WORLD TUNNELLING

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DIFFERING SITE CONDITIONS

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DIFFERING SITE CONDITIONS

The Differing Site Condition (DSC) clause in US construction law has created some problems it was meant to solve. For one, claims for extras have become routine, and contractors often choose this clause as the most convenient tool to justify cost overruns or achieve extra profits.

On the other hand, owners and engineers have taken the hard line when asked to compensate contractors for legitimate claims because of unforeseen costs.

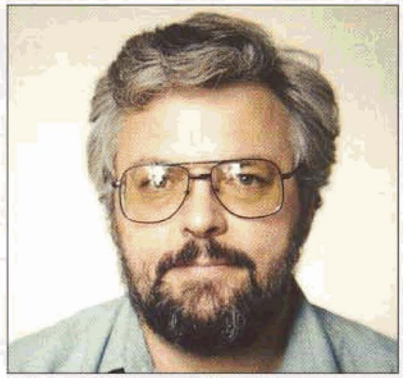
The clause was introduced to lower the price of construction by removing a contractor's cost for contingencies. The contractors in turn received protection against unanticipated site conditions from the owner.

What can a contractor provide the owner or engineer to illustrate that a differing site condition was encountered? What should an owner/engineer look for in evaluating the merits of such a claim?

The fundamentals are the same for a contractor preparing a claim or for an engineer reviewing the merits of a presented claim. The following guidelines are based on the technical aspects of differing site condition clauses and consistent with various jurisdictions.

Contractors and engineers could use the same following list as a framework when preparing differing site condition claims. The engineer would then have the same guidelines by which to review the submitted claim. Parties will then have a common set of principles or specific points to use while resolving an impasse.

The technical elements or principles of such a claim may be summarized as follows: there must be a difference between reasonable anticipated and encountered conditions; there has to be a difference between reasonable anticipated and encountered construction performance; a cause-and-effect relationship must be demonstrable between the differences in conditions and construction performance; there must be a visible impact on time or costs; all contract conditions must be fulfilled; and no other factors can have caused the difference between anticipated and encountered performance. These points provide a framework for the preparation of differing site conditions claims; serve as a checklist for the preparation and justification of a differing site condition claim for the contractor; and make a review of the claim easier by providing a checklist for the owner/engineer when evaluating a claim.



The author is president of Geoconsol and first wrote in World Tunnelling *ten years ago.*

When the contractor adheres to these principles, he will build a strong case for differing site condition claims, and will give the engineer the reassurance that all elements have been fulfilled with a checklist for reviewing the claim.

Analyses and principles illustrated herein may also be used to improve site investigation, encouraging better presentation of factual geotechnical data and its interpretation for construction estimating. What becomes apparent is the importance of pertinent exploration, reasonable interpretation, and the crucial representation of average, range and most adverse anticipated conditions. Furthermore, the analyses will also provide a better understanding of the relationship between geotechnical conditions, index properties of natural materials, and their interaction with construction methods and equipment to produce a "ground response".

The contractor benefits from these guidelines when he prepares the bid. They remind him to document all data used, assumptions made and interpretations developed. At the same time, he evolves a checklist for evaluating and fulfilling the requirements of a differing site condition claim during construction before it becomes a problem or source of controversy with the resident engineer. The immediate cause, effect and impact can then be assessed properly. Examples of compliance and non-compliance of each technical element are illustrated below with actual case histories.

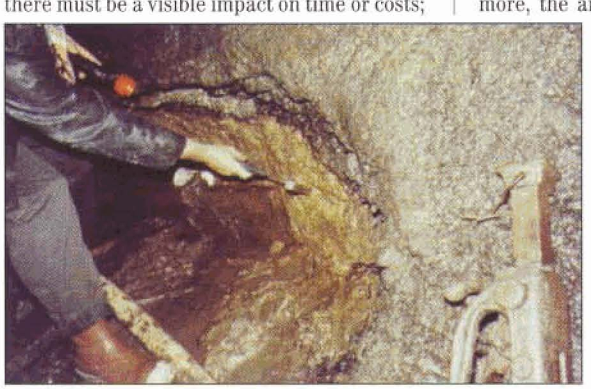
The Differing Site Condition Clause was brought about to lower the cost of construction by removing a contractor's cost of contingencies in return for protection against unanticipated conditions.

Since its inception in 1921 the clause has been subject to some scurrility. For some contractors, claims for extras are a matter of course, merely selecting the most viable vehicle, often the differing site condition clause. Similarly, owners and engineers have been known to be unreasonable in recognizing and acknowledging legitimate claims and compensating the contractor for unanticipated costs.

