The Geotechnical Baseline Report in the new FIDIC Emerald Book – Suggested Developments

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ABSTRACT: The Emerald Book is a new FIDIC form of Contract for Tunnelling and Underground Construction. One of the key features of the Emerald Book is the remeasurement of time and quantities for excavation, support and lining, depending on the encountered geotechnical conditions compared to the contractually predicted – "foreseen" – ground conditions. The Geotechnical Baseline Report (GBR) will play a critical role as the only contractual definition of "Foreseen Ground Conditions" valid for the chosen design and construction methodology of excavation and. The GBR thereby defines the border line between ground related risks retained by the Employer and the performance related risks for which the Contractor shall be responsible.
To match these requirements, the GBR will have to be developed and elaborated further than what is traditional. The paper will discuss ad give examples of the suggested development of a GBR needed for being part of an Emerald Book Contract.

1 INTRODUCTION AND ACKNOWLEDGEMENTS

As is well known to the Tunnelling Industry, there is an ever-growing demand for utilizing underground space for infrastructure. The difficulty in predicting underground behaviour and physical conditions poses unique challenges regarding construction practicability, time and cost. Thus, allocation of underground risks among the stakeholders becomes critical in underground construction. To address these unique risks the International Tunnelling and Underground Space Association (ITA) and the International Federation of Consulting Engineers (FIDIC) joined forces to draft the new FIDIC Form of Contracts for Underground Works (the "Emerald Book"). To accomplish this, the two organizations setup a joint task group (TG10).

The Emerald Book has been modelled on the 2017 FIDIC Yellow Book (Conditions of Contract for Plant & Design Build) but with significant innovations tailored to the specifics of underground construction. Consistent with FIDIC's philosophy of achieving a fair allocation of risks among the parties, the Emerald Book has been drafted with a view to promoting a balanced risk allocation that is specifically adapted to the risks inherent and unique for underground works.

While a balanced risk allocation reduces the overall cost of the project and the risk of disputes, the uncertainty and risk inherent to underground works mean that projects comprising such works remain, to an even greater degree than other construction projects, prone to claims and disputes.

A key element for an improved contractual practice in underground construction is a clear definition of "Foreseen Physical Underground Conditions" in the contract which then forms the firm basis for the tenders and which is also the central tool for adjustment of construction time and cost from the assumptions made in the bid to the physical conditions actually encountered during construction. In the FIDIC Emerald Book, the Geotechnical Baseline Report (GBR) takes this role. However, to achieve these goals, it has been found that some developments of a GBR under the Emerald Book are required compared to the way GBR's have been written and used so far.

This contribution aims at presenting the historic development of the GBR and to describe the further development needed, as identified during the drafting of the Emerald Book and the associated Guidance Notes for Preparation of Tender Documents.

ACKNOWLEDGEMENT: This contribution is based upon the work of the FIDIC Task Group 10 "New Form of Contract for Tunneling and Underground Works". The author wishes

to thank FIDIC, the ITA and his colleagues Hannes Ertl (D2 Consultants, Linz, Austria), James Maclure (Independent Consultant, Durham, United Kingdom), Andres Marulanda (Ingetec, Bogotà, Columbia), Charles Nairac (White & Case LLP, Paris, France), Matthias Neuenschwander (Neuenschwander Consulting Engineers Ltd, Bellinzona, Switzerland) and Martin Smith (Matrics Consult Ltd., Seoul, Republic of Korea) for their important contributions.

At the moment of drafting this contribution, the Emerald Book is not yet published. Therefore, there may be differences in wording between the referenced sub-clauses in this paper and the published Form of Contract.

2 BACKGROUND

The use of Geotechnical Baseline Reports (GBRs) has gradually increased in the Tunneling Industry in recent years. Initially, following the Guidelines introduced by ASCE 1977 and the second edition 2007, the GBRs were mainly adopted in the USA. The Joint Code of Practice for Risk Management of Tunnel Works produced in the UK by the Association of British Insurers and the British Tunneling Society 2003, the Code of Practice for Risk Management of Tunnel Works by the International Tunneling Insurance Group 2006 and the Guidelines for Tunneling Risk Management: ITA Working Group No. 2, have subsequently promoted the use of GBRs also in Europe and elsewhere.

The main objective of a GBR is to define the contractual allocation of ground related risks between the Employer and the Contractor.

