

**GEOLOGICAL EXAMINATION OF TUNNELLING FROM A SMALL-SCALE
HYDROPOWER PROJECT IN NORTHERN PAKISTAN: IMPLICATIONS FROM
PETROGRAPHY AND ROCK MASS CHARACTERIZATION**

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Abstract

A tunnel from a small-scale hydropower project in northern Pakistan has been examined in detail to investigate the rock mass characterization, discontinuity analysis and other important geological parameters. The area dominantly contains meta-sediments of Precambrian Formations intruded by Cambrian granite. The detailed petrographic investigations of samples collected at regular intervals reveal the presence of following dominant rock types across the tunnel i.e. garnetiferous schist, quartz-mica schist, calcareous schist, schistose marble, hornblende bearing quartz mica schist and micaceous marble. All rock mass classification systems, consider a few of the key rock mass parameters and assign numerical values to the classes within which the parameters lie for a given rock type. Rock mass quality system (Q-system) has been used for the current project. After the estimation of pertinent rock mass parameters for each rock mass type, a Q-value has been calculated upon rating of each parameter. The petrographic studies and rock mass characterization reveal that quartz mica schist, schistose marble and micaceous marble are weak and intensely jointed rocks, falling in the category of class B, C and D i.e. good, fair and poor rock mass classes respectively. While garnetiferous schist, calcareous schist and quartzite, being relatively strong and intact rocks, are characterized in class A, B and C. Few of the rock types like quartz mica schist fall in class E and F (very poor rock mass class) which is attributed to their maximum jointing, water dripping conditions and discontinuities orientation. Support estimates are also proposed based on rock mass characterization using the Q-system ratings. The ultimate supports for rock class D, E and F are systematic bolting, fibre reinforced shotcrete > 9-12 cm + bolting and fibre reinforced shotcrete > 15 cm + reinforced ribs respectively. The class A, B and C can withstand without giving any major support, however, spot rock bolting may be applied in certain desired regions. A geological longitudinal section of the tunnel has been constructed which represents its division into different domains based on distinct rock types and rock mass classes i.e. domain-I dominantly comprises quartz mica schist and garnet bearing quartz mica schist (Class D), domain-II contains quartz biotite schist and garnet mica schist and marble (Class C), domain-III holds calcareous schist and marble (Class A and B), domain-IV covers Garnet mica schist (Class D), domain-V contains quartzite and quartz mica schist (Class E and F) and domain VI which dominantly have Garnet mica schist and calcareous schist (Class A and B).