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# PERFORMANCE OF BORED CAST-IN-SITU R.C.C. PILES IN BANGLADESH

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## ABSTRACT

The major part of Bangladesh is formed of young fluvio-deltaic sedimentary deposits, laid down by the mighty rivers Ganges and Brahmaputra. There are some older deposits in the hilly regions and Pleistocene terraces.

The young fluvio-deltaic deposits are composed of unconsolidated sediments, where the upper strata are very soft. The water table remains near to the surface throughout the year. As such construction of deep foundations has become essential for tall buildings, bridges and hydraulic structures. Bored Cast-in-Situ reinforced concrete pile is widely adopted as deep foundations. It is cost effective, time saving and the equipment and technology are readily available.

This paper reviews and summarizes the performance of Bored Cast-in-Situ reinforced concrete piles in Bangladesh with special emphasis on present construction practice. This paper also evaluates the deficiencies in design and construction of such piles and suggests remedial measures for acceptable piles.

## KEYWORD

Bored Cast-in-Situ R.C.C. Piles, Defects in pile, Integrity Tests.

## INTRODUCTION

Geologically Bangladesh is formed of young fluvio-deltaic deposits, except some older deposits of Mio-Pleistocene age. The existence of weak upper stratum and scouring of bed and bank of the rivers are primary reasons for adopting deep foundations for tall buildings, bridges and drainage structures.

Till seventies, tall buildings, hydraulic structures were normally constructed on pre-cast concrete driven piles. The bridges were constructed on masonry caisson foundation. Presently instead of driven pre-cast concrete piles and caissons Bored Cast-in-Situ reinforced concrete pile is widely adopted in building bridge foundation, because it is found cost-effective, it saves appreciable construction time and the equipment and technical know how are readily available.

Construction of such piles involves excavation of an un-cased or unlined pile hole and under water tremie concreting. Drilling of pile hole is done by percussion method i.e. by means of chopping bit, attached at the end of drill rods. The bore hole is filled with bentonite-slurry or sometime locally available clay-slurry.

The slurry circulates through drill rod and flow up along the sides of the bore holes with cutting to the surface and are separated from the slurry by decantation for recirculation.

The bentonite-slurry stabilizes the sides of boreholes. And in addition the hydrostatic head, due to higher specific gravity of fluid, does not allow the borehole to collapse. The back flow of water into boreholes is avoided. The thixotropic action of bentonite mud on the wall of boreholes acts as further protection against caving in.

Often defects in the pile shafts like decrease or increase in diameters, voids, separation, inclusion, necking and shortening in length are identified. These defects originate either for difficult sub-soil condition or for faulty construction procedure.

## PERFORMANCE OF BORED CAST-IN-SITU R.C.C PILES

Random studies were made on the performance of Bored Cast-in-Situ R.C.C piles. Integrity Test and Static Load Test were undertaken. Many major defects were detected in pile shafts.

The observed defects along the pile shafts are necking, shortening of length, separation, increases or decreases in diameters etc. On many occasions piles under Static Load Test failed to withstand design load. Detailed investigation was under taken to evaluate the causes of such deficiencies of bored pile.
In following paragraphs causes of defects in pile shaft are described. Remedial measures are also suggested.

### Necking

Necking in pile shaft are observed at the upper part of the piles; many times at the tip of temporary steel lining. In soft ground condition withdrawal of temporary steel lining out of plumb causes such necking. It is advisable to use thin permanent steel lining to avoid such defects in pile shaft in soft ground environment.

### Shortening of length

Shortening of length is the most common defect for pile shaft. Use of unspecified, arbitrary slurry thickness results continuous eroding of the walls of drilled hole. Breaking out of walls accelerate at the time of lowering of re-bar cages and tremie pipe. All those debris should be removed by fresh circulation of slurry fluid of desired characteristic through tremie pipe prior to start pouring operation, failing which shortening of length should occur. Piles so constructed fails to mobilize end bearing.

### Separation in pile shaft

Separation in pile shaft occurs if the tremie is not handled properly. The tip of tremie pipe assembly should always be embedded atleast by two meter into green concrete, through out the concrete pouring operation, failing which separation is expected.

### Increase or decrease in diameter

This type of defect generally common in stratified silt and sand layers. This may be avoided using design slurry thickness and use of direct circulation rotary drill rigs.

### Failure of pile under test load

Inadequate mobilization of skinfriction and/or end bearing are responsible for failure of piles under static load which is short of evaluated test load. If the drilled pile hole is left for long time, before pouring of concrete, skinfriction fails to mobilize adequately and pile should fail at much lower designated load. Similarly, deposition of debris at borehole, causes shortening of piles resulting inadequate mobilization of end bearing.

These piles are also found to fail at a very nominal applied test load.