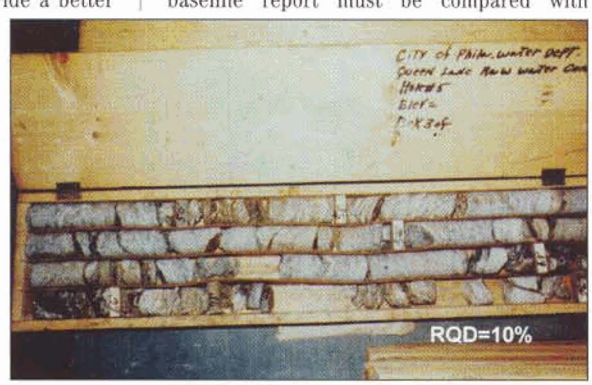
In the preparation of a differing site condition claim, the contractor must effectively deal with the concerns of the engineer as he is reviewing the claim document.

DIFFERENCE IN CONDITIONS

In order to arrive at a difference in conditions, "reasonable" anticipated conditions, preferably documented, indicated or specified on a baseline report must be compared with



(Left) Figure 1.



(Right) Figure 2.

encountered conditions. All available information, including a site visit and other readily available information must be utilized to formulate "reasonable" anticipated conditions.

The encountered conditions may be obvious; however, the method of measure or evaluation should be consistent between the owner, engineer, and contractor and should be consistent with pre-bid methods used initially to define the anticipated conditions. Such consistencies eliminates annoying differences and promote a straightforward comparison of anticipated and encountered conditions.

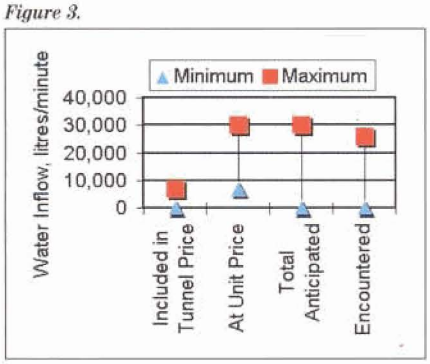
When an easily demonstrable difference between "réasonable" anticipated and encountered conditions can be illustrated, this condition is fulfilled.

The pitfall here for the engineer is that a contractor is generally not required to have the same level of expertise as the engineer. The pitfall for the contractor is lack of documentation and difficulties in consideration of all available information.

● A tunnel boring machine (TBM) encountered decomposed rock, clay and shear gouge while excavating a sewer tunnel. The clay gouge could not support the heavy TBM which sank below grade into a soft invert. The contractor considered the subsequent delay was caused by a differing site condition.Our investigation revealed that the encountered conditions illustrated in Figure 1 were indicated by a 10% RQD in a nearby boring illustrated in Figure 2. Based on this simple visual evidence and the boring logs, we concluded that the contractor did not have a basis for a differing site condition claim.

● A 6 km tunnel was to be driven through a high rainfall area, several fault zones, and highly fractured unweathered rock. Water inflow was difficult to predict; however, the solution was to specify that 7,500 liters/minute be included in the bid price for tunnel excavation while an additional 22,500 liters/minute was to be unit priced. Anticipated and encountered tunnel inflow into the bored tunnel as illustrated in Figure 3 clearly indicates that anticipated flows were never exceeded. Some of the higher measured weir readings were associated with ice blockage of the weir and on other occasions the measured weir flow included flows from an intermittent stream (during heavy rains), emptying into a shaft and the tunnel.

Figure 3.



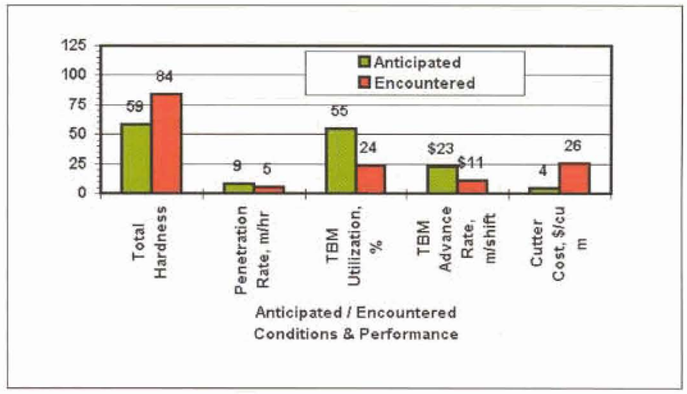


Figure 4.

The engineer refused the claim, the contractor went to arbitration, and the arbitrators, to the surprise of all, awarded half of the claimed amount.

DIFFERENCE IN PERFORMANCE

An essential ingredient for determining the difference between anticipated and encountered performance, is establishing a "reasonable" anticipated performance. "Reasonable" performance must: reflect anticipated conditions, be confirmed by past experience, be consistent with methods, and be consistent with equipment condition and capabilities.

Interpretation of anticipated conditions into excavation performance must be well documented.

