ON CLASSIFICATION SYSTEMS

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What are classification systems?

According to Webster’s dictionary

classify  is to arrange in classes, and

classification  is the act or process of classifying; it is systematic arrangement in groups or categories
according to established criteria

In rock mechanics and rock engineering classification is used as a matter of describing or characterizing the
ground quality with respect to certain purposes. Most classification systems are for rock support estimates,
the reason being that this is the field of main importance as is mentioned by Hoek and Brown, 1980: "After
all, design of underground excavations is basically the design of underground rock support systems."

Figure 1 shows the unified classification system presented by Deere Deere et al., which shows where rock
mechanics and rock engineering are located in the field of geo mechanics.

Figure 1  The unified classification chart (from Deere et al., 1969)
The main types of classification and characterization systems can be grouped into the following types:

- **Descriptive:** the input to the system is mainly based on descriptions
- **Numerical:** the input parameters are given numerical ratings according to their character
- **Behaviouristic:** the input and classes are based on the behaviour of the rock mass in a tunnel
- **General:** the system is worked out to serve as a general characterisation
- **Functional:** the system is structured for a special application (for example for rock support)

Table 1 shows some of the main systems for characterizing and classification of rock masses connected to constructions in rock:

**What has been presented in the literature on experience with classification systems?**

Brekke and Howard declared already in 1972:

"Rock masses are so variable in nature that the chance for ever finding a common set of parameters and a common set of constitutive equations valid for all rock masses is quite remote. Simplified engineering-geological classifications, as well as sophisticated mathematical formulations have in many instances proven to be valuable tools in assessing rock mass behaviour. However, they are often both in literature as well as in engineering practice given a general validity although they may be highly inadequate both from the point of view of restrictive assumptions, and from the point of view of the variability of rock masses. Misused in this way, they may be more misleading than helpful, giving a false feeling of adequate design procedures."

"Most of them have proven to be of great value in geological engineering when carefully used, considering the conditions that they are specific to each individual site. On the other hand, most of them are continuously misused because the premises for and assumptions made in developing the classification systems have not been carefully studied by users, and because they have been given a validity for "quantification" of rock mass behaviour that is far more general than was intended by their authors."


Other authors have expressed similar opinions, given in the following quotations, which are arranged chronologically:

"If the art of soil classification is far from satisfactory, the confusion is often made worse in that users are unaware of its limitations and apply it for purposes other than that originally intended".
Arthur M. Casagrande, 1948

"The success of the field investigation will depend on the geologist's ability to recognise and describe in a quantitative manner those factors, which the engineer can include in his analysis."
Douglas R. Piteau, 1970

"In view of the scarcity of reliable information on the strength of rock masses and of the very high cost of obtaining such information, it is unlikely that a comprehensive quantitative analysis of rock mass strength will ever be possible."
Evert Hoek and Edwin T. Brown, 1980
Table 1  Some of the main classification and characterization systems