## CASE STUDIES

In the process of constructing Bored Cast-in-Situ R.C.C piles, detail study and observations were made on locally developed equipment, slurry fluid characteristics, sub-soil parameters, drilling techniques, clearing of boreholes, installation of re-bar case and tremie pouring of concrete. These reveal various shortcomings in the prevailing practices, procedures and techniques of Bored Cast-in-Situ R.C.C piles construction in Bangladesh. It was found that adoption of certain inexpensive and simple quality control measures to the existing procedure can some times produce good results. The study undertaken in the major geological regions of the country are summarized in the following paragraphs.

### a) Defects in shaft

Defects (necking) in pile shaft was found at the tip of temporary casing when pile integrity test was done on Bored Cast-in-Situ R.C.C piles (Diameter-1000mm, Length - 30m) of Godown Ghat Karnafulli Bridge, Rangunia, Chittagong. The diameter of pile shaft observed at 3.33meter depth was 775mm, which was 225 mm less than the nominal diameter of the pile.

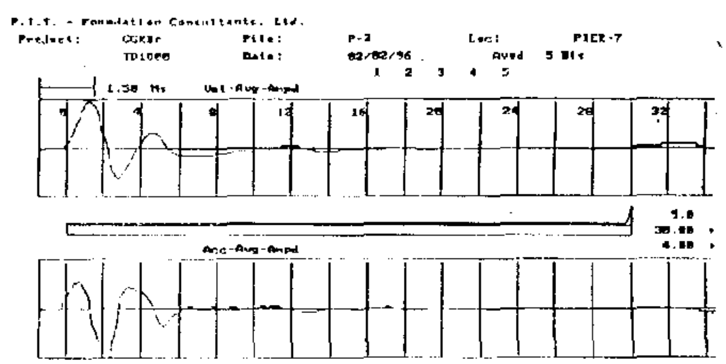

Figure 1: Defects (necking) in pile shaft formed at the tip of temporary casing.

### b) Inadequate mobilization of end bearing

The absence of end resistance is presumed to be due to one or both of the following reasons : i) Accumulation of cutting from sides of the boreholes at the bottom of the pile. ii) Loosening of the soil at the bottom of the hole by the chopping bit and incomplete cleaning of the loosened materials. Presence of loosened materials at each pile bottom have also been indicated in the integrity test results. As the piles could not derive end resistance, the ultimate load capacity are based on side friction only.

The example of two piles in Dhaka City located 5m apart is shown in Figure 2, where performance of two identical piles was found to be quite different. These piles were taken under static load test. The pile hole of pile No.1 was constructed with Rotary drilling technique and cleaned by compressed air injected through inverted funnel attached to tremie tip. The gross settlement was found only 7.35mm at 350 tons load. Where in pile No.2, pile hole was drilled by conventional percussion (chopping bits) technique, failed at 229 tons.

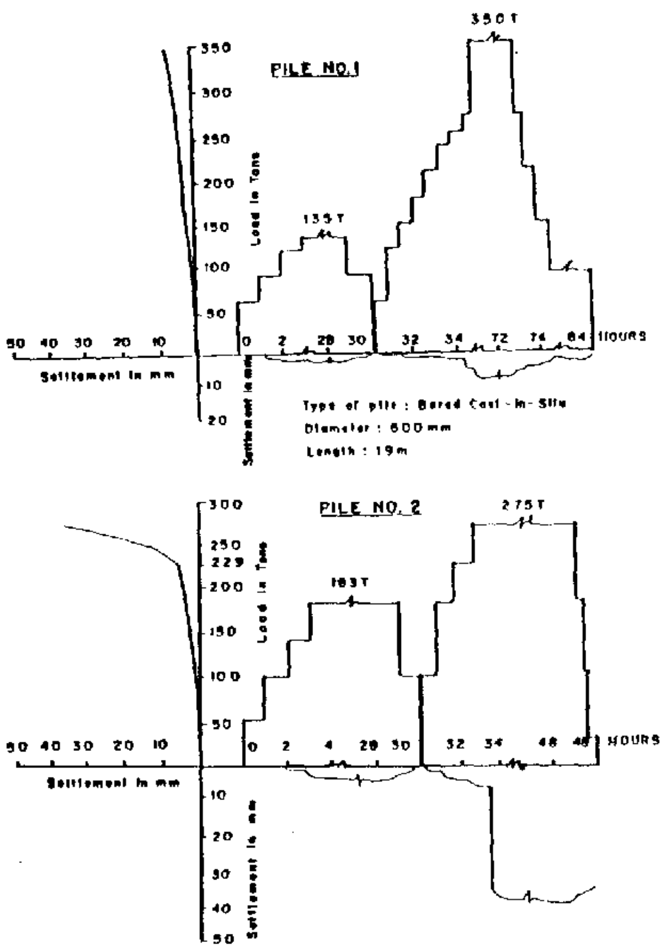


Figure 2: Static load test diagram.

