CHARACTERIZATION OF FOUNDATION ROCK OF KALPONG H.E. PROJECT IN NORTH ANDAMAN

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SYNOPSIS: Characterisation of foundation rock is the basic requirement for taking up investigation of a river valley project. The determination of in-situ shear strength parameters, deformation characteristics and detailed laboratory investigations of rock mass are of vital importance in order to find representative essential parameters required for designing and determining the stability of concrete gravity dam. This paper presents the details of in-situ shear and deformability tests conducted on the foundation rock of Kalpong Hydro Electric Project, North Andaman, Andaman and Nicobar Islands. The in-situ parameters obtained have been compared with results of the laboratory investigation. The results show that deformation modulus increases with increase in applied stress level. The values of shear strength parameters and deformation modulus as determined from laboratory are much higher than those evaluated from in-situ testing.

INTRODUCTION

The Kalpong Hydro Electric Project, North Andaman, Andaman and Nicobar Islands envisages construction of two storage dams across the two arms of river Kalpong, which originates from highest saddle hill of North Andaman, flowing through a distance of nearby 5 Km before reaching the arial way near Diglipur. The dams have been proposed with overflow and non-over flow spillway on left and right fork of the Kalpong river. Reservoirs are to be connected through a link channel for maintaining the hydraulic conductivity. The presence of considerable command area in and around Kalra and Kalighat villages, and demand of power by Mayabunder, Tugapur and nearby populated area, coupled with a necessity for flood moderation has resulted in contemplation of this project. The completion of the project is likely to augment power supply of North and Middle Andaman and will reduce dependence generation of power through diesel sets.

On the left fork of the river, the project envisages the construction of 25m high and 126.5m long concrete gravity dam with central spillway near Kalara Village, which is 16 km from Diglipur and 8 km from Kalighat, both of which are connected by motor boat from Maya bunder, the main locality in North Andaman. The average annual rainfall is 300cm. The catchment area of the dam is 10.70 Km^2. At the maximum water level the reservoir will have approximately 184 hectares area of submergence. The proposed power house is of dimension 31.5 m x 8.5m x 15m. Three units of francis turbine will be used for generation of firm power of 1.43 MW at the gross maximum head of 161.8m and at the installed capacity of 1.75 Mw each.

Rock mass is inhomogeneous and anisotropic and is frequently described by the discontinuities. Persistence or extent of discontinuity is an important characteristic of rock mass. The results of laboratory investigation conducted on rock cores do not truly represent the actual behaviour of large rock mass, because smaller the specimen, the less likelihood of it including a major plane of weakness and also simulation of in-situ stress condition is difficult in laboratory. Therefore laboratory tests results should be used to provide as an indication of relative strength of various rock zones. Actual strength parameters should be predicted by conducting both insitu and laboratory tests and by incorporating suitable factor of safety based on experience.

The rock formations at the dam site consist of mainly ultra basic rock along with patches of volcanic and basic rock. The rock is highly fractured and jointed. The rocks are exposed in parts of the river bed and along and around the dam axis. Alteration (serpentinization) is a common phenomenon on the surface of exposed rock and these features also extend depth wise. The bedrock is intersected by number of discontinuity plains. The red soil formation along the slope is the product of in-situ decomposition of ultra basic rock.

For the characterisation of the foundation rock, it is therefore necessary to conduct in-situ deformability and shear tests on the foundation rock. This paper discusses the field

investigation works with particular reference to shear strength (concrete to rock) and deformability characteristics of foundation rock in addition to laboratory tests conducted for determining the index and engineering properties of rock, which was taken up by the Central Soil and Materials Research Station (CSMRS).

RESULTS AND DISCUSSIONS

Five blocks of concrete were cast over the rock for conducting in-situ shear tests and three test sites were prepared for conducting plate loading tests in the right abutment drift of proposed dam. Since the height of the proposed dam is very low, it was decided to find insitu shear strength parameters of concrete to rock interface only. The in-situ shear and plate loading tests were conducted as per International Society for Rock Mechanics (ISRM, 1981) Suggested Methods. The results were arrived through linear regression analysis. Laboratory tests were also conducted for determining engineering and index properties of rock cores. The results obtained from both in-situ tests and laboratory tests have been compared.

Plate loading Test

Deformability of rock mass was determined by conducting three in-situ plate load tests in right abutment drift. The details of these tests have been described in the report CSMRS (1999a). Tests were conducted up to three cycles by applying different stress level, as it was very difficult and quite risky to conduct the deformability tests up to five cycle of higher stress level. The risk was due to falling of loose blocks inside the drift.

