Prediction of Strength and Modulus of Jointed Rocks Using P-wave Velocity

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Abstract

Strength and deformation characteristics of jointed rocks are important parameters for the design of many civil and mining engineering structures. These parameters are difficult to obtain from direct testing of jointed rocks, hence it is usual practice to derive them through indirect approaches. In the present study, an attempt has been made to obtain rough estimates of strength and modulus of jointed rocks through P wave velocity. Jointed specimens of a model rock were prepared for laboratory testing. Joints at different orientations and comprising of different joint roughness coefficients were used (JRC=2-4, 12-14 and 18-20). Ultrasonic P-wave velocity and UCS tests were conducted on the specimens. The effect of joint orientation and joint wall roughness on P-wave velocity was studied. An index, Joint Factor was used to quantify the effect of joint attributes on strength and modulus of jointed rock. It was observed that P-wave velocity is closely linked with Joint Factor. This study suggests a correlation to obtain Joint Factor Jf from P-wave velocity. It is recommended that this correlation may be used in the field to assess the Jf. The computed Jf may then be used to get the strength and modulus values of jointed rocks in the field. Charts are also suggested to roughly assess the shear strength parameters c and ϕ of the jointed rock.

Full Text

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Figures

Figure 1

Flow chart showing experimental program.

Figure 2

Test samples with joint orientation (0°, 15°, 30°, 45°, 60°, 75°) and (JRC=2-4,12-14,18-20) a. 2-4, b. 12-14, c. 18-20.

Figure 3

Joint roughness profiles

Figure 4

Lower half specimens of the perspex sheet to achieve the desired joint angle orientation.

JRC 2-4

JRC 12-14

JRC 18-20

Figure 5

Rock chunks selected for imprinting roughness over the artificial joint wall surface

Figure 6

a. Moldsil-15 rubber after removing from the rock chunk and b. membrane pasted over the half perspex specimen.

Figure 7

a. Ultrasonic Pulse wave velocity apparatus and b. transducers are kept along the axis of the sample

Figure 8

Cyclic cum static rock triaxial testing machine used for the present study.

Figure 9

Variation of V_p with θ°

176

177

Figure 10

Stress-strain plots for jointed specimens

Figure 11

Variation of UCS with θ°

Figure 12

Variation of E_{tj} with θ°

Figure 13

Failure modes of specimens (JRC=2-4)

Figure 14

Failure modes of specimens (JRC=12-14)

Figure 15

Failure modes of specimens (JRC = 18-20)

Figure 16

Variation of Vp with θ° and UCS with θ° altogether for three JRCs.

Figure 17

Variation of Vp and Etj with θ° for three JRCs.

Figure 18

Variation of $\sigma_{cr} = \sigma_{cj}/\sigma_{ci}$ and $E_r = E_j/E_i$ with J_f (Ramamurthy, 1993).

Figure 19

Normal stress acting on joint plane under unconfined state

Figure 20

Variation of J_f with $(V_{pj}/V_{pi}) \times n$

Figure 21

Relationship of σ_{cj}/σ_{ci} with J_f

Figure 22

Relationship of E_j/E_i with J_f

Figure 23

Failed specimens in UCS tests for validation

Figure 24

Comparison of observed and predicted value of UCS of shale.

Figure 25

Comparison of observed and predicted value of modulus of shale.

Figure 26

Chart for computing angle of shearing resistance for jointed rock

Figure 27

Chart for computing cohesion of jointed rock