Quality Control of In-Situ Concrete Spread Pile

Contrôle de la qualité de pieux forés en béton

Qualitätskontrolle bei Ortsbetonpfählen mit Pfahlkopverbreiterung

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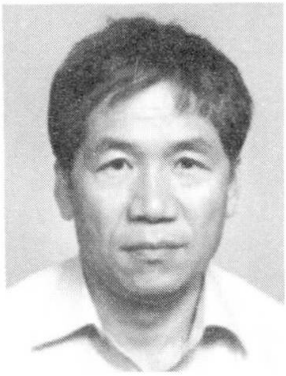

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SUMMARY
The present paper deals with the realization of the geometric management of in-situ concrete spread piles. Such spread piles are constructed under strict quality control of their geometrical shape and concrete strength. The field experiments on several spread piles show good results of quality control on their geometric shape especially of pull-out test concrete piles.

RÉSUMÉ
Ce rapport expose la réalisation du contrôle géométrique des pieux forés en béton. Ces pieux forés sont exécutés sous contrôle strict de la forme géométrique et de la résistance du béton. Les essais in-situ de quelques pieux forés montrent de bons résultats de la qualité contrôlée, spécialement pour la forme géométrique et les essais d'extraction.

ZUSAMMENFASSUNG
Im Beitrag wird gezeigt, wie die Kontrolle der Geometrie und der Abmessungen bei Ortsbetonpfählen mit Pfahlkopfverbreiterung erfolgt. Die strikten Qualitätskontrollen umfassen auch die Betonqualität. Die Feldversuche zeigen die Effizienz der durchgeführten Qualitätskontrollen.

1. INTRODUCTION

Since the mid-sixties buildings have become larger in the size and number with development of construction technology against strong earthquakes and soft soil layers as alluvium in Japan. This demands the development of more sophisticated foundation. Since the ramming piling provides noise and vibration to surroundings, the earth augering piling including the in-situ concrete pile are applied especially in the urban dense area. The vertical strength formula of piles is recommended by AIJ as,

$$R_a = \frac{1}{3} R_u - W, \qquad R_u = R_p + R_f$$

where R_a means the permissible vertical strength of pile for the long term, R_u, the ultimate supporting strength, R_p, the bearing capacity, R_f, the friction resistance, and W, the weight of pile, respectively. This formula can provide the larger strength the more the tip area of pile becomes large. Thus, economically it is better to spread the tip of pile as the in-situ spread concrete one. The present paper deals with the realization of the geometric control on concrete figure of in-situ spread pile. The construction of in-situ spread pile can be accomplished by augering machine and versatile technique under the strict quality control. After confirmation of boring hole geometry by the ultrasonic measuring device the concrete placing can be made under the standardized working chart. By the field experiments with measurement of concrete piles and its mechanical properties of material tests the present geometric management method is appropriately realised.

