An update on new and future earthworks standards in the UK and Europe

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Introduction

Over the past five years we have been involved in developing earthworks standards for the UK and Europe. This paper has been prepared to give a general summary of the development of those standards. To illustrate the topic we provide some detail on certain subjects we believe are fundamental to understanding the direction that these earthworks standards have taken.

In the paper we refer to aspects of BS 6031:2009 [ref 1] in a selective manner to illustrate the topics presented, we have not attempted to cover all of its content because it is available for people to read and use. An insight is given into the current moves towards European standardisation in the field of earthworks.

We have endeavoured to deal with the UK and European activities in a joined up manner to show where there are similarities and differences. We hope this paper will provide a helpful briefing note for earthworks practitioners and encourage you to read the updated British Standard.

(The original form of this paper was prepared to accompany the presentation delivered at the Ground Engineering conference Slope Stability 2010 entitled "Understanding the implications of the updated BS 6031 for earthworks designs". We have taken the opportunity to delay publication to update the second half regarding progress towards European standards.)

Background to BS 6031:2009 Code of Practice for Earthworks

In 2006 BSI called together a steering group tasked with undertaking an update of BS 6031, the Code of Practice for Earthworks (see acknowledgements). The version available was published in 1981, but included a lot of content from the original version published in 1959 and was out of date with industry practice. BS 6031:1981 was no longer widely referenced, being used most often to justify common practice of requiring a Factor of Safety of 1.3 for slope stability design – this was actually an oversimplification of the standard.

The challenge was to ensure that the revised BS 6031 document would be in line with both current good practice in the UK, and the framework that is created by the Eurocodes (as explained in the BS 6031 foreword). The size of the document was to be reduced by including references to other existing documents. The revised BS 6031 was published in December 2009 as an all-encompassing code of practice covering all forms of earthworks (with the exception of the special requirements of dams).

Progress towards European Earthworks Standards

In recent years the European geotechnical community has started to link up to endeavour to share good practice and research in the field of earthworks. This process was initiated by the French who, in 2006, hosted an International Seminar on Earthworks in Europe. The second seminar took place in London in June 2009 with participation of delegates from many European countries. A third seminar is due to take place in Berlin, Germany on 19 and 20 March.

In 2008 the European Committee for Standardisation (CEN) requested that interested European countries provide delegates to a working group to explore whether it was appropriate to develop European earthworks standards. BSI requested that Peter Gilbert attend as the UK delegate to champion our draft BS 6031. It was identified that earthworks form a major part of civil engineering projects, but the topic is very poorly covered by CEN activities, and understanding of each other's national practices is poor (which is perceived to be a barrier to trade). In addition, many countries in Europe have limited standards in the field of earthworks.

Also, there is an underlying concern that the changing nature of the earthworks industry is resulting in a significant reduction in the number of highly experienced earthworks practitioners. There was a concern that these factors would restrict the industry's ability to utilise poor quality fills and thus inhibit environmental sustainability.

Following the working group report CEN established a new technical committee – CEN/TC396:Earthworks – in September 2009 with the task of delivering an appropriate level of standardisation. One of the stated aims is to harmonise national guidelines and recommendations throughout Europe to ensure mutual understanding and co-operation.

UK team of experts has been drawn together to cover the various work items (as shown in Table 1 overleaf).

Layout of BS 6031:2009

The initial meetings of the steering group identified that a full re-write of BS 6031:1981 was required, and agreed the overall nature of the content. It was considered important to ensure that all topics would continue to be covered.

The 1981 standard had covered temporary excavations with vertical or near vertical sides that require support to ensure stability (e.g. traditional trench shoring systems). Most engineers today would not immediately think of these as an earthworks activity, therefore the specific content of the standard that is only relevant to such works is separated into section 3 of the new standard (we won't comment further on this section of the revised BS).

