A UK perspective of geotechnical baseline reports: a commercial or a technical document?

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All projects, but especially major infrastructure projects where there are very many critical programme interfaces, are at risk of delay and additional costs should the ground model upon which the various contracts are planned and bid subsequently prove to be inaccurate. With very high levels of programme complexity and interdependency, no party can afford not to establish a single common accurate and reliable ground model and take this through procurement and into construction.

High Speed 2 (HS2) is an example of a project with high levels of programme interdependency that will involve the construction of some 225km of new railway in Phase 1 from London to Birmingham and a further 365km in Phase 2 from Birmingham to Leeds and Manchester (Figure 1). The works are linear and comprise significant geotechnical works including numerous tunnels.

Figure 1 High Speed 2

With a budget of nearly £50 billion, HS2 is not the only major project in the UK. The UK is seeing unprecedented levels of investment in major infrastructure and particularly in transport infrastructure. Recent and current projects include Crossrail 1, upgrades of major main line railway termini, upgrades of the London's major underground rail interchanges (e.g. Tottenham Court Road, Victoria Station, Bank Station, Kings Cross Station), the Northern Line Extension, the Lee Tunnel sewer and the Thames Tideway 'supersewer' across London. Future planned projects also include a second Crossrail (the Chelsea-Hackney Line of old), a third Crossrail (north-south), a Bakerloo Line Extension and improved rail connectivity with Heathrow Airport, together with numerous underground station upgrades.

Reinvigoration of GBRs

Ground reference conditions or geotechnical baseline reports (GBRs) originated in the UK in the mid-1970's but for some reason they never really caught on and it is only in the past 4 to 5 years that GBRs have been reintroduced. Many of the major projects identified above are currently using or will use GBRs in their contracts. In the UK, GBRs have very rapidly become accepted, particularly for major geotechnical works and underground projects. It is worthwhile briefly examining the various factors that have encouraged the uptake of the GBRs, these include:

- Employer is usually public sector or major listed private company working within a regulated industry;
- Both the Employer and Project are high profile;
- Sensible budgets and timescales are set;
- Mature business and project risk management processes are being used;
- Obligations under health and safety legislation where the tolerance is often 'below zero';
- Competent management teams;
- All parties motivated to avoid failures and disputes – they all know it costs!
- Set good example for industry – go out of their way to do so;
- Contractors now demand GBRs;
- Informed by better quality ground investigation;
- Accepted by all as being the right way to go - no negative feedback.

Times have changed and one does not have to go too far back to remember the considerable dilemma that, as an Employer, the Author had in deciding what information should be provided to bidders on the ground and include in the contract. An Employer would do its utmost to avoid taking any risk for the ground, despite the provisions of standard forms of contract which meant that the risk for the ground was theirs (a reversal of the position in law). It was common not to provide any information or, if any, just factual ground investigation reports and definitely not a geotechnical interpretative report.

Figure 2 Construction of the Channel Tunnel using a wedge block lining meant that is was vulnerable to small variations in geotechnical characteristics of the Upper Cretaceous Chalk Marl.

The Channel Tunnel suffered from changed physical ground conditions, which were due to the fact that there was insufficient ground investigation on the tunnel alignment just offshore of the United Kingdom and also to the choice of construction method, which involved the construction of a wedge block lining behind a tunnel boring machine without a tailskin and without the option of bolting them (Figure 2). Consequently, the ground was found

to be vulnerable to caving and water ingress, making the works dangerous and severely reducing progress initially. There was no GBR (though at the time the principle of using one existed) and no geotechnical interpretative report, just a few off-line boreholes. The Author collected and collated information on the ground as part of the Contractor's successful claim for unforeseen ground conditions. This example highlights the sensitivity of the construction method to the variation in ground conditions and its behaviour. The difficulties were made all the more impactful by the fact that there was no flexibility in the construction method; underlining the importance of having a single accurate ground model agreed between the parties.

The primary purpose of the Employer providing information on the physical conditions at the site is to ensure scope, cost and programme certainty. Yes, the Contractor could undertake the ground investigation but the scheme could be very different and would definitely be far more costly than the original bid. Furthermore, the process would be unacceptably too long. Essentially, the Employer is 'buying' cost and programme certainty in exchange for identifying and providing information on the condition of the site. It logically follows that the Contractor should also rely on the very same information that the Employer has also relied upon to develop the scheme. It is questionable as to what practical and contractual value caveats or warranties placed on site information have. Arguably they have none; though it is interesting that some Employer's try to hide behind them and, to a greater extent, standard forms of contract still try to promote this illusion. It is far simpler to have a single common agreed contractual basis for the ground.

