# Table 4 - Classification of Rock Material Decomposition Grades

| Descriptive Term | Grade Symbol | General Characteristics for Granitic & Volcanic Rocks & Other Rocks of Equivalent Strength in the Fresh State | Additional Typical Characteristics for Specific Rock Types | | | |
|---|---|---|---|---|---|---|
| | | | Granite | Granodiorite | Coarse Ash Crystal/Lithic Tuff | Fine Ash Vitric Tuff |
| Residual Soil | VI | Original rock texture completely destroyed<br>Can be crumbled by hand and finger pressure into constituent grains | Reddish brown<br>Feldspars completely destroyed<br>Quartz is only remaining primary mineral; usually dull, etched or pitted and reduced in size compared with fresh condition | Dark reddish brown<br>Feldspars completely destroyed<br>Quartz only remaining primary mineral; grains reduced in size compared with fresh condition | Brown or reddish brown<br>Quartz only remaining primary mineral | Yellowish brown |
| Completely Decomposed | V | Original rock texture preserved<br>Can be crumbled by hand and finger pressure into constituent grains<br>Easily indented by point of geological pick<br>Slakes when immersed in water<br>Completely discoloured compared with fresh rock | Yellowish brown to reddish brown<br>Feldspars powdery to soft<br>Hand penetrometer shear strength index < 250 kPa<br>Zero rebound from N Schmidt hammer | Yellowish brown to reddish brown<br>Plagioclase feldspars powdery to soft, very easily grooved by pin<br>Orthoclase feldspars gritty, less easily grooved<br>Zero rebound from N Schmidt hammer | Brown to reddish brown<br>Slakes slowly in water<br>Mafic minerals soft, dull, dark green to brown, difficult to distinguish | Yellowish brown<br>Slakes readily in water |
| Highly Decomposed | IV | Can be broken by hand into smaller pieces<br>Makes a dull sound when struck by geological hammer<br>Not easily indented by point of geological pick<br>Does not slake when immersed in water<br>Completely discoloured compared with fresh rock | Yellowish brown to yellowish orange/brown<br>Feldspars powdery<br>Hand penetrometer shear strength index > 250 kPa<br>Positive N Schmidt rebound value <25 | Yellowish brown to yellowish orange/brown<br>Plagioclase feldspars powdery to gritty<br>N Schmidt rebound value 15-30 | Yellowish brown<br>Mafic minerals soft, dull, dark green | Yellowish grey<br>Surface can be scratched by knife |
| Moderately Decomposed | III | Cannot usually be broken by hand; easily broken by geological hammer<br>Makes a dull or slight ringing sound when struck by geological hammer<br>Completely stained throughout | Yellowish brown<br>Feldspars gritty<br>Biotite not shiny<br>N Schmidt rebound value 25-45 | Yellowish brown<br>Plagioclase feldspars party decomposed to gritty small pieces<br>N Schmidt rebound value 25-50 | Yellowish grey<br>Mafic minerals generally not shiny, soft, black or stained dark brown | White or light grey<br>Surface cannot be scratched by knife |
| Slightly Decomposed | II | Not broken easily by geological hammer<br>Makes a ringing sound when struck by geological hammer<br>Fresh rock colours generally retained but stained near joint surfaces | Feldspars hard to slightly gritty<br>Orthoclase feldspars often pink<br>Biotite slightly stained and dull around edges<br>N Schmidt rebound value >45 | Plagioclase feldspars slightly gritty<br>Biotite and hornblende slightly stained and dull<br>N Schmidt rebound value 45-70 | Light grey or greenish grey<br>Mafic minerals shiny, hard, black, may be slightly stained and dull around edges | Grey, light grey or greenish grey<br>Cloudy appearance |
| Fresh | I | Not broken easily by geological hammer<br>Makes a ringing sound when struck by geological hammer<br>No visible signs of decomposition (i.e. no discolouration) | Overall rock colour grey/white<br>Feldspars hard and shiny<br>Biotite shiny, not stained<br>Quartz colourless or grey, glassy | Overall rock colour grey<br>Feldspars hard and shiny<br>Biotite and hornblende shiny; not stained<br>Quartz colourless or grey, glassy<br>N Schmidt rebound value >60 | Overall rock colour ranges from light greenish grey (JSM) to grey (JSM, JYT)<br>Feldspars hard and shiny<br>Mafic minerals shiny, hard, black<br>Quartz colourless or grey, glassy | Overall rock colour black<br>Glassy appearance |
| General Notes | | (1) Not all these general characteristics are applicable to rocks whose strength in the fresh state is moderately strong or less (see Table 2). Alternative classifications may be more appropriate for such materials (see Section 2.3.4).<br>(2) Use of geological hammer applicable mainly to materials confined in a field exposure. | (3) Based on Moye (1955), Hencher & Martin (1982) and unpublished work by the GCO.<br>(4) Assessments of minerals applicable to medium and coarse-grained granite; may be difficult or impossible to assess in fine-grained granites. | (5) Based on Irfan & Powell (1985a,b). | (6) Based on unpublished work by the GCO.<br>(7) JYT = Yim Tin Tsai Formation<br>JSM = Shing Mun Formation<br>(see HKGS maps and memoirs).<br>(8) Mafic minerals referred to are biotite and hornblende. | (9) Based on unpublished work by the GCO. |
| Notes on Index Tests | | (10) Slake test: samples already close to saturation moisture content are less likely to slake.<br>(11) Feldspar alteration test: Hard = cannot be cut by knife or grooved by pin; Gritty = can be cut by knife or grooved by pin with pressure; Powdery = easily grooved by pin, can be crushed to silt fragments in fingers; Soft = easily grooved by pin, can be moulded very easily to clay in fingers.<br>(12) N Schmidt hammer test: rebound values are for hammer held perpendicular to rock face: take initial 'seating' blows to ensure good contact and record average value from a minimum of five consecutive impacts, ignoring unusually low readings.<br>(13) Hand penetrometer test: press instrument head slowly and smoothly into sample, take an average of ten values and divide by two to give shear strength index; test may be impractical on very small samples.<br>(14) Test results in general may be affected by sample moisture content and degree of microfracturing. | | | | |

