Background

The suite of engineering property datasets are developed for use within a GIS environment. They demonstrate the spatial distribution of geological unit properties, primarily, for the uppermost 2 m across Great Britain. Within this limited depth, weathering of material is to be expected and, therefore, the effects of weathering are considered. The classifications are indicative of the characteristics expected. This might cover most of the range of the characteristics or as minimum, typical and maximum expected values for each geological unit. Earlier national datasets for some of these properties at 1:1 000 000 are presented in Dearman et al. 2011a, 2011b, 2011c, (Dobbs et al. 2012).

Excavatability

Excavations are dug for civil engineering purposes, cuttings, tunnels, borrow pits, quarries and mines. Other applications, generally of more limited depth, include ground investigation, foundations, utilities infrastructure, cellar construction and burial pits. A number of excavation methods have been devised to efficiently and cost-effectively remove material (digging, ripping or use of explosives). The selection of the method largely depends on the material characteristics, primarily ‘strength’ and mass characteristics, i.e. the spacing, number of and orientation of mechanical discontinuity sets. Materials that behave as engineering soil, that is, those described with a principal material type of clay, silt, sand, gravel or cobble, are diggable, and are more easily extracted than those described as rock (Pettifer and Fookes 1994). The classification is given in Appendix 1 - Excavatability classification terms and descriptions (Lee et al. 2012).

Strength

Definitions of the engineering strength of rocks (and fine soils) are provided as minimum, maximum and typical strengths. This tri-fold classification allows for the wide range of variation encountered within some stratigraphic units. For example: the Mercia Mudstone Group where sandstones are included is classified as firm to strong because it has some mudstone beds that are firm due to weathering but also contains stronger sandstone and dolomitic beds. Because these locally weaker and stronger beds make up a small proportion of the deposit/formation, the most common ‘strength’ near surface is determined as stiff. Additionally, this ‘typical’ classification takes into account its weathered state, water content, and other variations.

Definitions of the engineering strength of coarse soils are provided as minimum, maximum and typical densities. Again, this tri-fold classification allows for the wide range of variation encountered within some stratigraphic units. For example; the Kempton Park Gravel Formation is classified as loose to very dense because where it is at surface, it tends to be in a loose state, whereas, at depth it may become very dense. However, in the upper 2 m it is loose to dense and most commonly
Discontinuities

Various terms have been used over the years to describe discontinuities and these often vary depending upon discontinuity type and the scale at which they are observed. Two of the more succinct and comparable ‘engineering geology’ definitions are provided below:

*Discontinuities are breaks, fractures or planes of weakness in the rock mass.* (BSI, 2015[9]). Types of engineering discontinuities are joints, faults, bedding fractures, cleavage fractures and might include incipient fractures.

*The general term for any mechanical discontinuity in a rock mass having zero or low tensile strength. It is the collective term for most types of joints, weak bedding planes, weak schistosity planes, weakness zones and faults* (Ulusay & Hudson, 2007[10]).

The ‘Engineering Properties: Discontinuities’ dataset defines discontinuities as a break in the continuity of a rock mass that has the potential to have zero or very low tensile strength. It can include all stratification planes (bedding, layering and lamination) (Figure 1), all foliation planes (fissility, cleavage, banding) (Figure 2) and includes all fractures (joints, faults, fissures) (Figure 3) as defined in British Standard BS5930 (BSI 2015[9]) and International Society for Rock Mechanics (ISRM 2007). It does not include interfaces (other than stratification planes/depositional interfaces) and chemical-solution breaks (such as solution cavities). The classification is given in Appendix 3 - Discontinuities classification terms and descriptions.

![Figure 1](image1.png) Examples of stratification.

![Figure 2](image2.png) Examples of foliation.

![Figure 3](image3.png) Examples of rock mass character.
Bulking of soils and rocks

The excavation of rocks or soils is usually accompanied by an increase in volume. This change in volume is referred to as ‘bulking’ and the measure of the change is the ‘bulking factor’. The ‘bulking’ of excavated rocks and soils is an important consideration in civil engineering and extractive industry.

The bulking factor might be influenced by a number of different characteristics including lithological properties (specifically mineralogy, particle-size distribution, particle shape, porosity, density, and strength), alteration (weathering, hydrothermal alteration, and metamorphism) and the excavation method (digging, ripping or blasting).

The ‘Engineering Properties: Bulking of soils and rocks’ dataset is intended to provide information about the bulking factor of geological units as a desk-study tool for the planning and design for construction and resource extraction. The classification is given in Appendix 4 - Bulking of soils & rocks classification descriptions.

