Chapter 5

TERMINOLOGY AND DESCRIPTIONS FOR DISCONTINUITIES

General

Structural breaks or discontinuities generally control the mechanical behavior of rock masses. In most rock masses the discontinuities form planes of weakness or surfaces of separation, including foliation and bedding joints, joints, fractures, and zones of crushing or shearing. These discontinuities usually control the strength, deformation, and permeability of rock masses. Most engineering problems relate to discontinuities rather than to rock type or intact rock strength. Discontinuities must be carefully and adequately described. This chapter describes terminology, indexes, qualitative and quantitative descriptive criteria, and format for describing discontinuities. Many of the criteria contained in this chapter are similar to criteria used in other established sources which are accepted as international standards (for example, *International Journal of Rock Mechanics*, 1978 [1]).

Discontinuity Terminology

The use of quantitative and qualitative descriptors requires that what is being described be clearly identified. Nomenclature associated with structural breaks in geologic materials is frequently misunderstood. For example, bedding, bedding planes, bedding plane partings, bedding separations, and bedding joints may have been used to identify similar or distinctly different geological features. The terminology for discontinuities which is presented in this chapter should be used uniformly for all geology programs. Additional definitions for various types of discontinuities are presented in the *Glossary of Geology* [2]; these may be used to further describe structural breaks. The following basic definitions should not be modified unless clearly justified, and defined.

Discontinuity.—A collective term used for all structural breaks in geologic materials which usually have zero to low tensile strength. Discontinuities also may be healed. Discontinuities comprise fractures (including joints), planes of weakness, shears/faults, and shear/fault zones. Depositional or erosional contacts between various geologic units may be considered discontinuities. For discussion of contacts, refer to chapter 4.

Fracture.—A term used to describe any natural break in geologic material, excluding shears and shear zones. Examples of the most common fractures are defined as follows:

1. Joint.—A fracture which is relatively planar along which there has been little or no obvious displacement parallel to the plane. In many cases, a slight amount of separation normal to the joint surface has occurred. A series of joints with similar orientation form a joint set. Joints may be open, healed, or filled; and surfaces may be striated due to minor movement. Fractures which are parallel to bedding are termed bedding joints or bedding plane joints. Those fractures parallel to metamorphic foliation are called foliation joints.

2. Bedding plane separation.—A separation along bedding planes after exposure due to stress relief or slaking.

3. Random fracture.—A fracture which does not belong to a joint set, often with rough, highly irregular, and nonplanar surfaces along which there has been no obvious displacement.

4. Shear.—A structural break where differential movement has occurred along a surface or zone of failure; characterized by polished surfaces, striations, slickensides, gouge, breccia, mylonite, or any combination of these. Often direction of movement, amount of displacement, and continuity may not be known because of limited exposures or observations.

5. Fault.—A shear with significant continuity which can be correlated between observation locations; foundation areas, or regions; or is a segment of a fault or fault zone reported in the literature. The designation of a fault or fault zone is a site-specific determination.

6. Shear/fault zone.—A band of parallel or subparallel fault or shear planes. The zone may consist of gouge, breccia, or many fault or shear planes with fractured and crushed rock between the shears or faults, or any combination. In the literature, many fault zones are simply referred to as faults.

7. Shear/fault gouge.—Pulverized (silty, clayey, or clay-size) material derived from crushing or grinding of rock by shearing, or the subsequent decomposition or alteration. Gouge may be soft, uncemented, indurated (hard), cemented, or mineralized.

8. Shear/fault breccia.—Cemented or uncemented, predominantly angular (may be platy, rounded, or contorted) and commonly slickensided rock fragments resulting from the crushing or shattering of geologic materials during shear displacement. Breccia may range from sand-size to large boulder-size fragments, usually within a matrix of fault gouge. Breccia may consist solely of mineral grains.

9. Shear/fault-disturbed zone.—An associated zone of fractures and/or folds adjacent to a shear or shear zone where the country rock has been subjected to only minor cataclastic action and may be mineralized. If adjacent to a fault or fault zone, the term is fault-disturbed zone. Occurrence, orientation, and areal extent of these zones depend upon depth of burial (pressure and temperature) during shearing, brittleness of materials, and the in-place stresses.

Terminology for joint (JT), foliation joint (FJ), bedding joint (BJ), incipient joint (IJ) or incipient fracture (IF), random fracture (RF), mechanical break (MB), and fracture zone (FZ) is given on figure 5-9 (drawing No. 40-D-6499 following later in this chapter). Suggested abbreviations are in parentheses.

Indexes for Describing Fracturing

Fracture Density

Fracture density is based on the spacing between all natural fractures in an exposure or core recovery lengths from drill holes, excluding mechanical breaks, shears, and shear zones; however, shear-disturbed zones (fracturing outside the shear) are included. In this context, fracture is a general term and includes all natural breaks such as joints, bedding joints, foliation joints, and random fractures. Fracture density should always be described in physical measurements, but summary descriptive terms relating to these measurements are a convenient aid in communicating characteristics of the rock mass. Standard descriptors apply to all rock exposures, such as tunnel walls, dozer trenches, outcrops, or foundation cut slopes and inverts, as well as boreholes. Fracture descriptors presented in table 5-1 and figure 5-9 are based on drill hole cores where lengths are measured along the core axis.

When describing fracture density, a percentage of the types of fractures should be provided. A complete description for fracture density might read: Slightly Fractured (FD3), recovered core in 0.8- to 4.7-feet (0.2- to 1.4-meter [m]) lengths, mostly 1.7 feet (520 millimeters [mm]), 25 percent bedding joints/75 percent joints.

Fracture Frequency

Fracture frequency is the number of fractures occurring within a unit length. The number of natural fractures is divided by the length and is reported as fractures per foot or fractures per meter.

Rock Quality Designation

Rock Quality Designation (RQD) [2] is a fracture index used in many rock classification systems. To determine the RQD value, add the total length of solid core that is 4 inches (100 mm) or more long regardless of core diameter. If the core is broken by handling or the drilling process (mechanical breaks), the broken pieces are fitted together and counted as one piece, provided that they form the requisite length of 4 inches (100 mm). The length of these pieces is measured along the centerline of the core. This sum is divided by the length of the run (drill interval) and recorded on the log as a percentage of each run. Figure 5-1 illustrates RQD measurements and procedures.

