Designation: D5878 – 19

Standard Guides for Using Rock-Mass Classification Systems for Engineering Purposes[1]

This standard is issued under the fixed designation D5878; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 These guides offer the selection of a suitable system of classification of rock mass for specific engineering purposes, such as tunneling and shaft-sinking, excavation of rock chambers, ground support, modification and stabilization of rock slopes, and preparation of foundations and abutments. These classification systems may also be of use in work on rippability of rock, quality of construction materials, and erosion resistance. Although widely used classification systems are treated in this standard, systems not included here may be more appropriate in some situations, and may be added to subsequent editions of this standard.

1.2 The valid, effective use of this standard is contingent upon the prior complete definition of the engineering purposes to be served and on the complete and competent definition of the geology and hydrology of the engineering site. Further, the person or persons using this standard shall have had field experience in studying rock-mass behavior. An appropriate reference for geotechnical mapping of large underground openings in rock is provided by Guide D4879.

1.3 This standard identifies the essential characteristics of seven classification systems. It does not include detailed guidance for application to all engineering purposes for which a particular system might be validly used. Detailed descriptions of the first five systems are presented in STP 984 (**1**),[2] with abundant references to source literature. Details of two other classification systems and a listing of seven Japanese systems are also presented.

1.4 The range of applications of each of the systems has grown since its inception. This standard summarizes the major fields of application up to this time of each of the seven classification systems.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are mathematical conversions to inch-pounds units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This standard offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education ore experience and shall be used in conjunction with professional judgement. Not all aspects of this standard may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor shall this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D4879 Guide for Geotechnical Mapping of Large Underground Openings in Rock (Withdrawn 2017)[4]

[1] These guides are under the jurisdiction of ASTM Committee D18 on Soil and Rock and are the direct responsibility of Subcommittee D18.12 on Rock Mechanics.

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[2] The boldface numbers given in parentheses refer to a list of references at the end of the text.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] The last approved version of this historical standard is referenced on www.astm.org.

***A Summary of Changes section appears at the end of this standard**

D5731 Test Method for Determination of the Point Load Strength Index of Rock and Application to Rock Strength Classifications
D5777 Guide for Using the Seismic Refraction Method for Subsurface Investigation
D6026 Practice for Using Significant Digits in Geotechnical Data
D6032/D6032M Test Method for Determining Rock Quality Designation (RQD) of Rock Core
D7012 Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

3. Terminology

3.1 *Definitions:*

3.1.1 *classification, n*—a systematic arrangement or division of materials, products, systems, or services into groups based on similar characteristics such as origin, composition, properties, or use (*Regulations Governing ASTM Technical Committees*).[5]

3.1.2 *rock mass (in-situ rock), n*—rock as it occurs in situ, including both the rock material and its structural discontinuities (Modified after Terminology D653 [International Society for Rock Mechanics, ISRM]).

3.1.2.1 *Discussion*—Rock mass also includes at least some of the earth materials in mixed-ground and soft-ground conditions.

3.1.3 *rock material (intact rock, rock substance, rock element), n*—rock without structural discontinuities; rock on which standardized laboratory property tests are run.

3.1.4 *structural discontinuity (discontinuity), n*—an interruption or abrupt change in a rock's structural properties, such as strength, stiffness, or density, usually occurring across internal surfaces or zones, such as bedding, parting, cracks, joints, faults, or cleavage.

NOTE 1—To some extent, 3.1.1, 3.1.2, and 3.1.4 are scale-related. A rock's microfractures might be structural discontinuities to a petrologist, but to a field geologist the same rock could be considered intact. Similarly, the localized occurrence of jointed rock (rock mass) could be inconsequential in regional analysis.

3.1.5 For the definition of other terms that appear in this standard, refer to STP 984, Guide D4879, and Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *classification system, n*—a group or hierarchy of classifications used in combination for a designated purpose, such as evaluating or rating a property or other characteristic of a rock mass.

4. Significance and Use

4.1 The classification systems included in this standard and their respective applications are as follows:

4.1.1 *Rock Mass Rating System (RMR) or Geomechanics Classification*—This system has been applied to tunneling, hard-rock mining, coal mining, stability of rock slopes, rock foundations, borability, rippability, dredgability, weatherability, and rock bolting.

