Sub → Engg. Geology
Faculty Name → Gaurav Srivastava
Branch → Civil
Year → 2nd
Unit → 2

Topics Covered: Faults, Joint, Unconformity: and their classification, causes & relation to Civil Engg.

[C. Unit 2 : contd. from last class]

4.3 FAULT & FAULTING

- Those fractures along which there has been relative movement of the blocks past each are termed as **FAULTS.**
- The entire process of development of fractures and displacement the blocks against each other is termed as

FAULTING CLASSIFICATION OF FAULTS

Following factors are more commonly considered important in classification of faults:

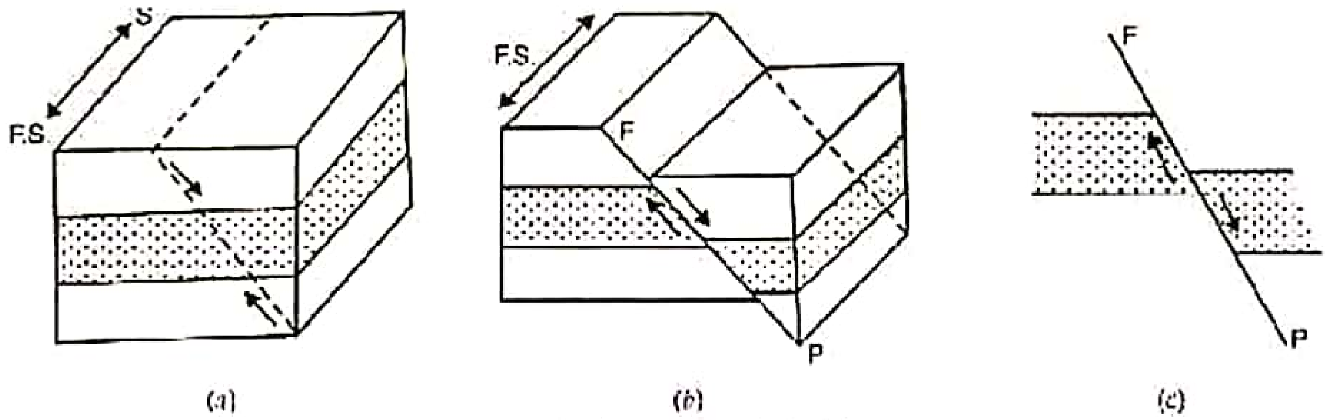
The apparent movement of the disrupted blocks along the fault plane;
The direction of slip;
The relation of fault attitude with the attitude of the displaced beds;
The amount of dip of the fault;

Mode of Occurrence.

Three fundamental types of faults are commonly distinguished on the basis of apparent movement: normal faults, reverse faults and strike slip faults.

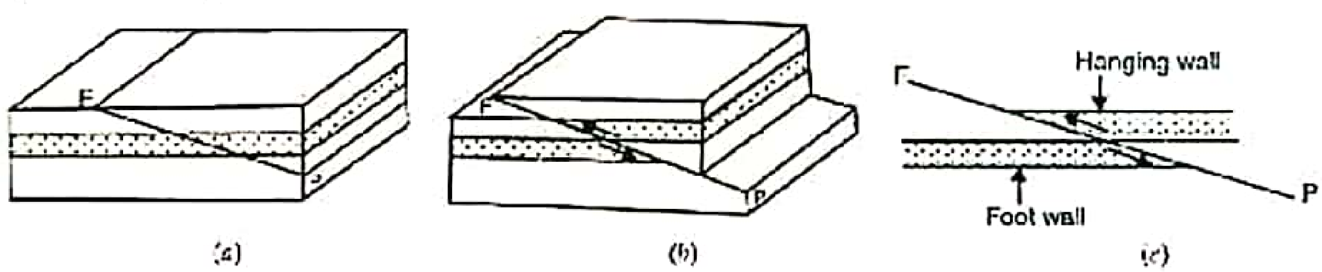
Normal Faults

- Such a fault in which hanging wall has apparently moved down with respect to footwall is classified as a Normal Fault.
- In this definition it is clearly implied that nothing can be said with certainty whether it was the hanging wall which moved down or the foot wall which moved up or both the walls moved down, the hanging wall moving more than the foot wall and hence the appearance.
- when the fault satisfies the definition of hanging wall standing at a lower position with respect to the footwall it may be classed as a normal fault.
- In normal faults, the fault plane may be inclined at any angle between horizontal and vertical, but most commonly, the fault angles are between 45 and vertical.
- further, due to the inclined nature of the fault plane and downward displacement of a part of the strata, normal faults cause an extension in the crust wherever they occur.



