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16. Abstract

Construction cost inflation is affecting many state highway agencies including the Texas Department of Transportation  While some of this increase can be attributed to factors such as soaring cost of energy, reports of large variations in cost of bid items among different districts indicate that the problem is more complex. Indeed, there are many other factors affecting the recent increase in construction cost including design requirements, work restrictions, bidding procedures, and competition. The goal of this research is to identify these factors, or the root causes contributing to the increase in construction cost, and propose the methods that can address them.  The research approach is based on four sequential steps: identification of the methods, collection of the data from the interim workshops, assessment of the impact of the methods on adopted performance measures, and development of recommendations and guidelines on how to modify construction projects to reduce or contain the construction cost while maintaining quality. The results from a Delphi study show that the cost reduction methods (both on a project or program level) could be used to reduce or contain the cost of highway construction.

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# EVALUATION OF WAYS AND PROCEDURES TO REDUCE CONSTRUCTION COST AND INCREASE COMPETITION

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The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Federal Highway Administration (FHWA) or the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation. The researcher in charge of the project was Ivan Damnjanovic.

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# 1 INTRODUCTION

The imperative of many public organizations including state transportation agencies is to manage limited financial resources in the most efficient manner. While this task is difficult *per se*, with increases in costs of construction it becomes ever more challenging. For example, the Highway Construction Index (HCI), an index developed to provide a means to compare the current cost of construction to the cost of construction in the base year (1997), suggests that the purchasing power of the Texas Department of Transportation (TxDOT) has substantially decreased (Bohuslav, 2006). A construction project in 2006 is valued almost twice that of a similar project in 1997, an increase that is considerably higher than the increase in the consumer price index (CPI), a general measure of inflation. Just in 2005, bid items such as earthwork and asphalt experienced cost increases of 23 and 31 percent, respectively. While some of this increase can be attributed to increases in the cost of fuel and other construction materials, large variations in the cost of bid items among different states and even among different districts indicate that the problem is more complex than it initially appears.

To determine the extent of the problem, the American Association of State Highway and Transportation Officials (AASHTO) conducted a survey to identify the factors contributing to increases in construction costs. The results of this survey indicated that the most effective method to control construction cost is rejecting non-competitive bids and re-advertising (Sanderson, 2006). By doing so, an agency sends a clear signal to potential bidders that non-competitive bids will be rejected. While there are no specific data to support such a claim, surveys from the Kentucky and Missouri Departments of Transportation (DOTs) reported annual savings of $1.8 million and $5 million, respectively, using similar strategies.

In a similar effort, the Florida Department of Transportation (FDOT) developed a number of short-term and long-term strategies for cost control (Prasad, 2006). Short-term approaches included strategies such as encouraging bid options and bid alternatives—“got to have” versus “nice to have,” developing a more comprehensive price index for construction contracts to manage risk, optimizing night shift work, and redefining project scope. Long-term approaches considered more fundamental changes in the bid letting process as well as development of more accurate cost estimating tools. Similar efforts are reported by the Washington Department of Transportation (WSDOT) and TxDOT. WSDOT identified issues/factors that can be controlled by the department, such as reduced cost through increased competition, while TxDOT proposed 50 cost-saving ideas related to maintenance, pavement design, alternative materials, aesthetics, competition, and others.

Even though a number of agencies and professional organizations have attempted to address this issue, very few studies, if any, have approached the problem from a more methodological viewpoint. The focus was on *ad hoc* cost control methods without considering the role of the cost reduction methods in the project development process. This research attempts to fill this gap in the body of knowledge.

## 1.1 RESEARCH SCOPE

This research focuses only on activities carried out in the phases of the project development process that precedes construction and is limited to qualitative assessment. The scope includes reviewing the current practices of TxDOT and other DOTs, conducting fact-finding workshops that involved TxDOT design and construction engineers, conducting workshops involving contractors, collecting data using Delphi process, analyzing the collected data, and developing guidelines for implementation of cost reduction methods. No software or information technology was generated through this project.

## 1.2 RESEARCH GOAL AND OBJECTIVES

The goal of this research is to develop a set of guidelines that can help TxDOT reduce contracting costs and control cost increases. More specifically, the objectives supporting these research goals are:

1. Identify and assess the impacts of the factors that affect increases in costs of bid items and the methods and strategies that can help reduce the cost.
2. Develop comprehensive guidelines on how to modify projects to reduce initial construction costs while maintaining equal or better performance.
3. Assess how TxDOT can improve its project development and contracting procedures or processes to increase competition.

## 1.3 REPORT STRUCTURE

This report is organized into six chapters. Chapter 1 presents introduction, study objectives, and the scope of the study. Chapter 2 presents research methodology used in this project, while Chapter 3 reviews the factors and the methods affecting cost increases and cost reductions, respectively. Chapter 4 provides information about the data collection process including the workshops and the Delphi study, while Chapter 5 summarizes the study results and presents ranking of the methods. Chapter 6 provides practical guidelines for method selection based on the design review milestone points. Finally, Chapter 7 summarizes the findings and conclusions of the research.

## 2 RESEARCH METHODOLOGY

To address the research objectives, it is of critical importance to develop a research framework to guide the research process. Figure 1 shows the research framework based on the following four steps.

1. Identify factors, methods, and strategies (Conduct Literature Review).
2. Collect data through interactive workshops (Organize Interim Workshop).
3. Analyze collected data using Delphi process (Conduct Delphi Analysis).
4. Develop guidelines and recommendations (Synthesize Results).

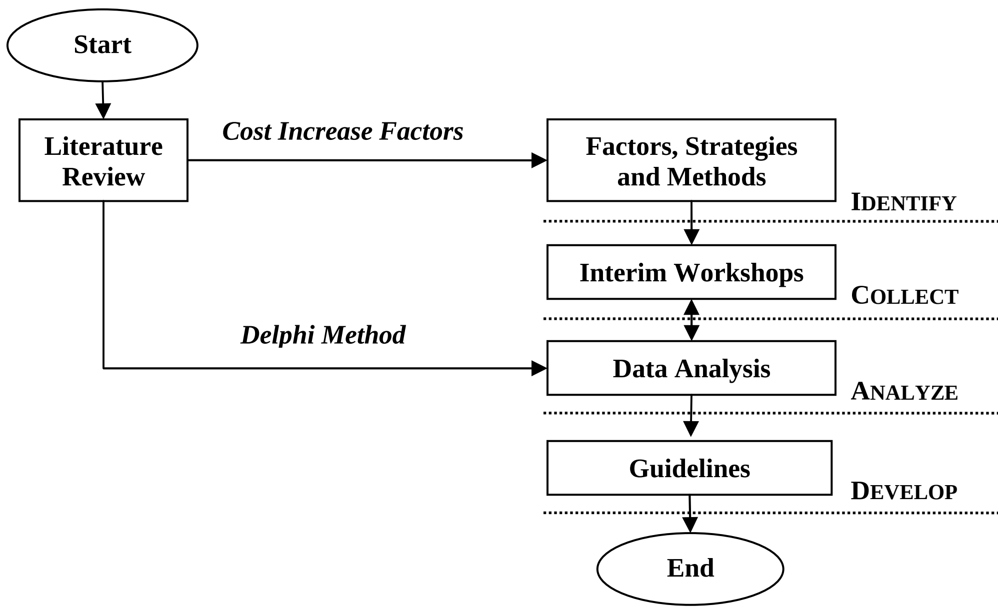


**Figure 1. Research Framework.**

While most of the considered tasks were conducted in a sequential manner, data collection and data analysis steps overlapped. The motivation for this overlap was to provide the second and third workshop participants the results from the Delphi analysis. The following sections explain the implemented research framework and the steps in more detail.

### 2.1 CONDUCT LITERATURE REVIEW

The main objective of the literature review was to undertake a series of activities to generate a broad understanding of actions state DOTs and other contracting agencies use to address the problem of rising construction costs, as well as to collect needed information for successful implementation of the interim workshops. Utilizing library, computerized database, and on-line resources, the research team gathered relevant literature. This literature review synthesis provided understanding of the factors affecting cost increases and methods used to reduce or contain the rising construction costs.

## 2.2 ORGANIZE AND CONDUCT WORKSHOPS

The objective of this step was to gather national experts, contactors, and state and district engineers to discuss and identify possible factors affecting cost increases and methods that can reduce or contain costs. The goals of these workshops were as follows:

1. Reveal new practices and information on national, state, and district levels.
2. Identify the potential of different methods and strategies.
3. Develop participant support and ensure their buy-in of the strategies and methods eventually recommended and deployed by TxDOT.

The research team conducted three separate workshops in the following order: 1) plenary workshop with national experts and TxDOT engineers, 2) workshop with the representatives from the construction industry's Association of General Contractors (AGC), and 3) workshop with state and district engineers (from design, construction, and maintenance divisions). More specifically, the objectives of the workshops were as follows. The objective of the first workshop was to survey the experience that TxDOT and other state DOTs have with increases in construction costs. This workshop included a brainstorming session to discuss the factors affecting construction costs and the strategies and methods to reduce or contain project costs. The objective of the second workshop was to survey the opinions of contractors on the factors affecting their market behavior as well as gather their feedback on the possible effects of different cost reduction strategies and methods. The objective of the third and final workshop was to discuss implementation strategies for the cost reduction methods by considering project performance indicators such as quality, schedule, and safety.

To enhance their effectiveness, researchers carefully planned the interim workshops. Because of its central location and ability to accommodate as many district offices and contractors as possible, the research team organized all the interim workshops in Austin. To encourage discussion, the workshops were organized in sessions, where each session covered a specific topic.

## 2.3 DISTRIBUTE DELPHI SURVEY AND CONDUCT ANALYSIS

After the first workshop and initial identification of the factors and methods, a Delphi analysis was utilized to formulate a group judgment about the effectiveness of the methods and the expected impacts of these methods on the cost of construction along with three other important performance indicators: quality, schedule, and safety. The Delphi technique was used to elicit information and judgments from a panel of independent experts over two or more rounds. After each round, the Texas Transportation Institute (TTI) research team provided an anonymous summary of the experts' judgments and their comments. When experts' opinions changed little between rounds, the process was stopped. As a result, researchers obtained the group judgment about the methods for reducing or containing construction costs and expected impacts of different strategies and methods. The Delphi process concluded in two rounds due convergence of responses. These results were then used to develop a portfolio for the second and the third workshops.

## 2.4 DEVELOP GUIDELINES AND RECOMMENDATIONS

The final step in the research project was to develop comprehensive guidelines for the use of cost reduction methods by TxDOT engineers. The comprehensive guidelines provide a blueprint on how to modify projects to reduce costs while maintaining equal or better performance. The final research report fully documents the research performed, methods used, and results achieved. As required by TxDOT, guidelines for method selection were developed and included in Appendix I. This appendix can be used independently of the report.

# 3 REVIEW OF THE STATE OF THE PRACTICE

As previously mentioned, many DOTs across the country face the problem of increasing costs of highway construction projects. In order to develop a series of recommendations to reduce and contain construction costs, a comprehensive literature review and interviews were conducted to survey both national and international experience. This was followed by a review of the surveyed methods for applicability to TxDOT's project development process and was used as a point-of-departure during the first workshop. This chapter synthesizes initially identified factors and methods.

In the context of this research project, factors, strategies, and methods are defined as follows. A **factor** is defined as an issue, cause, procedure, or force that impacts highway project costs. A **method** is defined as a specific action, technique, or procedure targeted at reducing or containing the cost of highway construction projects. A **strategy** is defined as a set of actions targeted to achieve the goal of reducing or containing highway construction costs. In this formulation, a set of methods can comprise a strategy.

