Numerical analysis of uplift load-carrying capacity of inversely tapered piles

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ABSTRACT

The uplift capacity of cylindrical piles has been studied by several researchers. However the effect of the taper angle on inversely tapered piles has not studied yet. In this paper, five groups of piles with different slenderness ratio have been investigated. A finite difference software as coded into FLAC (Fast Lagrangian Analysis of Continua) has been used for the analysis of inversely tapered piles. Two types of soils with different densities are used in this investigation. Also some models have been performed with two layered soils. The pile was assumed to be elastic, and the soil was modeled based on the Mohr- Coulomb failure criterion. To ensure the accuracy of the constructed numerical model results, the data resulted from FLAC analyses have been compared with those obtained from experiments. This comparison showed a very good agreement. The results show that with making the pile inversely tapered, the pile uplift capacity increases considerably, especially for piles with lower slenderness ratios. This may be a useful in practice and thus is interesting for geotechnical engineers to use inversely taper piles when uplift loads if great concern. The main conclusion of this research indicates that an inversely tapered pile offers greater capacity than a cylindrical pile of the same volume and length.

Keywords: pile, inversely taper, uplift capacity, FLAC and slenderness.

INTRODUCTION

The tensile behavior of piles has less investigated by researchers whereas their compressive behavior has been relatively investigated. In some cases, foundations may be subjected to uplift loads. Such loads may be so heavy that needs to be transferred by piled foundations. The loads applied to piles are transferred to soil beneath them by two mechanisms: end bearing and shaft friction of pile wall. In piles subjected to uplift loads, the strength is completely provided by shaft friction. Thus, an optimum design method that improves this way would be cost effective. The uplift behavior of piles has been studied by several investigators (e.g., Abdullah, 2001; Byrne 1999; Dash and Pise, 2003; Ilamparuthi et al, 2002; Ilamparuthi and Dickin, 2001a; Ilamparuthi and Dickin, 2001b; Ismael, 2001; Palmer et al, 2003; Patra and Pise, 2003; Patra et al, 2004). The outcome of studies performed on the bearing capacity of taper piles under compression loads (Ghazavi and Alimardani, 2006; Wei and El Naggar, 1998), indicates that the taper of piles have considerably better effects on their compressive bearing capacity. Also the behavior of taper piles subjected to uplift loads have been investigated in an experimental study (e.g., El Naggar and Wei, 2000), the behavior of inversely tapered piles subjected to uplift loads has not been investigated yet. It seems that the inversely tapered pile may be a new idea and needs to be explored.

This paper presents the numerical analysis of inversely tapered piles subjected to uplift loads. The results for inversely tapered piles have compared with cylindrical piles.

GENERAL PROCESS OF STUDY

Five groups of piles with different slenderness ratios have been used for analysis in this study. The slenderness ratios for piles are L/r_m = 20,30,40,50, and 60, where L is the pile length and r_m denotes the mean radius for pile. Each group of piles has modeled with different inverse taper angles ranging 0˚-2˚ with 0.5˚ intervals. To consider the practical limitations, for more slender