

CONTRACTUAL RELATIONS IN TUNNEL CONSTRUCTION

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STATE OF THE ART

Most tunnels are constructed by contractors according to plans, specifications, and contract documents prepared by professional engineers. Because ground conditions can be quite variable, the engineer usually designs several cross sections for the tunnel supporting system or the shape of the tunnel or both. Usually an effort is made to estimate the amount and the type of temporary and permanent support required. Alternate methods of support are frequently designed and allowed for in the bid schedule.

The actual amount of support may differ widely from that contemplated before the start of construction and has been found to vary by more than 100 percent from the estimated quantities. Sometimes the engineer will include in the bid schedule larger quantities of support items than may be required to ensure that the work will be completed within the estimated time. On the other hand, the engineer may underestimate the amount of support required because of inadequate knowledge of the ground conditions. In either case, substantial variations in quantities often lead to claims by the contractor. If the amount of support is underestimated, the result can be higher prices and costs to the owner.

Contract documents usually include or make reference to geological reports and drill logs so that the contractor will have all the information available to the engineer. Occasionally, all data are not made available to the contractor before bids are taken, and such cases frequently result in claims that have disastrous results to the owner. Most contract documents provide for adjustment to the contract price if changes are made in the contract or if changed conditions are encountered as the work progresses.

Because of safety requirements, the final decision as to whether to use temporary support and how much is usually left up to the contractor. If the contractor has a profitable price on support items, the temptation is to use more support rather than less, sometimes considerably more than necessary.

A certain amount of overbreak is bound to occur in tunnels driven by drilling and blasting. Additional overbreak results from the configuration of joints in the rock and the manner in which the work is performed, including the time of placing temporary supports. Attempts by the engineer to control overbreak include the specifying of a maximum pay line, a minimum line within which there may be no rock protrusions, and the payment for concrete at bid prices to the neat line only, sometimes with allowance only for the materials cost of cement or aggregates or both for filling the overbreak.

Contracts may be of the following types.

1. The unit price is the base for most tunnel contracts, i.e., a price per cubic meter for excavation and concrete, a price per kilogram for steel tunnel support, a price per cubic meter for grout, and so on. If the type of ground to be penetrated and the amount and type of support can be forecast with reasonable accuracy, this type of contract can be used

to good advantage.

2. The lump sum contract can only be used if thorough exploration is made before bidding or the geology is well known so that the quality of the rock to be penetrated is understood before work is started. This type of contract may be in the form of a price per meter of tunnel, including temporary support and permanent lining. This latter type of contract puts the entire burden of cost of overbreak and support on the contractor. It eliminates the concern of the engineer about the use of too much support but can result in excess cost to the owner if actual support used is less than the parties to the contract assumed to be required and can still result in claims for overruns.

3. The cost plus fixed fee type of contract eliminates the problem of changes and changed conditions but provides no profit incentive to the contractor to reduce costs to the minimum.

4. The target estimate type of contract requires the contractor and the engineer to agree on a target estimate of cost and a base fee. The base fee is increased or decreased by the contractor sharing in a percentage of the cost savings or overruns; maximum and minimum limits are placed on the amount of fee to be paid. This type of contract is useful if contracts are to be negotiated rather than awarded on the basis of competitive bids or if plans are not fully developed. Since the estimate can be modified from time to time as the plans are completed, the contractor has almost the same incentive as on unit price or lump sum work to keep the costs as low as possible, and the owner is assured of reasonable costs if a competent contractor is selected. It largely avoids the unpleasantness of claims.

Further information on tunnel construction contracts is contained in a report, *Better Contracting for Underground Tunnels*, prepared by the U.S. National Committee on Tunneling Technology and published in 1974 by the National Academy of Sciences.

FUTURE RESEARCH

Payment for Overbreak

Payment or nonpayment for overbreak has been handled by different owners in many different ways in an effort to reduce its impact on costs. Research into the results of the various methods could help in developing the best approach to this problem.

Amount and Type of Temporary Support

No satisfactory solution has been found for controlling the amount or type of temporary support in tunnels and at the same time satisfying all concerned that safe conditions exist with limited support. Research is needed to develop contract terms that would protect the contractor and at the same time make it profitable to use the most inexpensive type of support that would produce safe working conditions.

Bidding Arrangements for Temporary Supports

Bid quantities for temporary support items, because of alternate types, are difficult to accurately determine before construction starts. Research is needed to develop better arrangements for bidding and controlling the use of these items. For example, an incentive might be given to the contractor for underruns in the amount of support used.

Comparison of Original and Final Costs

A research study of the various types of contracts that have been performed would help in determining the best type to use on a specific project. How much does the actual total cost of tunnels, including settlement of claims and final cost of supports, differ from the original contract price?

Handling Water

Research is needed to determine the best way to contract for handling of water. Should it be cost per cubic meter of water pumped? increased cost of excavation for different amounts of water? other means?

Consolidation Grouting

What is the best way to handle consolidation grouting performed during excavation?

Insurance

Should insurance be owner or contractor furnished?

Payments for Mobilization

Are there advantages or disadvantages in making payments for mobilization?

Value Engineering

A study is needed of the advantage of including a value engineering clause in the contract.

Delays in Review of Plans

A study is needed of the effect of delays in replies by the owner or engineer to plans or shop drawings submitted by the contractor.

Delayed Payments

A study is needed of the effect of delayed payments to the contractor for changed conditions when both parties to the contract have agreed that such a change has taken place. Frequently payment is delayed until completion of the contract, requiring the contractor to carry the great burden of financing a major part of project cost.