INTRODUCTION

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EQUIPMENT SPECIFICATIONS - END RESULT

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Abstract

The highway construction industry is trending toward a greater use of end result specifications. The singular criteria for their use is that they provide the owner with the desired final product. Given that this can be achieved through judicious application of the concept and the precise, descriptive development of the specifications, end results can yield numerous benefits to both the private and public sectors. The private sector benefits through increased opportunity for competition, which provides contractors and suppliers alike a chance to consider all options in their least cost analyses. Those options can include method proposals for an unlimited number of scenarios for labor, equipment, and materials. The public sector, or owner in this case, also benefits from increased competition because it is the recipient of the theoretical least cost alternative for the desired end product. Many other benefits accrue from the end result approach, such as greater flexibility, material and equipment economies, and conservation of resources. Perhaps, of greater significance, is the message that the marketplace is the most efficient mechanism for providing choice of method, when end results can be properly defined and method can be permitted to become variable. There is a place for end result specifications in highway construction and they should be considered at every opportunity.

INTRODUCTION

In order to discuss the economic consequences of constraints on the use of construction equipment it is first necessary to recognize the purpose of a specification, the types that are currently being used in construction, and the descriptions of those specification classifications. Generally, the owner/entity develops a specification to provide a desired or perceived final product, for which the owner has ascertained a need, established a budget, and analyzed the life cycle benefits for that product. How best can the owner proceed from idea to final product?

He creates a specification, and the purposes of that specification are manifold. First, it requires the engineer/designer to define the material or construction requirements needed to achieve the desired end product. Second, it serves as a guide for those contractors bidding the work. Third, it becomes a working document and reference tool for both parties during construction, and finally, it forms part of the contractual agreement between the owner/entity and contractor.

Today's specifications can be categorized into four classifications. They are (1) proprietary product, (2) method, (3) end result, and (4) performance specifications.

The proprietary product specification specifies a particular brand name of manufacturer, or an approved equal, and relies on past performance as a basis for expected quality. As can be presumed, this specification approach often times inhibits competition, while making the designer's job easier and less time consuming.

Method specifications prescribe the procedure or process to be used in arriving at a desired end product, whereas end result specifications establish acceptable minimum requirements for a completed in-place product. Either one can be used effectively, but their use jointly for a product creates many problems to which we can all attest.

Performance specifications are those that define insitu performance for a product over a fixed minimum time period. These so-called "warranty specifications", while effective for many applications, are seldom employed in the public highway construction sector because of the difficulty for risk assignment on a finished highway product and a perceived higher cost associated with this alternative.

The purpose of this presentation is to discuss the third of these specification types, those being end results. In particular, how does the choice of end result specifications impact the use of construction equipment?

A brief history of the evolution of end result specifications follows along with the Colorado Department of Highways' experience with them, their economic impact on the private sector, and the benefits of that specification approach.

Trend to End Result Specifications in Highway Construction

Historically, public entities have employed method specifications to provide themselves with a highway infrastructure through the construction process. In so doing, they have assumed and maintained many risks, not the least of which has been the need to define construction methods that would yield the desired end products. That effort, among other things, has proven over the years to be labor intensive.

In recent years, consideration of end result specifications as something more than a novelty has taken on greater importance. With increasing shortfalls in public sector manpower brought on in part by improvements in construction funding and freezes on manpower, entities have been faced with finding alternative construction methods.

Initially, end result specifications had been considered in an effort to avoid the conflict brought on so many times between entity and contractor because those specifications had been used jointly with method specifications. Classic cases have involved concrete and bituminous asphalt materials specifications. While processes for materials have been prescribed, end results have been defined for acceptance. Naturally, that arrangement created a ripe environment for conflict.

Presently, many entities are moving away from the cookbook approach wherever possible, not only to eliminate this potential conflict, but to reduce the manpower necessary to monitor methods specifications. That move however, is not without its problems.

Inherent in the use of end result specifications are several key requirements. First, the

specification parameters must reflect the end product as it is perceived. If the specification does not closely define the desired product, the entity runs the risk of purchasing a product that is not the most cost effective. That is to say, the specification will not provide the anticipated end product.

A second criteria for an end result specification is the need for accurate and repeatable test methods. Because the risk for providing a specification end product is shifted to the contractor, acceptance criteria for that product must be precise. The entity/owner is not involved with production testing and process control, thereby placing greater significance on the accuracy of acceptance tests.