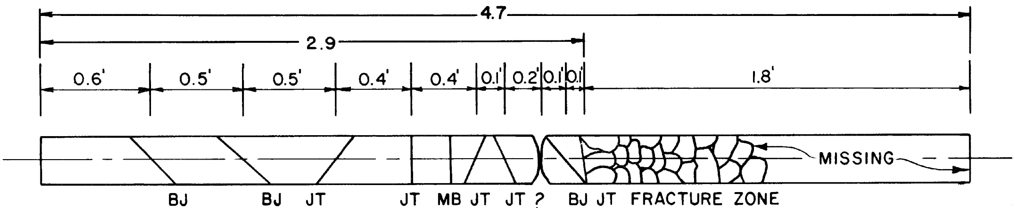
RQD estimates can be determined from outcrops. RQD = 115 - 3.3 where *Jv* equals the total number of joints in a cubic meter. RQD may also be estimated from an

1. PERCENTAGE OF SOLID CORE SEGMENTS LONGER THAN 0.33 ft (100mm) RELATIVE TO CORE RUN LENGTH, EXCLUDING MECHANICAL BREAKS.

2. RECORDED AS CALCULATED PERCENTAGE FOR EACH RUN.

3. BEST FOR N-SIZE OR LARGER SIZE CORE.

4. MAY NOT BE APPLICABLE FOR VERY LOW STRENGTH, FISSILE OR FOLIATED ROCKS WHICH BREAK OR PART EASILY.



$$RQD = \frac{\text{Sum of length of pieces} \geq 0.33\text{ ft (4in)}}{\text{(total length of core run)}} \times 100 = \frac{2.4}{4.7} \times 100 = 51\%$$

Figure 5-1.—Rock Quality Designation (RQD) computation.

Table 5-1.—Fracture density descriptors

Alpha-numeric descriptor	Descriptor	Criteria (excludes mechanical breaks)
FD0	Unfractured	No observed fractures.
FD1	Very slightly fractured	Core recovered mostly in lengths greater than 3 feet (1 m).
FD2	Slightly to very slightly fractured	
FD3	Slightly fractured	Core recovered mostly in lengths from 1 to 3 feet (300 to 1,000 mm) with few scattered lengths less than 1 foot (300 mm) or greater than 3 feet (1,000 mm).
FD4	Moderately to slightly fractured[1]	
FD5	Moderately fractured	Core recovered mostly in lengths from 0.33 to 1.0 foot (100 to 300 mm) with most lengths about 0.67 foot (200 mm).
FD6	Intensely to moderately fractured[1]	
FD7	Intensely fractured	Lengths average from 0.1 to 0.33 foot (30 to 100 mm) with fragmented intervals. Core recovered mostly in lengths less than 0.33 foot (100 mm).
FD8	Very intensely to intensely fractured[1]	
FD9	Very intensely fractured	Core recovered mostly as chips and fragments with a few scattered short core lengths.

[1] Combinations of fracture densities are permissible where equal distribution of both fracture density characteristics are present over a significant core interval or exposure, or where characteristics are "in between" the descriptor definitions.

outcrop by determining the sum of solid rock (fracture free) in lengths 4 inches long or greater along a line that simulates either a 5- or 10-foot "core run." Detail line surveys provide the data needed to calculate RQD. Orienting the lines in different directions reduces directional bias. Either of these methods offers an advantage over RQDs determined from drill core, because all fracture orientations are included. Also, these RQD values more realistically represent rock conditions.

Description of Fractures

An accurate description of fractures is as important as the physical characteristics of the rock mass. Fractures affect and usually control the strength, deformation, and permeability characteristics of a rock mass. Fractures are grouped into sets based on similar orientations, and each set is labeled and described. Along with the physical measurements, such as attitude, spacing, and continuity, include information such as composition, thickness, and hardness of fillings or coatings; characteristics of surfaces such as hardness, roughness, waviness, and alteration; healing; fracture openness; and presence of water or water flow. Joint and fracture properties also may be useful for correlating purposes. Cleavage (CL) in metamorphic rocks includes slaty cleavage, crenulation cleavage, phyllitic structure, and schistosity (after Davis [4]) and often can be used to evaluate the tectonic setting.

Figure 5-9 may be used for geologic reports or specifications where the standard descriptors and terminology established for discontinuities are used during data collection.

Format for the Description of Fractures

Identifying and recording the physical characteristics of fractures during mapping and logging is the least expensive part of most geologic investigations. An accurate and concise description of these characteristics permits interpretation in geologic terms directly applicable to design and construction. As many of the characteristics should be described as possible, limited only by the type of observation. For example, continuity and waviness cannot be provided for joints observed in core. Examples of fracture descriptions recorded for a drill hole log and for an outcrop or exposure are in a following section. A general format for recording fracture descriptions follows:

- Orientation
- Spacing
- Continuity
- Openness
- Fillings
  - Thickness
  - Composition
  - Weathering/alteration
  - Hardness
- Healing
- Surfaces
  - Roughness
  - Waviness
  - Weathering/alteration
  - Hardness
- Field index test results
- Moisture

Descriptors for Fracture Characteristics

The following paragraphs present terminology, descriptor criteria, and descriptors for recording fracture data. Alphanumeric descriptors are amenable to computer sorting. Alphanumeric descriptors are not a substitute for a complete description of the fracture characteristics.

Orientation.—The orientation of all fractures with respect to applied loads can be critical to deformation or stability. Seepage or grouting also may be affected or controlled by orientation. Orientation is usually measured in the field, and the raw data tabulated and interpreted. The analysis typically includes stereonets, contour diagrams, fracture sets, and their areal distribution. A detailed statistical analysis of the fracture data may be necessary. Azimuths or quadrants may be used, but azimuths are becoming the standard, in part because they are easier to computerize. The American right-hand rule for dip direction notation is preferred. The method of measuring the dip of planar discontinuities, foliation, and bedding in cores is shown in figure 5-9. Figures 5-1 and 5-2 illustrate how inclination of a joint in core from an angle hole can be interpreted as a horizontal joint (A) or vertical joint (B) by rotating the core 180 degrees (°). If the core is oriented and the top of the core is known, the inclination can be recorded as positive (+) or negative (-) to avoid ambiguity and to assist in determining sets.

Fracture orientation is recorded as strike and dip, or as azimuth and dip, preferably using the right-hand rule. Orientation of planar features with undetermined strike can be measured directly and reported as dip in vertical holes. In angle holes, where true dip is not known, the angle of the plane should be measured from the core axis and reported as inclination, i.e., "bedding plane joints inclined 65 degrees from the core axis."

Spacing.—Spacing affects block size and geometry in the rock mass. Spacing is a required input to several rock mass classification systems. When a set can be distinguished (parallel or subparallel joints), true spacing can be measured and is described for each joint set, as shown on figure 5-2 and in table 5-2. If apparent spacing is given, label as such.

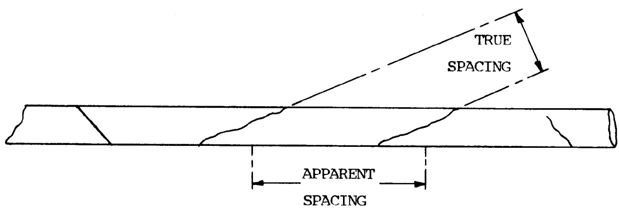


Figure 5-2.—Comparison of true and apparent spacing.

