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THE ROLE OF EXPERTS IN TUNNELLING PROJECTS – EXPERIENCE FROM GREECE AND THE WORLD

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ABSTRACT

Experts play an important role in tunnelling, particularly in difficult geological conditions, such as those which occur in Greece. These experts include specialists in engineering geology, geotechnical engineering, hydrogeology, tunnel design, structural design in both steel and concrete, traffic engineering, ventilation, fire hazard control and other disciplines relevant to the design and construction of tunnels. Their role is to bring their experience and knowledge to each tunnelling project where the local staff cannot be expected to have the skills required to deal with this wide range of problems. Selection of these experts must be made very carefully since their advice can have a significant impact upon the cost and schedule of a major project. This paper explores the various roles that these experts play in tunnelling projects.

1. INTRODUCTION

A Consultant can be defined as an expert who is called in for professional or technical advice or opinions. An Expert is a person who is very skilful or highly trained and informed in some special field. This paper explores the role that these persons can play in tunnelling.

The large transportation tunnels currently under design and construction in Greece are amongst the most difficult in the world. The tunnels are typically 12 m in span and they are located at varying depths in extremely complex lithology. These conditions, associated with the tectonic processes involved in the formation of the Greek mountains, have resulted in highly variable and generally weak rock mass conditions. The need to construct tunnels quickly and economically in such conditions demands a very high level of tunnelling experience and skill. Experts of various types have brought this skill and experience to Greece and have helped geologists and engineers to become experts in their own right.

2. CONTRACTUAL ARRANGEMENTS

A wide range of contractual arrangements have emerged over the past half century as Owners and Contractors have tried to come to grips with the increasing complexities and escalating costs of large civil engineering projects. Many of these projects have budgets well in excess of one billion US dollars and are beyond the capacity of any but the wealthiest owners.

When project owners have limited in-house technical capability it has become common practice for them to embark on Design-Build contractual arrangements in which the Contractor (usually in the form of a Joint Venture Partnership) is responsible for both the design and construction of the project. In many cases the Joint Venture Partnership has responsibility for arranging part or all of the financing for the project and there are many different arrangements for the eventual transfer of the project back to the owner. These arrangements are not relevant in the context of the issues discussed in this paper.

A more traditional contractual arrangement, favoured by Owners with significant in-house technical capability, is one in which the owner retains the responsibility for the financial arrangements and for the design of the project. In the simplest form of this arrangement, the Contractor is only responsible for constructing the project in accordance with the designs provided by the Owner.

The basic elements of these two contractual arrangements are illustrated in Figures 1 and 2. These show the boundary between the responsibility of the Owner and Contractor in the two cases. Also shown are the areas in which the input of experts is most important.

Having had extensive experience with both types of contractual arrangement, the author's opinion is that the Design-Build arrangement can work well for forms of construction involving man-made engineering components. Hence, in constructing concrete dams, buildings and surface transportation routes the properties and quality of most of the construction materials can be controlled by the rigorous application of existing specifications and codes. Provided that the designs are reasonably conventional and that the Owner employs a competent independent supervisory agency to monitor the construction quality, a satisfactory outcome can usually be achieved.

However, in projects involving significant underground construction, the Design-Build arrangement can run into serious problems. In this author's opinion, the arrangement illustrated in Figure 2, termed the Owner-Design contractual type for simplicity, is preferable for such projects. This is largely because of the difficulty of accurately predicting the geological conditions that are likely to be encountered underground and the need to make refinements to the design to deal with actual conditions as they are encountered. These refinements are most easily accommodated by the Owner on the basis of recommendations made by designers who are employed directly by him. The Owner-Design arrangement was traditionally used by national utilities such as hydroelectric companies, which employ large staffs of experienced and highly skilled technical specialists. Privatisation of many of these organisations and the creation of new project management organisations has created a new generation of Owners who do not have adequate in-house technical capability. For those organisations who have not wished to enter into Design-Build contractual arrangements or who, from experience, have found them to be unsatisfactory, this has resulted in the appointment of external designers who are responsible directly to the Owner as shown in Figure 2.

It is important to point out that any Owner embarking on an Owner-Design type of contract must be prepared to develop sufficient in-house engineering capability to ensure that the project is controlled effectively. Selection of consultants, approval of specifications and designs and overall control of the project must remain in the hands of the Owner, even if consultants carry out the detailed designs.