Important feedback of experience has, for example, been reported in;

- Recent development in the use of Geotechnical Baseline Reports (Essex & Klein 2000)
- Crossrail's experience of Geotechnical Baseline Reports (Davis 2017)

The number of significant projects having used GBRs has increased in recent years and numerous lessons have thereby been learnt, in particular that;

Contractual allocation of risks determines fundamental matters such as;

- The Contractor's Bid Contingency
- Contractual behaviour and attitudes
- One sided contracts shifting all risk to Contractor lead to dversarial relationships, speculative bids and a false sense of security
- Effective contracts promoting fair and equitable risk-sharing mechanisms lead to partnering approach by the involved parties which is benificial for all stakeholders in a project
- Risk should be allocted to the party in best position to manage it

In Lump Sum Contracts all geotechnical risk is often shifted to the contractor. He then recovers through claims arguing differing site conditions which in turn leads towards litigation, loss of time and more costly projects (and even uncompleted projects)

The main conclusions from this situation, which have been important drivers for the development of the FIDIC Emerald Book are that Contracts should;

- Accept that the Ground belongs to the Employer
- Accept that the Employer has responsibility to pay reasonable costs required to handle ground conditions encountered during construction
- Include a clear contractual definition of foreseen physical ground conditions as the basis for Tenders

- Encourage cost-reimbursable contracts
- Include differing ground conditions clauses
- Include contractual procedures for handling unforeseen conditions
- Disclose all available data

3 FIDIC EMERALD BOOK SPECIFICATION OF THE GEOTECHNICAL BASELINE REPORT

The following is a summary of how the Geotechnical Baseline Report is specified in the Emerald Book Guidance Notes for Preparation of Tender Documents.

The Geotechnical Baseline Report (GBR)is intended to form the basis for establishing the ground related risks in the design and construction for the execution of Underground Works, and as such is critical in providing a balanced allocation of risk between the Parties.

The GBR shall be the single source contractual document that defines what sub-surface physical conditions are to be assumed to be encountered in the execution of the Works through referenced baseline statements for the contractual allocation of the foreseeable ground related risks of physical conditions of the ground between the Parties.

The GBR thereby allocates risks between the Employer and the Contractor for specifically defined physical conditions and related elements of work as set out in the Baseline Schedule.

Consequently, the GBR is the only contractual definition of the foreseeable physical conditions for Underground Works and shall be considered as the basis for the preparation of the Tender and execution of the Works. The procedure for the management of these allocations shall be described in the Contract Risk Management Plan.

The design concept selected by the Employer and the interpretations stated in the GBR collectively represent the Employer's preferred risk allocation for the physical conditions of the ground. This shall apply to the Employer's reference design and any alternative design and method of construction submitted in the Contractor's Proposal by a tenderer.

The GBR baseline statements may also be based on previous experience or exploration data from other sources of relevant information on the physical conditions of the ground. This implies that the GBR might deviate from the factual geological data contained in the Geotechnical Data Report or (GDR).

The GBR also serves to convey and highlight the key project constraints and requirements to enable the tenderer appreciate the key project issues.

The GBR shall include parameters that state the physical characteristics of the ground and ground water conditions, as well as the most likely ground behavior to be encountered during the various Excavation and Lining stages in an adequate format. Focus shall be on the behavior of the ground and ground water caused by or having impact on the method of construction for the Excavation and Lining Works rather than on pure scientific data.

Physical and behavioral baseline statements in the GBR shall be described using quantitative terms (with limits where appropriate e.g. water inflow, speed of deformation) to the maximum extent possible. As far as possible the selected baseline parameters shall have the ability to be confirmed by the physical conditions encountered quantitively in the field, to reduce ambiguity in the scope of work, avoid delays and potential for disputes, and improve time and cost certainty.

The GBR shall also, where possible, present summaries of relevant, local construction experience encountered physical conditions similar to those anticipated to be encountered for the proposed Works.

Each risk of foreseeable ground related physical conditions shall, with the ambition to achieve a balanced risk, be allocated in the Contract Risk Register to the Party that is best positioned to control it, which leads to more effective risk control. Balanced and equitable allocation of ground related risks, by experience, leads to lower cost of the Works and more competitive Tenders. The Employer should therefore avoid establishing an overly conservative GBR, as this would render it ineffective. Instead, the Employer is advised to provide sufficient rationale in the GBR for how the baseline statements have been set to give the tenderers confidence in the fairness of the Baseline Schedule as the basis for the Tender.

