Foundation Investigations in Thick Overburden Matrix Material of a Proposed Dam – A Case Study

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Abstract There is acute scarcity of water during peak summer season in Andaman & Nicobar Islands. Most of the rain water is wasted during rainy season. If storage facility is available by constructing dams, rain water could be entrapped for further use. Absence of perennial rivers and need for drinking, irrigation and other purposes it was proposed to construct a dam across a small stream to store water to encounter such problems. This paper presents foundation investigation at various locations such as dam axis, left and right abutments, upstream and downstream of dam axis. There was thick layer of about 6 m overburden of matrix material including boulders of different sizes mixed with sand silt and clayey soil at the dam axis and exposed rock could be seen at some locations. It was not possible to carry out SPT testing and undisturbed sampling. Drilling of five numbers of drill holes at predetermined locations were carried out. Various field tests such as permeability by Packer method (single and double Packer), open end permeability tests and extracting of core recovery to ascertain RQD value were carried out in all the drill holes to ascertain feasibility of foundation materials for constructing dam. Geotechnical challenges has been discussed in present paper during foundation investigations such as drilling in thick overburden in matrix materials at dam axis, Packer tests in fractured rocks and also extracting of rock core. It was concluded from Field permeability and RQD values that the foundation consisted of fractured rock with semi pervious nature.

Keywords: dam, foundation, permeability, drilling.

1 Introduction

Absence of perennial rivers in Andaman & Nicobar Islands causes shortage of water for drinking, irrigation and other purposes. There is acute scarcity of water during peak summer season. Most of the rain water is wasted during rainy season. If storage facility is available by constructing dams, rain water could be entrapped for further use. It was proposed to construct a dam across a small stream to store water to encounter such problems. Depending upon the geographical and geological profile of proposed site for dam construction, it is also important to evaluate the engineering properties of foundation materials to access the strength, permeability and other important parameters. It is therefore proposed to construct dam across stream in North Andaman in Andaman and Nicobar Islands. This paper presents results of foundation investigations at various locations such as dam axis, left and right abutments, upstream and downstream of dam axis and engineering characteristics of foundation materials.

2 Project details

Locations Plan of bore holes at proposed dam in North Andaman is shown in figure 1.

Fig. 1 Location Plan of bores holes at proposed dam

It is proposed to drill five drill holes at various locations such as dam axis, left and right abutments, upstream and downstream of dam axis. There was thick layer of about 6 m overburden of matrix material including boulders of different sizes mixed with sand silt and clayey soil at the dam axis and exposed rock could be seen at some locations.

3 Foundation investigations

The project site is located in North Andaman. It takes about twelve hours to reach from Port Blair by road and ship journey for crossing small channels. It is about 270 km from Port Blair. The site is situated in thick forest area and the approach to the project site is very difficult. Drilling of bore holes (BH 1 to BH 6) were carried out at six locations which includes one bore hole (BH 1) at the center of dam axis, one bore hole (BH 3) on right abutment, one bore hole (BH 2) on left abutment along the dam axis, one bore

hole (BH 4, 6) upstream of the dam axis and one bore hole (BH 5) downstream of the dam axis. However due to presence of exposed rock/rocky strata collection of undisturbed samples and SPT testing (Arora, 2000; Gulati,2005) was not possible in most of the drill holes. Therefore only field permeability test (IS 5529-Part 1) was carried out by single and double packer packer tests in the drill holes.

Foundation investigations were carried out at following locations and the details of the finding are tabulated in table 2 and table 1 presents RQD classification index (Deere 1989).

Table 1 RQD classification index (Deere 1989)

RQD	Rock mass quality
25%	Very poor
25-50%	Poor
50-75%	Fair
75-90%	Good
90-100%	Excellent

Table 2 Results of field tests in bore holes

Bore Hole (BH)	Location	Permeability Test (cm/sec)	Method of permeability test	Results	RQD	Lithology
BH 1	Centre of dam axis	3.265×10^{-4} to 6.70×10^{-5}	Packer test (single packer/double packer)	semi impervious in nature	10.00 to 43.33 (depth 0 m to 20 m)	Highly fractured to fractured rock
BH 3	Right bank (R/B)	1.84×10^{-5} to 6.65×10^{-5}			0 to 68 (depth 0 m to 48 m)	
BH 2	Left bank (L/B)	1.04×10^{-4} to 7.30×10^{-5}			0 to 59 (depth 0 m to 48 m)	
BH 5	Downstream (D/S)	1.75×10^{-4} to 7.51×10^{-4}			0 to 51.33 (depth 0 to 51.33 m)	
BH 6	Upstream (U/S)	8.32×10^{-5} to 1.28×10^{-4}			0 to 74 (depth 0 m to 74 m)	