In 2008, the Author instigated a meeting of major UK client organisations and contractors to discuss the use of GBRs. The initial reaction was that whilst they knew very little about them all were very positive and all could see the immense benefits they could bring. Used properly, GBRs are an important risk management tool but in the UK there were other important drivers encouraging their use.

In 2003 the British Tunnelling Society and Association of British Insurers published the Joint Code of Practice for the Management of Risk of Tunnel Works. The Code mandates the use of ground reference conditions or a GBR. The 'Conditions' are to be prepared by (or on behalf of) the Employer and issued with bid documentation or, alternatively, by the Bidder to be submitted with bids to be used by the Employer in the tender assessment process. The objective was to overcome the 'fuzziness' and inconsistent approach in standard forms of Conditions of Contract, to obviate any argument as to the basis of the Contract and to very simply demonstrate and confirm that somebody has given some rational thought to the ground and its implications for design and construction.

In the UK construction and its design is controlled through a very powerful and successful piece of legislation called the Construction (Design and Management) Regulations 2007 (CDM), which supplements the main health and safety legislation. The regulations impart particular responsibilities on all the parties, not least on the Employer and the Designer. It is recognised that the role of the Designer is unique in identifying risk and eliminating it and the Designer must consider health and safety of all those involved in the project from its conception and through construction; including those who will repair, maintain, clean, refurbish and eventually demolish it. It has a duty to inform the Employer of its obligations under the regulations. The Designer is obliged to communicate the risks and hazards to others, prepare a project specific risk assessment, add key information on health and safety on the construction drawings and provide information on how the design is to be constructed. Integral to this is the Designer's Risk Assessment (DRA). Clients, whether they are an Employer or a Contractor, can now no longer accept a design submission without one. Importantly, DRA's must not be generic but address specific issues relating to the works shown on the drawings; they must include limitations placed on the design by information available on the ground and they must include a plan to obtain this information to resolve any outstanding design issues. This consequently drives the requirement for ground investigations and ensures that there are sufficient arrangements, including funds to deal with issues regarding the ground.

Issues arising

Contractors are increasingly risk averse, their strength is their ability to efficiently mobilise resources to provide a cost effective engineering solution and their competitive edge is to be innovative in how they do it. During the bid stage they are not particularly interested in finding where they might be able to make a claim, should they win, they are far more focussed on winning. Rather they want to understand what the risks are and to be able to discuss uncertainty and the costs of these risks up front with an Employer. Interestingly, Contractors now actively seek a GBR and may be reluctant to bid a project if one is not presented. They will use the GBR to measure the effectiveness of the Employer's Site Information and gain an understanding of the Employer's tolerance to risk. They also want their competitors to be equally informed. Importantly, they also want to pass the risk for the ground down through their supply chain and they will use the GBR to do this. Arguably, a GBR should be negotiable, as a Contractor may propose a means or method that changes the risk profile for an element of work.

The quality of the GBR demonstrates to the Bidders how well the Employer understands what it seeks to buy, its knowledge of the constraints on the provision of the works, its understanding of risk and where its limits for responsibility lie and whether they are sensible and practical. The Employer seeks cost and programme certainty (with few claims) and will usually prepare a detailed cost estimate prior to procurement. A smart Employer will also ensure that it has prepared a risk register based on its design for the works and that this is also costed so as to determine value and likelihood so that a robust contingency can be allocated. Employers may ask that the Risk Register is also priced by the Contractor so that a common value can be agreed for the contingency, which is then shared with the Contractor (this can include, for example, provisional sums based on agreed uncertainties). The Contractor's take on the risk register and the quality of its price for the risk items is a key item of scrutiny during bid assessment. It should be noted that the cost of preparing a GBR is negligible, compared to the cost of the project.

A concept fundamental to geological and geotechnical interpretation and essential for GBRs is that of Homogeneous Zones. A Homogeneous Zone is a 2D representation of 3D volume of ground that has the same or similar properties. These properties may be constant of vary very slightly within stated bounds and are usually tied to a single design solution or form of construction, such that there is a direct link between the properties and the cost/programme for delivering that aspect of the work within it. The geological/geotechnical interpretation must be sufficiently refined to enable the cost/programme couple to be accurately defined. Sometimes, particularly with traditional tunnelling methods, payment may be explicitly linked to the Homogeneous Zone and payment may be based on measurement of the ground as it is revealed by the works. In some countries, the Employer may seek compensation on a lump sum contract should ground conditions be actually better than anticipated.

