BEHAVIOUR OF LATERALLY LOADED PILES IN COHESIONLESS SOILS

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Abstract

The response of an individual pile to externally applied lateral load is one of the most complex soil-structure interaction problems in the field of foundation engineering. Piles that are used under tall chimneys, television towers, high-rise high retaining walls, offshore structures etc. Several methods are available for predicting the ultimate lateral resistance to piles in cohesionless soils. However these methods often produce significantly differently ultimate resistance values. This makes it difficult for practicing engineers to efficiently select the method when designing laterally loaded piles in cohesionless soils. This paper gives a comparative study of the lateral load behaviour of piles in cohesionless soils based on Finite Difference Method and Matlock &Reese Method. Slope, deflection, shear and moments were calculated for a typical pile in both methods and their results were presented.

Keywords: *Pile, Cohesionless soil, Lateral load, FDM, Matlock& Reese, Free head pile.*

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1. INTRODUCTION

When a soil of low bearing capacity extends to a considerable depth, piles are generally used to transmit vertical and lateral loads to the surrounding soil media. Piles are structural members that are made of steel, concrete or timber. To understand the deformation behaviour of each of the pile in a pile group subjected to lateral loads, it is necessary to have a clear idea about the behaviour of single piles under lateral loads. Usually laterally loaded single piles are analyzed by methods derived directly from the classical "beam on elastic foundation" mode in which the soil support is approximated by a series of independent elastic spring. Based on this concept, an extensive amount of analytical work has been reported on the behaviour of single piles under lateral loads. Reese and Matlock (1956) were the first who assumed that the soil modulus increases with depth and developed solutions for laterally loaded piles in a non-dimensional form. For stiff clays, they assumed a parabolic variation in subgrade reaction modulus with depth. Matlock and Reese (1960) developed general solutions for laterally loaded piles supported by an elastic medium. According to them, the expressions could be developed for shear force, bending moment, soil reaction and deflection. Davisson and Gill (1963) developed solutions assuming a parabolic variation in subgrade reaction modulus with depth. Here, they assumed a constant value for modulus of subgrade reaction and obtained the moments and deflections along the length of the piles. Reese (1975) presented a computer program using the finite difference approach to solve the deflection and bending moment of pile under lateral as well as axial loads as a function of depth. The soil properties define by a set of nonlinear "p-y" curves. Meera et al. (2007) developed generalized procedure to analyze and predict the flexural behaviour of axially and laterally loaded pile foundations under liquefied soil conditions. The response of the piles as found by using the proposed model are found to be in excellent agreement with theoretical and experimental values reported in literature. Phanikanth et al. (2010) studied the behaviour of single pile in cohesion less soils subjected to lateral loads. The modulus of subgrade reaction approach using finite difference technique is used and the same was coded in MATLAB for the analysis.

2. OBJECTIVES

The main objectives of this paper were:

a) To find the lateral load carrying capacity of single pile in sandy soil.
b) To compare the load carrying capacity of pile by Finite Difference Method and Matlock & Reese Method.

3. METHODOLOGY

The various methods employed in this paper were discussed with the results in the following topics:

3.1Finite Difference Method

The principle of Finite Difference Method is close to the numerical schemes used to solve ordinary differential equations. It consists in approximating the differential operator by replacing the derivatives in the equation using the differential quotients. For any form of variation of Es with depth, the numerical Finite Difference Method is the most convenient method. A convenient way of solving the equation suggested by Glesser The method of Glesser can suitably be adopted for computer solution. The differential equation required to be solved is of the form,

$$\frac{d^4y}{dx^4} + \frac{Es}{EI}y = 0$$

The basic forms of different relationships may be explained with reference to a laterally loaded deflected pile. The pile of length L is divided into t equal parts each of length h. Two imaginary points are taken below and above the tip of the pile.

3.2 Matlock & Reese Method

Matlock and Reese (1956) were the first who assumed that the soil modulus increases with depth and developed solutions for laterally loaded piles in a non-dimensional form. According to them, the expressions could be developed for shear force, bending moment and deflection. Matlock and Reese (1960) have given equations for the determination of deflection, slope, moment and shear at any point x along the pile based on dimensional analysis.

