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Engineering properties of subsoil under 2nd Bhaiarb railway bridge & static pile load test by Osterberg cell at location P3

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ABSTRACT: The 2nd Bhairab Bridge is one of the most important bridges to be constructed in Bangladesh. It connects Bhairab Bazar and Ashuganj across the Meghna River. It will improve the communication between Dhaka-Chittagong providing services along with the existing Bhairab railway bridge at Meghna River. The soil formation under this construction is by alluvium deposition of the river. This soil is characterized by the dominance of loose to dense fine sand. Also we can observe a large variety within the soil layers beneath the Meghna river bed. The variety of soil occurs within very shallow depth. So, this soil is much challenging to construct any massive structure. To understand the nature and strength of this soil, a rigorous testing and observation of the soil samples collected from the borings under Meghna river bed was performed. From these tests and observations, we found that, there is a lack of clay dominating soil strata in the borings and the soil is mostly of silt formation. Osterberg cell test for pile capacity was performed to identify the pile capacity for design load and the practical test results were compared with the theoretical pile capacity in this paper.

1 INTRODUCTION

It is desired to understand the soil characteristics under the river bed of Meghna to properly design and construct the 2nd railway bridge at Bhairab. The soil under the river is characterized by frequently varied layers with very short depth. We observed that the SPT values were mostly dominated by the soil types at various depths. There are only two types of dominating soil layers within the borings; silt layers and sand layers. And we observed that, the SPT values suddenly decreased at the starting of silt layers in most of the cases, except at vary large depth.

2 GENERAL PROPERTIES OF SOIL

The routine tests were performed for soil samples collected from different depths of different borings. The test results indicated that; there is a greater dominance of silt layers along with sand layers, and absence of clay layer formation. The approximate range of the test results are presented below.

Table 1. Ranges from test results.

Test property	Average result
In-situ water content	18 to 26
Specific gravity	2.57 to 2.79
%sand (sand layer)	57 to 99
%sand (silt layer)	9 to 48
% passing #200 sieve (sand layer)	1 to 43
% passing #200 sieve (silt layer)	52 o 91

3 REGIONAL GEOLOGY

The soil of upazilla Bhairab is the inter-stream deltaic deposition of Meghna River formed mostly in the Holocene era. The alluvium deposition of Meghna River dominates the soil strata. The network of the Ganges-

Brahmaputra river systems is responsible for the thick sedimentary deltaic deposition in most of the part of Bengal Basin (Monsur, 1995). These two mighty rivers are originated from Himalayas and they discharge into the Bay of Bengal. But the origin of Meghna differs from these two; it originates from the hilly regions of eastern India. This is why the river bed soil of Meghna differs from the other two rivers.

4 GENERALIZED SITE CONDITION (SITE STRATIGRAPHY)

In general, the sands are fine graded with significant proportion of silt content. The stratigraphy at this site may be divided into two generalized strata.

Stratum 1: Sand strata. Stratum 2: Silt strata.

