

Contracting Methods for Highway Construction

DONN E. HANCHER, *University of Kentucky*

Transportation construction is a large industry—particularly highway construction, on which more than \$50 billion is spent annually. Small improvements can result in significant savings in time and cost, as well as better quality and fewer disputes. In recent years, many innovations have occurred in highway construction. The atmosphere within the industry is highly charged with optimism, uncertainty, and debate. Contracting methods for highway construction work are no exception to these developments.

CURRENT HIGHWAY CONSTRUCTION PRACTICES

The highway sector is perhaps the most conservative segment of the construction industry. Although highway contractors have implemented many new construction technologies, owner contracting methods have until recently remained the same. The traditional approach to contracting for highway construction projects has been design–bid–build. Under this approach, projects are awarded to the qualified bidder with the lowest total price, pay items are established on a unit price basis, the specifications for highway projects are strict method specifications, and the role of the owner or agent is to *inspect*.

By the 1970s, as a result of this approach, the industry had developed into a highly litigious environment of owners, contractors, lawyers, and claims consultants. In the 1980s, as the total quality management movement grew in the United States, transportation agencies started to question whether these traditional contracting methods were really cost-effective and quality oriented. As a result, many research projects addressing highway construction were initiated.

The traditional lowest-responsive-bidder system is well-understood and accepted throughout the country. Most contractors are comfortable with the procedure and understand its risks and rewards. The approach is also generally considered to be fair. However, it does have some limitations. The system is slow and does not favor a life-cycle cost approach to projects. Innovation is often stifled; some innovative ideas necessitate changes in laws and regulations and are therefore difficult to implement. In addition, there is little opportunity for contractor input into design, and quality is often an issue of dispute. Moreover, the traditional system requires that the highway department have a large staff to conduct all of its necessary functions.

CATALYSTS FOR CHANGE

Starting in the mid-1980s, several initiatives were undertaken that led to significant changes in highway contracting. A major factor was the willingness of the Federal Highway Administration (FHWA) to allow highway departments to try innovative contracting approaches on federally funded projects; as a result, the departments were encouraged to

consider practices long used in the private sector. A second major factor was the influence of innovative highway contracting practices in Europe. These practices had been used to produce roadways of much higher quality than those in the United States. Several industry studies of the European practices generated high interest in the possible adoption of similar practices in the United States:

- In 1987 the Transportation Research Board, with FHWA cooperation, formed a task force to identify promising innovative contracting practices. The task force's report was issued in 1991. FHWA subsequently approved Special Experimental Project No. 14, which was aimed at evaluating innovative contracting proposals suggested by the task force or by the states.
- In 1990 a team of asphalt concrete pavement specialists from the United States visited six European countries to study advances in highway technology in those nations.
- In 1992 representatives of U.S. transportation agencies and the concrete construction industry conducted a European tour similar to the asphalt study tour of 1990.
- In November 1992 eight leading highway industry organizations signed a pact for a National Policy on the Quality of Highways, which was focused on providing quality products, information, and service to the highway industry.
- In 1993 FHWA conducted a European Contract Administrative Techniques for Quality Enhancement Study Tour. This effort included an attempt to link contract administration practices to the high levels of highway quality in Europe.

INNOVATIVE PRACTICES IN HIGHWAY CONTRACTING

Innovations in highway contracting, such as those reviewed below, will be the focus of increased attention as the new millennium begins. Case studies of the implementation of various innovations will be invaluable for evaluating these methods. The state of Utah has created a website—Utah Technology Transfer Center—that covers innovative contracting methods from each state department of transportation (DOT). The site includes a searchable directory of articles on the subject submitted by DOTs and researchers. The site address is www.utaht2.usu.edu/projects/InnovativeContracting/ICHomepage.html.

Warranties

A warranty is an assurance that a product will serve its useful life and that if it does not, the provider will replace the product or pay to return it to its proper condition. The current warranty for almost all government-funded projects is the performance bond. This bond provides assurance that the materials and workmanship of the contractor will be good during the project and up to 1 year after project completion and acceptance.

The use of long-term warranties is a common practice in Europe and other countries. The governments of both Europe and America believe warranties motivate the contractor to do a better job than would be done without such assurance. Warranties have a perceived higher initial cost, but may result in lower life-cycle costs than those of traditionally contracted projects. In practice, some believe the cost of a warranted contract is comparable to that of a nonwarranted contract.

The warranty approach has, however, met with stiff resistance from contractors, surety companies, and contracting agencies in the United States. Many contractor organizations are opposed to warranties because small firms may not be able to obtain bonding to cover

warranty projects, and may therefore be denied the ability to bid on such projects. Large contractors, on the other hand, could see a reduced volume of contracts. Surety companies are skeptical, but have backed some contractors bidding on highway work that requires long-term warranties. Most of the work warranted to date has involved asphalt paving, pavement striping, and bridge painting.