Continuity.—A continuous joint or fracture is weaker and more deformable than a short discontinuous fracture bridged by intact bedrock. Recording trace lengths to describe continuity is useful in large exposures. Identification of the more continuous fractures is an important aspect of formulating rock stability input data, especially for high cut slopes and in large underground openings. Record the longest observable trace regardless of end type and note whether it is a strike (S), dip (D), or apparent (A) trace. Descriptors for continuity are provided in table 5-3.

Table 5-2.—Fracture spacing descriptors

Alpha-numeric descriptor	Joint or fracture spacing descriptor	True spacing
SP1	Extremely widely spaced	Greater than 10 feet (ft) (<3 m)
SP2	Very widely spaced	3 to 10 ft (1 to 3 m)
SP3	Widely spaced	1 to 3 ft (300 mm to 1 m)
SP4	Moderately spaced	0.3 to 1 ft (100 to 300 mm)
SP5	Closely spaced	0.1 to 0.3 ft (30 to 100 mm)
SP6	Very closely spaced	Less than 0.1 ft (<30 mm)

Table 5-3.—Fracture continuity descriptors

Alpha-numeric descriptor	Descriptor	Lengths
C1	Discontinuous	Less than 3 ft (>1 m)
C2	Slightly continuous	3 to 10 ft (1 to 3 m)
C3	Moderately continuous	10 to 30 ft (3 to 10 m)
C4	Highly continuous	30 to 100 ft (10 to 30 m)
C5	Very continuous	Greater than 100 ft (>30 m)

This information alone is not sufficient to completely assess joint or fracture continuity because trace lengths may be partially obscured. When performing joint studies or surveys, record the number of ends (fracture terminations) that can be seen in the exposure using the alphanumeric descriptors shown in table 5-4. The size of the exposure should be noted because this is a determining factor when surveying for visible ends.

Table 5-4.—Descriptors for recording fracture ends in joint surveys

Alpha-numeric descriptor	Criteria
E0	Zero ends leave the exposure (both ends of the fracture can be seen in the exposure).
E1	One end can be seen (one end of the fracture terminates in the exposure).
E2	Both ends cannot be observed (two fracture ends do not terminate in the exposure).

Openness.—The width or aperture is measured normal to the fracture surface. This aperture or openness affects the strength, deformability, and seepage characteristics. Describe fracture openness by the categories shown in table 5-5. For drill logs, if actual openness cannot be measured or estimated, use only open or tight and do not assign an alphanumeric descriptor.

Characteristics of Fracture Fillings.—Describing the presence or absence of coatings or fillings and distinguishing between types, alteration, weathering, and strength and hardness of the filling material may be as significant as fracture spatial relationships or planarity. Strength and permeability of fractures may be affected by fillings. Descriptions of fracture coatings and fillings are site specific but must address the following considerations:

1. ***Thickness of fillings.—***Table 5-6 provides descriptors for recording the thickness of fracture fillings or coatings.

Table 5-5.—Fracture openness descriptors

Alpha-numeric descriptor	Descriptor	Openness
O0	Tight	No visible separation
O1	Slightly open	Less than 0.003 ft [1/32 inch (in)] (<1 mm)
O2	Moderately open	0.003 to 0.01 ft [1/32 in to 1/8 in] (1 to 3 mm)
O3	Open	0.01 to 0.03 ft [1/8 to 3/8 in] (3 to 10 mm)
O4	Moderately wide	0.03 ft [3/8 in] to 0.1 ft (10 to 30 mm)
O5	Wide	Greater than 0.1 ft (>30 mm) (record actual openness)

Table 5-6.—Fracture filling thickness descriptors

Alpha-numeric descriptor	Descriptor	Thickness
T0	Clean	No film coating
T1	Very thin	Less than 0.003 ft [1/32 in] (<1 mm)
T2	Moderately thin	0.003 to 0.01 ft [1/32 to 1/8 in] (1 to 3 mm)
T3	Thin	0.01 to 0.03 ft [1/8 to 3/8 in] (3 to 10 mm)
T4	Moderately thick	0.03 ft [3/8 in] to 0.1 ft (10 to 30 mm)
T5	Thick	Greater than 0.1 ft (>30 mm) (record actual thickness)

2. Composition of fillings.—The mineralogical classification of fillings, such as quartz, gypsum, and carbonates, must be identified to convey physical properties of fractures that may be significant criteria for design. Soil materials in open fractures should be described and classified according to the Unified Soil Classification System (USCS) (see USBR 5000 and USBR 5005 [5]).

Fractures may be filled or "healed" entirely or over a significant portion of their areal extent by quartz, calcite, or other minerals. Veins may be present without healing the fracture or may have been broken again forming new surfaces. Soluble fillings, such as gypsum, may cause foundation or structural degradation during the facility's expected lifetime. Fracture fillings must be considered during design, construction investigations, and monitoring or potential long-term stability, deformability, and seepage problems may require expensive rehabilitation efforts.

Coatings or fillings of chlorite, talc, graphite, or other low-strength materials need to be identified because of their deleterious effects on strength, especially when wet. Some fillings, such as dispersive, erosive, or micaceous materials, can squeeze, pipe under fluid flow, and contribute to a loss of strength and stability. Montmorillonitic clays may swell or cause swelling pressures. Cohesionless materials, such as sands and silts, or materials which have been crushed or altered may run or flow into underground excavations or serve as seepage conduits.

3. Weathering or alteration.—Descriptors for weathering or alteration of fracture fillings (excluding soil materials) are the same as those used for rock weathering.

4. Hardness/strength.—Descriptors for hardness/ strength of fillings should be the same as those presented for bedrock hardness or soil consistency (chapters 3 and 4). Various field index tests may also be performed to determine strengths of fillings. Refer to the Field Index Tests in chapter 4.

5. Healing.—Fractures may be healed or recemented by one or more episodes of mineralization or precipitation of soluble materials. A description of fracture healing or rehealing should include not only the type of healing or cementing agent, but an estimate of the degree to which the fracture has been healed. The subjective criteria and descriptors shown in table 5-7 should be used to describe healing.

Characteristics of Fracture Surfaces.—The physical characteristics of fracture surfaces are very important for deformability and stability analyses. Dimensional characteristics such as roughness and waviness (see figure 5-3) and characteristics, such as weathering and hardness of the surfaces, are important in evaluating the shear strength of fractures. Fracture roughness descriptors are given in table 5-8. Surface characteristics are less important only when low-strength materials comprise fracture fillings.