Figure 2 illustrates the relationship between the factors and the methods. For each cost increase factor, one or more methods can be identified. It is important to note that the methods correspond to different stages of the project and could be applicable only to the projects with specific characteristics. As illustrated in Figure 2, Method A can be considered to address the cost increase factor X; but before such method is applied, Method A's expected performance in terms of defined performance measures and applicability with the respect to the project's development phase and characteristics must be considered.

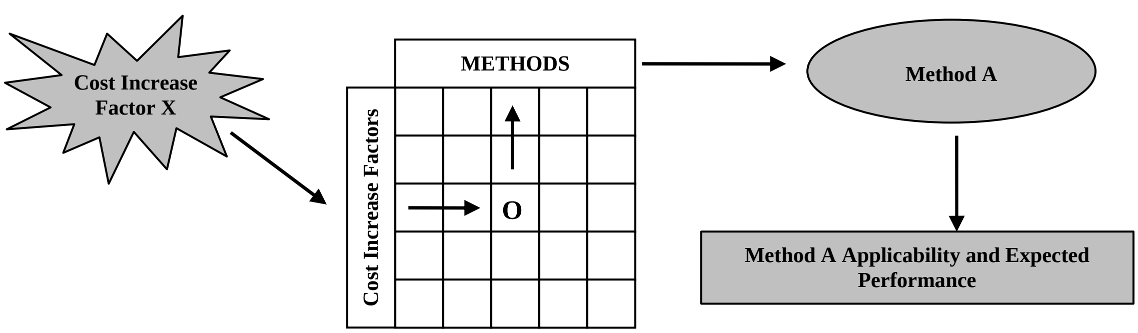


**Figure 2. Factors and Methods.**

The following sections summarize the identified factors that can potentially cause an increase in construction costs and the methods and strategies identified to reduce and/or contain the construction costs. The methods and strategies are summarized in sections that correspond to the phases of the project development process where they can be implemented.

## 3.1 FACTORS

In recent years many state DOTs are observing construction cost inflation. Based on the Federal Highway Administration's index, Engineering News Record (ENR) construction cost index, and the Bureau of Labor Statistics (BLS) producer price index (PPI) for highways and streets, the American Road and Transportation Builders Association (ARTBA) estimates that the purchasing power of state DOTs is decreasing and will further decrease.

The overall trend of increasing cost of construction is illustrated in Figure 3. As it can be observed from Figure 3, the increase in cost of construction is not unique to only one state. In absolute terms, over a period of 10 years, highway cost has significantly increased in California, Florida, and Georgia (FHWA, 2008). This increasing cost of construction can be attributed to many factors. While state DOTs are aware that the rising cost of diesel fuel and materials significantly contributes to increases in the cost of bid items, it is still unclear how much of the total increase in bid items can be attributed to such increases and how much can be attributed to other factors.

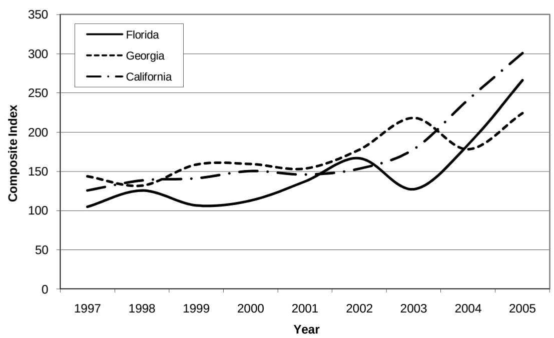


**Figure 3. Price Trends for Federal-Aid Highway Construction.**

One of the most fundamental factors determining the prices of any products or services including construction is the relationship between demand and supply in which the market prices are determined by the equilibrium conditions. In construction market, such equilibrium is determined by the demand/supply of materials and services in sectors such as residential, commercial, industrial, and heavy construction.

However, this equilibrium is not static. It is determined by dynamic forces of the market and evolves over time as some sectors become more attractive than the others. For example, reconstruction efforts following Hurricane Katrina have added demand in the housing market and created a shortage of construction labor in certain regions. Such an increase in demand for reconstruction work coupled with a continued strong demand for infrastructure projects have led to increase in demand for materials and labor. As a result, these coupled effects, along with external increase in the price of crude oil, have created an almost exponential increase in construction costs. Indeed, FDOT attributed the increases in costs of transportation projects to saturation of the construction market and, hence, availability of contractors and labor; material shortages; and increases in material, labor, and fuel prices (FHWA, 2006).

In general, the cost increase factors can be classified based on two broad classification methods. The first classification considers who can control the factors; hence, there are **internal** and **external** factors. While the owner can control planning, procurement, development of designs and specifications, selection of contractors, contract administration, and allocation of risk, some factors are beyond the owner's control. For example, the prices of material and labor, availability of labor, contractors' overhead costs, overall number of projects in the market, and resources of the contractor are some factors over which the owner has no control. In addition to this intuitive classification method, factors can be classified based on the process and market forces. This classification is broader and includes five categories as follows (Warsame, 2006):

1. Cost of materials, or factors affecting increases in cost of materials;
2. Design and specifications, or factors that relate to effects of design requirements and specifications;
3. Project-specific factors, or factors that are limited to specific locations or type of projects;
4. Competition and market conditions, or factors that relate to market and contracting and letting procedures; and
5. Macroeconomic factors or factors that relate to effects from changed macroeconomic conditions.

In the following sections, these five categories of cost increase factors are discussed in more detail. While some factors addressed in this report are not directly affecting the cost of construction in the highway sector, due to the previously discussed interconnected nature of the construction market, their indirect effects can still be significant.

### *3.1.1 Cost of Materials*

Costs of materials and oil-based fuels significantly impact the overall price of bid items. With demand for construction in both domestic and international markets increasing in past several years, the prices of construction materials have also increased. This can be attributed to a number of factors including limited capacity to produce materials, lack of competition, and price of energy. In fact, the prices of some materials are in direct correspondence to the prices of oil-based fuels (e.g., asphalt) and energy in general. Figure 4 shows the increase in the price of asphalt from December 1999 to August 2008 (ACAF, 2008).

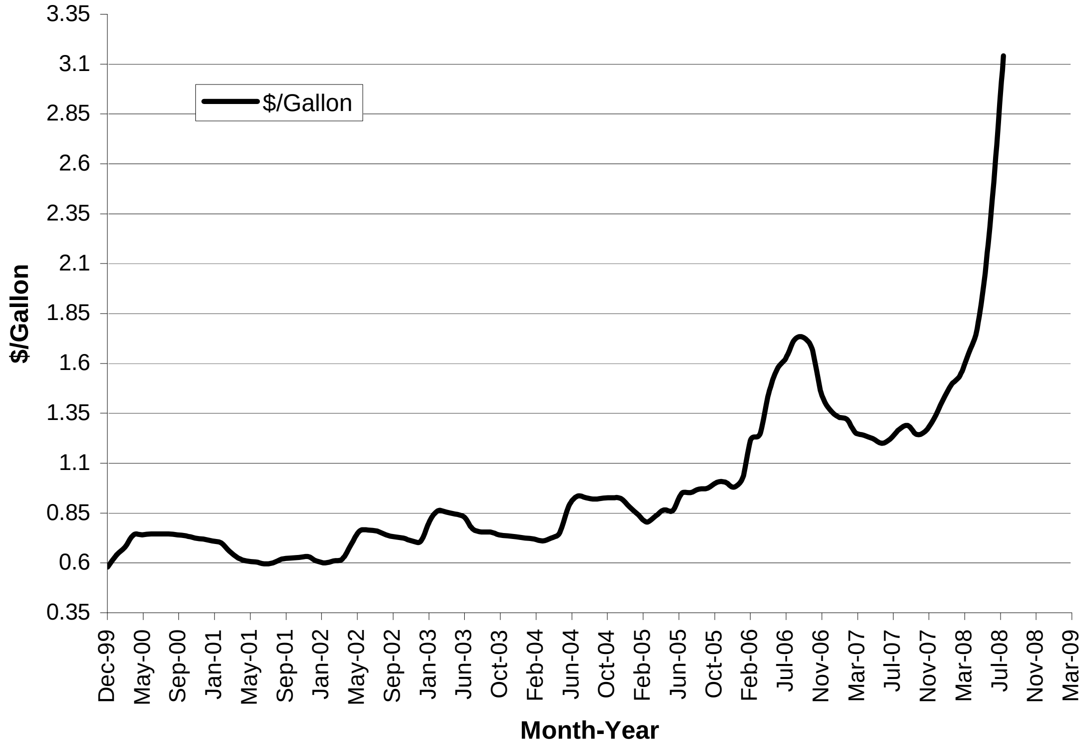


**Figure 4. Asphalt Cement Index.**

Recent trends in the costs of construction materials indicate dramatic changes. Structural steel is among the materials that have experienced the greatest increase in cost. Since 2003, the cost of structural steel has risen over 45 percent. Other materials follow less dramatic yet still significant trends. The cost of crushed stone increased 10 percent from 2003 to 2005, the cost of ready-mixed concrete increased over 18 percent for the same period, while the cost of asphalt paving mixtures increased approximately 9 percent just in the last year (Buechner, 2006).

Overall, highway material costs have risen more than 20 percent in two years, and it is expected that the market will continue to put an upward pressure on prices, mainly due to: 1) limited supply, since in the near future little, if any, new capacity will be installed in production of aggregates, cement, and asphalt, and 2) strong demand for construction work in other construction submarkets such as the residential, manufacturing, and commercial submarkets. Some relief to this upward pressure might come in the form of imports from Mexico and a slowing of the housing market, but the risks related to exchange rate fluctuations and, more importantly, the risk of developing a "cost-push" cycle (inflationary spiral), where owners accelerate projects to beat cost increases, will still drive costs up. As a result, contractors will continue to incorporate the uncertainty premium in the cost of bid items, leaving state DOTs in a position that will require rescaling of their construction programs.

### 3.1.2 Design and Specifications

It is well recognized that design and material specification decisions influence the total cost of construction. For example, while use of more expensive materials and designs can promote quality and longer life cycle, it is questionable whether such materials should be used on all projects, in particular projects where traffic utilization does not warrant such level of quality. For example, specification of high grade "Cadillac" asphalt for projects with a low level of annual traffic is questionable and does not support efficient use of available resources. In addition to erroneous specifications in terms of material quality, some designs and material specifications require the use of materials that are not locally available or materials that are in high demand and provided by only few suppliers. Much like specification of "Cadillac" asphalts for projects with low traffic utilization, these location/high demand "misspecifications" can significantly affect the cost of construction.

### 3.1.3 Project-Specific Factors

Project characteristics and location can influence project costs. Often, a significant variation in price of bid items is observed depending on whether the project is in urban or rural areas. This can be due to many factors including availability and prices of materials, restrictions, and others. Also, smaller firms are more interested in projects nearer to their headquarters. In addition, very specialized projects typically involve fewer players, and hence higher bid prices are expected due to lack of competition.

### 3.1.4 Competition and Market Conditions

Often the number of bidders interested in a particular project is determined by type of work, duration, and size of the project. In fact, the number of available jobs in the market at a particular time can significantly affect competition. Some DOTs consider that timing of the letting may be a factor influencing the bid price, mainly due to too many or too few projects to let within a time frame. Interviews conducted in a research study in Louisiana revealed the belief that contracts let in the fourth quarter of a fiscal year are likely to have higher bid prices compared to those let earlier in the fiscal year attributed to the accumulation of projects and a resultant reduction in competition (Wilmot and Cheng, 2003).