When a demonstrable difference between "reasonable" anticipated and encountered performance can be illustrated, this condition is fulfilled.

The pitfall here for the engineer is to assign blame to the contractor in some form without adequate grounding or evidence. Similarly, the pitfall for the contractor is often a lack of rigorous documentation and substantiation of "reasonable" anticipated and encountered performance.

● A sewer project in an elegant neighborhood specified mechanical excavation due to the undesirability of blasting. Since the tunnel was only 600 m long, a new TBM was not practical and all contractors tendered the project with used (old technology) TBMs. The first contractor defaulted because the TBM could not deal with encountered blocky rock conditions in the beginning of the tunnel. The second contractor overcame the blocky rock and encountered rock harder than anticipated and shear zones much wider than indicated in the geotechnical report.

The unanticipated hard rock (Figure 4) reduced the penetration rate and increased cutter costs. The wider-than anticipated shear zones required timber blocking to maintain a reaction under the TBM grippers. The lower penetration rate, the higher frequency of cutter changes, and the delay caused by the inadequate gripper bearing, contributed to lower progress and higher downtime than reasonably anticipated. These various differences in TBM performance are strikingly illustrated in Figure 4.

A panel of three arbitrators found on behalf of the contractor in the case of the harder rock and the wider shear zones.

● In a water conveyance tunnel excavation, half of the tunnel was expected to be steel rib supported and the contractor elected to install ribs throughout the tunnel and was paid for the installed steel. However, a claim was submitted for a 7-month delay. An analysis of the contractor's records indicated that the total time lost for all support installation, was less than a half month as illustrated in Figure 5. This revelation settled the dispute.

GROUND RESPONSE

The issue of "cause and effect" associated with construction in natural materials is simplified such that geology is identified as the culprit. This "blame" is unjustified and contrary to scientific principles.

Geology pre-exists construction as well as mankind. Pre-existing geology at rest is inherently stable, at least until disturbed by changes in boundary conditions and forces that affect the natural mass. It is only when construction disturbs conditions at rest that we begin to see a change in the existing stability. It is the manner of disturbance of existing stable conditions that has the single most acute impact on the consequences.

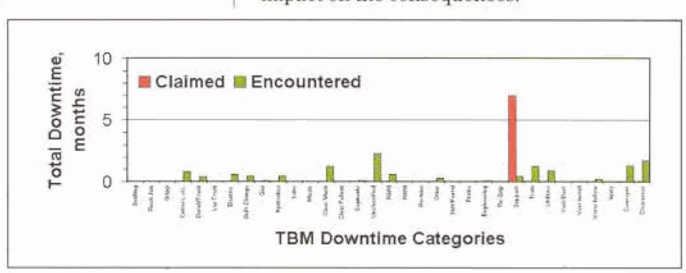


Figure 5.

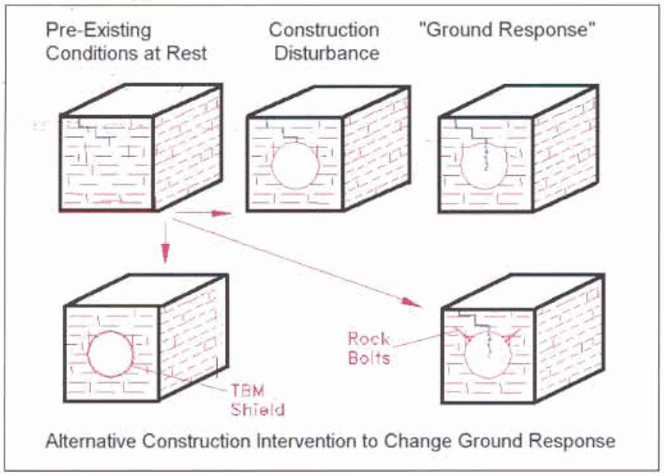


Figure 6.

● In Figure 6, a tunnel is excavated in a blocky rock mass beneath the water table, the consequence or the "ground response" is that some of the blocks fall out and water infiltrates the tunnel opening. If an alternative "ground response" is desired, an alternative method of construction is necessary such as the use of a shield for temporary support. A more long-term "ground response" may be attained by rock bolting of the blocks. Water inflow may be eliminated by grouting.

CAUSE AND EFFECT RELATIONSHIP

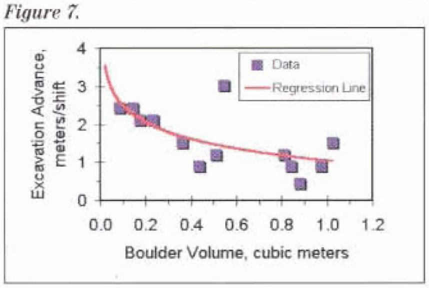
As differences in conditions and performance have been established, it is essential to show that these caused the difference in performance. Empirical relationships for geological and construction data tend to have a limited degree of correlation because not all variables (both geological and construction related) can be taken into account. Correlation coefficients may vary from 0.25 to 0.75 or more and should not be discounted purely on a quantitative basis. Each case has to be evaluated on its own merits and tempered with judgement.

