ΕΓΝΑΤΙΑ ΟΔΟΣ Α.Ε.

ΔΙΗΜΕΡΙΔΑ
"ΟΙ ΣΗΡΑΓΓΕΣ ΤΗΣ ΕΓΝΑΤΙΑΣ ΟΔΟΥ"

OVERVIEW OF TUNNEL CONTRACTS

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1. Introduction

The purpose of this paper is to take an overview at the general development of tunnelling methods and processes up to the present day with regard to the particular challenges associated with tunneling in Northern Greece in an attempt to understand the difficulties that have to be overcome, the risks and liabilities that have to be assessed, quantified and accounted for and the everyday construction and supervision activities that must be properly controlled in order to achieve our objective ie the completed structure and mechanical and electrical components to our required standards of quality, time and cost. This is not an easy task and we will also be looking at the preparation required to incorporate sufficient data and analysis into the precontract documentation in order to clearly define the risks and to allow the apportionment of those risks to the party best equipped to handle them. We shall take cognizance of the technical skills of the geologists and geotechnical engineers in their assessments of the conditions that are likely to be encountered but this must be tempered with the realization that this is not an exact science, data is often limited and engineering decisions are made which may later require changes in the field. Clearly without a very clear and proceduralised way of working bound up into a contract that can be properly administered there is the potential for major technical or contractual problems to arise. Therefore in working our way through the problems and in making clear our objectives the structure of the contract can be better understood.

2. Early Development

The need to drive tunnels through mountains has long been necessary in Greece due to it's very difficult topography and the need to supply water without wasting energy. On the island of Samos one of the earliest surviving examples can be seen in the Eupalinio cut a hydraulic tunnel of 1036m length which was constructed in 10 years in Archaic times (550BC) by the Samian engineer Eupalinos. Tales of silver and gold mines are the stuff of legend in Greece and important mining works are evident from the Classical times at Lavrio and at Mount Pangaio are the famous gold mines that were fully exploited by Philip II and Alexander the Great. Underground transportation works in the form of railway tunnels first appeared when Greek Railways started to develop at the end of the 19th and beginning of the 20th century. The development of the Metropolitan Railway in Athens also started to emerge. However it was not until the 1960's that mechanization began to play a major part as the hydraulic and hydroelectric demands of the country needed to be satisfied. Now small road tunnels were constructed such

as those leading to Sounio, at Philippiada, at Delphoi and on Crete but it was not until the 80's that longer tunnels were established such as at Artemisio in the Pelopponese and the Katara Tunnel designed and built as a single bore bi-directional tunnel which will form part of Egnatia Odos and is now known as the Metsovo Tunnel. This tunnel was a very difficult construction and took over ten years to complete requiring to overcome many difficulties and we have gained benefit from this experience which is now helping us to improve our methods and procedures. At the outset in Egnatia Odos it was clear that we needed to bring together a team which could combine the experience available in country with that from the international market. This has been achieved with a good degree of success through bringing together experienced Greek engineers from PPC hydraulic and road tunneling who are familiar with the local conditions who work very closely with engineers from Brown & Root who have brought their international experience to bear. This team has drawn and continues to draw heavily on the expertise of Professor Paul Marinos and Dr Evert Hoek in spearheading the drive and breakthrough necessary to construct the 71 tunnels many of which are in difficult ground conditions. We have developed some very good working relations with a number of local and international designers and contractors with specialist tunneling experience and it can be said that at the Egnatia Project we are now at the leading edge of tunnel development in this part of the World.

3. The Challenge

We have heard from previous speakers of the significance of Egnatia Odos as a priority project and as part of the Trans European Network of transportation of the European Union. It can be seen as the vital link between Europe and Turkey and the Middle East and with the Balkans. However Egnatia Odos traverses the mountainous regions of the Pindos and Kastania with many areas of instability and areas of difficulty for tunnel construction. Tunnels up to 4.6km in length and of total length of bore of nearly 100km are required. Cost optimization of the alignment generally leads to a reduction in the length of the tunnels and we often have a series of tunnels of length 200m to 1km connected by bridges and or earthworks. This can be seen at contract 3.2 at contract 5.1 and 5.23 and will be required in Section 4 now under design. This does not lend readily to use of TBM machines and leads us to the drill and blast methods with temporary support and primary lining of the tunnel and with the use of face support and forepoling where required. Such methods require headings to be opened and the safety of the operatives and the tunnel itself and cost effectiveness of the construction work becomes highly sensitive to even small changes in the quality of the rock mass, the quality of the workmanship of the contractor and the control applied through the supervision of the work. We must therefore employ a system of procedures bound into a robust contract in order to control these works.