In an example of 18 storied IPGMR Kidney and Pediatric Unit Building, Dhaka four test pile (representing 1% of total estimated service piles) were installed at the site. Pile integrity and pile load test were conducted on each pile.
As the piles could not derive end resistance, the ultimate load capacities are based on side friction only. Test plies TI-1 and TP-2 are located in areas where side friction is mobilized throughout the entire length of piles. Because of the presence of approximately 20 ft soft layer at locations of test piles TP-3 and TP-4, side friction is mobilized at the bottom 40 ft of the piles. Test piles TP-1 and TP-2 are expected to carry more loads compared to piles TP-3 and TP-4,

From integrity testing it was observed that the length of the pile was short by 0.71 to 0.92m. The piles could not develop sufficient end resistance. From the static load test the ultimate load capacity was 212 ton. It end bearing is considered then the calculated ultimate bearing capacity becomes 300 tons.

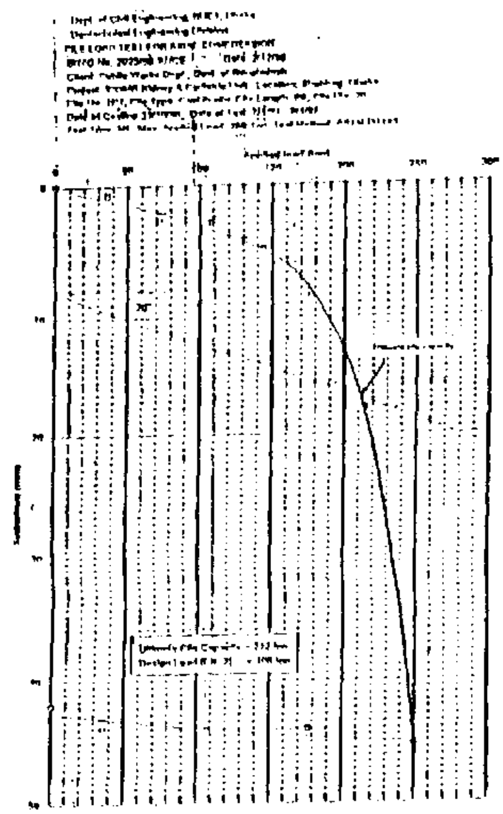

Figure 3: Load - settlement curve.

In DEPZ, Savar project out of 300 piles in four storied factory building, 10 piles were taken as sample for integrity testing. Of them 7 piles were found short by 0.54 to 2.54m. As a result calculated load was found 39 tons where as the design load was 80 tons.

## c) Inadequate mobilization of skinfriction

Exposure of the pile hole for long time to free water causes degradation of soil strength vis-a-vis poor performance. It produce inadequate mobilization of skinfriction.

The example of two piles in Dhaka-Aricha Highway Rehabilitation project of proposed structure No.-30, Dhaka-Aricha Road, Savar is shown in Figure 3, construction of pier test pile -1 was continuous from drilling of pile hole to completion of concrete pouring operation. The gross settlement of 12.15mm was recorded under 270 KN load. Construction of Abutment test pile-2 was disrupted because of concrete batch plant problem. The pile hole was filled in by drilling mud and cleaned after eight days. It is understood in the process of cleaning, around 1.6m additional depth of borehole was excavated. Abutment test pile-2 failed at 1400 KN under static load test which was much less than pier test pile-1.

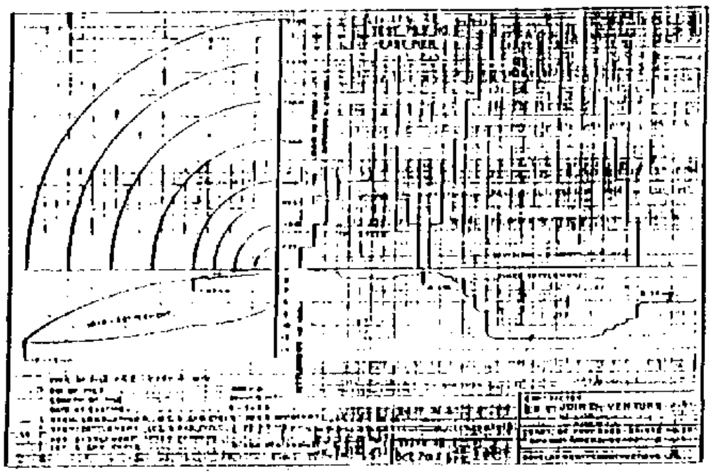

Figure 4: Static load test diagram.

## CONCLUSION

Bored pile has positive rule in infrastructure development of Bangladesh. But adoption of good engineering practices is necessary for quality and economy in foundation design and construction as well as to avoid probable major catastrophe.

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