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Part 3: Rock mechanics

Exploitation minière — Vocabulaire —

Partie 3: Mécanique des roches

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Foreword

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This document was prepared by Technical Committee ISO/TC 82, *Mining*.

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Introduction

The ISO 22932 series has been prepared in order to standardize and to coordinate the global use of technical terms and definitions in mining, for the benefit of the experts working on different types of mining activities.

The need for the ISO 22932 series arose from the widely varying interpretation of terms used within the industry and the prevalent use of more than one synonym.

Mining – Vocabulary —

Part 3:
Rock mechanics

1 Scope

This document specifies the rock-mechanics terms commonly used in mining. Only those terms that have a specific meaning in this field are included.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 General terms

3.1.1
abrasion
rubbing and wearing away

[SOURCE: Reference [1], 235]

3.1.2
angle of repose
maximum angle with respect to the horizontal plane that the surface of a pile of a loose material will assume

[SOURCE: Reference [1], 3]

3.1.3
erosion
process whereby soil or *rock mass* (3.5.25) is loosened or dissolved and removed from any part of the earth's surface

Note 1 to entry: It includes *weathering* (3.1.8), solution and transportation.

[SOURCE: IS 11358:1987, 2.109, modified — Note 1 to entry was originally part of the definition]

3.1.4
incompetent rock
rock (3.1.5) incapable of standing in underground opening or steep slopes at the surface without support

[SOURCE: IS 11358:1987, 2.155]

3.1.5
rock
solid material forming as part of the earths' crust

3.1.6
rock material
smallest element of *rocks* (3.1.5) not cut by any *fracture* (3.6.20)

Note 1 to entry: There are always some micro-fractures in the *rocks* (3.1.5) material.

[SOURCE: IS 11358:1987, 2.253, modified — Note 1 to entry was originally part of the definition.]

3.1.7
rock mechanics
theoretical and applied science of the mechanical behaviour of *rock* (3.1.5)

[SOURCE: Reference [1], 9]

3.1.8
weathering
process of disintegration and decomposition as a consequence of exposure to the atmosphere, to chemical action, and to the action of frost, water, and heat

[SOURCE: Reference [1], 99]

3.2 Stress

3.2.1
biaxial compression
compression caused by the application of *normal stresses* (3.2.20) in two perpendicular directions

[SOURCE: Reference [1], 20]

3.2.2
biaxial state of stress
state of *stress* (3.2.29) in which one of the three principal *stresses* (3.2.29) is zero

[SOURCE: Reference [1], 33]

3.2.3
coefficient of friction
μ
relating *normal stress* (3.2.20) and the corresponding critical *shear stress* (3.2.27) at which *sliding* (3.8.36) starts between two surfaces as follows:

$$\tau = \mu \cdot \sigma$$

where

τ is the shear stress;

μ is the coefficient of friction;

σ is the normal stress.

[SOURCE: Reference [1], 1]

3.2.4
cohesion
<stress> shear resistance at zero *normal stress* (3.2.20)

Note 1 to entry: An equivalent term in *rock mechanics* (3.1.7) is intrinsic shear *strength* (3.9.31).

Note 2 to entry: Compare with *cohesion* (3.9.8).

[SOURCE: Reference [1], 72, modified — Note 1 to entry was originally part of the definition.]

3.2.5
competent ground
rock mass (3.5.25) *strength* (3.9.31) which is higher than the ground *stresses* (3.2.29) imposed

Note 1 to entry: See Reference [4].

3.2.6
compressive stress
normal stress (3.2.20) tending to shorten the body in the direction in which it acts

[SOURCE: Reference [1], 50]

3.2.7
critical stress
maximum and minimum *compressive stress* (3.2.6) on the boundary of an opening

[SOURCE: IS 11358:1987, 2.75]

3.2.8
cyclical stress
stress (3.2.29) produced by repeated stressing and de-stressing

[SOURCE: IS 11358:1987, 2.82, modified — The phrase "stress produced" has been added and "of material" was originally part of the definition.]

3.2.9
dilatancy
property of volume increase under loading

[SOURCE: Reference [1], 75]

3.2.10
effective stress
pore water pressure (3.9.20) in *rock* (3.1.5) as a factor affecting *rock* (3.1.5) *strength* (3.9.31)

Note 1 to entry: The effective *normal stress* (3.2.20) is generally taken equal to the difference between normal stress and the pore water pressure.

Note 2 to entry: This is strictly valid only where pores, *cracks* (3.6.11) and *fractures* (3.6.20) are interconnected.

[SOURCE: IS 11358:1987, 2.107, modified — Notes 1 and 2 to entry were originally part of the definition.]

3.2.11
finite element
one of the regular geometrical shapes into which a figure is subdivided for the purpose of numerical *stress* (3.2.29) analysis

[SOURCE: Reference [1], 17]

3.2.12
hydraulic fracturing
method to measure the principal *stress* (3.2.29) situation by fracturing of the *rock* (3.1.5) surrounding a section of a drill hole

Note 1 to entry: The *fracture* (3.6.20) is obtained using increasing water pressure.

Note 2 to entry: See Reference [4].

3.2.13
hydrostatic pressure
state of *stress* (3.2.29) in which all the principal *stresses* (3.2.29) are equal (and there is no *shear stress* (3.2.27)

[SOURCE: Reference [1], 48]

3.2.14
incompetent ground
overstressed *rock masses* (3.5.25)

Note 1 to entry: See Reference [4].

3.2.15
inelastic deformation
portion of *deformation* (3.8.13) under *stress* (3.2.29) that is not annulled by removal of *stress* (3.2.29)

[SOURCE: Reference [1], 67]

3.2.16
keelformed overbreak
characteristic shape of overbreak caused by high, anisotropic *rock* (3.1.5) *stress* (3.2.29)

Note 1 to entry: See Reference [4].

3.2.17
Kirsch's equation
equation, which may be used for evaluating the tangential *stresses* (3.2.29) around tunnels and other underground openings

Note 1 to entry: See Reference [4].

3.2.18
k-value
ratio between horizontal and vertical *stresses* (3.2.29) within the *rock mass* (3.5.25)

Note 1 to entry: See Reference [4].

3.2.19
Mohr's envelope
envelope of a sequence of Mohr's circles representing *stress* (3.2.29) conditions at *failure* (3.6.15) for a given material

[SOURCE: Reference [1], 12]

3.2.19.1
angle of internal friction
angle of shear resistance
angle, ϕ, (degrees) between the axis of *normal stress* (3.2.20) and the tangent to the *Mohr's envelope* (3.2.19) at a point representing a given *failure* (3.6.15)-*stress* (3.2.29) condition for solid material

[SOURCE: Reference [1], 2]

3.2.20
normal stress
stress (3.2.29) in a *rock* (3.1.5) perpendicular to the *shear stress* (3.2.27)

[SOURCE: IS 11358:1987, 2.203, modified — The phrase "(normal)" was removed of the definition]

3.2.21
primary state of stress
state of *stress* (3.2.29) in a geological formation before it is disturbed by an opening

Note 1 to entry: Adapted from Reference [1], 46.

3.2.22
primitive stress
virgin rock stress
ground which is in a state of equilibrium before excavation of a tunnel or any underground opening

Note 1 to entry: At this stage, the *stresses* (3.2.29) at any point within the ground are termed as "primitive", "primary" or "pre-excavation" *stresses* (3.2.29).

[SOURCE: IS 11358:1987, 2.234, modified — Note 1 to entry was originally part of the definition.]

3.2.23
plasticity
property of a material to continue to deform indefinitely while sustaining a constant *stress* (3.2.29)

[SOURCE: Reference [1], 94]

3.2.24
relaxation
rate of reduction of *stress* (3.2.29) in a material due to *creep* (3.8.10)

Note 1 to entry: An alternate term is *stress* (3.2.29) relaxation.

