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Prediction of overbreak depth in Ghalaje road tunnel using strength factor

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ABSTRACT

It is well known that the overbreak caused by the blasting damage during tunnel excavation increases costs associated with filling the collapsed area with shotcrete and results in filing of a claim by the contractor. This paper outlines a new approach for prediction the overbreak depth during tunnel construction. Hence, firstly excavation damage zone (EDZ) are determined by average specific charge in each zone. Numerical modelling is used to simulate the EDZ around tunnel boundary and the overbreak depth are calculated by the rock strength factor. The predicted overbreak depth compared with observed field data from a case study. The results show that there exists an approximately up to 40% difference between the prediction and the observed volume of overbreak depth. Therefore, the method can be well used to predict the overbreak depth to estimate more precision of shotcrete and concrete volumes in tunnelling cost during design phase.

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1. Introduction

The presence of blast induced damaged zone around excavations has been an important concern during tunneling. The term excavation damaged zone (EDZ) is taken to mean the disturbed zone that includes the failed and damaged zones closest to the wall that are caused by the excavation method. The damaged zone around excavation is dependent upon the strength and deformation modulus of the rock mass, in situ rock stress, nature and properties of the discontinuity network, geometry of the excavation and excavation method [1]. According to Martino, the EDZ are divided into two main components: disturbed and damaged. In the disturbed zone only the stresses are altered while in the damaged zone the mechanical, hydraulic and physical properties of the rock mass are irreversibly changed or altered [2]. Overbreak in tunneling is defined as a part of damaged zone beyond the profile calculated for the support elements that falling during rock excavation. It increases total cost of tunneling to a level of 15% or even more of the scheduled cost of construction [3]. Many studies have been performed in order to identify the causes of overbreak during tunneling, but, approximately all approaches based on peak particle velocity (PPV) method that this method is needed to identify wave and other aspect of seismology. Mohammadi et al. studied minimizing overbreak in underground blasting operations by using fuzzy set theory [4]. The effects of rock mass quality on overbreak were investigated by Innaurato et al. [5]. Ibarra et al. studied the influence of geological conditions and blasting factors on overbreak and underbreak in tunnel [6]. Mandal et al. studied evaluating extent and causes of overbreak in tunnels [3]. Using two-dimensional analytical approach, Mahtab et al. assessed the overbreak during tunnel design [7]. Miao et al. studied geological environment and mining conditions of an excavation disturbed zone in coal mining [8]. Perras and Diederichs studied EDZ depths in brittle rocks and their results showed numerical limits can be used for preliminary depth prediction of the EDZs for circular excavations [9]. Using regression analysis, Dey and Murthy established a relationship between the overbreak percentage and rock mass as well as charge and blast design parameters [10]. Yang et al. studied the failure behavior in both inner and outer zones around a circular opening in a non-persistently jointed rock mass under biaxial compression [11]. The overbreak depth quantity deserves more studies due to its crucial role in project planning of tunnelling, particularly, exact estimation of filling volume of damaged zone. In this paper, firstly EDZ is determined by average specific charge in each zone. Numerical modelling is used to simulate the EDZ around tunnel boundary. Rock mass properties in these zone have been assigned based on Kwon et al. theory, and blast damage factor and the

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overbreak depth are calculated by the strength factor [12,13]. The predicted overbreak depth compared with observed field data from a case study. The results show that there exists an approximately up to 40% difference between the prediction and the observed volume of overbreak depth. Therefore, the method can be well used to predict the overbreak depth. To do so, the result of 538 blasting rounds in Ghalaje road tunnel in west of Iran are studied.

2. Project description

The Ghalaje road tunnel is located in west of Iran on the Eslam Abad–Eyvan (between Kermanshah and Ilam provinces) main road with a length of 2500 m, width of 12.2 and height of 8.3 m, with a cross section of 98 m^2. Construction of the tunnel will reduce the length of this main road more than 12 km, which indirectly facilitates all travel to Iraq and will increase the road safety. Fig. 1 represents the Ghalaje road tunnel location. Due to high strength properties of surrounding rocks in the tunnel path, the blasting method has applied to excavate the tunnel.

