International Journal of Rock Mechanics & Mining Sciences 65 (2014) 20–28

Contents lists available at ScienceDirect

International Journal of Rock Mechanics & Mining Sciences

journal homepage: www.elsevier.com/locate/ijrmms

Determination of the deformation modulus of dispersible-intercalated-jointed cherts using the Menard pressuremeter test

Celal Agan *

Department of Civil Engineering, Harran University, 63000 Sanliurfa, Turkey

ARTICLE INFO

Article history:
Received 28 February 2013
Received in revised form
26 September 2013
Accepted 3 November 2013
Available online 12 December 2013

Keywords:
Chert
Deformation modulus
Menard pressuremeter test
RMR
GSI
Confining stress

ABSTRACT

Due to the difficulties encountered during the preparation of representative cores from fragile/intercalated/weathered/jointed rock masses for laboratory-scale testing, various in-situ test methods, such as pressuremeter, dilatometer, plate loading, plate jacking, Goodman jacking, flat jack, cable jacking tests, etc., have been developed for determining the deformation modulus of rock masses. However, almost all of these in-situ tests require time-consuming procedures, have operational difficulties, and have high costs. Therefore, rock mass classification systems and empirical equations have been developed for estimation of parameters such as the deformation modulus. In this study, dispersible, fragile, intercalated and heavily jointed chert rock mass, supporting several large-scale structures under construction in Manisa (Turkey), was classified based on RMR, GSI, and UCS as input parameters for estimation of deformation modulus using some of well-known empirical equations. Three chert rock masses with different geomechanical qualities were identified. Point load tests were performed to determine the UCS of the cherts to characterize the rock masses. The deformation modulus obtained from the Menard pressuremeter tests was compared to the modulus estimated using empirical equations. In addition, an attempt also was made to examine the dependency of the deformation modulus of the studied chert rock masses to the confining stress. Empirical relationships and equations with high correlation were obtained for predicting the deformation modulus by using input parameters such as RMR, GSI, UCS, and confining stress.

1. Introduction

Heavily jointed chert rock masses are observed within the southern parts of some of the western provinces of Turkey such as Manisa, Kutahya, and Izmir. Significant energy projects are under construction and/or planned on the rivers of this region (e.g., Gordes, Sevisler, Demirkopru, Afsar, Golmarmara, Gurduk Dams, etc.). Parts of these projects are constructed on heavily jointed chert rock masses. Therefore, determination of strength and deformation characteristics of the weak rock masses is required during design stages of the projects. However, it is almost impossible to determine mechanical parameters using laboratory tests conducted on large cores of randomly oriented rock samples or to adjust the discontinuity of joint sets in these chert units due to the difficulties of the preparation of undisturbed rock mass cores including joint patterns (Fig. 1a). The weak rocks disintegrate under the action of the rock bit–core with water, and this result in extensive disturbance to the ground (Fig. 1b). Therefore, evaluation of the deformation modulus of these kinds of rock masses is mandatory.

The objectives of this study were (i) to experimentally determine the in-situ deformation modulus of a heavily jointed chert rock mass by performing the Menard Pressuremeter Test (MPT), (ii) to determine geomechanical characteristics of the chert rock mass, (iii) to examine the dependency of deformation modulus to the confining stress for the blocky rock masses, and (iv) to develop empirical equations for indirect estimation of the deformation modulus of the studied chert rock masses. For this purpose, MPT (insertion type pressuremeter) tests were performed to determine the in-situ deformation modulus of the chert rock mass. Rock mass characterization studies (basic RMR and GSI) were carried out at three different locations on outcrops, where the access to the drilling location was available. Due to the sampling difficulties, UCS values were indirectly estimated from point load tests. In addition, correlations were developed between the deformation modulus obtained from the MPT and the geomechanical parameters (e.g., RMR and GSI). Due to the recommendation of [1], an attempt also was made to develop a relationship between the in-situ deformation modulus (E_{MPT}) and the confining pressure (P_o) of the studied chert rock mass. Finally, regression analyses

* Tel.: +90 532 275 7494, +90 414 318 3783; fax: +90 414 318 3799.
E-mail addresses: agancelal@hotmail.com, celalagan@harran.edu.tr

1365-1609/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ijrmms.2013.11.004

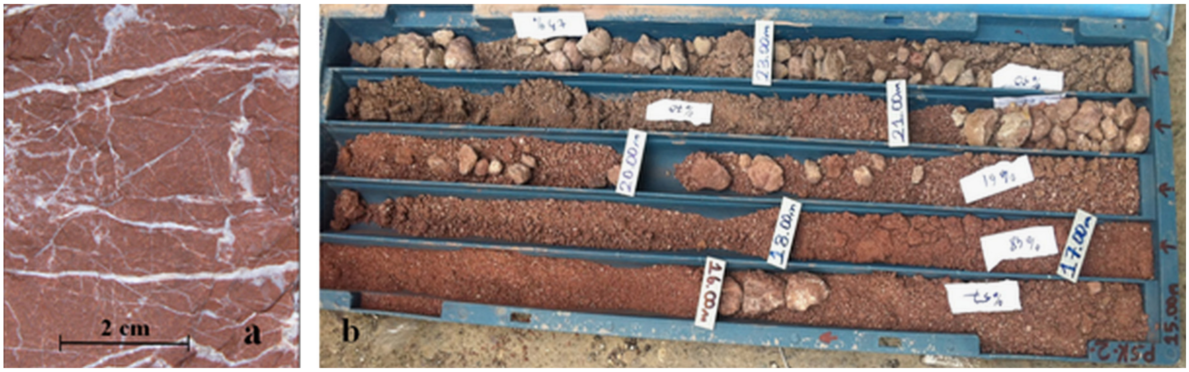

Fig. 1. (a) A close up view from the chert and (b) disintegration of the chert after drilling.

