NEWS AND NOTES

Report Based on Tunnel Seismic Prediction (TSP) at a Tunnel in Lesser Himalaya, Jammu & Kashmir

– Pratap Chandra Dhang, Ircon International Limited, JKRL Project, Ramban 182 144, Jammu & Kashmir
(E-mail: pratap09.isi@gmail.com)

The geological features like fault zones, water bearing zones, etc. are often encountered during tunnelling, especially in Himalayan region, which decreases the production efficiency and thereby significantly increases the costs and construction time (Dhang, 2016; 2017). Therefore, detection of hazardous fault zones and cavities, exploration of water bearing zones, etc. may prove to be quite beneficial. Tunnel Seismic Prediction (TSP) is a method available for predicting geological and geotechnical conditions ahead of the tunnel face (Lin and Li, 2014; Dickmann, 2014). However, this technique is very new in India. Recently, TSP (303) has been conducted under the supervision of the author, affiliated to Ircon International Limited at Main Tunnel of Dharam-Sumber Railway Tunnel (~10.2 km long) associated with J&K Rail Link Project, Jammu & Kashmir. This tunnel traverses through the meta-sedimentary rocks of autochthonous folded belt, sandwiched between Murree and Panjal thrusts (GSI, 2000; 2005). The tunnel face was at tunnel meter 7159.0 and the overburden was 493 m during the conduction of the test. The reference station chosen for the test was at tunnel meter 7097.7.

Twenty four shot holes in the horizontal direction at a distance of about 1 m between each hole have been drilled on the right wall of the tunnel, which have been loaded with explosives and detonators. The first shot hole drilled was about 10 m behind the face. Similarly four 2 m long and 50 mm diameter boreholes have been drilled on both walls (2 boreholes on each wall). These boreholes were about 60 m behind the face. The receiver units having tri-axial sensors were installed in the boreholes. Mild blasts have been taken, the vibration (seismic waves) created by the blasts travelled through the rock mass and receivers caught the signals. The entire arrangement and collection of data took about 3 hours. Then the seismic data were processed and evaluated. The prediction was possible up to tunnel meter 7239.0, i.e. about 80 m ahead from the face. P- and S-wave velocities have been measured based on which the mechanical properties (Poisson's ratio, Static and Dynamic Young's modulus) of the rock mass have been determined. These mechanical properties of the rock mass depend upon the stiffness and fracture density of the rock and water bearing zones within the rock mass. From the available data, the rock properties charts, longitudinal and plan view of the tested area, and 3D seismic model have been generated.

From the analysis of the obtained results regarding the rock properties it has been inferred that where the P-wave velocity was higher (4229-4288 m/s), the Poisson's ratio was towards higher side (0.31-0.33). Similarly where the S-wave velocity was lower (1931-2036 m/s); the Young's modulus was towards lower side (22.0-23.0). These indicate the stiffness of the rock mass decreases where the P- and S-wave velocities have decreased. Where the Poisson's ratio was higher (0.36) but the Young's modulus was lower (23.0), the water bearing zones have been predicted. The predicted information

from TSP has been compared with the actual information gathered during the excavation in this particular stretch of 80 m. From tunnel meter 7158.41 to 7164.98, decreasing of rock mass stiffness and high fractured density has been predicted; exactly the same condition has been encountered during the excavation work. Similarly, the rock mass from tunnel meter 7166.43 to 7204.11 has been predicted to be as fractured and water bearing. The predicted condition was exactly similar to the actual condition as observed during the excavation work in this particular zone and heavier support system with pipe roofing (8 m long, 76 mm diameter, 27 nos.) has been used. From tunnel meter 7211.92, the stiffness of the rock mass increased according to the TSP, the same has been experienced during excavation and therefore lighter support system has been used.

The information obtained by TSP for this stretch of 80 m was quite reliable as the predicted and actual conditions were almost similar. It has been concluded here that the spatial investigation ahead of the face, detection of shear zones and cavities and locating water bearing zones are possible by TSP. Prediction of changes in the mechanical properties of the rock mass is dependable by TSP, which is also useful for the evaluation of the support system. 3D geological models can be generated by the TSP data. The reliable data acquisition for long distances (80 m in the present case) is possible, which is not possible by probe hole drilling.

References

- Dhang, P.C. (2016) Tunnelling in Lesser Himalaya, Jammu and Kashmir, India with special emphasis on tectonic mélange, Jour. Geol. Soc. India, v.88, pp.593-602, doi.10.1007/s12594-016-0525-3
- Dhang, P.C. (2017) Tunnelling in overstressed rock: Example from lesser Himalaya of Jammu and Kashmir, India, Proceeding: Conference on Tunnelling in Himalayan Geology, Tunnelling Association of India, Jammu, 11th-13th October, 2017, Publ. No. 340, p. 378-389
- Dickmann, T. (2014) 3D Tunnel Seismic Prediction: A next generation tool to characterize rock mass condition ahead of the tunnel face. Jour. Rock Mechanics & Tunnelling Technology (JRMTT), v.20, pp.35-47
- Geological Survey of India (2000) Anantnag Quadrangle Jammu and Kashmir, Geological Quadrangle Map 430, Geological Survey of India, Calcutta
- Geological Survey of India (2005) Geological map of Himalaya, the Director General, Geological Survey of India
- Lin, C.J, and Li, S.C., (2014) Tunnel Seismic Prediction (TSP) and its application in tunnel engineering. Applied Mechanics and Materials, v.501-504, pp.1779-1782, DOI: 10.4028/www.scientific.net/AMM.501-504.1779

DOI: 10.1007/s12594-019-1372-9