Fig 2 Drilling work in progress at dam site

4 DISCUSSION OF TEST RESULTS

From the log of Bore Hole 1, it is inferred from the log that SPT test was conducted at a depth of 3.0m, 4.5m and 6.0m and the N value at these depths was 48, 53 and 82 respectively. It indicates presence of hard strata at these depths. SPT test could not be conducted further due to presence of boundary strata. Water table was at a depth of 0.45m from the surface. Field Permeability Test by Constant Head method at these depths which indicates complete water loss. Lithology of strata depicts overburden upto 6.0m. Further, lithology of the substrata from 6.0m to 20m indicates presence of fractured rock. Field Permeability Test by Packer Test from 8.0m to 20.m depicts that the value of field permeability value vary from 3.265×10^{-4}cm/sec to 6.70×10^{-5}cm/sec. Permeability values at different depths indicate that substrata are semi impervious in nature. RQD values vary from 10.00 to 43.33 (fractured rock).

From the log of Bore Hole 3 on R/B it is inferred presence of exposed rock from the surface. Water table could not be detected. Field Permeability Test by Constant Head method at 4.5m and 6.0m which indicates semi pervious strata. Field Permeability Test by Packer Test from 9.0m to 48.0m depicts that the value of field permeability value vary from 1.84×10^{-5}cm/sec to 6.65×10^{-5}cm/sec, indicating that substrata is semi impervious in nature. The lithology of the substrata from surface to 48.0m indicates presence of highly fractured rock. RQD values from 9.0m to 48m vary from 0 to 68.

From the log of Bore Hole 2 (L/B) it is inferred presence of exposed rock from the surface. Field Permeability Test by Packer Test at different depths from 9.0m to 48.0m depicts that value of field permeability vary from 1.04×10^{-4}cm/sec to 7.30×10^{-5}cm/sec indicating that substrata is semi impervious in nature. The lithology of the substrata from surface to 48.0m indicates presence of highly fractured rock. RQD values from 9.0m to 48m vary from 0 to 59.

From the log of Bore Hole 5 (D/S) it is inferred presence of exposed rock from the surface. Field Permeability Test by Constant Head method complete water loss at 4.5m and 12.0m and field permeability at 9.0m was 7.19×10^{-4}cm/sec which indicates semi pervious strata. Field Permeability Test by Packer Test from 12.0m to 21.5m depicts that the value of field permeability value vary from 1.75×10^{-4}cm/sec to 7.51×10^{-4}cm/sec indicating that substrata is semi impervious in nature. RQD values from 9.0m to 48m vary from 0 to 51.33.

From the log of Bore Hole 6 it is inferred field Permeability Test by Constant Head method at from 0 to 16.5m shows no water loss. Permeability value at 18.0m is 4.78×10^{-3}cm/sec . Field Permeability Test by Packer Test from 21.5m to 48.0m depicts that the value of field permeability value vary from 8.32×10^{-5}cm/sec to 1.28×10^{-4}cm/sec. Indicating that substrata is semi impervious in nature. The lithology of the substrata from surface to 48.0m indicates presence of highly fractured rock. RQD values from 0.0m to 48m vary from 0 to 74. Figure 3 & 4 shows the variation of permeability with respect to depth in bore holes 1 to 6

