Title	Discussion: Interaction factor for large pile groups
Author(s)	Wang, A.D.; Wang, W.D.; Huang, M.S.; Wu, J.B.; Sheil, Brian B.; McCabe, Bryan A.
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Discussion of Wang, A.D., Wang, W.D., Huang, M.S. & Wu, J.B. (2016) "Interaction factor for large pile groups" *Geotechnique Letters*, Vol. 6, No. 1, pp. 1-8.

by Brian B. Sheil[a*] and Bryan A. McCabe[b]

[a]*Postdoctoral researcher, University of Oxford, Parks Road, Oxford OX1 3PJ, U.K.*
[b]*Lecturer, College of Engineering and Informatics, National University of Ireland, Galway, Ireland.*
Corresponding author. Email: brian.sheil@eng.ox.ac.uk; Tel.: +44(0)1865 273129

Notation

d	Diameter of the pile
E_p	Young's modulus of the pile
E_s	Young's modulus of the soil
L	Length of the pile
m	Number of piles
α	Two-pile interaction factor
ν_p	Poisson's ratio of the pile
ν_s	Poisson's ratio of the soil

The authors present an interesting paper on the use of the interaction factor method (IFM) for settlement analysis of large pile groups. Some clarifications of the detail are sought for the benefit of readers. The discussers also have some concerns about the validity of the paper's findings.

Given that '*sheltering*' and '*reinforcing*' are central concepts to the formulation proposed, clear definitions of these terms would have been helpful at the outset of the paper. In Fig. 7, the authors compare predictions derived from (i) superposition of their 'sheltering-reinforcing' two-pile interaction factors and (ii) finite element (FE) analyses, where the entire (floating) pile group is modelled. All values of α in this figure exceed unity; therefore this use of the term α is not in keeping with the traditional definition as presented in the notation for the paper, which of course has a theoretical maximum value of unity (for two piles at zero spacing).

While discrepancies may be expected for end-bearing pile groups, the lack of agreement between IFM and 'direct' FE predictions shown in Fig. 7 for a floating pile group is surprising. This was attributed by the authors to the inability of IFM to capture group reinforcing effects. This finding is inconsistent with the research of El Sharnouby and Novak (1990), Southcott and Small (1996) and Cairo and Conte (2006), all of which demonstrated excellent agreement between IFM and direct analyses of floating pile groups in LE soil. This verdict was recently extended by the discussers to the case of a soil exhibiting stiffness nonlinearity hosting floating groups of up to 196 (14^2) piles (McCabe and Sheil, 2015), a much larger group size than that considered by the authors.

In order to examine the influence of group reinforcing effects on α directly, a limited number of simulations have been undertaken by the discussers using the FE software package PLAXIS 3D Foundation in conjunction with a LE soil model. An example FE mesh is shown in Fig. 2 for a group of 49 (7^2) piles; the particulars of the finite element modelling are available elsewhere (McCabe and Sheil, 2015, Sheil and McCabe, 2014). The discussers have adopted the same geometries employed by the authors and Ottaviani (1975), except that the group piles considered here are free-headed. The values of α have been calculated using two different sets of analyses: (i) the traditional α approach using only two piles (Fig. 2a); (ii) the consideration of two piles within a larger pile group (Fig. 2b). From the results presented in Fig. 3a, it can be seen that the presence of the additional non-loaded group piles has a very minor influence on the value of α, and significantly less than that reported by the authors for their corner pile. Moreover, it can be seen that the influence on the settlement of the loaded pile is also minimal with a reduction of less than 1.5% (Fig. 3b).

These results appear to contradict the authors' conclusion that group reinforcing effects play an appreciable role for floating pile groups. A comparison between the authors' interaction factors and two-pile interaction factors determined using their FE analysis may go some way to explaining the source of the incongruity. The authors are also invited to revisit their choice of lateral extent for their FE analyses; for a loaded (free-headed) 49-pile group, the discussers observed ~15% difference in the centre pile settlement when the distance to the lateral boundary was increased from 13 m (that used by the authors) to 30 m (used in deriving the data for Fig. 3).