4.1.2 *Rock Structure Rating System (RSR)*—This system has been used in tunnel support and excavation and in other ground support work in mining and construction.

4.1.3 *The Q System or Norwegian Geotechnical Institute System (NGI)*—This system has been applied to work on tunnels and chambers, rippability, excavatability, hydraulic erodibility, and seismic stability of roof-rock.

4.1.4 *The Unified Rock Classification System (URCS)*—This system has been applied to work on foundations, methods of excavation, slope stability, uses of earth materials, blasting characteristics of earth materials, and transmission of groundwater.

4.1.5 *The Rock Material Field Classification System (RMFCS)*—This system has been used mainly for applications involving shallow excavation, particularly with regard to hydraulic erodibility in earth spillways, excavatability, construction quality of rock, fluid transmission, and rock-mass stability (**2**).

4.1.6 *The New Austrian Tunneling Method (NATM)*—This system is used for both conventional (cyclical, such as drill-and-blast) and continuous (tunnel-boring machine or TBM) tunneling. This is a tunneling procedure in which design is extended into the construction phase by continued monitoring of rock displacement. Support requirements are revised to achieve stability (**3**).

NOTE 2—The Austrian standard (**4**) specifies methods of payment based on coding of excavation volume and means of support.

4.1.7 *The Coal Mine Roof Rating (CMRR)*—This system applies to bedded coal-measure rocks, in particular with regard to their structural competence as influenced by discontinuities in the rock mass. The basic building blocks of CMRR are unit ratings. The units are rock intervals defined by their geotechnical properties, and are at least 0.15 m (6 in.) thick. The unit ratings are combined into roof ratings, using additional geotechnical characteristics (**5**).

4.1.8 *Japanese Rock Mass Classification Systems*—The Japanese Society of Engineering Geology has recognized seven major classification systems in use in Japan (**6**). These are summarized in 4.1.8.1 – 4.1.8.7, without additional details in this guide.

4.1.8.1 *Rock-Mass Classification for Railway Tunnels by Railway Technical Research Institute*—Rock-masses are classified based on the values of *P*-wave velocity, unconfined compressive strength and unit weight. Support patterns for tunnels, such as shotcreting and rock bolting, is recommended depending upon the rock-mass classification obtained.

4.1.8.2 *Rock-Mass Classification for Tunnels and Slopes by Japan Highway Public Corporation*—This system classifies the rock-mass using RQD, *P*-wave velocity, unconfined compressive strength and unit weight.

4.1.8.3 *Rock-Mass Classification for Dam Foundations by Public Works Research Institute, Ministry of Construction*—In this system, the rock-masses are classified by observing spacing of joints, conditions of joints and strength of rock pieces.

[5] Available from ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

4.1.8.4 *Rock-Mass Classification for Water Tunnel Design by The Ministry of Agriculture, Forestry and Fisheries*—The rock-mass is classified into four categories based on values of *P*-wave velocity, compressive strength and Poisson ratio as well as rock type.

4.1.8.5 *Rock-Mass Classification by Central Research Institute of Electric Power Industry*—This system classifies rock-mass based on rock type and weathering characteristics.

4.1.8.6 *Rock-Mass Classification by Electric-Power Development Company*—This system is somewhat similar to the system developed by the Central Research Institute of Electric Power Industry (see 4.1.8.5). The three factors used for classifying rock-mass are weathering, hardness and joint spacing.

4.1.8.7 *Rock-Mass Classification for Weathered Granite for Bridge Foundation by Honshu-Shikoku Bridge Authority*—This system uses results of visual observations of rock-mass in-situ, geophysical logging, laboratory tests on rock samples, pressuremeter tests or other forms of in-situ tests or a combination thereof, to estimate strength and stiffness.

