

Measuring the excavation and lining in the Emerald Book

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ABSTRACT: One of the key features of the new FIDIC Form of Contracts for Underground Works (the “Emerald Book”) is the remeasurement of time and of quantities for excavation, support and lining of the works. It is an important aspect of the balanced allocation of risk related to the subsurface conditions, as in this way, the effectively encountered ground is taken into account. In the tender documents, the relevant quantities are presented in specific schedules for time related, quantity related and value related cost items. These items are the used by the Contractor and the Engineer in order to establish the realized works on a regular basis, allowing for a timely issuing of the necessary statements, as well as for the control of cost evolution in the project. The present contribution is one of several regarding the Emerald Book, and treats the remeasurement process and tools regarding time and quantity related cost items, as well as the documents that must be prepared by the Employer prior to issuing the tender documents during his procurement process.

1 INTRODUCTION

As is well known to all members of the tunneling industry, there is an ever-growing demand for utilizing underground space for infrastructure. The difficulty in predicting underground behaviour and 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**” (see Reference [1]). In order to accomplish this, the two organizations setup a joint task group (TG 10).

The Emerald Book has been modelled on the 2017 FIDIC Yellow Book (Conditions of Contract for Plant & Design Build) (see Reference [2]) but with significant innovations tailored to 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 to Underground Works.

The FIDIC “Rainbow Suite of Contracts” provides standard forms of contract for different types of risk sharing models, amongst which the “Red Book” (see Reference [3]), a Form of Contract for Construction Works designed by the Employer, the “Yellow Book”, a Form of Contract for Plant and for Construction Works, designed by the Contractor, and the “Silver Book” (see Reference [4]), a Form for EPC Contracts, where all the risk of Engineering, Procurement and Construction is taken by the Contractor against a lump sum price.

Two salient differences between the Yellow and the Red Book lie in the responsibility for design and in the mode of payment of the Contractor. While the first difference appears in the titles (“designed by the Employer” vs. “designed by the Contractor”), the second difference requires a comment.

2 MEASUREMENT UNDER THE FIDIC RED AND YELLOW BOOKS

Under the Red Book, the Contract Price is based upon a Bill of Quantities, where the Employer lists the payment items and estimates the quantities for each item, and where the Contractor offers a unit rate for each item. The Contractor is paid upon remeasurement of the quantities of the different items according to what he has actually realized. The General Conditions of Contract provide, amongst others, a mechanism for the case where an item is completely missing in the Schedule, and one for the case where the remeasurement of the quantities realized of an item show a remarkable difference against the estimated quantity. The unit rates typically include all charges that the Contractor has to sustain in order to realize the Works (including charges related to the time of construction, like i.e. costs for supervision, plus a profit of his choice). The items will usually cover all parts of the Permanent Works in more or less detail.

Under the Yellow Book, the Contract Price is a Lump Sum that, again, includes all charges the Contractor has to sustain in order to realize the Works, plus a profit of his choice. It is considered that, as the Contractor is in charge of the design of the Works, he should bear the quantity-related risks.

In both Forms, the General Conditions of Contract provide mechanisms for claims by the Contractor, in particular for the cases of Unforeseeable Physical Conditions.

3 THE CONTRACT PRICE IN UNDERGROUND WORKS

Compared to other kinds of Works, underground construction faces a main uncertainty due to the fact that in order to realize the Works, the necessary space must first be created by excavation in a ground mass that is neither known perfectly in its characteristics, nor in its reaction to excavation. It is therefore difficult to assess the effort (in terms of energy, time and money) it will take to excavate and to finish the Works.

3.1 *Risk allocation under the Emerald Book*

A balanced risk allocation is central to Underground Works contracts (this is also why FIDIC explicitly discourages the use of the Silver Book for sub-surface works). As a rule, the most important risks in Underground Works are related to the quality of the ground to be excavated and supported during construction (there are other important risks related to i.e. access points, available space for installation etc.). The Emerald Book specifies that the Geotechnical Baseline Report GBR shall be the only contractual source of allocation of the risk related to the sub-surface physical conditions: within the limits described in the GBR, the risk of production rates and related cost is allocated to the Contractor, while outside these limits it is considered to be in a situation of Unforeseeable Physical Conditions under Sub-Clause 4.12.