Table 5 - Classification of Solid Rocks and Superficial Deposits in Hong Kong

| Superficial Deposits * | | Grain Size (mm) | Solid Rocks * | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sedimentary Rocks | | Pyroclastic Rocks | Igneous Rocks | | | | | Metamorphic Rocks | |
| | Grain Size Term | | Detrital Rocks | Chemical & Biochemical Rocks | Pyroclastic Breccia | Grain Size Term | Acid (much quartz) | | Intermediate (some quartz) | Basic (little or no quartz) | Foliated | Non-Foliated |
| Boulders | | 200 | Conglomerate / Sedimentary Breccia | Limestone and Dolomite, Evaporites | | | Pegmatite | | | | | |
| Cobbles | | 60 | | | | | | | | | | |
| Gravel | Coarse | 20 | | | | | | | | | | |
| | Medium | 6 | | | Lapilli Tuff | Coarse-grained | Granite / Aplite | Granodiorite | Quartz Monzonite / Quartz Syenite | * Gabbro | | Fault Breccia Quartzite Marble |
| | Fine | 2 | | | | Medium-grained | | | | | | |
| Sand | Coarse | 0.6 | Sandstone | | Coarse Ash Tuff | Fine-grained | | | | | Schist | |
| | Medium | 0.2 | | | | | | | | | | |
| | Fine | 0.06 | | | | | | | | | | |
| Silt | Mud | | Siltstone / Mudstone | Chert | Fine Ash Tuff | | Rhyolite / Rhyodacite | Dacite | Quartz Latite / Quartz Trachyte / Trachyandesite / Andesite | * Basalt / Lamprophyre | Phyllite / Mylonite | |
| Clay | Mud | 0.002 | Claystone / Mudstone | Chert | | | | | | | | |

Legend :

* Engineering soils comprise superficial deposits and any solid rock which has weathered to the condition where it can be broken down by hand into constituent grains

* Equivalent to Dolerite in Allen & Stephens (1971)

Note : This table is based on the classification scheme used by the Hong Kong Geological Survey.

Table 10 - Classification of Rock Mass Weathering Zones

| Zone Description | | Zone Symbol | Zone Characteristics |
|---|---|---|---|
| Residual Soil | | RS | **Residual soil derived from insitu weathering; mass structure and material texture / fabric completely destroyed : 100 % soil** |
| Partially Weathered Rock | 0/30 % Rock | PW 0/30 | **Less than 30 % rock**<br>**Soil retains original mass structure and material texture / fabric (i. e. saprolite)**<br>Rock content does not affect shear behaviour of mass, but relict discontinuities in soil may do so<br>Rock content may be significant for investigation and construction |
| | 30/50% Rock | PW 30/50 | **30 % to 50 % rock**<br>Both rock content and relict discontinuities may affect shear behaviour of mass |
| | 50/90% Rock | PW 50/90 | **50 % to 90 % rock**<br>Interlocked structure |
| | 90/100% Rock | PW 90/100 | **Greater than 90 % rock**<br>Small amount of the material converted to soil along discontinuities |
| Unweathered Rock | | UW | **100 % rock**<br>May show slight discolouration along discontinuities |

