

Discrepancies Between Predicted and Actual Rock Mass Conditions in Himalayan Tunnelling: Lessons from the Upper Trishuli 3B Project, Nepal

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Abstract: Tunnelling in the Nepal Himalaya presents significant engineering challenges due to highly variable geological conditions, where rock mass characteristics can change within short distances. Inadequate pre-construction investigations can result in discrepancies between predicted and actual ground conditions, causing construction delays, increased costs, and inappropriate support designs. This paper examines these challenges through the Upper Trishuli 3B Hydropower Project in Nuwakot District, Nepal. Significant differences were observed between the geological conditions predicted in the Detailed Project Report and those encountered during tunnel excavation. The EPC contract further complicated construction, as certain additional support requirements were treated as contractual obligations, leading to excessive support installation in areas where it was unnecessary. Workmanship-related delays also affected project progress. The findings emphasize the importance of comprehensive geological investigations, including the identification of rock types, geological structures, and shear-band fabric. Rock mass classification should be supported by kinematic analysis and relevant design parameters. Furthermore, introducing intermediate support classes and flexible EPC contract provisions could allow support adjustments based on actual tunnel-face conditions. Independent oversight and clearer separation of technical and commercial decisions are essential for improving tunnelling efficiency in heterogeneous Lesser Himalayan geological environments.

Keywords: Himalayan tunnelling, Rock mass classification, EPC contract, Tunnel support systems, Geological investigation, Upper Trishuli 3B, Kinematic analysis.

Introduction

Tunnelling in the Himalayan region presents significant geological and geotechnical challenges due to the complex and highly variable nature of rock masses. In the Nepal Himalaya, geological conditions can change within a few meters along the same geological stretch, making accurate prediction of subsurface conditions difficult. These variations create uncertainties during tunnel planning, design, and construction, particularly when pre-construction investigations fail to identify important geological parameters. Differences between predicted and actual ground conditions can result in construction delays, increased costs, and inappropriate tunnel support systems.

The Upper Trishuli 3B (UT3B) Hydropower Project in Nuwakot District, Nepal, provides an example of these challenges. During tunnel excavation, significant differences were observed between the geological conditions predicted in the Detailed Project Report and those encountered at the tunnel face. Rock types and ground conditions differed from initial expectations, highlighting the limitations of pre-construction investigations in the Lesser Himalayan region.

In addition to geological uncertainties, contractual arrangements created further difficulties during construction. Under the Engineering, Procurement, and Construction (EPC) contract, certain additional support requirements were treated as contractual obligations, resulting in heavier support installations even where the actual rock mass conditions did not require them. Combined with workmanship-related delays, these issues affected overall project progress. The experience emphasizes the importance of detailed geological investigations, improved rock mass classification, flexible support specifications, and independent oversight to ensure that tunnel support systems are appropriate for actual ground conditions.

Geological uncertainty and tunnel support classification in the Upper Trishuli 3B project

The Upper Trishuli 3B Hydropower Project highlights the difficulties of predicting rock mass conditions in the geologically heterogeneous terrain of the Lesser Himalaya. Ground conditions along a tunnel alignment may change within a few meters, making it difficult for pre-construction investigations to capture every important geological and geotechnical parameter. In this project, the rock types and ground conditions encountered at the tunnel face differed significantly from those anticipated in the Detailed Project Report. These discrepancies affected construction activities and demonstrated how incomplete geological predictions can influence excavation progress, project costs, and the selection of appropriate tunnel support systems.

One of the major challenges was the application of tunnel support requirements under the EPC contract.

Certain additional support items were treated as contractual obligations, which resulted in heavier support being installed even in sections where actual rock mass conditions did not require it. This created difficulties in adjusting support systems according to the geological conditions observed during excavation. Workmanship-related delays further affected project progress, illustrating how geological uncertainties and construction-related issues can combine to influence overall project performance.

The experience emphasizes the importance of improving rock mass classification and support selection procedures during tunnel construction. Pre-construction investigations should consider the complete range of rock types and geological structures, including shear-band fabric, to better understand potential variations along the tunnel alignment. Tunnel-face mapping should also be combined with kinematic analysis and other relevant design parameters to provide a more complete assessment of rock mass behavior. Relying solely on RMR-based support classification may not adequately represent the complex conditions encountered in the Lesser Himalaya.

Introducing intermediate support classes within EPC specifications could provide greater flexibility when actual geological conditions differ from initial predictions. Instead of requiring a complete change in support classification, intermediate provisions would allow support requirements to be adjusted proportionately according to tunnel-face observations. Additionally, separating technical decisions from commercial considerations and introducing independent oversight of the classification process could help ensure that the selected support systems reflect actual ground conditions. These improvements would support more appropriate engineering decisions and address some of the difficulties experienced during the Upper Trishuli 3B Project.

Conclusion

The Upper Trishuli 3B Hydropower Project highlights the challenges caused by discrepancies between predicted and actual rock mass conditions in Himalayan tunnelling. Significant variations in rock types and geological structures resulted in differences between the Detailed Project Report predictions and conditions encountered during excavation. These discrepancies demonstrate the importance of comprehensive pre-construction investigations, particularly in the heterogeneous geological terrain of the Lesser Himalaya.

The project also revealed limitations in EPC contractual arrangements, where certain support requirements resulted in heavier installations even when actual ground conditions did not justify them. Along with workmanship-related delays, these challenges affected overall construction progress and

emphasized the need for more flexible support classification procedures.

Overall, integrating tunnel-face mapping with rock mass classification, kinematic analysis, and relevant design parameters can improve support selection. Introducing intermediate support classes, flexible EPC provisions, and independent oversight can help ensure that technical decisions reflect actual geological conditions rather than contractual considerations, supporting more appropriate and efficient tunnelling practices in the Himalayan region.