4.2 Other classification systems are described in detail in the general references listed in the appendix.

4.3 Using this standard, the classifier shall be able to decide which system appears to be most appropriate for the specified engineering purpose at hand. The next step shall be the study of the source literature on the selected classification system and on case histories documenting the application of that system to real-world situations and the degree of success of each such application. Appropriate but by no means exhaustive references for this purpose are provided in the appendix and in STP 984 (**1**). *The classifier shall realize that taking the step of consulting the source literature, which might lead to abandonment of the initially selected classification system and selection of another system, to be followed again by study of the appropriate source literature.*

NOTE 3—The quality of the results produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing, sampling, inspection, etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself ensure reliable results. Reliable results depend on many factors. Practice D3740 provides a means for evaluating some of these factors.

5. Basis for Classification

5.1 The parameters used in each classification system follow. In general, the terminology used by the respective author or authors of each system is listed, to facilitate reference to STP 984 (**1**) or source documents.

5.1.1 *Rock Mass Rating System (RMR) or Geomechanics Classification*

Strength of intact rock material (Uniaxial compressive strength (see D7012, Method C) or Point Load Strength Index (see D5731)
- Rock quality designation (RQD) (see D6032/D6032M)
- Spacing of discontinuities
- Condition of discontinuities
- Groundwater conditions
- Adjustment for joint orientations

5.1.2 *Rock Structure Rating System (RSR)*

Rock type plus rock strength
- Geologic structure
- Spacing of joints
- Orientation of joints
- Weathering of joints
- Groundwater inflow

5.1.3 *The Q System or Norwegian Geotechnical Institute (NGI) System*

Rock quality designation (RQD) (see D6032/D6032M)
- Number of joint sets
- Number of joint roughness
- Number of joint alteration
- Joint water-reduction factor
- Stress-reduction factor

5.1.4 *Unified Rock Classification System (URCS)*

Degree of weathering
- Uniaxial compressive strength (see D7012, Method C)
- Discontinuities
- Unit weight

5.1.5 *Rock Material Field Classification System (RMFCS)*

Rock Material Properties—*The results are applicable to hand specimens and representative specimens of intact rock material, which do not account for the influence of discontinuities or boundary conditions of the rock. Typical classification elements include:*
- Principal rock type
- Mineralogy
- Primary porosity, voids
- Discrete rock particle size
- Hardness category
- Uniaxial compressive strength (see D7012, Method C)
- Unit weight (dry)
- Color

Rock Mass Properties—*Normally, rock mass properties are too large or extensive to be observed directly in their entirety at a single outcrop and are difficult or impossible to sample for laboratory analysis. Typical classification elements include:*
- Discontinuity type
- Joint set spacing category
- Joint persistence category
- Aperture category
- Joint count number
- Roughness condition of joint walls
- Joint infilling (gouge)
- Type of large geomorphic features, geologic structures, major voids
- Seismic velocity (see D5777)
- Rock quality designation (RQD) (see D6032/D6032M)

Geohydrologic Properties—*Geohydrologic properties include material and mass properties, but also account for the interaction and behavior of subsurface water within the rock mass. Typical classification elements include:*
- Primary porosity
- Secondary porosity
- Hydraulic conductivity
- Transmissivity
- Storativity/specific yield

Soluble rock
Water table/potentiometric surface
Aquifer type
Electrical conductivity

5.1.6 *New Austrian Tunneling Method (NATM)*

A:1.Stable
2.Overbreaking
B:1.Friable
2.Very friable
3.Rolling/running
C:1.Rock bursting
2.Squeezing
3.Heavily squeezing
4.Flowing
5.Swelling

5.1.7 *Coal Mine Roof Rating (CMRR)*

Unit Ratings
Shear strength of discontinuities
Cohesion
Roughness
Intensity of discontinuities
Spacing
Persistence
Number of discontinuity sets
Compressive strength
Moisture sensitivity
Roof Ratings
Strong bed adjustment
Unit contact adjustment
Groundwater adjustment
Surcharge adjustment

5.2 Comparison of parameters among these systems indicates some strong similarities. It is not surprising, therefore, that paired correlations have been established between RMR, RSR, and Q (**7**). Some of the references in the appendix also present procedures for estimating some in situ engineering properties from one or more of these indexes (**7**, **8**, **9**, and **10**).