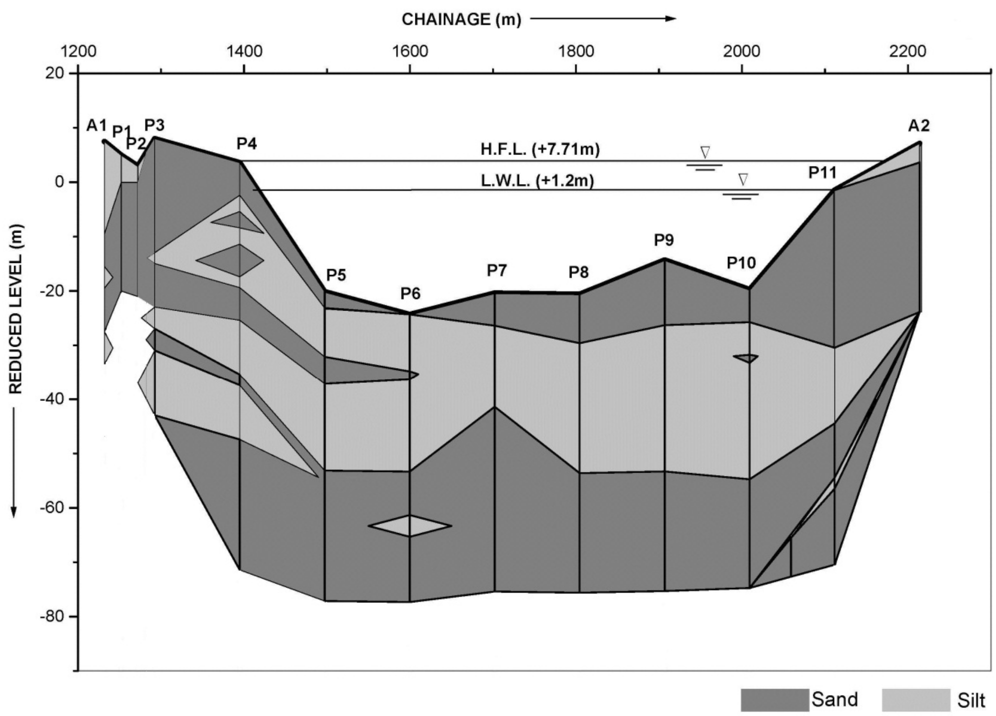

Figure 1. Generalized cross sectional profile at boring locations.

The varied cross sectional profile across the river bed along the boring locations is illustrated in Figure 1. Here we can see that there is a dominant silt soil strata which started from boring location P3 and continued up to A2. At location P3 the silt layer is at a depth of 21 m from EGL and gradually shifts to upward direction which is finally exposed at location P6. The thickness of the major silt layer varies in between 28 m to 30 m. The interesting portion of the soil profile is that, there is a major subsidence of the river bed between locations P7 and P10 (up to 16 m). The silt layer lies here under a sand blanket of thickness of approximately 6 to 12 m. This location demands much important observation and testing before any kind of construction (pier). The detailed information regarding to the boring depth, RL and the sand-silt layer percentages for different borings are given below,

5 PILE CAPACITY TEST BY O-CELL AND COMPARISION WITH THEORETICAL RESULT

The O-cell (Osterberg cell) static load test for pile was performed at boring location P3.This test is performed to know the pile capacity by creating hydraulic pressure; and strain gazes are installed at different depths to identify the displacement against load, skin friction and end bearing of pile. The cell is installed initially within the reinforcement cage before pile construction and is connected to hydraulic hose to create pressure in the cell. During loading, the cell is internally pressurized creating an upward force on the pile in upper side shear and an equal but downward force in combined lower side shear and/or end bearing (c.f. http://www.loadtest.com/services/ocell.htm).

Table 2. Information obtained from boring.

Boring name	Depth (m)	RL (m)	% of Silt layer	% of Sand layer
A1	41	(+)7.507	54.9	45.1
P1	25	(+)4.980	20.0	80.0
P2	24	(+)2.970	12.5	87.5
P3	54	(+)8.036	33.3	66.7
P4	79	(+)3.602	35.4	64.6
P5	58	(+)4.367	43.1	56.9
P6	53	(+)4.180	59.4	40.6
P7	55	(+)3.610	27.3	72.7
P8	55	(-)12.490	43.6	56.4
P9	61	(-)9.315	41.0	59.0
P10	55	(+)4.260	50.9	49.1
P11	69	(-)1.450	20.3	79.7
A2	31	(+)7.130	11.3	88.7

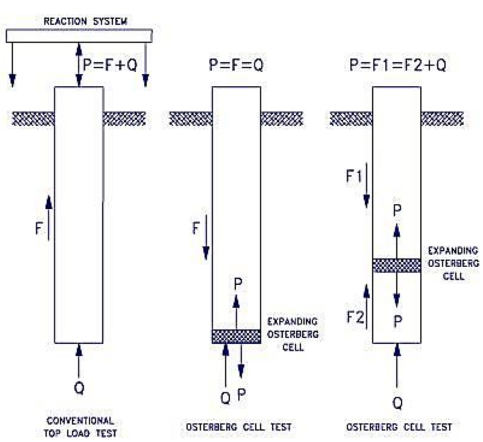

Figure 2. Conventional and O-cell test.