# Table 11 - Procedure for Rapid Identification and Description of Soils

## Basic Soil Type / Particle Size (mm) / Visual Identification

| Basic Soil Type | | Particle Size (mm) | Visual Identification |
|---|---|---|---|
| Very Coarse Soils | BOULDERS | 200 | Only seen complete in pits or exposures. |
| | COBBLES | 60 | Often difficult to recover from boreholes. |
| Coarse Soils (over 65% sand and gravel sizes) | GRAVELS | Coarse 20 / Medium 6 / Fine 2 | Easily visible to naked eye; particle shape can be described; grading can be described. Well-graded: wide range of grain sizes, well distributed. Poorly-graded: not well graded. (May be uniform: size of most particles lies between narrow limits; or gap-graded: an intermediate size of particle is markedly under-represented.) |
| | SANDS | Coarse 0.6 / Medium 0.2 / Fine 0.06 | Visible to naked eye; very little or no cohesion when dry; grading can be described. Well-graded: wide range of grain sizes. Poorly-graded: not well graded. (May be uniform: size of most particles lies between narrow limits; or gap-graded: an intermediate size of particle is markedly under-represented.) |
| Fine Soils (over 35% silt and clay sizes) — MUD | SILTS | Coarse 0.02 / Medium 0.006 / Fine 0.002 | Only coarse silt barely visible to naked eye; exhibits little plasticity and marked dilatancy; slightly granular or silky to the touch. Disintegrates in water; lumps dry quickly; possess cohesion but can be powdered easily between fingers. |
| | CLAYS | | Dry lumps can be broken but not powdered between fingers; they also disintegrate under water but more slowly than silt; smooth to the touch; exhibits plasticity but no dilatancy; sticks to fingers and dries slowly; shrinks appreciably on drying, usually showing cracks. Intermediate and high plasticity clays show these properties to a moderate and high degree, respectively. |
| Organic Soils | ORGANIC CLAY, SILT or SAND | Varies | Contains substantial amounts of organic vegetable matter. Often has noticeable smell and changes colour on oxidation. |
| | PEATS | Varies | Predominantly plant remains; usually dark brown or black in colour, often with distinctive smell; low bulk density. |

## Particle Shape and Plasticity

**Particle Shape**

Form: Equidimensional; Flat; Elongate; Flat and elongate

Angularity: Angular; Subangular; Subrounded; Rounded

Surface Texture: Smooth; Rough; Glassy; Honeycombed; Pitted; Striated

**Plasticity**

| | |
|---|---|
| Non-plastic or low plasticity | |
| Intermediate plasticity (Lean clay) | |
| High plasticity (Fat clay) | |

## Composite Soil Types (Mixtures of Basic Soil Types)

**Scale of Secondary Constituents with Coarse Soils**

| Term | | % of Silt or Clay |
|---|---|---|
| Slightly silty / Slightly clayey | GRAVEL or SAND | < 5 |
| - silty / - clayey | GRAVEL or SAND | 5 - 15 |
| Very silty / Very clayey | GRAVEL or SAND | 15 - 35 |

Coarse fraction may also be subdivided to give additional secondary constituent where applicable (Table 15).

For composite types described as: clayey: fines are plastic, cohesive; silty: fines are non-plastic or of low plasticity

**Scale of Secondary Constituents with Fine Soils**

| Term | | % of Gravel or Sand |
|---|---|---|
| Slightly gravelly / Slightly sandy | SILT or CLAY | < 35 |
| - gravelly / - sandy | SILT or CLAY | 35 - 65 |

Full explanation of the use of secondary constituents in Composite Soils is given in Tables 15 and 16.

## Strength (Compactness & Consistency)

| Strength Term | Field Test |
|---|---|
| Loose | By inspection of voids and particle packing |
| Dense | |
| Loose | Can be excavated with spade; 50mm wooden peg can be easily driven. |
| Dense | Requires pick for excavation; 50mm wooden peg hard to drive. |
| Very soft | Exudes between fingers when squeezed in hand. |
| Soft | Moulded by light finger pressure. |
| Firm | Can be moulded by strong finger pressure. |
| Stiff | Cannot be moulded by fingers. Can be indented by thumb. |
| Very stiff | Can be indented by thumb nail. |
| Compact | Fibres already compressed together. |
| Spongy | Very compressible and open structure. |
| Plastic | Can be moulded in hand, and smears fingers. |

## Structure and Weathering

| Structural Term | Field Identification |
|---|---|
| Homogeneous | Deposit consists essentially of one type. |
| Inter-stratified (Interbedded or Inter-laminated) | Alternating layers of varying types or with bands or lenses of other materials. Quantitative scale for bedding spacing may be used. |
| Heterogeneous | A mixture of types. |
| Fissured | Breaks into polyhedral fragments along fissures. Quantitative scale for spacing of discontinuities may be used. |
| Intact | No fissures. |
| Homogeneous | Deposit consists essentially of one type. |
| Inter-stratified (Interbedded or Inter-laminated) | Alternating layers of varying types. Interval scale for thickness of layers may be used. |
| Fibrous | Plant remains recognizable and retain some strength. |
| Amorphous | No recognizable plant remains. |

**Scale of Bedding Spacing**

| Term | Mean Spacing (mm) |
|---|---|
| Very thickly-bedded | > 2000 |
| Thickly-bedded | 600 - 2000 |
| Medium-bedded | 200 - 600 |
| Thinly-bedded | 60 - 200 |
| Very thinly-bedded | 20 - 60 |
| Thickly-laminated | 6 - 20 |
| Thinly-laminated | < 6 |

**Scale of Spacing of Other Discontinuities**

| Term | Mean Spacing (mm) |
|---|---|
| Extremely widely-spaced | > 6000 |
| Very widely-spaced | 2000 - 6000 |
| Widely-spaced | 600 - 2000 |
| Medium-spaced | 200 - 600 |
| Closely-spaced | 60 - 200 |
| Very closely-spaced | 20 - 60 |
| Extremely closely-spaced | < 20 |

