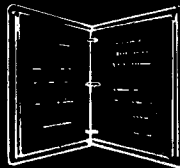


**ENGINEERING
TECHNICAL
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FIELD NOTES • TECHNICAL REPORTS
DATA RETRIEVAL • MANAGEMENT
PROFESSIONAL DEVELOPMENT

VOLUME 10 NUMBER 11

Field



Notes

Distribution Inquiry

Unified Rock
Classification System

Washington Office News



FOREST SERVICE

NOVEMBER 1978

U.S. DEPARTMENT OF AGRICULTURE

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ENGINEERING FIELD NOTES

Volume 10 Number 11

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← This issue contained a form that answered an inquiry about the distribution of the August and September *Field Notes*.

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE
Washington, D.C. 20013

WASHINGTON OFFICE NEWS

OPERATIONS

Harold L. Strickland
Assistant Director

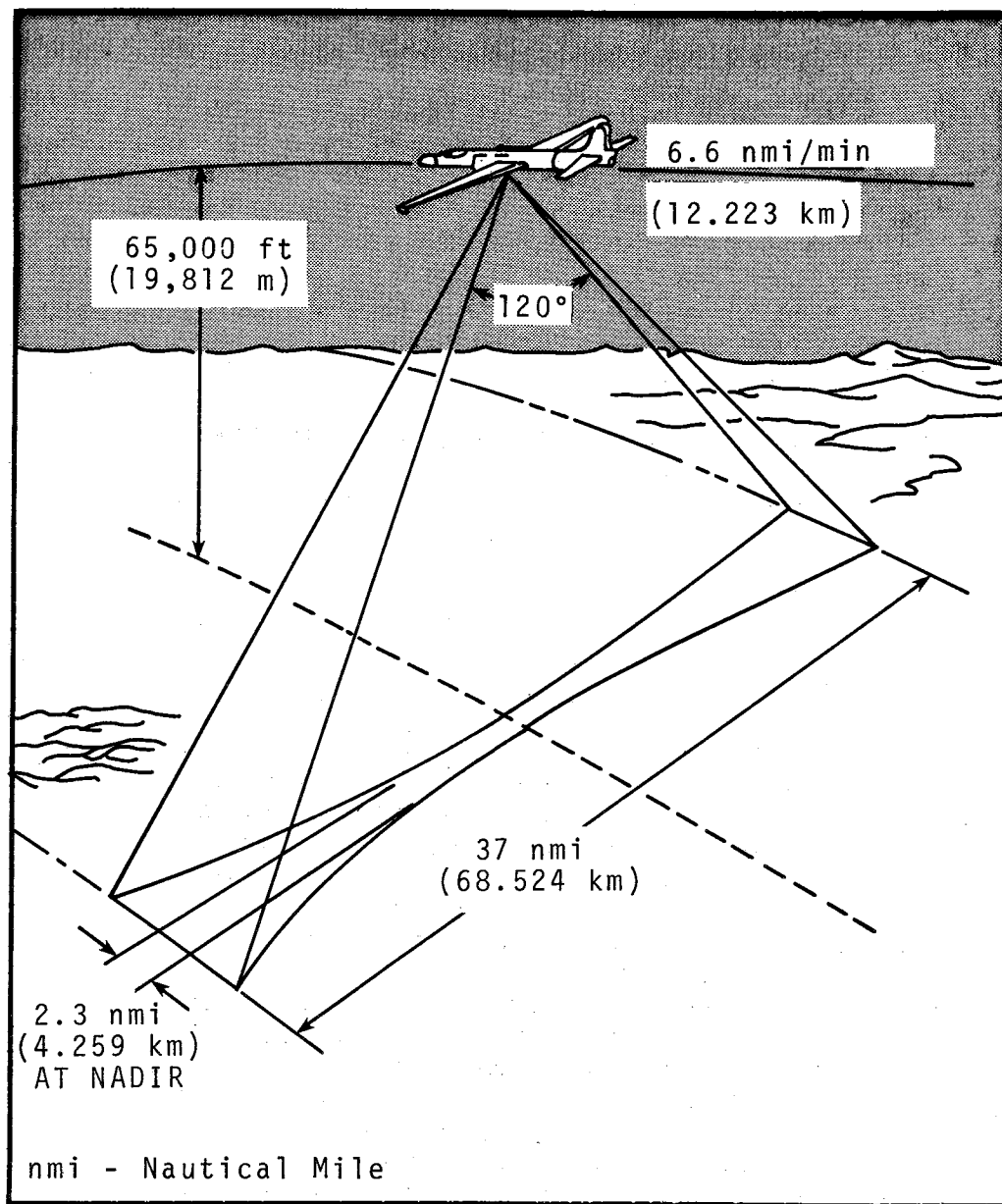
NEW AERIAL PHOTOGRAPHY FORMAT BEING EVALUATED