The description of fracture asperities is divided into two categories: small-scale asperities, or roughness, and large-scale undulations, or waviness. Figure 5-3 shows

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Table 5-7.—Fracture healing descriptors

Alpha-numeric descriptor	Descriptor	Criteria
HL0	Totally healed	Fracture is completely healed or recemented to a degree at least as hard as surrounding rock.
HL2	Moderately	Greater than 50 percent of fracture material, fracture surfaces, or healed filling is healed or recemented; and/or strength of the healing agent is less hard than surrounding rock.
HL3	Partly healed	Less than 50 percent of fractured material, filling, or fracture surface is healed or recemented.
HL5	Not healed	Fracture surface, fracture zone, or filling is not healed or recemented; rock fragments or filling (if present) is held in place by iits own angularity and/or cohesiveness.

examples of these asperities. Descriptors for roughness and waviness and additional items related to fracture surfaces follow.

1. Roughness.—The roughness (small-scale asperities) of fracture surfaces is critical for evaluating shear strengths. Roughness descriptors such as striated or slickensided should be used whenever observed. For oriented core or outcrops, the orientation of striations or slickensides should be recorded. The rake of striations or slickensides should be recorded when observed in core from vertical drill holes which have not been oriented. In

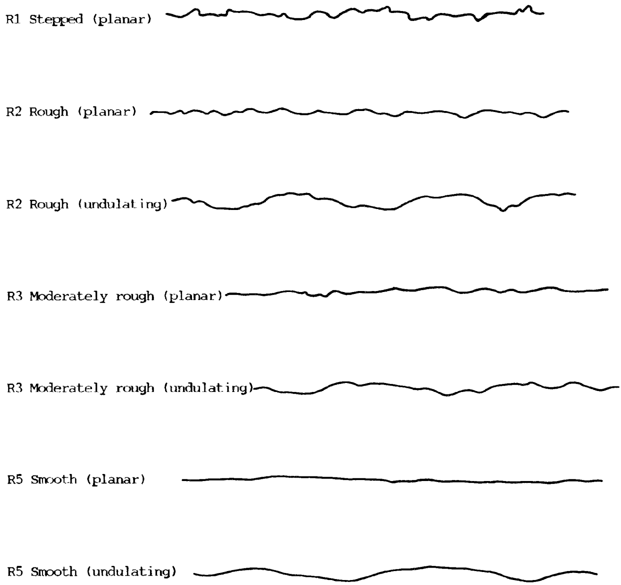


Figure 5-3.—Examples of roughness and waviness of fracture surfaces, typical roughness profiles, and terminology. The length of each profile is in the range of 3 to 15 feet (1 to 5 m); the vertical and horizontal scales are equal.

Coulomb's equation for shear strength (S = C + N tan n), the large scale undulations (*i*) are entered into the equation as N tan (n + *i*).

2. Waviness.—Waviness (large-scale undulations) also should be recorded for fracture surveys along

Table 5-8.—Fracture roughness descriptors

Alpha-numeric descriptor	Descriptor	Criteria
R1	Stepped	Near-normal steps and ridges occur on the fracture surface.
R2	Rough	Large, angular asperities can be seen.
R3	Moderately rough	Asperities are clearly visible and fracture surface feels abrasive.
R4	Slightly rough	Small asperities on the fracture surface are visible and can be felt.
R5	Smooth	No asperities, smooth to the touch.
R6	Polished	Extremely smooth and shiny.

exposures. This is done by recording amplitude and wavelength, or as a minimum, describing as either planar or undulating.

3. Weathering/alteration.—Weathering or alteration of fracture surfaces is one of the criteria used for classifying rock mass weathering. Even though it is inherent in the weathering categories, the actual description of surface alteration and the associated loss of strength of the rock needs to be reported. Qualitative information can be presented when describing a particular joint set, joint, or fracture. The condition of the surface(s), such as depth of penetration and degree of staining or oxidation, should be recorded.

Moisture Conditions.—The presence of moisture or the potential for water flow along fractures may be an indicator of potential grout takes or seepage paths. Criteria and descriptors shown in table 5-9 describe moisture conditions for fractures. The presence or absence of moisture cannot be determined in core, but evidence of previous long-term water flow is found in leaching, color changes, oxidation, and dissolutioning.

Table 5-9.—Fracture moisture conditions descriptors

Alpha-numeric descriptor	Criteria
M1	The fracture is dry, tight, or filling (where present) is of sufficient density or composition to impede water flow. Water flow along the fracture does not appear possible.
M2	The fracture is dry with no evidence of previous water flow. Water flow appears possible.
M3	The fracture is dry but shows evidence of water flow such as staining, leaching, and vegetation.
M4	The fracture filling (where present) is damp, but no free water is present.
M5	The fracture shows seepage and is wet with occasional drops of water.
M6	The fracture emits a continuous flow (estimate flow rate) under low pressure. Filling materials (where present) may show signs of leaching or piping.
M7	The fracture emits a continuous flow (estimate flow rate) under moderate to high pressure. Water is squirting, and/or filling material (where present) may be substantially washed out.

Field Index Tests

Schmidt Hammer tests can be used to estimate the hardness/strength of the rock surfaces along a discontinuity (which may be weaker than the body of the rock). The rebound of a spring-actuated projectile is measured from the surface being tested. The sample should be large enough, preferably intact or securely fastened to a stable base (i.e., concrete), so that it does not move during tests. Unclamped specimens should measure at least 0.7 foot (200 mm) in each direction. Direct testing on rock outcrops is usually the best method. Results should be obtained from both wet and dry surfaces. Ten readings are taken at various locations on each surface. The five lowest readings are discounted, and the five highest readings are averaged to obtain a realistic rebound number (Schmidt hardness). The hammer is always oriented perpendicular to the surface being tested. A unit dry weight must also be determined for the material being tested. Using the Schmidt hardness and the unit dry weight, the uniaxial compressive strength of the sample can be estimated.

Tilt-type sliding-friction tests are also useful in estimating the shear strength of fractures. Samples can be obtained from outcrops or rock core. A representative sample is tilted, and the angle at which the top of the sample slides relative to the bottom is measured. This angle is an approximation of the friction angle. Both wet and dry surfaces should be tested. The weight, thickness, and approximate dimensions of the sample parts also are recorded. A friction angle can be estimated in a similar manner using three pieces of core. Two representative pieces of core are used as a base, and the third piece is placed on top. The base is then tilted until the top piece of core slides, and this angle is measured.

Pocket penetrometers may be used to estimate the strength of soil-like fillings or surfaces. The surface or a filling is penetrated by the penetrometer to the line on the penetrometer (about a quarter of an inch), and the approximate compressive strength is read directly from a calibrated scale on the penetrometer.

Example Descriptions of Fractures

The examples which follow show a representative format for recording data. Actual descriptions vary and depend on whether the observations were recorded from exposures, drill core, or detailed joint surveys. Data report descriptions of discontinuities should be expanded to provide ranges and typical characteristics or additional significant data for each set or individual fractures from all observations.

