野立てソーラーシステムにおける複合鋼材支柱基礎の設計・開発に関する研究
A Study on Design and Development of Composite Pile Foundation for Solar Support

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Introduction

It is evident that solar plants are getting growing interest worldwide due to its renewable energy that combats climate change and assures a sustainable energy source. There are some researches on the concrete foundations of solar plants that were found in the NEDO Organization, Japan [1]. These are mainly made of concrete and steel bars as of reinforced concrete foundation and cost-performance was not taken into account. In addition with these, researches on photovoltaic cells were performed by the Japanese Industrial Standards (JIS) [2]. Design wind pressure coefficients on hip roofs of low-rise buildings with the variation of angle of solar panels were calculated by researchers of the Japanese Architectural Society and Aihara et al. [3]. The paper reports the load-displacement relationships of composite solar foundation and development of the technique as well as failure modes from the pullout, compression and lateral tests results.

Materials and Methods

The materials used are 76.3mm diameter steel pipe of lengths 1.5m and 2.0m and the sand-cement mortar mix with sand-cement ratio of 2.1 and water-cement ratio of 2:1. Outline of new solar foundation is shown in Fig.2. The anchoring length of the left pipe is 105cm and the right pipe is 125cm. In order to ease of pouring of the cement-sand mortar under the pipe, additional burrow of 10cm was done below the pipe (Fig.1).

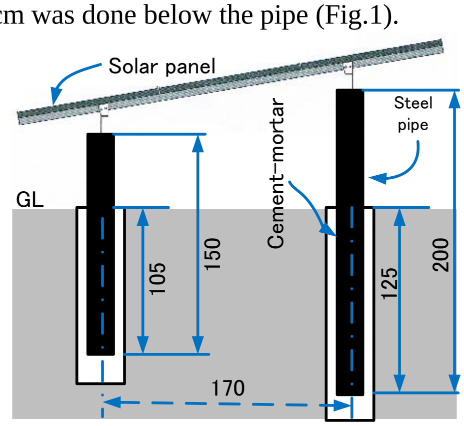

Fig.1 Outline of new solar foundation (cm)

Work Procedure

The details of the work procedure are given the following flow chart (Fig.2).

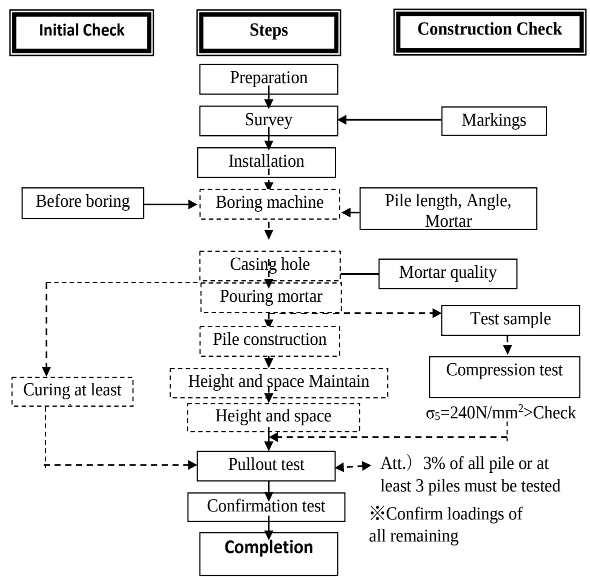

Fig.2 Work flow chart (Solid Line: Main Work, dotted Line: Specified Work, Construction Check: Formation and Quality Management)

Results and Discussion

The results of pullout, compression and lateral load tests of two piles of Matsuzaka area are presented in Figs. 3-4. It can be seen from Fig.3 that the pullout load displacement curves for both the piles at Matsuzaka site showed the similar trend as of flat curvilinear nature. The uplift load for both the piles increased in curvilinear characteristics with a slight increase in the displacement. The maximum uplift loads for Matsuzaka are obtained as 15kN for both the piles.
It can be seen from Fig.4 that the compression responses of both piles were non-linear. Both the piles showed very small displacement (nearly 0.7mm) in compression. The compression load-deflection curves for pile1 can be taken as three linear parts, namely, 0.1 to 0.4mm at initial stage, 0.4 to 0.5mm at mid-section and 0.5 to 0.7 at final stage while for pile2, it can be taken as flat shape with a slight fluctuation at diaplacement of nearly 0.5 to 0.6mm. The maximum

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compression load for Matsuzaka area was noted as 20 kN for both the piles.