4. Ground Classification, Tunnel Design and Observational Approach

Early tunneling work around the world was carried out using empirical methods and simplifications using closed-form analytical solutions which were in many cases inevitably

conservative (or in a few cases catastrophic) and therefore became costly in money and time. However, there have been significant recent improvements in numerical analyses techniques (hardware and software) and rock mass classification systems for tunneling. These include, for example, the work carried out by Drs Hoek and Brown and Professor Marinos who have developed rock mass classification systems (including an assessment of rock mass parameters and geological strength indices) suitable for many of the rock formations found in Greece and they have assisted in the development of powerful new computer software packages and methodologies. Consequently there is now a better understanding of the behaviour of the rock mass during the excavation and temporary conditions phase before the final lining is constructed.

In addition, at Egnatia an “observational approach” of tunnel construction which by definition requires the constant monitoring of the convergence which develops over time following excavation and installation of support and the back analysis of the design in an iterative process to confirm the effectiveness of the support against the expectation of the design. This process allows the validation of the design and the level of support that is required. I will leave further discussion on the technology of these methods to Dr Hoek and other eminent speakers and attendees here with us today. Clearly, however, these processes require a high level of skill and experience on the part of the team who carry out the work at the face. This team also need a clearly understood procedure and rules in order that the work can be controlled recorded and paid for in a satisfactory manner.

5. Risk

I would like to take a step back from the construction aspects and look at the general approach that we now take to the project. With the technical advances in the design and methods of tunneling we are now accepting more difficult and varied ground conditions as being acceptable. This requires however great depth of knowledge of the conditions that will be faced. It was Napolean Bonaparte who said *“the time spent in reconnaissance is rarely wasted”* which is true for all underground work and in particular for tunnels. At Egnatia we have instigated comprehensive programmes of Site Investigation for the whole of the Project which amount to some 8bn drs over the past 4 years. Sometimes with the alignment hundreds of metres below ground level and with extremely difficult terrain it is often impractical to obtain accurate data. Detailed geological studies have ben carried out by our designers to understand the likely condition and behaviour of the rock mass. Technical advice has been provided by our experts and particularly Professor Marinos and Dr Hoek to enable realistic assumptions to be taken. Risks are inevitable when sophisticated new design analysis and construction techniques are being introduced and where the level of experience is still young. To control these risks we must identify and understand them and then produce systems and procedures within the contract to ensure that they are carried by the party who is best able to deal with them and then to devise warning systems which can effectively deal with them as they arise in the design and construction process.

6. The Design

Thus it is necessary to produce a series of contracts to procure and administer the works. Dealing with these in turn I will start with the contracts for the design of tunnels to the level of prestudy. Generally we have packaged the work into sections of 20 to 30 km of the motorway and these design studies also include the final geological, geotechnical, highway and hydrology designs. These are procured following an open tender in accordance with law E92/50. In order for the designers to fully understand our requirements we introduced a very detailed scope of works which required the tenderers to submit the following:

- a study of 3 options and furnish approximate construction time and cost for each option.
- a schedule of deliverables (phased submission deadlines and payment milestones).
- authorised signatures, points of contact etc.
- construction budget
- basic parameters such as Design Life (120 years)
- design/construction Limitations & constraints (e.g. Environmental & other)
- plans of existing/planned services (if any)
- proposals in connection with the possible interface issues (advance and temporary works, existing and planned structures)
- mandatory requirement to furnish the Approval in Principle, H&S requirements, Risk Assessment, QA Certificate and the Company Quality System, Organogram, CVs and PI.
- three proposed schemes in sketch form with the price (resource based) for carrying out the study.
- company brochures and CVs.

Alongside all of the requirements of the Greek Law it is of interest to note that all of the procedures are in line with the guidelines set out for the UK ACE (Association of Consulting Engineers)
The evaluation process was then completed by a committee on the basis of the following parameters:

- Financial standing
- Technical competency
- Technical presentation
- Successful completion of similar projects
- Timely completion of the previous jobs (within budget)
- Competence of Environmental issues
- Health & Safety awareness.

This evaluation allowed the recommendation of the award on the basis of the best technical/economical offer.

Generally the procurement of the final design has been carried out following international tender, however in special cases a closed procedure with a selected list of designers has proved to be necessary. The final design brief is more specific and detailed and includes, in addition to the above, the specific deliverables such as Contract Documents, Drawings, Specification, Bills of Quantities, estimated cost of construction and construction programme.

