AQA Guidance – Liquid Limit

The Aggregate and Quarry Association has received many requests asking for clarification on the reporting requirement for the Cone Penetration Limit (CPL) for basecourse testing – particularly if the aggregate sample is non-plastic.

NZTA's M04:2024 specification requires reporting of CPL for Class 1 and 2 basecourse. The CPL is considered to be analogous to the Liquid Limit (LL). This advice note explains the liquid limit.

The following information is taken from the *Austroads Guide to Pavement Technology Part 4A: Granular Base and Subbase Materials 7.3.4*

Consistency Limits

Consistency limits are based on the concept that a fine-grained cohesive soil can exist in four states, depending upon its water content. Thus a soil is solid when dry, and with the addition and incorporation of water will proceed through the semi-solid, plastic and liquid states. The explanation for these changes lies in the interaction of the soil particles. The greater the amount of water a soil contains, the less interaction there will be between adjacent particles, and the more the soil will act like a liquid. The water contents at the boundaries between adjacent states are termed the shrinkage, plastic, and liquid limits respectively. These limits are defined in an empirical manner, and determined by standard test procedures. They give an indication of the amount and activity of the clay present in a soil.

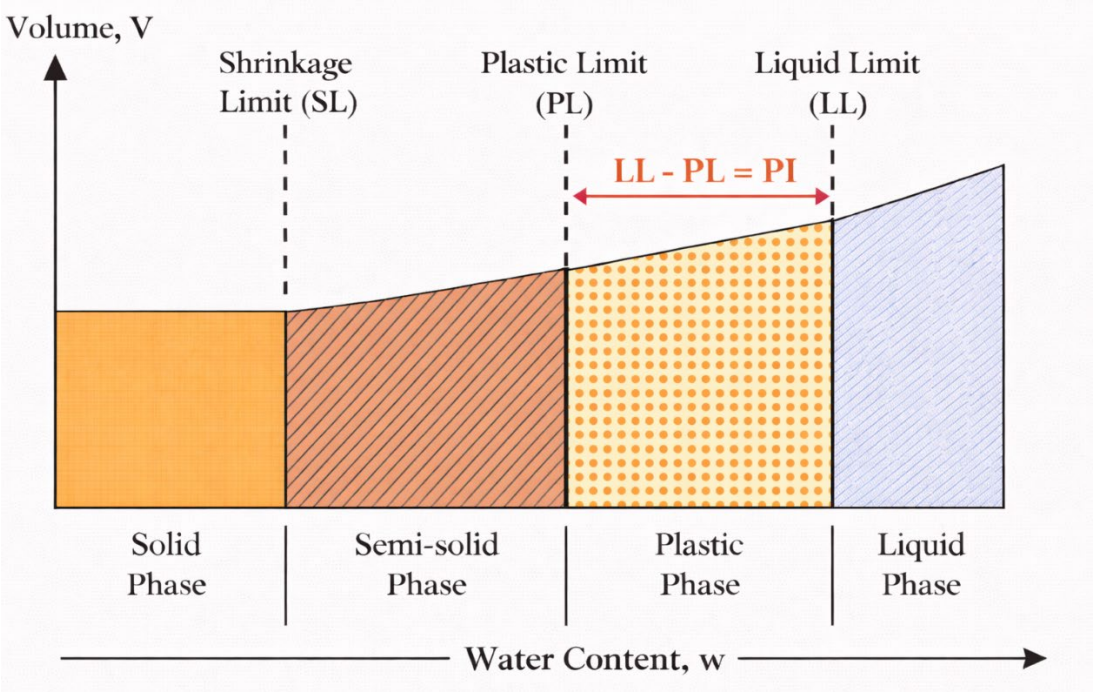

Figure 1: Solid to Liquid Phases

Plastic limit
The plastic limit is defined as that moisture content at which a thread of soil (comprised of material passing the 425 μm sieve) can be rolled without breaking until it is only 3 mm in diameter. It is dependent on both the type and amount of clay present. At the plastic limit sufficient water is required to wet all the surfaces and reduce cohesion so that the particles can move past one another under stress, but maintain a new moulded position. For pavement materials, a high plastic limit may indicate the presence of an undesirable amount or type of clay.

Liquid limit
The liquid limit of a soil is usually defined as the moisture content at which the soil passing the 425 μm sieve is sufficiently fluid to flow a specified amount when jarred 25 times in a standard apparatus (the Casagrande cup) or where an 80g 30° cone penetrates 20mm in 5 seconds (NZS 4407:2015 Test 3.2, the Cone Penetration Test). It is dependent upon both the type and amount of clay present, but is more sensitive to the type of clay than is the plastic limit.

At the liquid limit, a soil is water-saturated, and the distance between particles is such that the force of interaction between the soil particles is sufficiently weak to allow easy movement of the particles relative to one another.

The liquid limit of a soil generally increases with an increase in the amount of flaky, fibrous or organic particles present. It therefore often gives a useful warning of the presence of undesirable components which may affect packing, interlocking and cohesion of the soil particles, leading to poor stability of the compacted soil mass and indicates the magnitude of the range of moisture contents over which the soil remains plastic.

A high liquid limit (typically above 30%) means the material can hold a lot of water and has a greater risk of instability (less resistance to shear forces or transitioning from a plastic state to a liquid state too easily under traffic loading) when it's wet. This is why consultants are asking for LL < 25%.

Plasticity Index
The plasticity index is a commonly used test to assess the quality of granular material fines. Its value is the numerical difference between the liquid limit and plastic limit values (LL – PL = PI).

Except where a clay has unusual properties, the plasticity index generally depends only on the amount of clay present. It gives a measure of the cohesive qualities of the binder resulting from the clay content. Also it gives some indication of the amount of swelling and shrinkage that will result from wetting and drying of that fraction tested.

As some soils do not have sufficient mechanical interlock, they require a small amount of cohesive material to give satisfactory performance. A deficiency of clay binder may cause ravelling of gravel wearing courses during dry weather, and excessive permeability. An excess of clay results in softening of the binder and loss of stability when the gravel becomes wet. Materials with an excess of clay may also be difficult to work.