During the past 2 years, Forest Insect and Disease Management (FIDM) and Timber Management (TM) have procured a significant amount of high-altitude panoramic photography to support multistage insect damage surveys and timber salvage programs. The camera used was an Itek, KA80A, 24-inch (60.96 cm) focal length optical bar camera with a film format of 4-1/4 X 50 inches (10.795 X 127 cm). The camera system uses high-resolution color infrared film at a theoretical nadir scale of 1:32,500, and imagery is taken from a U-2 reconnaissance aircraft at an altitude of 65,000 feet (19,812 m) mean sea level (m.s.l.). The drawing shows the ground area coverage for one frame of optical bar photography. The camera system and U-2 aircraft are NASA-owned and based at NASA Ames Research Center in California.

Washington Office, Engineering has provided technical project support in collection, processing, interpretation, and data transfer activities to assist in the use of the photography. Portions of Regions 1, 2, 5, and 6 have optical bar coverage. The largest block of coverage is in Region 5, which has used photography in more than 13 forests. Approval for this coverage was contingent on the Region's participation in a development project to evaluate the potential of this imagery to support multidisciplinary Forest Service programs. All units now using optical bar photography and various resource disciplines in Region 5 will participate in the project, which will be coordinated by Washington Office, Geometronics.

The unique format of this imagery requires the development of photointerpretation guidelines and training support, the evaluation of viewing equipment requirements to support photointerpretation activities, and the development of photo-to-map transfer techniques to support data measurement activities. These areas will be addressed in the development project.

An awareness briefing package is also being developed to make potential users aware of this technology and the associated development program. Copies will be forwarded to Regional Geometronics Leaders.



Optical Bar Camera Ground Coverage

TECHNOLOGICAL IMPROVEMENTS

Heyward T. Taylor
Assistant Director

PAVEMENT DESIGN AND MANAGEMENT SYSTEM FOR FOREST SERVICE ROADS - IMPLEMENTATION

Under the terms of a cooperative agreement, the Forest Service and the University of Texas have been developing a Service-wide system for pavement design and management. The work was divided into three phases, and final reports describing the first two have been distributed Service-wide under the titles *Phase I - A Pavement Design and Management System for Forest Service Roads - A Conceptual Study* (July 1974) and *Phase II - A Pavement Design and Management System for Forest Service Roads - A Working Model* (February 1977).

The third and final phase of the work has now been completed, and the report describing the work in Phase III was prepared by the University and approved for publication by the Forest Service.

Copies of the report, *Phase III - A Pavement Design and Management System for Forest Service Roads - Implementation* are being printed by the University, and distribution to Forest Service personnel is scheduled for January or February.

In each phase of the project, a panel of Forest Service personnel representing the Regions and the Washington Office served as a "sounding board" for the University. The panel provided valuable input and insight, contributing to the development of a computer-based program for the design and management of the surfacing investment on Forest Service roads. During Phase III, four separate training sessions were held to introduce Forest Service users to the Low Volume Roads (LVR) Program. Over 70 Forest Service personnel representing 30 Forests and seven Regions were instructed in the use and operation of the program. This group represented a cross-section of planners, engineers, and managers who work in many different areas of the country; their response was that the program was a good one, and that they, the users, planned to use the program more frequently. The Phase III Report documents in detail the experience and reactions of the users, the methodology, and the problems encountered; the subsequent modifications to the program are described in the final report.

