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Rock Mass Classification Using a Computer Program-Classmass

A. H. Deliormanli & T. Onargan
Dokuz Eylui University, Mining Engineering Dept., Bornova, İzmir, Turkey

ABSTRACT: In this study, a computer programme coded as a ClassMass which is developed for determination of the geological strength index (GSI), rock quality index (Q) and mining rock mass rating (MRMR) is introduced. It examines the structure of the individual main and multi-level knowledge base created for each major and minor parameter for rock mass classification. ClassMass is primarily intended to work as an assistant to an engineer in planning stages in order to enable user to design underground constructions quickly.

1 INTRODUCTION

In rock engineering, the first major classification system was proposed over 60 years ago for tunneling with steel supports. Rock mass classifications today form an integral part of the most predominant design approach. Indeed, on many underground construction and mining projects, rock mass classifications have provided the only systematic design aid in an otherwise haphazard procedure (Bieniawski Z. T., 1989).

In this study, within the Beypazarı Trona Field-Main Drift Project, rock mass classification software which has been developed for the support design by the Dept. of Mining Engineering. Dokuz Eylül University is introduced. The system has been designed using a Visual Basic shell on a PC platform which runs under MS-Windows operation system (version 95, 98, and 2000) with min. 16 Mb RAM of memory and a 40 MB free disk space. ClassMass utilizes a multi-level knowledge base structure with a number of sub-knowledge bases; which are controlled by a main knowledge base that manages the whole system.

2 THE GENERAL STRUCTURE OF CLASSMASS

ClassMass utilizes a multi-level knowledge base structure with a number of sub-knowledge bases; these are controlled by a main knowledge base, which manages the whole system. The general structure of the ClassMass and input-output structure of the system are shown in Figure 1.

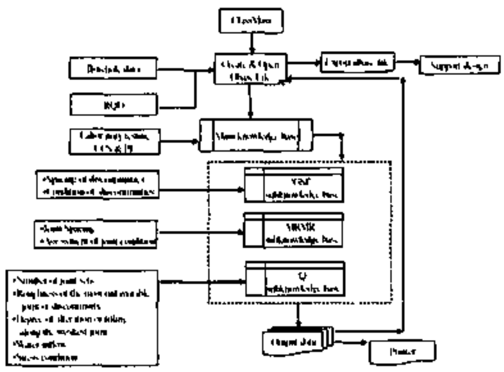


Figure I. The general structure of the ClassMass and input-output structure of the system

3 THEORETICAL BACKGROUND OF THE PROGRAM

ClassMass offers GSI results with Q and MRMR. The user must provide geotechnical parameters and laboratory results to ClassMass. Therefore, engineers should investigate these factors in detail to obtain a good result from the system.

3.1 Q Classification System sub knowledgebase

The Q-system of rock mass classification was developed in Norway in 1974 by Barton, Lien and Lunde, all of the Norwegian Geotechnical Institute. Its development represented a major contribution to the subject of rock mass classification for a number of ıeasons the system was pioposed on the basis ot an analysis ot over 200 tunnel case histoues from Scandinavia, it is a quantitative classification (Bi-emawskiZ T, 1989)

The Q system is based on a numencal assessment of the lock mass quality using six different parame-teis,

- Rock quality designation (RQD) %
- Number ot joint sets
- Roughness of the most untavoiable joint or dis-continuity
- Degree ot alteiation 01 filling along the weakest joint
- Water inflow
- Stiess condition

The first two parameters represent the overall struc-ture ot the rock mass, and their quotient is relative measuie the block size The quotient ot the third and the touith paiameters is said to be an indicator ot the inter block shear stiength The fifth parameter is a measure ot water pressure, while the six parameter is a measuie ot ı) loosening load in the case ot shear zones and clay bearing lock, n) rock stress in com-petent lock, in) squeezing and swelling loads in plastic incompetent rock The quotient ot the fifth and sixth parameters describes the active stress Baiton et al (1974) consıdeı the parameters J_n, J, and J, as playing a moie impoitant inle than joint onen-tation and if joint orientation had been included, the classification would have been less geneial How-evei onentation is implicit in paiameters J, and J, because they apply to the most unfavorable joints (Milne et al 1998) Rates of paiameteis are given Table 1

These six paiameters aie gıouped into thiee quo-tients to give the overall lock mass quality Q as fol-lows

$$Q = \frac{RQD}{J_n} \frac{J_r}{J_a} * \frac{J_w}{SRF}$$

(D

where

RQDC%) = rock quality designation, (1 Pa-tametei)