Section 1 and section 2 of BS 6031:2009 respectively cover general matters and design/management of earthworks. These sections form the majority of the new standard and address the topics most engineers today would consider for earthworks. Section 2 includes temporary excavations which are designed to be self supporting. If the excavation requires soil reinforcement then general matters (including construction of fill and global stability covered by BS 6031, and reference is made to BS 8006 for all other aspects relating to reinforced soil (including internal stability).

The structure of the new standard has been set out to reflect the sequence of processes that might be followed on a typical project to deliver the earthworks, as it moves from planning to design, then construction and on to use. It attempts to set out the contents to aid the various parties who may have some involvement in determining the final nature of earthworks (client, consultant and contractor). The approach followed is to consider earthworks activities within clauses that follow the “lifecycle of an earthworks project” (see Figure 1).

This approach avoids the need for repetition of processes that are common to both construction of new earthworks and repair of existing earthworks – where

![Figure 1: Diagram of lifecycle of an earthworks project (reproduced from BS 6031:2009 with the clause numbers shown in brackets).](image-url)
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» there are significant differences these are highlighted. There are a number of underlying principles that run through BS 6031:2009. These reflect the fact that decisions will be taken by a number of different individuals and organisations on an earthworks project. These principles are:
- management of risk through the life of the project;
- requiring earthworks design, construction and maintenance to be undertaken by personnel who are competent for the task;
- planning schemes with a view to construction and to enable environmentally sustainable earthworks;
- undertaking ground investigation that will meet the needs of all parties;
- addressing the needs of new build, modification and asset management of earthworks.

BS 6031 relationship to other documents

The standard is set up to link with other fundamental documents, the most notable being:
- Specification for Highway Works (SHW) 600 series [ref.2]. This is set as the default approach for earthworks specification unless stated otherwise by the designer (see below).
- Eurocode 7 parts 1 and 2 [ref 3 & 4] and associated National Annexes plus amendments. BS 6031 summarises the aspects of EC7 that form the overall framework for undertaking earthworks projects, providing interpretation of certain key points and adds some commentary to explain how to apply the “dry rules” of EC7; in so doing it forms non-conflicting complementary information (NCCI).
- CDM Regulations 2007 [ref 5]. All projects involving earthworks come under the requirements of CDM, BS 6031 advises on how this is best applied at the various lifecycle phases of an earthwork project.

Earthworks specifications

A fundamental topic for earthworks is the specification that details how the fill is to be excavated, placed and compacted to form a body of fill. Different approaches can be followed depending on the particular situation being considered.

The use of the SHW 600 series for the construction of earthworks is widespread. The SHW is one of only two major documents in Europe that include a detailed method compaction system, the other being part of the French earthworks standard [ref 6]. Both were developed by extensive laboratory testing and site trials.

The UK testing took place between 1946 and 1990 [ref 7], and in France mostly in the 1960s and 1970s – it is a process that is unlikely to ever be repeated. This has been recognised in BS 6031 by making the SHW the default approach for earthworks specification, although other options are recognised and can be followed if an alternative specification is provided by the designer.

In this way it was possible to ensure that BS 6031 could meet the aims described above, and retain the advantages of the SHW which can be updated on a regular basis by the Highways Agency (HA) as new information becomes available.

Various sections of BS 6031 draw upon the work of the Building Research Establishment with regard to the special requirements for earthworks undertaken to form large bodies of engineered fill (eg infilling quarries) or to provide a platform for buildings. In these situations the designer’s task of managing the self weight settlement of the fill and determining the required degree of compaction becomes particularly onerous. It is recognised that these are situations that extend beyond the intended scope of the SHW.

Figure 2 is an attempt to summarise the particular issues associated with this form of earthwork. Within TC396 we are taking this further by drawing upon the Spanish standard that deals with relatively dry fills and sets out criteria to ensure adequate compaction to avoid collapse settlement (ref 8).

BS 6031 has been written as a framework that enables a project to use either a method, end product or performance specification, and to enable flexibility to suit the type and scale of the earthworks project. This is an approach that European earthworks standards hope to embrace (with the addition of continuous compaction control where appropriate). It is important to realise that even when end product or performance specifications are utilised there will be somebody within the project who has to consider the method that will be required to compact the fill to achieve the required result (this is an earthworks design activity regardless of who undertakes it).