Management decisions and instructions for Service-wide use of the program are being prepared, and their distribution is planned for February. Forest Service personnel who have responsibility for surfacing design and management are urged to read the Phase III report.

CONSULTATION AND STANDARDS

Walter E. Furen
Assistant Director

We must have trained, qualified operators for Forest Service wastewater treatment systems. This has certainly been the object in the past and, with stricter environmental requirements and controls, it has become increasingly important.

The following is paraphrased from an editorial by Mr. Martin Lang, President-elect, Water Pollution Control Federation, that was published in "*Water and Sewage Works*." We feel this brief passage speaks very directly to the need for qualified operators.

Operators come to meetings now, and they are beginning to hear strange jargon: legal talk, esoteric legislative discussions, esoteric academic discussions, and talk about complex compounds and new techniques of analyses. All of them are increasingly important. But while operators are getting comfortable with the polysyllabic terminology of ecology, we must not lose sight of the fact that the whole water pollution abatement program can be a vast inverted pyramid. On top are Congressional legislation, EPA rules and regulations, and sophisticated process designs, concrete, steel, and equipment needed to comply with the requirements. This whole pyramid is resting on the back of one individual--a lone operator with an emergency in a campground treatment plant on a Sunday morning of a Fourth of July weekend. He can't call on a consultant committee, he can't write away to the technology transfer program, and he can't call on some distinguished professor or EPA official. He must be *trained* to do the right thing. Therefore, the Forest Service must dedicate itself to the importance of the operator and realize that the training of the operator is as important as figuring out the mean cell residence time or knowing the theoretical kinetics of complete mixing.

The need for trained operators applies equally well to the operation of Forest Service potable water systems. This must be emphasized by both line managers and technical staff.

UNIFIED ROCK CLASSIFICATION SYSTEM

Douglas A. Williamson
Engineering Geologist
Willamette National Forest, R-6

The Unified Rock Classification System (URCS) was originally developed by Douglas A. Williamson in 1959 and 1960. The system has been used extensively by him and others on projects for the U.S. Army, Corps of Engineers, and the USDA Forest Service.

The URCS is being considered for publication in the directives system, Forest Service Handbook.

Readers' comments and experiences with rock classification systems including URCS would be helpful. Please send your comments to the author or to Jim Mandigo, Engineering Staff Unit, WO.

The Unified Rock Classification System (URCS) allows rapid preliminary assessments of rock conditions by simple field tests that establish natural strength parameters. The URCS is useful for all earth-associated design and construction projects. It is especially useful because the pertinent natural conditions, related to design strengths, can be read at a glance or be confirmed by referring to the original data base. In many instances, the data base is too detailed for collective analysis.

The URCS is an engineering shorthand used to convey maximum information. The URCS classifies rock in simple, easily understood terms that convey evidence of strength and behavior. The terms used convey uniform meaning to engineering geologists, design engineers, inspectors, contractors, and contract appeal boards.

Geotechnical field reports or drill logs sometimes lack a uniformity of notation to assure that sufficiently identical interpretations will be made by designers. A working classification system based on simple field tests, which can be

refined by laboratory testing, can assure this needed uniformity. The URCS is not intended to replace the existing geologic classification but rather to supplement it with engineering design parameters.

The purpose of this paper is:

1. To present a rock classification system useful for engineering geology and geotechnical investigations.
2. To describe a field identification procedure that requires simple field apparatus.
3. To establish the classification's relationship to design and performance.

The URCS provides an indication of rock performance and permits a crude estimate of the three primary properties of a rock: compressive strength, permeability, and shear strength.

When combined with other geotechnical information such as stress history and water table location, the classification allows a rough estimate of rock performance for applications such as:

- Foundation suitability
- Ease or difficulty of excavation
- Slope stability
- Suitability for embankments
- Suitability for aggregate
- Blasting characteristics
- Water transmission

The URCS will not replace laboratory testing, but it can reduce the quantity of testing needed and increase the design success by reducing the range of properties that must be assumed.

