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Excavatability and the effect of weathering degree on the excavatability of rock masses: An example from Eastern Turkey

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ABSTRACT

In this study, the effect of the weathering degree on the excavatability of rock masses was investigated. The ophiolitic rock mass along the route of Komurhan Tunnel was chosen as the case study. Both laboratory and field studies were carried out for this purpose. In the first stage, the ophiolitic rock mass along the tunnel route was classified into three subzones according to the weathering degree and the ophiolitic rock masses of the each subzones were classified using the empirical excavatability classifications proposed by the different researchers. Furthermore, in-situ excavatability classes of rock masses in each zone were determined and the results were compared. The in-situ excavatability class of fresh (Zone-I) and slightly weathered (Zone-II) rock masses was determined as Blasting and that of moderately weathered (Zone-III) rock mass was determined as Very Hard/Very Difficult. As the obtained results were compared, it was found that the weathering degree has a significant effect on the excavatability and that it is more appropriate to prefer empirical classifications in the empirical determination of excavatability classes of rock masses having the same lithology by taking the weathering degree into account.

1. Introduction

Excavatability is defined as the snapping off degree of rocks from whereabouts by excavating equipment and rippability is defined as the relative expression for rocks to be ripped and ruptured by a ripper-dozer (Ceylanoglu et al., 2007). Selection of the suitable excavation method and equipment in surface and underground excavations depends on the excavatability properties of rock masses. Therefore, realistic evaluation of geotechnical properties of rock mass and the determination of suitable excavation method would minimize problems encountered during the excavation and thus lower the excavation cost.

A number of empirical excavatability and rippability classification systems have been developed by using material and mass properties of rocks for pre-design purposes (Franklin et al., 1971; Atkinson, 1971; Bailey, 1975; Weaver, 1975; Kirsten, 1982; Abdullatif and Cruden, 1983; Scoble and Muftuoglu, 1984; Singh et al., 1987; Smith, 1986; Bozdag, 1988; Pasamehmetoglu et al., 1988; Karpuz, 1990; Pettifer and Fookes, 1994; Hadjigeorgiou and Poulin, 1998; Hoek and Karzulovic, 2000; Ceylanoglu et al., 2007; Tsiambaos and Saroglou, 2010). These empirical classification systems have been used by a number of researchers in order to determine the excavatability and rippability class of rock masses with different engineering properties (Bozdag, 1988; Kentli and Topal, 2004; Gurocak et al., 2008; Alemdag et al., 2011; Kaya et al., 2011).

Many of the proposed empirical classification systems are based on the data obtained from the field observations, laboratory tests or in-situ trial excavations. The fact that some part of the input data used in these classification systems are based on observation data results in differences between classifications and practical application. Thus, in terms of testing the reliability of the classification systems, it is of utmost importance to apply the available classification system to different rock masses and compare the results with those obtained during the excavation.

In this study, the excavatability and rippability classifications and their input parameters that have been proposed by different researchers until today were examined and the effect of the weathering degree on the excavatability of rock masses was investigated. As a case study, the ophiolites along the route of Komurhan Tunnel on the Elazig-Malatya highway where the excavations were completed have been selected. The excavatability properties of the ophiolites were examined, the obtained results

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were compared with the in-situ excavatability of the rock masses and it was attempted to determine which empirical classification system coincides with the excavatability classes of the ophiolites having different degree of weathering.

2. Empirical excavatability/rippability classifications and used parameters

In the empirical classifications used in determining the excavatability and rippability of rock masses, it is observed that different parameters have been preferred which are thought to be effective on the excavatability and rippability of rock mass. The classifications that have been proposed by different researchers and the input parameters used in these classifications are given in Table 1.

As the classifications and the parameters used in these classifications presented in Table 1 are examined, these parameters can be classified into three main categories as following;

A Engineering properties of the joints,
B Engineering properties of rock material, and
C Engineering properties of rock mass.

In the classifications proposed by Franklin et al. (1971), Scoble and Muftuoglu (1984), Smith (1986), and Pettifer and Fookes (1994) engineering properties of discontinuities and rock material in the Categories A and B were used as input parameters. While Bailey (1975), Church (1981), Abdullatif and Cruden (1983), Hoek and Karzulovic (2000), and Tsiambaos and Saroglou (2010) have used only the engineering properties of rock mass (Category C), Weaver (1975), Kirsten (1982), Smith (1986), Pasamehmetoglu et al. (1988), Karpuz (1990), Hadjigeorgiou and Poulin (1998), Basarir and Karpuz (2004) and Ceylanoglu et al. (2007) have preferred to use engineering properties of discontinuities, rock material and rock mass (Category-A, B and C) in the excavatability classifications they proposed.

The most frequently used parameters in these empirical classifications are joint spacing, uniaxial compressive strength/point load index, weathering degree and seismic velocity. All of these parameters are used in classifications proposed by Weaver (1975), Singh et al. (1987), Pasamehmetoglu et al. (1988), Karpuz (1990) and Ceylanoglu et al. (2007). Bailey (1975) and Church (1981) used only seismic velocity as input parameter whereas Abdullatif and Cruden (1983) used RMR and Q values in the classification they proposed and Tsiambaos and Saroglu (2010) used GSI value of rock mass as input parameter. As the parameters used in determining rock mass classes such as RMR, Q and GSI used in these classifications are taken into account, it is possible to see that the engineering properties of rock material and discontinuities have been used indirectly. Hoek and Karzulovic (2000) classified rock masses in terms of excavatability by using uniaxial compressive strength and GSI value.

The parameters used in the classifications mentioned above are generally similar. Therefore, it should be expected that the results to be obtained from these classifications for the same rock masses should be consistent. However, having the significant differences

Table 1
Excavatability and rippability classifications and the input parameters used.

Category	Parameters	Excavatability and rippability classifications																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Category -A	Joint orientation			✓					✓					✓				
	Number of joint					✓												
	Joint spacing	✓		✓				✓	✓	✓	✓	✓	✓			✓	✓	
	Joint continuity			✓					✓									
	Filling			✓					✓									
	Roughness					✓												
	Joint weathering			✓		✓												
Category -B	Uniaxial compressive strength	✓				✓		✓		✓	✓	✓				✓	✓	
	Point load index	✓										✓	✓	✓		✓		
	Hardness			✓							✓	✓					✓	
	Degree of weathering							✓	✓	✓	✓	✓		✓			✓	
	Abrasivity									✓								
Category –C	RQD					✓												
	Block size													✓				
	RMR						✓											
	Q						✓											
	GSI														✓			✓
	Seismic velocity		✓	✓	✓					✓	✓	✓				✓	✓	
	Rock mass strength														✓			

1- Franklin et al. (1971).
2- Bailey (1975).
3- Weaver (1975).
4- Church (1981).
5- Kirsten (1982).
6- Abdullatif and Cruden (1983).
7- Scoble and Muftuoglu (1984).
8- Smith (1986).
9- Singh et al. (1987).
10- Pasamehmetoglu et al. (1988).
11- Karpuz (1990).
12- Pettifer and Fookes (1994).
13- Hadjigeorgiou and Poulin (1998).
14- Hoek and Karzulovic (2000).
15- Basarir and Karpuz (2004).
16- Ceylanoglu et al. (2007).
17-Tsiambaos and Saroglou (2010).