Reverse Faults

- It is such a type of fault in which the hanging wall appears to have moved up with respect to the footwall.
- In reverse faults, the fault plane is generally inclined between horizontal and 45 degrees although reverse faults with steeply inclined fault surface have been also encountered.
- By virtue of their inclination and direction of movement, reverse faulting involves shortening of the crust of the Earth (compare with normal faults).

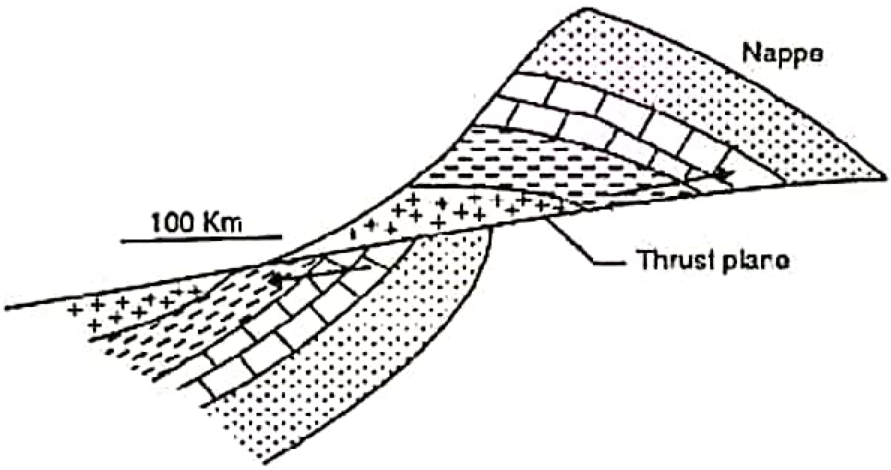


Thrust Faults

- Ø These are, broadly speaking, such varieties of reverse faults in which the hanging wall has moved up relative to the footwall and the faults dip at angles below 45 degrees.
- Ø The thrust faults or simply thrusts are of very common occurrence in folded mountains and seem to have originated as a further step in the process of adjustment of rocks to the imposed stresses.
- Ø Thrusts are sometimes further distinguished into two sub-types: the over thrusts and the under thrusts.