References

Cairo, R. & Conte, E. (2006) Settlement analysis of pile groups in layered soils. *Canadian Geotechnical Journal* **43(8)**:788-801.

El Sharnouby, B. & Novak, M. (1990) Stiffness constants and interaction factors for vertical response of pile groups. *Can. Geotech. J.* **27(6)**:813-822.

McCabe, B. A. & Sheil, B. B. (2015) Pile group settlement estimation: suitability of nonlinear interaction factors. *ASCE Int. J. Geomech.* **15(3)**:04014056.

Ottaviani, M. (1975) Three-dimensional finite element analysis of vertically loaded pile groups. *Geotechnique* **25(2)**:159-174.

Sheil, B. B. & McCabe, B. A. (2014) A finite element based approach for predictions of rigid pile group stiffness efficiency in clays. *Acta Geotechnica* **9**:469-484.

Southcott, P. H. & Small, J. C. (1996) Finite layer analysis of vertically loaded piles and pile groups. *Comp. Geotech.* **18(1)**:47-63.
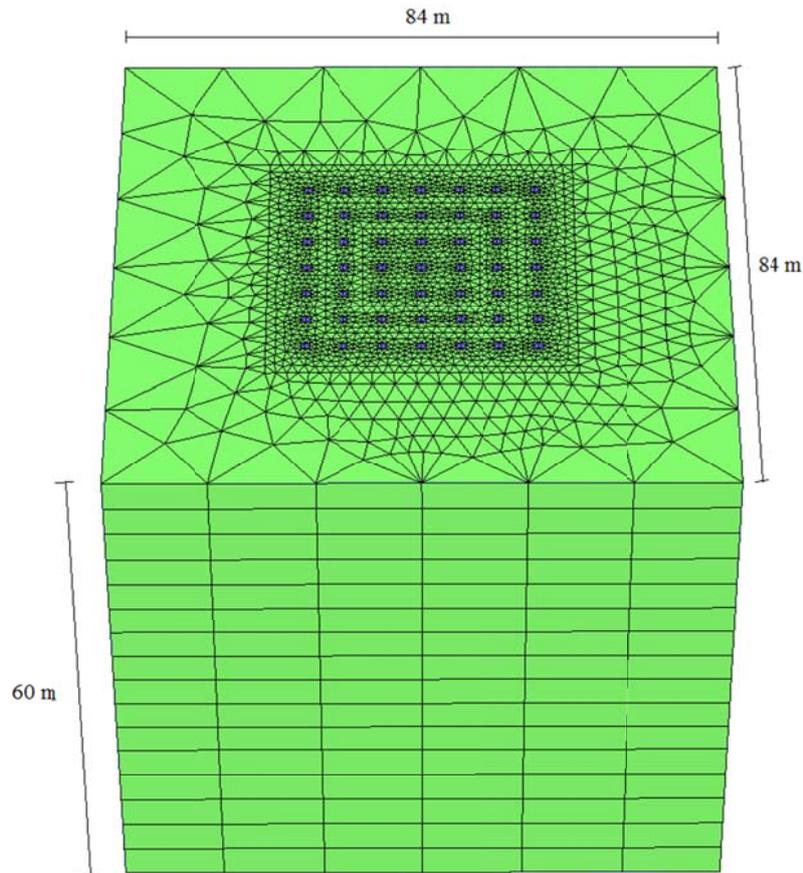