The URCS can be accomplished by simple field tests or estimation in a simplified form, or with experience and testing in a more refined form. It is suitable for determination by beginning as well as experienced geotechnical personnel. The system is verifiable and reproducible and allows serial and final review by geotechnical supervisors.

The URCS employs a simple system of notation for graphic representation of geotechnical inventories, boring logs, sections, maps, etc. The notation registers rapidly in the mind and minimizes the required drafting effort.

UNIFIED ROCK CLASSIFICATION SYSTEM (URCS)
ROCK MASS STRENGTH ESTIMATE - BASIC ELEMENTS

EFFECT OF WEATHERING

WEATHERED (1)				ALTERED	REPRESENTATIVE	
SAND SIZE		GRAVEL SIZE		STAINED STATE (STS)	VISUALLY FRESH STATE (VFS)	MICRO FRESH STATE (HAND LENS) (MFS)
COMPLETELY DECOMPOSED STATE (CDS) E		PARTLY DECOMPOSED STATE (PDS) D				
PLASTIC	NON PLASTIC	PLASTIC	NON PLASTIC	COMPARE TO FRESH STATE	UNIT WEIGHT RELATIVE ABSORPTION	

MINERAL GRAIN BONDING

REMOLDING (1)	REACTION TO IMPACT			
MOLDABLE, (FRIABLE) (MBL)	"CRATERS" (SHEARS) (CQ)	"DENTS" (COMPRESSIVE) (DQ)	"PITS" (TENSIONAL) (PQ)	"REBOUNDS" (ELASTIC) (RO)
E	D	C	B	A
<1,000 PSI (7 MPa)	1,000 to 3,000 PSI (7 to 21 MPa)	3,000 to 8,000 PSI (21 to 55 MPa)	8,000 to 15,000 PSI (55 to 103 MPa)	>15,000 PSI (103 MPa)

PLANAR AND LINEAR ELEMENTS

TRANSMITS WATER				LATENT PLANES OF SEPARATION (LPS)	SOLID- PREFERRED BREAKAGE (SPB)	SOLID- RANDOM BREAKAGE (SRB)
YES	NO	YES	NO			
3 DIMENSIONAL PLANES OF SEPARATION (3-D)		2 DIMENSIONAL PLANES OF SEPARATION (2-D)				
E		D		C	B	A
INTERLOCK		ATTITUDE				

UNIT WEIGHT

LESS THAN 130 lbs/ft ³ (2.10 Mg/m ³) (<130)	130 to 140 lbs/ft ³ (2.10 to 2.25) Mg/m ³ (130)	140 to 150 lbs/ft ³ (2.25 to 2.40) Mg/m ³ (140)	150 to 160 lbs/ft ³ (2.40 to 2.55) Mg/m ³ (150)	GREATER THAN 160 lbs/ft ³ (2.55 Mg/m ³) (>160)
E	D	C	B	A

(1) CONSISTENCY VALUES
 Terzaghi, K. and Peck, R. B., *Soil Mechanics in Engineering Practice*, John Wiley and Sons, Inc., 1948.

SYMBOLS AND NOTATIONS

The letter design symbols of the four major element classes are grouped together in a four-letter notation that can be read at a glance when placed on maps, sections, or on drilling logs. The four letters are in caps and are underlined. The letter "A" denotes that the least design evaluation is required, while "E" denotes the most design evaluation is required. "O" in sequence means "no determination made." A lower-case "e" after a letter indicates "estimated value."

FIELD NOTATION

In the field the notation includes both the letter symbol and the abbreviated basis written under the letter. For example:

The classification: BCAD

Field notebook: B C A D
 VFS DQ SRB 130

Explanation: B--Visual fresh state; C--Dents with hammer blow; A--Solid with random breakage; and D--unit weight 130 to 140 pcf (2.10 to 2.25 Mg/m³)

The design values can then be established for this material for the intended purpose.

Notes: 1. AAAA requires the least design evaluation. EEEE requires the most design evaluation.

Some combinations do *not* occur, for example: completely Decomposed State, and Greater than 15,000 psi (103 MPa); Solid with random breakage, and Greater than 160 pcf (2.55 Mg/m³)
EAAA.

