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Testing and Analysis of Tapered Pile Response under Vertical Loading in Loose and Dense Cohesionless Material

Chinju Vijayan[1], Ramanathan Ayothiraman[1]
[1]Dept. of Civil Engineering, IIT Delhi,
New Delhi-110 016, India
cez198463@civil.iitd.ac.in; araman@civil.iitd.ac.in

Extended Abstract

When the shallow foundations resting on the surficial soil layers do not satisfy the design requirements of these layers for sufficient bearing capacity and/or settlement, the common solution is to transfer the building loads from this layer to a strong lower layer using pile foundations. There is a wide range of pile foundations with different cross sections and materials, and in recent years, tapered piles have received attention due to their assured pile quality and enhanced load-carrying capacity. Piles with variable cross-sections along the length are reported to be more economical than common uniform diameter/size piles [1]. The interesting fact is that tapered piles are used only in a few countries, despite having several advantages over uniform-diameter piles. This may be because of the lack of understanding about their distinctive behavior and the lack of rational design guidelines. The shaft resistance of tapered piles is found to be higher than that of cylindrical piles due to the inclined shaft surface of tapered piles [2]. Along with the pile's area or volume, different soil conditions and taper angles may also affect the ultimate resistance of the tapered piles which needs investigation.

Around 34 articles had been reported on the response of tapered piles under various static loading (vertical, lateral, and uplift) conditions. These include 18 experimental, 9 numerical, and 10 analytical works. A recent article authored by Shafaghat and Khabbaz [3] presented a comprehensive state-of-the-art review on tapered piles under static and dynamic loading and concluded that ample scope for research still exists on tapered piles. This paper focuses on tapered pile response under vertical loading.

In the present study, 1-g model experiments were carried out using model-reinforced concrete piles. Proper scaling laws were used to relate the model pile dimensions with prototype pile dimensions. Based on the materials used for the RCC model pile and the available test tank dimensions, the bottom pile diameter (40 mm) and the pile length (900 mm) are kept constant. The taper angle is varied (0, 0.5, 1.0, and 1.5°) considering the commonly adopted values in practice. The dimension of the model test tank is 1.5 m × 1.2 m × 1.2 m deep. Axial load tests were conducted on model piles embedded in loose sand (relative density = 25 to 35%) as well as dense sand (Relative density = 75 to 85%). The pluviation technique was used to prepare the soil bed in loose conditions, whereas densification by a mini plate vibrator was adopted for dense conditions. The results of 1-g model tests in loose sand indicate a 27% increase in the vertical capacity of tapered piles at 0.5° taper angle and a 53 to 62% increase in capacity with a further increase in tapering angle (1 to 1.5°). The percentage increase in vertical capacity for dense sand is 36 to 62% for tapered piles. This confirms that the percentage increase in vertical capacity is practically of similar order irrespective of the soil density.

References

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