Finally, tolerance criteria defining degrees of acceptability and the attendant price reductions must emphasize the appropriate need to meet specification requirements. In some cases, remedial options are limited, therefore price adjustments should be high and tolerances tight to reflect the significance of the risk.

Given that the above can be resolved by the entity and an adequate end result specification can be developed for a specific item of work, there is absolutely no doubt but that the private sector can assume the additional risk, perform the work under end result guidelines, and be competitive with the traditional methods approach. At the very least, the end result approach should transfer risk and work, hence more funds through contract payments, to the private sector. It should ideally reduce the burden of government operations and costs more than it increases contract payments for a like amount of work, i.e., the marketplace should yield more efficient results.

In the final analysis, end result specifications can provide a vastly superior approach in highway construction for one reason. They impose no artificial constraints on the marketplace. They allow the private sector to be as imaginative, and therefore as efficient, as necessary to accommodate the specification requirements. On the other hand, methods specifications often do not permit that flexibility, hence the possibility for less than optimum results.

Colorado's Experience With End Result Specifications

Two areas, previously mentioned, that have traditionally created problems for Colorado are concrete and asphalt specifications.

Because there are so many factors involved in the production of acceptable concrete, movement toward end results have been tedious. With the advent of super plasticizers, water reducing agents, retarders, and the use of fly ash, monitoring of process has been maintained. Acceptance tests still include air and slump, as well as strength tests. Additionally, certification of additives in the mix is required.

Even so, some advances have been made. In the instance where strength alone is specified for structural concrete, process is not monitored. Acceptance is based entirely on strength, therefore the contractor may provide any process and materials he chooses to meet the strength criteria.

Of more importance is the administration of the concrete items. The Colorado Department of Highways provides design mixes for its various classes of concrete to its contractors as a courtesy. However, it maintains that the contractor is responsible for proposing a mix for approval for use on a project. While not a classic end result application, this approach permits the contractor a degree of flexibility in considering alternative mix designs. It does not eliminate some monitoring and certification of the process.

Greater strides have been made in the area of bituminous pavements. Whereas, at one time Colorado required the use of a job mix involving aggregate gradations, asphalt cement content and temperature, along with plant process specifications and specifications for percent voids, stability and retained strength, it now considers the administration of the item differently.

As for concrete, the contractor has the responsibility for proposing an acceptable job mix formula that will meet all criteria for percent voids, stability, retained strength, and several other Colorado Test Procedures. After approval, acceptance of the completed product is based on aggregate gradation, asphalt cement content, temperature, and density of mat. Only in the instance where the processed material is believed to deviate from the job mix formula will a sample be checked for compliance with the Colorado Procedures and the contractor's production discontinued.

The basic change is that no process monitoring takes place. Acceptance of the item is based on in-place material after the initial approval of the job mix formula. The move has reduced manpower requirements, improved competition, and transferred quality control responsibility to the private sector.

Probably the most controversial item to surface recently involves recycling of asphaltic pavements. There is no question that recycling provides an alternative to traditional paving methods and in some instances allows a more effective utilization of resources. Therefore, Colorado now permits the use of recycled asphalt as an option for contractors and offers guidelines for its acceptance.

A tougher problem to resolve concerns the method of asphalt recycling to be permitted. Currently, Colorado is considering a generic specification approach which will define a required final typical section rather than a recycling process. Since numerous methods now exist for recycling asphalt mats, the above proposal would allow the most cost effective process to prevail.

Another difficult nut to crack is that of pavement smoothness and rideability. While it has long been recognized that there is a wide range of paving capabilities in the private sector, a method for compensating the better contractor and penalizing the poorer one has been slow in coming. Colorado has for two years collected data on construction methods, roadway types, project types, and numerous other variables, and is prepared to implement an end result specification on ultimate smoothness of ride.

This effort will provide an end result specification in the purest sense since it will define final acceptance criteria only. When the work is complete, the Department of Highways will measure its smoothness and compensate on the test results. The definition of acceptability and tolerances will be tight, because few options for remedial or corrective action will be considered. Colorado anticipates an improved level of paving quality on those projects where this specification is incorporated.

A number of other issues are either under consideration or are now being implemented by Colorado, all of which attempt to remove the Colorado Department of Highways from process control or monitoring.

For a number of years, alternative bids for

major structures have been developed to improve competition where the Department of Highways has recognized similar economies for the alternatives.

Also, contractor value engineering has been promoted where projects avail themselves of a wide range of alternative methods.