[SOURCE: IS 11358:1987, 2.240, modified — Note 1 to entry was originally part of the definition.]

3.2.25
residual stress
stress (3.2.29) remaining in a solid under zero external *stress* (3.2.29) after some process that causes the dimensions of the various parts of the solid to be incompatible under zero *stress* (3.2.29)

EXAMPLE 1 *Deformation* (3.8.13) under the action of external *stress* (3.2.29) when some parts of the body suffer *permanent strain* (3.3.7).

EXAMPLE 2 Heating or cooling of a body in which the thermal expansion coefficient is not uniform throughout the body.

[SOURCE: Reference [1], 49, modified — EXAMPLES 1 and 2 to entry were originally part of the definition.]

3.2.26
secondary state of stress
resulting state of *stress* (3.2.29) in the *rock* (3.1.5) around an opening

[SOURCE: Reference [1], 47, adapted]

3.2.27
shear stress
stress (3.2.29) directed parallel to the surface element across which it acts

[SOURCE: Reference [1], 51]

3.2.28
stability
condition of a structure or a mass of material when it is able to support the applied *stress* (3.2.29) for a long time without suffering any significant *deformation* (3.8.13) or movement that is not reversed by the release of stress

[SOURCE: Reference [1], 15]

3.2.29
stress
force acting across a given surface element, divided by the area of the element as follows:

$$\sigma = \frac{F_v}{A}$$

$$\tau = \frac{F_h}{A}$$

where

σ is the *normal stress* (3.2.20);

τ is the *shear stress* (3.2.27);

F_v is the vertical force;

F_h is the horizontal force;

A is the area of element.

[SOURCE: Reference [1], 66]

3.2.30
stress concentration factor
ratio of tangential *stress* (3.2.29) at a particular point along the periphery and the initial stress before excavation at that point

Note 1 to entry: Stress concentration takes place when a cavity is excavated in a *rock mass* (3.5.25).

Note 2 to entry: The higher the stress concentration factor, the greater are the chances of *failure* (3.6.15) of the rock mass or *rock burst* (3.8.30).

[SOURCE: IS 11358:1987, 2.311, modified — Notes 1 and 2 to entry were originally part of the definition.]

3.2.31
stress ellipsoid
representation of the state of *stress* (3.2.29) in the form of an ellipsoid whose semi-axes are proportional to the magnitudes of the principal stresses and lie in the principal directions

Note 1 to entry: The coordinates of a point P on this ellipse are proportional to the magnitudes of the respective components of the stress across the plane normal to the direction OP, where O is the centre of the ellipsoid.

[SOURCE: Reference [1], 5, modified — Note 1 to entry was originally part of the definition.]

3.2.32
tensile stress
normal stress (3.2.20) tending to lengthen the body in the direction in which it acts

[SOURCE: Reference [1], 52]

3.2.33
thermal stress
internal *stress* (3.2.29), caused in part by uneven heating

[SOURCE: IS 11358:1987, 2.327]

3.2.34
triaxial compression
compression caused by the application of *normal stresses* (3.2.20) in three perpendicular directions

[SOURCE: Reference [1], 21]

3.2.35
triaxial state of stress
state of *stress* (3.2.29) in which none of the three principal stresses is zero

[SOURCE: Reference [1], 24]

3.2.36
uniaxial compression
unconfined compression
compression caused by the application of *normal stress* (3.2.20) in a single direction

[SOURCE: Reference [1], 19]

3.2.37
uniaxial state of stress
state of *stress* (3.2.29) in which two of the three principal stresses are zero

[SOURCE: Reference [1], 22]

3.2.38
yield stress
stress (3.2.29) beyond which the induced *deformation* (3.8.13) is not fully annulled after complete distressing

[SOURCE: Reference [1], 68]

3.3 Strain

3.3.1
brittleness
material condition characterised by reduced ability to carry load as the *strain* (3.3.11) increases

Note 1 to entry: See Reference [4].

3.3.2
contraction
linear *strain* (3.3.11) associated with a decrease in length

[SOURCE: Reference [1], 25]

3.3.3
ductility
condition in which material can sustain permanent *deformation* (3.8.13) without losing its ability to resist load, or on the other hand for a known or particular *stress* (3.2.29) state (existing or imposed) to which a material can sustain *plastic deformation* (3.8.26) without *breaking* (3.6.7) or *rupture* (3.6.30)

Note 1 to entry: Elongation and reduction of area are common indices of ductility.

3.3.4
elastic strain energy
potential energy stored in a strained solid and equal to the work done in deforming the solid from its unstrained state less any energy dissipated by *inelastic deformation* (3.2.15)

[SOURCE: Reference [1], 7]

3.3.5
extension
linear *strain* (3.3.11) associated with an increase in length

[SOURCE: Reference [1], 30]

3.3.6
normal strain
change in length per unit of length in a given direction

[SOURCE: Reference [1], 35]

3.3.7
permanent strain
strain (3.3.11) remaining in a solid state with respect to its initial condition after the application and removal of *stress* (3.2.29) greater than the *yield stress* (3.2.38)

Note 1 to entry: Commonly also called "*residual strain*" (3.3.8).

[SOURCE: Reference [1], 38, modified — "solid" has been replaced by "solid state".]

3.3.8
residual strain
strain (3.3.11) in a solid state associated with a state of *residual stress* (3.2.25)

[SOURCE: Reference [1], 37, modified — "solid" has been replaced by "solid state".]

3.3.9
shear strain
change in shape, expressed by the relative change of the right angles at the corner of what was in the undeformed state an infinitesimally small rectangle or cube

[SOURCE: Reference [1], 36]

3.3.10
simple shear
shear strain (3.3.9) in which *displacements* (3.8.17) all lie in one direction and are proportional to the normal distances of the displaced points from a given reference plane

Note 1 to entry: The *dilatation* (3.8.15) is zero.

[SOURCE: Reference [1], 34, modified — Note 1 to entry was originally part of the definition.]

3.3.11
strain
relative elongation or shortening of a material as result of loading

Note 1 to entry: See Reference [4].

3.3.12
strain ellipsoid
representation of the *strain* (3.3.11) in the form of an ellipsoid into which a sphere of unit radius deforms and whose axes are the principal axes of strain

[SOURCE: Reference [1], 6]

3.3.13
strain energy release rate
rate of *strain* (3.3.11) energy released per unit area of the excavated surface in the underground minor tunnel openings

Note 1 to entry: If the strain energy release rate is more than a limiting value, *rock burst* (3.8.30) is likely to occur.

[SOURCE: IS 11358:1987, 2.306, modified — Note 1 to entry was originally part of the definition.]

3.3.14
strain hardening
material that is loaded beyond the yield point within the inelastic domain above the yield point

Note 1 to entry: Its state of matter is shown by continuous rise of the *stress* (3.2.29)-*strain* (3.3.11) curve.

Note 2 to entry: Adapted from IS 11358:1987, 2.307.

3.3.15
strain softening
during uniaxial or triaxial testing of *rocks* (3.1.5), it is generally observed that *strength* (3.9.31) decreases after certain *strain* (3.3.11)

[SOURCE: IS 11358:1987, 2.308]

3.3.16
viscoelasticity
property of materials that *strain* (3.3.11) under *stress* (3.2.29) partly elastically and partly viscously, that is, whose strain is partly dependent on time and magnitude of stress

[SOURCE: Reference [1], 95]

3.4 Both stress and strain

3.4.1
Young's modulus
modulus of elasticity
axial Young's modulus
E
ratio of the axial *stress* (3.2.29) change to the axial *strain* (3.3.11) produced by the stress change for a cylindrical specimen tested in *uniaxial compression* (3.2.36)

Note 1 to entry: It may be calculated using any of the following methods.

a) Tangential Young's modulus, E_T — This is the tangential Young's modulus at a stress level which is some fixed percentage of the ultimate *strength* (3.9.31) and is generally 50 % of the ultimate *uniaxial compressive strength* (3.9.10).

b) Average Young's modulus, E_{ar} — The average Young's modulus is defined as the average slope of more or less straight portion of the axial stress-strain curve.

c) Secant Young's modulus, E_s — The secant Young's modulus is usually measured from zero stress to some fixed percentage of the ultimate strength, generally 50 %.

