Development of Sheet-Pile Foundation Combining Footing with Sheet-Piles

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1. Sheet-pile foundation

In foundation works in urban areas where the construction sites are confined or located near railways, it has become necessary to consider not just providing sufficient earthquake resistance and the bearing capacity of the foundation, but also economics, work efficiency and consideration for the environment (reduction of noise, vibration and industrial waste).

A sheet-pile foundation is one that combines a spread foundation with sheet-piles used for earth-retaining works during excavation (Fig. 1 (b)). It falls between the spread foundation and the pile foundation. With this type of foundation, it is expected that the sheet-piles will enhance the enclosure of the ground immediately under the footing (ground constraining effect), increase bearing capacity of the ground by their skin friction and improve the horizontal seismic resistance of the foundation. In addition, the sheet-pile foundation eliminates the need to remove the form work from around the footing and pull out the sheet-piles after completion of the foundation work. Furthermore, the sheet-pile foundation permits a redution in the amount of soil to be excavated since it requires a smaller area of excavation. Unlike a pile foundation, a sheet-pile foundation does not require pile driving work, and hence it is economical and easy to construct. It is also friendly to the environment since it produces neither sludge nor muddy water during excavation.

2. Verification experiment using full-scale models

With the aim of confirming the workability of the sheet-pile foundation and the horizontal resistance of the foundation during an earthquake, full-scale bridge pier models, one with a spread foundation and the other with a sheet-pile foundation, were constructed and subjected to a full-scale horizontal loading test in which test loads were applied to the tops of the bridge piers. Assuming that the pier models were for an elevated single-track railway bridge 6 m in height, the footing was set at 3.6 m square and the sheet-piles were embedded to a depth of 3.5 m from the surface of the ground. The sheet-pile foundation being constructed is shown in Fig. 2. Anchor bars were welded to the sheet piles so that the sheet piles and the footing were joined. To make the footing and concrete into one unit, anchor bars were welded to the sheet-piles.

At the points upon which the force of inertia of the girders acts during an earthquake, the test loads were applied horizontally at a height of 6.5 m from the bottom of the footing. Fig. 3 shows a scene from the loading test, and Fig. 4 shows the relationship between horizontal load and horizontal displacement (P-δ curve). The sheet-pile foundation displayed seismic resistance about four times greater than the spread foundation.

3. Future prospects

Concerning the economics of the sheet-pile foundation, it can be expected that the cost of foundation work will be cut by about 20% for sandy ground with an N-value of approximately 20. In addition, the construction period could be shortened significantly. This type of foundation has already been applied in some 20 projects. It will become more widespread in the future. As a method of reinforcement of seismic resistance, it can be applied not only to new structures but also to existing ones.

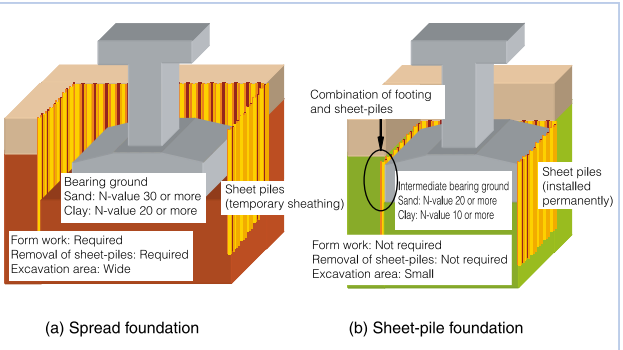

Fig. 1 Spread foundation and sheet-pile foundation

Fig. 2 Assembly of footing reinforcing bars

Fig. 3 Loading test

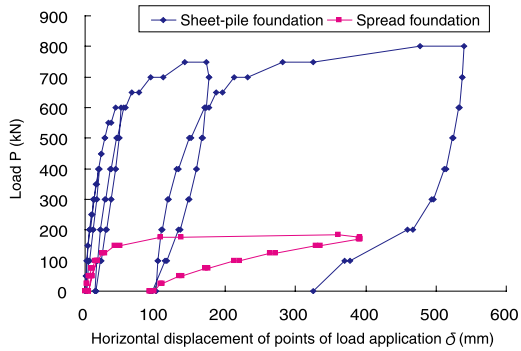

Fig. 4 Load-horizontal displacement relationship (P-δ curve)