### 3.1.5 Macroeconomic Factors

Fluctuations in Federal Reserve risk-free rate, weakened dollar, global crude oil demand, and world prices are some of the macroeconomic factors that govern the prices of materials. Indeed, the condition of the construction market in the United States is not only a result of domestic market conditions but is also affected by global macroeconomic conditions and supply and demand around the world (Cross, 2005). For example, increases in global construction activities resulted in soaring cement and steel prices.

### *3.1.6 Summary of Factors Affecting Increase in Costs of Construction*

In summary, the main factors governing the increases in highway construction costs are the costs of materials, changes in design and specifications, competition and market conditions, project-specific factors, and macroeconomic factors (Craig, 2006; Roads & Bridges.2006). While TxDOT has control over some of these factors, it has no control over others. For example, it would be impossible to control global demand for materials or macroeconomic factors. Also, the number of available contractors in a district or county cannot be known with any certainty. However, there are other factors such as design, specifications, project scope, and size of the contract, which are controllable by TxDOT. Table 1 summarizes the relationship between some of the discussed factors and TxDOT's ability to control them.

**Table 1. Examples of the Factors Affecting Cost.**

| Control | Factors Affecting Cost |
|---|---|
| **Internal** | Design |
| | Specifications |
| | Physical layout |
| | Project duration |
| | Project scope |
| | Size of the project |
| | Contract provisions |
| | Timing of the letting |
| | Communication |
| | Unique or complex design |
| | Accuracy of design and estimates |
| **External** | Competition |
| | Macroeconomic factors |
| | Local project conditions |

## 3.2 METHODS AND STRATEGIES

In this research the methods used to control cost increase factors are identified according to the project development phase they are introduced in. While the project development process can be quite complex and fragmented in many different phases depending on the type of construction program and adopted procurement practices, the project development process in many DOTs broadly consists of the following phases: 1) planning and programming; 2) development of designs, plans, specifications, and estimates (PS&E); and 3) letting and post-letting.

Figure 5 shows an example of classification of these methods with respect to project phases. However, it is important to note that while some methods are uniquely applicable to a specific phase, other methods can be potentially applied in more than one phase. In such cases, the method can be classified to a phase in which its impact would be the most significant. Hence, for the purpose of developing a comprehensive review of the reported cost reduction methods, the methods are classified by project development phase.

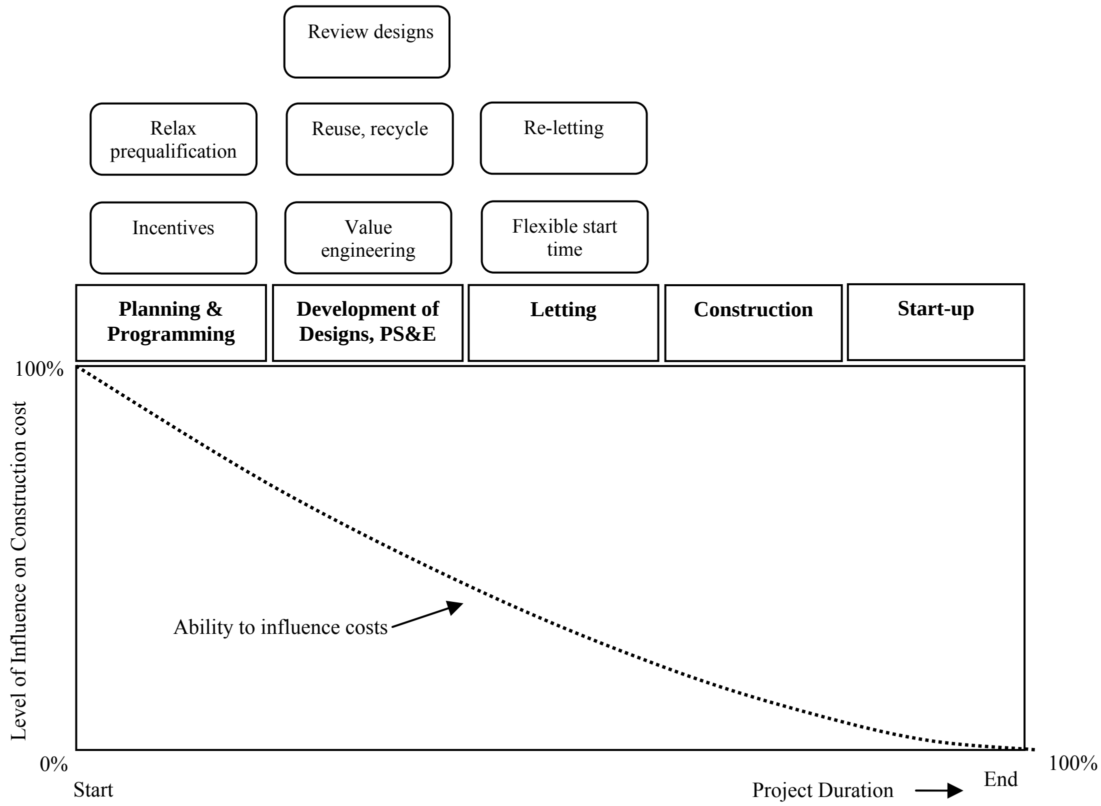


**Figure 5. Methods to Control Cost and Their Influence in Different Project Phases.**

In addition to project development phases, Figure 5 shows a theoretical cost influence curve for assessing the effectiveness of cost reduction measures in the different project phases. As can be observed, some early actions, taken during the planning and programming phase, should yield better results in cost savings compared to those taken in later phases, such as letting. Various cost reduction methods thus can be associated with project phases. While cost reduction methods in the planning and programming phase can be considered policy changes and more strategic in nature, the cost reduction methods associated with design and PS&E phase should be considered more technical in nature. Hence, in the later phases of project development, the decisions regarding the implementation of cost reduction methods can be based on sound engineering judgment, checking the considered actions against applicable codes and possible effects on performance measures.

The following sections summarize the cost reduction methods or strategies reported in literature. As previously mentioned, it is important to note that some of the considered methods can be applied in more than one phase. Researchers based the following allocation of methods on initial preliminary assessment (AASHTO, 2007); that has been tested and revised later through the Delphi study and discussions during the last workshop.

### *3.2.1 Planning and Programming*

*Bundle or Split Projects to Reduce Costs and Delays*

As previously mentioned, the size of the project may affect the cost of construction. For example, some construction projects are too small to attract the best and most highly qualified contractors, whereas other projects are too large to attract more than a few bidders, as smaller contractors may not be able to compete. In the AASHTO survey on the strategies and methods to address increasing highway construction cost and reduction in competition, a method based on bundling small projects or splitting large projects was ranked in the top 10 most effective strategies to reduce construction costs (Sanderson, 2006).

There are two possible benefits to bundling small projects into one large project. The first benefit relates to the principle of economies of scale. Grouping several small projects into one large project can reduce the ratio of fixed cost to overall cost, ultimately resulting in reduced bid price. The second potential benefit of grouping small projects into one large project is to increase competition. It is expected that medium-size projects will attract more bidders and therefore increase the competition.

A method opposite to bundling small projects is splitting one large project into several smaller ones. This strategy might be beneficial when there are only a few large competitors on the market able to take on the large project. By splitting a large project into several medium-size projects, a larger pool of contractors should be attracted to bid. For a more quantitative assessment of the likely effectiveness of this method(s) an analysis of previous bids submitted on projects versus contract size is needed. This analysis would lead to recommendations about the circumstances in which small projects should be combined into larger contracts and, conversely, large projects divided into smaller contracts, to take advantage of the best bidding market.

*Utilize Existing Assets More Efficiently*

TxDOT, much like other “big” owners, can act opportunistically and take advantage of reduced cost of materials and construction during certain periods of underutilization of contractors’ and material producers’ resources. This typically occurs off-season or during winter months, when asphalt and concrete construction is curtailed. However, it is important to note that exploring such opportunities largely depends on the technical feasibility of conducting construction work during off-season periods. For example, the technical feasibility of asphalt-cement paving operations will critically depend on weather and environmental conditions during the winter. More study is needed to determine the technical possibilities for off-season work and the cost savings that might accrue due to more efficient utilization of contractors’ and suppliers’ physical assets during such underutilization periods.

*Manage Material Cost Risks*

In preparing bids, contractors must balance risks and rewards. In this context, there is an opportunity for the owner to reduce contractor's risks and hence reduce the contingencies included in bid prices. This may result in lower average costs for TxDOT for the bid items that have built-in substantial risk premiums. TxDOT, a larger organization and financially stronger than any contractor, is in a better position to diversify its risks. Therefore, it may be more cost-efficient for TxDOT to assume some additional risks in order to reduce bid item costs. For example, TxDOT can assume some of the risk in increases in future material costs and lower the premium contractors incorporate in bid items due to uncertainty in material prices. Even though TxDOT does not have any control over such external factor contributing to increases in construction costs—increases in costs of materials—it can try to "lock-in" the prices of materials and hedge the risk of paying much higher prices later; however, such an approach could also lead to an unfavorable situation if prices go down. In such a scenario, the agency could effectively lose money by speculating on price trends. An alternative approach to hedging price risks is to allow for price adjustments and lower the premium. In summary, agencies' involvement in managing risks associated with the cost of materials can be a valuable method of reducing the premium cost contractors add to the bid items. A more detailed risk analysis is needed to determine this relationship and produce some recommendations about the contract terms and conditions that would lead to lower TxDOT costs.

*Control Frequency and Timing of Preventive Maintenance Work*

Re-evaluation of scheduled preventive maintenance is a method that reduces the scope of construction programs rather than addresses the costs of bid items. Typically, DOTs conduct studies to determine the frequency of preventive maintenance actions. However, such analysis is sometimes questionable as there are no consistent guidelines about when to apply different types of preventive maintenance and ultimately what their effects are. In fact, sometimes even the decisions regarding maintenance or rehabilitation work are made without considering life-cycle costs. There are suggestions to time preventive maintenance actions for better efficiency. For example, critical review of the sealing of shoulders every cycle can result in substantial savings at the program level.

*Outsource Maintenance*

Many DOTs outsource maintenance of certain activities such as painting, lawn mowing, crack repairs, and others. However, these small-value activities may not necessarily substantially contribute to cost savings. Other DOTs outsource complete maintenance of their pavement networks. Examples from Canada and Australia indicate that by outsourcing maintenance, the cost of the maintenance program can be significantly decreased. Alberta Transportation and Utilities division (AT&U) outsourced the maintenance of highways by geographically dividing the work to achieve lower costs. The scope of outsourcing was maintenance of highway and bridges. This outsourcing concept is based on identification and allocation of the risk to the organization who can best manage it (Bucyk and Lali, 2005).

In this case, it is expected that by allocating risks to the entity that can influence the performance risk, the cost of long-term maintenance costs can be reduced.

### *3.2.2 Development of Designs and PS&E*

During this broadly defined category of project development, a number of methods can be implemented to reduce costs. Design and specification reviews can be carried out in a formal and informal way. Over the years, a number of ideas including alternative materials and designs have been developed and considered. Critical reviews of these ideas, problems, or hindrances in implementation of such ideas as well as observed cost savings from the documented cases can help in their future consideration. This section discusses several methods that are often implemented during this phase of project development.