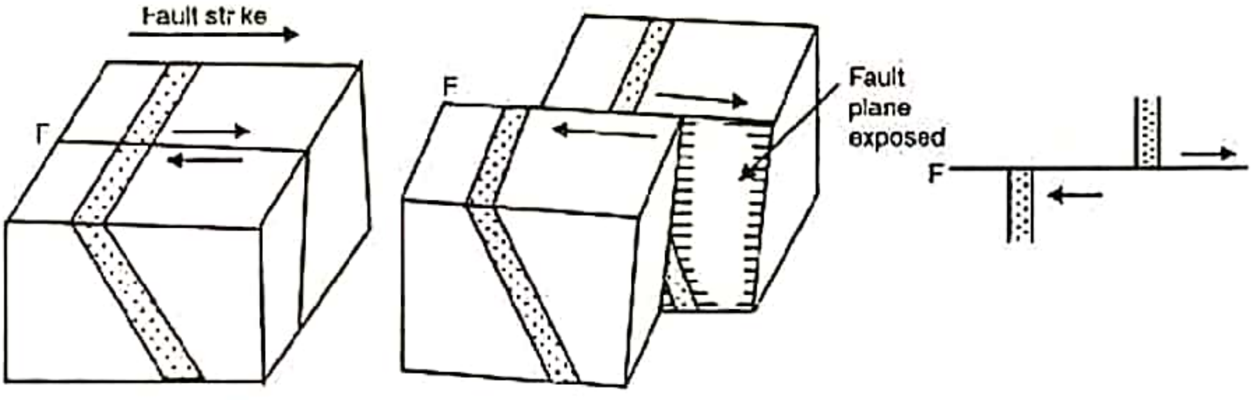
Nappes

- Ø This term is used for extensive blocks of rocks that have been translated to great distances, often ranging to several hundred kilometers, along a thrust plane.
- Ø The large-scale movement maybe attributed to a major over thrusting or a recumbent folding followed by thrust faulting.
- Ø When a series of thrust faults occur in close proximity, thrust blocks are piled up one above another and all fault surfaces dip in the same direction, the resulting interesting structure is known as an imbricate Structure.



Strike-Slip Faults

- Ø These may be defined as faults in which faulted blocks have been moved against each other in an essentially horizontal direction.
- Ø The fault plane is almost vertical and the net slip may be measured in great distances.
- Ø There are some other terms used for strike slip faults such as lateral faults, transverse faults, wrench faults and transform faults.
- Ø Of these, the transform faults are very common and denote strike slip faults specially developed in oceanic ridges.



(a) Before faulting. (b) After faulting. (c) Plan.

ENGINEERING CONSIDERATIONS

- Ø The safety of a civil engineering structure built on or near a faulted rock can be ascertained only in a general way.
- Ø The tectonic history of the area under consideration must be known (or studied if not known) thoroughly.
- Ø Faults of any significance are always associated with earthquakes.
- Ø So, such a study would virtually mean obtaining information about frequency of the earthquakes as also their magnitude and effects that they have left from time to time on the rocks of the region.
- Ø The exact position of the area of construction with respect to the seismic zoning of the country must be thoroughly established.
- Ø Even if the evidence collected from the study of the tectonic history of the area leads to the conclusion that no movement may be expected in the rocks of the area during the projected life span of the structure raised on them, some factor of safety must be introduced into the design of the structure, especially in the big projects in faulted areas, so that if the unexpected happens, there is minimum loss to the project.
- Ø In all big countries, maps of seismic classification are available.
- Ø In most cases recommendations of the statutory authorities are available about introducing suitable factor of safety in major civil engineering projects of any public importance that are proposed to be constructed in areas of known seismic zones.

4.4 JOINTS AND JOINTING

Terminology

- Ø Joints are defined as divisional planes or fractures along which there has been no relative displacement.
- Ø These fractures divide the rocks into parts or blocks and unlike the faults, the parts have not suffered any movement along the fracture plane.
- Ø There may be or may not be an opening up of blocks perpendicular to the joint planes.
- Ø Nature. Joints may be **open or closed** in nature.
- Ø **Open joints** are those in which the blocks have been separated or opened up

for small distances in a direction at right angles to the fracture surface.

- Ø These may be gradually enlarged by weathering processes and develop into fissure in the rocks.
- Ø In **closed joints**, there is no such separation.
- Ø Even then, these joints may be capable of allowing fluids (gases and water) to pass through the rock
- Ø Similarly, the joints may be smooth or rough on the surface and the surface may be straight or curved in outline the joints may be small in their extension