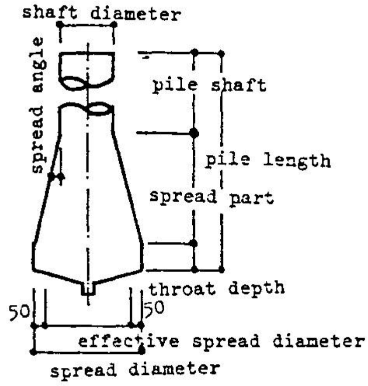

Fig.1 Spread pile

2. IN-SITU SPREAD CONCRETE PILE

The present spread piling system consists of the cutting bit, stabilizer, drill pipe, swivel joint, rotary table and power unit. The construction process is divided into the two stages; the pile augering of shaft and spread part as the formwork, and the concrete placing. The pile shaft augering are made by such as an earth drilling or reverse circulation with stability mud water. The following discussion concentrates on the spread augering and concrete placing. After the shaft augering the spreading machine, which has hydraulic drilling cutters, is inserted in the bottom of bored shaft. Fig. 1 shows details of the spread part, which provides the concrete figure with the important geometries of spread angle, concentricity and throat depth. Furthermore, the centering, verticality and the slime treatment are necessary for the appropriate piling foundation. The present spread piling has the spread ratio r=A/Ao less than 3.20, due to the maximum expected soil strength $f=250t/cm^2$ and the concrete permissive stress $s=800t/cm^2$, where A means the spread area, Ao, the shaft area, respectively. The range of spreading possesses shaft diameters, 1,200 to 1,600mm with effective spread diameters, 1,500 to 2,300mm, reduced 50mm from actual augering diameter. The spread augering has the following three processes;

Shaft vertical augering---after shaft augering at depth 300 to 500mm upon the spread bottom to make vertical extension augering by the spread machine.

Spread augering---to make spread augering against shaft hole by the spread cutter with hydraulic cylinders. Spread completion probe device can predict the augering level corresponding to the prescribed spread angle and pressure gauge level on the rotary table with the standard throat depth, D=300mm.

Spread extension augering---necessary under the extended state of spread cutters when D needs larger than 300mm. The ring soil on the bottom is extracted by the trimming augering.

Since the above three processes provide necessary concrete figure, mud water exchange and a suction pump can extract remaining soil with bit racing. This corresponds to the primary slime treatment. Then an ultrasonic measuring device provides shaft and spread figures. When this geometry becomes proper within the prescribed errors, reinforcement basket is inserted and the secondary slime treatment is made by air lift or suction through a tremie pipe. Then concrete placing is implemented.

Since each augering process and concrete placing become invisible, it is necessary to develop the refined geometric control techniques on the following items closely correlated each other.

Stability mud water---material, quality control

Spread augering---quality control, optimal slime treatment, figure measurement

Reinforcement basket---spacer

Concrete---coarse aggregate grading, proportioning, slump, air content, tremie pipe inserting, concrete placing, curing, surplus concrete-slime

3. GEOMETRIC CONTROL PROCESS

Analysis of work processes on the disordered construction site leads to the standardization of work units, whose combination can accomplish the geometric management of spread pile with the aid of the human engineering and AI techniques. Thus the following work units are obtainable from the observation of field works and the knowledge of field experts.

- pile center
  - base point
  - center line
  - curing center line
  - curing standard pile
- stand pipe(SP)
  - recognition of pile center
  - geometry of stand pipe
  - geometry of curing standard pile
  - setting of SP by boring machine
  - pre-augering in SP
  - pouring stability mud water
- shaft augering
  - comparison to boring log
  - level of augering tip — shaft bottom
  - augering speed control
  - verticality of leader — transit instr.
  - mud watering boiling, collapsing

- specific gravity control (1.02-1.20)
- setting of spread machine
  - setting of rotary table
  - spread angle, spread diameter of bits
  - joints of spread bits (oil leak)
  - eccentricity of spread bits
- spread augering
  - vertical augering
  - spread augering
  - extension augering
  - trimming augering
  - mud water supply — leveler
  - verticality of kelly
  - augering probe device
  - sampling of supporting layer
  - root depth larger than 1,000mm
- slime treatment
  - sedimentation of slime — time, size
  - exchange of mud and natural water
  - primary treatment — suction pump
- draw-up of spread machine
  - complete closing of spread bits
  - prevention from wall collapse
- measurement of hole wall
  - ultrasonic measuring device — vertical, spread figure
  - direction of probe
  - surveying speed
  - eccentricity of spread bottom
  - decision of additional treatment
- reinforcement
  - reference figure
  - jointing — welding
  - coverage by spacer
  - prevention from wall collapse
- tremie pipe
  - tremie and hole lengths
  - leak from joint
  - placing of transit-mix truck
- slime treatment
  - level of primary treatment
  - air lift (7 to 10 kg/cm^2)
  - sedimentation
  - comparison to primary treatment
- concrete placing
  - material
    - coarse aggregate grading,
    - w/c, admixture
  - slump, air content, compressive test
  - tremie pipe — length, joint

