Available online at www.sciencedirect.com

SCIENCE DIRECT®

Engineering Geology 81 (2005) 131–145

ENGINEERING GEOLOGY

www.elsevier.com/locate/enggeo

Analysis of support requirements for a shallow diversion tunnel at Guledar dam site, Turkey

H. Basarir [a,*], A. Ozsan [b], M. Karakus [a]

[a] *Department of Mining Engineering, Inonu University, 44280 Malatya, Turkey*
[b] *Department of Geological Engineering, Ankara University, 06100 Ankara, Turkey*

Received 25 March 2005; received in revised form 21 July 2005; accepted 22 July 2005
Available online 16 September 2005

Abstract

Engineering geological properties and support design of a planned diversion tunnel at Guledar dam site, which was located at the North of Ankara, Turkey were studied in this article. The main purpose of the construction of the planned tunnel is to regulate, drainage and to provide water for irrigation purposes. The diversion tunnel runs mainly through formations of limestone, sandstone and diabase. Rock masses at the site were characterized using Rock Mass Rating (RMR), Rock Mass Quality (Q), Rock Mass Index (RMi) and Geological Strength Index (GSI). RMR, Q, RMi and GSI were determined by using field data and mechanical properties of intact rock samples, measured in the laboratory. Support requirements for the planned diversion tunnel were determined accordingly in terms of the rock mass classification systems. Recommended support systems by empirical methods were also analyzed using 2D Finite Element method. Calculated parameters based on empirical methods were used as input parameters in the finite element models. The results from both methods were compared with each other. This comparison suggests that more reliable support design could be achieved by using the finite element method together with the empirical methods.

Keywords: Rock mass classification; RMR; Q; RMi; GSI; Convergence–confinement method; Hoek–Brown failure criterion; Finite element method; Tunnel support design

1. Introduction

Empirical and numerical methods are commonly used methods when underground engineering structures are designed. Empirical methods are generally preferred by rock engineers and engineering geologists due to their practicality. In designing tunnel supports, rock mass classification systems, RMR, Q and RMi have been used by many researchers and gained a universal acceptance. These classification systems have been originally obtained from many tunneling case studies and they have been applied to many construction designs. However, these empirical

* Corresponding author. Tel.: +90 422 3410030; fax: +90 422 3410046.
E-mail address: hbasarir@inonu.edu.tr (H. Basarir).

0013-7952/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.enggeo.2005.07.010

methods cannot adequately calculate stress redistributions, support performance and deformations around the tunnel. Therefore, particular attention has to be given when they are used. Especially, determination of their values in terms of the rock mass, subjected to the analysis, is very sensitive to the field observations. In the same manner, numerical methods such as finite element method are very dependent on the strength parameters of rock masses, which are input into the finite element models. Therefore, both methods should be used carefully and their parameters should be determined as close as possible to field data. On the other hand, providing reliable input parameters to finite element method can produce meaningful calculations on the ground control. In this article, two methods were used and their estimations and recommendations on tunnel support design were evaluated.

Engineering geological and rock mechanics studies were carried out at Guledar irrigation dam site. The project area is located 30 km north of Ankara, capital city of Turkey. The dam project is designed to regulate the drainage and to irrigate the agricultural areas. The design of Guledar dam project is under supervision of General Directorate of State Hydraulic Works (DSI), of the Ministry of Energy and Natural Resources, Turkey. The planned length of the diversion tunnel is 310 m, having circular geometry with 3 m diameter. The dam site is located within Karakaya complex formation, which is composed of sandstone, limestone and diabase. The location map of Guledar dam site is given in Fig. 1.

Both laboratory and field studies were completed. Geological mapping, core drilling, pressured water test and geotechnical descriptions were conducted in the field. Index and design properties of rocks were determined on intact rock samples in the laboratory. These are uniaxial compressive strength (σ_c), Young modulus (E), Poisson's ratio (v), tensile strength (σ_t), internal friction angle (ϕ), cohesion (c), bulk unit weight (γ) and porosity (n).

The properties of rock mass around the opening, tunnel diameter, tunnel depth, geometry and the support characteristics to be used are the basic input parameters for a safe tunnel design (Ozsan and Basarir, 2003). Therefore, the rock mass properties of the site were determined by using different rock mass classification systems and GSI. The support performance proposed by rock mass classification systems was analyzed and preliminary support design of the diversion tunnel was proposed.

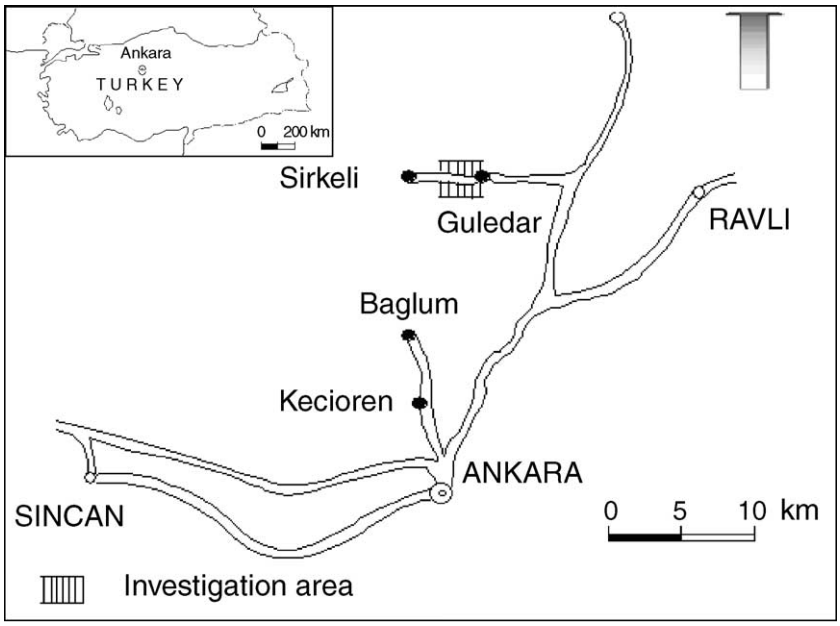

Fig. 1. Location map of Guledar dam site.