A system of contractor certification of materials is being considered. While not strictly end result, it does eliminate process control. Materials testing, materials pre-inspection, and structural certification are now under consideration as areas for future transfer of responsibility to the private sector.

Alternatives for pipe culverts and storm sewers are currently permitted under many circumstances. With the introduction of many new pipe materials, this area provides a terrific challenge for the application of an end result specification.

To date, Colorado's experience with end result specifications has been limited, but fairly successful and very encouraging. With manpower shortages an established way of life, the end result specification offers one option or tool for mitigating that problem.

Economic Impact on the Private Sector

Where end result specifications are possible and can provide the desired final product, the potential benefits are numerous. One of the major areas of impact is that of equipment and material economies.

Obviously, the option to choose the most efficient and productive equipment or to match equipment to project type should reside in the marketplace. The expertise on equipment capability and the awareness of state of the art advances lies with those people working within the private sector, be they contractors or equipment manufacturers.

The same thing can be said for materials and manufacturing processes. With contractor profit margins diminished in today's economy, the smart money is on those who constantly monitor opportunities for new and less costly materials and production methods.

The intelligent contractor will seek to reduce his unit costs wherever possible. If end result specifications allow him to be flexible, he will consider the most efficient fleet of equipment that coincides with his operational strategy and he will choose those materials and production methods that meet specifications, but provide the best margin.

While it is recognized that the end result approach offers much greater flexibility in construction methods, the private sector should consider that approach with caution. The end result approach permits contractor choice, but with that choice come the attendant responsibilities and risks for that opportunity. The possibility for wider ranges of success and failure exist with this approach because it permits a broader field of competition and an unlimited spectrum of alternatives.

The contracting agency, on the other hand, should not arbitrarily limit itself by specifying methods, when in fact there may be other alternatives. If there are, and they are competitive in providing the specification product, the private sector will embrace those alternatives in order to remain viable in the marketplace.

By specifying methods, the contracting agency must assume the responsibility for knowing the marketplace, or run the risk of overlooking an economical alternative. This promotes both short-term and long-term adverse ramifications.

First, the entity or its designers may not be fully cognizant of all available options. Second, the entity must bear the cost for that expertise, whether or not it remains current and functional. If it is not, the probability is high that under that scenario, project costs will be higher than necessary due to lost potential economies. The private sector will always seek out and employ potential economic opportunities before entity operatives would consider them as being viable.

Long range, the end result approach encourages a dynamic marketplace, whereas methods specifications inhibit change. Without the constant quest for new economies that can be provided by the private sector, owners and entities may very well be foregoing the one opportunity they have for stretching their capital budget productivity, as mandated by their respective constituencies.

Benefits of the End Result Approach

The application of any specification approach to highway construction has as its basis the intent to provide the most cost effective end product. In those instances where end result specifications are employed, many benefits can be realized.

First, because method is not an issue, more methods might be considered, therefore competition should be maximized. More flexibility for choice of method should enhance contractor creativity and thus yield a concerted review of all possible alternatives that might provide the specified product.

As a result of greater competition, product costs for the owner/entity should be optimized. That is to say, given an end result specification that will insure a desired final product, all possible alternatives will have been considered and the least cost alternatives will have prevailed. Oversight of alternative or arbitrary constraint on an alternative will never become issues.

A secondary benefit of the end result approach is the possibility for conservation of natural and human resources. With today's climate of expensive energy and dwindling natural resources reserves, a re-evaluation of method costs should be constant. Given the opportunity, the private sector can provide this service and determine for the owner/entity what the optimum allocation of resources should be.

Finally, end results allow contractors to provide value engineered solutions as their basis for establishing least cost alternatives. This process would create a more responsive contractor community and further enhance the contributions of the private sector to the highway construction industry.

Summary

In conclusion it is not difficult to see that the end result specifications can be applied to the highway construction industry and can provide a multitude of benefits. Conversely, a poor end result specification or its improper application can cause problems and create controversy.

There is no doubt that the current trend in highway construction is to implement end result specifications. The FHWA even promotes the approach during plan development and review. The ultimate evaluation on the success of the end result approach is whether or not it provides the desired or perceived final product. If it does, then it follows that the least cost alternative has been provided for the product desired.

All of the benefits derived from the use of end result specifications emanate from the contrac-

tor's choice of method. Due to that choice, the benefits include greater competition, lower costs, conservation of resources, and more flexibility.

Departments of Highways and Transportation and other highway contracting agencies should consider end result specifications at every opportunity because of the possibility for improved least cost construction.