The location of the ground for the construction of the Underground Works is selected and made available by the Employer. Consequently, the Employer's documents i.e. the GBR and the Employer's reference design need to be compatible with the other Employer's Requirements as these constitute the basis for the assumptions in the Tenders. The Contractor's Proposal of design methodology, the detailed means and measures including methods of construction for Excavation and Lining and the associated production rates for any given set of circumstances, are then selected by the tenderer and submitted in the completed Baseline Schedule consistent with the Employer's reference design and/or alternative design (if any).

If the encountered physical conditions of the ground vary within the limits stated in the GBR, there will be an influence on time and cost for the Excavation and Lining Works.

This difference in the time and cost for Excavation Works is due to how the selected means and measures (necessary to excavate and ensure the long-term stability of the surrounds of the space created by the Excavation process) depend (compromised or constrained) on the physical nature of the ground encountered (including everything contained in the ground, like e.g. water, gas, natural or man-made obstacles etc.).

The contractual time and cost for Excavation, (including all necessary support) shall be adjusted accordingly based on the variations between the physical conditions of the ground encountered and those stated in the GBR.

Any physical sub-surface conditions that are outside the limits stated in the GBR shall be considered Unforeseeable physical conditions, and the "differing ground conditions clause "of the Emerald Book General Conditions of Contract will be applicable.

The Contractor, when making any claim based for Unforeseeable sub-surface physical conditions, should be able to demonstrate:

i) that the Contractor in his Tender relied on the physical conditions defined in the GBR and
ii) the impact of any changes in scope, time, risk allocation or cost was caused by the difference of the encountered sub-surface physical conditions against the limits stated in the GBR. Purely numerical differences in the physical conditions encountered do not provide sufficient basis for any compensation to be adjusted.

Variations within the baseline limits stated in the GBR, for example regarding a given percentage distribution of excavation and support classes, will be re-measured according to a procedure defined in the Emerald Book.

The physical conditions stated in the GBR shall be described, and later monitored, measured and recorded, in terms of the means and measures required for the Excavation and ensuring the stability of the space created by the Excavation, and the effect on the surrounds including adjacent property affected by the Excavation. The data should generally be allocated to the different variations and combinations of homogeneous and heterogeneous zones along the length of the different drives.

Baseline statement conditions shall be described in terms of the:

i) anticipated methods of construction
ii) logistics determining access to the working faces and ensuring suitable working conditions

The parameters contained in the GBR shall for each type of excavation and support and each type of construction methodology focus on ground behavior and/or ground response rather than geologically oriented parameters. For example, rather than to establish permeability parameters for the ground, seepage estimates and grouting requirements should be stated to the maximum extent possible, baseline statements should best be stated using quantitative terms that can be measured and verified on Site during construction. For example, maximum allowed convergence or settlement for different support classes at specific locations should be included.

The GBR will need to use a contractual ground classification system that properly reflects the effort (time and cost) of excavating and supporting the cavity in the expected ground conditions. For this purpose, the definition of a ground classification system, together with the associated quantitative criteria for the application on Site, is convenient.

The ground classes should be first established in accordance with:

i) the type of Excavation Works (e.g. open cut, shafts, portals, tunnels, other openings, caverns with top headings and benches, etc.);
ii) the associated anticipated methods of construction, for each type of excavation works, e.g. tunneling or mining techniques, drill and blast or mechanical excavation; full face or partial excavation including pre-treatment (if any), and
iii) the method of support (where stability, ground movement, squeezing etc. should be considered).

The ground classification system should then consider:

i) the behavior of the ground when excavated,
ii) the support measures required for stabilization of the surrounds, and
iii) conditions generated by unique geological features, such as fault (active or passive) or shear zones.

The description of the contractual ground classification system for Excavation Works should include:

i) The quality and structure of the soil and/or rock in relationship to the excavation process, influence of water on the excavation process, methods of Excavation, average types and quantities of support, different ground classes, installation sequence, expected/allowable deformations, and ancillary methods of construction (i.e. grouting, soil improvement, freezing etc., if any);
ii) A percentage distribution of ground classification classes based on the foreseeable physical conditions of the ground and represented spatially in information associated to the Excavation profile and location within specific Sections of the Works.;
iii) Drawings showing the ground classes for different working conditions and methods of construction in soils, rock and/or mixed ground for each drive.

The nature of the foreseeable physical conditions of the ground and the measures to control them, will have significant impact on how to define the contractual ground classification system. The use of geomechanical classification systems as a contractual ground classification system may have to be integrated with the selected design and construction methodology in order to serve the purpose of the GBR.