NOTE 4—Reference (**7**) presents step-by-step procedures for calculating and applying RSR, RMR, and Q values. Applications of the first five systems are discussed in STP 984 (**1**), as is a detailed treatment of RQD.

6. Procedures for Determining Parameters

6.1 The annex of this standard contains tabled and other material for determining the parameters needed to apply each of the classification systems. These materials shall be used in conjunction with detailed, instructive references such as STP 984 (**1**) and Ref (**7**). The annexed materials are as follows:

6.1.1 *Guide A—Rock Mass Rating System (RMR)*

Classification parameters (a total of five) and their ratings (Sum ratings)
Rating adjustment for joint orientations (Parameter No. 6) *(RMR = adjusted sum)*
Effect of discontinuity strike and dip orientations in tunneling
Adjustments for mining applications
Input data from the Geomechanics Classification

6.1.2 *Guide B—Rock Structure System (RSR)*

Schematic of the six parameters
Rock type plus strength, geologic structure (Parameter "A")
Joint spacing and orientation (Parameter "B")
Weathering of joints and groundwater inflow (Parameter "C")

$$(RSR = A + B + C) \qquad (1)$$

6.1.3 *Guide C—The Q System or Norwegian Geotechnical Institute (NGI) System:*

Rock quality designation, RQD
Joint set number, J_n
Joint roughness number, J_r
Joint alteration number, J_a
Joint water reduction factor, J_W
Stress reduction factor, SRF

$$(Q = (RQD/J_n) \times (J_r/J_a) \times (J_W/SRF) \qquad (2)$$

6.1.4 *Guide D—Unified Rock Classification System (URCS)*

Degree of weathering (*A–E*)
Estimated strength (*A–E*)
Discontinuities (*A–E*)
Unit weight (*A–E*)
Schematic of notation (*results = AAAA* through *EEEE*)

6.1.5 *Guide E—Rock Material Field Classification System (RMFCS)*

Schematic of procedure through performance assessment
Classification (description and definitions),
Rock unit
Classification Elements—Including rock material properties, rock mass properties, and geohydrologic properties.
Performance Assessment—Performance objectives
Hydraulic erodibility in earth spillways
Excavation characteristics
Construction quality
Fluid transmission
Rock Mass stability
Classification by objective
Determine class of rock or each selected performance objective

6.1.6 *Guide F—NATM*

Rock mass types
Calculation of support factor (SF)
Excavation class matrix for conventional tunneling (The excavation class matrix for continuous (TBM) tunneling is determined by standup time and the support factor, the latter calculated in the same way as for conventional tunneling, although there may be some differences in the way in which rating factors, RF, are assigned.)
Support elements and rating factors

NOTE 5—Standup time is the length of time following excavation that an active span in an underground opening will stand without artificial support. An active span is the largest unsupported span between the face and artificial supports (**11**).

6.1.7 *Guide G—CMRR*

CMRR calculation
Immersion test
Field data sheet
Directions for field data sheet
Cohesion-roughness rating

Spacing-persistence rating
Multiple discontinuity set adjustment
Strength rating
Moisture sensitivity rating
Unit rating (UR) calculation sheet
Roof rating (CMRR) calculation sheet
Strong bed adjustment
Unit contacts adjustment
Groundwater adjustment
Surcharge adjustment
CMRR values

6.2 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

6.2.1 The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy with which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

7. Precision

7.1 Precision statements will be available for some components of some of the classification systems, such as uniaxial compressive strength and rock quality designation.

8. Keywords

8.1 classification; classification system; coal mine roof rating (CMRR); Japanese rock mass classification systems; new Austrian tunneling method (NATM); Q-system (NGI); rock mass; rock mass rating system (RMR); rock material field classification system (RMFCS); rock quality designation (RQD); rock structure rating system (RSR); unified rock classification system (URCS)

ANNEX

(Mandatory Information)

A1. CLASSIFICATION SYSTEM MATERIAL

A1.1 The materials presented in this Annex for RMR, RSR, and URCS have been extracted from STP 984 (**1**). The materials for Q (NGI) are from Ref (**9**). The materials for NATM are from Ref. (**3**). The materials for CMRR are from Ref. (**5**). The materials for RMFCS are from Ref. (**2**).