Drill Core.—The following metric example is taken from a log of a rock core interval from a vertical drillhole; in an angle hole, orientation would be recorded as inclination from the core axis:

> “. . . Moderately to slightly fractured (35% bedding joints, 65% joints). Core recovered in 210 to 730 mm lengths, mostly as 300 mm lengths. Bedding joints dip 30 to 35°, widely spaced (SP3) at 370 to 790 mm, avg 580 mm; 29 are tight, 6 are open; all are clean; 20 are moderately rough (R3), 15 are slightly rough (R4); oxidation penetrates 30 mm from surfaces (W4); all surfaces can be scratched by moderate knife pressure (H4). Joint set A dips 50 to 75°, mostly 60 to 65°, normal bedding; very widely spaced (SP2) at 0.9 to 1.2 m, avg 1 m; 3 are open, 1 is tight, and 9 are tight and healed by 3 to 30 mm thick, fresh (W1), very hard (H2), quartz-calcite fillings; the 3 open joints are clean, slightly rough (R4), oxidation stains penetrate

60 mm from surfaces (W4) which can be scratched by light to moderate knife pressure, all 3 show evidence of water flow (W6) . . .. ”

Exposure Mapping.—An example of fracture descriptions for an exposure, using English units, follows:

“Joint set A-1 strikes N. 20-38° W., mostly N. 20-25° W.; dips 50-65° NE, averages 54° NE. Very widely spaced (SP2), 3.8 to 7.3 ft apart, mostly 5 ft apart; most have moderately to highly continuous (C3 to C4) 25 to 55 ft trace lengths. Approx. 60% are open to moderately wide (O3 to O4), ranging in openness from 0.1 to 0.3 ft, remainder are tight to slightly open (O0 to O1). Approx. 10% of the joints contain thin, hard quartz fillings, 25% are clean, and 65% contain firm fat clay (CH) fillings which can be indented with thumbnail. All rock surfaces are moderately weathered with dendritic iron oxide staining which can be scratched with light to moderate knife pressure. Most surfaces are slightly rough (R4) and undulatory, approx. 20% are rough (R2) and planar. Undulations have wavelengths of 10 to 20 ft, average 15 ft, and amplitudes range from 0.2 to 0.5 ft. Clean joints are dry but show evidence of moisture flow (M3), most clay filled joints are damp but show no evidence of flow (M4).”

Fracture Survey.—Statistical evaluations are valuable, so it is important to collect joint properties for analysis. This can be readily accomplished using fracture survey techniques. Data sheets are prepared with appropriate columns for recording the data, a traverse distance and direction are established, and all pertinent data are measured and recorded. Data are analyzed using statistical methods. Refer to chapter 7 for detailed descriptions of discontinuity surveys.

Descriptions of Shears and Shear Zones

Shear, fault, and associated terminology are defined at the beginning of this chapter. The following describes a method to classify shears, shear zones, and their associated features. A format to describe and quantify shear and fault physical characteristics and example descriptions is provided. For each discussion, the word "fault" can be substituted for "shear."

Identification or Naming of Shears

Significant shears should be named for ease of identification in logs of exploration, mapping of exposures, interpretations on geologic drawings, discussion in reports, sample identification, and design treatment. Identification of a shear or shear zone by letter/number designation, such as S-9 (shear zone No. 9) or F-1 (fault zone No. 1), is recommended. Major splays may be identified by an appropriate combination of letters and numbers such as S-la or F-2c. Shears also may be named by their location such as "powerplant shear," "Salt Creek Shear zone," or "left abutment fault" if only a few shears are present in the study area.

Uniform and Structured Shear Zones

The identification and correlation of shears and shear zones from multiple but separate observations in boreholes, trenches, and limited outcrops are often difficult. The identification and description of shear and shear zone components and their physical characteristics are necessary to both assist in correlating observations and for design analyses. Together with physical measurements of attitude and thickness, the description of the component parts and internal structure of a shear may be used for correlation in much the same way that geophysical signatures or lithology are used to identify certain stratigraphic units. The composition of a shear or shear zone at each exposure can be described as either uniform or structured. Illustrated in figure 5-4 is a 0.5-foot (150-mm) thick uniform shear composed of 40 percent breccia distributed relatively uniformly throughout 60 percent clay gouge. Although the shear contains two components, clay gouge and brecciated fragments, the components are distributed uniformly throughout the 0.5-foot shear zone.

Figure 5-4.—Uniform shear zone.

In contrast, a structured shear zone is composed of two or more zones which differ significantly in composition or physical properties. A structured shear zone could consist of components similar to the uniform shear described above with an additional 0.2-foot (60-mm) thick quartz vein along one contact, as shown on figure 5-5.

A more complex structured shear zone might have a 0.1-foot (30-mm) thick chloritic gouge layer adjacent to the vein as shown on figure 5-6.

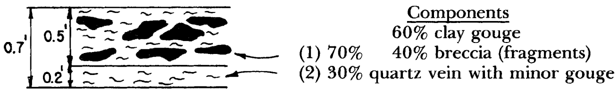


Figure 5-5.—Structured shear zone (two zones or layers).

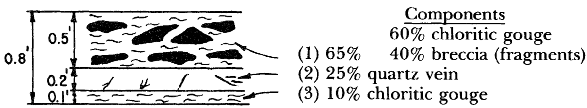


Figure 5-6.—Structured shear zone (three layers).

Numerous small quartz-calcite or other mineral veinlets commonly occur irregularly distributed throughout shears. The veinlets do not form distinct layers; therefore, they should be considered a percentage component of a uniform shear as illustrated on figure 5-7.

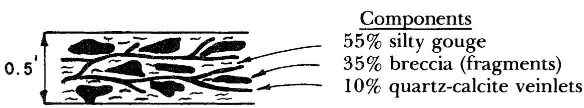
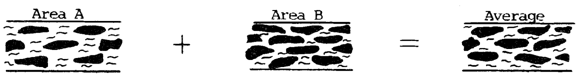


Figure 5-7.—Uniform shear zone with veinlets.

Shear zones may have minor or major lateral variations in the percentages of components within short distances at an exposure. The shear zone illustrated in figure 5-4 consists of 60 percent clay gouge and 40 percent rock fragments. Because the various components are not arranged in layers, the shear is of the uniform type. In an adjacent tunnel, the same shear zone may consist of 40 percent clay gouge and 60 percent rock fragments. If the exposure is limited, as in most tunnels or exploratory trenches, the percentages of the various components should be averaged, as illustrated on figure 5-8, and the average composition should be described.



Area A	Area B	Average
60% clay gouge	40% clay gouge	50% clay gouge
40% breccia	60% breccia	50% breccia

Figure 5-8.—Uniform shear zone (composite).

Descriptors and Description Format for Shears and Shear Zones

For shears to be uniformly and adequately described, a brief discussion of each applicable item in the following list should be included. The recommended format for describing a shear or shear zone, either uniform or structured as follows:

- Attitude
- Thickness

- Composition

  Gouge
  - Percent by volume
  - Color
  - Moisture content
  - Consistency (hardness/strength)
  - Composition
  - Occurrence — layers or matrix

  Breccia
  - Percent by volume
  - Fragment size(s)
  - Fragment shape(s)
  - Fragment surface characteristics
  - Lithology
  - Hardness/strength

  Other components (vein or dike materials)
  - Percentage
  - Thickness
  - Composition (mineralogy, texture, fracturing, etc.)

