DESIGN OF MAT FOUNDATION FOR MULTI STORY BUILDING IN OLD MALAKPET, HYDERABAD

1.N.PRATHYUSHA 2.DR.SIVA SANKAR REDDY
1.M.Tech, Department of Civil Engineering, Nalla malla reddy engineering college, Hyderabad
2.Professor, Nalla malla reddy engineering college, Hyderabad

Abstract

Most of experimental studies have been carried out on MAT Foundation. This paper has tried to do the design of MAT foundation by conventional rigid method. Optimum design of mat foundation for residential multi story buildings is presented in this research.

Mat foundations are used where soil has low bearing capacity and/or the column loads are so large that more than 50 % of the area is covered by conventional spread footings. By combining all individual footings into one mat, the contact pressure is not only reduced, but also soil bearing capacity is increased. A true mat is a flat concrete slab having a uniform thickness throughout the entire slab. This type is most suitable where the column loads are small or moderate and the column spacing is fairly small and uniform. The slab may be thickened under the large column loads to provide the sufficient strength for shear and negative moment.

This work presents the design of Mat foundation for Multi story building in old Malakpet. The content of this paper is analysis in medium sand with respect to the geometrical features which include the size and thickness of MAT foundation under compression. Mat foundations can be used to equalize the differential settlements or to bridge over the cavities. In this work complete design of Mat foundation is presented for construction of a multi stored building under loose soil

INTRODUCTION

The raft foundation is continuous footing that covers the entire area beneath a structure and supports all the walls and columns. The term mat is also used for foundation of this type. It is used generally on soil of low bearing capacity and where the area covered by spread footings is more than half the area covered by the structure.

Raft foundation is also used where the soil mass contains compressible lenses or the soil is sufficiently erratic so that differential settlement would be difficult to control. The raft tends to bridge over erratic deposits and reduces the differential settlement. Foundation is a mediator to transfer the load from superstructure to the soil effectively, without any failure for both the structure and the soil.

MAT foundation is one of the effective types of shallow foundations, which carries the load to the soil without any differential settlement in the soil. A MAT foundation may be used where the
base soil has a low bearing capacity and/or the Columns loads are so large that more than 50 percent of the area is covered by conventional spread footings.

There are various theories for the design of MAT foundation. Those are varying from conventional manual calculation methods to most modern computer based methods. Finite element method is one of the effective and economic numerical methods for analyzing these foundations. For MAT foundation, advanced numerical modeling techniques are utilized by dividing the MAT into grid elements and predicting the behavior of the structure under loading for critical elements. The Finite element software Annoys has been extensively used in most of the previous studies for structural elements, foundations and in many other fields.

In this work, variation of the load carrying capacity of mat foundation with size and thickness is considered. Finite element software Annoys is used for understanding the behavior of MAT foundation under different parameters.

**FOUNDATIONS**

**Definition:**

A foundation is that transfers loads to the earth. Structures or other constructed works are supported on the earth by foundations. The word “foundation” may mean the earth itself, something placed in or on the earth to provide support, or a combination of the earth and the elements placed on it. Foundations are used to spread the loads from columns or walls to the underlying soil or rock.

**Types of foundations:**

- Deep foundations
  - Piles
  - Piers
  - Caissons
✓ Compensated foundations

➢ Shallow foundations

✓ Footings
  ✓ Strap (cantilever footing)
  ✓ Spread footing
    ✓ Continuous (strip/wall footings)
    ✓ Isolated (individual footings)
  ✓ Combined footing
    ✓ Rectangular
    ✓ Trapezoidal

✓ Mat (Rafts)
  ✓ Flat plate ---- The mat is of uniform thickness
  ✓ Flat plate thickened under columns
  ✓ Beams and slabs
  ✓ Slab with basement walls

MAT FOUNDATION

Definition

Mat or Raft foundations are required on soil of low bearing capacity, or where structural column or other loads areas are so close in both directions that individual pad will nearly touch each other.

The function of raft foundation are to spread the load over as wide an area as possible, and to give a measure of rigidity to the sub-structure to enable it to bridge over local areas of weaker or more compressible soil.

The degree of rigidity given to the raft also reduces differential settlement. It is useful in reducing different settlement on variable soils or there is a wide variation in loading and adjacent column or other applied loads.
Typical use:

Mat or Raft foundations are used to bridge over soft spots if the spots are very localized and to reduce the average pressure applied to the soil. Raft foundation can be used as a matter of constructional convenience in structure supported by a grid of fairly closed spaced columns. In such case, an overall raft will avoid obstruction of the site by a number of individual excavations with their associated heaps of spoil.

Some designer work on the rule that if more than 50% of the area of the structure is occupied by individual pad or strip foundation it will be more economical. Normally built at for support construction at low bearing capacity such as abandon mining site or at the slopping site which are refilled or not.