● Pipejacking for a sewer installation encountered boulders through a section of tunnel where none was indicated or anticipated. Total boulder volume was over 20% of the excavation. The contractor proved that boulders delayed pipejacking as illustrated in Figure 7.

IMPACT

It is also necessary to illustrate an impact such as an increase in cost and/or a time delay. This impact must be related to the unexpected conditions encountered either in space or time, preferably both.

Figure 7.



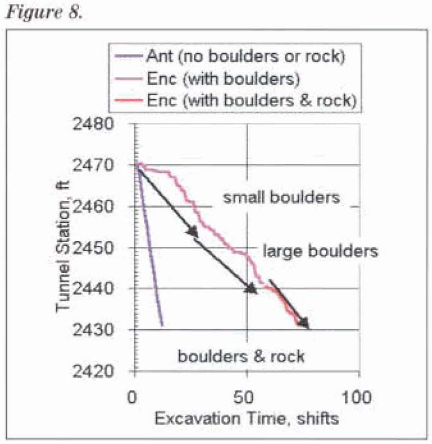
● A short pipejacking operation encountered unanticipated boulders from almost the beginning of excavation. Figure 8 was used to illustrate the coincidence of encountering boulders in the face and the impact on excavation advance. A great deal of time was spent removing the boulders, digging out boulders when extending outside the perimeter of the pipe, grouting to fill voids left by the boulders, and stabilizing the face in flowing silt above the boulder pavement. The pipejackers encountered boulders immediately and were unable to develop excavation rate experience without boulders.

After initial rejection of the contractor's claim, the engineer conceded the claim's legitimacy based on Figure 8.

● On a 7 km tunnel excavated by TBM, the contractor claimed an adverse impact when encountering water inflow. Review of the contractor's shift reports and an analysis of labor efficiency (manhours/m of excavation) revealed the contractor's claim to be unsubstantiable. Figure 9 clearly illustrates the initial inefficient learning curve, peak efficiency achieved in the 7th week of excavation, loss of efficiency after 7th week, and initial water inflow and continued decreasing inefficiency.

The project was losing efficiency and out of control long before the excavation encountered the anticipated water inflow. Nevertheless, an indecisive arbitration panel awarded half of the claimed amount.

Figure 8.



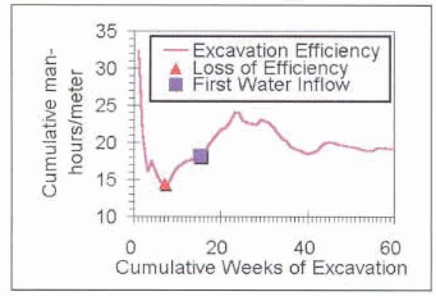


Figure 9.

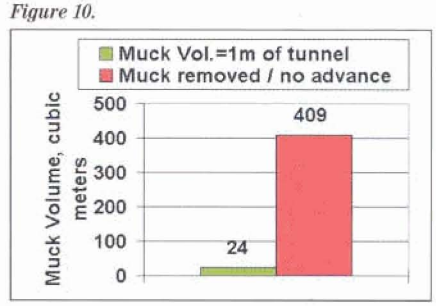
FULFILLING CONTRACT REQUIREMENTS

After having satisfied all of the previous requirements, it is also necessary to fulfil the requirements of the contract, especially if they apply to a differing site condition.

Typically, these include: reliance on available information, a thorough site visit, appropriate construction methods & equipment, notice of DSC, and mitigation of impact.

● An old TBM used to excavate a 4.1 m-diameter tunnel encountered a shear zone containing squeezing ground. The TBM became stuck because the operator was inattentive to developing conditions and the shield did not have the ability to decrease its perimeter. The TBM could not develop sufficient thrust reaction on the ribs and lagging to push itself free. In an attempt to free the TBM, the contractor turned the head and continued to muck the heading. Muck representing 17 m of tunnel (Figure 10) was removed without advancing the heading before a major collapse developed and a chimney extended to the surface.

Figure 10.



The contractor's delay was largely attributable to stabilizing and filling the voids created by overmining and compensation was denied.

by Peter Tarkoy

Dr Peter J. Tarkoy is an underground construction consultant who has been instrumental in defining the interaction of geotechnical conditions with construction. He has pioneered the technical elements of a DSC. He has provided independent assessments of DSC claims for WMATA, US Dept of Justice, US Corps of Eng, the US Bureau of Reclamation, EuroTunnel, and while serving on disputes review boards. He can be contacted by telephone at +1 508 650 3600.