2. Design values of the four major elements are not equivalent even though the same letter notation might apply.

Under the URCS, the degree of weathering is restricted to "chemical weathering." The effect of weathering can be defined practically by determining the relative loss of cohesion and the reduction of unit weight. Five categories are defined: E--Completely Decomposed State; D--Partly Decomposed State; C--Stained State; B--Visually Fresh State; and A--Micro Fresh State.

EFFECT OF WEATHERING

WEATHERED (1)				ALTERED	REPRESENTATIVE	
SAND SIZE		GRAVEL SIZE		STAINED STATE (STS)	VISUALLY FRESH STATE (VFS)	MICRO FRESH STATE (HAND LENS) (MFS)
COMPLETELY DECOMPOSED STATE (CDS) E		PARTLY DECOMPOSED STATE (PDS) D		C	B	A
PLASTIC	NON PLASTIC	PLASTIC	NON PLASTIC	COMPARE TO FRESH STATE	UNIT WEIGHT RELATIVE ABSORPTION	

(1) CONSISTENCY VALUES

Terzaghi, K. and Peck, R. B., *Soil Mechanics in Engineering Practice*, John Wiley and Sons, Inc., 1948.

E--Completely Decomposed State (CDS).

The Completely Decomposed State is when the rock material is all remoldable to sand, silt, or clay, or mixtures of two or more sizes. The resulting remolded material is determined to be plastic or nonplastic, and Dry Strength, Dilatency, and Toughness tests are performed. The in-place strength is estimated by consistency values (1).

D--Partly Decomposed State (PDS).

The Partly Decomposed State is when the rock material is remoldable to gravel-size and larger rock fragments, with or without sand, silt, or clay mixtures. The relative percentage of rock fragments are estimated, and the material is determined to be plastic or nonplastic. The in-place strength is estimated by consistency values (1), or by size, shape, and gradation of remolded aggregate.

C--Stained State (STS).

The Stained State describes a condition when the rock material shows partial or complete discoloration due to oxidation, but cannot be remolded. The rock material is usually shades of yellow or brown, has a reduced unit weight, and a higher

absorption of water. The strength estimate is made by comparing the Stained State with Fresh State material at a given area examined. Weight reduction is expressed as a percentage of the Fresh State unit weight.

B--Visually Fresh State (VFS).

The Visually Fresh State is present when the rock material is representative of the standard of quality and not expected to change within economic excavation limits. The rock material is evaluated with the naked eye, and such an evaluation is usually acceptable for all foundation and excavation design. The rock material has uniform color and is usually shades of gray, green or blue. The sample tested is representative of maximum unit of weight, maximum specimen strength, and least relative absorption from which comparisons to Stained State are made.

A--Micro Fresh State (MFS).

The Micro Fresh State is determined in the field with a hand lens. It is desirable, but not necessary, to make this determination except when making investigations for rock sources. This condition exists when there is no oxidation alteration of any of the mineral components when viewed with a hand lens.

Mineral Grain Bonding or Specimen Strength is defined as the degree of cementation or adhesion between mineral grains that defines the fundamental strength of the rock mass independent of the planar and linear elements. For purposes of classification, the "limit of moldability" is estimated at 1,000 psi (7 MPa). There are four distinct reactions to impact loading by means of a 1-lb (450-g) ball-peen hammer. The reaction is independent of intensity of blow within the limitations of the tool used and the investigators' strength. The reactions are defined as "Craters," "Dents," "Pits," and "Rebounds." Based on these reactions plus the moldability factor, five categories of specimen strength are denoted: E--Moldable; D--Craters; C--Dents; B--Pits; and A--Rebounds.