[SOURCE: IS 11358:1987, 2.19, modified — Note 1 to entry was originally part of the definition and "modulus of elasticity" and "Young's modulus" were added as equivalent terms.]

3.4.2
deviator of stress
deviator of strain
stress (3.2.29)/*strain* (3.3.11) tensor obtained by subtracting the mean of the *normal stress* (3.2.20)/ strain components of a stress/strain tensor from each normal stress/strain component

[SOURCE: Reference [1], 4]

3.4.3
deformation modulus
E_c
ratio of *stress* (3.2.29), σ to the total *strain* (3.3.11), in repeated loading-unloading tests, as follows:

$$E_c = \frac{\sigma}{\epsilon_{total}} = \frac{\sigma}{\epsilon_{el} + \epsilon_{ir}}$$

where

E_C is the deformation modulus;

σ is the normal stress;

ϵ_{el} is the elastic strain;

ϵ_{ir} is the irreversible strain.

Note 1 to entry: This modulus is thus based on the total measured strains, that is, elastic plus inelastic (irreversible or plastic) strains, ϵ_{el} and ϵ_{ir}, respectively.

Note 2 to entry: Total strain = ϵ_{el} + ϵ_{ir}.

[SOURCE: IS 11358:1987, 2.86, modified — Notes 1 and 2 to entry were originally part of the definition.]

3.4.4
modulus ratio
ratio between the *Young's modulus* (3.4.1) and the *uniaxial compressive strength* (3.9.10)

Note 1 to entry: The higher the value of the modulus ratio, the more *brittle* (3.8.4) is the *rock* (3.1.5).

Note 2 to entry: The *rock material* (3.1.6) is classified as high, medium and low modulus ratio for modulus ratios of > 500, 500-200 and < 200 respectively.

[SOURCE: IS 11358:1987, 2.194]

3.4.5
modulus reduction factor
M_{RF}
ratio between static elastic modulus of *rock mass* (3.5.25) (E or estatic) obtained from in-situ tests and the elastic modulus of *rock* (3.1.5) matter {E_r) obtained from, laboratory test

[SOURCE: IS 11358:1987, 2.195]

3.4.6
Mohr's circle of stress
Mohr's circle of strain
graphical representation of the components of *stress* (3.2.29)/*strain* (3.3.11) acting across the various planes at a given point, drawn with reference to axes of *normal stress* (3.2.20)/strain and *shear stress* (3.2.27)(strain)

[SOURCE: Reference [1], 11]

3.4.7
plane stress
plane strain
state of *stress* (3.2.29) (*strain* (3.3.11)) in a solid body in which all stress (strain) components normal to a certain plane are zero

[SOURCE: Reference [1], 31]

3.4.8
Poisson's ratio
ratio of the shortening in the transverse direction to the elongation in the direction of an applied force in a body under tension below the proportional limit

[SOURCE: Reference [1], 100]

3.4.9
principal stress
principal strain
stress (3.2.29) (*strain* (3.3.11)) normal to one of three mutually perpendicular planes on which the *shear stresses* (3.2.27) (strains) at a point in a body are zero

[SOURCE: Reference [1], 32]

3.4.10
pure shear
state of *strain* (3.3.11) resulting from that *stress* (3.2.29) condition most easily described by a Mohr circle centred at the origin

[SOURCE: Reference [1], 33]

3.4.11
secant modulus
slope of the line connecting the origin and a given point on the *stress* (3.2.29)-*strain* (3.3.11) curve

[SOURCE: Reference [1], 90]

3.4.12
stress field
strain field
ensemble of *stress* (3.2.29) (*strain* (3.3.11)) states defined at all points of an elastic solid

[SOURCE: Reference [1], 8]

3.4.13
stress rate
strain rate
rate of change of *stress* (3.2.29) (*strain* (3.3.11)) with time

[SOURCE: Reference [1], 13]

3.4.14
stress tensor
strain tensor
second order tensor whose diagonal elements consist of the *normal stress* (3.2.20) (*strain* (3.3.11)) components with respect to a given set of coordinate axes and whose off-diagonal elements consist of the corresponding *shear stress* (3.2.27) (strain) components

[SOURCE: Reference [1], 16]

3.4.15
tangent modulus
slope of the tangent to the *stress* (3.2.29)-*strain* (3.3.11) curve at a given stress value

Note 1 to entry: Generally taken at a stress equal to half the *compressive strength* (3.9.10).

[SOURCE: Reference [1], 91, modified — Note 1 to entry was originally part of the definition.]

3.4.16
unloading modulus
slope of the tangent to the unloading *stress* (3.2.29)-*strain* (3.3.11) curve at a given stress value

[SOURCE: Reference [1], 92]

3.5 Rock mass

3.5.1
allowable bearing pressure
allowable pressure transmitted by a foundation to the *rock mass* (3.5.25) such that no damage occurs either in the structure or in the rock mass

Note 1 to entry: It is based upon safe *bearing pressure* (3.9.4) (satisfying criteria of shear, total and differential settlement and tilt), correction factors, and past experience and judgment of experts.

[SOURCE: IS 11358:1987, 2.6, modified — Note 1 to entry was originally part of the definition.]

3.5.2
attenuation
decrease of the amplitude of waves as they travel through *rock mass* (3.5.25)

Note 1 to entry: This reduction in amplitude is known as attenuation.

Note 2 to entry: Attenuation is energy loss with distance per cycle.

[SOURCE: IS 11358:1987, 2.18, modified — Notes 1 and 2 to entry were originally part of the definition.]

3.5.3
bedding
rocks (3.1.5) resulting from consolidation of sediments and exhibiting surfaces of separation (bedding planes) between layers of the same or different materials

Note 1 to entry: The materials can be that is, shale, siltstone, sandstone, limestone, etc.

[SOURCE: Reference [1], 123, modified — Note 1 to entry was originally part of the definition.]

3.5.4
blocky
rock mass (3.5.25), with wide open seams in all directions and filled with gouge, or which is shattered or *fissured* (3.6.18)

[SOURCE: IS 11358:1987, 2.126 e)]

3.5.5
cleavage plane
parallel surface along which a *rock* (3.1.5) or mineral cleaves or separates; the plane of least *cohesion* (3.2.4), usually parallel to a certain face of the mineral or crystal

[SOURCE: ASTM D653-14]

3.5.6
cleft water
water that exists in or circulates along the geological *discontinuities* (3.6.13) in a *rock mass* (3.5.25)

[SOURCE: ASTM D653-14]

3.5.7
contact pressure
unit of pressure that acts at the surface of contact between a structure and the underlying soil or *rock mass* (3.5.25)

[SOURCE: ASTM D653-14]

3.5.8
exfoliation
process by which thin, curvilinear scales or shells or *rock* (3.1.5) are successively spalled or stripped away from the bare surface of a *rock mass* (3.5.25) or boulder under the action of mechanical and/or chemical *weathering* (3.1.8) and release of confining pressure by *erosion* (3.1.3)

Note 1 to entry: Often results in a rounded rock mass. Commonly seen in granite corestones.

Note 2 to entry: See Reference [4].

