CS-233 Cost Reduction by the Adoption of New Cast-in place Concrete Pile Method

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1. Introduction

As the economy of Japan grows, road traffic become much more congested. To meet traffic demand, width of main roads and highways are widened in some cases because of new road construction difficulty. Usually, cast-in-place concrete piles are utilized in the foundation of bridge width extension portion. Toe resistance of cast-in-place concrete pile is effective after a certain settlement. In bridge width extension, there are need of complicated execution. In the case of bridge width extension of Chiba Higashi, Keiyo Road, the adoption of new cast-in-place concrete pile method realized much more simple execution and resulted in cost reduction.

2. New cast-in-place concrete pile method

From an environmental point of view, noise and vibration during construction of a driven pile, especially in urban areas, make a cast-in-place concrete pile more acceptable than a driven pile. But, because of stress release and disturbance of ground at pile toe, the cast-in-place concrete piles usually have smaller toe resistance than that of the driven concrete piles. Small toe resistance may cause differential settlement of foundation, causing heavy damage to superstructures. According to Foundation Design Standard for Railways(JSCE,1986), in order to reduce the differential settlement of the piled foundations, the settlement of individual piles should not exceed 2 cm for 95% reliability in design. Because of the displacement limitation, design load of cast-in-place pile is mainly borne by shaft resistance. Compared with a driven pile, toe resistance of a cast-in-place pile is usually not mobilized well within a settlement of 2 cm.

In order to improve the resistance mechanism of a cast-in-place pile, a new construction method has been developed. (Okumura et al. 1992 and 1994) In this method, between excavation and concrete casting, concentric-circle divided concrete rings are intruded at the pile toe by hydraulic jacks repeatedly into the soil. The concrete rings are 20 cm high with diameters of 40, 60 and 80 cm. Repeated normal stress will cause shear strain in the ground and the strength of the loosened ground is recovered or improved. Using divided rings, large intrusions can be introduced into the soil under the limitation of capacity of the hydraulic jacks. Schematic image of capacity improvement effect by this method is shown in Figure 1. In this figure, shadowed portion indicated the effect. Execution procedure of this method is shown in Figure 2. Between slime withdrawal and concrete casting, concrete ring intruding and slime withdrawal by slime extraction machine. From comparative loading test results, preloading makes the toe resistance of the developed pile 50% higher than that of conventional one.

3. Schematic design of widened road

As the width of bridge was widened to 4.46m, the width of foundation was widened to 5.37m and nine cast-in-place concrete piles were added. In the original design of bridge widening portion, slot

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method was adopted. In this method, foundations and piers of new portion was constructed separately from the original bridge. To avoid unequal settlement, second execution for attachment was awaited for finish of settlement of the new portion. After a certain period , second execution shown in Figure 3 was executed. This waiting period results in cost increment.

To reduce the cost dramatically, the new method wad adopted. By using the new method, ground reaction of the new added piles are high enough after execution. Then there are no need of waiting time. Design condition for the added piles are shown in Table 1. By the intruding effects, bearing capacity and vertical coefficient (k_v) of soil reaction at pile toe of the new pile are 1.67 and 5 times higher than those of the conventional one, respectively.

4. Execution results

During execution, concrete rings were intruded repeatedly and intruded force and settlement were measured. The value of k_v was calculated from these values and was used for execution control. Maximum intruding force for the first ring was over 4.9 MPa. After k_v reached the controlling value, intruding was finished. The values of k_v of all piles were checked during execution. After bridge width extension, settlements of bridge and strain of reinforced bars were measured. These measured values are sufficient for superstructure utilization.

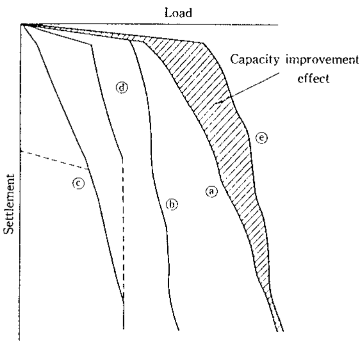


Figure 1 Image of load and settlement curve of cast-in-place concrete pile

Table 1 Design condition of piles

	conventional pile	new pile
bearing capacity at pile toe	q_d=2.9MPa	4.9 MPa
vertical coefficient of soil reaction at pile toe (kgf/cm^3)	$k_v = \frac{1}{30}\alpha \cdot E_0\left(\frac{B_v}{30}\right)^{-3/4}$	$k_v = \frac{5}{30}\alpha \cdot E_0\left(\frac{B_v}{30}\right)^{-3/4}$

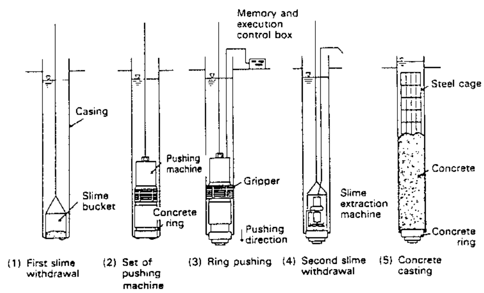
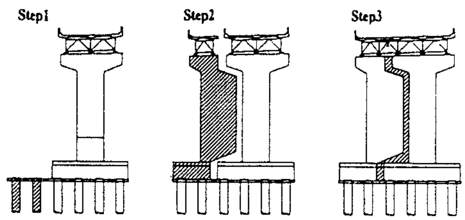
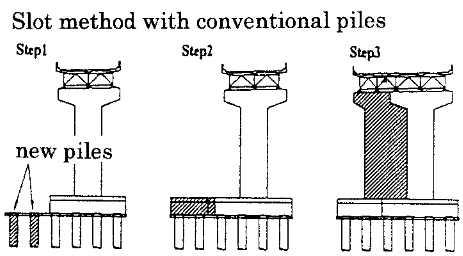


Figure 2 Schematic Image of execution of the new method



(a) Slot method with conventional piles



(b) Direct attachment method with new piles

Figure 3 Execution method of bridge width extension

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