*Provide Material Sources and Other Alternative Materials Including Recycled Materials*

To reduce and contain the prices of construction materials, the owners can engage in direct contracting with the suppliers of construction materials (aggregate, concrete, asphalt, etc.). With its combined buying power, TxDOT should be able to obtain lower prices for guaranteed high volumes of materials. Moreover, TxDOT might be able to get suppliers to guarantee prices for a longer period of time or to provide options on future material prices. With material prices fixed by long-term contracts, perhaps with a defined escalation clause, TxDOT would be in a better position to determine which projects to let for construction and which projects to put on hold. In such a contractual setting, material hauling costs would be a major factor, so the benefits of volume purchases and guarantees would have to be weighed against the potential for increased hauling costs. More quantitative studies would be needed to determine the effectiveness of this method based on the geographical locations of future projects and potential material volumes and the optimum locations.

As one of the major cost drivers for construction cost increases is energy costs, an analysis of the energy content of new asphalt versus recycled asphalt pavement, new aggregate versus recycled concrete, and other materials would provide needed information on whether to use alternative materials. For example, if the energy content of recycled asphalt pavement is less than that of new asphalt per square yard, then the recycled material may be less sensitive to future energy price increases than virgin materials. Other factors that would also need to be considered include hauling costs, costs of disposal of used asphalt and concrete, and different environmental factors. However, it is possible to generate a straightforward economic analysis that would compare the total costs of recycled material versus virgin material for TxDOT projects.

In the past, TxDOT has carried out studies on recycled materials. Several materials are identified as having some economic value like recycled aggregates, tires, bottom ash, and so on (Senadheera et al., 1999). Besides having lower costs, these materials also offer environmental benefits. There may be a need to look at these materials and determine the ways and means to improve their usage on TxDOT projects.

*Accept Equivalent Pavement Designs*

Consideration of alternate designs represents a potentially viable strategy to reduce project costs. In fact, some contracting agencies use the concept of equivalent alternate designs when there is a possibility that the least costly design will depend on competitive circumstances (Sanderson, 2006). Here, it is critical that the alternate and original designs have comparable life-cycle costs. However, it is very difficult, if not impossible, to develop truly equivalent alternate designs for concrete and asphalt pavements. This is a reason why FHWA has traditionally discouraged the use of alternate pavement designs in bidding but has still allowed the use of alternate pavement type bidding with bid adjustments to account for differences in life-cycle costs. Several DOTs have implemented various alternate pavement-type bidding procedures, while some, like the Pennsylvania DOT, instituted a policy of allowing optional alternate bridge design submissions by contractors. Regardless of whether alternate designs are considered for new construction or maintenance work, full consequences of such actions should be assessed on principles of value engineering and technical feasibility with the purpose of achieving essential functions of the project at the lowest cost.

*Consider Design Staging*

New highway construction or pavement rehabilitation designs are often based on estimates of future traffic, which can vary significantly. Since the actual realization of traffic could be just a fraction of the predicted traffic, it could be beneficial to construct the facilities in stages. This phased or stage-based construction can be considered as a method to reduce the initial construction costs by changing the design to take into account uncertainty in future demand. After the uncertainty is resolved by observing the actual realization of the traffic, TxDOT can take a recourse action, such as adding additional structural capacity or constructing another lane to reduce congestion, if the observed traffic warrants such an action. Here, the initial construction cost can be significantly reduced by initially underdesigning facilities in response to large uncertainties in the future utilization. It is unclear to what extent state DOTs overdesign highways, and therefore more study is needed to determine the cost of overdesigning facilities and possible opportunities for cost savings.

*Employ Value Engineering*

Value engineering was first introduced by General Electric Company (GEC) during World War II to combat shortages of certain materials. Over the years, value engineering has evolved as a means of systematically reviewing project costs. It involves review of the project or individual tasks for possible improvement in value or performance without affecting the cost or compromising the performance requirements. Value engineering is defined as an application of a systematic process by a team of experienced professionals to identify the function of an item or service, determine the worth of that function, generate potential alternatives, and finally, provide the needed function at the lowest possible overall cost (FHWA, 2007). This value is defined as the ratio between performance and cost. Value engineering is concerned with increasing value by increasing or maintaining performance and reducing cost.

The first step in the value engineering process is defining the initial goal and selecting a review team comprised of experienced and trained value engineers. Often, outside consultants conduct value engineering reviews. In subsequent stages, information regarding the items or services is collected followed by an analysis of its primary function. In the speculative phase new ideas are generated through a brainstorming process or already known ideas are identified as alternatives to the original item. In the next phase, the ideas generated in the previous phase are evaluated against the set criteria that differ for different projects. The idea is evaluated for its overall performance/cost ratio compared to the original design. The selected idea is then further developed for implementation.

Presently DOTs have different standards for value engineering program implementation. The most common criterion for a project to be considered for value engineering initiatives is when the project budget exceeds a predetermined amount. Federal-aided projects require a value engineering review for all projects exceeding $25 million in costs. However, in view of rising prices, value engineering may be beneficial even for smaller projects. Federal-aid projects have shown a very impressive cost to benefit ratio on value engineering proposals, as shown in Table 2.

**Table 2. Value Engineering (VE) on Federal-Aided Projects.**

| Description | FY 2007 | FY 2006 | FY 2005 | FY 2004 | FY 2003 |
|---|---|---|---|---|---|
| Number of VE Studies | 316 | 251 | 300 | 324 | 309 |
| Cost of VE Studies Plus Administrative Costs | $12.54 Mil | $8.15 Mil. | $9.80 Mil. | $7.67 Mil. | $8.42 Mil |
| Estimated Construction Cost of Projects Studied | $24.81 Bil | $21.53 Bil. | $31.58 Bil. | $18.7 Bil. | $20.48 Bil. |
| Total No. of Recommendations | 2861 | 1924 | 2427 | 1794 | 1909 |
| Total Value of Recommendations | $4.60 Bil | $3.06 Bil. | $6.76 Bil. | $3.04 Bil. | $1.97 Bil. |
| No. of Approved Recommendations | 1233 | 996 | 1077 | 793 | 794 |
| Value of Approved Recommendations | $1.97 Bil. | $1.785 Bil. | $3.187 Bil. | $1.115 Bil. | $1.110 Bil. |
| Return on Investment | 157:1 | 219:1 | 325:1 | 145:1 | 132:1 |

*Use Project-Specific Designs and Processes*

Use of standardized documents may save on design costs but sometimes may result in activities or processes that are not necessary for the given project (FHWA, 2003). A careful review of all the elements is necessary when adopting standardized or prototype designs.

This process needs to be designed in such a way to provide flexibility in the delivery of the project, as it significantly affects the schedule and costs (FHWA, 2003).

*Use Performance-Based Specifications*

Many contract specifications restrict contractors from using available resources and instead make it mandatory for them to use materials or resources that are not available to them or that might not be beneficial to them. By moving toward performance-based specifications, contractors can use materials and resources, which reduce their costs and in turn can reduce the costs of new construction and maintenance over an extended period of time. Thus, by providing this flexibility, contractors are motivated to look for materials, which are more economical.

*Conduct Constructability Analysis*

Another important method that can reduce initial project cost is constructability analysis, which is an effort that considers all aspects of a project from a construction perspective, including, but not limited to, design modifications to improve construction efficiency. Thus, constructability analysis considers delivery approaches, major construction methods, and sequencing of construction activities, among other areas. National Cooperative Highway Research Program (NCHRP) Project 10-42 developed a workbook that describes a constructability review process for highway projects (NCHRP Report 391). The research team suggests that a constructability review process is an important factor in achieving better value for cost. For example, early evaluation of major construction methods and delivery strategies can impact major technical components of a project with an objective of reducing construction costs. Constructability reviews might be particularly important when evaluating construction phasing in relation to traffic management, for example.

*Update Construction Cost Estimates*

While cost estimating is not a method that will *per se* increase competition or reduce construction costs, the implications of inaccuracy in engineer's cost estimates can significantly affect the bidding process. A study of 258 infrastructure projects found that project costs are underestimated in approximately 90 percent of projects, and actual costs average 28 percent higher than estimated based on this sample (NCHRP Project 8-49). In general, two methods of pricing dominate state DOT practice: detailed and historic-bid averages. Regardless of the method used to estimate project costs, to obtain accurate estimates, it is essential to update cost estimation data so that the engineer's estimate will accurately reflect current market conditions. Even though this method does not directly relate to the methods for increasing bidding competition, it is still ranked as one of the most effective strategies for reducing construction costs (Sanderson, 2006).

### *3.2.3 Letting*

*Reject Non-competitive Bids and Re-advertise*

This method was ranked as the most effective method for reducing construction costs in the recent AASHTO survey. The objective of this method is to increase competition by re-letting projects. For example, if the lowest bid is substantially above the engineer's estimate, agencies can reject all bids, make changes to the project scope and/or requirements, and then re-advertise the project. Surveys from Kentucky and Missouri DOTs reported that by re-letting projects the agencies reduced annual construction costs by \$1.8 million and \$5 million, respectively. However, it is unclear whether such reductions were due to re-scoping or increased competition. Alberta Transportation & Utilities (AT&U) re-tendered 17 maintenance contracts to achieve a 28 percent reduction, totaling \$26.4 million (Bucyk and Lali, 2005).

*Eliminate Limitations That Constrain the Number of Bidders*

It is well known that the larger the number of bidders for a project, the lower is the winning bid. For example, based on a calibrated simulation model, for a particular set of parameters, the lowest bid when eight bidders are present would be predicted to be approximately 25 percent lower than the lowest bid with only two bidders present, all other things being equal. This is illustrated in Figure 6.

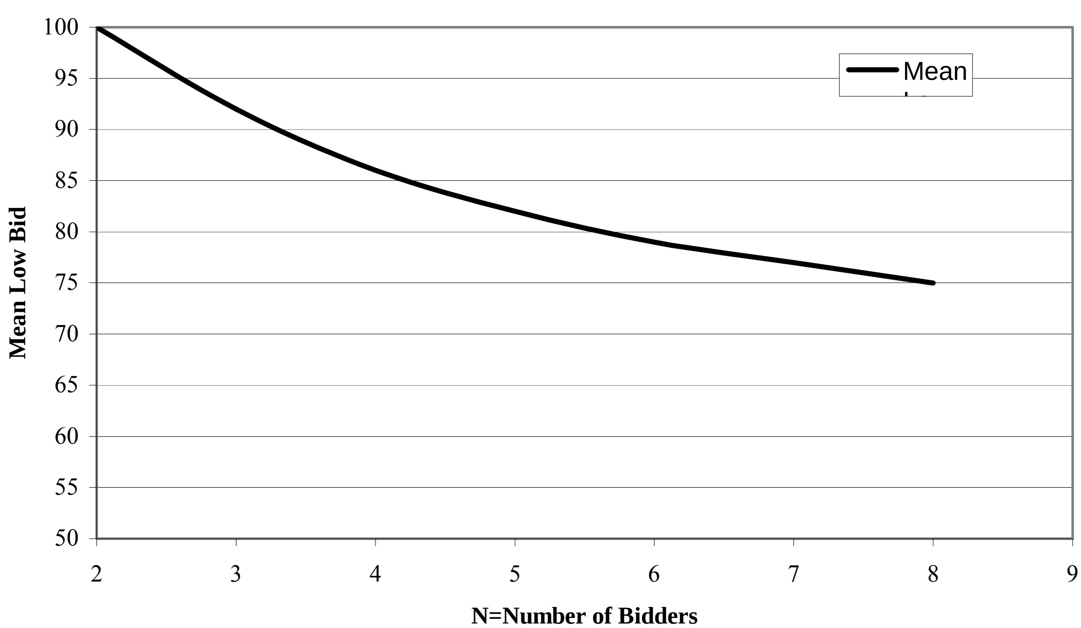


**Figure 6. Mean Low Bids Given Numbers of Bidders.**

In this context, the increase in construction costs in Texas does not come as a surprise. The mean number of bidders per contract in Texas has been falling since 2002. Figure 7 shows the change in the average number of bidders per contract over the last few years in Texas and Florida; the pattern in Texas and Florida, both of which have been experiencing high increase in construction costs, is quite similar.