3.5.9
foliation
somewhat *laminated* (3.5.15) structure resulting from segregation of different minerals into layers parallel to the *schistosity* (3.5.30)

[SOURCE: Reference [1], 135]

3.5.10
ground
<rock excavation> in situ *rock mass* (3.5.25) subjected to *stresses* (3.2.29), groundwater, and other external factors

Note 1 to entry: See Reference [4].

3.5.11
ground response curve
diagram curve representing the behaviour of the *ground* (3.5.10) without and with *rock* (3.1.5) support

Note 1 to entry: Such curve is limited to continuous materials, i.e. *massive rock* (3.5.19) or highly jointed and crushed (particulate) *rock masses* (3.5.25).

Note 2 to entry: See Reference [4].

3.5.12
grout
fluid used for *grouting* (3.5.12.1) of *rock masses* (3.5.25) or soils with the purpose of sealing off water

Note 1 to entry: The fluid may be a cement slurry, a mix of cement and sand and other additives, or a mixture of special chemicals.

Note 2 to entry: See Reference [4].

3.5.12.1
grouting
injection of a fine-grained cement mixture or chemical agent into the *rock mass* (3.5.25)

Note 1 to entry: See Reference [4].

3.5.13
intact rock
material of the *rock mass* (3.5.25), typically represented by whole drill core not affected by gross structural *discontinuities* (3.6.13)

[SOURCE: Reference [1], 70]

3.5.14
karst
geologic setting where cavities are developed in *massive* (3.5.18) limestone beds by solution of flowing water

Note 1 to entry: Caves and even underground river channels are produced into which surface runoff drains and often results in the land above being dry and relatively barren.

[SOURCE: Reference [1], 140, modified — Note 1 to entry was originally part of the definition.]

3.5.15
laminated
rock mass (3.5.25) having thin layers of 30 cm to 100 cm *thickness* (3.5.32) with horizontal seams with little or no gouge

[SOURCE: IS 11358:1987, 2.126 c)]

3.5.16
landslide
perceptible downward *sliding* (3.8.36) or movement of a mass of earth or *rock* (3.1.5), or a mixture of both

[SOURCE: Reference [1],141]

3.5.17
lineation
parallel *orientation* (3.6.25) of structural features that are lines rather than planes

EXAMPLE Parallel orientation of the long dimensions of minerals, long axes of pebbles and cleavage-bedding plane intersections.

[SOURCE: Reference [1],134, modified — EXAMPLE was originally part of the definition.]

3.5.18
massive
solid or dense *rock mass* (3.5.25) with practically no seams

[SOURCE: IS 11358:1987, 2.126 a)]

3.5.19
massive rock
rock mass (3.5.25) with a *strength* (3.9.31) of the bond across partings or *joints* (3.6.23) comparable to the *rock* (3.1.5) strength

[SOURCE: IS 11358:1987, 2.189]

3.5.20
moisture content
percentage by weight of water contained in the pore space of a *rock* (3.1.5) or soil with respect to the weight of the solid material

[SOURCE: Reference [1], 157]

3.5.21
overburden
loose soil, sand, silt, or clay that overlies bedrock

Note 1 to entry: In some usages it refers to all material overlying the point of interest (tunnel crown), that is, the total cover of soil and *rock* (3.1.5) overlying an underground excavation.

[SOURCE: Reference [1], 129, modified — Note 1 to entry was originally part of the definition.]

3.5.22
percolation
movement, under *hydrostatic pressure* (3.2.13), of water through the smaller interstices of *rock* (3.1.5) or soil, excluding movement through large openings such as caves and solution channels

[SOURCE: Reference [1], 160]

3.5.23
polyhedral
shape term for a *rock mass* (3.5.25) with no consistent joint sets, such that individual *rock* (3.1.5) *blocks* (3.6.6) usually vary widely in shape and size

Note 1 to entry: See Reference [4].

3.5.24
pre-grouting
grouting (3.5.12.1) of the *rock masses* (3.5.25) ahead of the tunnel working face

Note 1 to entry: See Reference [4].

3.5.25
rock mass
rock (3.1.5) as it occurs in situ, including its structural *discontinuities* (3.6.13)

[SOURCE: Reference [1], 14]

3.5.26
rock mass quality
Q
numerical index depending upon the *rock mass* (3.5.25) quality and geological conditions, used to classify a rock mass and it is equal to (RQD/J_n) (J_r/J_a) (J_w/SRF)

$$Q = (R_{QD}/J_n)\ (J_r/J_a)\ (J_w/S_{RF})$$

where

R_{QD} is the rock quality designation;

J_n is the *joint set number* (3.6.23.11);

J_r is the *joint roughness number* (3.6.23.10);

J_a is the *joint alteration number* (3.6.23.1);

J_w is the *joint water reduction factor* (3.6.23.14);

S_{RF} is the stress reduction factor.

[SOURCE: IS 11358:1987, 2.251]

3.5.27
rock mass rating
R_{MR}
numerical index depending upon the quality of a *rock mass* (3.5.25) and geological conditions, used to classify a rock mass

Note 1 to entry: It is the sum of ratings for *uniaxial compressive strength* (3.9.10), *spacing* (3.6.13.5), *condition of joints* (3.6.9), *ground* (3.5.10) water conditions, RQD and *joint orientation* (3.6.23.7).

[SOURCE: IS 11358:1987, 2.252, modified — Note 1 to entry was originally part of the definition.]

3.5.28
schistosity
variety of *foliation* (3.5.9) that occurs in the coarse-grained metamorphic rocks and is generally the result of the parallel arrangement of platy and ellipsoidal mineral grains within the *rock* (3.1.5) substance

[SOURCE: Reference [1], 133]

3.5.29
seamy
rock mass (3.5.25) with many thin layers

[SOURCE: IS 11358:1987, 2.126 d)]

3.5.30
self-supporting opening
opening, in good quality *rock masses* (3.5.25), made without using any kind of support system and which will stand for long periods of use

[SOURCE: IS 11358:1987, 2.274]

3.5.31
sheet
rock mass (3.5.25) having layers or beds 1 m to 3 m thick with thin horizontal seams

[SOURCE: IS 11358:1987, 2.126 b)]

3.5.32
thickness
perpendicular distance between bounding surfaces such as *bedding* (3.5.3) or *foliation* (3.5.9) planes of a *rock* (3.1.5)

[SOURCE: Reference [1], 124]

3.6 Discontinuity

3.6.1
angle of internal friction
<peak> slope of *strength* (3.9.31) envelope, corresponding to maximum *shear stress* (3.2.27) in shear stress/*displacement* (3.8.17) plot

[SOURCE: IS 11358:1987, 2.9]

3.6.2
angle of internal friction
<residual> angle corresponding to *shear stress* (3.2.27) at large *displacement* (3.8.17)

Note 1 to entry: That is, corresponding to *residual shear strength* (3.9.26).

[SOURCE: IS 11358:1987, 2.10, modified — Note 1 to entry was originally part of the definition.]

3.6.3
aperture
perpendicular distance between adjacent *rock* (3.1.5) walls of a *discontinuity* (3.6.13), in which the intervening space is air or water filled

[SOURCE: IS 11358:1987, 2.95 f)]

3.6.4
asperity
small undulation along a *discontinuity* (3.6.13)

Note 1 to entry: There are two types of asperities called primary and secondary asperities. Primary asperities are major asperities while secondary asperities are micro-undulations of the primary asperities.

[SOURCE: IS 11358:1987, 2.17, modified — Note 1 to entry was originally part of the definition.]

3.6.5
basic sliding angle of friction of joint
angle of *sliding* (3.8.36) friction between flat non-dilatant *rock* (3.1.5) surfaces in dry or wet conditions

Note 1 to entry: It is obtained from residual tests on flat unweathered *rock* (3.1.5) surfaces.