2.1. Geological and geotechnical investigations

The region is located in the folded sedimentary formations of Zagros belt, consisting of numerous anticlines and formed synclines. The tunnel path is located in Asmari formation belonging to the Cretaceous-Eosin period, comprised of massive, thick bedded and jointed varieties of limestone. According to the engineering geological data and rating scores inferred from surface and underground mapping, the host rocks were divided into three zones: zones I, II and III at the construction stage as shown in Fig. 2.

Zone I consists of limestone with some clay interbedding with a thickness of about 50 cm in some locations. Zone II, assigned to the most competent part of the host rock, and consists of limestone and dolomitic limestone. Lastly, limestone with clay and marl interbedding constitutes the host rocks of Zone III. Main lithology in the tunnel face is shown in Fig. 3.

The rock mass quality has been scored using the RMR classification system. Detailed information of rock mass rating and properties of rock mass are demonstrated in Table 1. The cohesive,

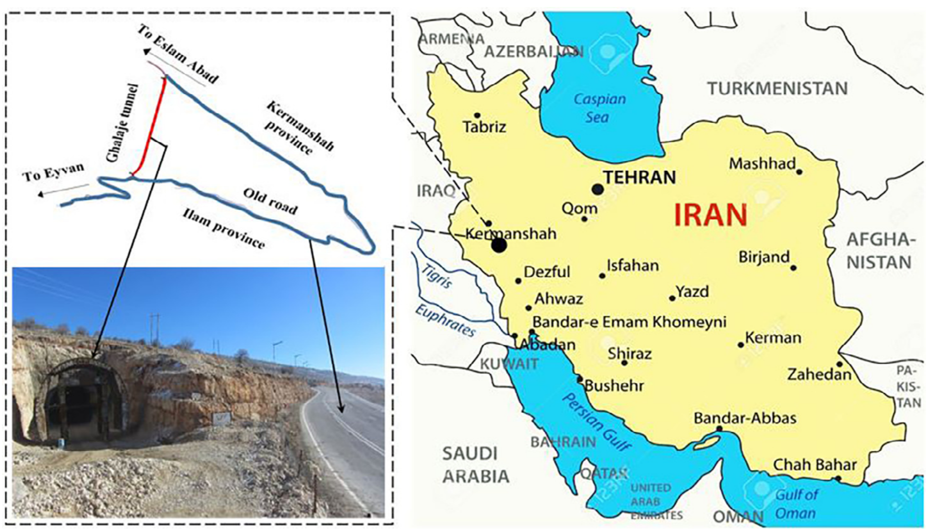


Fig. 1. A close up view of Ghalaje road tunnel.

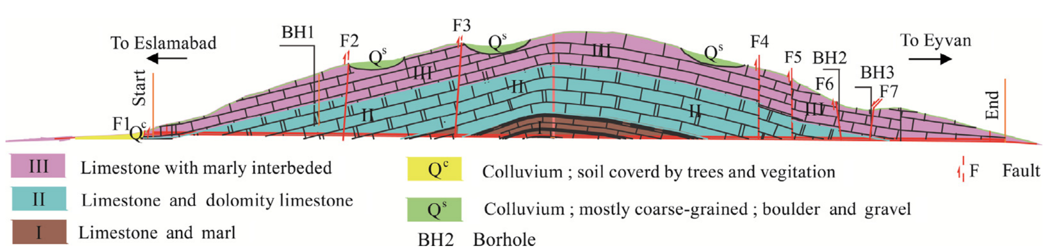
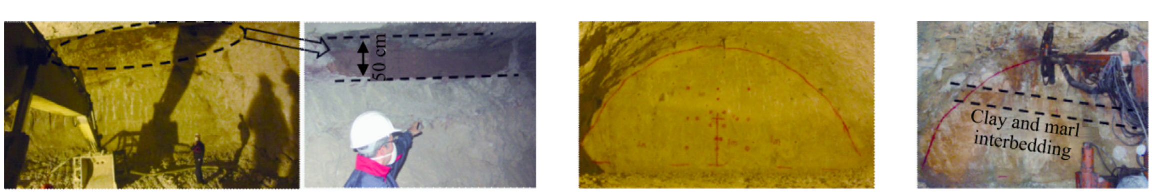


Fig. 2. Longitudinal section of Ghalaje tunnel.



(a) Clay interbedding with 50 cm thickness in Zone I

(b) Limestone and dolomitic limestone in Zone II

(c) Limestone with clay and marl interbedding in Zone III

Fig. 3. Main lithology in the tunnel face.

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