J„ = joint set numbei,

J, = joint roughness number,

J, = joint alteration number,

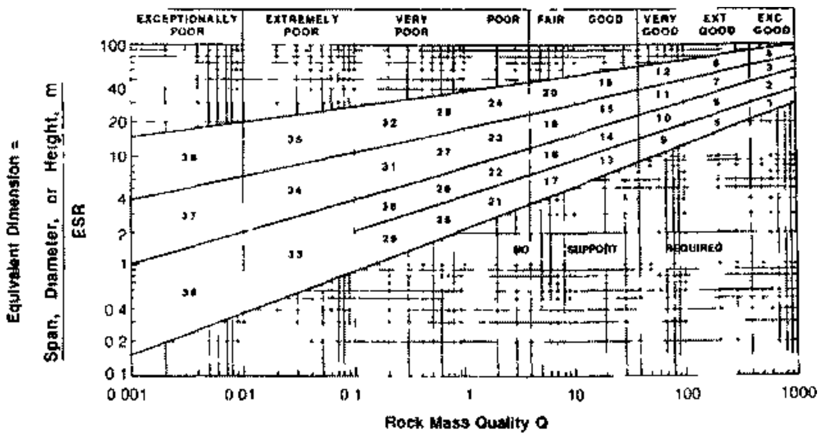
J_w = stress i eduction factor,

SRF= stiess condition.

The lock quality can range from Q=0 001 to Q=1000 on a logarithmic rock mass quality in Fig-ure 2 System and it is an engineering system fa-cilitating the design ot tunnel supports (Barton N 1988)

Table 1 Rating of Q systems paiameteis

Parameters	Rating	
	Min	Max.
2 loint sel numbei	0<>	20
loint roughness numbei	1	4
4 loint alteiation numbei	O?'!	20
5 Stiess ıeduction t.iuoi	(HVS	1
6 *Stu\s condition*	0*5	400



Figuie 2 Q system equivalent dimension veisus lock mass quality (Aftei Barton et al, 1974)

3 2 MRMR Classification S^ stem Sub knowledge base

The classification system known as the mining lock mass îatmg (MRMR) system was introduced in 1974 as development ot the CSIR geomechamcal classification system

The development is based on the concept ot in situ and adjusted ratings, the parameteis and values being related to complex mining situations Since that time, theie have been modifications and ımpiovements and system has been used successfully in mining piojects in Canada, Chile, South Africa and USA (Laubscher 1990)

This system employs the following paiameters,

- Uniaxial Compressive Stiength(UCS)
- Rock quality designation (RQD) %
- Joint Spacing
- Assessment ot joint condition
    - o Joint waviness
    - o Joint roughness
    - o Joint wall alteration
    - o Joint filling

The rates and meaning of the parameters aie given in Table 2-3

Table 2 Paıameteıs value ot MRMR system

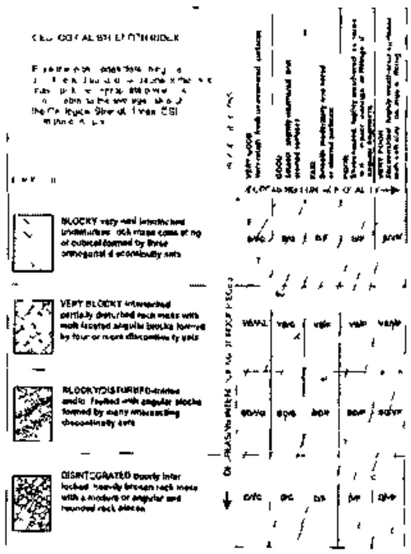
Parameters	Rating	
	Min	Max
UCS (MPa)	1	20
RQD(%)	0	li
Joint Spacing	0	2S
loint Condition	0	40

Table 1 Meaning ot the ratings

Rating	Description
10081	Veiy Good
80 61	Good
60-41	F.UI
40-21	Pool
20-0	Veiy Pool

Table 4 *Killing* ot GS1 parameters (Arıoğlıı E, Yüksel A 1999)

1 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
[illegible]	15	12	7	4	2	1	0
2 RQD [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	<2		
[illegible]	20	17	13	8	3		
3 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
Rat	30	25	20	10	5		
4 [illegible]							
Rat	25	20	12	6	0		



Fıgııe 1 Chaıacteıi7atıon ot rock masses on the basis of inlei locking and surface condition of discontinuities GS1 classification

? 3 GSI Sub knowledgebase

Deteimination of the sttength ot closely jointed lock masses is dilficult since the size of ıepıesentatıve specimens is too large for laboıatoıy testing This difficulty can be overcome by using the Hoek-Biown taıluıc ciiteuon Since its introduction in 1980, the cnterion has been îefined and expanded ovci the yeais, pailiculaily due to some limitations in its application to poor quality lock masses In the latest version, the geological strength index (GSI) was intioduced into the cnterion by its originators Howevei, the GSI classification scheme, in its existing lorm, leads to rough estimates ot the GSI values Anothci paıtıculaı issue is the use ot undisturbed and distuibed lock mass categones tor determining the paıameteıs in the ciiteuon, for which clear guidelines aie lacking Furthermore, the data supporting some ot these revisions, particularly the latest one, have not been published, making it difficult to judge their validity (Sönmez et al. 1999).