Discontinuities (General)

For full description of individual discontinuities, use methods and terms given in Section 2.4.3

Weathering

In fine soils: describe discolouration where evident

In coarse soils: describe overall discolouration of soil and degree of decomposition of gravel and larger fragments

## Colour

Lightness: Light; Dark

Chroma

Hue: Pinkish; Reddish; Yellowish; Orangish; Brownish; Greenish; Bluish; Purplish; Greyish

Pink; Red; Yellow; Orange; Brown; Green; Blue; Purple; White; Grey; Black

Non-uniform Distribution: Spotted; Mottled; Dappled; Streaked; Striped

Select one value of lightness, chroma and hue as required, qualified by a term for non-uniform distribution where appropriate. See Table 3.

Table 12 - Soil Strength in Terms of Compactness and Consistency

| Soil Type | Descriptive Term for Compactness / Relative Density | SPT N Values (Blows / 300mm penetration) |
|---|---|---|
| Sands and Gravels | Very loose | 0 - 4 |
| | Loose | 4 - 10 |
| | Medium dense | 10 - 30 |
| | Dense | 30 - 50 |
| | Very dense | > 50 |
| **Soil Type** | **Descriptive Term for Consistency** | **Undrained Shear Strength (kPa)** |
| Silts and Clays | Very soft | < 20 |
| | Soft | 20 - 40 |
| | Firm | 40 - 75 |
| | Stiff | 75 - 150 |
| | Very stiff or hard | > 150 |

Table 13 - Particle Form

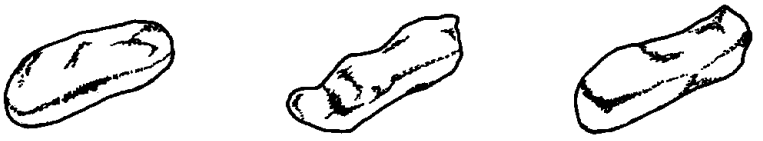
| Descriptive Term | Illustration |
|---|---|
| Equidimensional |  |
| Flat |  |
| Elongate |  |
| Flat and Elongate |  |

Table 14 - Particle Angularity

| Descriptive Term | Illustration |
|---|---|
| Angular |  |
| Subangular |  |
| Subrounded |  |
| Rounded |  |

Table 19 - Names and Descriptive Letters for Grading and Plasticity Characteristics

| Soil Components | Terms | Descriptive Name | Letter |
|---|---|---|---|
| Coarse Components | Main terms | GRAVEL | G |
| | | SAND | S |
| | Qualifying terms | Well-graded | W |
| | | Poorly-graded | P |
| | | Uniform | Pu |
| | | Gap-graded | Pg |
| Fine Components | Main terms | FINE SOIL, FINES<br>may be differentiated into M or C | F |
| | | SILT (M-SOIL) *<br>plots below A-line of plasticity chart of Figure 8 (of restricted plastic range) | M |
| | | CLAY<br>plots above A-line (fully plastic) | C |
| | Qualifying terms | Low plasticity | L |
| | | Intermediate plasticity | I |
| | | High plasticity | H |
| | | Very high plasticity | V |
| | | Extremely high plasticity | E |
| | | Upper plasticity range *<br>incorporating groups I, H, V and E | U |
| Organic Components | Main term | PEAT | Pt |
| | Qualifying term | Organic<br>may be suffixed to any group | O |

Legend:

* See Note 5 in Table 20

* This term is a useful guide when it is not possible or not required to designate the range of liquid limit more closely, e.g. during the rapid description of soils