<table>
<thead>
<tr>
<th>Name of classification</th>
<th>Form and Type*)</th>
<th>Main applications</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Terzaghi rock load classification system</td>
<td>Descriptive and behaviouristic form&lt;br&gt;Functional type</td>
<td>For design of steel support in tunnels</td>
<td>Terzaghi, 1946</td>
</tr>
<tr>
<td>Lauffer's stand-up time classification</td>
<td>Descriptive form&lt;br&gt;General type</td>
<td>For input in tunnelling design</td>
<td>Lauffer, 1958</td>
</tr>
<tr>
<td>The new Austrian tunnelling method (NATM)</td>
<td>Descriptive and behaviouristic form&lt;br&gt;Tunnelling concept</td>
<td>For excavation and design in incompetent (overstressed) ground</td>
<td>Rabcewicz, Müller and Pacher, 1958 - 64</td>
</tr>
<tr>
<td>Rock classification for rock mechanical purposes</td>
<td>Descriptive form&lt;br&gt;General type</td>
<td>For input in rock mechanics</td>
<td>Patching and Coates, 1968</td>
</tr>
<tr>
<td>The unified classification of soils and rocks</td>
<td>Descriptive form&lt;br&gt;General type</td>
<td>Based on particles and blocks for communication</td>
<td>Deere et al., 1969</td>
</tr>
<tr>
<td>The rock quality designation (RQD)</td>
<td>Numerical form&lt;br&gt;General type</td>
<td>Based on core logging; used in other classification systems</td>
<td>Deere et al., 1967</td>
</tr>
<tr>
<td>The size-strength classification</td>
<td>Numerical form&lt;br&gt;Functional type</td>
<td>Based on rock strength and block diameter; used mainly in mining</td>
<td>Franklin, 1975</td>
</tr>
<tr>
<td>The rock structure rating (RSR) classification</td>
<td>Numerical form&lt;br&gt;Functional type</td>
<td>For design of (steel) support in tunnels</td>
<td>Wickham et al., 1972</td>
</tr>
<tr>
<td>The rock mass rating (RMR) classification</td>
<td>Numerical form&lt;br&gt;Functional type</td>
<td>For use in tunnel, mine and foundation design</td>
<td>Bieniawski, 1973</td>
</tr>
<tr>
<td>The Q classification system</td>
<td>Numerical form&lt;br&gt;Functional type</td>
<td>For design of support in underground excavations</td>
<td>Barton et al., 1974</td>
</tr>
<tr>
<td>The typological classification</td>
<td>Descriptive form&lt;br&gt;General type</td>
<td>For use in communication</td>
<td>Matula and Holzer, 1978</td>
</tr>
<tr>
<td>The unified rock classification system</td>
<td>Descriptive form&lt;br&gt;General type</td>
<td>For use in communication</td>
<td>Williamson, 1980</td>
</tr>
<tr>
<td>Basic geotechnical classification (BGD)</td>
<td>Descriptive form&lt;br&gt;General type</td>
<td>For general use</td>
<td>ISRM, 1981</td>
</tr>
<tr>
<td>The Geological Strength Index (GSI)</td>
<td>Numerical form&lt;br&gt;Functional type</td>
<td>For design of support in underground excavations</td>
<td>Hoek, 1994</td>
</tr>
<tr>
<td>The Rock Mass index (RM) system</td>
<td>Numerical form&lt;br&gt;Functional type</td>
<td>For general characterisation, design of support, TBM progress</td>
<td>Palmström, 1995</td>
</tr>
</tbody>
</table>

*) Definition of the following expressions:
- Descriptive form: the input to the system is mainly based on descriptions
- Numerical form: the input parameters are given numerical ratings according to their character
- Behaviouristic form: the input is based on the behaviour of the rock mass in a tunnel
- General type: the system is worked out to serve as a general characterisation
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"Provision of reliable input data for engineering design of structures in rock is one of the most difficult tasks facing engineering geologists and design engineers."
Z.T. Bieniawski, 1984

"We must realise that no classification system can be devised that deals with all the characteristics of all possible rock materials or rock masses."
Williamson D.A. and Kuhn C.R., 1988

"Judgement is thus the intelligent use of experience or, more cautiously expressed, it is the recognition of one's limitations of the methods one uses, and of the limitations and uncertainties of the materials one works with; and this brings us back to geology."
Herbert H. Einstein, 1991
So, back to this workshop. We are gathered here today to inform each other and discuss what our opinion is and what can be done to improve reliability of classification systems. From the experience of Doug and myself the following items have been selected:

- The inevitable uncertainties and errors in geology
- How the input parameters are collected
- How the calculations are performed to find the classification value or number
- The implementation of the classification system in our assessments
- When and how the classification is used (and misused) during planning and construction

The agenda has been chosen according to this. What we hopefully should end up with is some statements or recommendation on:

- limitations of classification systems,
- What can be done to improve their reliability?
  - how to improve collection and quality of input parameters?
  - clarify confusions of the ratings of input parameters
  - the correlations used between the classification systems?
- Recommendations when and where classification systems can be best used
- Possible further developments into improved classification system(s)