Design of earthworks

Clause 7 is the largest section of the revised BS, it deals with the topic of earthworks “design” and describes issues to be considered by the designer. The topics covered fall into two general groups:

1. Geotechnical design – this being principally assessing slope stability and settlement below an embankment. These activities have a numerical calculation aspect that needs to follow the approach set out within EC7 part 1 and the relevant National Annex.

2. Earthwork fill design – the management of the earthworks (including Specification) and the process of fill selection for a particular earth structure. This includes fill classification and identifying the requirements to achieve an adequate degree of compaction (which leads on to assessment of appropriate site control methods, estimation of self weight settlement, etc). We think it is fair to say that EC7 never intended to focus on these activities.

The concept of an earthworks design covering both of these elements is well established in the UK (partly because SHW Table 6/1 requires information to be added by the designer). In some countries such as Spain there are defined items to be addressed within the design (ref 8). However, the action of “designing” earthworks does not translate well in all of Europe. For example, in French the closest applicable description for this task would be “conception”, but that is used only to describe the role of the architect for buildings.

It has become evident from our involvement with European standards that in some countries earthworks are undertaken by following well-established procedures (with the onus on the earthworks contractor to judge which procedure to follow) and using conventional fill materials, such that the role of the designer is limited to the geotechnical design. However, attempts to bring earthworks practices together across Europe, and the environmental requirement to use all available materials as fill, have resulted in recognition across TC396 that there is a process of decision making that extends beyond numerical calculation and is simplest to describe as “design”.

TC396 is drafting the future
European earthworks standards to cover the earthworks fill design topics andleave geometrical design entirely within EC7 part 1. We have summarised this separation of topics by defining:

- “Earth structures” are products. Earth structure design is covered by EC7.

- “Earthworks” is a process. Earthworks design is the process of determining what material is appropriate for construction of the earth structure, and will be covered by TC396.

Generally the divide is clear, but there are some earthworks specific issues that extend across the boundary and are difficult to separate; for example the interplay between assessing self weight settlement and fill parameter selection, or earthworks drainage requirements to enable successful earthworks construction.

A complication for drafting standards relating to “earthworks” is that the subject does not lend itself to the normal CEN approach of setting out clear rules that are to be satisfied. Instead, much of earthworks is about good practice and that varies depending on the particular combination of factors, such as: climate, geology, fill type and plant. However, the documents developed must still focus on the requirements to be addressed, unlike BS 6031 which as a “code of practice” provides “guidance and recommendations” on all aspects related to design of earthworks.

Achieving an acceptable balance requires careful consideration but we are making good progress and we believe we will provide a document that is useful for the European earthworks industry.

Fill classification

In drafting BS 6031 we realised that there is a need to clarify the differences in how a soil may be classified depending on whether the designer is undertaking geotechnical analysis or considering fill material suitability. This is a topic that tends to be taken for granted by geotechnical engineers in the UK, and a fairly consistent approach is followed. We endeavoured to capture this in BS 6031 clause 3.1 to set a fundamental underlying assumption. The clause clarifies how this approach does in fact follow the logic of EC7 and its related documents. The key criterion for earthworks fills is whether a composite soil has sufficient fine fraction (passing the 63 micron sieve) to determine the engineering properties of the soil.

- >35% fines classifies a soil as a "cohesive fill" (in accordance with SHW)

- >15% fines classifies a soil as a "cohesive fill" (in accordance with BS 6031 as a useful initial reference document)

BS 6031 clarification of EC7

A significant part of the content of BS 6031 deals with the application of EC7 parts 1 and 2 on an earthworks project. The aim is to provide an explanation of how the dry rules of EC7 should be applied for earthworks, and clarify some aspects that are less easy to follow, which should help to ensure a common approach across the industry.