Transfer of Quality Control

Quality control has for some time been a major requirement on highway construction projects and the subject of many problems for highway agencies. With increasing costs and shrinking staff resources, many agencies are addressing these problems by specifying that contractors are responsible for quality control, with the DOT only performing quality assurance tests to ensure that the contractor is fulfilling its quality control responsibilities properly. This approach allows the government agency to reduce its staff, which in turn results in lower operating costs and, therefore, lower overhead costs. The contractor can reduce project costs by having more control over materials and workmanship, but this cost savings is lowered somewhat by the need to hire more people to handle the quality control activities.

The government agencies involved in the construction process still set the standards each project must satisfy. To ensure that a project meets those standards, government representatives spot-check some parts of the project for quality assurance. The contractor is penalized if the project is not meeting its requirements. Penalties can include being removed from the contract if the project is of very poor quality. On the other hand, incentives are given to those contractors achieving significantly better results than required.

In 1994, the Wisconsin DOT compiled a manual covering the use and evaluation of quality management projects. References are made to the existing sampling and testing standards of the American Association of State Highway and Transportation Officials, ASTM, and the state of Wisconsin. The manual instructs contractors on the duties involved in acceptable quality control and encourages them to try innovative practices aimed at improving quality. Contractors are also required to submit and have approved a plan for carrying out the quality control function.

Multiparameter Bidding

Cost plus time (or $A + B$) bidding is a contracting procedure that still involves looking at the lowest initial cost, but also factors into the selection process the added cost of time to complete the project. The time cost for bidding is calculated by multiplying the estimated time of the project by a set daily user cost. The bid for award consideration is based on a formula comprising the traditional price bid by the contractor (A) and the amount of time allowed for the project (B). The award formula is as follows: award bid = $(A) + (B \times \text{road user cost/day})$. This formula is used only to determine the lowest effective bid for award, and not to determine payment to the contractor.

Estimating road user costs is quite difficult. The basis for the estimate is the expected impact of the construction on the public using the road during the construction time period. The user cost varies for different roads. These types of contracts work best with rehabilitation projects and projects that require quick completion.

Other elements can be added to the cost plus time contract to form multiparameter contracts. Those elements can include any that the DOT considers part of the construction process, such as quality, warranties, safety, past performance, lane rental, performance

specifications, or any combination of these. Such elements usually do not affect the bid price, but the payment the contractor receives through incentives/disincentives. Of all of these elements, quality is most frequently considered for incorporation into cost plus time contract clauses. By incorporating a quality element into the bid, the contractor is promising to perform at a set level, or to receive a disincentive for failing to do so.

Constructibility Reviews

Constructibility reviews involve a formal process of allowing contractors to provide input on the design of a project. The contractor reviews the design to determine the level of difficulty of construction, and to suggest design revisions that could enhance the construction process while resulting in possible cost and time savings and fewer disputes. Such reviews result in greater potential for a better-quality final product.

Constructibility review is most effective when contractor input is sought during the preliminary design phase, not just before the bidding process begins. It is much easier to implement changes in philosophy early in the design process, instead of waiting until the design effort is nearly complete. One reason for the failure of value engineering on highway projects was the animosity that occurred among designers when contractors expressed criticism of nearly completed designs. Value engineering input is now sought only for minor changes after a project has been awarded.

Constructibility input can be provided by a single contractor or several contractors serving as consultants to the project. One of the major issues is whether the contractor(s) providing the input will later be allowed to bid on the project. Some states, such as Wisconsin, have worked with their contractor associations to obtain constructibility input for major projects on a volunteer basis. The North Carolina DOT has had good experience with constructibility reviews, experiencing very few problems with implementation. The Kentucky Transportation Cabinet is using constructibility heavily on its Lexington to Paris road project, a major widening project that runs through a historic district containing some of the oldest horse farms in the world. Five contractors were prequalified by a special evaluation process to provide constructibility input throughout the design process and are the only contractors allowed to bid on the work packages. Public input on the project has been obtained successfully, and constructibility input has been improving with time.

Design-Build

Design-build is probably the most discussed and controversial issue in transportation construction today. A popular contracting method in the private sector for many years, it has not seen significant use in the public sector. Under the design-build approach, design and building of a project are performed by a single company or a joint venture of companies. This approach provides the government with one source of responsibility for the project. The design-build group shares information throughout the project, beginning with the design phase. The responsibility for all problems is centralized in the design-build firm.

Design-build does face legal barriers in some states where the process is not allowed. Because of federal statutes regarding design and construction contracts, FHWA considers such contracts to be experimental. However, the agency has been supportive of DOTs wishing to try this method. The most visible example of design-build is the rehabilitation of Interstate 15 in Salt Lake City, Utah. This project involves the complete renovation of 16

miles of roadway and 137 bridges in preparation for the 2002 winter Olympics, at an estimated cost of \$1.36 billion. Three bidders pursued this historic project, and the two that were not selected received a complimentary stipend to cover their costs for the preliminary bidding. A 10-year maintenance warranty is also included in the bid to ensure that the contractor will complete the project as expected.