See 5.1.1 & 6.1.1 Rock Mass Rating System (RMR)

TABLE 1—*Geomechanics Classification of jointed rock masses.*

A. CLASSIFICATION PARAMETERS AND THEIR RATINGS

<table>
<tr><th colspan="3">PARAMETER</th><th colspan="7">RANGES OF VALUES</th></tr>
<tr><td rowspan="3">1</td><td rowspan="2">Strength of intact rock material</td><td>Point-load strength index</td><td>>10 MPa</td><td>4 -10 MPa</td><td>2 - 4 MPa</td><td>1 - 2 MPa</td><td colspan="3">For this low range – uniaxial compressive test is preferred</td></tr>
<tr><td>Uniaxial compressive strength</td><td>>250 MPa</td><td>100 - 250 MPa</td><td>50 - 100 MPa</td><td>25 - 50 MPa</td><td>5-25 MPa</td><td>1-5 MPa</td><td><1 MPa</td></tr>
<tr><td colspan="2">Rating</td><td>15</td><td>12</td><td>7</td><td>4</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">2</td><td colspan="2">Drill core quality RQD</td><td>90% - 100%</td><td>75% - 90%</td><td>50% - 75%</td><td>25% - 50%</td><td colspan="3">< 25%</td></tr>
<tr><td colspan="2">Rating</td><td>20</td><td>17</td><td>13</td><td>8</td><td colspan="3">3</td></tr>
<tr><td rowspan="2">3</td><td colspan="2">Spacing of discontinuities</td><td>>2 m</td><td>0,6 - 2 m</td><td>200 - 600 mm</td><td>60 - 200 mm</td><td colspan="3"><60 mm</td></tr>
<tr><td colspan="2">Rating</td><td>20</td><td>15</td><td>10</td><td>8</td><td colspan="3">5</td></tr>
<tr><td rowspan="2">4</td><td colspan="2">Condition of discontinuities</td><td>Very rough surfaces.
Not continuous
No separation
Unweathered wall rock.</td><td>Slightly rough surfaces.
Separation < 1 mm
Slightly weathered walls</td><td>Slightly rough surfaces.
Separation < 1 mm
Highly weathered walls</td><td>Slickensided surfaces
OR
Gouge < 5 mm thick
OR
Separation 1-5 mm.
Continuous</td><td colspan="3">Soft gouge > 5 mm thick
OR
Separation > 5 mm.
Continous</td></tr>
<tr><td colspan="2">Rating</td><td>30</td><td>25</td><td>20</td><td>10</td><td colspan="3">0</td></tr>
<tr><td rowspan="4">5</td><td rowspan="3">Ground water</td><td>Inflow per 10 m tunnel length</td><td>None</td><td><10 litres/min</td><td>10-25 litres/min</td><td>25 - 125 litres/min</td><td colspan="3">>125</td></tr>
<tr><td>Ratio (joint water pressure / major principal stress)</td><td>OR
0</td><td>OR
0,0-0,1</td><td>OR
0,1-0,2</td><td>OR
0,2-0,5</td><td colspan="3">OR
>0,5</td></tr>
<tr><td>General conditions</td><td>OR
Completely dry</td><td>OR
Damp</td><td>OR
Wet</td><td>OR
Dripping</td><td colspan="3">OR
Flowing</td></tr>
<tr><td colspan="2">Rating</td><td>15</td><td>10</td><td>7</td><td>4</td><td colspan="3">0</td></tr>
</table>

B. RATING ADJUSTMENT FOR JOINT ORIENTATIONS

Strike and dip orientations of joints		Very favourable	Favourable	Fair	Unfavourable	Very unfavourable
Ratings	Tunnels	0	−2	−5	−10	−12
	Foundations	0	−2	−7	−15	−25
	Slopes	0	−5	−25	−50	−60

C. ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS

Ratings	100←81	80←61	60←41	40←21	< 20
Class No.	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