The average values of moduli of deformation and elasticity are shown in Table 1 at different stress levels. The values of modulus of deformation range from 0.05 GPa to 0.16 GPa at an applied stress level of 1 MPa to 3.5 MPa. The values of moduli of elasticity vary from 0.16 GPa to 0.57 GPa at same range of stress applied stress level. It is seen from Table 1 that average value of modulus of deformation increases with increase of applied stress level. The values of modulus of elasticity are on higher side as compared to modulus of deformation. This indicates that deformations are in general plastic and there is very less elastic recovery. The low values of moduli also indicate that rock is of poor quality. The ratio of modulus of elasticity and modulus of deformation is more than 2.75 except at the stress level of 1.5 MPa, this confirms that structure of rock mass is highly fractured and jointed.

Table 1: Average, Minimum and Maximum Values of Moduli of Deformation and Elasticity

Stress L MPa	Modulus of Deformation			Modulus of Elasticity,			Ratio E_e/E_d
	Min.	Max.	Ave.	Min.	Max.	Ave.	Ave.

In-Situ Shear Test

Determination of in-situ shear strength of rock mass involves the measurement of two related parameters i.e. cohesion and angle of friction of the sliding plane. Shearing may take place along one or more number of planes, particularly if the orientation of the plane is unfavorable. However in case of concrete block constructed over the rock surface the most likely failure plane will be at the interface of rock and concrete. Direct shear tests on the large rock specimens involve careful cutting and preparation of blocks. Thus it is very difficult to measure the shear strength of rock, as specimen cannot be prepared without causing any damage to it.

Five number of in-situ shear tests on concrete to rock interfaces were conducted in the right abutment drift of the proposed dam (CSMRS, 1999b). The shear strength parameters of concrete to rock interface were evaluated by linear regression analysis as shown in Fig. 1.

The peak and residual values of in-situ test results have been presented in Fig. 1 Based on in-situ test results the recommended values for angle of friction is 59^o and 45^o for peak and residual stresses, respectively. Where as the cohesion values are 0.11 MPa and 0.02 MPa for peak and residual shear stresses, respectively.

The peak and residual values of both parameters are quite low which indicates that rock mass is of relatively low shear strength. However, since the proposed height of the dam is only 25m therefore the dam is expected to be quite safe.

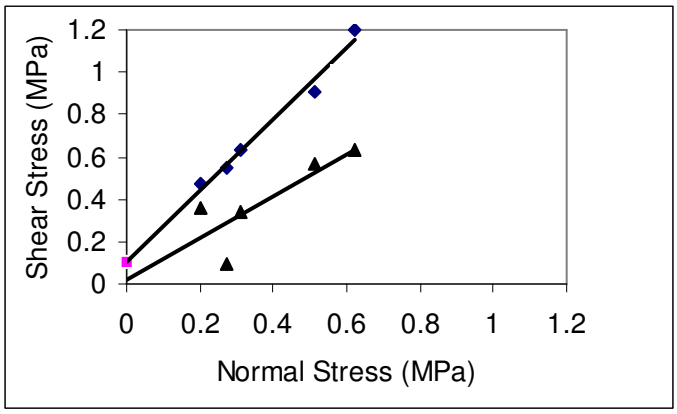

Figure 1: Normal Stress Versus Shear Stress Plot

Comparison of In-situ and Laboratory Test Results

Values of evaluated basic parameters at in-situ field condition and in laboratory (CSMRS, 1999c) are given in Table 2. It is seen from Table 2 that the cohesion and modulus of elasticity values are much higher in laboratory than in field condition. Though the laboratory values are always on higher side by 5 to 20 times the extreme difference between laboratory and in-situ values of cohesion and modulus of elasticity are due to the highly fragmented and jointed nature of rock mass.

Table 2: In-Situ and Laboratory Values

	Parameter	In-situ values (Peak values)	Laboratory values
	Modulus of Deformation (GPa)	0.16	-
	Modulus of Elasticity (GPa)	0.57	69
	Cohesion (MPa)	0.12	7
	Friction Angle	59^0	52^0

CONCLUSIONS

The results bring out the facts that average value of Modulus increase with increase in applied stress level. Deformations are in general quite high and plastic. The elastic

recovery is very less. Large deformations and the moduli ratio confirm that the rock mass is highly fractured and jointed.

The rock mass has relatively poor shear strength. However, the dam is expected to be quite safe based on the height of the proposed concrete gravity dam.

REFERENCES

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