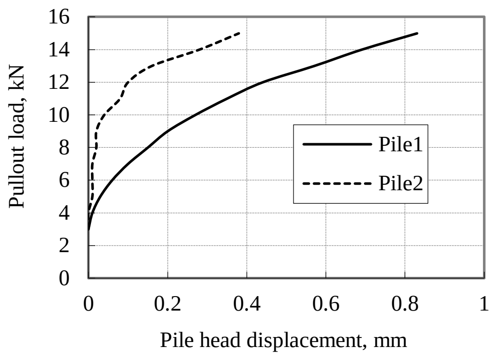

Fig.3 Pullout load-displacement relationships (Matsuzaka)

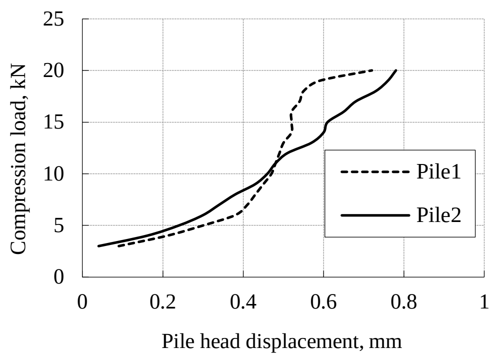

Fig.4 Compression load-displacement relationships (Matsuzaka)

The lateral load-displacement curve of Matsuzaka pile (Fig.5) can be characterized into three parts: the first linear part up to a displacement of 2mm, followed by the second linear component with a displacement ranging from 3mm to 14mm, and the third linear component with a near-horizontal slope up to a displacement of nearly 30mm.

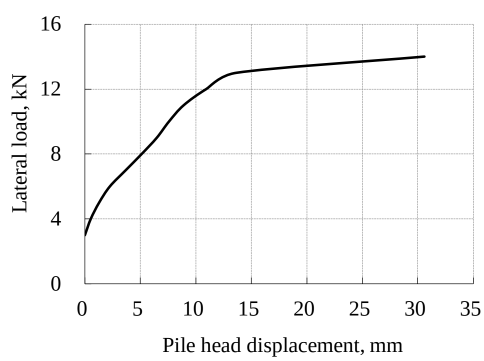

Fig.5 Lateral load-displacement relationships (Matsuzaka)

The maximum lateral load for Matsuzaka soil was obtained as 14kN at which the soil failure occurred along with lateral bending failure of the pile (Fig.6).

Fig.6 Bending failure of steel pipe after lateral test

Conclusions

Composite foundation structures of solar support systems that have been designed and constructed. Results obtained showed that the uplift pullout loads, compression loads and lateral loads of the piles are strong enough to support the solar plants against strong winds loads of about 40m/s and have the bearing capacity enough to support the weight of the solar plants.

Acknowledgements

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References

[1] NEDO: New Energy and Industrial Technology Development Organization, http://www.nedo.go.p/

[2] JIS C8955: Japanese Industrial Standards, Design guide on structures for photovoltaic array, 2004.

[3] Aihara T., Asami Y., Nishimura H., Takamori K., Asami R. and Somekawa D.: An area correct factor for the wind pressure coefficient for cladding of hip roof －The case of square plan hip roof with roof pitch of 20 degrees－The 22nd Wind Engineering Symposium, pp.339-344, 2008.

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