The following four parameters are used to classify a rock mass using the GSI (RMR_{76}):

- Uniaxial Compressive Strength(UCS) or point-load index(PL) of rock
- Rock quality designation (RQD) %
- Spacing of discontinuities
- Condition of discontinuities

The GSI=RMR_{76} classification is presented in Figure 3 (Sofianos et al. 2002). The rating of the parameters is given in Table 4.

If GSI is less then 18, the following equation is used

$$GSI = 9\ln(Q') + 44 \quad (2)$$

$$Q' = \frac{RQD}{J_n} * \frac{J_r}{J_a} \quad (3)$$

4 DESCRIPTION OF THE PROGRAM

Computer software known as ClassMass has been developed to help engineers in designing mining project. ClassMass describes the knowledge base structures. It describes the main components of the system and their operation The initial system was purely interactive. A number of support features have been provided. These include a user interface, an explanation facility and a knowledge base editor. ClassMass's user interface contains two groups of features; menus and help screens or windows. ClassMass is menu driven; all the options available to user are presented in screen forms or windows for selection of using the keyboard cursor keys or a mouse. Help and explanation facilities are provided to the user throughout the consolation.

4.1 Create or open data base file

It requires a database file to be created for the data entered into the programme and recorded at the end of the programme. The created dbase file is Microsoft Access based and it can easily be exported to the other database programs.

4.2 Input data

The data is input into the main knowledge base and sub knowledge bases. Firstly, the code of the borehole, depth limits, formation and lithology are entered and finally the RQD values regarding this lithology are input. All these data are saved under the main knowledge base and controlled. Then, data are input for the desired rock mass classifications. These data are also saved and controlled by the sub knowledge bases they belong to. The data input into the programme is given in the Figures 4, 5, 6.

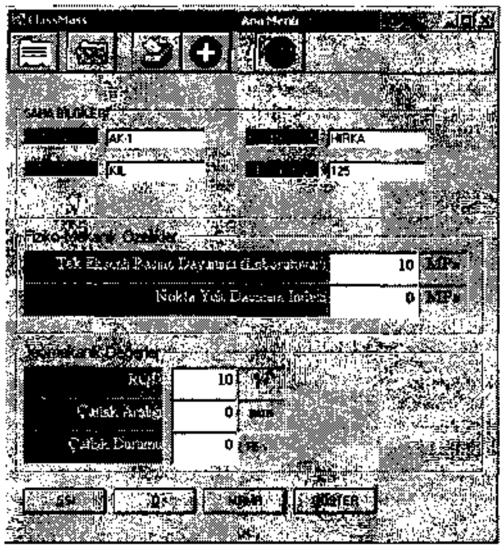


Figure 4. Input data of main knowledgebase and GSI sub knowledgebase.

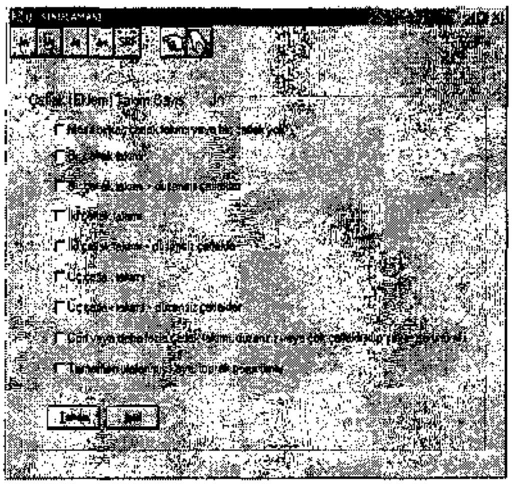


Figure 5. Input data of Q system sub knowledgebase.