4. RESPONSE OF SINGLE PILE UNDER LATERAL LOADS

Lateral load behaviour of piles in cohesionless soils was analysed based on Finite Difference Method and Matlock & Reese Method. Slope, deflection, shear and moments were calculated for a typical pile in both methods and their results were presented. To study the response of pile under lateral loads (under 100 kN lateral load), 20 m length and 0.5 m diameter of piles was considered. The results are shown in Fig.1 to 4, which indicate that deflection, slope, moment and shear force predicted based on Matlock & Reese was lower than Finite difference method.

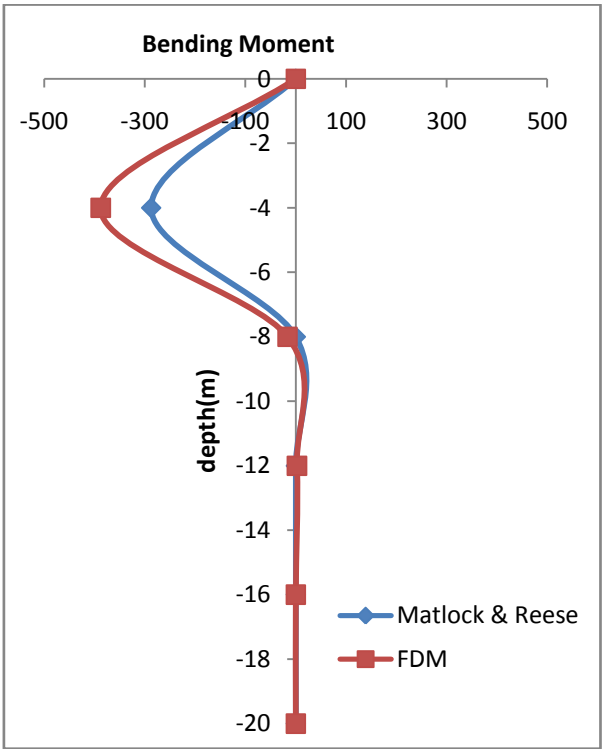

Fig.1. Bending Moment

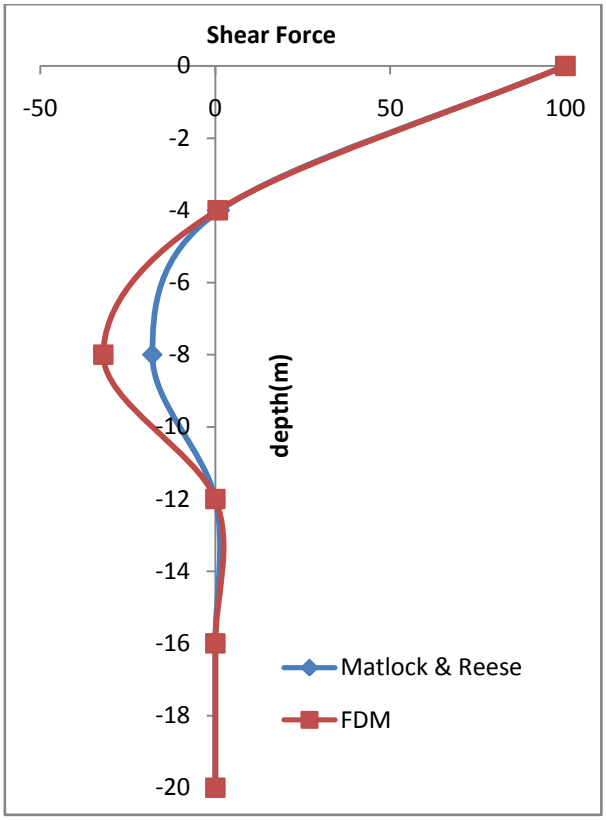

Fig.2. Shear Force

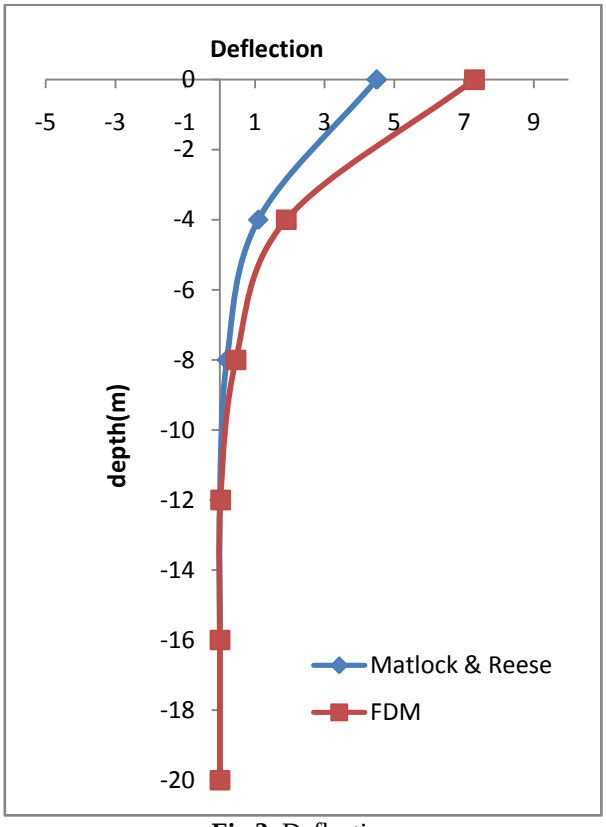

Fig.3. Deflection

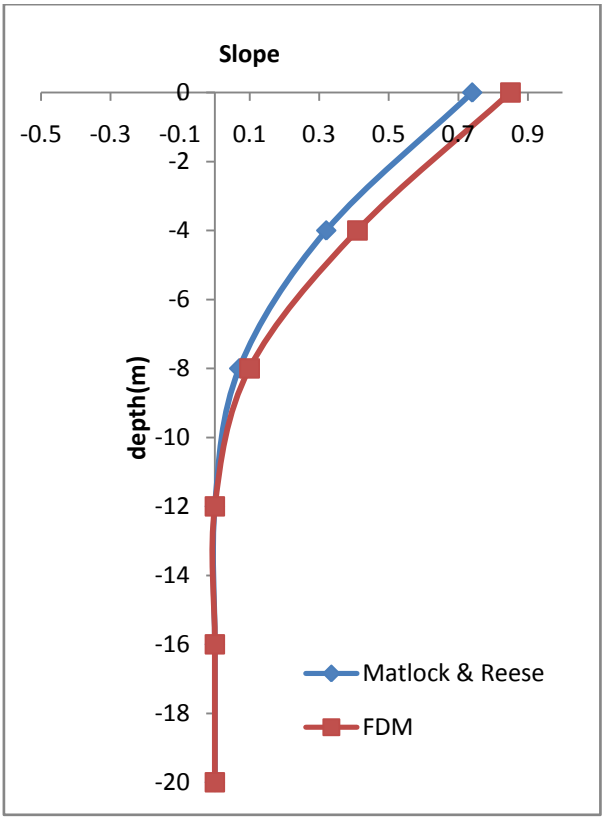

Fig.4. Slope

5. CONCLUSIONS

The response of an individual pile to an externally applied lateral load is one of the most complex soil-structure interaction problems in the field of foundation engineering. Usually, laterally loaded single piles are analysed by methods derived directly from the classical "beam on elastic foundation" mode in which the soil support is approximated by a series of independent elastic spring. Based on this concept, an extensive amount of theoretical and analytical work has been reported on the behaviour of single and group of piles under lateral loads. This paper summarizes the response of single pile under lateral loads by Finite Difference Method and Matlock & Reese approach. Results indicate that deflection, slope, moment and shear force predicted based on Matlock & Reese was lower than Finite difference method.

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