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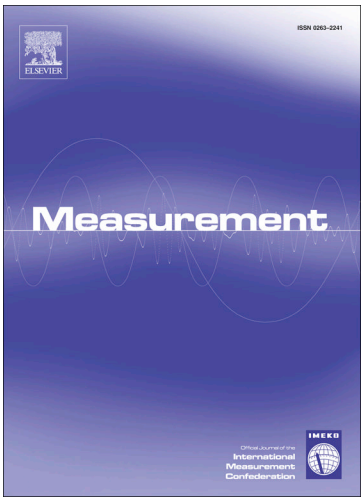

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PII: S0263-2241(17)30383-4
DOI: http://dx.doi.org/10.1016/j.measurement.2017.06.001
Reference: MEASUR 4800

To appear in: *Measurement*

Received Date: 10 July 2016
Revised Date: 6 January 2017
Accepted Date: 2 June 2017

Please cite this article as: H. Moayedi, M. Mosallanezhad, Uplift Resistance of Belled and Multi-Belled Piles in Loose Sand, *Measurement* (2017), doi: http://dx.doi.org/10.1016/j.measurement.2017.06.001

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Uplift Resistance of Belled and Multi-Belled Piles in Loose Sand

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Abstract
In this study, a series of small scale tests are conducted on belled and multi-belled piles in dry loose sand. The installed piles were carefully instrumented with several LVDTs, strain gauges, and a load cell. Results recorded from a laboratory model tests were used to investigate the potential benefits of installing belled and multi-belled piles in increasing the uplift load capacity and also to reduce vertical ground deformation adjacent to the pile. Finite element modeling (FEM) is also performed to assess the soil particle movement, inside the glass box, during pile uplift displacement. The results unveils that increasing the number of wings will not always increase the uplift resistance of piles. For instance, in comparison with the straight pile, the uplift resistance increases up to 60% when the belled installed at the pile base and it decreases about 4% when installed at the depth equal to 33% of the pile length. In addition, for a similar uplift displacement, the pile with installed belled at the base could reduce 75% of the ground surface deformation, comparing to the straight pile.

Keywords: *Sand, Piling; Deep foundations; Multi-belled piles; Data Acquisition.*

1 Introduction

Belled drilled shaft (belled piers) foundations widely used as foundations of heavy structures such as highway bridges, transmission line towers, and tall buildings. These foundations plays a key role in development of the both compression and uplift bearing capacity. The belled and multi-belled pile can improve the tip (base) resistance, friction of pile shaft, and reduce the effect of negative skin friction [1]. It has also proven to be economical foundation providing resistance to extensive pullout and/or any uplift load [2]. Numerous laboratory and field works were performed to study the behavior of uplift loaded belled and multi belled pier [2, 3], ultimate uplift capacity of single piles in loose and dense sand [4], uplift capacity of pile groups in sand [5], tension cables such as guyed mast and

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