D. MEANING OF ROCK MASS CLASSES

Class No.	I	II	III	IV	V
Average stand-up time	10 years for 15 m span	6 months for 8 m span	1 week for 5 m span	10 hours for 2,5 m span	30 minutes for 1 m span
Cohesion of the rock mass	> 400 kPa	300 - 400 kPa	200 - 300 kPa	100 - 200 kPa	< 100 kPa
Friction angle of the rock mass	> 45°	35° - 45°	25° - 35°	15° - 25°	< 15°

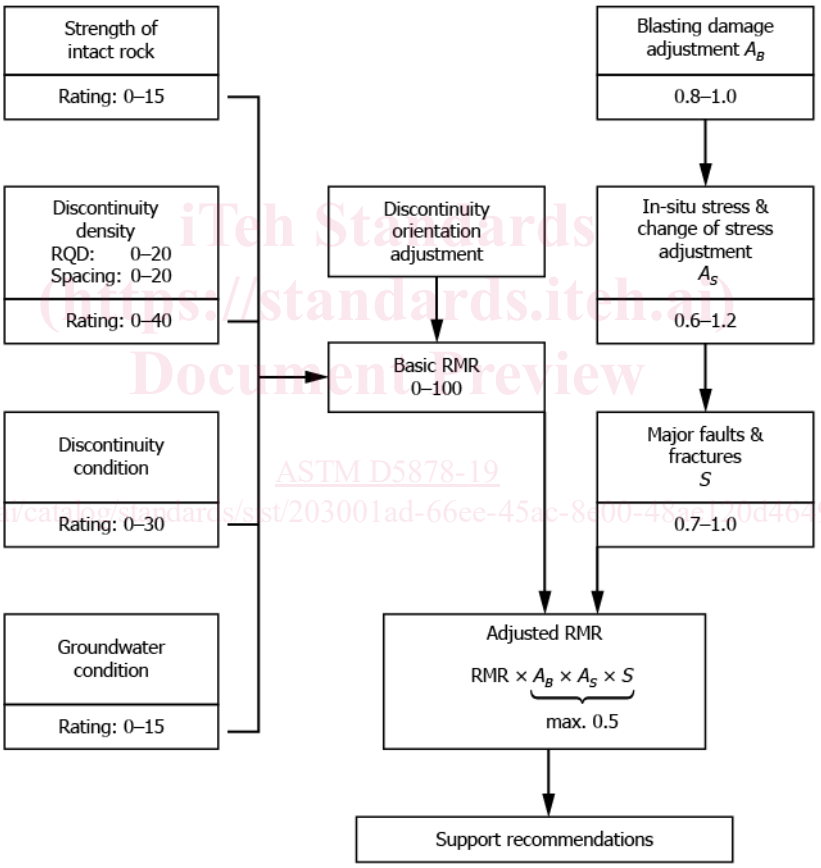
See 5.1.1 & 6.1.1 Rock Mass Rating System (RMR)

TABLE 2—*Effect of discontinuity strike and dip orientations in tunneling.*

Strike Perpendicular to Tunnel Axis			
Drive with Dip		Drive against Dip	
Dip 45–90°	Dip 20–45°	Dip 45–90°	Dip 20–45°
Very favorable	Favorable	Fair	Unfavorable

Strike Parallel to Tunnel Axis		Irrespective of Strike
Dip 20–45°	Dip 45–90°	Dip 0–20°
Fair	Very unfavorable	Fair

TABLE 3—*Adjustments to the Geomechanics Classification for mining applications.*



See 6.1.1 Rock Mass Rating System (RMR)

Input data form for the Geomechanics Classification (RMR System)

Name of project:
Site of survey:
Conducted by:
Date:

STRUCTURAL REGION	ROCK TYPE AND ORIGIN

DRILL CORE QUALITY R.Q.D.*

Excellent quality:	90 - 100%	.....
Good quality:	75 - 90%	.....
Fair quality:	50 - 75%	.....
Poor quality:	25 - 50%	.....
Very poor quality:	<25%	.....