Fig. 1 Illustration of FE mesh for 7^2 pile group; 68,400 15-noded elements
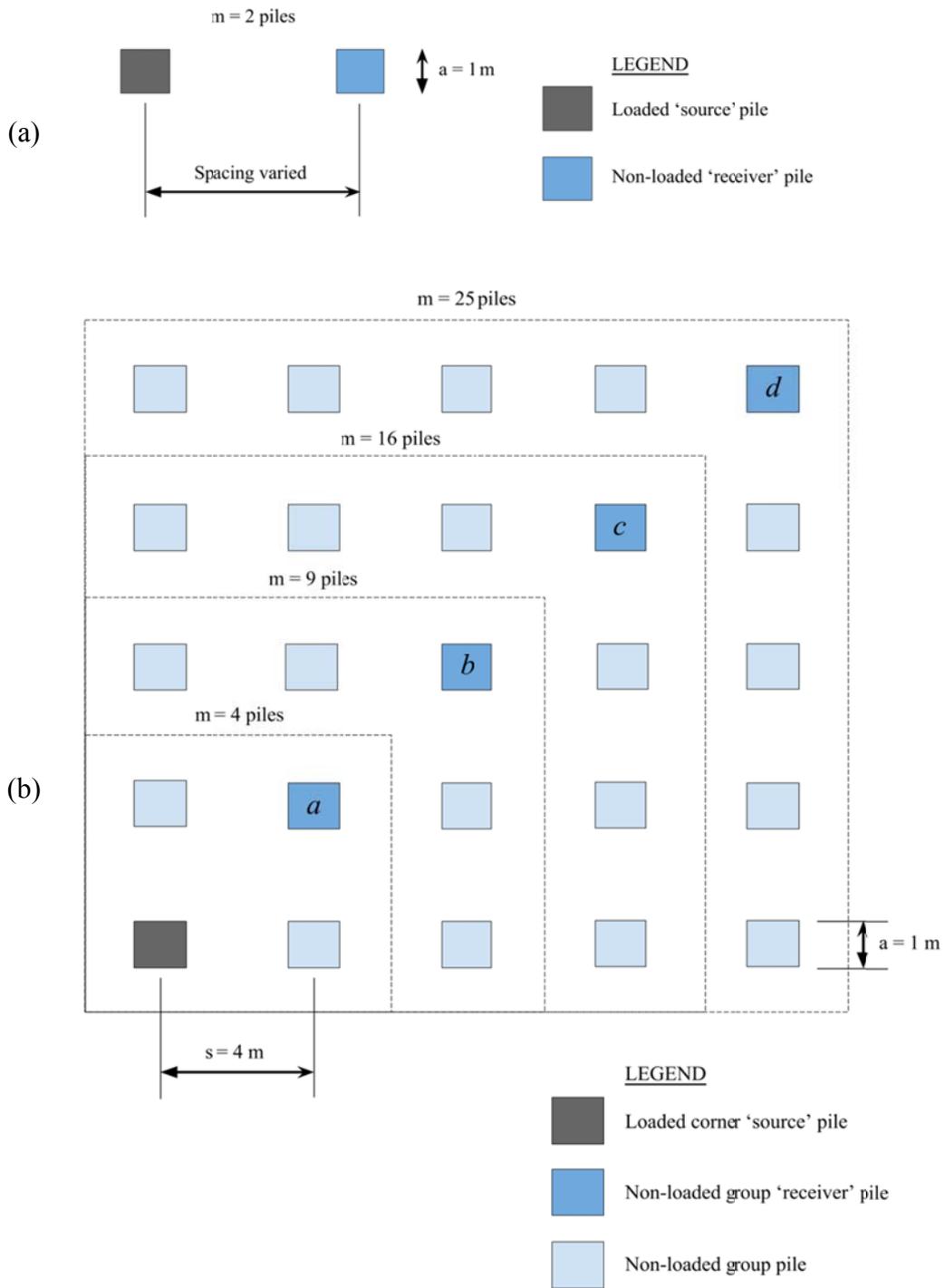
Fig. 2 Illustration of (a) two-pile and (b) pile group geometry (only groups of up to *m*=25 piles shown for clarity)
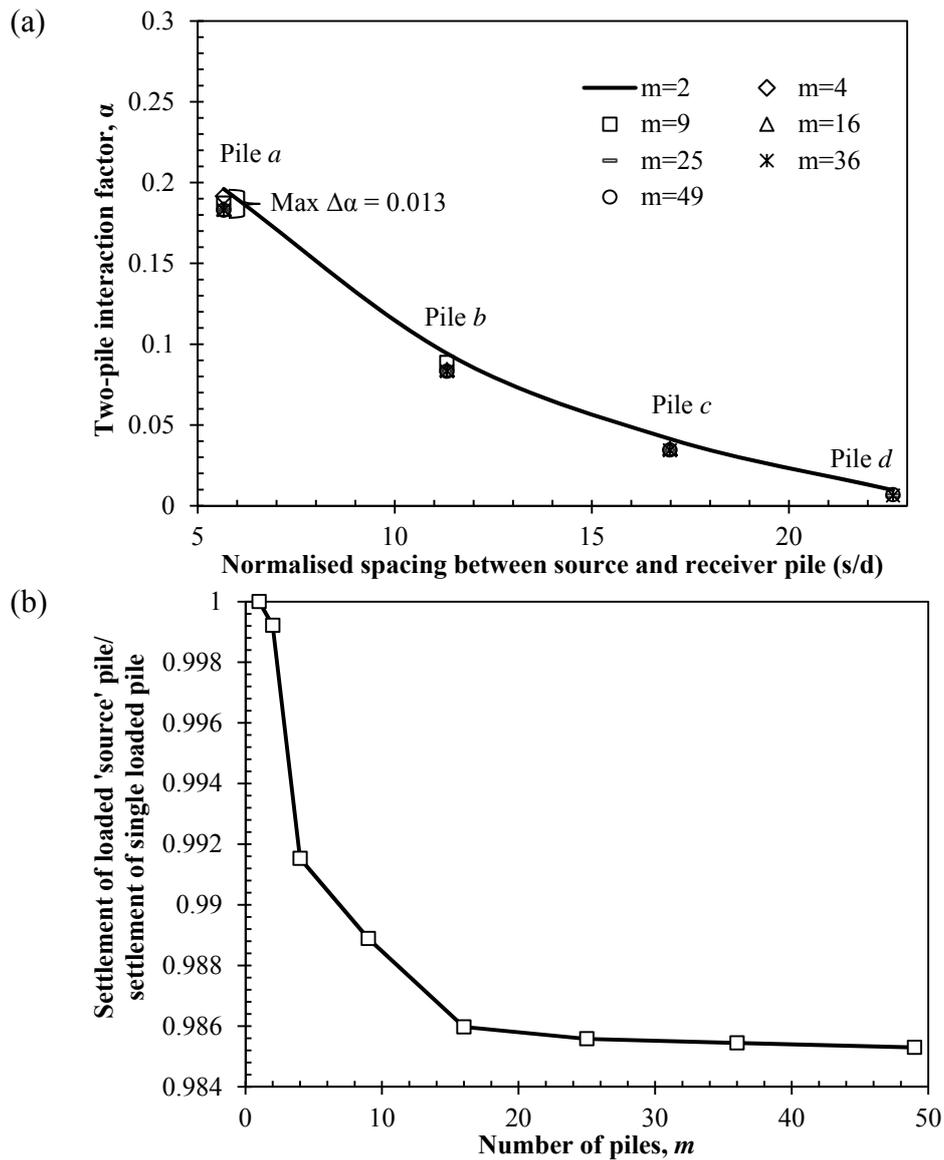
Fig. 3 Influence of free-headed group piles on (a) two-pile interaction factor and (b) the settlement of the loaded 'source' pile; $L = 40$ m, $E_s = 24.5$ MPa, $E_p = 19600$ MPa, s = 4 m, $a = 1$ m, $\nu_p = 0.25$, $\nu_s = 0.45$