[SOURCE: IS 11358:1987, 2.23, modified — Note 1 to entry was originally part of the definition.]

3.6.6
block
general term for individual pieces of *rock* (3.1.5) bounded by *discontinuities* (3.6.13) in a *rock mass* (3.5.25)

Note 1 to entry: See Reference [4].

3.6.6.1
block size
rock (3.1.5) *block* (3.6.6) dimensions resulting from the mutual *orientation* (3.6.25) of intersecting *joint sets* (3.6.23.3)

Note 1 to entry: Resulting from the *spacing* (3.6.13.5) of the individual *discontinuities* (3.6.13) may further influence the block size and shape.

[SOURCE: IS 11358:1987, 2.95 k), modified — Note 1 to entry was originally part of the definition.]

3.6.7
break
discontinuity (3.6.13) in the *rock* (3.1.5), such as fault, *fracture* (3.6.20), or a small cavity

Note 1 to entry: See Reference [4].

3.6.8
circular wedge failure
failure (3.6.15) defined by a single *discontinuity surface* (3.6.14)

Note 1 to entry: Circular wedge failure occurs by having weak materials in soil slope, the *rock mass* (3.5.25) very heavily jointed or broken as in waste dump and will tend to follow a circular *failure* (3.6.15) path.

3.6.9
condition of joint
parameter which includes *roughness* (3.6.13.2) of *joint* (3.6.23) surfaces, their continuity, their opening or separation (distance between the surface), the infilling (gouge) material, and *weathering* (3.1.8) of the wall *rock* (3.1.5)

[SOURCE: IS 11358:1987, 2.63]

3.6.10
conjugate joint
conjugate fault
two sets of *joints* (3.6.23) (faults) that formed under the same *stress* (3.2.29) conditions (usually shear pairs)

[SOURCE: Reference [1], 149]

3.6.11
crack
small *fracture* (3.6.20) that is small with respect to the scale of the feature in which it occurs

[SOURCE: Reference [1], 122]

3.6.11.1
macrofracture
crack (3.6.11) in *rock* (3.1.5) wider than 0,1 mm

Note 1 to entry: This may be up to several metres or more in length.

[SOURCE: IS 11358:1987, 2.185, modified — Note 1 to entry was originally part of the definition.]

3.6.11.2
tension crack
vertical *cracks* (3.6.11) which occur on the top terrace of a slope which is under distress

Note 1 to entry: These cracks are called tension cracks, as they develop due to existence of *tensile stresses* (3.2.33) in that region.

Note 2 to entry: Tension cracks can also occur along the slope but this is usually rare.

[SOURCE: IS 11358:1987, 2.324, modified — Notes 1 and 2 to entry were originally part of the definition.]

3.6.12
cross joint
joint (3.6.23) which generally occurs in a direction normal to bedding plane

Note 1 to entry: This is invariably discontinuous *joint* (3.6.23).

[SOURCE: IS 11358:1987, 2.76, modified — Note 1 to entry was originally part of the definition.]

3.6.13
discontinuity
collective term for most types of *joints* (3.6.23), weak bedding planes, weak *schistosity* (3.5.28) planes, weakness zones and faults

Note 1 to entry: The ten parameters selected to describe discontinuities and *rock masses* (3.5.25) are *orientation* (3.6.25), *spacing* (3.6.13.5), *persistence* (3.6.13.1), *roughness* (3.6.13.2), *wall strength* (3.6.13.6), *aperture* (3.6.3), *filling* (3.6.17), *seepage* (3.6.13.3), *number of sets* (3.6.23.16) and *block size* (3.6.6.1).

Note 2 to entry: Adapted from IS 11358:1987, 2.95.

3.6.13.1
persistence
discontinuity (3.6.13) trace length as observed in an exposure and which may give a crude measure of the areal extent or penetration length of a discontinuity

Note 1 to entry: Termination in solid *rock* (3.1.5) or against other *discontinuities* (3.6.13) reduces the persistence.

[SOURCE: IS 11358:1987, 2.95 c), modified — Note 1 to entry was originally part of the definition.]

3.6.13.2
roughness
inherent surface roughness and waviness relative to the mean plane of a *discontinuity* (3.6.13)

Note 1 to entry: Both roughness and waviness contribute to the shear *strength* (3.9.31); large scale waviness may also alter the dip locally.

[SOURCE: IS 11358:1987, 2.95 d), modified — Note 1 to entry was originally part of the definition.]

3.6.13.3
seepage
water flow and free moisture visible in individual *discontinuities* (3.6.13) or in the *rock mass* (3.5.25) as a whole

[SOURCE: IS 11358:1987, 2.65 b)]

3.6.13.4
slabbing
creation of axial *cracks* (3.6.11) due to uniaxial *compressive stresses* (3.2.6), which results in slabs of *rock* (3.1.5) popping out into the cavity

[SOURCE: IS 11358:1987, 2.288]

3.6.13.5
spacing
perpendicular distance between adjacent *discontinuities* (3.6.13)

Note 1 to entry: Normally refers to the mean or moda J spacing of a set of *joints* (3.6.23).

[SOURCE: IS 11358:1987, 2.95 b), modified — Note 1 to entry was originally part of the definition.]

3.6.13.6
wall strength
equivalent compression *strength* (3.9.31) of the adjacent *rock* (3.1.5) walls of a *discontinuity* (3.6.13)

Note 1 to entry: It may be lower than *rock* (3.1.5) *block* (3.6.6) *strength* (3.9.32) due to *weathering* (3.1.8) or alteration of the walls.

Note 2 to entry: An important component of shear strength if *rock* (3.1.5) walls are in contract.

[SOURCE: IS 11358:1987, 2.95 e), modified — Notes 1 and 2 to entry was originally part of the definition.]

3.6.14
discontinuity surface
surface across which some property of a *rock mass* (3.5.25) is discontinuous

Note 1 to entry: This includes *fracture* (3.6.20) surfaces, weakness planes, and bedding planes, but the term should not be restricted only to mechanical continuity.

[SOURCE: Reference [1], 116, modified — Note 1 to entry was originally part of the definition.]

3.6.15
failure
exceeding the maximum *strength* (3.9.31) of the *rock*

[SOURCE: Reference [1], 101, adapted]

3.6.15.1
catastrophic failure
failure (3.6.15) of large *rock mass* (3.5.25) giving almost no warning

EXAMPLE A sudden *failure* (3.6.15).

[SOURCE: IS 11358:1987, 2.53, modified — EXAMPLE was originally part of the definition.]

3.6.15.2
failure criterion
theoretically or empirically derived *stress* (3.2.29) or *strain* (3.3.11) relationship characterizing the occurrence of *failure* (3.6.15) in the *rock* (3.1.5)

[SOURCE: Reference [1], 102]

3.6.15.3
plane wedge failure
failure (3.6.15) which occurs when a geological *discontinuity* (3.6.13) such as a bedding plane, strikes parallel to the slope face and dips into the excavation at an angle greater than the angle of friction

[SOURCE: IS 11358:1987, 2.220]

3.6.16
fault gouge
clay-like material occurring between the walls of a fault as a result of the movement along the fault surfaces

[SOURCE: Reference [1], 151]

3.6.17
filling
material generally occupying the space between *joint* (3.6.23) surfaces, faults, and other *rock* (3.1.5) *discontinuities* (3.6.13)

Note 1 to entry: The filling material may be clay, gouge, various natural cementing agents, or alteration products of the adjacent *rock* (3.1.5).

[SOURCE: Reference [1], 142, modified — Note 1 to entry was originally part of the definition.]