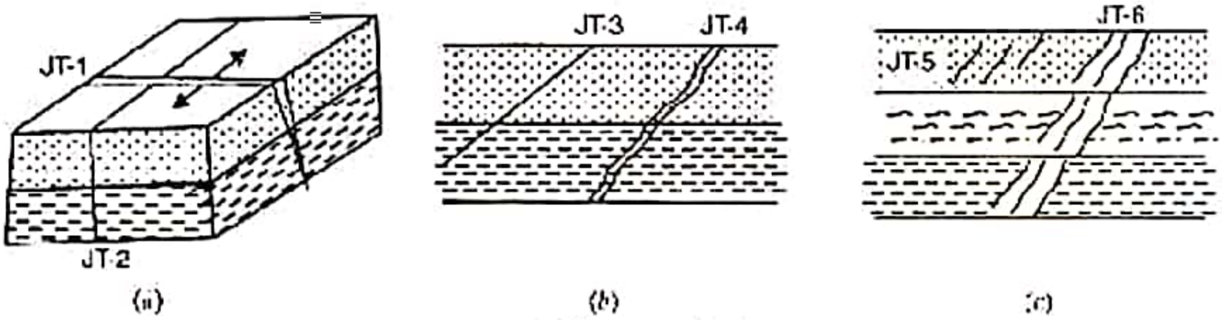


Fig. 7.26 Nature of Joints
JT-1, Open joint JT-2, Closed joint,
JT-3, Smooth joint JT-4, Rough joint,
JT-5, Small joint JT-6, Master joints

Attitude

- Ø Joints are fracture planes or surfaces and their occurrence often takes place in such a way that their position in space or attitude (dip and strike) may be described conveniently either independently or with respect to the attitude of the rocks in which they occur.

CLASSIFICATION

- Ø Joints have been classified on the basis of spatial relationships, geometry and genesis.

A. Spatial Relationship

All joints are divided into two main groups on the basis of presence or otherwise of some regularity in their occurrence:

1. Systematic joints (regular joints).

- Ø These show a distinct regularity in their occurrence which can be measured and mapped easily.
- Ø Such joints occur in parallel or sub-parallel joint sets that are repeated in the rocks at regular intervals.

- Ø The columnar joints and the mural joints described below are examples of regular or systematic jointing.

2. Nonsystematic (or irregular) joints.

- Ø As the name implies, these joints do not possess any regularity in their occurrence and distribution.
- Ø They appear at random in the rocks and may have incompletely defined surfaces. In many cases these are related to the systematic joints in that these occur between them.

- Ø At other times, the non- systematic joints may show no relationship with the systematic joints and their curved and rough surfaces may even cut across the former.

B. Geometry

In stratified rocks, joints are generally classified on the basis of relationship of their attitude with that of the rocks in which they occur.

Three types recognized on this basis are :

Strike joints in which the joint sets strike parallel to the strike of the rocks.

Dip joints in which the joint sets strike parallel to the dip direction of the rocks; **Oblique joints** are those joints where the strike of the joints is at any angle between the dip and the strike of the layers. These are also called diagonal joints when they occur midway between the dip and strike of the layers.

C. Genesis (Origin)

In such cases, joints are classified into one of the following genetic types:

Tension joints are those, which have developed due to the tensile forces acting on the rocks. The most common location of such joints in folded sequence is on the outer margins of crests and troughs. They are also produced in igneous rocks during their cooling. Joints produced in many rocks during the weathering of overlying strata and subsequent release of stresses by expansion are also thought to be due to the tensile forces (Fig. 7.31).

Shear joints. These are commonly observed in the vicinity of fault planes and shear zones where the relationship with shearing forces is clearly established (Fig. 7.32). In folded rocks, these are located in axial regions.

Compression joints. Rocks may be compressed to crushing and numerous joints may result due to the compressive forces in this case. In the core regions of folds where compressive forces are dominant, joints may be related to the compressive forces.

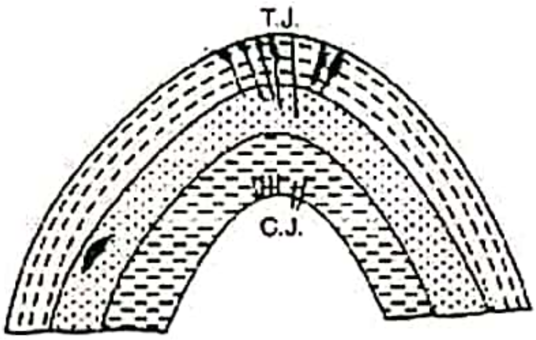


Fig. 7.31 Tension Joints (T.J).

