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## Tunnelling in Himalayas under Water Charged Conditions: Estimation and Remediation

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Tunnelling projects in Himalayas often face unprecedented problems owing to uncertain geological and geohydrological conditions. Out of these problems, sudden ingress of water during tunnel excavation through water charged zones is perhaps the most severe issue. Pre-assessment of the geo-hydrological conditions in Himalayas has limitations owing to difficulties involved in deep investigation techniques for engineering applications. It has been experienced that sudden ingress of water under high hydrostatic head through fault-zones/shear zones or fractured rockmass abruptly halts the tunnelling activity for a long period. This is particularly true when sufficient provisions do not exist in contract which in turn results in catastrophic collapses, flooding, submergence, detouring, time and cost overrun and contractual obligations/arbitrations as experienced in head race tunnels of Dulhasti (Figure-1), Parbati-II and Tapovan-Vishnugad (Figure-2) Hydropower Projects of India. Prediction of likelihood of water charged zones along tunnel route and assessment of quantity of water ingress in advance is necessary to allocate adequate provisions in the contract/GBR for their mitigation.



*Figure 1: Flow of Silt Laden Water under pressure due to puncturing of Shear Zone by TBM at HRT-Dulhasti Hydro-electric Project, J&K, India*



*Figure 2: Water Ingress from segment number 1905 in HRT of Tapovan-Vishnugad Hydro-electric Project, Uttarakhand, India*

With the ambitious plan of capacity addition and infrastructure development by the Govt. of India, many hydropower as well as transportation projects are coming up in interior parts of Himalayas involving long tunnelling works. In order to avoid problems pertaining to geological and hydrogeological uncertainties in these projects, pragmatic investigation practices need to be adopted religiously. Detailed geotechnical as well as geohydrological model of the tunnel needs to be developed with clear demarcation of the critical reaches involving risks. Attempts have been made by researchers to collate some of the major factors like hydraulic conductivity, water table, properties of joints within rock mass, storage and recharge capacity of the aquifer etc. and develop empirical methods and analytical solutions to estimate the groundwater ingress during tunnelling. The above studies need to be included in the Project Investigation Plan so that aquifers/poor ground conditions can be identified before execution

and can be either bypassed or pre treated so that these zones can be negotiated without much hindrance.

The present paper briefly discusses some of the commonly used methods for assessment of water ingress in tunnels and their applicability by comparing the results obtained by these methods with that of actually encountered conditions during construction of few Himalayan tunnels through water charged zones and remedial measures adopted thereon.

*References:*

[1] Chakraborty Arindom and Rao K. Seshagiri (2015). Water ingress assessment in tunnels – an overview; Special Publication Journal of Engineering Geology, October, 2015 International Conference "EGNM 2015" October 27-29, 2015, New Delhi, India; pp 1020-1043.

