

Ground engineering, geology and man, Northern England

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Introduction

The main engineering considerations briefly identified here include foundation conditions, excavatability and suitability as fill. In the characteristically hilly terrain, other local factors such as gradient of the ground, position of a site on a slope, and how well that site drains will also be of importance. Geohazards are discussed separately in the subsequent section of this chapter.

Although the rocks of northern England are generally suitable for most types of foundations, they may be weakened locally by weathering, dissolution, faulting or mineralisation. The effects of such alteration on the engineering characteristics will depend partly on the rock type and partly on local factors, as will the ease of excavation and appropriateness of the excavated material as fill. Methods used to excavate strong or very strong rocks (mostly igneous or Carboniferous and older if sedimentary) will depend on bedding, faulting and jointing; the weaker rocks (mostly Permian and Triassic) and the unconsolidated Quaternary deposits are much more easily removed. The strong rocks are generally too expensive to extract and crush for fill material unless they have been processed from mine or quarry waste. The weaker rocks and many Quaternary deposits provide suitable fill material, although some mudstones, clays and organic deposits are unsuitable.

Note that in an engineering context, the terms weak, strong, very strong etc., and stiff, soft etc., have a precisely defined meaning.

Bedrock

In the Lake District and the Isle of Man, most of the pre-Carboniferous rocks are strong and often very strong when fresh, but foundation conditions will vary locally with the degree of alteration and the intensity, orientation and fill of discontinuities, including jointing, bedding, cleavage and vein networks.

Carboniferous limestone is strong to very strong but is slightly soluble in acid rain water and groundwater, allowing the formation of karst features such as sinkholes and caves, particularly

along zones of weakness such as major joints or faults. The upper few metres of limestone may be more generally weathered into loose, gravel-to boulder-grade material. Sinkholes may be open and easily identified or hidden beneath a superficial cover, or they may be infilled by soft to firm or loose material that has been washed in and which will have dramatically different engineering properties from the surrounding rock. Dissolution cavities at depth may collapse and migrate upwards to the surface. When considering construction on karstic Carboniferous limestone areas, it is important to identify where dissolution cavities occur. Small sinkholes may be spanned by a variety of foundation types including reinforced strip or strengthened raft. Alternatively, piled foundations may be used to transfer the load to deeper, good quality rock.

Carboniferous sandstone is generally moderately strong or very strong when fresh and in general provides good foundation conditions. However, it may weather to sand near surface, producing an uneven engineering rockhead surface. Namurian sandstones are locally weathered to depths greater than 6 m, which may lead to differential settlement.

Carboniferous mudstone and siltstone usually provide good foundation conditions, although, when fully weathered, the mudstone becomes a firm to stiff clay. Since this weathered material has a lower bearing capacity than unweathered rock, it may be necessary to place foundations below the weathered zone. Oxidation of pyrite in the mudstone will produce acid and sulphate-rich ground conditions; subsequent reaction with calcium carbonate will then form gypsum. Where this has occurred, buried ironwork will need to be protected from the acid conditions and the use of sulphate-resisting cement may be required.

Permian rocks generally provide good foundation conditions though weathering may affect their behaviour. In north-east England, the weak sandstone of the Yellow Sands Formation weathers to a very weak condition or even to loose sand. The succeeding Zechstein Group is highly variable. The weak mudstones weather to a firm to stiff clay; dolomitic limestone, moderately strong when unweathered, may also weather to friable sand. In the Newcastle and Sunderland areas, and around Darlington, beds of gypsum have dissolved, leaving residual clay horizons and causing severe disruption to the overlying limestone, leading to collapse and surface subsidence. Similar phenomena in north-west England, notably in the Vale of Eden, arise from gypsum dissolution in the Permian Eden Shales Formation (Cumbrian Coast Group), and may also lead to subsidence. In the Triassic Mercia Mudstone Group rocks of north-west Cumbria, weak to moderately strong mudstone weathers to firm clay, but weak interbeds of halite and gypsum may have been removed by groundwater movement; halite at depths greater than 50 m, and gypsum near to the surface. The degree of disruption to the overlying deposits largely depends on the thickness of beds that have been removed. Where construction is above gypsiferous deposits, surface drainage should not be via soakaways sited near buildings.

The Permian and Triassic sandstones of north-west England, typified by those of the Sherwood Sandstone Group, are generally moderately weak to strong when fresh and provide good foundation conditions. However, weathering of the sandstone to dense sand, sometimes to considerable depths, results in a highly variable engineering rockhead. Calder Formation sandstones are generally weaker, more porous and prone to deeper weathering than the other formations of the Sherwood Sandstone Group.