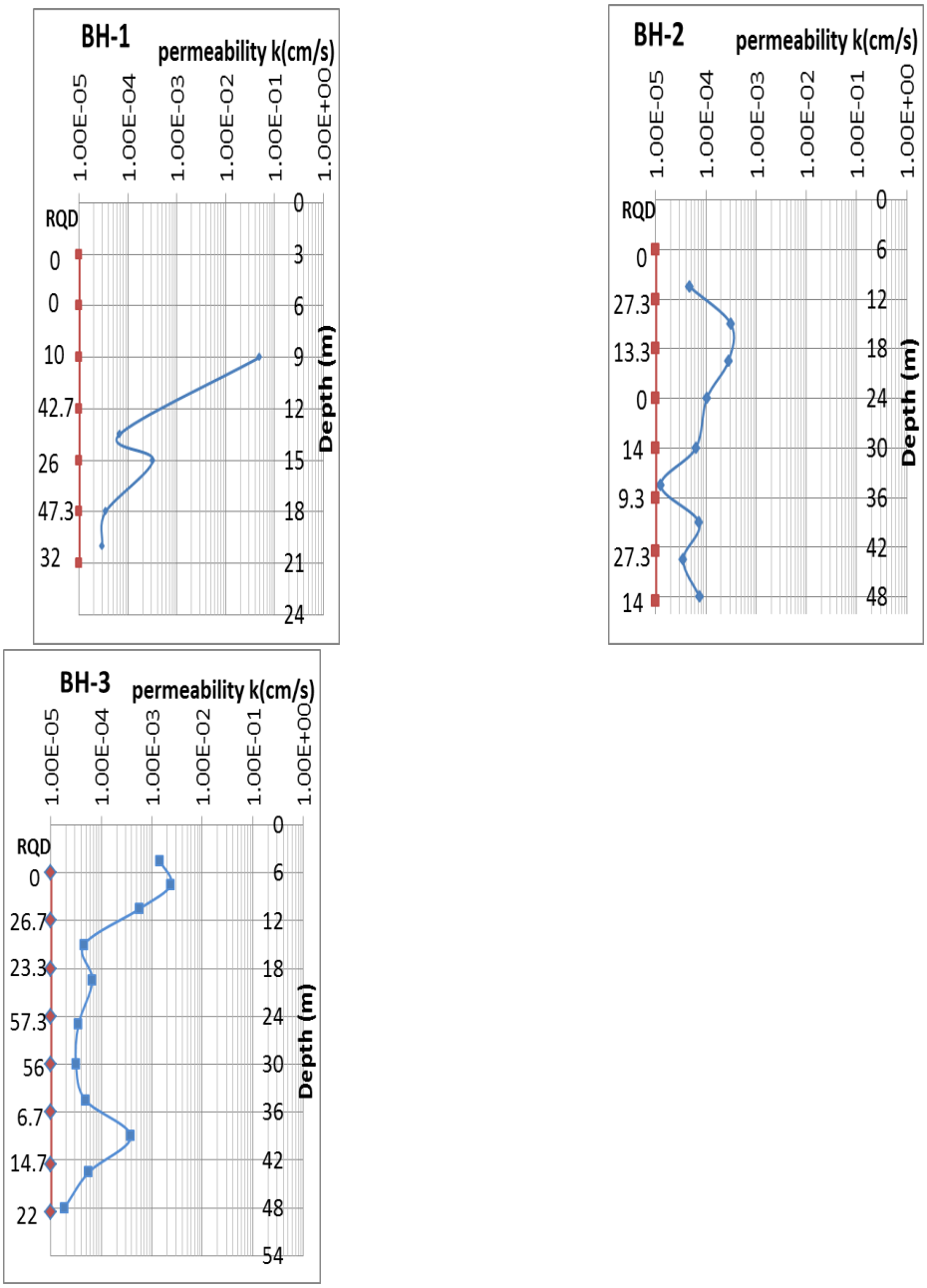

Fig 3 Variation of permeability with respect to depth in bore holes 1, 2 and 3

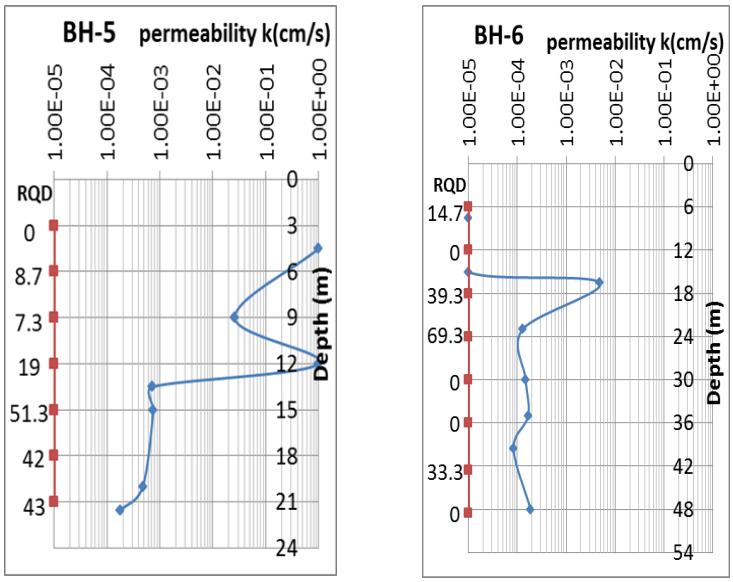

Fig 4 Variation of permeability with respect to depth in bore holes 5 and 6

0 -10.5m 10.5 -16.5m 16.5 – 20.0m

Fig 5 Display of core recovery in core boxes of bore hole 1

5 CONCLUSIONS

Based on the findings of the foundation investigations of five drill holes for the proposed dam in Andaman & Nicobar Islands, the following conclusions have been arrived at:

- Overburden is about 6m depth with the presence of bouldery strata.
- Lithology of all five drill holes depicts presence of fractured rock throughout the depth (max. 50m).
- Substrata is semi pervious in nature

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