# Table 20 - British Soil Classification System for Engineering Purposes

| Soil Groups (1) | | | Subgroups and Laboratory Identification | | | | |
|---|---|---|---|---|---|---|---|
| GRAVEL and SAND may be qualified by an additional secondary constituent for coarse fraction where appropriate (Table 15) | | | Group Symbol (2)(3) | Subgroup Symbol (2) | Fines (% less than 0.06mm) | Liquid Limit (%) | Name |
| Coarse Soils (less than 35% of the material is finer than 0.06mm) | GRAVELS (more than 50% of coarse material is of gravel size (coarser than 2mm)) | Slightly silty or clayey GRAVEL | G GW<br>GP | GW<br>GPu GPg | 0 - 5 | | Well-graded GRAVEL<br>Poorly-graded / Uniform / Gap-graded GRAVEL |
| | | Silty GRAVEL<br>clayey GRAVEL | G-F G-M<br>G-C | GWM GPM<br>GWC GPC | 5 - 15 | | Well-graded / Poorly-graded silty GRAVEL<br>Well-graded / Poorly-graded clayey GRAVEL |
| | | Very silty GRAVEL<br>Very clayey GRAVEL | GF GM<br>GC | GML, etc<br>GCL<br>GCI<br>GCH<br>GCV<br>GCE | 15 - 35 | | Very silty GRAVEL : subdivide as for GC<br>Very clayey GRAVEL ( clay of low, intermediate, high, very high, extremely high plasticity ) |
| | SANDS (more than 50% of coarse material is of sand size (finer than 2mm)) | Slightly silty or clayey SAND | S SW<br>SP | SW<br>SPu SPg | 0 - 5 | | Well-graded SAND<br>Poorly-graded / Uniform / Gap-graded SAND |
| | | Silty SAND<br>Clayey SAND | S-F S-M<br>S-C | SWM SPM<br>SWC SPC | 5 - 15 | | Well-graded / Poorly-graded silty SAND<br>Well-graded / Poorly-graded clayey SAND |
| | | Very silty SAND<br>Very clayey SAND | SF SM<br>SC | SML, etc<br>SCL<br>SCI<br>SCH<br>SCV<br>SCE | 15 - 35 | | Very silty SAND : subdivide as for SC<br>Very clayey SAND ( clay of low, intermediate, high, very high, extremely high plasticity ) |
| Fine Soils (more than 35% of the material is finer than 0.06mm) | Gravelly or sandy SILTS and CLAYS (35% - 65% fines) | Gravelly SILT (4)<br>Gravelly CLAY (4) | FG MG<br>CG | MLG, etc<br>CLG<br>CIG<br>CHG<br>CVG<br>CEG | | < 35<br>35 - 50<br>50 - 70<br>70 - 90<br>> 90 | Gravelly SILT : subdivide as for CG<br>Gravelly CLAY ( of low, intermediate, high, very high, extremely high plasticity ) |
| | | Sandy SILT (4)<br>Sandy CLAY (4) | FS MS<br>CS | MLS, etc<br>CLS, etc | | | Sandy SILT : subdivide as for CG<br>Sandy CLAY : subdivide as for CG |
| | SILTS and CLAYS (65% - 100% fines) | SILT (M-soil)<br>CLAY (5) (6) (7) | F M<br>C | ML, etc<br>CL<br>CI<br>CH<br>CV<br>CE | | < 35<br>35 - 50<br>50 - 70<br>70 - 90<br>> 90 | SILT : subdivide as for C<br>CLAY ( of low, intermediate, high, very high, extremely high plasticity ) |
| Organic Soils | | Descriptive letter 'O' suffixed to any group or sub-group symbol. | | | | | Organic matter suspected to be a significant constituent. Example MHO : Organic SILT of high plasticity. |
| Peat | | Pt Peat soils consist predominantly of plant remains which may be fibrous or amorphous. | | | | | |

Notes :

(1) The name of the soil group should always be given when describing soils, supplemented, if required, by the group symbol, although for some applications (e.g. diagrams) it may be convenient to use the group symbol alone.

(2) The group symbol or sub-group symbol should be placed in brackets if laboratory methods have not been used for identification, e.g. (GC).

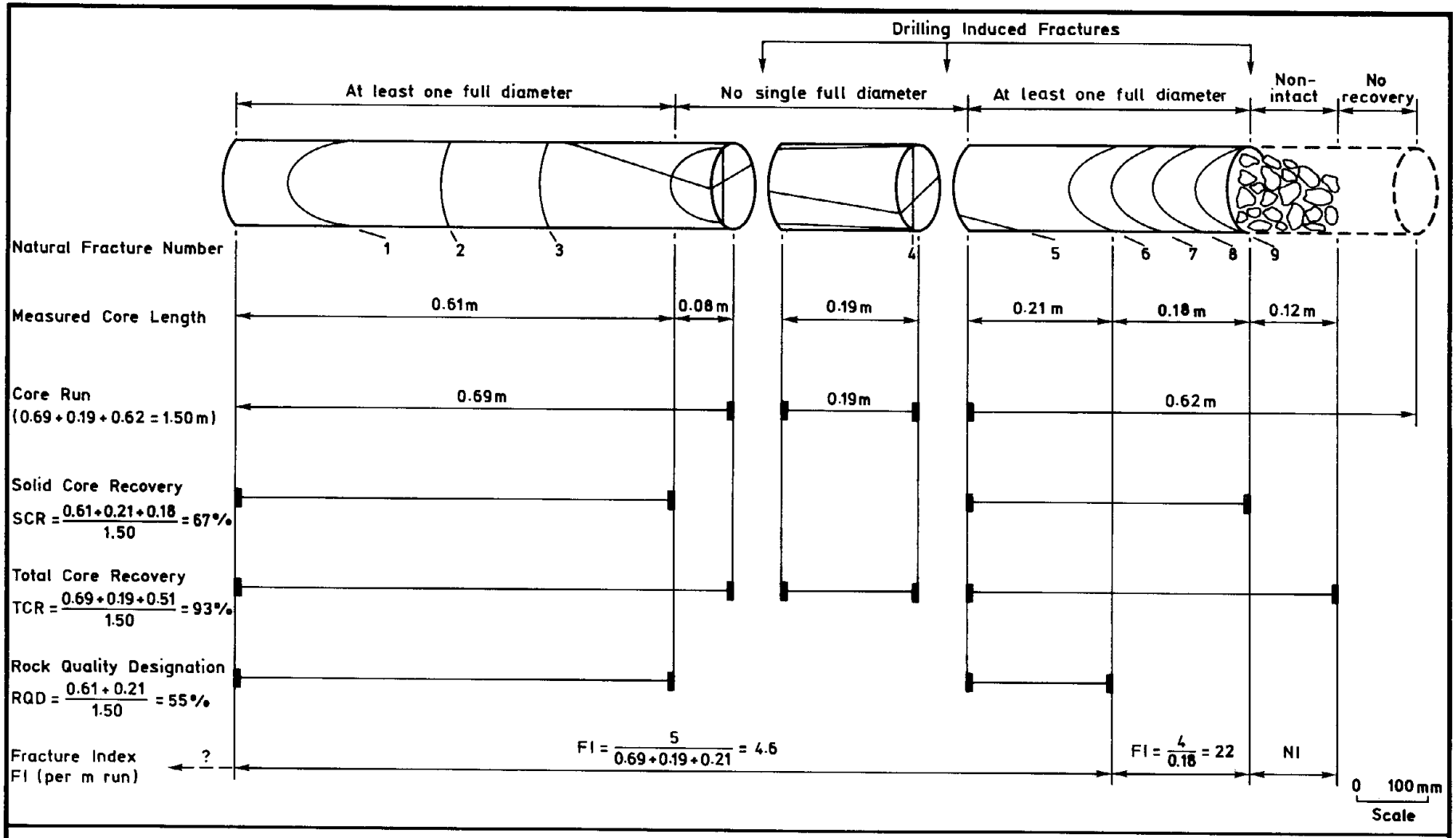
(3) The designation FINE SOIL or FINES, F may be used in place of SILT, M, or CLAY, C, when it is not possible or not required to distinguish between them.