Superficial deposits

Glacial till, when fresh, is a firm to stiff or very stiff gravelly sandy clay containing pebbles, cobbles and sometimes boulders. It generally provides good foundation conditions for normal foundations but is commonly weathered to a depth of 3 to 4 m, up to 8 m thick in places; this weathered upper

layer is weaker and fissured. Bearing capacity near surface may vary depending on the weather conditions, becoming softer when wet and stiffer when dry. The softened near-surface material may need to be removed prior to construction. An abundance of cobbles and boulders within the till, or the presence of interbeds of gravel, sand or laminated clay and silt, may change the foundation conditions locally and engender differential settlement.

Glaciofluvial sand and gravels generally make an adequate foundation for domestic and light industrial buildings, but lateral and vertical variation in density, and the presence of clay and silt lenses, may lead to differential settlement; deeper foundations, perhaps piles, are often required for large buildings. Excavation in saturated sand below the water table may produce 'running' conditions.

Laminated clay and silt, often of glaciolacustrine origin, are generally soft to stiff, finely laminated and sometimes include sand laminae. The top metre or so may be stiffer due to desiccation. Such deposits usually have low to moderate compressibility and, generally, a moderate to fairly rapid rate of consolidation due to horizontal drainage along the coarser-grained laminae. Where the water content is high, the low shear strength reduces bearing capacities and foundations must be designed to take this into consideration. Low strength also means that excavations and cuttings will require support. Laminated clay layers have been associated with failure beneath spoil mounds and embankments. Typically, the widespread Pelaw Clay, is generally soft, has lower strength than the laminated silts and clays that lie beneath, and is very unstable in excavations. Laminated clay and silt is usually unsuitable as a fill material.

Fine-grained river and estuarine alluvium may not be suitable for standard foundations as this material often has low bearing capacity, a problem exacerbated by peat or organic clay layers within the alluvium. Such localised variations in character may lead to differential long-term settlement. Excavations will probably require support and dewatering as the water table is likely to be near surface. In general, construction on peat should be avoided unless specialised methods of construction are used.

Artificial deposits, waste disposal and landfilling

Man-made deposits are widespread in northern England, occurring not only in urban and modern mining areas but also in rural areas where mining, quarrying and related industrial activities have taken place. They are potentially very variable and may have contrasting foundation conditions within a short distance; those associated with metal mining are likely to be toxic. Important factors include composition, extent, thickness, method of emplacement and the length of time over which settlement has taken place. In general, buildings should not straddle the man-made material and the enclosing bedrock since there is a strong probability of differential settlement, which may affect not only the building but also the associated services.

Many of the region's numerous abandoned quarries have been employed for the disposal of domestic and industrial waste. In at least one instance, at the Florence Mine near Egremont, west Cumbria, a large subsidence hollow over old mine workings has been used as a landfill site.

Some landfill sites are well documented, such as landscaped opencast coal workings and recently active, domestic waste tips but many older sites are poorly documented. These older sites may contain a heterogeneous mixture of materials, including methane-generating and toxic components, whilst voids may present an additional problem. Alternatively, the fill material may be a relatively innocuous combination of local waste rock and overburden derived from opencast workings.

The reclamation and landscaping of colliery spoil heaps has involved the redistribution of spoil over

large areas. The colliery waste is largely composed of rock fragments but may also contain substantial quantities of coal and pyrite. This can result in combustion, with associated settlement and generation of toxic gases. Weathering of colliery waste may produce high sulphate and acid groundwater. With the decline of the region's steel industry, large quantities of metal-rich slag have been redistributed during landscaping of the old industrial sites.

Particularly sensitive issues surround the disposal of low-level radioactive waste at Drigg, just to the south of the Sellafield nuclear plant in west Cumbria. The Drigg site is the UK's national low-level waste disposal site and has been in operation since 1959. The material received typically comprises paper, packing materials, plastic sheeting, protective clothing and redundant machinery, derived from other UK nuclear facilities, hospitals, research laboratories and industrial processes. The waste is compacted and containerised before disposal in concrete vaults built into Quaternary marine and lacustrine silts and clays overlying glacial till. A very large geological database was generated for the whole Sellafield area in the early 1990s, during investigation of the site's suitability for the deep disposal of low- and intermediate-level radioactive waste. Proposals for further research were rejected at a public enquiry that ran from 5 September 1995 to 1 February 1996.

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