The contractual ground classification system should typically include:

- Profile type
- Ground behavior;
- Ground behavior for TBM intervention (where relevant);
- Geological hazard scenarios;

- Stand up time, if applicable;
- Ground excavation and support sequence;
- Support type;
- Grouting type and sequence;
- Expected deformations for the ground type and the means to control the deformations;
- Expected ranges of ground mass parameters that could affect the productivity and cost of the methods of construction for each type of Excavation and potential situation during the drive (e.g. include abrasivity, bit & cutter wear, drillability, groutability and cuttability, risk of slurry loss during D-wall construction)
- Geotechnical "Hold Points" with attention and alarm values related to reference values established in the Employer's reference design and/or in the Contract Risk Management Plan;
- Required monitoring.

The GBR should:

- avoid the inclusion of design parameters
- present the general description of the geology and hydrogeology of the Works and in the GDR;
- include a thorough discussion on anticipated ground water levels, seasonal and/or tidal (if any) variations, the baseline physical conditions, including items such as inflows, estimated pumping volumes and rates, anticipated ground water chemistry and temperature;

The GBR should provide referenced baseline statements on:

i) acceptable construction impacts on adjacent property and facilities;
ii) parameters such as maximum/differential settlement, rate and tendency of deformation etc., on affected property;
iii) and other known natural geotechnical, hydrogeological, hydrological and/or man-made sources of potential difficulty or hazard that could impact the construction process such as:

- Natural Hazards:

  Boulders, cavities and other obstructions, high or low top of bedrock, mixed face physical conditions, occurrence of hard strata, geological contact zones, highly stressed or permeable physical conditions, gas, coal seams or oil deposits, high temperatures and hot water inflows, intrusions, isolated aquifers, seismic conditions etc.;

- Man-made Hazards:

  Other obstructions such as: identified or unidentified deep foundations and/or abandoned piles, exploratory shafts, pits, wells, boreholes, buried utilities, buried debris, unexploded ordnance, engineered and/or reclaimed ground, waste tips, contaminated ground and ground water within the impact zone etc.;

as well as

- Items of Value and/or Interest according to governing Laws:

  Any anticipated items of value or interest described under Sub-Clause "Archaeological and Geological Findings".

All conditions that are not explicitly included in the scope of the GBR are considered as Unforeseeable physical conditions.

It should be noted that the Geotechnical Data Report (GDR) is one of the "any other documents forming part of the Contract", and as such has the lowermost priority of contract documents.

The GDR should be issued to the tenderers as part of the Invitation to Tender only to enable tenderers to make their own interpretations and assessment of the risks associated with the referenced baseline statements in the GBR.

4 CONCLUSION

As can be seen above, a GBR under the Emerald Book will be a comprehensive and highly qualified document, setting considerably increased requirements on how it is written compared to what is normal today.

It typically means that the writer(s) need to;

- Understand and be fully aligned with the Employer‘s preferred risk level as it is illustrated by the Emloyer’s Requirements, the Employer’s Reference Design (or, as may be the case, the Contractor’s Alternative Design) and the suggested methods of construction
- Understand in what way each specific construction method chosen for the project and for each type of excavation and support within the project may be compromised by unforeseen conditions and provide baselines for such conditions
- Understand the general geological / geotechnical setting of the site, the variations within the site
- Understand the limitations of the factual site investigation data presented in the GDR and what may have to be considered by baselines outside what is described by the ground investigation data
- Understand that the baseline statements are the only definition of what is foreseen and conditions outside the baseline limits, as well as any conditions not covered by the GBR baselines are by definition unforeseen physical conditions
- Understand the link between the GBR and the compensation mechanisms of the Contract, i.e. both the mechanisms for re-measurement within the baseline limits set in the GBR and the mechanism for compensation for conditions outside the GBR baseline limits, i.e.unforeseen conditions

This broad and in-depth scope suggests that the writing of a GBR needs an integrated teamwork - and therefore that it will probably not be possible for a single individual to cover all necessary aspects.

Major projects, split into many contracts, will further require several GBR’s. In that case there is in addition a need for consistency in approach and contents between the different GBR’s. Thus, it is suggested that the responsibility for producing the GBR should be given to a limited core team which then provides the various involved parts of the project organization with a document framework where they can see the overall context and then fill in their relevant details. The core team shall also be responsible for organizing necessary reviews and revisions, in close liaison with the concerned parts of the project organization.

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