MINERAL GRAIN BONDING

REMODELING (1)	REACTION TO IMPACT			
MOLDABLE, (FRIABLE) (MBL) E	"CRATERS" (SHEARS) (CQ) D	"DENTS" (COMPRESSIVE) (DQ) C	"PITS" (TENSIONAL) (PQ) B	"REBOUNDS" (ELASTIC) (RQ) A
<1,000 PSI (7 MPa)	1,000 to 3,000 PSI (7 to 21 MPa)	3,000 to 8,000 PSI (21 to 55 MPa)	8,000 to 15,000 PSI (55 to 103 MPa)	>15,000 PSI (103 MPa)

(1) CONSISTENCY VALUES

Terzaghi, K. and Peck, R. B., *Soil Mechanics in Engineering Practice*, John Wiley and Sons, Inc., 1948.

E--Moldable Quality (MBL).

Moldable Quality is present when the otherwise continuous and visually similar rock material can be remolded with finger pressure. This indicates an estimated unconfined compressive strength less than 1,000 psi (7 MPa). Strength estimates are made by determining consistency values (1). In all cases, the material is examined and tested as a "soil," and a dual classification is given. Usually, the material cannot be recovered by diamond core drilling, and can be excavated by machinery:

D--Crater Quality (CQ).

Crater Quality rock material is, as the term implies, a reaction under point of impact producing a shearing and upthrusting of adjacent mineral grains. This category has an estimated unconfined compressive strength range from 1,000 to 3,000 psi (7 to 21 MPa). Usually, The rock material can be recovered during rock core drilling operations, has

high absorption, and will respond to freeze/thaw stresses by at least cracking and checking. It has a very low energy transfer when blasted, produces poorly drained embankments, and is not suitable for road aggregate material.

C--Dent Quality (DQ).



Dent Quality rock material produces a "dent" or depression under the point of impact. It indicates the presence of "pore space" between the mineral grains. This category or quality of material has a estimated unconfined compressive strength range of 3,000 to 8,000 psi (21 to 55 MPa), and is roughly equivalent to the strength range of concrete. Dent Quality material has low energy transfer in response to blasting, and often produces a "boulders and sand" result.

B--Pit Quality (PQ).



Pit Quality rock material produces an "explosive" departure of mineral grains under the point of impact, resulting in a shallow, rough, pit. This quality of specimen has an estimated unconfined compressive strength range of 8,000 to 15,000 psi (55 to 103 MPa), and is considered "hard rock" by the construction industry. Pit Quality rock produces free-draining fill and is suitable for road aggregate material. Pit Quality material has high energy transfer in response to blasting and no special blasting design procedure is necessary.

A--Rebound Quality (RQ).



Rebound Quality rock material has "no reaction" to impact and is a true "brittle-elastic" substance in a mechanical sense. This quality of specimen strength has an estimated unconfined compressive strength of greater than 15,000 psi (103 MPa). Rebound quality rock produces free-draining fill that is suitable for road aggregate. However, this rock material is often sharp and angular due to its brittleness and therefore produces a less desirable material. It also has a very high energy transfer in response to blasting.

Directional weaknesses of a rock mass are determined "planar" and "linear" features. Planar separations are natural separations already existing in the rock mass. Linear features are directional weaknesses that usually require blasting or mechanical crushing to produce a separation. Planar and linear elements are defined by continuity, relief, and shape of the intact rock material between the discontinuities. The five categories of decreasing design consideration are: E--Three-Dimensional Planes of Separation; D--Two-Dimensional Planes of Separation; C--Latent Planes of Separation; B--Solid-Preferred Breakage; and A--Solid-Random Breakage.

TRANSMITS WATER				LATENT PLANES OF SEPARATION (LPS) C	SOLID- PREFERRED BREAKAGE (SPB) B	SOLID- RANDOM BREAKAGE (SRB) A
YES	NO	YES	NO			
3 DIMENSIONAL PLANES OF SEPARATION (3-D) E		2 DIMENSIONAL PLANES OF SEPARATION (2-D) D				
INTERLOCK		ATTITUDE				

E--Three-Dimensional Planes of Separation (3-D).