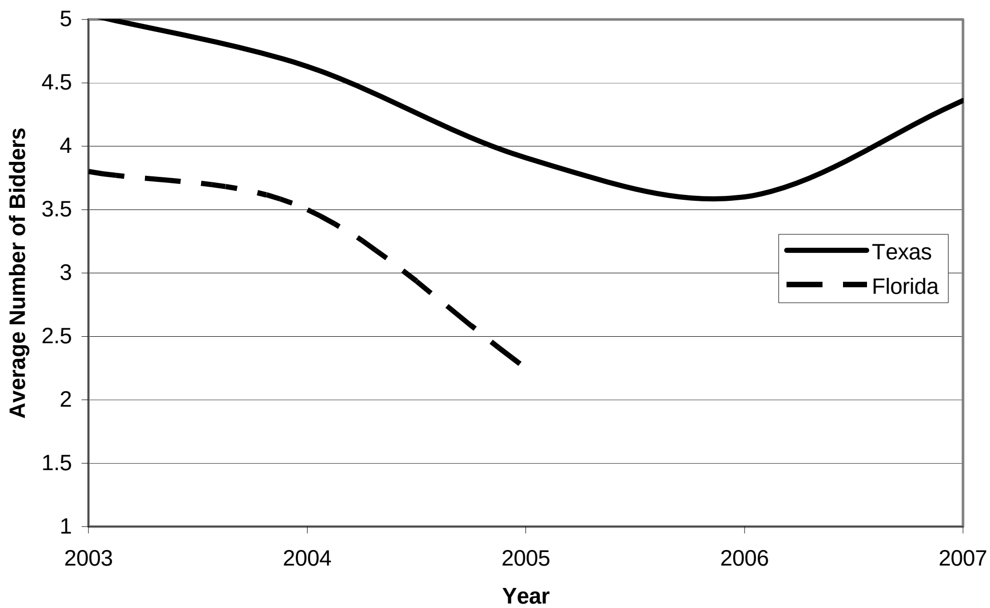


**Figure 7. Average Number of Bidders per Contract in Texas and Florida.**

Using historical data, the average cost of excavation bid items from TxDOT's Highway Cost Index (HCI) was compared for the projects with different number of bidders. This is illustrated in Figure 8.

The recent boom in construction in general has created a great demand for construction services and increased business opportunities for contractors. Many of these contractors may be diversifying their risk by moving into different construction submarkets. Contractors who can make greater profits in residential or commercial construction move into these areas and the number of bidders for transportation construction projects falls. Supervisors, construction engineers, construction managers, and skilled craftsmen are in short supply, and compensation has increased. Contractors without adequate escalation clauses in contracts may have been severely affected by the recent run-up in commodity prices and may be trying to recoup their finances by bidding fewer jobs and bidding higher when they bid. Contractors who bid on transportation construction must pay more to retain their personnel. If they perceive that the number of competitors is decreasing, they feel able to increase their bids and their markup. Insofar as contractors may be underestimating the number of bidders and overestimating the markup they can obtain in competitive bidding, rejecting these high bids and re-bidding contracts may be beneficial in providing better information to all concerned about the supply and demand in the construction market.

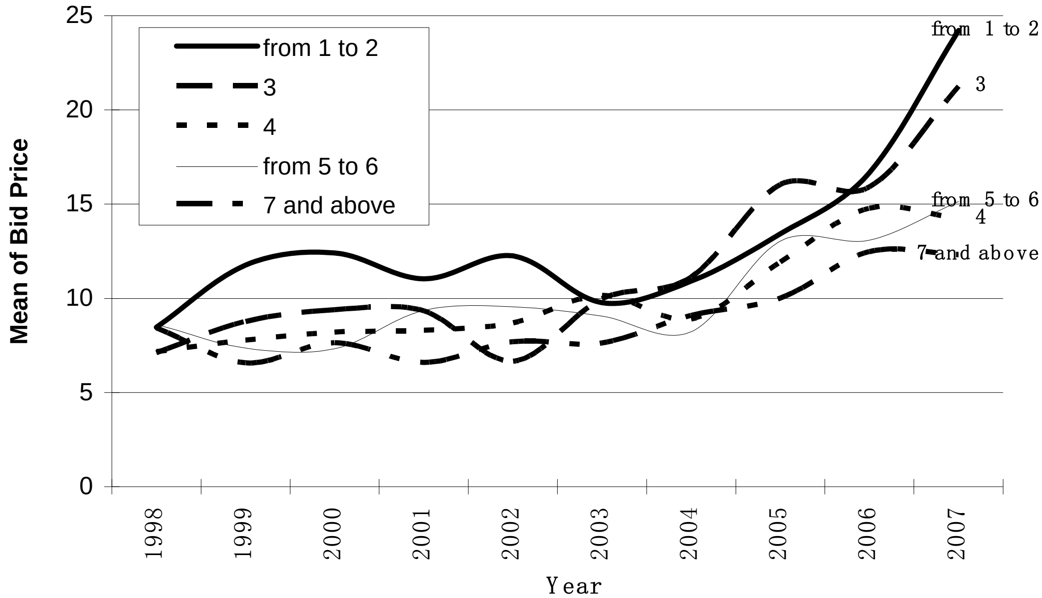


**Figure 8. Effect of Number of Bidders on Average Unit Price of Excavation.**

*Delay Start Time and Time Suspensions Known at Bidding*

Delaying projects may result in cost savings if there is reason to believe that the construction market will cool off and lower bid prices will be obtained in future solicitations. Conversely, prices might continue to increase, particularly if they are driven by increasing energy prices.

When appropriate, certain projects may use a flexible notice to proceed. A flexible start date provides the contractor discretion in when to start a project, within time limits. Once the project starts, the contractor is required to complete the project within a defined time frame or by a prescribed latest date. Application of this alternative contracting method may result in reduced construction costs if the contractor can exploit this flexibility in scheduling, in the context of the contractor's existing workload, to obtain more efficient use of its workforce, equipment, and subcontractors. A quantitative study is needed to develop guidelines for the application of these methods to projects, and determine the circumstances in which it may or may not be cost effective to delay bid solicitations or to apply flexible notice to proceed.

*Improve Project Communications*

A number of engineers have suggested that costs can be reduced by improving project communications. For example, additional pre-bid meetings, allowing more time to contractors for bidding, and providing additional plans, drawings, and details at the time of bidding can result a better understanding of the project for the contractors, and hence more accurate bids. The bid information may also include photographs of the site or description of site conditions. Clarity in drafting the specifications and a special outreach for unusual projects are also factors that are important in achieving lower prices of bid items (Dayton et al., 2006).

*Consider Price Escalation Clauses and Material Advance*

Inserting a price escalation clause into a contract based on the duration of the project can result in lowering loading of risk premiums by the contractor. While short-duration projects are not influenced by price fluctuations and risks, projects with longer durations are extremely vulnerable to price variations. In the absence of proper mechanisms to address escalation of prices, contractors tend to bid with higher risk premiums.

*Involve the Contractor*

TxDOT can motivate contractors to get involved in the cost reduction program. One of ways to motivate contractors is by sharing the actual savings. This can take place at the bid level and at the construction level. At the bid level, contractors can submit alternatives to the primary bid, and the owner can evaluate the potential savings from the alternative. If such a proposal is accepted, then the savings from adoption of that alternative can be shared with the contractor. During the construction phase, similar arrangements can also be made.

*Share Lessons Learned across Districts*

By implementing projects in different geographical regions, on different types of projects, TxDOT can learn valuable lessons. These lessons often remain with individuals or small groups. Sharing of lessons learned about losing or winning cost control issues across the state can be immensely beneficial. More formally, this can be done by organizing workshops where engineers and contractors can participate and share their views on cost cutting ideas.

*Other Methods*

Other methods that have the potential to decrease construction costs are also identified in the literature review. A few examples of such methods are: 1) conducting early pre-bid meetings which can result in increased scope clarity and reduced change orders during project implementation due to the feedback agencies get from the contractors; 2) providing sites to the contractors for setting up their plants and yards close to right of way, thereby minimizing mobilization and hauling costs; 3) increasing time for preparation of bids which may result in more accurate bids by the contractors; and 5) including a price adjustment clause in the contract which can result in lowering the risk premium contractors incorporate in their bids, and hence reduce the bid prices.

AASHTO's Primer on Contracting for the 21st Century (AASHTO, 2006) lists several alternative contracting methods that can potentially reduce the initial construction costs and increase competition. For example, more contractors would be willing to bid on projects where agencies share cost savings through incentives.

## 3.3 TXDOT TASKFORCE ON COST REDUCTION

In an effort to investigate construction cost increases, TxDOT set up an internal task force to investigate methods that can potentially reduce the costs of construction. The methods identified by the task force constituted an initial point-of-departure for this research effort. However, these methods mostly focused on very specific issues that required more detailed and quantitative analysis to assess whether they can reduce costs without jeopardizing quality. For the purpose of this research effort, these methods are grouped into several broader categories as follows: pavement maintenance, alternate pavement designs, alternative materials, structures and structure aesthetics, roadside maintenance and landscaping, markings, competition, project scope, and miscellaneous. APPENDIX A summarizes the methods proposed by the task force. According to the task force recommendations, and in the context of broader categories previously defined, reviewing frequency of maintenance can potentially reduce costs. Other examples of the methods considered by the task force include: 1) using concrete pavement in place of flexible pavement is a costlier alternative and is only preferable for high traffic volume roads; 2) using alternate materials is beneficially applicable to any project; and, 3) using repetitive designs can reduce the cost of bridge projects. Increasing competition is another recommendation by the task force; therefore using relaxed contract terms can increase competition by employing methods such as giving more time to contractors for bidding, creating an "open to business" environment, deciding appropriate contract size, and providing flexible start times.

## 3.4 IMPACT OF COST REDUCTION METHODS

Before cost reduction methods are applied, it is important to assess their impacts on several project performance indicators. Many cost-saving proposals can appear appealing, but they may fail to satisfy the performance requirements. For example, a highway project overlay decision may affect noise, tire friction, and even road safety. Every employed method to reduce the cost should at least maintain the performance requirements, if not improve them. Hence, the impact of the method needs to be evaluated before making any decision on implementation. Some important criteria in deciding appropriateness of the methods are discussed next.

### *3.4.1 Life Cycle Cost*

Every cost saving proposal needs to be substantiated by detailed calculation of the cost savings offered by that proposal. However, a decision based only on the initial cost reduction of the alternative is not a satisfactory approach in making sound project decisions. When selecting between alternatives, the life-cycle cost approach needs to be considered. This approach involves comprehensive economic analysis of alternatives proposed. This refers to determining the initial as well as subsequent costs over the useful life of that asset discounted to the present value. The alternative offering the least present value including initial investment cost, capital cost, installation cost, operating cost, maintenance cost, and energy cost over the useful service life is preferred. Many cost saving alternatives may fail to provide cost reduction effects on a life-cycle cost basis.

### *3.4.2 Environmental Impact*

Cost saving methods can also affect environmental standards and requirements. Recycling of materials, use of industry waste, use of environmentally friendly materials, and avoidance of use of materials which cannot be replenished are ways of making a sustainable project development decision that will positively affect the environment. Even use of locally available materials results in saving transportation costs.