(4) Gravelly if more than 50 % of coarse material is of gravel size. Sandy if more than 50 % of coarse material is of sand size.

(5) SILT (M-soil), M is material that plots below the A-line, and has a restricted plastic range in relation to its liquid limit, and relatively low cohesion. Fine soils of this type include clean silt-sized materials and rock flour, micaceous and diatomaceous soils, pumice, and volcanic soils, and soils containing halloysite. The alternative term 'M-soil' avoids confusion with materials of predominantly silt size, which form only a part of the group.
Organic soils also usually plot below the A-line on the plasticity chart, when they are designated ORGANIC SILT, MO.

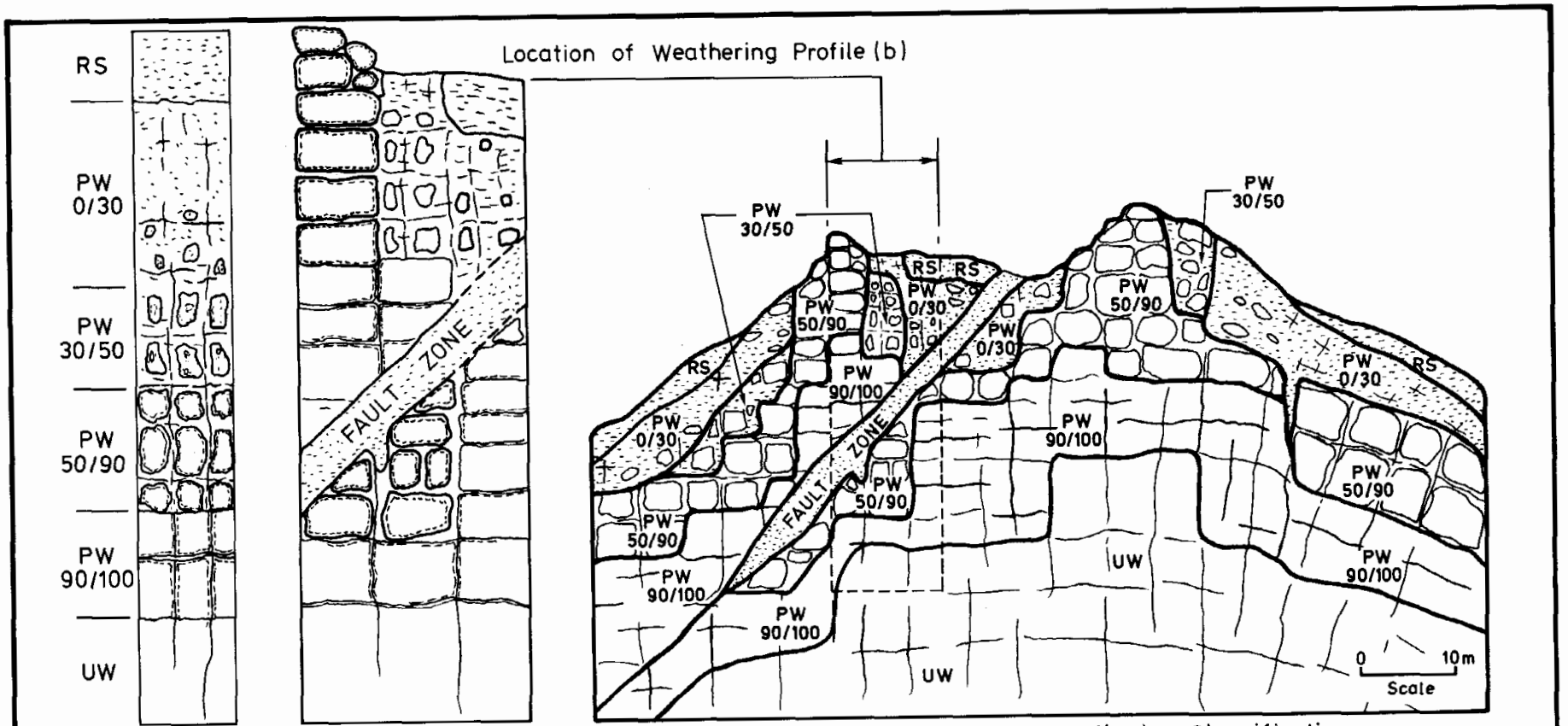
(6) CLAY, C is material that plots above the A-line, and is fully plastic in relation to its liquid limit.

