Rock Mass Prognostication at the Tunnel Grade: Case Study of Damanganga-Pinjal River Link Project, Western Ghats

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Abstract

A trans-basin water transfer project envisaged to harness the water potential available in Damanganga and Pinjal river basins for supply of potable water to Mumbai City. The project area is located within the northern part of the Western Ghats falling in Valsad District of Gujarat and Nasik and Thane districts of Maharashtra. The project components proposed are three dams of about 72m, 80m and 70m height across Damanganga River near village Bhugad (Lat: 20˚12'30", Long: 73˚17'52"), across Vagh River near Behadpada village (Lat: 20˚05'05", Long: 73˚16'27") (Khargihill) and across Pinjal River near Khidse respectively. The three reservoirs thus formed will be linked by two stretches of 5 and 5.25m diameter tunnels, having cummulative length of 42.50 km.

The project area falls within the Sahyadri Hills, characterised by moderately to highly dissected plateau landforms, with deeply entrenched valleys. Two types of physiographic landforms *viz.* plateau landforms and fluvial landforms are commonly observed in the area. The plateau landforms can further be divided as residual hills with flat summits and mural slopes, less dissected undulating plateaus and moderately dissected plateaus. Fluvial landforms noticed are point bar, channel bars, depositional terraces, etc.

The site is occupied by flow basalts of Deccan Trap Supergroup belonging to Salher and Ratangarh formations of Upper Cretaceous to Lower Palaeocene age. Basalt lava flows of simple and compound types and intrusive dykes of basaltic and doleritic composition are exposed all along the tunnel corridor area (*District Resources Map, Nasik District (2001): GSI Published map*). The

basalts exposed along the tunnel corridor have been classified into four classes such as massive basalt, amygdular basalt, fragmentary porphyritic basalt and massive porphyritic basalt based on the macroscopic examination of the rock.

The rock mass in general blocky, tabular and seamy, controlled by most prominent joint set, parallel to flow bedding, spaced at < 10 cm to 1m. Subhorizontally dipping flow beddings have been observed to be askew to the proposed tunnel alignment. Five sets of joints, moderately to widely spaced, are present in the entire rock section exposed along the total length of the alignment. But, in specific locations only three sets of joints are occurring as predominant sets in the rock mass. The joints in general are fresh, tight to moderately open, smooth planar, at places filled with secondary silica/carbonate veins and at select location slickensides are observed. Based on subsurface explorations carried out along the proposed River Link tunnels and adits, a classification of rock mass characters have been attempted and the Q-values *(Grimstad, E. and Barton, N. 1993)* determined for each type of rock mass encountered. Massive basalt, amygdular basalt, sheared basalt, dykes and sheared dykes are the rock mass encountered. The Q-values have been worked by deriving parametric inputs, based on surface and exploratory subsurface data. The nature of some of the parameters may vary at the tunnel grade, particularly in dykes. Hence, the values may vary. All these Q-values have been worked out assuming the ground water conditions as dry or minor flow of less than 5 liters/minute and Stress Reduction Factor value (SRF) for excavation depth > 50m i.e. condition at tunnel grade level. The Q-values for massive basalt, amygdular basalt, sheared basalt, dyke rock and sheared dyke rock are of the order of 4.33 to 13.33; 4.33 to 13.33; 0.11 to 0.28; 1.66 to 4.00 and 0.15 to 0.37 respectively. Shear zones, dykes sheared dykes are the geological adversities prognosticated at the tunnel grade.

In general, the Rock Quality Designation (RQD) varies from 50 to 100%. Less than 50% RQD at some depths are also worked out. These low RQD values are

attributed to breaking of core while handling and not due to rock mass characteristics or structural fabrics. This is evident in view of high percentage (80-90%) of core recovery and nature of the broken core edges at these low RQD depths. Based on RQD %, the rock mass in general, categorized as fair to very good categories.

Based on the logging and assessment of the borehole cores, it is inferred that massive basalt (<10% amygdules) and amygdular basalt (10-75 % amygdules) will be the tunneling media for the link tunnels, whereas and massive porphyritic basalt and fragmentary porphyritic basalt will be the tunneling media in the initial reaches of the Adit – I and Adit-II of Khargihill–Pinjal Link.

In the Bhugad-Khargihill reach of the link tunnel, seven weak zones have been projected which, constitutes only about 1% of the total length. About 0.2% and 0.74% length of tunnel reach is prognosticated to be through poor and very poor tunneling media and rest of the length will be driven through fair to good categories of rock mass. Khargihill - Pinjal section of the tunnel, would intersect 12 weak zones with cumulative width of about 102m. Based on field studies, this comes to be about 0.4% of the total length through which, driving a tunnel will be hazardous,. About 0.18% and 0.14% length of this tunnel is prognosticated to be driven through poor and very poor tunneling media.

Central Soil and Material Research Station (CSMRS), New Delhi, carried out geo-mechanical testing of some of the rock core samples of massive basalt, amygdular basalt, massive porphyritic basalt and fragmentary porphyritic basalts which have Uniaxial Compressive Strength (UCS) in dry state as 60-112, 22-95, 16-98 and 21-55 MPa respectively. The angle of internal friction is in the range of 50° to 60° and cohesion 2.0 to MPa. The values show that the hard and competent medium would be encountered during tunneling.

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