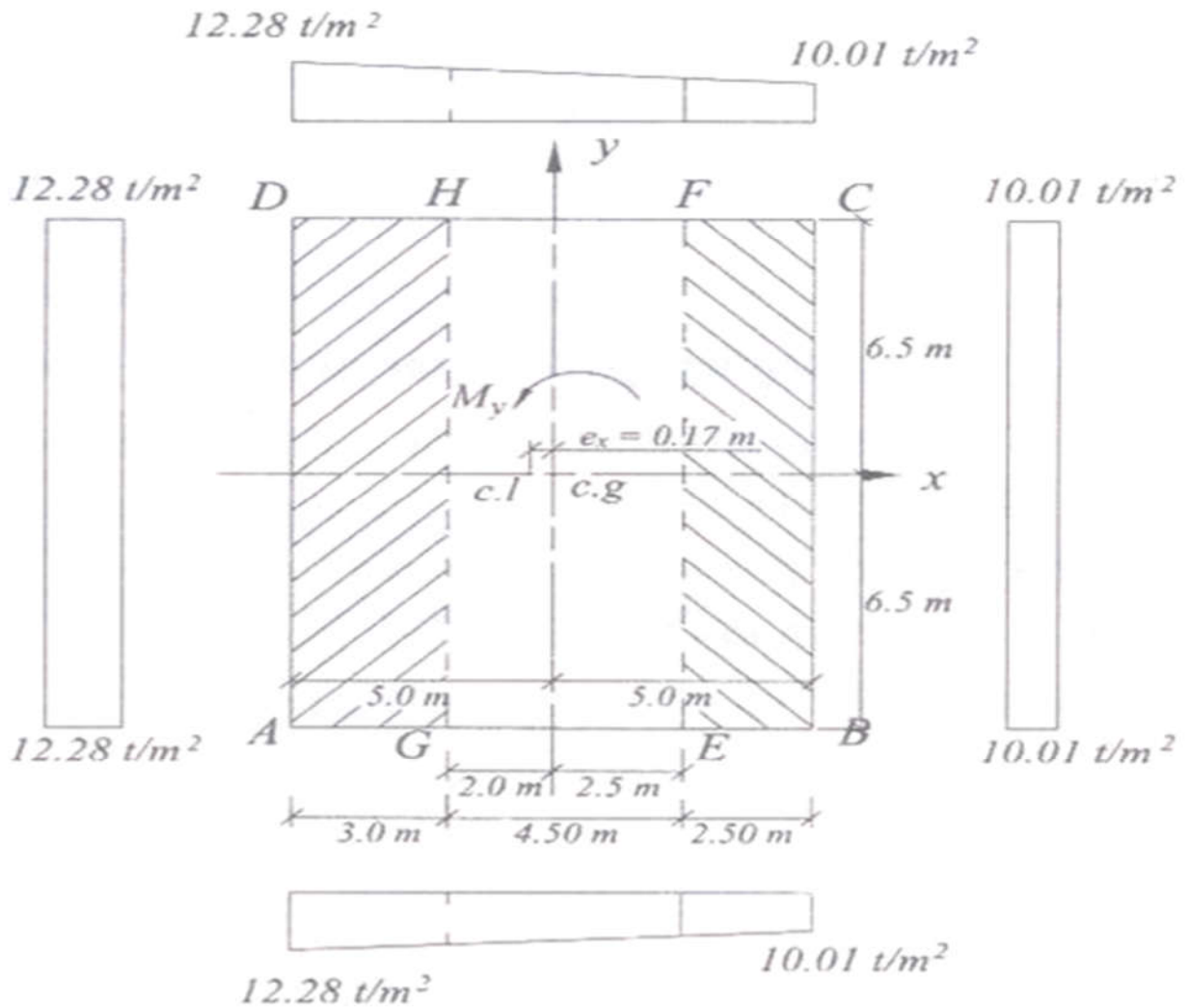
## Reinforcement details



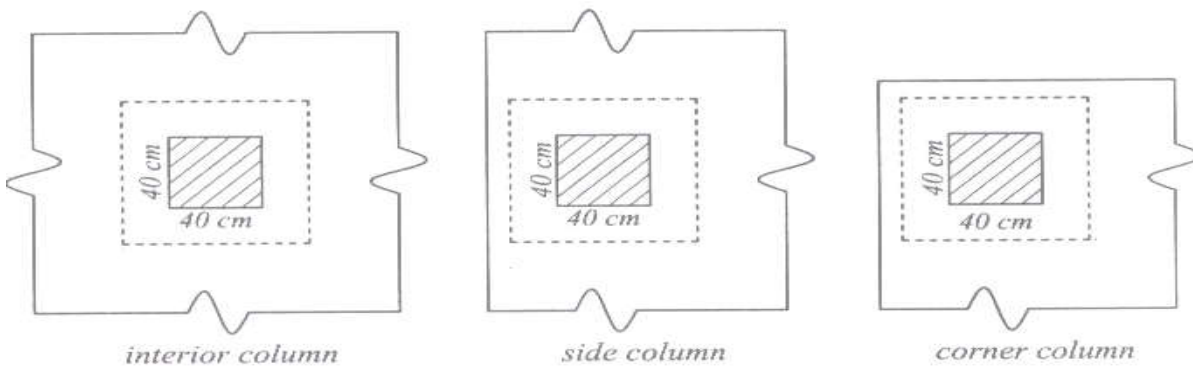
# Mat Foundation

$$q = \frac{\sum P}{A} \pm \frac{M_x y}{I_x} \pm \frac{M_y x}{I_y}$$