- Healing

- Zone strength

- Direction of movement (if determinable)

Attitude.—Measure strike and dip in exposures and from oriented core, report dip in vertical core, and measure angle from core axis for inclined drill core. Report an average figure if only moderate variations are observed. Provide both a range and average if large variations in orientation are apparent.

Thickness.—Report the true thickness of the shear or shear zone. True thickness can be measured directly or computed. Indicate an average figure for minor variations, as well as a range and average for significant variations. Do not include associated features beyond the shear contacts (the shear-disturbed zone), or intact blocks of rock around which the shear has bifurcated as components of the thickness.

Composition.—Report an average percentage for each description-format component. The various layers or zones of structured shears may be indicated by use of bracketed numbers [i.e., shear 1(1), 1(2)]. Describe each individual layer or zone in the order it occurs as if each were a uniform shear.

1. ***Gouge.—***

   - **Percentage.—**Report an average percent by volume for each exposure or layer.

   - **Color.—**Report color to help distinguish between several types of gouge or to indicate alteration. The Munsel Color System can be used to record both the wet and dry color.

   - **Moisture content.—**Describe the apparent moisture content upon initial exposure, using the following terms: wet (visible free water); moist (damp but without visible water); and dry (absence of moisture, dusty, dry to the touch).

   - **Consistency (strength/hardness).—**Report the ease with which gouge can be worked by hand: Very soft [thumb penetrates gouge more than 1 in (25 mm) if the gouge occurs in a sufficient quantity]; soft [easily molded, penetration of thumb about 1 in (25 mm)]; firm [easily crumbled, can be penetrated by thumb up to 1/4 in : (5 mm)]; hard (can be broken with finger pressure, no indentation with thumb, readily indented with thumbnail); and very hard (cannot be indented with thumbnail). Use a pocket penetrometer to estimate gouge strength.

- **Composition.—**Report identifiable mineral types; talc, chlorite, mica. Otherwise, report the soil classification group name and/or symbol, such as CH, ML, lean clay, etc.

- **Occurrence.—**Describe how the gouge occurs, such as thin coatings on fragments, a matrix, or a layer.

2. Breccia.—

- **Percentage.—**Report an average percent by volume for each exposure or layer.

- **Fragment size.—**Estimate or measure the dimension of the most common fragment sizes and report as a range. Use fractions of an inch and tenths of a foot or metric equivalents.

- **Fragment shape.—**Unless the distribution of several shapes is nearly equal, report the most common shapes and degree of angularity as shown in figure 5-9.

- **Fragment characteristics.—**These should be included because they affect or provide an indication of the strength of the zone or help to identify a particular zone in several exposures or observations. Descriptions should include striated, slickensided, polished, rough, chloritic coatings, and weathering.

Figure 5-9.—Standard descriptors and descriptive criteria for discontinuities.

DISCONTINUITY TERMINOLOGY

DISCONTINUITY - A collective term used for all structural breaks in geologic materials which usually have zero or low tensile strength. Discontinuities also may be healed. Discontinuities comprise fractures (including joints), planes of weakness, shears/faults, and shear/fault zones. Contacts between various units also may be considered discontinuties.

FRACTURE - A term used to describe any natural break in geologic material excluding shears and shear zones. Additional fracture terminology is provided below.

SHEAR - A structural break where differential movement has taken place along a surface or zone of failure by shear; characterized by striations, slickensides, gouge, breccia, mylonite, or any combination of these. Often direction, amount of displacement, and continuity may not be known because of limited exposures or observations.

FAULT - A shear with significant continuity which can be correlated between observations; occurs over a significant portion of a given site, foundation area, or region; or is a segment of a fault or fault zone defined in the literature. The designation of a shear as a fault or fault zone is a site-specific determination.

SHEAR/FAULT ZONE - A shear that is expressed in relative terms of width. The zone may consist of gouge, breccia, or many related faults or shears together with fractured and crushed rock between the shears or faults, or any combination of these. In the literature, many fault zones simply are referred to as faults.

SHEAR/FAULT-DISTURBED ZONE - An associated zone of fractures and/or folds adjacent to a shear or shear zone where the country rock has been subjected to only minor cataclastic action and may be mineralized. If adjacent to a fault or fault zone, the term is fault-disturbed zone. Occurrence, orientation, and areal extent of these phenomena depend upon depth of burial (pressure and temperature) during shearing, brittleness of materials, and the stress envelope.

FRACTURE TERMINOLOGY

EXAMPLES SHOWN FOR CORE, BUT APPLICABLE TO ANY OBSERVATION

JOINT (JT) - A relatively planar fracture along which there has been little or no shearing displacement.

FOLIATION JOINT (FJ) OR BEDDING JOINT (BJ) - A relatively planar fracture which is parallel to foliation or bedding along which there has been little or no shearing displacement.

BEDDING PLANE SEPARATION - A separation along bedding after extraction or exposure due to stress relief or slaking.

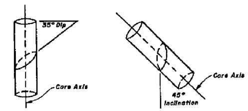
INCIPIENT JOINT (IJ) OR INCIPIENT FRACTURE (IF) - A joint or fracture which does not continue through the specimen or at least not seen with the naked eye. However, when the specimen is wetted and then allowed to dry, the joint or fracture trace is evident. When core is broken, it breaks along an existing plane.

RANDOM FRACTURE (RF) - A natural break (fracture) with a generally rough, very irregular, nonplanar surface which does not belong to a joint set.

MECHANICAL BREAK (MB) - A break due to drilling, blasting, or handling. Mechanical breaks parallel to bedding or foliation are called Bedding Breaks (BB) or Foliation Breaks (FB), respectively. Recognizing mechanical breaks may be difficult. The absence of oxidation, staining, or mineral fillings, and often a hackly or irregular surface are clues for recognition.

FRACTURE ZONE (FZ) - Numerous very closely spaced intersecting fractures. Often fragmented core cannot be fitted together.

METHOD OF MEASURING DIP OF PLANAR DISCONTINUITIES, FOLIATION, AND BEDDING IN CORE

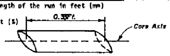


1. Vertical hole - true dip is measured and reported.
2. Angle hole - true dip usually not known; angle is measured from core axis and is called inclination.

ROCK QUALITY DESIGNATION (RQD)

$$RQD = \frac{\text{Sum of length of solid core pieces} \geq 0.33 \text{ ft [4 in] (100 mm) long}}{\text{Length of the run in feet (mm)}} \times 100$$

Expressed as percent (%)



FRACTURE FREQUENCY

FRACTURE FREQUENCY - The number of natural fractures occurring within a base length or core run. The number of fractures is divided by the length and is reported as fractures per foot or fractures per meter. Expressed as 3/m or 6/ft.