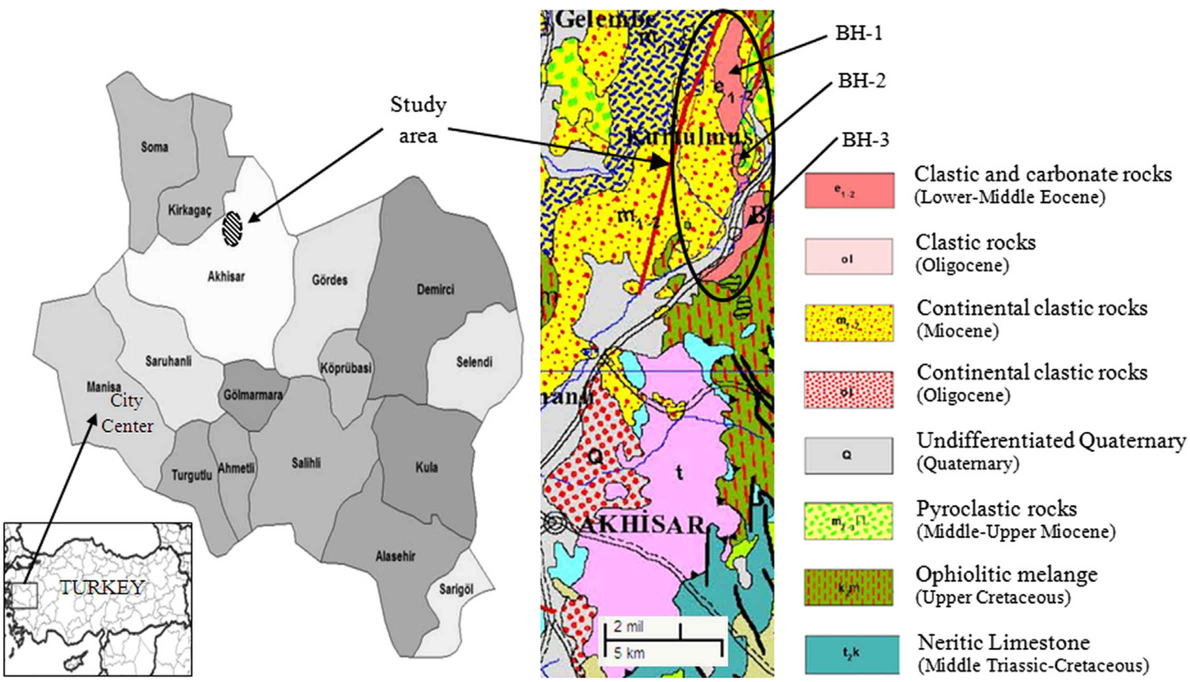

Fig. 2. Location and geological maps of the study area [31].

were performed on 11 derived equations to obtain empirical equations to predict the deformation modulus based on geomechanical quality of the studied chert rock mass.

2. Engineering geological characteristics of the studied cherts

The chert rock masses investigated in this study was located in the province of Manisa to the northeast of the city of Manisa. Due to dense vegetation and sloping terrain, the chert outcrops are rather limited for sampling, drilling, and in-situ testing. After preliminary site visits, three locations were selected for observation, drilling, and MPTs as shown in Fig. 2. The boreholes BH-1 and BH-2 were located near the Gurduk Dam site in the vicinity of the town of Kurtulmus. The borehole BH-3 was located near the Gordes Dam site in the vicinity of the town of Baslamis near the city of Akhisar.

The reddish cherts in the region include some small clear spheres of Jurassic-aged radiolaria (siliceous plankton). The cherts are intercalated with pelagic shale and veined carbonate rock. The bedding of the cherts is generally horizontal with some vertical orientation due to undulation (Fig. 1a). The chert rock mass at the location of BH-3 (Fig. 3b) is blocky and the rock is sligthly better in terms of less-jointed when compared with those at the BH-1 and BH-2 boreholes (Fig. 3a).

3. MPTs and other laboratory tests

The experimental testing program consisted of in-situ MPT, point load tests, and laboratory unit weight tests.

3.1. MPT

Several in-situ test methods (such as Goodman jack, plate loading, hydraulic jack, MPT, etc.) are available for determining the deformation modulus of rock masses. MPT was preferred in this study, because the strength and deformation properties of soils or weak jointed rock masses can be determined over a large volume using this method. MPT measures the in-situ lateral deformation characteristics of ground at a particular depth. A typical result from a pressuremeter test is shown in Fig. 4.

The initial volume of cavity is identified as point *A*, up to this point the pressure increases linearly with strain. The pocket wall unloads elastically during pre-boring and responds elastically on reloading once the membrane is in contact with the wall. This