3.6.18
fissure
gapped *fracture* (3.6.20)

[SOURCE: Reference [1], 120]

3.6.19
foliation parting
small *discontinuity* (3.6.13) developed along the *foliation* (3.5.9) planes in metamorphic rocks

Note 1 to entry: See Reference [4].

3.6.20
fracture
mechanical *discontinuity* (3.6.13) in the *rock* (3.1.5)

Note 1 to entry: It therefore is the collective term for *joints* (3.6.23), faults, *cracks* (3.6.11), etc.

[SOURCE: Reference [1], 119, modified — Note 1 to entry was originally part of the definition.]

3.6.20.1
angle of friction of fracture
sliding (3.8.36) angle (tangential) of friction at normal pressure of 10 kg/cm^2 across *joints* (3.6.23)

[SOURCE: IS 11358:1987, 2.8]

3.6.20.2
brittle fracture
sudden *failure* (3.6.15) with complete loss of *cohesion* (3.2.4) across a plane

[SOURCE: Reference [1], 104]

3.6.20.3
fracture index
ratio of seismic velocity for *intact rock* (3.5.13) samples to seismic velocity of *rock mass* (3.5.25) in situ

Note 1 to entry: See Reference [4].

3.6.20.4
fracture frequency
number of natural *discontinuities* (3.6.13) in a *rock* (3.1.5) or soil mass per unit length, measured along a core or as exposed in a planar section such as the wall of a tunnel

[SOURCE: ASTM D653-14]

3.6.20.5
fracture pattern
spatial arrangement of a group of *fracture* (3.6.20) surfaces

[SOURCE: Reference [1], 105]

3.6.21
footwall
mass of *rock* (3.1.5) beneath a *discontinuity surface* (3.6.14)

[SOURCE: Reference [1], 138]

3.6.22
hanging wall
mass of *rock* (3.1.5) above a *discontinuity surface* (3.6.14)

[SOURCE: Reference [1], 137]

3.6.23
joint
break (3.6.7) of geological origin in the continuity of a body of rock along which there has been no visible displacement

[SOURCE: IS 11358:1987, 2.160]

3.6.23.1
joint alteration number
J_a
degree of alteration of the *joint* (3.6.23) surface used in classification of a *rock mass* (3.5.25) by the Q-system

[SOURCE: IS 11358:1987, 2.161]

3.6.23.2
joint diagram
diagram constructed by accurately plotting the strike and dip of *joints* (3.6.23) to illustrate the geometrical relationship of the joints within a specified area of geologic investigation

[SOURCE: Reference [1], 148]

3.6.23.3
joint set
fault set
group of more or less parallel *joints* (3.6.23)

[SOURCE: Reference [1], 145]

3.6.23.4
joint system
fault system
system consisting of two or more *joint sets* (3.6.23.3) or any group of *joints* (3.6.23) with a characteristic pattern, that is, radiating, concentric, etc.

[SOURCE: Reference [1], 146]

3.6.23.5
joint frequency
number of *joints* (3.6.23) per meter for a given set of joints

[SOURCE: IS 11358:1987, 2.162]

3.6.23.6
joint opening
mean opening of surfaces of *joints* (3.6.23) of the same set

[SOURCE: IS 11358:1987, 2.163]

3.6.23.7
joint orientation
orientation (3.6.25) measured by the dip and strike of *joints* (3.6.23)

[SOURCE: IS 11358:1987, 2.164]

3.6.23.8
joint pattern
group of *joints* (3.6.25) that form a characteristic geometrical relationship, and which can vary considerably from one location to another within the same geologic formation

[SOURCE: Reference [1], 147]

3.6.23.9
joint roughness coefficient
J_{RC}
joint (3.6.23) parameter which accounts for *roughness* (3.6.13.2) of a joint profile

Note 1 to entry: Its value is higher for rougher joints. The value of the joint roughness coefficient can be obtained by comparing joint surfaces with typical roughness profiles. Its value may also be obtained from a tilt test on *rock* (3.1.5) joints surface.

[SOURCE: IS 11358:1987, 2.165, modified — Note 1 to entry was originally part of the definition.]

3.6.23.10
joint roughness number
J_r
roughness (3.6.13.2) of a *joint* (3.6.23) profile used in classification of *rock mass* (3.5.25) by the Q-system

[SOURCE: IS 11358:1987, 2.166]

3.6.23.11
joint set number
J_n
number of *joint sets* (3.6.23.3) present in the *rock mass* (3.5.25)

Note 1 to entry: The joint set number is used in the classification of a rock mass by the Q-system.

[SOURCE: IS 11358:1987, 2.167, modified — Note 1 to entry was originally part of the definition.]

3.6.23.12
joint spacing
spacing (3.6.13.5) between two adjacent *joints* (3.6.23) of the same set

[SOURCE: IS 11358:1987, 2.168]

3.6.23.13
joint wall compressive strength
J_{CS}
parameter of a *joint* (3.6.23) wall which gives the *compressive strength* (3.9.10) of the *asperities* (3.6.4) of the joint surface in clean unweathered joints

Note 1 to entry: The joint wall compressive strength may be taken as the minimum value of uniaxial compressive strength of *rock* (3.1.5) cores, otherwise it may be obtained from the correlation between the Schmidt hammer number and the uniaxial compressive strength.

Note 2 to entry: It is expressed in kg/cm^2.

[SOURCE: IS 11358:1987, 2.171, modified — Notes 1 and 2 to entry were originally part of the definition.]

3.6.23.14
joint water reduction factor
J_w
measure of water pressure which has an adverse effect on shear *strength* (3.9.31) of *joints* (3.6.23) due to reduction in *normal stress* (3.2.20)

Note 1 to entry: Water may, in addition, cause softening and possible outwash in the case of clay filled joints.

[SOURCE: IS 11358:1987, 2.172, modified — Note 1 to entry was originally part of the definition.]

3.6.23.15
normal stiffness of joint
K_n
normal pressure corresponding to unit closure of the joint

Note 1 to entry: The ratio between the *Young's modulus* (3.4.1) of the *rock material* (3.1.6) and the normal *stiffness* (3.9.30) of a clean unweathered *joint* (3.6.23) is generally a constant which varies as 60, 25, 5 cm for continuous, discontinuous joints and *cleavage planes* (3.5.5) respectively.

Note 2 to entry: It is expressed in kg/cm^2.

[SOURCE: IS 11358:1987, 2.169 a), modified — Notes 1 and 2 to entry were originally part of the definition.]

3.6.23.16
number of sets
number of *joint sets* (3.6.23.3) comprising the intersecting *joint system* (3.6.23.4)

Note 1 to entry: The *rock mass* (3.5.25) may be further divided by individual *discontinuities* (3.6.13).

[SOURCE: IS 11358:1987, 2.95 j), modified — Note 1 to entry was originally part of the definition.]

3.6.23.17
shear stiffness of joint
K_s
shear stress (3.2.27) corresponding to unit slip across the joint

Note 1 to entry: It is generally taken as the ratio of shear *strength* (3.9.32) of *joint* (3.6.23) and the peak slip which is normally taken equal to 1/100 of the length of joint surface along the slip direction.

Note 2 to entry: It is expressed in kg/cm^2.

Note 3 to entry: It should be noted that shear *stiffness* (3.9.30) of a joint is very small compared to its normal stiffness.

[SOURCE: IS 11358:1987, 2.169 b), modified — Notes 1, 2 and 3 to entry were originally part of the definition.]

3.6.24
mylonite
microscopic breccia with flow structure formed in *fault* zones

[SOURCE: Reference [1], 144]

3.6.25
orientation
attitude of a *discontinuity* (3.6.13) in space described by the dip direction (azimuth) and dip of the line of steepest inclination in the plane of the *discontinuity* (3.6.13)

Note 1 to entry: Termination in solid *rock* (3.1.5) or against other *discontinuity* (3.6.13) reduces the *persistence* (3.6.13.1).