FRACTURE DENSITY

FRACTURE DENSITY - Based on the spacing of all natural fractures in an exposure or core recovery lengths in boreholes; excludes mechanical breaks, shears, and shear zones; however, shear-disturbed zones (fracturing outside the shear) are included. Descriptors for fracture density apply to all rock exposures such as tunnel walls, dozer trenches, outcrops, or foundation cut slopes and inverts, as well as boreholes. Descriptive criteria presented below are based on borehole cores where lengths are measured along the core axis, for other exposures the criteria is distance measured between fractures (size of blocks).

UNFRACTURED (FD0): No fractures.

VERY SLIGHTLY FRACTURED (FD1): Core recovered mostly in lengths greater than 3 feet (1 m).

SLIGHTLY TO VERY SLIGHTLY FRACTURED (FD2)*

SLIGHTLY FRACTURED (FD3): Core recovered mostly in lengths from 1 to 3 feet (300 to 1000 mm) with few scattered lengths less than 1 foot (300 mm) or greater than 3 feet (1000 mm).

MODERATELY TO SLIGHTLY FRACTURED (FD4)*

MODERATELY FRACTURED (FD5): Core recovered mostly in 0.3- to 1.0-foot (100- to 300-mm) lengths with most lengths about 0.6 foot (200 mm).

INTENSELY TO MODERATELY FRACTURED (FD6)*

INTENSELY FRACTURED (FD7): Lengths average from 0.1 to 0.3 foot (30 to 100 mm) with scattered fragmented intervals. Core recovered mostly in lengths less than 0.3 foot (100 mm).

VERY INTENSELY TO INTENSELY FRACTURED (FD8)*

VERY INTENSELY FRACTURED (FD9): Core recovered mostly as chips and fragments with a few scattered short core lengths.

* Combinations of fracture densities (e.g., Very Intensely to Intensely Fractured or Moderately to Slightly Fractured) are used where equal distribution of both fracture density characteristics are present over a significant interval or exposure, or where characteristics are "in between" the descriptor definitions.

FRACTURE SPACING

JOINT SET, OR FRACTURE SPACING DESCRIPTOR	TRUE SPACING
EXTREMELY WIDELY SPACED (SP1)	Greater than 10 ft (>3 m)
VERY WIDELY SPACED (SP2)	3 to 10 ft (1 to 3 m)
WIDELY SPACED (SP3)	1 to 3 ft (300 mm to 1 m)
MODERATELY SPACED (SP4)	0.3 to 1 ft (100 to 300 mm)
CLOSELY SPACED (SP5)	0.1 to 0.3 ft (30 to 100 mm)
VERY CLOSELY SPACED (SP6)	Less than 0.1 ft (<30 mm)

FRACTURE CONTINUITY

CONTINUITY DESCRIPTOR	DISCONTINUITY LENGTH
DISCONTINUOUS (C1)	Less than 3 ft (<1 m)
SLIGHTLY CONTINUOUS (C2)	3 to 10 ft (1 to 3 m)
MODERATELY CONTINUOUS (C3)	10 to 30 ft (3 to 10 m)
HIGHLY CONTINUOUS (C4)	30 to 100 ft (10 to 30 m)
VERY CONTINUOUS (C5)	Greater than 100 ft (>30 m)

FRACTURE ENDS (JOINT SURVEYS)

FRACTURE ENDS DESCRIPTOR	DESCRIPTIVE CRITERIA
E0	Zero ends leave the exposure (both ends can be seen).
E1	One end of the fracture terminates in the exposure (one end can be seen).
E2	Two fracture ends do not terminate in the exposure (both ends cannot be seen).

FRACTURE OPENNESS OR FILLING THICKNESS

FILLING THICKNESS DESCRIPTOR	THICKNESS/OPENNESS	OPENNESS DESCRIPTOR
CLEAN (T0)	No film or coating	
	No visible separation	TIGHT (O0)
VERY THIN (T1)	Less than 0.003 ft [1/32 in] (<1 mm)	SLIGHTLY OPEN (O1)
MODERATELY THIN (T2)	0.003 to 0.01 ft [1/32 to 1/8 in] (1 to 3 mm)	MODERATELY OPEN (O2)
THIN (T3)	0.01 to 0.03 ft [1/8 to 3/8 in] (3 to 10 mm)	OPEN (O3)
MODERATELY THICK (T4)	0.03 ft [3/8 in] to 0.1 ft (10 to 30 mm)	MODERATELY WIDE (O4)
THICK (T5)	Greater than 0.1 ft (>30 mm) Actual thickness or openings recorded	WIDE (O5)

FRACTURE MOISTURE CONDITIONS

MOISTURE DESCRIPTOR	DESCRIPTIVE CRITERIA
M1	The fracture is dry. It is tight or filling (where present) is of sufficient density or composition to impede waterflow. Waterflow along the fracture does not appear possible.
M2	The fracture is dry with no evidence of previous waterflow. Waterflow appears possible.
M3	The fracture is dry but shows evidence of waterflow such as staining, leaching, and/or vegetation.
M4	The fracture or filling (where present) is damp, but no free water is present.
M5	The fracture shows seepage. It is wet with occasional drops of water.
M6	The fracture emits a continuous flow (estimate flow rate) under low pressure. Filling materials (where present) may show signs of leaching or piping.
M7	The fracture emits a continuous flow (estimate flow rate) under moderate to high pressure. Water is squirting and/or filling material (where present) may be substantially washed out.

FRACTURE ROUGHNESS

Refers to small scale asperities of surfaces, not large scale undulations or waviness

STEPPED (R1): Near-normal steps and ridges occur on the fracture surface.
ROUGH (R2): Large, angular asperities can be seen.
MODERATELY ROUGH (R3): Asperities are clearly visible and fracture surface feels abrasive.
SLIGHTLY ROUGH (R4): Small asperities on the fracture surface are visible and can be felt.
SMOOTH (R5): No asperities, smooth to the touch.
POLISHED (R6): Extremely smooth and shiny.

FRACTURE SURFACE AND / OR FILLING ALTERATION AND HARDNESS

Descriptors for weathering or alteration of fracture surfaces and fracture fillings (excluding soil materials) are the same as those used for weathering and alteration of rock.

Descriptors for hardness/strength of fillings and/or fracture surfaces are the same as those presented for hardness of rock or consistency of soils.

DISCONTINUITY HEALING

TOTALLY HEALED (HL1) - All fragments bonded, discontinuity is completely healed or recemented to a degree at least as hard as surrounding rock.

MODERATELY HEALED (HL3) - Greater than 50 percent of fractured or sheared material, discontinuity surface or filling is healed or recemented; and/or strength of healing agent is less hard than surrounding rock.

