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 Beyazari Trona Field-Main Drift Project, rock mass classification software which has been developed for the support design by the Dept. of Mining Engineering, Dokuz Eylul 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.

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
reasons the system was proposed on the basis of an analysis of over 200 tunnel case histories from Scandinavia, it is a quantitative classification (Biemanski Z T, 1989).

The Q system is based on a numerical assessment of the rock mass quality using six different parameters,

- Rock quality designation (RQD) %
- Number of joint sets
- Roughness of the most unfavorable joint or discontinuity
- Degree of alteration 01 filling along the weakest joint
- Water inflow
- Stress condition

The first two parameters represent the overall structure of the rock mass, and their quotient is relative measure the block size. The quotient of the third and the fourth parameters is said to be an indicator of the inter block shear strength. The fifth parameter is a measure of water pressure, while the sixth parameter is a measure of i) loosening load in the case of shear zones and clay bearing rock, ii) rock stress in competent rock, iii) squeezing and swelling loads in plastic incompetent rock. The quotient of the fifth and sixth parameters is said to be an indicator of the inter block shear strength.

Barton et al (1974) consider the parameters J, J, and J, as playing a more important role than joint orientation and if joint orientation had been included, the classification would have been less general. However, orientation is implicit in parameters J, J, and J, because they apply to the most unfavorable joints (Milne et al. 1998). Rates of parameters are given Table 1:

Table 1 Rating of Q systems parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>joint set number</td>
<td>0.0 - 20</td>
</tr>
<tr>
<td>joint roughness number</td>
<td>1 - 4</td>
</tr>
<tr>
<td>joint alteration number</td>
<td>0.0 - 20</td>
</tr>
<tr>
<td>Stress reduction factor</td>
<td>0 - 5</td>
</tr>
<tr>
<td>Stress condition</td>
<td>0 - 500</td>
</tr>
</tbody>
</table>

The lock quality can range from Q=0.001 to Q=1000 on a logarithmic rock mass quality in Figure 2. System and it is an engineering system facilitating the design of tunnel supports (Barton N 1988)

\[
Q = \frac{RQD}{I_n} \times \frac{J_1 + J_4}{SRF}\]

where

- RQD(%) = rock quality designation, (1 Parameter)
- J = joint set number,
- J = joint roughness number,
- J = joint alteration number,
- SRF = stress reduction factor,

The lock quality can range from Q=0.001 to Q=1000 on a logarithmic rock mass quality in Figure 2. System and it is an engineering system facilitating the design of tunnel supports (Barton N 1988)

Figure 2 Q system equivalent dimension versus rock mass quality (After Barton et al, 1974)
3.2 MRMR Classification System Sub knowledge base

The classification system known as the mining lock mass rating (MRMR) system was introduced in 1974 as development of the CSIR geomechanical classification system. The development is based on the concept of in situ and adjusted ratings, the parameters and values being related to complex mining situations. Since that time, these have been modifications and improvements and system has been used successfully in mining projects in Canada, Chile, South Africa, and USA (Laubscher 1990).

This system employs the following parameters,

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

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

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Rating</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCS (MPa)</td>
<td>1</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>RQD (%)</td>
<td>0</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Joint Spacing</td>
<td>0</td>
<td>2S</td>
<td></td>
</tr>
<tr>
<td>Joint Condition</td>
<td>0</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Meaning of the ratings

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-88</td>
<td>Very Good</td>
</tr>
<tr>
<td>80-61</td>
<td>Good</td>
</tr>
<tr>
<td>60-41</td>
<td>FUI</td>
</tr>
<tr>
<td>40-21</td>
<td>Poor</td>
</tr>
<tr>
<td>20-0</td>
<td>Very Poor</td>
</tr>
</tbody>
</table>

3.4 GSI Sub knowledgebase

Determination of the strength of closely jointed lock masses is difficult since the size of representative specimens is too large for laboratory testing. This difficulty can be overcome by using the Hoek-Brown failure criterion. Since its introduction in 1980, the criterion has been refined and expanded over the years, particularly due to some limitations in its application to poor quality lock masses. In the latest version, the geological strength index (GSI) was introduced into the criterion by its originators. However, the GSI classification scheme, in its existing form, leads to rough estimates of the GSI values. Another particular issue is the use of undisturbed and disturbed lock mass categories for determining the parameters in the criterion, for which clear guidelines are lacking. Furthermore, the data supporting some of 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$_{68}$):
- Uniaxial Compressive Strength (UCS) or point-load index (PL) of rock
- Rock quality designation (RQD) %
- Spacing of discontinuities
- Condition of discontinuities

The GSI–RMR-6 classification is presented in Figure 3 (Sofianos et al. 2002). The rating of the parameters is given in Table 4.

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

$$GSI = 9.1\ln(Q') + 44$$  \hspace{1cm} (2)

$$Q' = \frac{RQD}{J_s} - \frac{J}{J_s}$$  \hspace{1cm} (3)

4 DESCRIPTION OF THE PROGRAM

Computer software known as ClassMass has been developed to help engineers in designing mining projects. 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 the 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 consultation.

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 database 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.
The programme saves the rock mass classification values within the database file opened at the beginning phase of the programme. 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 of export tile system convened into various formats in order to be used in other programmes. The data output from the programme is given in Figure 7.

5 CONCLUSIONS

Rock mass classification is one of the only approaches to estimating large-scale rock mass properties. In the mining industry, the GSI, Q and MRMR classification system from the basis of many empirical design methods, as well as the basis of failure criteria used in many numerical modeling programs. In this study, a computer program, ClassMass developed and described by Dehoimanli and Onargan was employed. It examines the structure of the individual knowledge bases created (or each major and minor parameter for rock mass classification) ClassMass is ultimately developed to assist geological engineers in designing underground openings more easily. The user must provide geomechanical parameters and laboratory results to ClassMass. Therefore, engineers should investigate these factors in detail to obtain a good result from the system. An example of input to this is given in Table 5. These observations are tried to prove with the geotechnical data obtained from the boreholes.
### Table 5: Typical input form used for rock mass classification

<table>
<thead>
<tr>
<th>岩层序号</th>
<th>岩层描述</th>
<th>岩层举例</th>
<th>岩层特点</th>
<th>岩层影响</th>
<th>岩层性质</th>
<th>岩层用途</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>岩层1描述</td>
<td>岩层1举例</td>
<td>岩层1特点</td>
<td>岩层1影响</td>
<td>岩层1性质</td>
<td>岩层1用途</td>
</tr>
<tr>
<td>2</td>
<td>岩层2描述</td>
<td>岩层2举例</td>
<td>岩层2特点</td>
<td>岩层2影响</td>
<td>岩层2性质</td>
<td>岩层2用途</td>
</tr>
</tbody>
</table>

REFERENCES