3.2 *Measurement in a Design-Build approach*

If the Contractor is responsible for the design of the Works he should logically bear the risks related to the construction method he selects and to the quantities: unless a situation of Unforeseeable Physical Condition occurs, the Contractor's remuneration and allowance for time to perform the Works should be fixed (except cost escalation according to the Contract). This is the main incentive to the Contractor for finding cost-effective solutions, while satisfying the fitness for purpose required by this type of Contract.

3.3 *Cost uncertainty in Underground Works*

In Underground Works, the greatest uncertainty is related to the sub-surface conditions, and in particular to

- the difficulty in excavating the necessary space for the Works, including but not limited to natural or man-made obstacles, water inflow etc.,

- the reaction of the surrounding ground mass to the excavation of this space,
- the effort to create the provisional and final support and lining of the surrounds of the Works,
- and last but not least, the handling, transportation and disposal of the excavated ground (spoil), according to the nature of the ground, the excavation method, available space, recycling possibilities and legal environment.

The last of these factors will, as a rule, influence cost only, while the other three will have a strong influence on the cost of the Works as well as on the time for completing the underground excavation and lining and therefore in many cases on the Time for Completion of the Works.

Time is an important cost driver (not only) in underground works, because an important part of the charges that the Contractor sustains are independent from the actual performance of the Works and depend only on the necessary time, such as i.e. the devaluation of and interest rates for expensive equipment, or the site supervision and management. The uncertainty of the time available for excavation and lining due to the uncertainty of the sub-surface physical conditions leads therefore to a similar uncertainty regarding the time-related charges.

3.4 *Adjustment of the Contract Price*

Following the logic of the Employer carrying the risk of the sub-surface physical conditions, in relation with the contractually agreed construction methodology, and the Contractor carrying the risk of production rates and cost in any situation within the limits specified in the GBR, the Contract Price should be adjusted according to the difference between the agreed sub-surface physical conditions and the conditions as encountered during the Works.

On the other hand, no adjustment should be made for any difference between the Contractor's offered production rates and the real performance in ground conditions as described in the GBR.

The adjustment of the Contract Price should take into account the cost for performing the Works as such (quantity-related charges) and the cost related to the adjustment of Time for Completion (time related charges). Of course, an adjustment may mean an increase or a reduction of the Contract Price as compared to the Agreed Contract Amount: as a principle, if the sub-surface physical conditions as encountered lead to easier realization of the excavation, support and lining of the Works than what was contractually agreed, the Contract Price should be reduced, while in the opposite case it should be increased.

The adjustment is possible in two ways: either through a change in a lump sum by the claims procedure as foreseen by i.e. the FIDIC Yellow Book, or through measurement. For the Emerald Book it was decided that a measurement provision for the Excavation and Lining works and for the time related charge items necessary for these works was the most effective way of managing the adjustment.

No adjustment of the Contract Price should be made for any part of the works that is not subject to the risks related to sub-surface physical conditions: this portion of the contract price is a lump sum, and as such it shall not be adjusted through measurement, but may only be varied following a Contractor's Claim and/or a DAAB award.