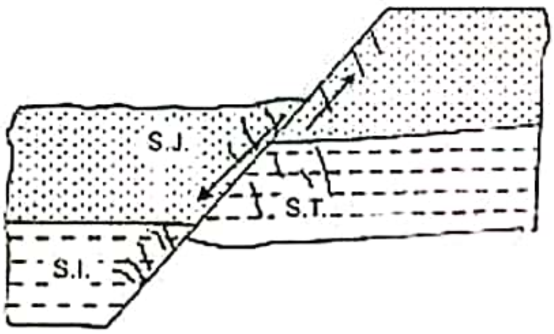


Fig. 7.32 Shear joints (SJ) and Compression Joints (C.J).

4.5 GEOPHYSICAL INVESTIGATIONS

A. Electrical Methods

Principle.

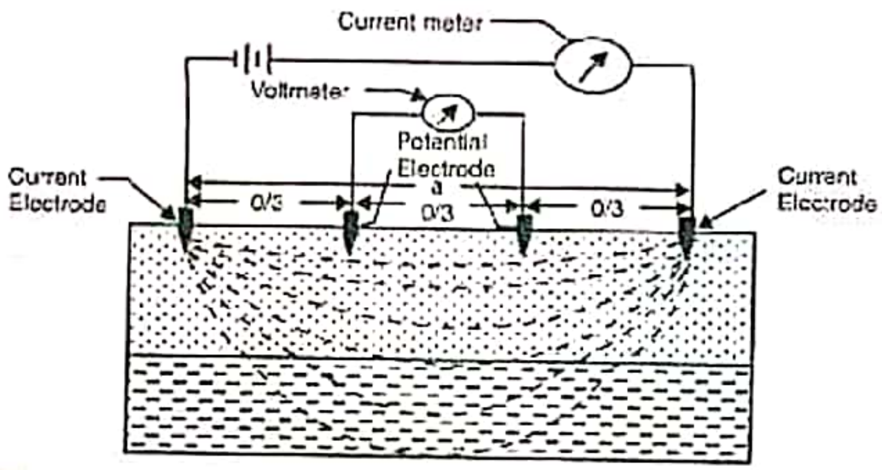
- Ø All electrical method are based on the fundamental fact that different materials of earth' s crust possess widely different electrical properties.
- Ø Resistivity, electrochemical activity and dielectrical constant are some of these properties that are generally studied through these methods
- Ø potential-drop methods: the natural potential may be due to electrochemical reactions between the solutions and the surrounding - subsurface rocks.
- Ø These reactions are not always of the same order throughout the dimensions of the

rock masses thereby creating a potential difference and conditions for flow of current from one end to the other end.

- Ø Elongated ore bodies of magnetite and pyrite etc. are easily delineated by this method.
- Ø Natural electrical potential is measured with the help of nonpolarising electrodes along definite directions and results are plotted in terms of potential gradient along horizontal distances which are then interpreted.

Potential Drop Methods.

- Ø These include a variety of methods in which electrical current is artificially introduced from an external source at certain points and then its flow through subsurface materials recorded at different distances.
- Ø In the Equipotential Method two primary electrodes are inserted into the ground, 6-7 meters apart from each other, across which current is introduced.
- Ø The position of these primary electrodes remains fixed in the subsequent investigations.
- Ø Potential between these primary electrodes is determined with the help of two search electrodes and points of equal potential found out along the entire region under investigations, which are jointed to get equipotential lines.



- Ø Under normal conditions, that is, when the material below is of uniform nature, electrically c the ec lines would be regular in character.
- Ø But in cases when the material w is not of uniform character (that is, it contains patches of high or low conductivity), equipotential lines would show clear distortions or irregularities which would include probable location of rock masses of different characteritics.
- Ø The Resistivity Method is similar to equipotential method but in this case it is the resistivity of the material of the subsurface which is determined and from which important interpretations are made
- Ø Here also, a known current is introduced through two electrodes- current electrodes, which are inserted at some distances apart from each other.,