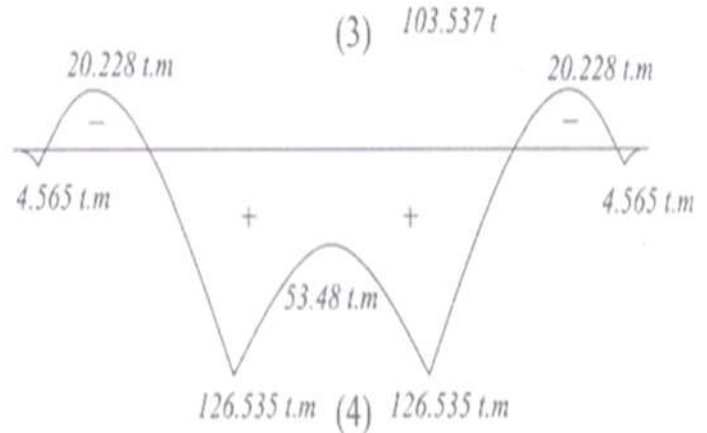
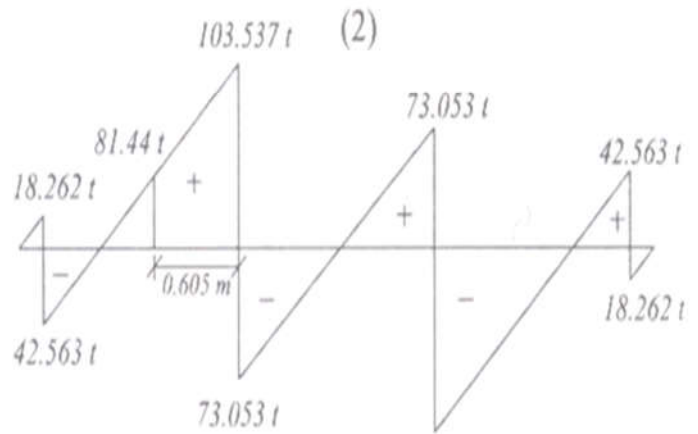
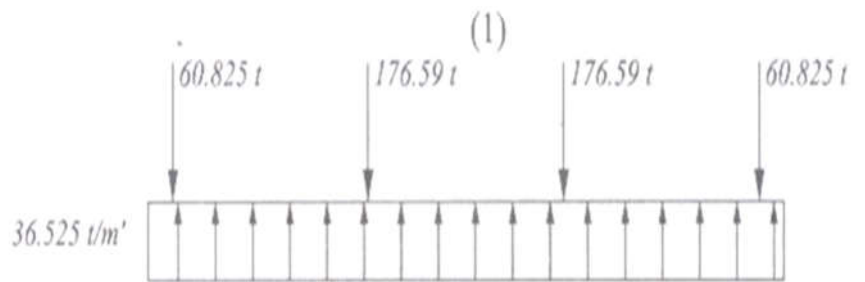
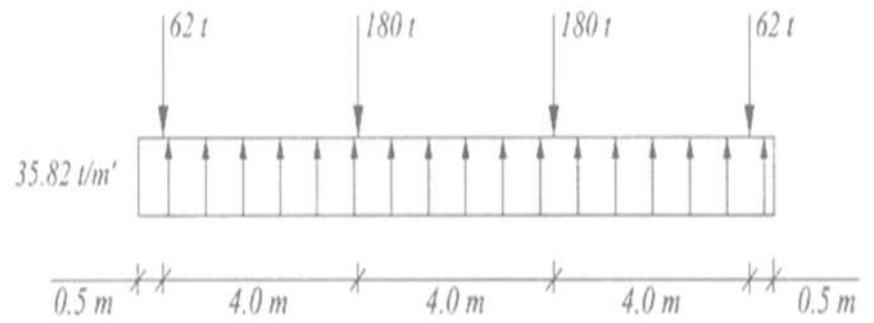