Attitudes about design-build are beginning to change, and more DOTs are considering use of the approach in the future. A major benefit is reduced time for the total project and better design for complex projects as a result of the designer-builder interaction that occurs from the outset. There is, however, a great deal of resistance from the design community, which fears that cost will dominate decision making and result in lower-quality designs. There is also fear of becoming subcontractors to contractors. Variations on design-build, such as design-build-maintain, are also being considered. Regardless of the legal and other concerns involved, design-build will be a major issue in transportation construction into the new century.

Quality-based Contractor Prequalification

Prequalification of contractors has been used for years by most DOTs to screen out firms that represent a risk of not adhering to state highway project specifications. Although many standards are set with which interested contractors must comply for prequalification, essentially all that is required is the ability to secure a bid or performance bond for a project. One of the major qualification criteria is the quality of prior work performed, but this criterion has generally been discussed and not enforced. The emphasis on quality performance, however, is now becoming a major factor in evaluation.

The Ontario Ministry of Transportation has begun using a highly innovative approach to contractor prequalification to improve the quality of performance and reduce infractions on its projects. This approach involves evaluating the contractor in four areas: quality, safety, timeliness, and contract execution. Each area is given a different weight in the determination of a contractor's performance index: quality counts for 60 percent of the contractor's rating, safety and timeliness each account for 15 percent, and contract execution for the remaining 10 percent. The performance index covers the past 3 years and is weighted to give the most recent projects more influence. Contractors are allowed to appeal and attempt to improve their rating. The performance index is used to either increase or decrease the amount of work a contractor can be given on the basis of the prequalification limit.

Electronic Bidding

Most contractor bids are prepared and updated using laptop computers and spreadsheets, but a paper copy must still be submitted to the DOT at a set time. This requirement can cause a hardship for contractors who live at a great distance from the DOT's main office and for those that receive subcontractor prices at the last minute. Moreover, the rushed nature of the process results in a greater chance of errors. Allowing electronic bidding can alleviate these problems. Electronic bidding is not limited to accepting bids from contractors. Announcement of the invitation to bid and the bidding documents, along with the relevant plans and specifications, can be placed on a DOT's website for the review of interested contractors. Contractors can send their bids either by submitting a disk, by using electronic mail, or by uploading the bid to the DOT website. The DOT can also list the bid reports on its website.

The use of electronic bidding should benefit both contractors and DOTs. The major concern with electronic bidding, however, is security. How can the DOT and contractors be certain that the files they send or receive have not been tampered with and have been sent by the correct person? Software exists for ensuring the privacy of transmission on the Internet; however, DOTs have not yet developed such in-house systems for handling full electronic bidding processes.

SURVEY OF DOTs

A survey was conducted of all 50 state DOTs and 4 Canadian DOTs to determine their experience with innovative contracting practices. The survey was conducted by Adam Ross, a construction engineering graduate student in the University of Kentucky Civil Engineering Department, as part of his Master's thesis. Each agency was asked to identify innovative practices that have been tried, and to rate the benefit of using each innovation and the difficulty of its implementation.

Of the DOTs surveyed, 24 responded, and some of these respondents were interviewed. The survey responses are shown in Table 1. The benefit perceived from each innovation was rated from 1.0 (low) to 5.0 (high). The difficulty of implementing the innovation was rated from 1.0 (easy) to 5.0 (very difficult). Several of the methods have been tried by most of the respondents. All of the methods tried are believed to be beneficial, but it is believed that most will be somewhat difficult to implement.

TABLE 1 DOT Survey Responses

Contract Innovation	Percentage of Respondent Use	Benefit Received	Difficulty of Implementing
Partnering	89.7	3.9	2.7
Quality Control by Contractor	93.1	3.9	3.4
Warranties	20.7	3.2	3.0
Lane Rental	52.0	3.1	2.8
Design-Build	48.3	3.0	3.3
A + B (Cost + Time)	69.0	3.5	2.4
A + B + C (Cost + Time + Quality)	3.4	4.0	4.0
Constructibility Review	65.5	3.9	2.9
Performance Specifications	52.0	3.3	3.0

FUTURE CHALLENGES

Innovations in highway contracting are just beginning to be implemented. After years of stagnation, many innovations are now being implemented in several states, while many others are under review for possible implementation. In addition to innovative contracting

practices, there will continue to be a demand for enhanced technologies, such as construction equipment automation, new construction materials, improved design methods, and improved construction operations. There will be much support for further study and evaluation of these innovative practices and technologies, and many will result in formal research projects conducted by DOTs, consultants, and university researchers.