PARTLY HEALED (HL5) - Less than 50 percent of fractured or sheared material, discontinuity surface or filling is healed or recemented.

NOT HEALED (HL6) - Discontinuity surface, fracture zone, sheared material or filling is not healed or recemented, rock fragments or filling (if present) held in place by their own angularity and/or cohesiveness.

SHEAR / FAULT DESCRIPTORS

SHEAR / FAULT GOUGE CONSISTENCY

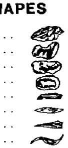
DESCRIPTOR	DESCRIPTIVE CRITERIA (Similar to consistency of soils)
VERY HARD	Gouge cannot be broken with finger pressure; cannot be indented with fingernail.
HARD	Gouge can be broken with firm finger pressure; can be indented with fingernail; cannot be indented with thumb.
FIRM	Gouge can be easily crumbled; can be indented with thumb 1 to 5 mm.
SOFT	Gouge can be easily molded; can be penetrated with thumb 5 to 25 mm.
VERY SOFT	Gouge can be penetrated with thumb more than 25 mm.

SHEAR / FAULT MOISTURE CONDITIONS

The apparent moisture content of gouge is described as **WET** (visible free water); **MOIST** (damp but no visible water); and **DRY** (absence of moisture, dusty, dry to the touch). Moisture descriptors M1 through M7 may be used to describe the shear or shear zone.

BRECCIA SHAPES

Angular . . . .
Subangular. . . . .
Subrounded. . . . .
Rounded . . . .
Platy . . . .
Lens-shaped . . . .
Wedge-shaped. . . . .
Contorted . . . .



ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

GEOLOGY FOR DESIGNS & SPECIFICATIONS
STANDARD DESCRIPTORS AND DESCRIPTIVE CRITERIA FOR DISCONTINUITIES

GEOLOGY NOMENCLATURE COMM. TECHNICAL APPROVAL [signature]
DRAWN [signature] SUBMITTED [signature]
CHECKED [signature] APPROVED [signature]
CHIEF, DIVISION OF GEOLOGY

DENVER, COLORADO — OCTOBER 1, 1984 — 40-D-6499

- **Lithology.—**The identification of rock fragments (rock type) is essential, particularly if different from the surrounding rock mass or if several rock types are present in the zone. Indicate if fragments within the zone are altered.

- **Fragment hardness/strength.—**Describe how the average-size fragment can be broken across its least dimension using the following format: can be broken with (light, moderate, heavy) manual pressure or hammer blow.

3. Other components (vein or dike material).— Describe any large veins or dikes which occur within the shear, either as a component of a uniform shear zone, usually occurring in the form of branching, discontinuous veinlets less than 1/2-inch (13-mm) thick, or as a layer (zone) within a structured shear. Dikes or large veins should be included as a single layer of a shear zone if they are bounded by shears. Also, they should be described as a rock unit. If a shear occurs only along one border of a dike or vein, the dike or vein should be described only as a rock unit.

- **Percentage.—**Report as an average percent by volume for the exposure or layer.

- **Thickness.—**Report as an average or range of thickness.

- **Composition.—**Provide a brief description of mineralogy and texture (e.g., leached, vuggy). Fracture density may be reported here if significant.

Healing.—Small veinlets which are components of a uniform shear zone and which actually form a bond between fragments tend to increase the strength of the shear zone (see following section). Healing should be determined by attempting to separate fragments manually or using a rock or pick. If fragments are bonded by some healing or cementing agent, the shear zone is described as partly healed (less than 50 percent of fragments bonded), mostly healed (more than 50 percent of fragments bonded), and totally healed (all fragments bonded by vein material).

Zone Strength.—When possible, the strength of the entire shear zone exposed in outcrops, tunnels, and exploratory trenches should be reported by the ease of which the sheared material can be dug from the exposure. The following guide is to be used: can be dug from wall, floor, or outcrop with light, moderate, or heavy finger pressure or hammer blow. Strength should be reported for each significant layer of a shear zone.

Direction of Movement.—If determinable, the amount, direction, and type of displacement are reported. Type and direction of displacement (dip-slip, strike-slip, oblique-slip, normal, reverse, right-lateral) may be directly observable as shown by drag, tension fractures, striations, offset "marker units" (such as beds, dikes, veins, or other structural units). The amount of both horizontal and vertical separation and, if possible, a net-slip solution should be included. Regional stress fields may be used to postulate displacement in the absence of site observations.

Example Descriptions for Shears and Shear Zones

The following are example descriptions for both a uniform and a structured shear zone; actual descriptions may depend on the type of observation.

A description, using metric units, of a uniform shear in an angle hole could be:

> "21.30 to 22.31: <u>Shear.</u> 210 mm thick, upper contact inclined 40°, lower contact inclined 61° from core axis, averages 51°, parallel to bedding. Composed of approx. 15%, blackish-green, moist, soft, chloritic clay and 85% 2 to 10 mm thick platy and lens-shaped, subrounded, polished, intensely weathered (W7) metasandstone fragments. Fragments break with light hand pressure. Fragments partly healed by 1 mm thick quartz-calcite veinlets."

A structured shear zone in a vertical drill hole core could be reported in English units as:

> "118.6 to 121.9': <u>Shear zone.</u> 2.3 ft thick, upper and lower contacts dip 40 to 45°, subparallel to foliation. Zone 1, upper 0.3 ft; consists of 45% green, moist, soft, chloritic clay gouge and 55% 0.05 to 0.1 ft subrounded, blocky, polished, fresh dike fragments; fragments break with moderate hammer blow. Zone 2 is 1.1 ft thick; consists of very intensely fractured, fresh dike which is partly healed by 0.01 to 0.3 ft-thick calcite veinlets and a 0.l ft-thick, vuggy quartz-calcite vein at base of dike. Zone 3 is 0.5 ft of No Recovery. Zone 4, the lower 0.3 ft; consists of 70% gray, moist, firm, silty gouge, and 15% 0.01 to 0.03 ft-thick, wedge-shaped, fresh, striated

horn-blende schist fragments, and 15% 0.02 ft-thick, angular, blocky, fresh quartz fragments. Fragments break with light hammer blow."

Description of Shear-Disturbed Zones

Fractures, fracture zones, drag zones, mineralized bedrock, and dikes or large veins along which one contact is sheared but are not themselves sheared or enclosed within a zone, are not included in the thickness of a shear or shear zone. The associated zone should be identified to adequately describe geologic conditions of engineering significance. For example, the shear-disturbed zone and an adjacent dike might be described as:

> ". . . The shear is bounded by a 1.5- to 4-ft wide shear-disturbed zone of very intensely to intensely fractured chloritized dike (FD8). This zone averages 3 ft wide along the upper contact and 2 ft wide in the associated chloritized dike adjacent to the lower contact. Hydrothermal alteration consisting of epidote, chlorite, pyrite, and quartz extends irregularly outward 2 to 7 ft normal to the shear boundaries."

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