7. The Category III Checker

The principle of carrying out detailed independent checking of important structures has long been established in UK and other EU countries and was introduced for Egnatia in the early stages of the project for all major structures, including tunnels. International competitions were tendered following EU Directive 92/50 which have bought a number of international firms and international/Greek partnerships together to check the designs. Following a slow and sometimes reluctant start the process is now firmly established into the Greek design industry. Tunnelling technology is moving very fast and this has allowed the direct exchange of ideas and technology between Greek and international designers which has increased the levels of skill awareness and confidence tremendously in a relatively short period of time and we are now seeing the benefits on the Project.

8. The Construction Manager

Construction Managers have been outsourced by international tender for the supervision of the construction works. These contracts are procured under Law XXX As the Supervisor under Law 1418 Article YYY the CM is responsible for the administration of the contract and for all measurement and quality of the construction. He is obliged to check method statements to ensure that the work is carried out safely and to the required quality. This role will be fully explained by Dr Bonner representing the Central Section CM later in the programme. It should be noted however that the CM does not carry responsibility for the design and therefore he needs assistance from the designer on site.

9. The Designer on Site

As explained above the “observational approach” for the design and construction form an iterative process which also requires the designer’s active participation in order to ensure the integrity of the design. Therefore we have introduced and have recently expanded the concept of appointing the Designer on Site to support the Construction Manager. New contracts have been drawn up and designers have been appointed following a closed procedure where selection of the candidates has been made on the basis of competence, availability, understanding and knowledge of the area. The experiences gained to date will be presented by Dr Kuhnhenn and Dr Rauscher who represent two designers currently appointed to this role.

10. The Construction Contract

The Egnatia Odos strategy has been to increase the size of the construction contracts in order to obtain large contractors who have the experience the necessary quality of management and the resources to carry out these major works in the time frame and to the quality that is required eg contract for 5.23 at 47bn drs, contract 5.1 at 77bn drs and contract 3.2 at 57bn drs. These contracts are traditional open tenders which are procured in accordance with law 1418/84 and are awarded subject to Law 2576/98, which provides a formula in order to exclude the exceptionally low financial proposals.

This has generally resulted in the selection of large joint ventures of Greek contractors and the tunnels are then being constructed by one of the JV partners under the management of the JV. Crucial to these contracts is the timologio which has been subject to continuous revision since being established based on the Ministry rates.
The approach for the remuneration of the contractors for the construction of tunnels has been different through the years.

- We started with the small bored and Cut&Cover tunnels of section 4.2.2 Grevena – Kozani (km 6+000 to 19+000), where drilling and temporary supports were paid as lumpsum per meter of length for design/construct according to different types of rock mass, and also C&C were paid as lumpsum for design/construct per piece. However, the remaining works (drainage, lining, E/M, etc) were paid with unit rates.
- The next approach was in the section 1.3.2 Dodoni tunnel, which was design/construct with lumpsum payment per meter of length of fully constructed tunnel.
- As experience and understanding of the work was gained, tunnels were tendered with unit prices, where boring and temporary support were rated per meter of length of the tunnel and all other works with unit rates. Such was the case for the section 5.2,3 Lefkopetra-Veria-Kouloura and the section 3.2 Anthohori-Metsovo.
- As more comprehensive designs of the tunnels were prepared before tendering, all works were paid with unit prices, as in Section 3.3 Anilio and Ag. Nikolaos tunnels and Section 2.3 Driskos tunnel, as well as the tunnels of the section 5.1 Polymylos-Lefkopetra at the Kastania passage.

Work is continuously being carried out to backanalyse the rates against actual performance in order to produce more accurate and realistic rates.

11. Conclusions

Summarising, therefore, I have described the long history of tunnel working in Greece and the very rapid development of the scientific and technical progress within the last 4 decades which together with the funding of the EU has fueled the acceleration of the technological progress that we have experienced at Egnatia over the past few years.
I have very briefly described the challenge of driving 98km of tunnel bores through some very difficult geological and engineering conditions and touched on the “observational approach” that is being employed.
All of these processes have been proceduralised and are procured and administered under contracts with the Company.
I have outlined the philosophy and practices that we have developed for:

- the design process of prestudy and final study
- the concept and implementation of category III checkers
- the procurement and establishment of the Construction Managers as the “supervisors” of the construction together with the Heads of Construction and Regional Offices of Egnatia Odos AE

- the introduction of the designer on the site as an active member of the team at the face of the construction to ensure the integrity of the design when optimizing the required temporary support
- the construction contracts themselves together with the methods of measurement and control of changes that are necessary for these underground works – I would also mention a personal desire for the introduction of unpriced bills of quantities for the tenders

Whilst I believe that we now have robust systems and procedures in place there is no room to relax as these must be constantly worked, refined and improved in order to ensure that the everpresent risks associated with the opening of underground works are controlled in an orderly, cost efficient manner, at the required speed with good quality construction and above all carried out in safety.

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