

**TESTING AND MODELING THE
BEHAVIOUR OF RIVERBED AND
QUARRIED ROCKFILL MATERIALS**

by

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Submitted in fulfillment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

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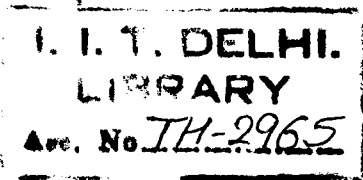
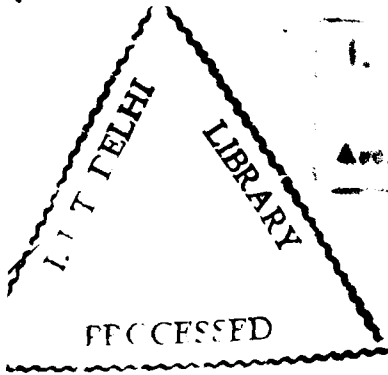


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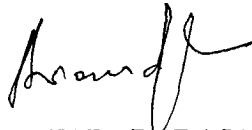
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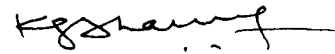
CERTIFICATE

This is to certify that the thesis entitled **“TESTING AND MODELING THE BEHAVIOUR OF RIVERBED AND QUARRIED ROCKFILL MATERIALS”** being submitted by **Mr. Syed Mohd Abbas** to the Indian Institute of Technology, Delhi is a record of bonafide research work carried out by him under our supervision and guidance. The thesis work, in our opinion, has reached the standard, fulfilling the requirements for **DOCTOR OF PHILOSOPHY** degree. The research report and the results presented in this thesis have not been submitted, in part or full, to any other University or Institute, for the award of any degree or diploma.



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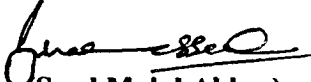
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At this time, I would like to remember my father who expired on 29th of December 2002. May Allah peace be upon him. He had a big role in my life. I am very much thankful to my mother without her support and help I could not come at this level of success. May Allah give her long life.

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ABSTRACT

Rockfill dams are increasingly used in the hydro-power projects. The behaviour of rockfill material used in the construction of these dams is affected by number of factors such as mineral composition, particle size, shape, grading, relative density and surface texture of the particles. The understanding and characterisation of the behaviour of rockfill material are of considerable importance for the analysis and the design of the rockfill dams.

For the present research work two types of rockfill materials viz. riverbed (from seven project sites) and quarried (from three project sites) have been considered. These materials have been modeled to three smaller maximum particle sizes (d_{max}) by parallel gradation technique to test in the laboratory.

Drained triaxial tests have been conducted on these modeled materials at four confining pressures. Breakage factors have been determined at the end of each triaxial test. The breakage factors at various stress levels (35% and 70% of failure load) have also been determined for the modeled quarried rockfill material obtained from Purulia dam site in addition to those at failure stress. For all the modeled rockfill materials, stress-strain-volume change responses have been plotted and ϕ -values have been determined. It is observed that (i) for quarried materials volume expansion is high as compared to that of riverbed materials, (ii) the rate of change of breakage factor with respect to confining pressure is higher in case of quarried materials than that for riverbed materials, (iii) ϕ -value increases for riverbed materials while decreases for quarried materials with increase in d_{max} .

Various index properties viz. unconfined compressive strength (UCS) and uncompacted void content (UVC) of the rockfill materials have also been determined in the laboratory. The UCS represents the strength of the particles and UVC represents grading, size, shape, angularity and surface texture of the particles. The behaviour of the rockfill materials has been explained in terms of these index properties.

To characterize the behaviour of the rockfill materials, a constitutive model based on disturbed state concept (DSC) has been adopted. The triaxial data of a material have been divided into two groups viz. A and B. Group A data has been used to determine the parameters of the constitutive model of that material while Group B data has not been used. The behaviour of the material has satisfactorily been predicted for both the groups. From the material parameters, it is observed that (i) the elasticity parameter, k increases for the riverbed and decreases for the quarried materials with respect to d_{max} while n' does not have any definite trend, (ii) the ultimate parameter, γ increases for the riverbed and decreases for the quarried materials with respect to d_{max} while β is constant and has a value of 0.73 (iii) the hardening parameter, a_1 increases for quarried and decreases for riverbed materials with respect to d_{max} while η_1 has reverse trend.

Shear strength of the granular material is known to depend on the basic characteristics viz. relative density, size, shape, strength, angularity and surface texture of the particles. This concept has been extended to the rockfill materials in the present study. A method has been proposed to relate the basic characteristics in terms of UCS and UVC of the rockfill materials with the shear strength parameter (ϕ). The back prediction of ϕ -value with this method has been successfully made. The ϕ -values

of the prototype materials have also been predicted. The predicted ϕ -values of prototype materials have been compared with the existing extrapolation technique. The difference in ϕ -values obtained by the two methods is very high. It appears that the proposed method is realistic.

An extrapolation technique based on B' (which is a function of UCS and UVC) has been proposed to predict the material parameters of the constitutive model for prototype material. With these parameters, the stress-strain-volume change behaviour of the prototype rockfill materials has been predicted.

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