

The problem of swelling and shrinkage

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Keyword

Clays are commonly occurring rocks and soils which consist mainly of very small mineral particles. These particles are not only very small but have peculiar properties of their own which the larger silt and sand particles do not have. One of these is the ability to 'trap' water between them using forces other than capillarity. If water is removed from or added to the soil mass, forces between particles come into play which can cause significant volume changes in the soil mass.

Many conurbations, transport routes, services and structures are founded on clay-rich soils in the UK. These are either older bedrock formations or younger superficial deposits derived from bedrock. Clays are widespread within the latter and constitute a familiar hazard to engineering construction in terms of their ability to swell or shrink; that is the ability to change volume with an alteration in effective stress, usually caused by changes in moisture content produced by seasonal climatic variation. This often contributes to the phenomenon of subsidence. Of course, subsidence may also be caused by unrelated factors such as undermining, dissolution, and landsliding. The annual cost of subsidence attrib-

uted to swelling and shrinkage in the UK is about £500 million. As climate trends appear to be resulting in drier conditions for much of the country this figure can be expected to rise.

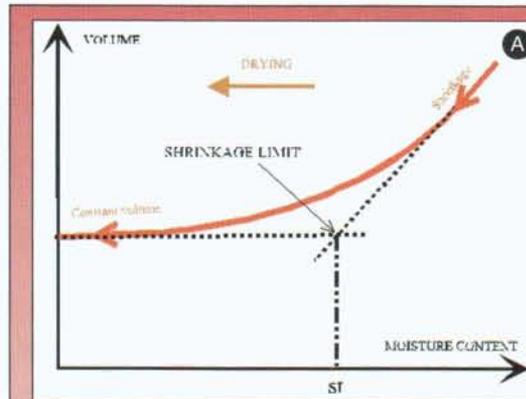
Whilst much study has been carried out worldwide to infer swelling and shrinkage behaviour indirectly from simple soil index test data such as plasticity, density, and moisture content, few data derived from direct swell/shrink measurements are available in UK geotechnical databases. This is partly due to the fact that index test standards are more explicit and accepted worldwide, and partly that direct swelling and shrinkage tests are often difficult to perform, particularly where undisturbed samples of weak or sensitive soil are required to carry out the tests. Soil structure, fabric, and moisture content contribute to test difficulties and tend to make correlation with indirect index test data derived solely from disturbed or reworked material impossible. A good example of a clay formation giving rise to these problems is the Lower Cretaceous Gault clay. Damage caused to buildings, roads and services constructed on this formation is well documented in the UK and has formed a key component of a recent BGS report.

Research is currently underway at the BGS to devise improved ways of

measuring the swelling and shrinking behaviour of difficult materials directly in the laboratory. At present, the two British Standard recommended methods for measuring volumetric shrinkage directly require the use of mercury which presents a health hazard in both liquid and vapour forms. The work has involved a prototype device incorporating a travelling microscope and a laser range-finder with digital output of volumetric strain, in order to determine shrinkage limit and other parameters without the use of hazardous substances or contact with the test specimen during drying.

The British Geological Survey has wide experience in the sampling and testing of clays; in particular the methods of examining swelling and shrinkage, and the contribution of these to subsidence hazard. A large database of geotechnical data for clays in the UK has been built up, and numerous interpretations of these data for hazard assessment and specific engineering applications made. Currently, work developing new test methods in clay swelling and shrinkage seeks to make direct laboratory measurements more user-friendly and widespread in the geotechnical industry and permit identification of the fundamental factors influencing this important phenomenon.

Clays



A. A plot of shrinkage (volumetric) as a function of moisture content for a typical clay soil.

B. Shrinkage crack pattern in highly plastic clay slurry.

C. New shrinkage limit apparatus showing balance with test specimen (centre) and travelling microscope with rangefinder (right).