They are useful in the following cases:

- for lightly loaded structures on low bearing capacity ground;
- for heavier structures such as multi-storey buildings;
- where mining subsidence is likely to occur; and
- Where the column loads and/or soil conditions are such that the resulting footings occupy most of the site.

Types of Mat Foundation:

1. Flat plate ---- The mat is of uniform thickness
2. Flat plate thickened under columns
3. Beams and slabs
4. Slab with basement walls

Choice of type of foundations:

The choice of the appropriate type of foundation is governed by some important factors

1. The Nature of the structure
2. The loads exerted by the structure
3. The sub soil characteristics
4. The allotted cost of foundations

Therefore to decide about the type of foundation, subsoil exploration must be carried out. Then the soil characteristics within the affected zone below the building should be carefully evaluated. The allowable bearing capacity of the affected soil strata should then be estimated.

After this study, one could then decide whether shallow foundations or deep foundations should be used. Shallow foundations, such as footings and rafts, cost less and easier to execute. They could be used if the following two conditions are fulfilled:

1. The superimposed stress caused by the building lies within the allowable bearing capacity diagram of different soil strata
2. The building could withstand the expected settlement estimated for that type of foundation

To Design a Mat Foundation:

1- Determine the bearing capacity of the foundation
2- Determine the settlement of the foundation
3- Determine the differential settlement
4- Determine the stress distribution beneath the foundation
5- Design the structural components of the mat foundation using the stress distribution obtained from (4).

From Step (4)

a- The mat foundation is assumed to be a rigid foundation
b- The mat foundation is assumed to be a Flexible Foundation; here use Beam on Elastic Support Method.

Bearing Capacity of Mat Foundations: The gross ultimate bearing capacity of a mat foundation is same as for shallow foundations: The net ultimate capacity is

\[ q_{ult,net} = q_{ult} - q \]

Mat design by conventional rigid method:

- The raft dimension is established and the resultant of all loads and the soil pressure is computed at various locations beneath the base
- The raft is subdivided into a series of continuous strips (beams) centered on column rows
- The shear and moment diagrams can be established, using either combined footing analysis or beam coefficient the beam moment coefficient \( Pf^2/10 \) for long directions and \( Pf^2/8 \) for short directions may be adopted. The negative and positive moments will be taken as equal. The depth is selected to satisfy shear requirements without using stirrups and the tensile reinforcement is selected. The depth will usually be constant but the steel requirements may vary from strip to strip. The perpendicular directions are analyzed similarly.

**DESIGN PROCEDURE FOR MAT FOUNDATION**

- **Conventional Rigid Method:**
  - The conventional rigid method of mat foundation design can be explained in step by step manner with reference to fig (1). The steps are as follows.
  - **Step 1:**
    - Fig (1) shows that the mat has a dimension of \( L \times B \).
    - \( Q_1, Q_2, Q_3 \ldots \) are column loads. Calculate the total column loads as
    - \( Q = Q_1 + Q_2 + Q_3 + \ldots \) ..................(1)
  - **Step 2:**
    - Determine the pressure on the soil (q) below the mat at points A, B, C, D. by using the equation
    - \[ q = \frac{Q}{A} \pm \frac{M_y x}{I_y} \pm \frac{M_x y}{I_x} \]
    - Where, \( A = L \times B \)
    - \( I_x = \frac{BL^3}{12} = \) moment of inertia about the x-axis
    - \( I_y = \frac{LB^3}{12} = \) moment of inertia about the y-axis
- \( M_X = Q \) ey = moment of the column loads about the x-axis

- \( M_Y = Q \) ex = moment of the column loads about the y-axis

- ey, ex are the loads eccentricities in the direction of x and y coordinates as

\[
X' = \frac{Q_1 x_1 + Q_2 x_2 + Q_3 x_3 \ldots}{Q}
\]

- And, \( e_x = x' - \frac{B}{2} \)

- Similarly, \( Y' = \frac{Q_1 y_1 + Q_2 y_2 + Q_3 y_3 \ldots}{Q} \)

- And, \( e_y = y' - \frac{L}{2} \)

- Step 3:

  - Compare the values of the soil pressure determined in step 2 with the net allowable soil pressure to check if \( q_{net(all)} \)

- Step 4:

  - Divide the mat into several strips in x and y directions (see fig). Let the width of any strip be \( B_1 \).

- Step 5:

  - Draw the shear (V) and the moment (M) diagrams for each individual strip (in X and Y directions). For example, take the bottom strip in the X direction of fig 1(a); its average soil pressure can be given as

\[
Q_{avg} = \frac{q_{I} + q_{F}}{2}
\]

  - Where \( q_I \) and \( q_F \) are the soil pressures at points I and F as determined from step 2.