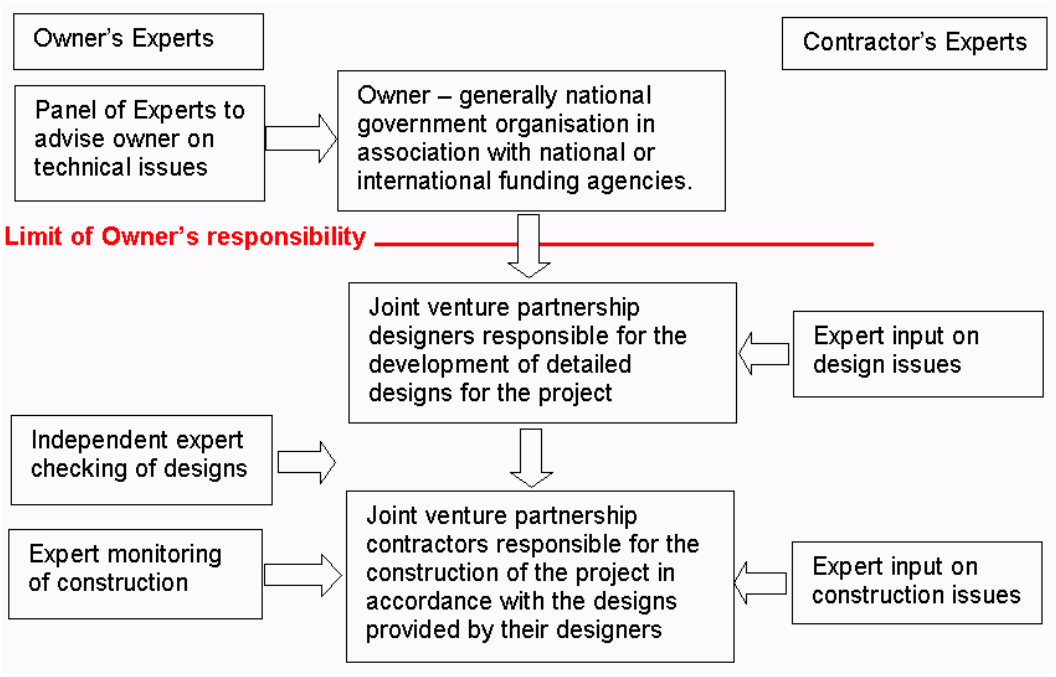

Figure 1: Typical arrangement for a Design-Build contract.