EQUIPMENT USE RESTRICTIONS UNDER METHOD TYPE SPECIFICATIONS

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Construction equipment has evolved greatly from the early part of this century to the present time. During this period of rapid technological advancement, method specifications have played an important role in advancing the use of various types of construction equipment and many types of construction processes.

Looking back at the early construction equipment, the requirements from past specifications and the development of specifications for more modern equipment types reveal many interesting facts. Why were specifications written in a format using method requirements and why do some specifications remain basically unchanged with time?

In the early days of technological development in construction equipment, the manufacturer of new types of equipment was the expert in its mechanical operation and functional proficiency. Therefore, one method of specification development was that when an agency wrote a specification to provide for the use of a particular type of equipment, the manufacturer's specifications were usually used as a guide. Often these original specifications became "gospel" and for some reason, and sometimes to the detriment of progress, have been maintained in later specifications because "that's the way it has always been done -- and it works." (If it is not broke - don't fix it).

Today we find ourselves still using this same procedure. The new equipment of recent time, i.e., cold milling machines, concrete grinding machines, recycling equipment (both hot plant and in-place types), pavement cleaning units, pressure grouting units and others, have specifications incorporated in many contracts using manufacturer's specifications as guidelines. Cold milling equipment, drum mix plants and diamond grinders are examples of these new types of equipment.

As engineers, we generally tend to be very detailed, cautious and conservative. If we are unfamiliar with a piece of equipment or a process, we write specifications which are very detailed, using all of the information we can gather from manufacturers, other agencies, research,, etc., in order to make certain we will not get anything less than what we want. Hot surface recycling is an example of the type work and equipment in which we have limited exposure and may tend to over spec.

Another avenue for the development of method specification is "a reaction to a bad experience using a particular piece of equipment or process."

Equipment manufacturers and transportation agencies seem to conduct schools and seminars year after year to cover some of the same subjects over and over. These efforts are generally predominant in the areas of asphalt and concrete production and placement. These areas are the ones in which agencies generally have the strongest method specifications. Because we continually have problems in these areas, the tendency seems to be to use method specifications in an attempt to cure the problems. This is too often the case of one bad apple spoiling the whole barrel. Each of you can probably think of a case where this process of specification development has taken precedent over the engineering and research process.

Method specifications have the potential of being too detailed and often redundant. First, under the method type, equipment to be used in accomplishing a particular type work has specifications that require certain capabilities or impose certain constraints. In some cases, method specifications also state how the particular piece of equipment is to be operated. In addition, method specifications generally set minimum requirements for the end product. The vibratory roller is the type of equipment which may have amplitude and vibration, operating speed and minimum density requirements.

Occasionally, however, a method specification will only provide for the "how to's" and "with what's" and leave the engineering properties of the finished product to be acceptable with no testing. Rolling of thin plant mix seals is an operation in which only "how to" roll is specified with the final density a product of this type rolling.

Equipment performance under method specifications has, over the years, generally been favorable. For the most part, our highway system, and for that matter, our entire modern public transportation system, was built through the years using variations of method specifications. The product that has resulted by using method specifications has generally been that which substantially meets or exceeds the minimum requirements.

Occasionally, though, we have jobs on which a major percentage of the work meets the minimum specification requirements with some quantity falling below the minimum but reasonably acceptable under certain limiting conditions (price reduction, adding material). In this latter case, because of the dual interpretation that can be given method specifications, potential for a dispute over standards of performance exists. The contractor will maintain that he followed all the methods specified and the fact that the end product does not meet specifications is not his fault but was caused by the owner. In turn, the owner takes the position that the contractor did not satisfactorily follow the methods specified and that if the methods had been properly followed the work would have met the minimum end result requirements.

Who loses in a situation like this? Often, the legal ramifications of our contracts yield a settlement where there is no winner -- not even the public. Compromise settlements, because of legal or operational considerations, often resolve the contract dispute but leave a project with a compromised end product. This dual characteristic of method specifications can be viewed as an entrapment to both parties and one which in most cases is unnecessary. Therefore, contracting agencies must decide what is most critical and necessary when specifying equipment requirements, and, in general, should specify only that requirement.

I am sure that many of you have been involved in discussions where it has been proclaimed that considerable savings could be experienced if method specification constraints were not imposed on equipment design characteristics, operational procedures or minimum numbers.

Method specifications, it can be said, have a tendency to inhibit the use of alternative equipment features. Equipment manufacturers continue, through research and development to design the most