[SOURCE: IS 11358:1987, 2.95 a), modified — Note 1 to entry was originally part of the definition.]

3.6.26
peak shear strength
maximum shear *strength* (3.9.31) along a *failure* (3.6.15) surface

[SOURCE: IS 11358:1987, 2.210]

3.6.27
plane of weakness
<zonary> surface or narrow zone with a (shear or tensile) *strength* (3.9.31) lower than that of the surrounding material

[SOURCE: Reference [1], 107]

3.6.28
plane of weakness
<rock> plane in *rocks* (3.1.5) that affects its structural properties

Note 1 to entry: The planes may be the result of *joints* (3.6.23), *fractures* (3.6.20), faults, *bedding* (3.5.3) or partings.

[SOURCE: IS 11358:1987, 2.219, modified — Note 1 to entry was originally part of the definition.]

3.6.29
progressive failure
failure (3.6.15) as a result of formation and development of localized *fractures* (3.6.20)

Note 1 to entry: The development of localized fractures is the result of increasing *stress* (3.2.29), possibly creating a continuous fractured surface with steady deterioration of the *rock* (3.1.5).

[SOURCE: Reference [1], 103, adapted]

3.6.30
rupture
stage in the development of a *fracture* (3.6.20) where instability occurs

Note 1 to entry: It is not recommended that the term rupture be used in *rock mechanics* (3.1.7) as a synonym for fracture.

[SOURCE: Reference [1], 121, modified — Note 1 to entry was originally part of the definition.]

3.6.31
shear failure
failure by rupture
failure (3.6.15) in which movement is caused by *shearing stresses* (3.2.27) in a *rock mass* (3.5.25)

[SOURCE: IS 11358:1987, 2.276]

3.6.32
volumetric joint count
J_v
total number of *joints* (3.6.23) in a unit cube of *rock mass* (3.5.25) of 1 m^3 volume

[SOURCE: IS 11358:1987, 2.345]

3.7 Anisotropy and inhomogeneity

3.7.1
anisotropy
quality of having different properties in different directions

EXAMPLE The state of geologic strata of transmitting sound waves with different velocities in vertical and horizontal directions.

Note 1 to entry: Situation of a material having different moduli of *deformation* (3.8.13) in different directions.

[SOURCE: IS 11358:1987, 2.11, modified — EXAMPLE and Note 1 to entry were originally part of the definition.]

3.7.2
heterogeneity
quality of having different properties at different points

[SOURCE: Reference [1], 84]

3.7.3
homogeneity
quality of having the same properties at different points

[SOURCE: Reference [1], 83]

3.7.4
isotropy
quality of having the same properties in all directions

[SOURCE: Reference [1], 86]

3.7.5
strength anisotropy index
ratio of the corrected point load *strength* (3.9.31) indices for tests, perpendicular and parallel to planes of weakness in samples of an *intact rock* (3.5.13)

[SOURCE: IS 11358:1987, 2.310]

3.7.6
transverse anisotropy
anisotropy (3.7.1) of sedimentary deposits of very special nature

Note 1 to entry: Only five elastic constants are sufficient to define the anisotropy of the *rock mass* (3.5.25).

[SOURCE: IS 11358:1987, 2.11.1, modified — Note 1 to entry was originally part of the definition.]

3.8 Mechanical behaviour of rock

3.8.1
bending
process of *deformation* (3.8.13) normal to the axis of an elongated structural member when a moment is applied normal to its long axis

[SOURCE: Reference [1], 18]

3.8.2
blastability
index value of the resistance of a *rock mass* (3.5.25) to blasting

[SOURCE: IS 11358:1987, adapted]

3.8.3
body force
force such as gravity whose effect is distributed throughout a material body by direct action on each elementary part of the body independent of the others

[SOURCE: Reference [1], 39]

3.8.4
brittle
material under conditions in which its *stability* (3.2.28) to resist loads decrease suddenly with increasing *deformation* (3.8.13)

[SOURCE: IS 11358:1987, 2.43]

3.8.5
buckling
instability of a column or a plate under sufficient high load due to sudden deflection of the structure

[SOURCE: Reference [1], 111]

3.8.6
bulk volume
volume contained within the gross external dimensions of a *rock* (3.1.5) specimen, denoting the volume occupied by the grains, voids and intergranular infillings

[SOURCE: IS 11358:1987, 2.46]

3.8.7
bump
<coal mine> strong seismic shock resulting from a *failure* (3.6.15) or a sudden *displacement* (3.8.17) at some point in the *rock* (3.1.5) surrounding an underground opening

[SOURCE: IS 11358:1987, 2.47]

3.8.8
burst
to *break* (3.6.7) suddenly into pieces from impact or from pressure within

[SOURCE: IS 11358:1987, 2.49]

3.8.9
constitutive equation
force *deformation* (3.8.13) function for a particular material

[SOURCE: Reference [1], 73]

3.8.10
creep
time dependent *deformation* (3.8.13) or *strain* (3.3.11)

Note 1 to entry: It is deformation that occurs over a period of time when a material is subjected to constant *stress* (3.2.29) at constant temperature.

Note 2 to entry: It is slow deformation that results from long application of stress.

Note 3 to entry: An imperceptibly slow, more or less continuous, downward and outward movement of slope-forming *rock* (3.1.5) or soil.

[SOURCE: IS 11358:1987, 2.37, modified — Notes 1, 2 and 3 to entry were originally part of the definition.]

3.8.10.1
creep strength
maximum *stress* (3.2.29) required to bring about a specified amount of *creep* (3.8.10) in a specified time

[SOURCE: IS 11358:1987, 2.74]

3.8.11
damping
reduction in the amplitude of vibration of a body or system due to dissipation of energy internally or by radiation

[SOURCE: Reference [1], 54]

3.8.12
decay time
interval of time required for a pulse to decay from its maximum value to some specified fraction of that value

[SOURCE: Reference [1], 56]

3.8.13
deformation
change in the shape or size of a solid body

[SOURCE: Reference [1], 27]

3.8.14
detritus
deposit of material produced by the *weathering* (3.1.8) and disintegration of *rocks* (3.1.5) that has been moved from its place of origin

[SOURCE: IS 11358:1987, 2.92]

3.8.15
dilatation
volumetric strain
quotient of the change in volume and the original volume of an element of material under *stress* (3.2.29)

[SOURCE: Reference [1], 26]

3.8.16
dispersion
phenomenon of varying speed of transmission of waves, depending on their frequency

[SOURCE: Reference [1], 57]

3.8.17
displacement
change in position of a material point

[SOURCE: Reference [1], 29]

3.8.18
distortion
change in shape of a solid body

[SOURCE: Reference [1], 28]

3.8.19
dynamic elastic modulus
E_{dyn}
modulus of elasticity (3.4.1) of *rock mass* (3.5.25) under dynamic loads

Note 1 to entry: During propagation of seismic waves through a rock mass it is the dynamic modulus which determines the velocity of waves.

Note 2 to entry: The static modulus is less than the dynamic modulus.

Note 3 to entry: The ratio of static to dynamic modulus is called the reduction factor which can be estimated from the *rock* (3.1.5) quality designation.

[SOURCE: IS 11358:1987, 2.106, modified — Notes 1, 2 and 3 to entry were originally part of the definition.]

3.8.20
external force
force that acts across external surface elements of a material body

[SOURCE: Reference [1], 40]

3.8.21
fatigue
decrease of *strength* (3.9.31) by repetitive loading

Note 1 to entry: On the other hand, fatigue is permanent structural change that occurs in a material subjected to fluctuating *stress* (3.2.29) and *strain* (3.3.11).