4 MEASUREMENT UNDER THE EMERALD BOOK

4.1 *The concept of measurement and the different cost items*

The Emerald Book distinguishes between those parts of the Works that are subject to the risk related to the sub-surface physical conditions, and those parts that are not. The underground excavation and temporary support and the final lining are deemed to be subject to these risks, while all other parts of the Works are deemed not to be subject to these risks. Therefore, the underground excavation, support and lining Works should be remeasured, while all other Works should be remunerated through the lump sum component of the Contract Price. This is consistent with the logics of a Design-Build Contract. For the purpose of measurement, the following categories have been postulated in the Emerald Book (Sub-Clause 13.8 "Measurement of Underground Works and Adjustment of Time for Completion"):

- Fixed rate items
- Quantity-related rate items
- Time-related rate items

4.2 *Fixed rate items*

All those items that are necessary for the performance of the underground excavation, support and lining Works, but that are independent from the variation of the sub-surface physical conditions, may be considered in the exclusive risk sphere of the Contractor's, and may therefore be paid with lump sums as fixed rate items. Typically, these items include the transportation to site, setting up, dismantling and evacuation of the Contractor's equipment, the construction of the site infrastructure and the making available of equipment and of site supervision and management for the time estimated by the Contractor for performing the works.

In the Bill of Quantities, the fixed rate items may be described in detail ("*113/861.101 Electro-hydraulic Drilling rig for drill&blast excavation with three drilling arms and working platform, maximum working height 6.75m, covering an excavation face of 120m², with a minimum drilling length of 5 m, including transportation to site, setting up, availability for the entire duration as estimated by the Contractor for completing the excavation of Section X, dismantling and evacuation*"), or in grouped items ("*113/121.111 Complete equipment for excavation and support of Section 1, according to Drawing XY in the Employer's Requirements, including transportation to site, setting up, availability for the entire duration as estimated by the Contractor for completing the excavation of Section X, dismantling and evacuation*").

4.3 *Quantity-related rate items*

The performance of excavation, support and lining Works, including all necessary ancillary activities such as i.e., the drainage of water seepage, the drilling of probe holes, the handling of the spoils etc., shall be remunerated through "quantity-related rate items". These are unit rate items that are paid according to the rate offered by the Contractor and agreed under the contract, with a price that shall be paid for each measured unit that was performed, irrespective of the real effort and/or time it took the Contractor to perform it. The items and units shall be as per the Bill of Quantities prepared by the Employer in his tender documents, and each item shall be completed with the respective rate by the Contractor.

In the BoQ, the quantity related rate items may be described and measured in detail (i.e., "*261/123.456 Excavation in support class 3A according to drawing XY attached to the Geotechnical Baseline Report, including transportation of spoil to Contractor's disposal area. Measurement according to theoretical cross section on drawing and measured tunnel length in situ. Unit: m³, Quantity: 125'000*"; "*261/234.567 Supply to excavation face and setting up of expanding rock bolts with adherence on the entire bolt length. Minimum yield load per bolt: 100 kN, bolt length: 4m. Including anchor plate 20x20cm. Unit: piece (pce), Quantity: 5000*") or as grouped items (i.e., "*261/111.211 Excavation and temporary support of tunnel cross section according to drawing XY attached to the GBR, including all necessary measures and activities, measurement in m in the tunnel axis of excavated and supported tunnel. Unit: m, Quantity: 2'500.*")

4.4 *Time-related rate items*

Time-related rate items are used for the remuneration of charges supported by the Contractor that don't depend on the quantity of performed Works, but on the time required. Typical time-related charges are the supervision and management on site, the running and maintenance of the construction yard, the workshops and the rail system (if any), and (without limitation) the availability of Contractor's key equipment not covered by the Fixes rates for the time lapse estimated by the Contractor in his tender.

While during the Contractor's estimated time these charges shall be covered by fixed rate items, the same charges due to adjustment and/or extension of time related to risks that are

not allocated to the Contractor, depend on the length of this adjustment and should be paid through time-related rate items.

The time-related rate items shall be measured in days (Calendar days) or weeks. They shall be related to the respective fixed rate items, and shall refer to the same (i.e. “113/891.861 *Extended availability of items 113/861.101 to 861.191. Unit: day, Quantity: 120*”; “113/891.862 *Reduced availability of items 113/861.101 to 861.191. Unit: day, Quantity: 90 (negative rate)*”).

