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Evaluation of rock mass engineering geological properties using statistical analysis and selecting proper tunnel design approach in Qazvin–Rasht railway tunnel

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ABSTRACT

Various geological and geotechnical conditions at different project sites require different design, calculation and construction methods. Stability of underground openings depends on ground conditions with different modes of behavior. An essential step in the design procedure is to assess the ground behavior and continuity factor in the tunnel. The objective of this research is to give a methodology for selecting appropriate design approach based on ground behavior and continuity factor in tunnels. The common procedure for determining rock mass properties and in situ stresses are empirical methods, back analysis, field tests and mathematical modeling. In most cases, estimation of rock mass parameters and in situ stresses using empirical methods are not accurate enough. Therefore, rock mass properties are estimated using several empirical equations and statistical analysis were performed to estimation of these properties in order to obtain rational and reasonable results with acceptable accuracy. The Qazvin–Rasht railway tunnel are taken as case study. Behavior types along the tunnel assessed as stable with the potential of discontinuity controlled block failure, several blocks irregular failure, shallow shear failure, plastic behavior (initial), swelling of certain rocks and water inflow. Therefore, appropriate approach for the tunnel support design selected based on classification systems, numerical modelling, observation methods, and engineering judgment. In order to evaluation of tunnel stability, necessary support types and categories RMR, Q, support weight and SRC were employed as empirical tunnel support design methods. The performances of the proposed support systems were analyzed and verified by means of numerical analysis. According to results of empirical and numerical methods and engineering judgment, shotcrete 0.15–0.2 m with wire mesh and light ribs steel sets (IPE160) were proposed as support elements for the tunnel. We found that using proposed approach the optimum support system could be designed.

1. Introduction

The Qazvin–Rasht railway tunnel is located 50 km north of Qazvin city in North–West Iran (Fig. 1). The planned length of the tunnel is 693 m with horseshoe shape with excavated dimensions of 12 m width and 9.3 m height (Fig. 2). The tunnel will be driven in the west Alborz Mountains (Haraz Rah Consulting Company, 2006). Evaluation of stability is one of the most important concerns in the design of tunnels. For the purposes of rock engineering design, different types of design tool or design system can be applied to the available information on the ground conditions, such as numerical modelling, analytical calculation, empirical (classification) systems or observational methods (Shahriar et al., 2009).

The various types of behavior require different assessments or calculation methods (rock engineering tools) for a proper design that can be depend onto cover the actual case (Palmstrom and Stille, 2007). It is clear that finding a single solution for tunnel stability problems is not an easy task. Uncertainties in the rock material strength parameters and stress are main impediments. Rock mass geomechanical parameters such as Hoek & Brown constants, deformation modulus and uniaxial compressive strength are input data for numerical analysis. Estimation of such parameters is important because the result of numerical analysis depends on accuracy of input data (Sari and Pasamehmetoglu, 2004).

The stability of an underground opening depends on the behavior of the ground surrounding it. Therefore, it is necessary to understand the actual type of behavior, as a prerequisite for rock

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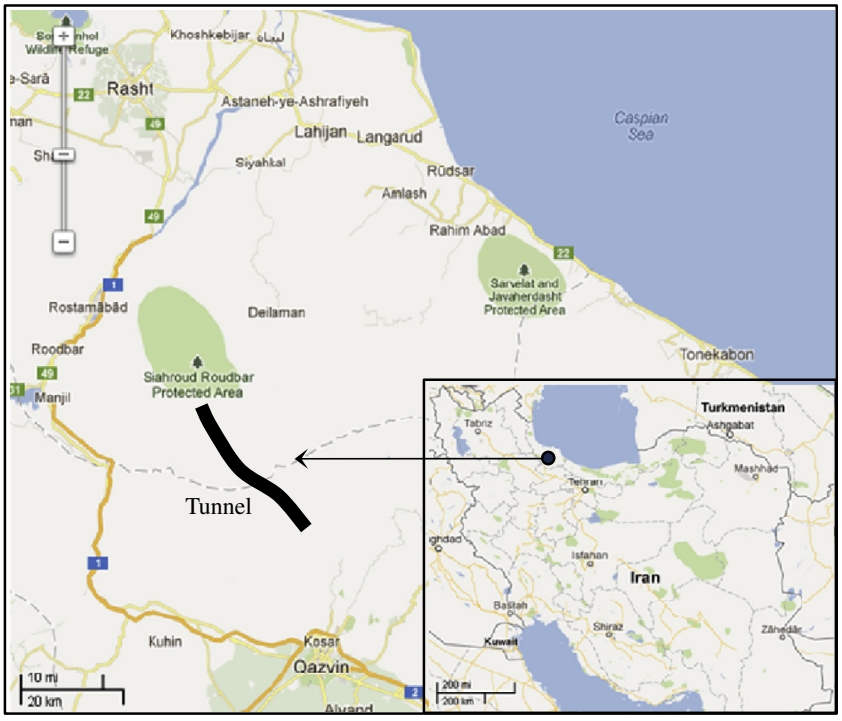