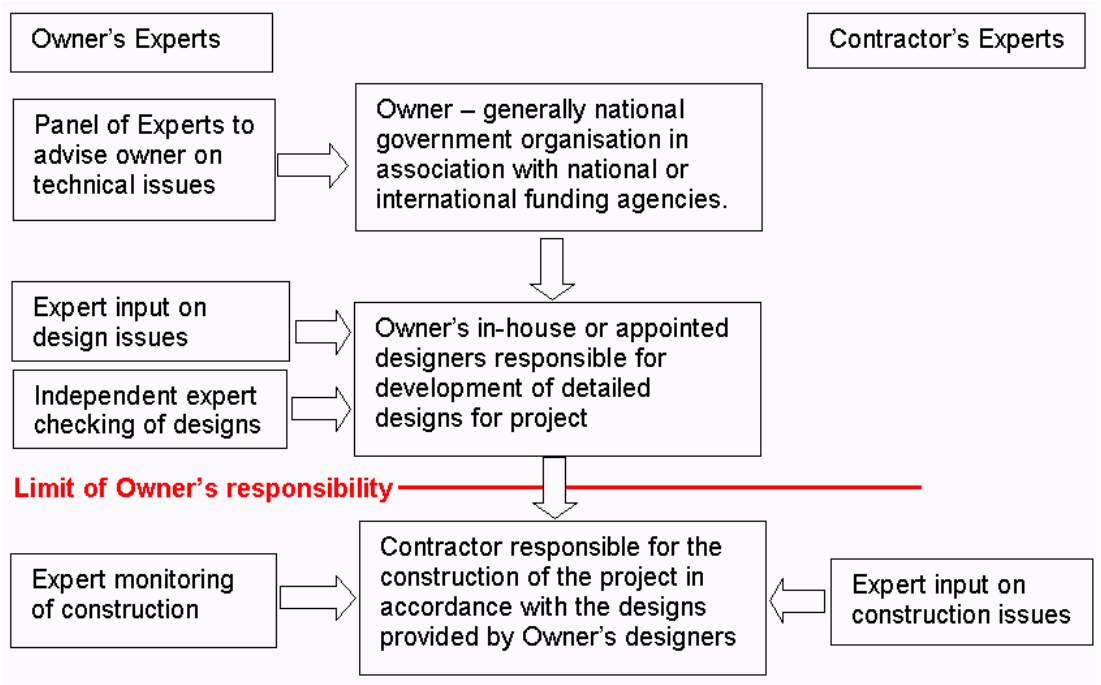

Figure 2: Typical arrangement for an Owner-Design contract.

Of course, neither of these arrangements guarantees that the project will be trouble-free and that it will not end up in some form of dispute. Many modern contracts include agreements for some form of disputes resolution or arbitration in which these disputes can be resolved without the need to resort to the courts. Experts play a critical role in these forms of arbitration and this will be discussed.

3. DIFFERENT TYPES OF EXPERTS AND THEIR ROLES

Many different types of experts are required in a large project that involves a significant amount of underground construction. These experts can be categorized roughly in terms of the level of technical skill and experience required for them to perform their duties.

3.1 CONSTRUCTION SUPERVISORS

Construction supervisors are essential in any large civil engineering contract to ensure that the construction procedures and quality are in accordance with those specified in the final approved designs. These inspectors are almost always employed directly by the Owner and it is preferable that they belong to an independent organisation or company that specialises in this work. The supervisors themselves are generally recruited from the construction industry and their construction experience is their main asset. They are seldom required to have a very high level of theoretical technical expertise although it is important that they have a sound basic understanding of the design concepts being employed.

3.2 CONSTRUCTION EXPERTS

These experts are employed directly by the Contractor and are usually brought in to advise on special topics such as concrete quality, controlled blasting design and the operation of Tunnel Boring Machines. It is in everyone's interest that these experts should have a very high level of technical knowledge and great wealth of practical experience. In some cases, contracts have been written to include provisions for the Contractor to bring in an expert, approved by the Owner, in the event of particular difficulties. The author has advised several Owners to include this provision for blasting experts in case of disagreement on blasting quality. Similar provisions could be very helpful in the case of TBM excavations.

3.3 DESIGNERS

Designs for large civil engineering projects are generally carried out by teams of designers. Such teams typically include a range of skill levels, consistent with the tasks to be performed. Relatively inexperienced graduates who are in the process of becoming experts in their own right generally perform routine calculations and prepare design drawings. This is completely acceptable provided that the team is directed by an experienced designer with an adequate technical background. This team leader should also be given the authority to bring in technical experts, as required, in order to resolve critical technical issues.

The author considers that the Design team, whether employed by the Owner or the Contractor, must have access to the very highest level of expertise in order for the project to be successful. This is particularly true for tunnelling in difficult ground, such as that encountered in

Greece, since misinterpretation of the available geological data, inadequate understanding of the technical details or lack of sufficient experience upon which to base sound engineering judgement can result in serious design errors. These errors, once implemented in construction, can be extremely difficult and costly to rectify.

The expertise referred to above is not readily imported. Tunnelling traditions and the technical basis upon which those traditions are based tend to be very strongly nationalistic. Hence, a tunnel engineer may have outstanding credentials and may be justifiably called an expert in his home country of, say, Canada. However, it may be entirely inappropriate to employ this individual to advise on tunnel design in flysch in Greece. Not only is this rock type seldom encountered in North America but the design methods that are appropriate for the hard rocks of the Canadian Shield are entirely inappropriate for the weak rocks of Greece. It would be much more appropriate to engage an expert from one of those countries associated with tunnelling where conditions are similar to those in Greece and where the tunnel design methods have evolved along similar lines.

The need to import specialists arises because of an almost inevitable imbalance between the demand and supply of expertise when major infrastructure projects are embarked upon. Considering the present situation in Greece, there is a shortage of adequately trained and experienced tunnel designers to deal with the demands of the Athens Metro, the Egnatia motorway development, the high speed railway system being constructed by Ergose, the Athens highway system, the Thessaloniki - Athens - Patras highway, the Acheloos Diversion Tunnel and other tunnelling projects which were all initiated within the space of a very few years. Experts had to be imported to help fill this gap and many Greek designers have learned very quickly from these experts and rightly deserve to be called experts in their own right.

