

# Comparative study of load carrying capacity of under-reamed, bored compaction and friction piles for muzaffarpur soil

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## Abstract

*The research work is done on the soil of muzaffarpur considering the site bela for determining the safe bearing capacity of under-reamed, bored compaction and friction piles for different diameter and length. The analysis of load is done by using the mathematical equation used for the determination of bearing capacity of soil. The results are obtain such as the bearing capacity of under-reamed pile is less than 1.92 times the bored compaction pile for single bulb and 1.45 times for double bulb. Whereas the bearing capacity of bored compaction pile is 3.84 to 5.29 times the friction pile and the bearing capacity of under-reamed pile compare to friction pile is between 2.84 to 2.74 times. So on comparing under-reamed, bored compaction and friction pile the conclusion is made that bored compaction pile is best suited for muzaffarpur soil as compare to under-reamed, bored compaction and friction pile.*

*Key words: - comparative, bearing capacity, under-reamed, bored compaction, friction pile, muzaffarpur soil.*

## INTRODUCTION

The Muzaffarpur city is situated at the bank of the river Burhi Gandak constitutes a glorious chapter of our heritage on account of being the center of literature and art.

Though there is no hill nearby and the city is located on plains, it is the richest agriculture belt. It is situated on the soil deposited by flood deposits. It is called the heart of north Bihar as it is the center of trade. The location is such that all the towns of north Bihar are nearly equally distant from this place.

Muzaffarpur, besides being the center of trade and learning, is growing fast as an industrial city. A number of heavy, medium and small scale industries are coming day by day. With the installation of a number of educational institutions and also due to large expansion of railways, a heavy network of highways and air fields are under planning. To meet the Demands and to provide genuine facilities to the increasing population, rapid industrialization of the city is the natural consequences

## INVESTIGATION AS PROPOSED:

As stated above, the rapid industrialization of the city is a natural sequence. The detailed investigation of the soils found in and around the city is the immediate need for planner's builders and engineers. With all these points in view, the investigations have been aimed in three parts.

- (1) First is to find the characteristics of the existing soils of Muzaffarpur including routine properties
- (2) On the basis of soil properties, under-reamed pile, bored compaction pile & friction pile has been designed for different depth & different diameters.
- (3) A comparative study will be made on the basis of result.

## DESIGN OF UNDERREAMED, BORED COMPACTION AND FRICTION PILE FOUNDATION

### DIMENSIONS

*Length of piles:* - In deep deposits of expensive soils, the minimum length of pile from ground level to pile

toe should not be less than 3.5m so that the piles are not affected by season.

**Stem and bulb diameter:-**Stem diameter of under-reamed piles generally ranges from 20cm to 50cm. however the piles of 60cm diameter have also been constructed manually. round movement. The top 1.2m may be neglected for skin friction. The diameter of the under-reamed bulb is normally two and a half times the diameter of pile stem, but under special design requirements, it can be made to vary from 2 to 3 times.

**Spacing of bulbs along pile stem:** - The topmost bulb should not be placed too close to the ground surface, particularly for piles subjected to uplift loading. The minimum desirable depth under all loading conditions is two times the bulb diameter in normal ground conditions. For pile groups with caps embedded in the ground, it should not be less than one-and-a half times the bulb diameter below the cap. In expansive soils for all conditions, it should not be less than 1.75m below ground level.

**Spacing of piles:** - The minimum spacing of piles in a group should be two times the bulb diameter. There is no upper limit for maximum spacing but increase in spacing needs larger pile caps which may be uneconomical. If the piles are spaced closer than two times the bulb diameter, a reduction should be applied in the allowable loads. For spacing of one and a half times the bulb diameter, a 10% reduction may be made if the piles are spaced closer than two times the bulb diameter, a 10% reduction may be made. Spacing closer than this is not advisable. In situations where the piles of two different diameters are adjacent, the spacing considerations are the same but the average bulb diameter may be considered for calculations.

**Batter piles:** - For inclined loads on high lateral loads, under-reamed piles can be provided at a batter. A maximum batter of 30 degree is possible for piles under dry ground conditions and 10 degree or 15 degree batter can be providing for submerged grounds. Batter under-reamed piles are used under transmission lines, tower foundations and as anchors under direct and lateral loads.