Sulfate and sulfide potential

The presence of sulfur in rocks and soils is, in certain forms and in certain conditions, of importance to the engineered environment as it can give rise to aggressive ground conditions. Sulfate ions react with some types of cement and concrete weakening it (mostly in slightly acid to alkali conditions). Sources of sulfate ions are primarily from gypsum (calcium sulfate), which is an evaporite deposit found in certain geological units; and due to the oxidation usually of very fine grained iron sulfide (framboidal iron pyrites). The oxidation produces sulfuric acid which can react with calcium carbonate, commonly found in many grey clays and mudstone, to form gypsum (see BRE 2005[11], Cripps & Edwards 1997[12], Czerewko & Cripps 2006[13], Taylor et al. 2013[14]). If there is no calcium carbonate (or insufficient to buffer the sulfuric acid) then acid ground condition are formed such as in acid mine-waters. Also, where sulfide-rich mudstone is used as backfill beneath buildings the formation of gypsum increases the volume of the now weathered mudstone. The resulting ground heave can disrupt the floors of buildings (DCLA 2008[15]).

Much of the research has been focussed on the damage caused to concrete associated with sulfate ions associated with calcium sulfate (gypsum) as this is the most likely sulfate present near surface. Other sulfate minerals such as magnesium sulfate (Epsom salts) and sodium sulfate (Glauber’s salt) are more soluble and generally dissolve into the groundwater well below most engineering activities. However, these can occur at surface via natural springs.

This dataset provides a guide to the potential sulfate/sulfide geohazard for geological units found at surface for Great Britain. It can be used as an indicator of primary sulfate and the potential presence or likely formation of sulfate species due to oxidation. It should be considered as a part of desk study for civil engineering purposes to inform the intrusive ground investigation and construction in the ground (Entwisle et al. 2015[16]). The classification is given in Appendix 5 - Sulfate/sulfide potential classification descriptions.

Corrosivity (ferrous)

Ferrous (iron) structures and pipelines in the ground are susceptible to surface pitting and corrosion, weakening the asset and increasing the potential for failure. Such assets are more prone to failure where ground movement occurs due to the change in stress around the asset. The creation of the Corrosivity (ferrous) dataset was in response to the growing awareness of the cost of
maintenance of iron structures in the ground such as infrastructure pipelines and building foundations. The cost of corrosion to the UK has been estimated at 4% of Gross National Product per year (Institute of Corrosion; http://www.icorr.org/). Some of this cost is due to the corrosion of ferrous underground assets, particularly in what are termed ‘aggressive soils’ conditions. Thus the new dataset identifies where the ground beneath the topsoil has potentially ‘corrosive’ or ‘aggressive’ characteristics and places them within the recognised scoring framework developed by the Cast Iron Pipe Research Association (CIPRA) now the Ductile Iron Pipe Research Association (DIPRA).

Scores for 5 properties are used to assess corrosive conditions:

i. Water content
ii. Redox status
iii. pH
iv. Sulphates/Sulphides
v. Electrical resistivity

These factors have been combined to give a final corrosivity score for each geological unit. Each score gives an indication as to whether the ground conditions in the uppermost 2 m are likely to cause corrosion of underground ductile iron assets. The classification is given in Appendix 6 - Corrosivity classification descriptions (Tye et al. 2011[17]).

Use for engineered fill

The ‘use for engineered fill’ of rocks and soils is an important consideration in civil engineering and extractive industry. The rapidly increasing cost of removal and disposal of material offsite, of unused material, means that a great deal of effort is now taken to identify how extracted materials are to be used on site. Engineered fill is used in earthworks, which includes infill, raising or levelling ground, embankments, foundation pads, road bases and landscaping. The earlier this process is carried out the greater the likelihood that it can be done efficiently.

The ‘use as engineered fill’ classification is based on the geological material, type of geological materials (e.g. Chalk), maximum particle size, presence of sulfate or readily oxidised sulfide, which might affect the use of the material and the presence of unsuitable materials (e.g. peat).

Much of the classification used to create this dataset is based on the ‘Specification for Highway Works’ Series 600 Earthworks (Highways Agency, 1991a[18], 1991b[19]). More detailed specification tests will be required prior to use on site. The classification is given in Appendix 7 - Use for engineered fill classification descriptions (Entwisle et al. 2012[20]).

References

editions) map of the United Kingdom, 1:1 000 000. British Geological Survey, Keyworth, Nottingham, UK. [http://nora.nerc.ac.uk/19268/]


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