Only the differences between the estimated and the measured amounts in the Baseline Schedules may give rise to the adjustment of time for completion of the Works, a Section or any other Milestone. Further, in order for an adjustment to be applicable, the respective part of the Works must be on the critical path of the same Milestone. For example, it is possible that the measurement in a Baseline Schedule leads to extended time for completion of the Milestone “End, Excavation of tunnel Section XY”, but does not lead to extended time for completion of the Works, because the Excavation of tunnel Section XY is not on the critical path for completion of the Works. This is to be considered when adjusting and/or extending time.

4.4.1 Adjustment and extension of time

In order to measure any quantity for time related charge items, the respective time for completion must first be adjusted and/or extended. As pointed out above, if the sub-surface physical conditions are better than expected (i.e. if the amount of rock requiring light support is higher than expected and the amount of rock requiring heavy support is lower than expected), this will lead to a shortening of the time available to the Contractor as measured in the Baseline Schedule (see Reference [5]). Vice versa, if the sub-surface physical conditions are worse than expected (i.e. if the amount of rock requiring light support is lower than expected and the amount of rock requiring heavy support is higher than expected), this will lead to a lengthening of the time available to the Contractor as measured in the Baseline Schedule. To the total of adjusted time, extensions of time under Sub-clause 4.12 shall be added.

4.4.2 Measurement of quantity of time related rate items

Time related rate items shall be measured in units of days of extension and/or reduction of the Time for Completion of the respective Milestone. For example, if the Time for Completion of the Milestone “End, Excavation of tunnel Section XY” is extended according to the measurement in its Baseline Schedule by 45 days, then the measurement for all the time related rate items for the same Milestone should also be 45 days.

4.5 Value-related charges

Some charges that the Contractor must support are value-related, such as i.e. the premium for construction insurance, or interest on retention money, etc. In order for these charges to be properly taken into account, they should be added as percentage rates to all items in the Bill of Quantities. In this way it is assured that the Contractor’s cost will be covered according to the contractually agreed payment plan and to the remeasured quantities of Works performed, as the case may be.

4.6 Adjustment of the Contract Price

The Contract Price shall be adjusted according to the results of the measurement of all items in the BoQ and according to any awarded claim of the Contractor’s. As with all measured contracts, the adjusted Contract Price may result higher or lower than the Accepted Contract Amount.

4.7 Validity of Unit Rates

The rates and prices shall remain fixed irrespective of the actual quantities measured. This is a major difference against the measurement principle as postulated in the Red Book (both the 1999 and the 2017 Editions), where in the case of a difference between the estimated and the measured quantities of more than 10%, a change in the rate or price may be asked for.

The difference between the Emerald and the Red Book lies in particular in the distinction between the time-related and the quantity-related rate items. Because the time related charges are covered irrespectively of the actual quantity of work performed, the cost supported by the Contractor for the performance of a quantity-related charge item varies much less due to the actual quantity performed than in a situation where the time-related charges must be included in the unit rates.

4.8 *Absence of unit rates*

In the case of absence of unit rates (i.e., if a new type of rock bolt is instructed by the Engineer, for which there is no unit rate in the BoQ), there are two possibilities: either a new unit rate is negotiated between the parties, in analogy with similar items wherever possible, or the particular part of the works shall be remunerated through day-work rates.

4.9 *Payment in exceptional situations*

As the Yellow Book, 2017 Edition, the Emerald Book includes two provisions regarding exceptional situations: Sub-Clause 4.12 “Unforeseeable Physical Conditions” (UPC) and Clause 18 “Exceptional Events”. In both cases, the Contractor is entitled to reimbursement of the Cost (and Extension of Time, if any) he has suffered (meaning that he is entitled to reimbursement of the entire Cost but not to Profit). The particularity of the Emerald Book resides in the treatment of time-related cost the Contractor may have suffered under Sub-Clause 4.1 (Unforeseeable Physical Conditions): in case of such an event relating to Excavation and Lining Works, the Cost “shall be determined by reference to the time-related rate items provided in the corresponding Bill of Quantities, to the extent that unit rates exist and are comparable, deducting profit as defined in Sub-Clause 1.1.27 [Cost plus Profit]”. This provision relieves the Contractor from the burden of the proof of the cost he suffered per unit of time under the said UPC, and allows the parties to simply use the time-related rate items and the duration of time loss that was agreed or determined.