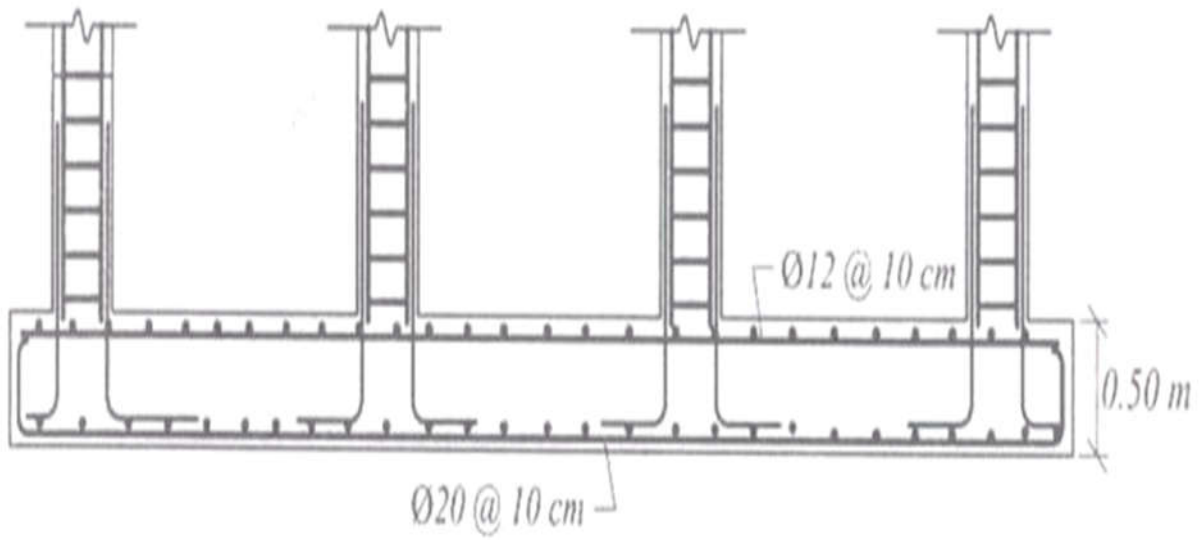
### Check for punching Shear



General Example, <sup>Ref. 3</sup>

Modified load







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