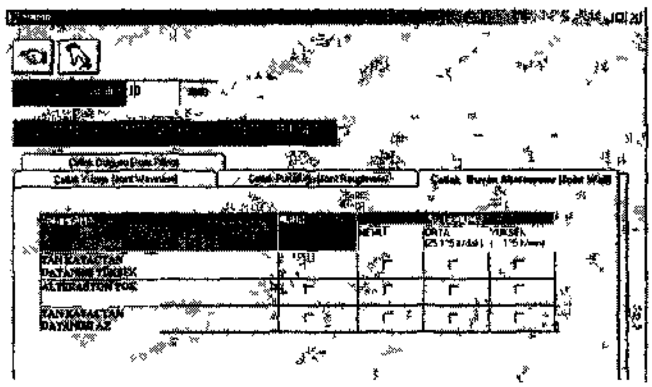


Fıgure 6 Input data of MRMR system sub knowledgebase

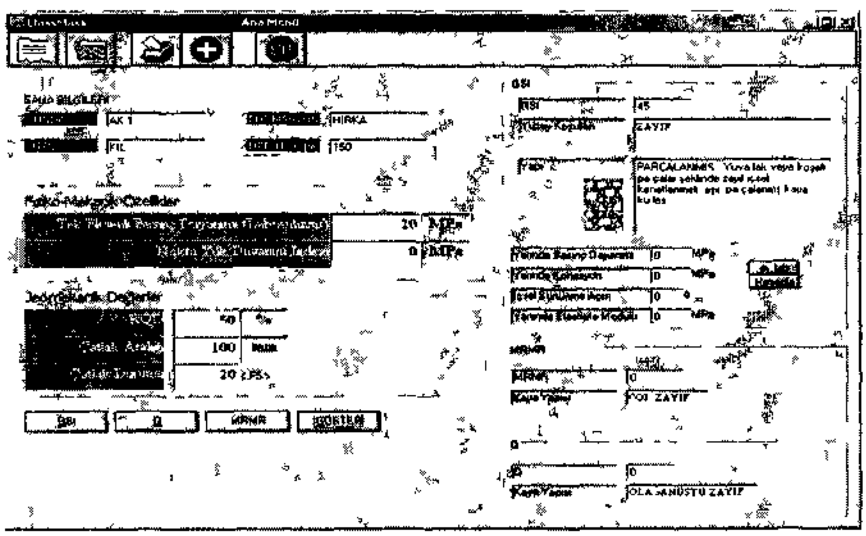


Figure 7 Display output of the ClassMass

4 3 Output data

The progiamme saves the rock mass classification values within the dbase file opened at the beginning phase ot the progiamme These savings are presented to the user in 3 forms The first of all is the sheet appealing screen print, the second is the one sent to the printer and the last one is the form ot expoit tile system convened into vanous formats in ordei to be used in other programmes The data output horn the programme is given in the Figure 7

5 CONCLUSIONS

Rock mass classification is one the only approaches toi estimating large-scale rock mass properties In the mining industry, the GSI, Q and MRMR classification system fiom the basis ot many empirical design methods, as well as the basis ot failure criteria used in many numerical modeling piograms

In this study, a computer program, ClassMass developed and desciibed by Dehoimanli and Onargan was employed It examines the structure of the individual knowledge bases cieated (or each major and minor parameter tor rock mass classification ClassMass is ultimately developed to assist geotechnical engineers in designing underground openings more easily The usei must provide geomechanical parameters and laboratoiy results to ClassMass Therefore, engineeis should investigate these factors in detail to obtain a good result from the system An example ol input toim is given in Table 5 These observations are tned to prove with the geotechnical data obtained fiom the boreholes

Table 5 Typical input form used for rock mass classification

Depth (m)	Core Loss (%)	25	50	75	Joint Condition: Type	Infilling	Dip			Description	RMR	Graphical Log	RQD %	Joint Frequency (f/m): 5	10	15	20	25	30	35<	Spacing (cm)	Joint Roughness (Jr)	Joint Alteration (Ja)	Weathering	Water	Groundwater Condition	
[illegible]-354.55	0.4				W					[illegible]	[illegible]		84.3	4.73							21				Wet	Flow	General
354.55-[illegible]	0.4				J+B+W		40	63	13	Claystone	[illegible]		86.1	2.70							37	P SS	8	HW	Wet		CD DW WJ
[illegible]	[illegible]				HW	Clay	40	60	70	Fractured Claystone	[illegible]		35.3			12.9					7.3	P S / US	8	SW	Wet		
[illegible]	[illegible]				J-W	Clay	30	40	45	Silicified Claystone	[illegible]		89.5		3.20						31.2	P SR	6	HW	Wet		

REMARKS

F Fault
W Weakness
B Bedding
J Joint
SW Slightly Weathered
MW Moderately Weathered
HW Highly Weathered
CW Completely Weathered
RS Residual Soil
[illegible]

Discontinuity Roughness

C SR Planar Slightly Rough
[illegible]

Joint Alteration

[illegible]

Lithological Descriptions

Silicified Limestone
Silicified Limestone
Marl
Claystone
Clay
Silicified Marl
Silicified Claystone
[illegible]

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