*R.Q.D. = Rock Quality Designation

WALL ROCK OF DISCONTINUITIES

Unweathered .....
Slightly weathered .....
Moderately weathered .....
Highly weathered .....
Completely weathered .....
Residual soil .....

GROUND WATER

INFLOW per 10 m of tunnel length ..... litres/minute
or
WATER PRESSURE ..... kPa
or
GENERAL CONDITIONS (completely dry, damp, wet, dripping or flowing under low/medium or high pressure:

.....

STRENGTH OF INTACT ROCK MATERIAL

Designation	Uniaxial compressive strength, MPa	OR	Point-load strength index, MPa
Very high:	Over 250		>10
High:	100 - 250		4-10
Medium high:	50 - 100		2-4
Moderate:	25 - 50		1-2
Low:	5 - 25		< 1
Very low:	1 - 5		

SPACING OF DISCONTINUITIES

		Set 1	Set 2	Set 3	Set 4
Very wide:	Over 2 m	.....	.....	.....	.....
Wide:	0,6 - 2 m	.....	.....	.....	.....
Moderate:	200 - 600 mm	.....	.....	.....	.....
Close:	60 - 200 mm	.....	.....	.....	.....
Very close:	<60 mm	.....	.....	.....	.....

NOTE: These values are obtained from a joint survey and not from borehole logs.

STRIKE AND DIP ORIENTATIONS

Set 1	Strike: ..... (average)	(from ..... to .....)	Dip: ..... (angle)	..... (direction)
Set 2	Strike:	(from ..... to .....)	Dip:	.....
Set 3	Strike:	(from ..... to .....)	Dip:	.....
Set 4	Strike:	(from ..... to .....)	Dip:	.....

NOTE: Refer all directions to magnetic north.

CONDITION OF DISCONTINUITIES

PERSISTENCE (CONTINUITY)		Set 1	Set 2	Set 3	Set 4
Very low:	<1 m	.....	.....	.....	.....
low:	1 - 3 m	.....	.....	.....	.....
Medium:	3 - 10 m	.....	.....	.....	.....
High:	10 - 20 m	.....	.....	.....	.....
Very High:	> 20 m	.....	.....	.....	.....
SEPARATION (APERTURE)					
Very tight joints:	<0,1 mm	.....	.....	.....	.....
Tight joints:	0,1 - 0,5 mm	.....	.....	.....	.....
Moderately open joints:	0,5 - 2,5 mm	.....	.....	.....	.....
Open joints:	2,5 - 10 mm	.....	.....	.....	.....
Very wide aperture	> 10 mm	.....	.....	.....	.....
ROUGHNESS (state also if surfaces are stepped, undulating or planar)					
Very rough surfaces:		.....	.....	.....	.....
Rough surfaces:		.....	.....	.....	.....
Slightly rough surfaces:		.....	.....	.....	.....
Smooth surfaces:		.....	.....	.....	.....
Slickensided surfaces:		.....	.....	.....	.....
FILLING (GOUGE)					
Type:		.....	.....	.....	.....
Thickness:		.....	.....	.....	.....
Uniaxial compressive strength, MPa		.....	.....	.....	.....
Seepage:		.....	.....	.....	.....

MAJOR FAULTS OR FOLDS

Describe major faults and folds specifying their locality, nature and orientations.

GENERAL REMARKS AND ADDITIONAL DATA

NOTE:
(1) For definitions and methods consult ISRM document: *'Quantitative description of discontinuities in rock masses.'*
(2) The data on this form constitute the minimum required for engineering design.
The geologist should, however, supply any further information which he considers relevant.