Note 2 to entry: In general, fatigue *failure* (3.6.15) occurs at a stress level below the *elastic limit* (3.9.15).

[SOURCE: Reference [1], 79, modified — Notes 1 and 2 to entry have been added.]

3.8.21.1
fatigue limit
point on *stress* (3.2.29)-*strain* (3.3.11) curve below which no *fatigue* (3.8.21) can be obtained regardless of number of loading cycles

[SOURCE: Reference [1], 80]

3.8.22
hysteresis
incomplete recovery of *strain* (3.3.11) during unloading cycle due to energy consumption

[SOURCE: Reference [1], 85]

3.8.23
long-term rock pressure
ultimate *rock* (3.1.5) pressure on the supports in underground openings

[SOURCE: IS 11358:1987, 2.181]

3.8.24
loosening pressure
rock (3.1.5) pressure exerted at supports by dead weight of loosened *rock mass* (3.5.25) above a cavity

[SOURCE: IS 11358:1987, 2.182]

3.8.25
mathematical model
representation of a physical system by mathematical expressions from which the behaviour of the system can be deduced with known accuracy

[SOURCE: Reference [1], 10]

3.8.26
plastic deformation
deformation (3.8.13) that remains after the load causing it is removed

Note 1 to entry: It is the permanent part of the deformation beyond the *elastic limit* (3.9.15) of a material resulting in plastic *strain* (3.3.11), plastic flow and irrecoverable.

[SOURCE: IS 11358:1987, 2.221, modified — Note 1 to entry was originally part of the definition.]

3.8.27
point load strength index
I_s
point load *strength* (3.9.31) of a *rock* (3.1.5) core tested in point load tester

Note 1 to entry: It is defined as the ratio of peak load at *failure* (3.6.15) to the square of diameter of core.

Note 2 to entry: The standard size of the core is Nx size that is, about 50 mm.

[SOURCE: IS 11358:1987, 2.225, modified — Notes 1 and 2 to entry were originally part of the definition.]

3.8.28
quasi-elastic
seemingly almost elastic

Note 1 to entry: It is considered as elastic for practical purposes.

[SOURCE: IS 11358:1987, 2.236, modified — Note 1 to entry was originally part of the definition.]

3.8.29
retardation
delay in *deformation* (3.8.13)

[SOURCE: Reference [1], 97]

3.8.30
rock burst
sudden explosive-like release of energy due to the *failure* (3.6.15) of a *brittle* (3.8.4) *rock* (3.1.5) of high *strength* (3.9.31)

[SOURCE: Reference [1], 108]

3.8.31
sagging
phenomenon that usually occurs in sedimentary rock *formations* (3.5.17) as separation and downward *bending* (3.8.1) of sedimentary beds in the roof of an underground opening

[SOURCE: IS 11358:1987, 2.264]

3.8.32
scabbing
fracturing of *rock* (3.1.5) in the form of slabs, due to interference between the wave front of an incident compressive wave and its reflection from *rock* (3.1.5) surfaces

[SOURCE: IS 11358:1987, 2.266]

3.8.33
shear force
force directed parallel to the surface element across which it acts

[SOURCE: Reference [1], 42]

3.8.34
shear plane
plane along which *failure* (3.6.15) of material occurs by shearing

[SOURCE: Reference [1], 71]

3.8.35
size effect
influence of specimen size on its *strength* (3.9.31) or other mechanical parameters

[SOURCE: Reference [1], 113]

3.8.36
sliding
relative *displacement* (3.8.17) of two bodies along a surface, without loss of contact between the bodies

[SOURCE: Reference [1], 109]

3.8.37
spalling
<line> longitudinal splitting in *uniaxial compression* (3.2.36)

[SOURCE: Reference [1], 110]

3.8.38
spalling
<surface> breaking-off of plate-like pieces from a free *rock* (3.1.5) surface

[SOURCE: Reference [1], 110]

3.8.39
subsidence
downward *displacement* (3.8.17) of the *overburden* (3.5.21) (*rock* (3.1.5) or soil, or both) lying above an underground excavation or adjoining a surface excavation

Note 1 to entry: It is also the sinking of a part of the Earth's crust.

[SOURCE: Reference [1], 139, modified — Note 1 to entry was originally part of the definition.]

3.8.40
surface force
force that acts across an internal or external surface element in a material body, not necessarily in a direction lying in the surface

[SOURCE: Reference [1], 43]

3.8.41
transverse wave
shear wave
wave in which the *displacement* (3.8.17) at each point of the medium is parallel to the wave front

[SOURCE: Reference [1], 62]

3.9 Physical properties of rock

3.9.1
abrasive
rock (3.1.5), mineral, or other substance that, owing to its superior *hardness* (3.9.17), *toughness* (3.9.32.4), consistency, or other properties, is suitable for grinding, cutting, polishing, scouring, or similar use

[SOURCE: ASTM D653-14]

3.9.2
abrasiveness
property of a material to remove matter when scratching and grinding another material

[SOURCE: Reference [1], 250]

3.9.3
angular
shape term for a *rock* (3.1.5) particle with sharp edges and corners

Note 1 to entry: See Reference [4].

3.9.4
bearing pressure
load per unit area which can be safely supported by the *ground* (3.5.10) (*rock* (3.1.5) and/or soil)

[SOURCE: IS 11358:1987, 2.24]

3.9.5
bond strength
stress (3.2.29) required to *rupture* (3.6.30) the bond in a material, or between two kinds of material cemented one to another

EXAMPLE A concrete *block* (3.6.6) cemented on *rock* (3.1.5).

[SOURCE: IS 11358:1987, 2.286, modified — EXAMPLE was originally part of the definition.]

3.9.6
bulk modulus
incompressibility
ratio of *hydrostatic pressure* (3.2.13) to the *volumetric strain* (3.8.15) which it produces

[SOURCE: Reference [1], 93]

3.9.7
coefficient of volumetric expansion
ratio between the increase in volume of *rock mass* (3.5.25) and its initial volume

[SOURCE: IS 11358:1987, 2.60]

3.9.8
cohesion
<physical properties> property of *rock* (3.1.5) particles to bind together, given by the vertical intercept or *strength* (3.9.31) envelope, that is, of shear strength versus *normal stress* (3.2.20) plot

Note 1 to entry: Compare with *cohesion* (3.2.4).

[SOURCE: IS 11358:1987, 2.61]

3.9.9
compressibility
property of a soil or *rock* (3.1.5) pertaining to its susceptibility to decrease in volume when subjected to load

[SOURCE: ASTM D653-14]

3.9.10
compressive strength
uniaxial compressive strength
unconfined compressive strength
load per unit area at which an unconfined cylindrical specimen of soil or *rock* (3.1.5) will fail in a simple compression test

Note 1 to entry: Commonly the *failure* (3.6.15) load is the maximum that the specimen can withstand in the test.

[SOURCE: ASTM D653-14, modified — Note 1 to entry was originally part of the definition.]

3.9.11
degree of squeezing
ratio of *uniaxial compressive strength* (3.9.10) (q_c) of *rock mass* (3.5.25) to the tangential *stress* (3.2.29) (σ_θ)

Note 1 to entry: The degree of squeezing may be mild, moderate or high depending upon the value of q_c / σ_θ.

[SOURCE: IS 11358:1987, 2.87, modified — Note 1 to entry was originally part of the definition.]

3.9.12
density
ρ
mass per unit volume

[SOURCE: IS 11358:1987, 2.89]

3.9.12.1
dry density
ρ_d
mass of a *rock* (3.1.5) sample or specimen after drying to constant mass at 150 °C per unit gross volume of the sample or specimen

[SOURCE: IS 11358:1987, 2.103]