3.4 DESIGN CHECKERS

Because of the complexity of many of the large civil engineering project designs, particularly for tunnels, a tradition has evolved to employ a independent design organisation to carry out a comprehensive check on those designs which are critical in terms of technical difficulty or cost. These design organisations are usually similar to those that could be employed to carry out the designs and the level of technical skill required is just as high as that discussed in the previous section. These design organisations are generally located outside the country in which the project is constructed in order to ensure that they are completely independent and that the designs are viewed through fresh eyes.

3.5 PANELS OF EXPERTS

Panels of Experts, also referred to as Consulting Boards, report directly to the Owner and their role is to provide technical advice on the most complex technical issues. While their terms of reference generally exclude them from involvement in the financial aspects of the project, it is not unusual for them to be asked to comment on contractual and schedule issues that have a direct impact on the overall construction of the project. They also act as technical auditors in that their reports are generally made available to the funding agencies and are used by these organisations to judge whether or not the overall objectives of the project are being met.

These Panels of Experts or Consulting Boards are generally very small, typically two or three persons, and it is essential that they have the very highest level of technical skill and extensive experience in projects similar to that on which they are advising. Even more important is the requirement that they be completely independent of any of the organisations involved in the project and that they be of sufficient seniority and maturity that they can give sound unbiased and balanced opinions to the most senior representatives of the Owner or, if necessary, the government. The requirements and method of operation of Consulting Boards were discussed in a paper by Hoek and Imrie (1995).

Thirty or forty years ago, these Consulting Boards tended to be made up of senior retired engineering company executives and their visits tended to be rather formal with their brief reports being delivered to a small group of senior representatives of the Owner over an expensive lunch. They were seldom involved in detailed discussions with the geologists and engineers on the project and never with the "Contractor". This practice has changed drastically over the years and today it is not unusual to have practicing consulting geologists and engineers as members of these Panels of Experts. The site visits tend to be significantly more "hands on" and detailed discussions with design and contracting staff are considered normal. The reports produced by these Panels are generally very detailed and contain specific recommendations and sometimes calculations or design details, where it is felt that there have been omitted or misunderstood by the project designers.

3.6 EXPERT WITNESSES

When things go wrong on a project, as unfortunately they do from time to time, the disputes that arise may have to be settled by a Disputes Review Panel, by Arbitration or by the courts. Well-prepared contracts frequently include the condition that if agreement cannot be achieved by means of a Disputes Review Panel, the decisions of an Arbitrator or Arbitrators will be final.

A Disputes Review Panel typically consists of three experts - one appointed by the Owner, a second appointed by the Contractor and the third appointed on the recommendation of the first two experts. Obviously these experts must possess the appropriate level of technical expertise and experience but it is also essential that they should be completely independent of any previous involvement in the project. A Panel of well-matched, mature and balanced experts can usually achieve agreement and make recommendations on most of the disputes that arise in a typical contract.

When the disputes review process fails, the dispute then moves on to Arbitration or to the courts. The procedures followed in these two systems are now rather similar although arbitration tends to be less adversarial than the legal process of the courts. In either case the Owner and the Contractor are both represented by expert witnesses. These experts are chosen not only for their technical skill and experience but also for their ability to present their evidence clearly and convincingly under the unfamiliar and sometimes confrontational conditions of examination and cross-examination by lawyers. These lawyers are frequently specialist in contractual issues and it is not unusual for them to have engineering qualifications as well. Unlike the Disputes Review requirement for complete independence of any previous involvement in the project, expert witnesses may have had a long and detailed association with the project. In technically complex

cases, the role of expert witnesses can be crucial since decisions and awards may depend heavily upon the credibility of their evidence.

4. FINAL COMMENT

A consultant has been defined as someone who has gained his experience at someone else's expense - or is about to gain it at yours. This definition is true for all the "experts" discussed in this report. Those responsible for the appointment of such experts should ensure that sufficient resources are devoted to the selection process and to the definition of the terms of reference in order that these appointments do not result in very expensive training for future consultants.

5. REFERENCE

Hoek, E and Imrie, A.S. 1995. Consulting Boards for large civil engineering projects. *Water Power and Dam Construction*, Vol. 47, No. 8, pp 33-34.