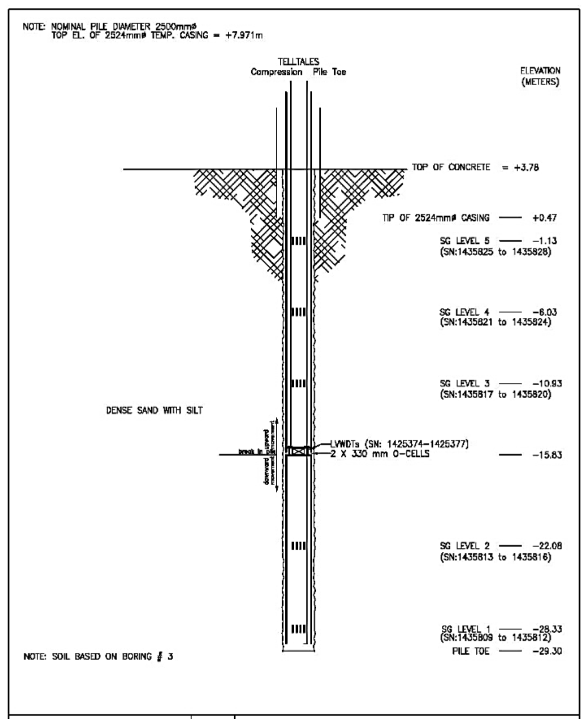

Figure 3. Load Transfer Zone and of strain gauge

Upper Skin Friction Resistance: The maximum upward net load applied to the upper skin friction was 4.67 MN. At this loading, the upward displacement of the top of O-cells was 7.13 mm.

Combined End Bearing and Lower Skin Friction Resistance: The O-cell assembly applied a maximum downward load of 5.98 MN. At this loading, the average downward displacement of the O-cell base was 7.71 mm.

Table 3. Skin Friction of Pile at P3

Load Transfer Zone	Displacement	Net Unit Skin Friction
Zero Shear to Strain Gauge Level 5	↑6.66 mm	14.1 kPa
Strain Gauge Level 5 to Strain Gauge Level 4	↑6.71 mm	11.5 kPa
Strain Gauge Level 4 to Strain Gauge Level 3	↑6.81 mm	36.9 kPa
Strain Gauge Level 3 to O-cell	↑7.00 mm	59.0 kPa
O-cell to Strain Gauge Level 2	↓6.63 mm	42.9 kPa
Strain Gauge Level 2 to Strain Gauge Level 1	↓5.09 mm	70.9 kPa

The amount of skin friction in the lower portion from O-Cell is 5.586 MN and the remaining portion is associated with the end bearing (0.394 MN). From this test we could understand the pile is too good to resist the design load mostly by the skin friction capacity onlywith an insignificant end bearing value which could be further increased if required.

From the theoretical calculation of pile capacity, we found a total ultimate skin friction value of 9.0 MN (Bowels, 1996a) and the O-Cell test value was (4.67+5.586) MN = 10.27 MN for a load applied 1.5 times of the design load. If we divide it by factor 1.5 we find a value 6.85 MN which is 76% of the theoretical ultimate value. So, we can observe a compatible similarity between these two values. The end bearing value that we found from theoretical calculation is much greater than the practically observed value (Theoretical: 2.5 MN, O-Cell: 5.98 MN). The theoretical end bearing calculation is given below:

$Q_p = 10*N*A_p$; (Bowels, 1996b).
$= [10*51*3.1416*(2.5)^2/4]$ MN
=2.5 MN

where,
Q_p = ultimate end bearing capacity of pile;
N = statistical average of the SPT values in a zone of about 8B above to 3B below the pile point;
A_p = tip area of pile (m^2);

This situation can be explained by the fact that, O-Cell measures the end bearing value of pile in a much more conservative way. It emphasizes the capacity of pile up to the point of hairline crack formation in the pile concrete. So, there may be a greater value of end bearing than O-Cell method if the total collapse of pile is considered.

6 CONCLUSIONS

The 2ndBhairab Bridge is a structure of great importance. The subsoil characteristics of this structure require close and deep observation to confirm the structural safety. We found from our observations that the subsoil of this structure is special in so many aspects. The absence of any mica soil dominating strata is a specifically noticeable character. The dominance of silt and sand layer is an important character to observe which affects the pile capacity actually and theoretically found.

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