The same provision does not apply to Clause 18 “Exceptional Events”. In this case it was the opinion of the authors of the Emerald Book that a full claim by the Contractor would be justified.

4.10 *Treatment of a particular case: geological overbreak*

How can particular cases be treated under the provisions of Sub-Clause 13.8 “Measurement of Underground Works and Adjustment of Time for Completion and of Contract Price”, such as i.e. geological overbreak?

Geological overbreak per definition is a void outside the theoretical excavation line which is due neither to poor workmanship, nor to the excavation methodology, but to the nature of the ground mass. The cost generated by overbreak is typically caused by the need of evacuating more soil than originally estimated, and by the need to backfill the extra void with concrete, sprayed or vibrated. Of course, overbreak may cause quantity-related cost and time-related cost. According to the logics of the Emerald Book, the risk regarding geological overbreak cannot be assigned entirely to the Contractor. As with other natural phenomena such as, i.e., flood), this risk to the Contractor should be capped. The way of limiting the Contractor’s risk depends on the legal environment and the culture of the Employer’s. In the following, two possibilities amongst several are presented:

One possibility is to assign the risk of geological overbreak in percentage rates of the theoretical excavation surface, taking into account the fact that in order to create the minimum necessary space for construction of the Lining, some overbreak will be inevitable. There might therefore be three categories of overbreak: a), the inevitable (technical) overbreak to be included in the rates and prices for excavation. The percentage of overbreak to include in the excavation rates should be defined by the Employer (i.e. 5%, 10% or x%, according to the Employer’s estimation). Outside this surface of $(1+x\%) \times$ (theoretical excavation surface), another percentage may be allocated to the Contractor as a risk, i.e. the additional void ranging from 10% (included in the unit rates) to 15% will be in the Contractor’s risk sphere, while

the handling and backfilling of all geological overbreak beyond 15% shall be remunerated through especially created quantity-related unit rate items.

The other possibility presented here is based upon distances from the theoretical excavation line.

In the tender documents, the Employer shall specify the distance from the theoretical excavation line that is the limit of the Contractor's risk sphere for geological overbreak (boundary line G).

In his tender, the Contractor shall define up to which distance from the theoretical excavation line any overbreak shall be considered "technical" and therefore included in the unit rates for excavation.

Any overbreak that remains inside the boundary line "G" shall be considered in the risk sphere of the Contractor's, meaning that the Contractor shall have no entitlement for either Extension of Time for Completion or additional remuneration due to this overbreak. For any overbreak with a boundary outside the "G" line, the volume for which there is an entitlement for spoil handling and backfill, if any, is measured as indicated in Figure 1.

An estimation of the total volume may also be specified in the Baseline Schedule, so that the incidence of the hindrances due to the overbreak on production rates may be contractually agreed beforehand, and the entitlement to adjustment of Time for Completion be a mere question of measurement without the need for a claim.