Fig. 1. Location of the study area Qazvin–Rasht railway tunnel.

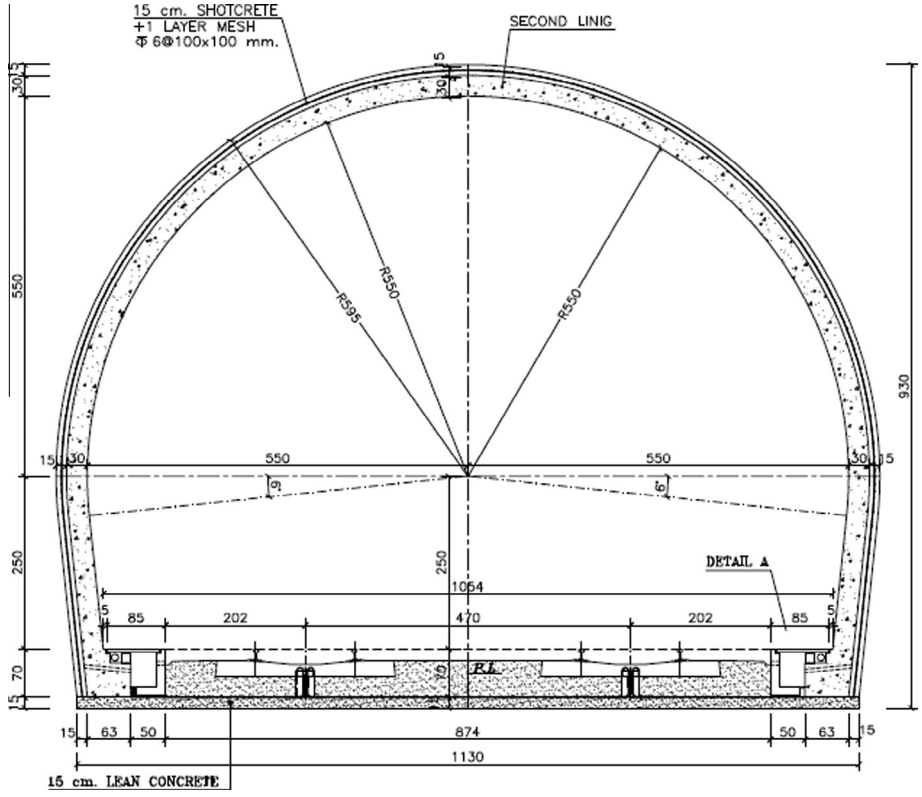

Fig. 2. The Qazvin–Rasht railway tunnel cross-section.

support and other evaluations. Ground behavior is the way the ground acts in response to the rock mass conditions, the forces acting and the project related features (Stille and Palmstrom, 2007). The objective of this research is to give a guideline for selecting proper design methods of tunnels, in order to increase in the quality of engineering assessments and design parameters, and realistic application of classification systems. An essential step in the design procedure is to assess the ground behavior. It is related to mode of failure or behavior type. Knowledge and understanding of the complexity of the ground are essential for a good geotechni-