### *3.4.3 Safety*

All decisions related to highway projects are typically required to maintain road user safety; hence, alternative proposals must be scanned for their impact on road safety. For example, it is often argued that value engineering initiatives compromise safety. A number of road safety prediction models have been developed to assess different geometric conditions on safety measures (Wilson, 2005).

### *3.4.4 Constructability*

If the alternate method proposed results in construction designs that are difficult to implement using available expertise, tools, equipment, and plants, contractors may still bid higher to account for constructability problems. Variations in the design can reduce repeatability and thereby increase costs.

### *3.4.5 Institutional Framework*

Some decisions may create a need for additional institutional mechanisms and change in department policies. A good example of this could be a suggestion to manage the risks related to material cost escalation on projects with longer durations. Such a method may require a change in the institutional framework for successful implementation.

### *3.4.6 Effect on Traffic Operations*

If project decisions that relate to cost reduction have the potential to affect traffic operations, such impacts need to be evaluated. For example, a change in project sequencing may increase or decrease the traffic speed as well as cause congestion.

### *3.4.7 Right of Way*

Right of way acquisition is an important phase in project development. Design decisions are governed by various guidelines and codes. For example, decisions involving geometric alternatives must be evaluated for their impacts on right of way costs, feasibility of acquisition, and political acceptability.

### *3.4.8 Impact on Schedule*

The proposed cost reduction method needs to be evaluated based on the projected impact on project schedule. Methods involving long lead times for materials, imported materials, or scarce materials affect project schedule.

# 4 DATA COLLECTION AND DELPHI SURVEY

## 4.1 DATA COLLECTION APPROACH

The data collection approach used in this study was two-folded. After the literature review, TTI research team relied on interim workshops and the Delphi study to identify methods and evaluate their potential impact.

### *4.1.1 First Workshop: Generating Ideas*

The first workshop involved experts from North Carolina Department of Transportation, Florida Department of Transportation, California Department of Transportation, Washington Department of Transportation (WSDOT), and Tom Warne & Associates. The representatives from the DOTs shared their experiences of cost increases and the strategies and methods employed to curb rising construction costs.

*North Carolina DOT*

The NCDOT representative reported that NCDOT has seen substantial cost increases since 2003. In view of discrepancies between the CPI and the Producer Price Index, the increase in cost of materials cannot be seen as the only reason for the cost increase. North Carolina reported cost increases of 2.5 percent per year from 1996 to 2002 and 16 percent per year from 2002 to 2006. Some of the strategies proposed by NCDOT include use of design-build and fixed-price contracts, constructability review process, and formation of joint committees with the industry representatives.

*Florida DOT*

The FDOT presentation attributed part of the higher costs of highway projects to competing housing construction. Florida has also seen consolidation of some of the large construction firms, leading to reduced competition. The other reasons for cost increases cited by FDOT are high energy costs, labor shortages, and imbalances in letting.

The method employed by FDOT to address cost increases is refinement of award criteria to increase completion. Improving estimates to receive accurate bids is another method used by FDOT. The other methods used by FDOT to address cost increases in the short term are optimization of night work and implementation of bid maximum specifications.

As a long-term strategy, FDOT plans to conduct a workforce study, manage better the risk associated with material availability, conduct aggregate source studies, procure aggregates, and address program conflicts in mobility and freight. The emphasis is placed on increasing competition, as with more than three bidders FDOT in the past has received bids closer to the estimates. Simplifying contract administration, waiving bonds requirements for smaller contracts, and removing contractual restrictions that do not add value to the project are some of the methods FDOT uses to increase competition.

*National Perspective*

The presentation from Tom Warne & Associates highlighted inadequacies of estimating methods, decreasing competition, and staffing issues with contractors. The shortage of estimators for bidding when a larger number of projects are let simultaneously was discussed as an example. Some of the recommended cost reduction methods include reduce contract durations, change estimating methods to use built-up data rather than using historic data, aggressive marketing of projects, and better timing of the projects to create higher competition.

*Brainstorming Sessions*

Following the presentations and interaction with DOTs, the Austin workshop had three brainstorming sessions. The first brainstorming session resulted in identification of factors that affect construction costs. The processed list of factors with brief descriptions is presented in APPENDIX B. The second brainstorming session was a continuation of the first session on identification of factors. In the second session, methods were identified to address each of the cost increase factors. Some of the methods addressed more than one factor. A long list of methods was generated at the end of the second session and a brief description of the methods was added. This description was based on the discussions during the workshop. The methods, their description, and the factor(s) addressed by each of the methods are presented in APPENDIX C. They are identified by their serial number (SR#) which refers to their corresponding number in the exhaustive list of methods rearranged after workshop. Finally, the third session focused on the impact of the methods on project performance measures (indicators). The group of engineers involved in the brainstorming session came to the conclusion that quality, schedule, and safety should be key performance indicators in addition to the cost reduction potential when the methods are considered for implementation.

## 4.2 DELPHI PROCESS

The Delphi method was first developed by the RAND Corporation in the 1950s as a forecasting and decision-making tool. The objective of this method is to provide a procedure that is able to provide more reliable results for complex problems that are difficult to analyze quantitatively, compared to subjective decision-making by individuals. The Delphi technique involves an iterative process in which expert opinions are processed and used as a feedback for further refinement of opinions generated in the earlier round. The Delphi approach typically elicits a high response rate because the respondent receives almost immediate feedback. If the topic area is perceived to be of high importance, high participation is also likely. The Delphi technique is not intended to replace or substitute for statistical and model-based techniques or human judgment, but it is intended for use where objective decisions are not possible in the absence of historic, economical, or technical data pertinent to the subject (Rowe and Wright, 1999). The

Delphi technique captures decisions related to a specific issue made by a group having diverse experience and interest. In this research, the Delphi group is represented by design and construction experts and people having experience in different geographic regions, as well as representatives from the construction industry.

This research adopted the Delphi process to assess the impact of the proposed methods on the performance measures, mainly the cost reduction potential and measures such as quality, safety, and schedule. Since the long list of methods obtained from the first workshop included methods which previously were not tested or used, quantitative analysis using previous data was not feasible. Therefore the Delphi process was utilized. Delphi analysis allows synthesis of the collective opinion of experts when the issues are more of strategic nature and difficult to numerically quantify.

The Delphi process was adopted to identify and validate the effective methods evolved from the brainstorming sessions of the first workshop. The Delphi process consisted of four steps toward group decision-making. The overall process involved the following steps: 1) assembling the Delphi group, 2) developing and administrating the questionnaire, 3) processing the responses, 4) providing controlled feedback to the participating experts to review their judgment until convergence is achieved, and finally 5) processing and summarizing the outcomes of the survey. A flow chart of the Delphi process adopted for the research is presented in Figure 9.

### *4.2.1 Delphi Group*

The first step toward Delphi decision-making is formation of the expert group. While the Delphi method does not have a specific requirement for the number of participants, for a successful implementation of the method, it is critical to have an appropriate selection of participants. In other words, the participants should be experts in the field that is being analyzed. With the TTI research team facilitating the Delphi process, the Delphi group was formed from the experts participating in the first workshop and TxDOT district engineers or their representatives. The research team targeted a level of participation of about 30 experts in the Delphi process including a few participants that represented engineers from other DOTs, TxDOT district engineers, and representatives of district engineers having design or construction backgrounds. The experience of the experts in their relevant field ranged from a minimum of 12 years to a maximum of 30 years. Four engineers from other DOTs also participated in the survey to add broader perspective.

### *4.2.2 Delphi Survey*

Researchers conducted the Delphi survey by administering the questionnaire to the expert group. The 108 methods identified during brainstorming sessions were reviewed by the research team. Similar methods from the list were consolidated, while duplicate methods were eliminated. At the end of the review process, a list of 74 methods was finalized to be included in the questionnaire. The questionnaire was in the form of a Microsoft Excel file. The file had three sections. The first section included the survey introduction, guidance for filling out the questionnaire, evaluation criteria, and other administrative details for submitting the questionnaire. In the second section, a space was provided to enter details about the respondent, mainly contact details and the background of the respondent. The full questionnaire was presented in the third section, as illustrated in Figure 10. The respondent had to select the options from given choices for cost, quality, schedule, safety, and legal or institutional barriers in implementing the method. The questions that needed to be answered for each cost reduction method were as follows: 1) What is the anticipated impact of this method on reduction in total cost of construction (either on bid price or escalation of cost during construction)? 2) What is the anticipated impact of this method on quality? 3) What is the anticipated impact of this method on schedule? 4) What is the anticipated impact of this method on safety? and 5) Is there a legal or institutional barrier to implementing this method?

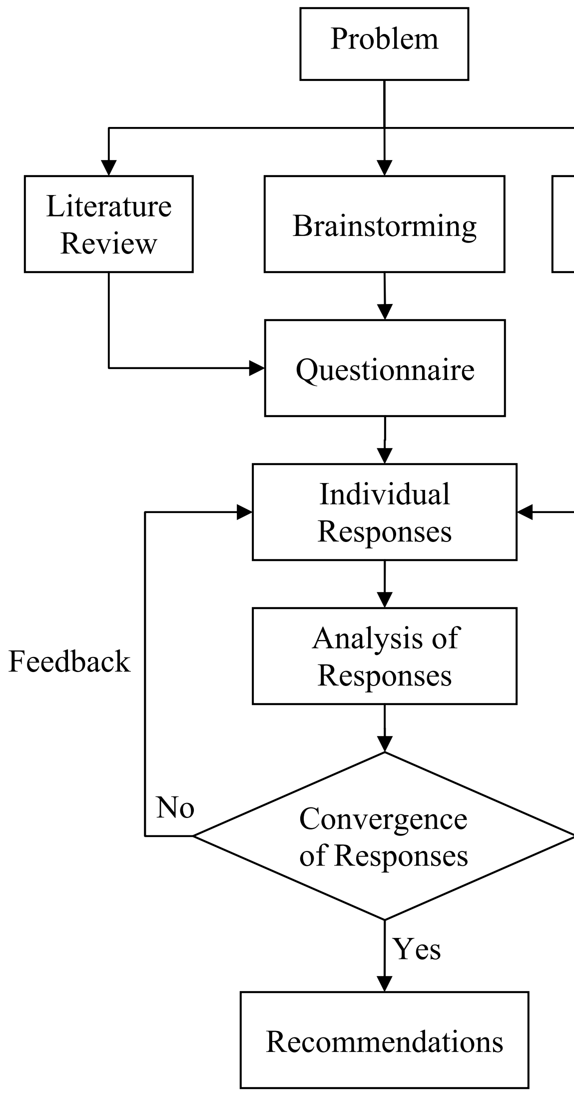


**Figure 9. Delphi Process.**

The methods that were not perceived to be effective in cost reduction or to even likely to increase the cost were evaluated "No," signifying that they are not effective in cost reduction and have zero or negative effect on cost. The "Low" impact methods were evaluated where cost reduction potential was in the range of 1 to 5 percent. Similarly, "Medium," "High," and "Very High" responses were assigned when cost impact was anticipated to be in the ranges 6 to 10 percent, 11 to 15 percent, and ≥ 15 percent, respectively.