- Clause 7 (Design of Earthworks) covers a wide range of subjects including the following (the main BS 6031 clause numbers for these topics are given in brackets):
  - factors governing the stability of slopes and modes of failure (7.2.1 & 2);
  - actions, including surcharge loads (7.2.3);
  - selection of design parameters, including the influence of strain on soil strength (7.2.4).

Future European earthworks standards

The third plenary meeting of CEN/TC396 in September 2011 was called to draw together the initial work of the five working groups of TC396. The tasks were to agree a set of documents for the working groups to develop, and to decide how these would interact to cover the subject area. The tasks were to agree a set of documents for the working groups to develop, and to decide how these would interact to cover the subject area. Table 1 summarises the seven agreed parts that are to be developed by separate working groups to form the new family of documents. At this stage the agreed resolutions identify the parts as potential future new work items in the work programme of CEN/TC 396, as summarised in Table 1. These are described as “potential” in line with CEN programme procedures; this gives flexibility for the final nature of the likely document(s) to be clarified as work progresses.

- Parts 1, 2, 5, and possibly 3, are likely to be joined together within a single “umbrella standard”, a final decision will be taken on this once each working group develops their text. This umbrella standard has been developed considering BS 6031 as a useful initial reference document, although the final document will inevitably be very different to ensure that it is acceptable to all European nations.

- Parts 1 to 5 will cover earthworks undertakings on the land (rather than underwater). It is intended that existing national method
specifications (such as SHW) will be incorporated in some way under the European system (the approach to achieve this is still under consideration). Earthworks specification creates an added complication because each existing method specification is based on a particular classification system. Therefore, the desire to draw towards a common classification system must include appropriate flexibility to enable existing method specification principles to remain valid.

As with other European standards the total number of documents that will form the family of standards relevant to earthworks will be far greater than seven because laboratory or insitu tests will be covered under individual test standards in the normal CEN way (developed by TC341 “Geotechnical investigation and testing”). Most of these tests have been identified as existing in some form and can either be simply cross referenced or adapted by working with the original drafting group so that it extends to cover earthworks.

Working groups may opt to produce a European standard and/or another form of document such as a technical specification or technical report. There is also the potential to refer to works of major importance via an informative annex that would explain how to use the document and thus avoid the need to reproduce the work, an example being the CIRIA rock manual.

Table 1 provides an introduction to the work that is now in hand. Working groups from across Europe are developing European standards on earthworks and the UK is actively involved.

Conclusions
The updated version of BS 6031 provides the UK civil engineering industry with a code of practice that covers most common forms of earthworks undertaken in the UK. The SHW is set as the default specification for earthworks in the UK, this enables the application of a well-established method specification that is underpinned by a wide body of knowledge.

It also provides a framework for utilising end product or performance specifications. Moves towards standardisation of earthworks practices across Europe are progressing well, our experience from developing BS 6031 is being fully utilised because it is seen as the sort of inclusive approach that is needed to harmonise European practices.

In this way CEN TC396 aims to enable good practice to be shared and various approaches accommodated to the benefit of all earthworks projects across Europe.

Acknowledgements
BSI policy is that British Standards no longer include the names of the authors so I’d like to take this opportunity to acknowledge the hard work of those who had the largest involvement with the preparation of BS 6031 (2009), who were as follows:
- Steering group members and authors: Donald Lamont (chair, HSE); Phil Dumelow (Balfour Beatty); Peter Gilbert (Atkins); Tony Gould (Groundforce Shorco); Richard Hocking (representing ADEPT); Alex Kidd (HA); Brian McGinnity (LUL); Eifion Evans (NR). BSI content developer: John Devaney (BSI).
- Those who provided content for certain chapters: Bob Stork (Atkins); Andrew Charles (BRE); Lee Parry (Mott MacDonald).
- Reviewers/advisers regarding EC7 compatibility: Andrew Bond (Geoconcentrix); Brian Simpson (Arup); John Powell (BRE/GeoLabs).
- The team would also like to thank the Highways Agency and Network Rail which provided some funding for the task, and all those who reviewed the Draft for Public Comment, in particular Chris Daneliwicz (Halcorw) who undertook a very thorough and helpful review.

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