**DETERMINATION OF SAFE LOAD**

*The equation used for calculation of safe bearing capacity of under-reamed pile is given below.*

For bulb = 1

$$Q_u = A_p(\frac{1}{2}D \cdot \gamma \cdot N\gamma + \gamma \cdot d_f \cdot N_q) + A_a[\frac{1}{2}D_u \cdot n \cdot \gamma \cdot N\gamma + \gamma \cdot N_q \cdot d_1] + \frac{1}{2}\pi \cdot D \cdot \gamma \cdot k \cdot \tan\delta \cdot df^2$$

For bulb = 2

$$Q_u = A_p(\frac{1}{2}D \cdot \gamma \cdot N\gamma + \gamma \cdot d_f \cdot N_q) + A_a[\frac{1}{2}D_u \cdot n \cdot \gamma \cdot N\gamma + \gamma \cdot N_q \cdot \sum_{n=1}^n dr] + \frac{1}{2}\pi \cdot D \cdot \gamma \cdot k \cdot \tan\delta \cdot (d_1^2 + df^2 - d^2n)$$

Where,

Qu (kg) = ultimate bearing capacity

Here, Ap (cm sq.) = cross-sectional areas of pile stem at toe level =  $\pi/4 \times D^2$

Aa (cm sq.)= area of under-reamed =  $\pi/4(D_u^2 - D^2)$

$\gamma$  (kg/cm<sup>3</sup>) = average unit weight of soil ( $\gamma' = 1.956\text{g/cm}^3$ )

N $\gamma$  and N $_q$  = bearing capacity factors depending upon the angle of internal friction Table

df (cm) = total depth of pile below ground level

K= earth pressure coefficient(1.75)

d1 = L - (bucket length + 0.55D)

*The equation used for calculation of safe bearing capacity of bored compaction pile is given below.*

For bulb = 1

$$Q_u = A_p [\frac{1}{2}D \cdot \gamma \cdot N\gamma + \gamma \cdot d_f \cdot N_q] + A_a [\frac{1}{2}\gamma \cdot D_u \cdot N\gamma + \gamma \cdot N_q] + \frac{1}{2}\pi \cdot D \cdot \gamma \cdot k \cdot \tan \delta \cdot df^2 \dots\dots\dots (i)$$

**For determination of friction pile the following formula is used**

$$Q_u = A_s r_f + A_p r_p$$

Here, Qu = Ultimate Bearing Capacity

As = Surface area of Pile = ( $\pi \times D \times L$ )

rf =Average Skin Friction = ( $k \times \tan\delta \times \gamma$ )

Ap=Area of Cross – section of Pile =  $\pi/4 \times D^2$

rp =Unit Point or toe Resistance =  $k \times \gamma \times D$

**RESULTS AND DISCUSSION**

The result shows that the soils of muzaffarpur are silty loam belonging to MI group. The percentage of clay vary from 2% to 5%, percentage of silt varies 71% to 74% and sand varies 22% to 25%

respectively. The water table is generally met with at depth ranging 6m (during rainy season) below existing ground level. The optimum moisture content of the soils of this city varies between 18percent to 19.7% while maximum dry density varies between 1.63gm/cc to 1.66gm/cc. The value of cohesion as found from undrained triaxial test ranges between 0.28kg/cm sq. to 0.35kg/cm sq. for muzaffarpur soils. The value of the angle of internal friction 25 degree to 28 degree. The specific gravity of soil of muzaffarpur varies between 2.62 to 2.635. The CBR values for muzaffarpur soils is unsoaked condition ranges between 7.1% to 7.7% for 2.5mm penetration while its range between 5.6% to 6.9% for 5mm penetration. The CBR value in soaked condition after 96hour soaking has, however reduced for both the penetration it ranges between 6.1% to 6.8% for 2.5mm penetration while it range between 5.8% to 6.5% for 5mm penetration. These data indicate that the soil of the city of muzaffarpur inherit good strength are normally suitable for foundation of structures and also for pavement. The safe bearing capacity of under-reamed varies 9.56t to 61.65t for bela soils respectively. It has been found that safe load carrying capacity of bored compaction pile varies from 19.59t to 101.91t for bela soil. For friction pile it is found to be 5.3t to 29.8t.

### CONCLUSION

Based on the discussion following conclusion have been drawn

The safe load carrying capacity depends upon the stem diameter and number of bulbs in case of under reamed pile where as in the bored compaction pile load carrying capacity depends upon the stem diameter of piles. Number of bulbs play significant role in load carrying capacity of under reamed pile where as in the case of bored compaction pile generally constructed with one bulb and hence the bulb does not play any significant role in load carrying capacity of pile. Friction piles are constructed with no bulb and hence bulb does not play any role in load carrying capacity of pile. In case of friction pile having same length with different stem diameter, the load carrying capacity may not increase with increasing stem diameter of pile. Where as in varying, lengths the load carrying capacity increases stem diameter. It is clear from above established relation among the load carrying capacity of piles the load carrying capacity factor decreases

with increasing length of piles. Bored compactions piles are the best suited for muzaffarpur soil and under reamed piles are better than friction piles in similar situation.

### RECOMMENDATIONS

Due to constraints of time and resource only few sample have been considered for analysis. In this research work, the load carrying capacity has been calculated theoretically on the basis of soil properties for different types of piles. To know the accuracy of work, pile load test should be conducted for each type of piles at least at one site and result should be compared with results found theoretically. . Therefore as much data we will observe by testing on soil of the town we will come to know the different conclusion of bearing capacity for under-reamed, bored compaction and friction pile for muzaffarpur soil.

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