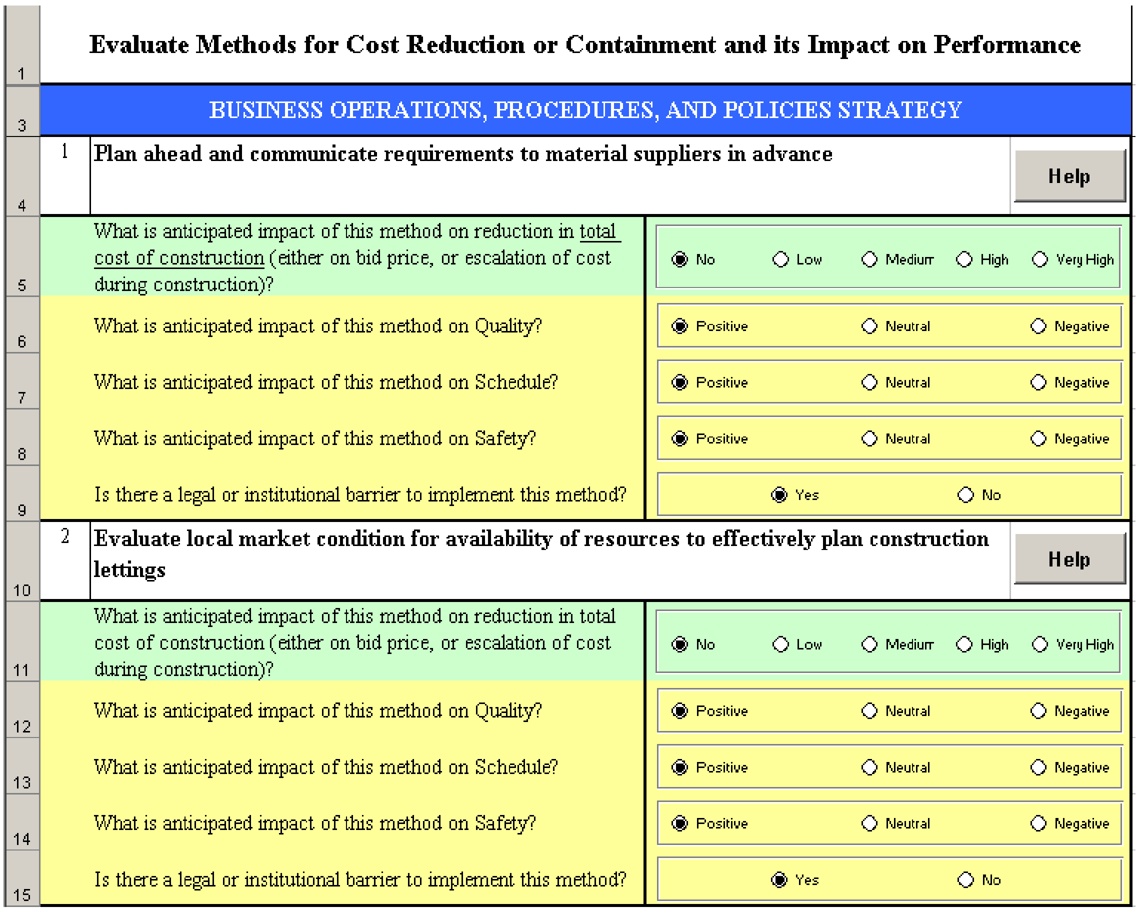


**Figure 10. Questionnaire for First Round of Delphi Process.**

The methods were also evaluated for their impact on the selected performance measures (quality, schedule, and safety) based on the following criteria. When the method was perceived to improve performance, the respective performance was evaluated as "Positive." Similarly, when the method was evaluated "Neutral" or "Negative," its effect on performance was perceived to be either not significant or adverse, respectively.

In addition to performance measures, participants evaluated the methods for anticipated legal or institution barriers in their implementation. If the method is likely to create a legal barrier or may require modification in the existing project development process, it was evaluated "Yes;" otherwise "No."

### *4.2.3 Response and Feedback*

The responses were processed at the end of each round. The task included summarizing the responses and calculating descriptive statistics. The distribution of the responses was prepared for each category of response. This aggregate feedback was then sent to the Delphi participants individually showing evaluated methods and performance evaluation of each method by the group. The comments for each method were also summarized and forwarded to the participants of the second round. The respondent also received their individual response so that they could compare their response against the aggregate response.

At the end of the first round, 29 responses were received from the Delphi experts. A summary of responses was prepared covering the distribution of the responses within options. The comments given by the experts were also summarized and sent as a separate file to second-round participants. Some experts recommended additional methods, resulting in seven additional methods in the second-round questionnaire. The modified second-round questionnaire included the responses of the individuals in the first round and the distribution of the group response. The comments given by the experts for each method were also summarized in a separate file and circulated along with the questionnaire. The typical second-round questionnaire is illustrated in Figure 11.

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | | Your Response Round-2 | Your Response Round-1 | Group response Round-2 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | BUSINESS OPERATIONS, PROCEDURES, AND POLICIES STRATEGY | | | | | | | | |
| 1 | Plan ahead and communicate requirements to material suppliers in advance | Help | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | ○ No ○ Low ◉ Medium ○ High ○ Very High | Medium | Medium | 3% | 13% | 56% | 13% | 3% |
| | What is anticipated impact of this method on Quality? | ○ Positive ◉ Neutral ○ Negative | Neutral | Neutral | 40% | 43% | 0% | | |
| | What is anticipated impact of this method on Schedule? | ◉ Positive ○ Neutral ○ Negative | Positive | Positive | 77% | 10% | 0% | | |
| | What is anticipated impact of this method on Safety? | ○ Positive ◉ Neutral ○ Negative | Neutral | Neutral | 10% | 73% | 3% | | |
| | Is there a legal or institutional barrier to implement this method? | ○ Yes ◉ No | No | No | 7% | 80% | | | |
| 2 | Evaluate local market condition for availability of resources to effectively plan construction lettings | Help | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | ○ No ○ Low ◉ Medium ○ High ○ Very High | Medium | Medium | 6% | 9% | 53% | 16% | 3% |
| | What is anticipated impact of this method on Quality? | ◉ Positive ○ Neutral ○ Negative | Positive | Positive | 43% | 40% | 0% | | |
| | What is anticipated impact of this method on Schedule? | ◉ Positive ○ Neutral ○ Negative | Positive | Positive | 83% | 3% | 3% | | |
| | What is anticipated impact of this method on Safety? | ○ Positive ◉ Neutral ○ Negative | Neutral | Neutral | 17% | 67% | 0% | | |
| | Is there a legal or institutional barrier to implement this method? | ○ Yes ◉ No | No | No | 7% | 80% | | | |

**Figure 11. Questionnaire for Second Round of Delphi Process.**

At the end of round two, 24 responses were received. In second round of Delphi, experts were required to evaluate 81 methods, with inclusion of seven additional methods after round one. APPENDIX D provides the questionnaire and Delphi group response for 74 methods in first round and 81 methods in second round. The two rounds of Delphi process resulted in convergence of the responses.

## 4.3 SECOND WORKSHOP – CONTRACTORS' PERSPECTIVE

The second workshop was organized in Austin where the representatives of contractors were the main participants. The TTI team had circulated a questionnaire to AGC members prior to this workshop. Association of General Contractors conducted a meeting with its members and prepared a collective response to the questionnaire. Following their collective response a follow up meeting was held, where the AGC's response to the 74 cost reduction methods was discussed. The AGC response has not been included in the Delphi study, but their comments are incorporated in the report.

In the AGC's opinion, project cost increases are due to many factors putting pressure on the material prices, including escalation of construction activities worldwide. Further, due to the ramp up of the TxDOT program, a huge demand was set on the resources. However, construction programs also face recession, which can cause problems for contractors to maintain resources. On the construction side, projects are increasingly restrictive on lane closures and often demand work during night hours. In AGC's opinion, a project's specifications can affect the cost, and often requirements from TxDOT are very stringent in terms of materials and design elements. In addition, AGC reported that some of the aesthetics requirements create a demand for unique forms and fewer repetitions; this in turn affects the cost. All these factors force contractors to pass the cost increases to TxDOT. Further, it is important to note that in AGC's opinion, contractors do absorb the volatility in material prices and low bid selection automatically levels the price.

In its response to the first-round questionnaire, AGC evaluated certain methods not to be effective even though the Delphi group was of opinion that the methods can be quite effective. The follow-up discussion emphasized the following arguments. AGC remarked that the purchase of materials by TxDOT will create logistics problems rather than reduce costs. The price adjustment clause may not really benefit TxDOT; AGC stated that contractors are already absorbing price fluctuations and are not overpricing that risk. Regarding the opportunity to increase the flexibility of traffic control planning, AGC representatives concluded that this method may increase the liability of contractors and in turn will not serve the purpose of cost reduction.

# 5 DATA ANALYSIS AND RESULTS

In order to assess and compare the effectiveness of methods, each method was ranked according to its perceived cost reduction effectiveness criteria. To rank the methods, the number of responses in each category was multiplied by a score number ranging from 0 to 4 for a 'no' to 'very high' response, respectively. Finally, the cost score was obtained by standardizing this number. This process is illustrated in Equation 1:

$$C_{ST} = \frac{\sum_{i=1}^{N} S_i}{N} \quad (1)$$

where $S_i$ is the response of Delphi participant $i$ on the scale from 0 to 4, as previously defined, $N$ is the total number of participants, and $C_{ST}$ is standardized cost score.

The score calculated in this manner was used to rank the methods. The scores reported for each method are out of a maximum possible score of 4.00. The complete list of ranked methods with the performance evaluation is presented in APPENDIX E where methods are consolidated and ranked. For example, method Sr. #76 has been merged with methods 33, 34, 38, 39, and 40. Hence, after the consolidation (merger), methods 33, 34, 39, and 40 have been removed from the list. The outcome of the Delphi survey suggests that some methods have high potential for cost reduction. The top 10 high ranking methods as evaluated by the Delphi group are summarized in Table 3 below.

**Table 3. Top Ranking Cost Reduction Methods.**

| Rank | Method | Score (out of 4.00) |
|---|---|---|
| 1 | Take time to develop sound designs using appropriate design criteria and technical information. Incorporate pavement evaluation, geotechnical, and utility data in designs. | 2.42 |
| 2 | Provide alternative materials in PS&E. | 2.21 |
| 3 | Standardize designs and provide more design repetition. | 2.21 |
| 4 | Educate and train designers, consultants, and contractors. | 2.21 |
| 5 | Coordinate lettings based on the availability and capacity of contractors in the region. | 2.17 |
| 6 | Better define and optimize the project scope initially and subsequently control scope creep by accountable authority. | 2.17 |
| 7 | Minimize detours and diversions. | 2.13 |
| 8 | Evaluate alternate contracting methods including design-build (D-B) and construction manager at risk (CM @ Risk). | 2.08 |
| 9 | Use contractor inputs in the development of design, specifications, and schedule. Involve contractors in constructability review process. | 2.08 |
| 10 | Plan ahead and communicate requirements to material suppliers in advance. | 2.04 |

The effectiveness of the methods (in terms of cost scores) with the respect to different project review milestones is ilustrated in Figure 12. This allows a comparison of the method's effectiveness with the theoretical influence curve. The solid line connects average cost scores, while the dotted lines connect the 95th percentile confidence intervals. In general, the method score tends to decrease from review milestones design concept conference (DCC) to postletting (PL), although this trend is not conclusive. This implies that the methods are less effective in reducing costs as the project develops, which is in accordance with the expetcted trend from theoretical cost influence curves.

