

## Tunneling

- **Bedrock**- Generally indurated or crystalline materials that make up the Earth's crust.
- **Surficial Deposits**- relatively younger materials occurring at or near the Earth's surface overlying bedrock. They occur as two major classes: (1) **transported** deposits generally derived from bedrock materials by water, wind, ice, gravity, and man's intervention and (2) **residual** deposits formed in place as a result of weathering processes.
- **Overburden**- the mining term for “surficial deposits”
- **Classification of materials for tunneling**
  - **Intact rock**- spalls may drop off the roof hours or days after blasting
  - **Stratified Rock**- individual strata with little separation resistance. Spalling common
  - **Moderately jointed rock**- hairline cracks interlocked; vertical walls do not require support
  - **Blocky and seamy rock**- mostly intact rock fragments, imperfectly interlocked. May require support
  - **Crushed but chemically intact rock**- fragments are small with no recementation.
  - **Squeezing Rock**- movement a result of overstressing and plastic failure
  - **Swelling Rock**- capacity to swell usually due to **smectite**, a montmorillonite group of clay minerals.

### Ground Behavior for Earth Tunneling with Steel Supports

Ground classification      Reaction of ground to tunneling operation

**HARD**      Tunnel heading may be advanced without roof support.

**FIRM**      Ground in which a roof section of a tunnel can be left unsupported for several days without inducing a perceptible movement of the ground.

**RAVELING**      Chunks or flakes of soil begin to drop out of roof at some point during the ground-movement period.

**SLOW RAVELING**      The time required to excavate 5 feet of tunnel and install a rib set and lagging in a small tunnel is about 6 hours. Therefore, if the stand-up time of raveling ground is more than 6 hours, by using ribs and lagging, the steel rib sets may be spaced on 5-foot centers. Such a soil would be classed as slow raveling.

**FAST RAVELING** If the stand-up time is less than 6 hours, set spacing must be reduced to 4 feet, 3 feet, or even 2 feet. If the stand-up time is too short for these smaller spacings, liner plates should be used, either with or without rib sets, depending on the tunnel size.

**SQUEEZING** Ground slowly advances into tunnel without any signs of fracturing. The loss of ground caused by squeeze and the resulting settlement of the ground surface can be substantial.

**SWELLING** Ground slowly advances into the tunnel partly or chiefly because of an increase in the volume of the ground. The volume increase is in response to an increase of water content. In every other respect, swelling ground in a tunnel behaves like a stiff non-squeezing, or slowly squeezing, non-swelling clay.

**RUNNING** The removal of lateral support on any surface rising at an angle of more than  $34^{\circ}$  (to the horizontal) is immediately followed by a running movement of the soil particles. This movement does not stop until the slope of the moving soil becomes roughly equal to  $34^{\circ}$ . If running ground has a trace of cohesion, then the run is preceded by a brief period of progressive raveling.

**VERY SOFT SQUEEZING** Ground advances rapidly into tunnel in a plastic flow.

**FLOWING** Ground supporting a tunnel cannot be classified as flowing ground unless water flows or seeps through it toward the tunnel. For this reason, a flowing condition is encountered only in free air tunnels below the watertable or under compressed air when the pressure is not high enough in the tunnel to dry the bottom. A second prerequisite for flowing is low cohesion of soil. Therefore, conditions for flowing ground occur only in inorganic silt, fine silty sand, clean sand or gravel, or sand-and-gravel with some clay binder. Organic silt  
er as a flowing or as a very soft, zing ground.