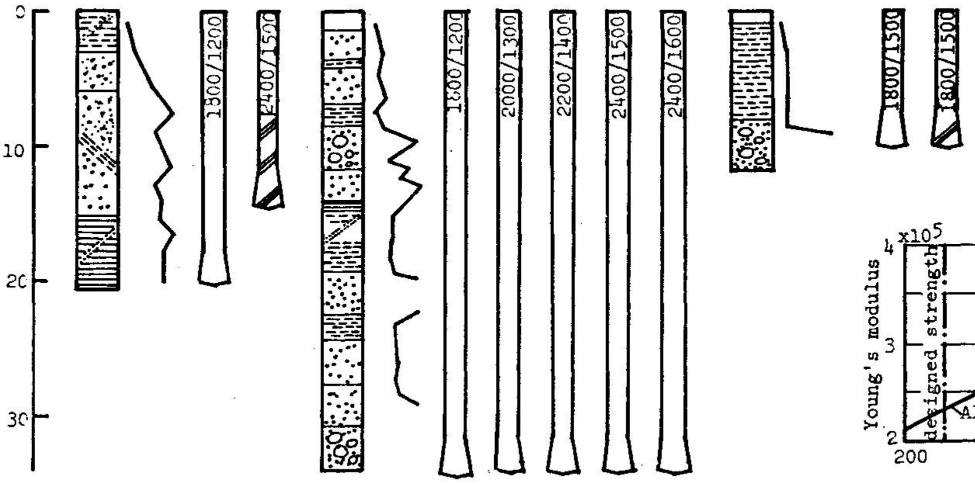

Fig.2 Field experiment

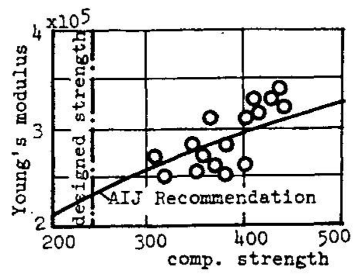

Fig.6 E-F relations

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│                  ├concrete hopper
│                  ├introduction of transit-mix truck
│                  ├timing of placing
│                  ├extract pump of mud water
│                  ├concrete level
│                  ├tremie tip in concrete ( H=2,000mm )
│                  └surplus concrete ( 500 to 1,000mm )
├extract of SP ────┬timing ( 3hrs )
│                  └confirm concrete level
└soil filling
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The above work units can be summarized in a form of check sheet, which is filled as the progress of field works. Thus the concrete geometry control can be completed.

4. FIELD EXPERIMENT

To evaluate the present geometric management method nine in-situ augering including two concrete piles are carried out as in Fig. 2. Three experimental sites are chosen; the rather uniform sandy layer for the preliminary augering, the relatively hard layer with successive sand and clay sublayers typical in alluvium, and the supporting thick layer with coarse sand and gravel for actual concrete piling. Fig. 3 shows the figures of boring wall by the ultrasonic diameter measuring device in two directions just after the primary slime treatment. Various measurements from these figures are summarized in Table, which provides proper evaluation to the prescribed verticality, spread angle and throat depth necessary for the geometric control. Material tests including compression strength and elastic modulus are made on the boring cores from the concrete solid specimens. Fig. 4 shows a histogram of compressive strength after four weeks providing the satisfactory strength and weak diversion not influenced by mud water and soil. Fig. 5 illustrates the compressive strength along pile depth, which provides gradual increase of strength at the lower bottom of pile though sparsed relatively. This tendency results from the influence of concrete gravity. Fig. 6 shows the relationships between compressive strength and static elastic modulus resulting weak diversion. Furthermore, the bonding tests shows 2.25 times bonding stress in average to the permissible value.

