

Soil strength refers to a soil's ability to resist deformation, which is a function of the friction and cohesion in the grain-to-grain contact in a soil. Sand dunes are able to stand at the angle of repose because of the grain-to-grain friction. *Cohesion* is the measure of the capacity of soil particles to stick together, and high cohesion is most often associated with clays. *Shear strength* is the measure of the frictional resistance and cohesion of a soil. To test shear strength, a four-bladed vane is driven into the soil and then turned using a wrench that measures the force (*torque*) necessary to turn the vane. The shear strength of the soil is the force applied at the time of failure. In situ field tests are preferred because soil is in its natural condition.

Bulk density refers to the weight per volume of any unit of soil. As a rule of thumb, the higher the bulk density of a soil, the greater the support it can provide for a foundation. Materials with low bulk densities do not provide a solid foundation for construction.

The Atterberg Limits and Soil Classification method quantifies the variations in soils caused by grain size distribution, clay mineralogy, and organic content. The Atterberg limits are actually two measures: the liquid limit and the plastic limit. These procedures measure the water in a soil at the point at which the soil begins to act as a liquid or begins to flow as a plastic. Water is measured as a percentage of the weight of the soil when it is dry.

The *liquid limit* (LL) is the moisture content at which a soil tends to flow and will not retain its shape. It is determined in a liquid-limit cup in which a molded wet soil patty is placed. A V groove is cut through the patty with a tool designed for that purpose. Using a hand crank, the cup is repeatedly lifted and dropped until the soil flows to close the groove. When the moisture content is sufficient to close the groove at up to 25 drops such that the soil "flows," it is said the liquid limit has been reached.

The *plastic limit* (PL) is the moisture content at which a soil deforms plastically. The soil is rolled into long threads until the threads just begin to crumble at a diameter of about 3 mm. If a soil can be rolled into finer threads without cracking, it contains more moisture than its plastic limits; if it cracks before 3 mm is reached, it has less.

The numerical difference between the LL and the PL is called the *plasticity index* (PI). The PI gives the range of moisture in which a soil behaves as a plastic material. Some clays can absorb water several times their own weight and would be said to have a large range of moisture content in which they behave plastically and before they start to flow. A PI over 15 is a good indicator of an expansive soil.

The Balanced Site

In general, the most economical grading plan is one in which there is a minimum of earthwork and the amounts of cut and fill are in balance. There are several factors that influence the balance. For example, soils with a high plasticity index or with a high organic content may have to be removed and replaced under building pads or under other site structures. Some soils have