$$\rho = 2\pi \frac{a.v}{I}$$

Unconformities

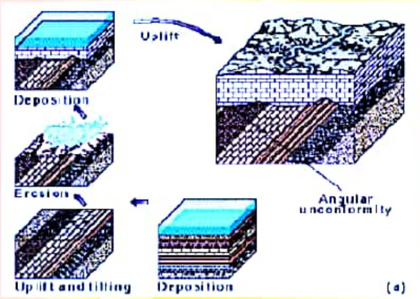
Unconformities are gaps in the geologic record that may indicate episodes of crustal deformation, erosion, and sea level variations. They are a feature of stratified rocks, and are therefore usually found in sediments (but may also occur in stratified volcanics). They are surfaces between two rock bodies that constitute a substantial break (hiatus) in the geologic record (sometimes people say inaccurately that "time" is missing). Unconformities represent times when deposition stopped, an interval of erosion removed some of the previously deposited rock, and finally deposition was resumed.

Commonly three types of unconformities are distinguished by geologists:

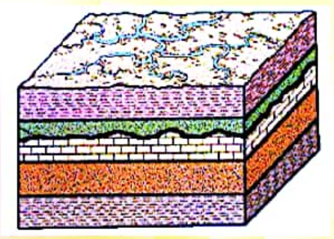
- ANGULAR UNCONFORMITIES
- DISCONFORMITIES
- NONCONFORMITIES

Angular Unconformities

are those where an older package of sediments has been tilted, truncated by erosion, and than a younger package of sediments was deposited on this erosion surface. The sequence of events is summarized in the pictures at left. **First:** ***subsidence*** and sediment ***deposition*** occurs; **Second:** rocks are ***uplifted*** and ***tilted*** (deformation); **Third:** ***erosion*** removes the uplifted mountain range; **Fourth:** ***subsidence*** occurs, the sea covers the land surface, and new sediments ***deposition*** occurs on top the previous land surface. Then the cycle may repeat.

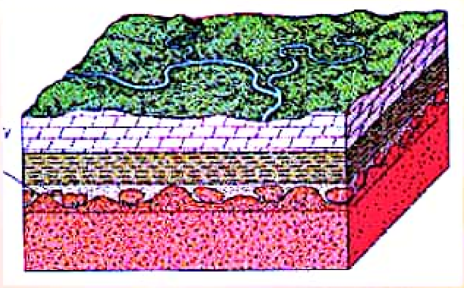


For geologists, one of the most famous angular unconformity is the *Grand Unconformity* in the Grand Canyon of Arizona. Here tilted sedimentary rocks of Precambrian age (lower half of photo) are overlain by younger sedimentary rocks of Phanerozoic age (Cambrian and younger, upper half of photo). The two packages of strata are clearly separated by an angular unconformity that is best seen just left of the center of the photo.



Disconformities are also an erosion surface between two packages of sediment, but the lower package of sediments was not tilted prior to deposition of the upper sediment package. The sequence of events is as follows: **First: *subsidence*** and sediment ***deposition***; **Second: *uplift*** and ***erosion***; **Third:** renewed ***subsidence*** and ***deposition***. Because the beds below and above the disconformity are parallel, disconformities are more difficult to recognize in the sedimentary record. In the diagram at left, the disconformity is indicated by an irregular black line between the 3rd and 4th rock unit from the bottom.

This picture shows a disconformity in Capitol Reef National Park, Utah. The Chinle Formation (Triassic), the slope forming unit in the central portion of the picture, has a very sharp contact (black line) with the overlying Wingate Sandstone (uppermost Triassic, forms steep cliff). This contact is considered a disconformity.



Nonconformities are unconformities that separate igneous or metamorphic rocks from overlying sedimentary rocks. They usually indicate that a long period of erosion occurred prior to deposition of the sediments (several km of erosion necessary). In the diagram at left, the igneous/metamorphic rocks below the nonconformity are colored in red.

A nonconformity at the base of the Grand Canyon succession. The dark rocks in the bottom of the gorge are Archean Vishnu schist, and are overlain by younger Proterozoic and Phanerozoic sediments.

A nonconformity in the Wind River gorge of Wyoming. The red line points out the irregular contact between Precambrian granitic rocks and Phanerozoic sediments.