  - The total soil reactions are equal to \( q_{avg} B_1 B \). Now obtain the total column load on the strip as \( Q_1 + Q_2 + Q_3 + Q_4 \). The sum of the column loads on the strip will not be equal to \( q_{avg} B_1 B \) because the shear between the adjacent strip has not been taken into account. For this reaction, the soil reactions and the column loads need to be adjusted, or

\[
\text{Average load} = q_{avg} B_1 B + \frac{(Q_1 + Q_2 + Q_3 + Q_4)}{2}
\]

  - Now, the modified average soil reaction

\[
Q_{avg (modified)} = q_{avg} \left( \frac{\text{average load}}{q_{avg} B_1 B} \right)
\]

  - Also, the column load modification factor is

\[
F = \frac{\text{average load}}{Q_1 + Q_2 + Q_3 + Q_4}
\]

  - So, the modified column loads are \( FQ_1, FQ_2, FQ_3 \) and \( FQ_4 \). This modified loading on the strip under consideration is shown in fig 1(b). now the shear and the moment diagram for this strip can be drawn. This procedure can be repeated for all strip in the X and Y directions.
• Step 6:
  
  Determine the depth of the mat $d$. This can be done by checking for diagonal tension shear near various columns. According to ACI code 318=95, for the critical section
  
  $U = b_0d [\theta (0.34)\sqrt{f'c}]$

  Where,
  
  $U = \text{factored column load (MN)} = (\text{column load} \times \text{load factor})$

  $\theta = \text{reduction factor} = 0.85$

  $f'c = \text{compressive strength of concrete at 28 days (KN/ sq M)}$

  The units of $b_0$ in terms of $d$, in preceding equation are in meters. The expression for $b_0$ in terms of $d$, which depends on the location of the column with respect to the plan of the mat, can be obtained from Fig (c).

• Step 7:

  From the moment diagram of all strip in a given direction (that is $X$, or $Y$), obtain the maximum positive and negative moments per unit width (that is $M' = M/B_1$).

• Step 8:

  Determine the areas of steel per unit width for positive and negative reinforcement in $X$ and $Y$ directions from the following equations.

  $M_a = (M') (\text{load factor}) = \theta A_{sfy}

  (d - \frac{a}{2})$

  And,

  $a = \frac{A_{sfy}}{0.85 F'c b}$

  Where,

  $A_s = \text{area of steel per unit width}$

  $f_{sy} = \text{yield stress of reinforcement in tension}$

  $M_a = \text{factored moment}$

**Advantages:**

• It may be more economical to excavate the site to a level formation, construct individual close spaced pad foundation and then refill them.

• Basement with stiff slab or slab and beams floors are forms of foundation rafts; these and the special case of buoyancy rafts.

• Design of raft to counteract the effect of mining subsidence.

• The structure can protect the structure from failure if there is settlement or movement of the soil base because the raft base can hold the super structure. So it suitable for soil such as abandon mining site.

• Loads are spread over the whole area of the structure. Differential settlements are reduced.

• A concrete raft foundation avoids interaction of individual pad foundations (e.g. for columns) where these would otherwise be too close.
**Disadvantage:**

A lot of concrete inquired for base at the low density capacity soil by adding the thickness of the base. The footing should construct on 150mm filled sand to avoid racking from horizontal raft footing should increase by construction side beam reinforcement increase the depth of raft wasn’t give an efficient increase of foundation strength

**Limitations:**

- The mat (or raft) foundation can be considered a large footing extending over a great area, frequently an entire building. All vertical structural loadings from columns and alls are supported on the common foundation.
- Typically, the mat is utilized for conditions where a preliminary design indicates that individual columns or footings would be undesirably close together or try to overlap.
- The mat is frequently utilized as a method to reduce or distribute building loads in order to reduce differential settlement between adjacent areas. To function properly, the mat structure will be more rigid and thicker than individual spread footing.
- A mat foundation is typically used when there are poor and weak soil conditions.

- Raft foundation is provided in morrum soil where bearing capacity is normal.
- In Black cotton soil raft foundation is not the solution.
- The depth of foundation required is about 1m or so raft foundation is adopted.

**Conclusion:**

The paper presents the design of Mat foundation for residential building Multi story building in old malakpet. The choice of foundation depends both on structure and the ground. The purpose of mat foundation is when you a building built on a site with low soil bearing conditions. The raft foundation sometimes have haunches that go below the slab portion to resist punching shear on column. A Raft or mat is usually used when subsoil is weak, or columns are closely spaced.

The purpose of mat foundation is used here to distribute the building pressure over large area so the soil can bear the stress whose capacity is less

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