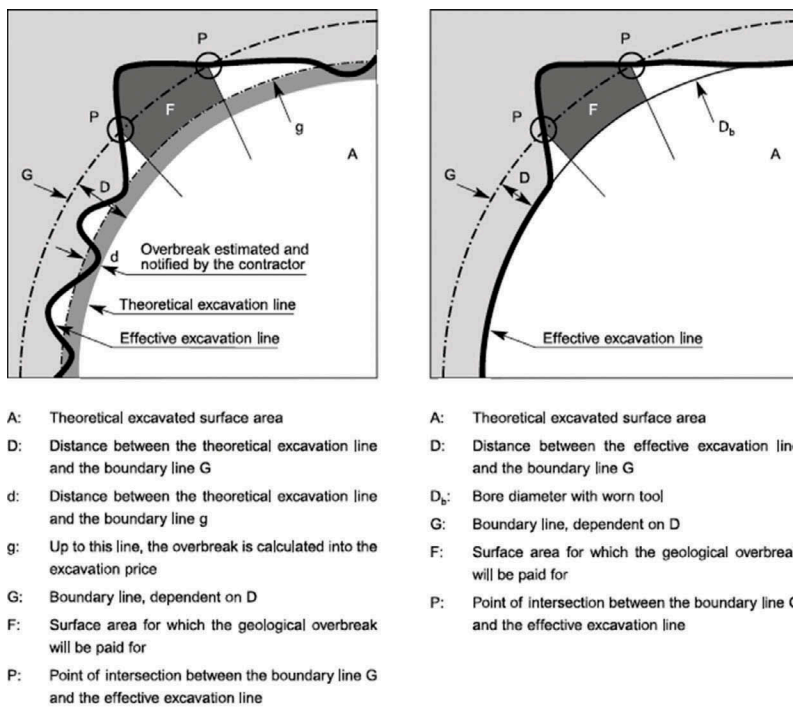


Figure 1. Definition of geological overbreak in rock excavation for conventional (Drill & Blast) and for mechanical (TBM) excavation. From: Swiss Code SN 507198, "General Conditions for Underground Construction" (see Reference [6]).

5 CONCLUSIONS

The Emerald Book combines the Design-Build approach with a balanced allocation of the risk related to sub-surface physical conditions. In particular, the definition of these conditions and of the relevant ground categories, including natural and man-made obstacles and hindrances, is proposed by the Employer in his tender documents (namely in the Geotechnical Baseline Report and in the Baseline Schedules). The production rates and the rates and prices for excavation, support and lining according to these ground categories are offered by the Contractor in his tender. Both the description of the ground categories with their estimated amounts and the production rates are contractually agreed. For all parts of the Works except Underground Excavation (including support and ancillary measures) and Lining, the Price shall be an agreed Lump Sum Amount.

The Underground Excavation and Lining shall be measured by the Contractor according to a Bill of Quantities. The Engineer shall determine whether the measurement by the Contractor applies to works that have been necessarily performed or not, and shall only certify payment and the adjustment of the Contract Price, if any, for those works that were necessary. In case of disagreement, the Contractor shall be entitled to claim the difference, and to address the Dispute Avoidance and Adjudication Board.

Because a high portion of the charges that the Contractor supports is time-related (such as, i.e. the devaluation and interest rates on equipment, the site supervision and management etc), the BoQ shall include Fixed rate items, Quantity-related rate items and Time-related rate items. The time-related rate items allow for a measurement and payment of the Contractor based upon the adjustment of time according to the differences between the contractually agreed and the encountered quantities of different ground categories. Thus, the Quantity-related charges become independent of the time-related elements, which greatly reduces their dependency on the actual amount of items produced. The Quantity-related rates may therefore remain unchanged irrespectively of the measured quantities.

Finally, there is no precise prescription on how the Bill of Quantities should be drafted, nor on what measurement rules should apply. These are specific to each project and to each legal and cultural environment, and should be defined in the Particular Conditions of Contract.

ACKNOWLEDGEMENT

This contribution is based upon the work of the FIDIC Task Group 10 “New Form of Contract for Tunneling and Underground Works”. The authors wish to thank FIDIC, the ITA and their colleagues Gösta Ericson (IC Consultants, Lund, Sweden), Hannes Ertl (D2 Consultants, Linz, Austria), James Maclure (Independent Consultant, Durham, United Kingdom), Charles Nairac (White & Case LLP, Paris, France) and Martin Smith (Matrics Consult Ltd., Seoul, Republic of Korea) for their important contributions.

Caveat: at the moment of writing of this article, the FIDIC Emerald Book is still under review. Part of the content may therefore be in contrast with the published Form of Contract. The reader should always consult the published FIDIC Form of Contract for Underground Works.

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