The three-dimensional planes of separation category indicates the presence of two or more intersecting planar discontinuities passing through the rock mass at the point of examination. The planar separations might form patterns or might be random in occurrence; thus will form "internal separations" that terminate within the rock mass, or will form "mass separations" that pass entirely across the rock mass and are "infinite" in extent in terms of design. By definition, three dimensions form a "shape." This "shape" is often referred to as a "joint block," which has a size and weight consideration that can be estimated. The degree of interlock between joint blocks defines the strength of foundation or stability of excavation factor. If mass planes of separation occur, the attitude of the plane(s) with respect to the design or slope is the chief design factor. Water transmission along the planes of separation can be determined by observation of the drilling operation or by water testing.

D--Two-Dimensional Planes of Separation (2-D).

The two-dimensional planes of separation category indicates the presence of one parallel plane or a series of parallel planes passing through the rock mass at the point of examination. The planar separations may vary in frequency but do not intersect. The attitude and relief of the plane(s) are the fundamental elements of design analysis. Whether or not the planes transmit water is estimated or determined as in class "E."

C--Latent Planes of Separation (LPS).

Latent Planes of Separation is an intermediate category that is between planar and linear. The latent planes are recognized as lines or lineations in an otherwise solid rock mass, and might be stronger or weaker than the rock mass. The reaction of the latent plane to an applied force, such as a hammer blow, will define the strength estimate. Latent planes occur in patterns or at random, are continuous or discontinuous, or the "plane" may be of a measurable thickness. In all cases, the infilling of the material in the latent plane of separation is greater than 1,000 psi (7 MPa). Latent planes of separation are usually not a foundation design consideration, because the material is, for all practical purposes, a "solid." In consideration of slope design or road aggregate source, blasting energy will, in most cases, be reflected by the plane producing a separation and directional or preferred breakage.

B--Solid-Preferred Breakage (SPB).

Solid-Preferred Breakage is indicated when there are no visible planar or linear elements, but the rock breaks along a constant angle or direction due to mineral grain alignment or internal stress. This condition is significant in judging the production of road aggregate. It is an adverse condition in some cases for the production of jettystone or dimension stone.

A--Solid-Random Breakage (SRB).

This category represents "ideal design conditions" where there is no effect from planar and linear features. "The specimen strength equals the mass strength," so that the strength value of any individual sample tested applies directly to the mass strength. Needless to say, this is seldom achieved, except in very limited foundation dimensions.

Density or unit weight has been found to be one of the most reliable means of making a field estimate of rock quality. It is useful in many ways, both in design and construction planning. The URCS denotes five categories of ranges of unit weight: E--Less than 130 pcf (2.10 Mg/m^3); D--130 to 140 pcf (2.10 to 2.25 Mg/m^3); C--140 to 150 pcf (2.25 to 2.40 Mg/m^3); B--150 to 160 pcf (2.40 to 2.55 Mg/m^3); and A--Greater than 160 pcf (2.55 Mg/m^3).

UNIT WEIGHT				
LESS THAN 130 lbs/ft^3 (2.10 Mg/m^3) (<130)	130 to 140 lbs/ft^3 $(2.10 \text{ to } 2.25)$ Mg/m^3 (130)	140 to 150 lbs/ft^3 $(2.25 \text{ to } 2.40)$ Mg/m^3 (140)	150 to 160 lbs/ft^3 $(2.40 \text{ to } 2.55)$ Mg/m^3 (150)	GREATER THAN 160 lbs/ft^3 (2.55 Mg/m^3) (>160)
E	D	C	B	A

Unit Weight-Design Evaluation.

The unit weight determination establishes the driving force in slope stability problems, establishes the relative usefulness of the rock material as a surface course or concrete aggregate, or establishes the weight-volume relationship for haul cost estimates. As a general rule-of-thumb, rock having a unit weight greater than 160 pcf (2.55 Mg/m^3) is suitable for use as road aggregate, concrete aggregate, riprap, or jettystone, more than 50 percent of the time without laboratory testing. Rock with a 150 to 160 pcf (2.40 to 2.55 Mg/m^3) unit weight may be acceptable, but will require laboratory testing for confirmation. Rock with a 150 pcf (2.40 Mg/m^3) is not usually acceptable for the above purposes, is not free-draining fill, and will degrade. Rock less than 130 pcf (2.10 Mg/m^3) approaches soil in terms of strength and durability.

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