See 5.1.2 & 6.1.2 Rock Structure Rating System (RSR)

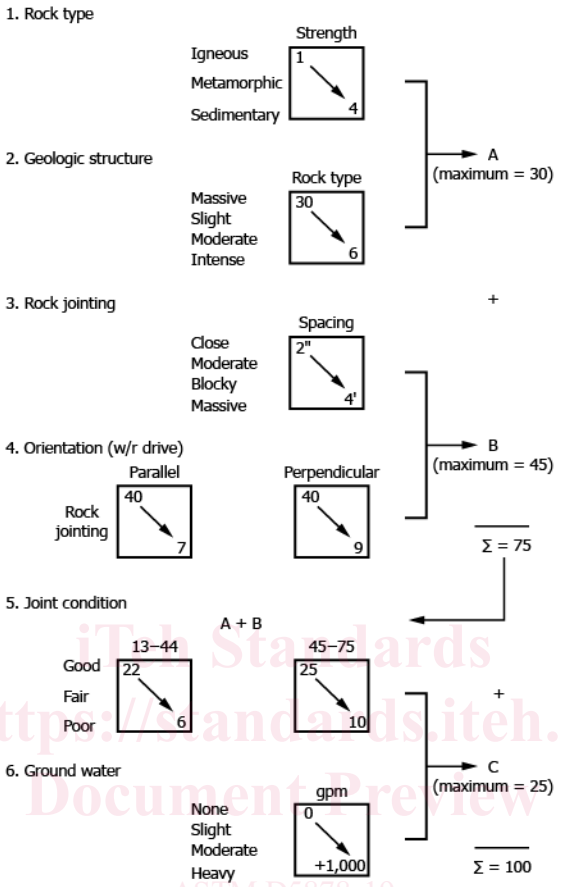


FIG. 1—*Schematic of Rock Structure Rating.*

Parameter A
Rock structure rating

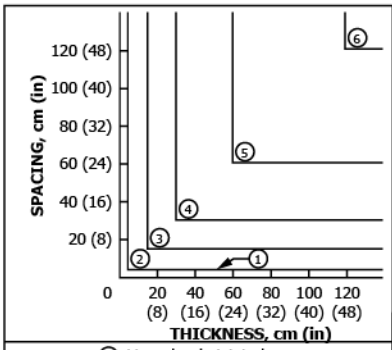
Rock type, strength index and geologic structure

Maximum value 30

Basic rock type	Hard	Medium	Soft	Decomp	Geological structure: Massive	Slightly faulted or folded	Moderately faulted or folded	Intensely faulted or folded
Igneous	1	2	3	4				
Metamorphic	1	2	3	4				
Sedimentary	2	3	4	4				
Type 1					30	22	15	9
Type 2					27	20	13	8
Type 3					24	18	12	7
Type 4					19	15	10	6

FIG. 2—*parameter A.*

See 5.1.2 & 6.1.2 Rock Structure Rating System (RSR)



Parameter B
Rock structure rating

Joint pattern and direction of drive

Maximum value 45

	Strike perpendicular to axis					Strike parallel to axis		
	Direction of drive					Direction of drive		
	Both	With dip		Against dip		Both		
	Dip of prominent joints					Dip of prominent joints		
	Flat	Dipping	Vertical	Dipping	Vertical	Flat	Dipping	Vertical
① Very closely jointed	9	11	13	10	12	9	9	7
② Closely jointed	13	16	19	15	17	14	14	11
③ Moderately jointed	23	24	28	19	22	23	23	19
④ Moderate to blocky	30	32	36	25	28	30	28	24
⑤ Blocky to massive	36	38	40	33	35	36	34	28
⑥ Massive	40	43	45	37	40	40	38	34

Flat: 0 - 20°; Dipping: 20 - 50°; Vertical: 50 - 90°

FIG. 3 —*Parameter B.*

Parameter C
Rock structure rating

Ground water and joint condition

Maximum value 25

Anticipated water inflow m^3/min/300 m (gpm/1,000 ft)	Sum of parameters A + B					
	13 – 44			45 – 75		
	Joint condition					
	Good	Fair	Poor	Good	Fair	Poor
None	22	18	12	25	22	18
Slight <0.75 m^3/min (<200 gpm)	19	15	9	23	19	14
Moderate 0.75 – 3.8 m^3/min (200 – 1,000 gpm)	15	11	7	21	16	12
Heavy >3.8 m^3/min (>1,000 gpm)	10	8	6	18	14	10

Joint condition: Good = Tight or cemented; Fair = Slightly weathered or altered; Poor = Severely weathered, altered or open

FIG. 4 —*Parameter C.*