5. CONCLUDING REMARKS

The typical alluvium in Japan distributes sometimes thick more than 40m with successive sand and clay sublayers, which demands construction of deep foundation such as an in-situ concrete spread pile necessarily with strict geometric management. Not only on the shaft but also on the spread part this geometric control becomes important because natural soil surface with mud film should be alternated by the ordinary wooden formwork. Hence it is more difficult to ensure the specified concrete figure. To control the geometry of spread pile from the ground level needs the proper implementation of centering of pile, verticality, concentricity of spread bottom and throat depth. This implies rigorous augering without any boring wall collapse, slime maltreatment on the bottom and with the quality control of concrete placing. The present management method pursues their completeness through the standardized work units from the analysis of field job processes. According to this method satisfactory results can be obtained which are demonstrated by the field experiment on the geometry of spread pile and material tests.

6. ACKNOWLEDGMENT

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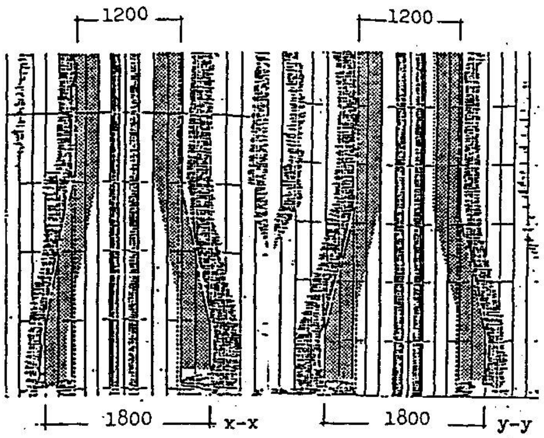

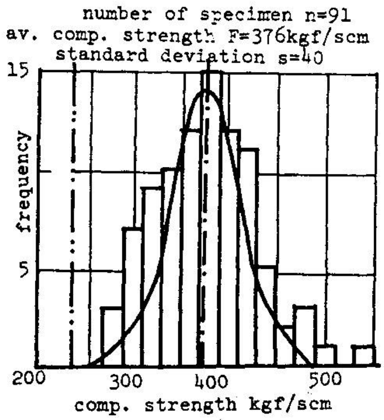

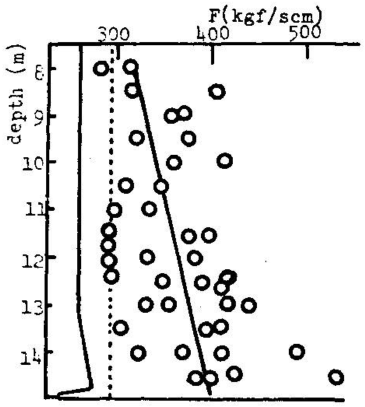

Fig.3 Ultrasonic measurement Fig.4 Histogram Fig.5 F-H relations

No	verticality X	verticality Y	spread diameter targt	spread diameter X	spread diameter Y	spread angle targt	spread angle X	spread angle Y	throat depth targt	throat depth X	throat depth Y	
1	1/225	1/400	1800	1800	1820	9°10'	9°10'	9°18'	500	500	500	Ed
2	1/183	1/800	2400	2480	2500	12°00'	12°00'	12°00'	700	730	710	Rv
3	1/650	1/1060	1800	1800	1800	9°10'	9°01'	9°05'	500	560	500	Ed
4	1/1320	1/940	2000	2050	2050	12°00'	11°55'	12°00'	300	400	480	Ac
5	1/450	1/2100	2200	2250	2310	10°00'	9°56'	9°50'	300	350	330	Rv
6	1/650	1/440	2400	2470	2420	12°00'	11°48'	11°55'	300	360	330	Ed
7	1/470	1/600	2400	2420	2450	12°00'	-	11°55'	300	360	330	Rv
8	1/530	1/155	1800	1800	1800	9°10'	9°10'	9°10'	300	300	300	Ed
9	1/870	1/400	1800	1800	1800	9°10'	9°10'	9°10'	300	300	300	Ed

Ed;earth drilling Rv;reverse circulation Ac;all casing

Table Experimental results