(7) SILT and CLAY may be qualified as slightly sandy, or slightly gravelly, or both, where appropriate (Table 15).




Notes: (1) All fractures shown on the core are natural unless otherwise stated.
(2) Table adapted from Norbury et al (1984).

Figure 4 - Schematic Illustration of Fracture Logging Terms

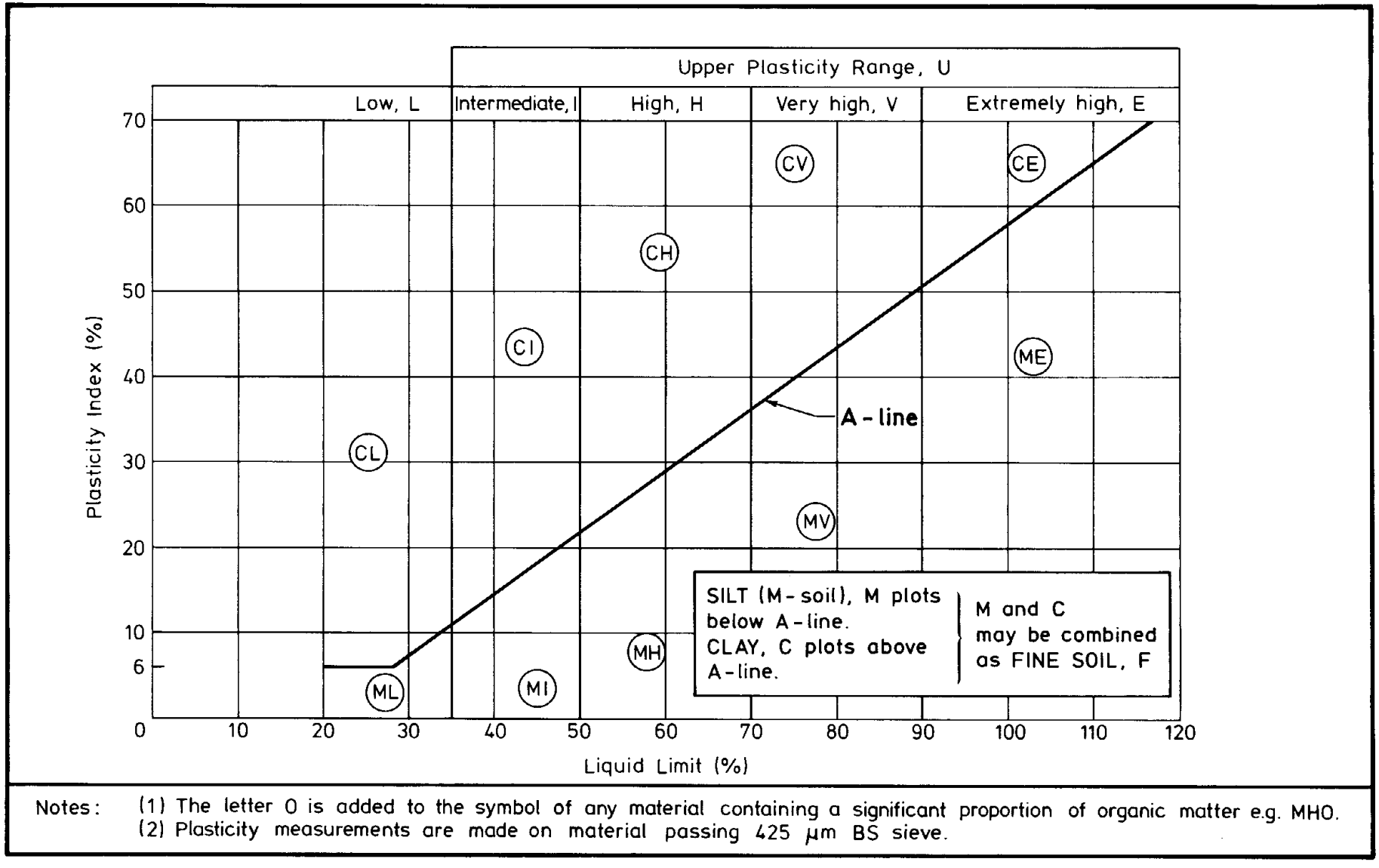



Legend :

| | | | | | |
|---|---|---|---|---|---|
| UW | Unweathered Rock | PW50/90 | Partially Weathered 50/90% Rock | PW0/30 | Partially Weathered 0/30% Rock |
| PW90/100 | Partially Weathered 90/100% Rock | PW30/50 | Partially Weathered 30/50% Rock | RS | Residual Soil |