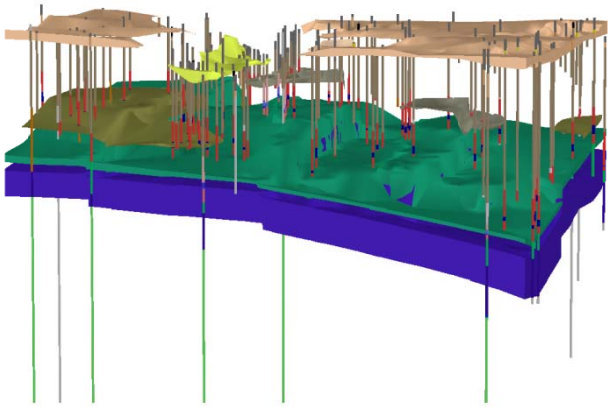

Figure 3 A detailed 3D geological model was produced using the software GSI3D for Farringdon Station for Crossrail because it proved impossible to reliably do the same using traditional 2D methods (ALDISS, D T, BLACK, M G, ENTWISLE, D C, PAGE, D P, and TERRINGTON, R L. 2012. Benefits of a 3D geological model for major tunnelling works: an example from Farringdon, east-central London, UK. Quarterly Journal of Engineering Geology and Hydrogeology, Vol. 45, 405-414).

Soon, GBRs will be interrogable 3D geological models of the ground fully compatible with the 3D BIM model of the design of the works. Some geological interpretation software currently available even also allows 'homogeneous volumes' to be attributed with geotechnical parameters allowing their value in space to be seen. A detailed geological model suitable for incorporation into the GBR was prepared for Farringdon Station for Crossrail (Figure 3).

A technical or commercial document?

Following a joint British Tunnelling Society/British Geotechnical Association meeting in London in October 2011, there was some debate as to whether a GBR was a technical document or a commercial one. The Author claimed that the document was a commercial one, whilst others (noticeably consultants!) thought it should be technical (Figure 4).

- Content of the report is technical
- Its purpose is to inform and influence – commercial
- Provide clarity on nature of risks and who owns them – commercial
- But not always backed by the accompanying Site Information; requiring both commercial and technical judgement to establish baselines
- A common basis for bidding a project – commercial
- A basis for assessing bids – commercial
- A measure for payment - commercial
- A measure for Compensation Events - commercial
- A technical reference for design? Categorical no. Not technical

Figure 4 A GBR is a commercial document.

There is no doubt that the report has a technical basis but the final document is very much a commercial one and should be prepared in much the same way as a specification or bill of quantities, as arguably, this is indeed what it is. The document should be prepared sufficiently early in the development of a project so that it can influence the cost model developed by the Employer and contingencies for variations in ground conditions can be properly priced. To commence its preparation at the conclusion of design is just too late. GBRs are best prepared independently from the design team by a geotechnical specialist, to allow the underlying assumptions made by the project team to be challenged and hence allow the risk, cost and programme model to be best informed. The process is iterative and the preparation of GBR is very useful at flushing out the true cost of the project.

Conclusions

GBRs are here to stay, as for all parties, they make commercial sense. However, they must be done well since a poor GBR will lead to poor definition of risk and it therefore follows that they will lead to cost and programme uncertainty and to claims and hence potentially to disputes. Common mistakes are to give this report to a junior member of the geotechnical design team to draft or to re-hash a geotechnical interpretative report previously produced for design.

No one rule fits all. Each project is different and risk definition and allocation will be variable, though a GBR provides the means to control this. No one rule fits all. The content of GBR depends on the scope and nature of the works. A GBR should not be used alone, it should be supported by good information on the site and integrated into the design and risk managements process being used on the project. A good geotechnical baseline should be exactly that - a baseline. It should be sufficient to confidently assure subsequent design and construction works. Anticipated variations from the baseline can be managed through the use of the Risk Register and/or provisional sums that should be discussed up front. It is, therefore, imperative that a geotechnical specialist is involved throughout the procurement process, including technical and commercial bid appraisal and contract negotiations.

The current trend is for GBRs to be prepared by the Employer, rather than by the Contractor, the reason for this is that Employer needs better definition of risk, cost and programme at the commencement of the project and cannot afford to have too much variation as a result of the bid process. And, whilst they are being routinely used for underground works, they are not commonly used on smaller geotechnical projects; this is an area where there has to be rapid change.

From a UK perspective the traditional roles of the Employer and Contractor are becoming blurred; the Employer is now often better informed than the Contractor with regards to its project risks. Consequently, we are now seeing a far more integration of the project teams with the various Contractor's bid teams through the procurement process, so that the risks are accurately captured pre-tender and well before a problem arises. There are many innovative forms of procurement, both formal and informal, that are now being adopted. As a result, the underlying basis of the standard forms of contract and the root cause of so much of the problem with changed ground conditions, is being replaced with more flexible contract terms, with the GBR at the core of this process.

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