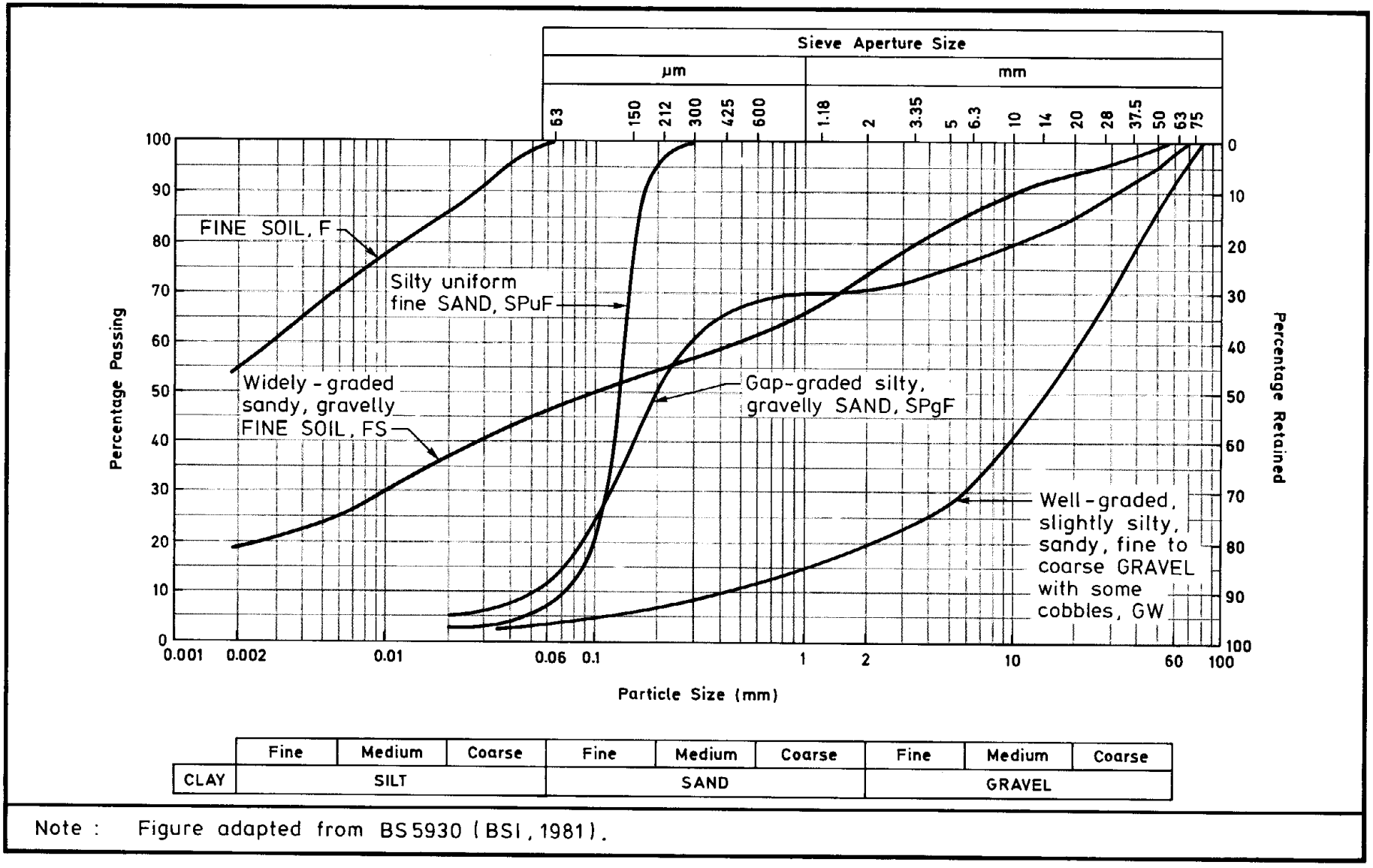
Note : For definitions of terms, see Table 10.

Figure 5 - Mass Weathering Profiles and Zonal Weathering Classification of a Mass Exposure




Notes: (1) The letter O is added to the symbol of any material containing a significant proportion of organic matter e.g. MHO.
(2) Plasticity measurements are made on material passing 425 μm BS sieve.

Figure 8 - Plasticity Chart for Classification of Fine Soils and the Finer Part of Composite Soils




Note : Figure adapted from BS 5930 (BSI, 1981).

Figure 9 - Grading Chart for Soils with Grading Curves of Selected Soil Types