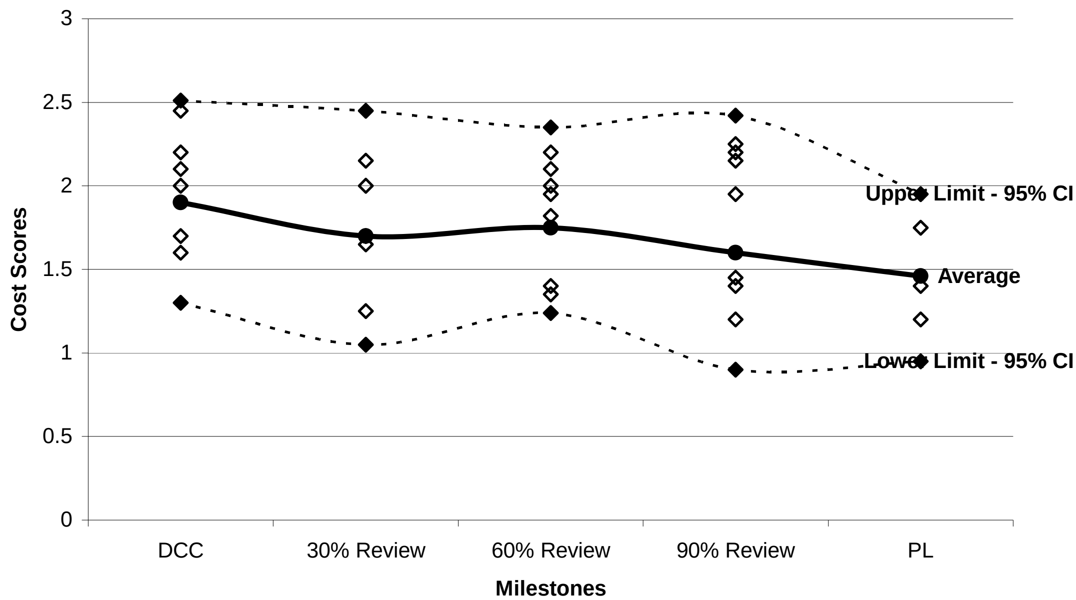


**Figure 12. Method Scores in Different Review Milestones.**

While the first two workshops were mostly focused on data collection, the third and final workshop with TxDOT was part of data analysis and interpretation of the results. The discussion during the third workshop on how to implement the cost reduction methods resulted in classification of the considered methods into two different categories: program-wide methods and project-based methods. A consolidation of the similar methods further resulted in a list of total of 56 methods. The methods which can be applied at program level, and which may require policy-level decisions for implementation, were classified as programmatic methods. The list of methods applicable at the program level is the following:

1. Standardize designs and provide more design repetition.
2. Educate and train designers, consultants, and contractors.
3. Evaluate restrictions on imported materials.
4. Create material sources by TxDOT.
5. Evaluate local market condition for availability of resources to effectively plan construction lettings.

6. Implement formal risk identification and management program.
7. Utilize owner buying power.
8. Add price adjustment clause to long term contracts.
9. Share lessons learned across districts.
10. Develop state-owned batch plants and crews for small and isolated jobs.
11. Develop selection tools for contracting methods based on past performance of alternative contracts.
12. Purchase commitments to suppliers by TxDOT with option for buying.
13. Improve design change procedure to increase responsiveness to change (fast and simple).
14. Reduce bond cost over project time.
15. Update design manuals.
16. Implement comprehensive approach to cost estimating.
17. Ease contracting requirements with TxDOT.
18. Relax prequalification requirements for certain projects.
19. Provide owner-controlled bonding for small contractors.
20. Require contractor evaluation/grading.
21. Provide design-build lump-sum contract for traffic control.

On the other hand, the list of methods applicable to individual projects that can be applied without a change in polices is the following:

1. Take time to develop sound designs using appropriate design criteria and technical information. Incorporate pavement evaluation, geotechnical, and utility data in designs.
2. Provide alternative materials in PS&E.
3. Coordinate lettings based on the availability and capacity of contractors in the region.
4. Better define and optimize the project scope initially and subsequently control scope creep by accountable authority.
5. Minimize detours and diversions.
6. Evaluate alternate contracting methods including design-build and construction manager at risk.
7. Use contractor inputs in the development of design, specifications, schedule, and in constructability review process.
8. Plan ahead and communicate requirements to material suppliers in advance.
9. Consider locally available materials in design.
10. Reuse and recycle materials.
11. Bundle construction projects for exploring economies of scale.
12. Consider alternative designs.
13. Increase flexibility in traffic control planning.
14. Increase bid preparation time and conduct pre-bid meetings.
15. Provide flexible project start time.
16. Check cost effectiveness of specialty items at early stage.
17. Share cost savings with contractors.
18. Minimize mobilization.

19. Use performance or end product specifications.
20. Increase knowledge of design guidance and use engineering judgment for design exceptions.
21. Market new projects aggressively.
22. Understand and manage environmental restrictions.
23. Provide state yards.
24. Group specialty items into a separate package.
25. Remove contract restrictions.
26. Reject non-competitive bids and re-advertise.
27. Reduce construction durations.
28. Review specifications for their applicability to the given project, e.g., relaxation of asphalt concrete temperature restrictions.
29. Split construction projects.
30. Understand impact of night work.
31. Consider multiple project completion dates.
32. Add alternate packages for aesthetics.
33. Better utilize inspectors and recognize cost of inspections in the estimates.
34. Plan adequate oversight for accelerated projects.
35. Schedule projects considering federal trucking requirements.

## 5.1 RANKING OF PROGRAMMATIC METHODS

The programmatic methods were ranked according to the scores obtained by aggregating the responses obtained in round two of Delphi survey. Table 4 shows the top 10 methods having programmatic or program-wide applications, while APPENDIX F summarizes a complete list of the program-wide methods with cost score values.

**Table 4. List of Top Ten Program-wide Applicable Methods.**

| Rank | Method | Score (out of 4.00) |
|---|---|---|
| 1 | Standardize designs and provide more design repetition. | 2.21 |
| 2 | Educate and train designers, consultants, and contractors. | 2.21 |
| 3 | Evaluate restrictions on imported materials. | 2.04 |
| 4 | Create material sources by TxDOT. | 2.04 |
| 5 | Evaluate local market condition for availability of resources to effectively plan construction lettings. | 2.00 |
| 6 | Implement formal risk identification and management program. | 1.96 |
| 7 | Utilize owner buying power. | 1.92 |
| 8 | Add price adjustment clause to contracts. | 1.83 |
| 9 | Cross-district sharing of lessons learned. | 1.63 |
| 10 | State-owned batch plants and crews for small and isolated jobs. | 1.58 |

The results show that the experts perceive using standardized designs and providing more design repetitions so that contractors achieve economy of scale to be the most effective method for controlling cost increases. Training of designers, contractors, and contractors' consultants on new design developments to help control the cost received an equal score. Further, the results show that effective methods are easing restrictions on imports (e.g., restrictions on cement imports), better planning of lettings considering market conditions, buying materials by TxDOT, and adding price adjustment clauses to contracts. Implementing risk management policies and proper allocation of risk to the parties who can manage them well is also perceived to be an effective method in reducing construction costs. The sharing of lessons learned also helps reduce cost. Small projects where no contractors are interested can be done by state-owned plants and crews to control cost.

## 5.2 RANKING OF PROJECT-BASED METHODS

The methods applicable to individual projects were classified as project-based methods. Thirty five methods are identified and their cost reduction potential assessed. Table 5 shows the top 10 project-specific methods, while a complete list of the project-specific methods is presented in APPENDIX G. Methods are ranked based on their perceived cost reduction effectiveness.

**Table 5. List of Top Ten Project Based Applicable Methods.**

| Cost Rank | Method | Score (out of 4.00) |
|---|---|---|
| 1 | Take time to develop sound designs using appropriate design criteria and technical information. Incorporate pavement evaluation, geotechnical, and utility data in designs. | 2.42 |
| 2 | Provide alternative materials in PS&E. | 2.21 |
| 3 | Coordinate lettings based on the availability and capacity of contractors in the region. | 2.17 |
| 4 | Better define and optimize the project scope initially and subsequently control scope creep by accountable authority. | 2.17 |
| 5 | Minimize detours and diversions. | 2.13 |
| 6 | Evaluate alternate contracting methods including design-build and construction manager at risk. | 2.08 |
| 7 | Use contractor inputs in the development of design, specifications, schedule, and in constructability review process. | 2.08 |
| 8 | Plan ahead and communicate requirements to material suppliers in advance. | 2.04 |
| 9 | Consider locally available materials in design. | 2.04 |
| 10 | Reuse and recycle materials. | 2.00 |

Experts perceived that taking adequate time for designs to do it right the first time and selecting appropriate design criteria to have the highest impact on construction cost without compromising performance requirements. Other important methods include obtaining pavement evaluation data such as falling weight deflectometer (FWD), ground-penetrating radar (GPR), and other data to make optimum pavement design decisions. This may also result in reducing the number of change orders during construction. To address the competition issue, better timing of projects and coordinating the lettings considering the capacity of contractors in the region can be effective in controlling project costs. Better definition of scope results in more accurate bids and lowers the chance of change orders during execution of the contract. Alternative materials in specifications and reuse and recycling specifications can help address material cost increases. Alternative contracting methods such as CM @ Risk and design-bid reduce the risk of price escalation.

## 5.3 IMPACT ON OTHER IMPORTANT PERFORMANCE MEASURES

The impact of the methods on other performance measures was also evaluated by Delphi experts. The methods, along with their performance measure the impact assessment are presented in APPENDIX D. In consideration of the methods, engineers need to consider the impact as assessed by the Delphi group, particularly for methods that showed negative impact on performance measures. Indeed, the methods that showed negative impact for any of the performance measures need to be adopted with caution. Examples of the methods perceived to have negative impact are:

- Providing a flexible start time may negatively impact schedule. By providing a flexible start time the schedule will become protracted as contractors commence work when it is convenient to them.
- Reducing construction duration may adversely affect quality, schedule, and safety. Shorter contract duration jeopardizes the construction quality, while tighter schedules risk more overruns.
- Increasing flexibility in traffic control planning may have a negative impact on safety. Contractors may not have safety as their foremost priority when designing traffic control elements, which may result in safety compromise.

# 6 SELECTION OF COST REDUCTION METHODS

For cost reduction methods to be effective, they must be applied in the appropriate project development stage. Failure to consider the methods in an appropriate stage may result in reduced effectiveness and in some cases even in cost increase. As project development is a complex process that involves many stakeholders and engineers at both the local and division levels, guidelines are needed to ensure that the cost reduction process will yield the desired effects. This chapter describes this process and presents general guidelines for selection of cost reduction methods that are project-specific (program-wide methods are not considered in this process as they require change in policy). It is important to note that due to the lack of a "typical construction/maintenance project," cost reduction should be considered with caution. While some projects warrant method implementation, projects with different characteristics may not receive the same benefits. In such settings, engineers must exercise their best judgment in addition to the guidelines provided in this report.

## 6.1 Overview of Selection Process

As previously mentioned, in the process of selecting cost reduction methods, review milestone points need to be taken into consideration. Hence, the exercise of a cost reduction method is a sequential process that starts from the very beginning of the project development and lasts until the project is let. Five critical milestone points are of particular importance: 1) Initial design concept conference; 2) 30 percent design review milestone meeting; 3) 60 percent design review milestone meeting; 4) 90 percent design review milestone meeting; and 5) Post-letting review meeting. To help with its implementation, the methods have been already classified into these five review points where they can be considered. Appendix H shows the methods classified based on the milestone review points and their perceived effectiveness to reduce the cost.

During the design cost conference and review meetings, cost reduction methods can be repeatedly considered in the following manner:

1) Check the project characteristics and determine if the project allows for method implementation. In this step evaluate whether some project characteristics warrant special consideration, such as very small dollar-value projects where the method effectiveness would be questionable;
2) Select the methods applicable to the considered milestone point. In this step, Appendix H should be consulted to determine what methods are applicable at that point of the project development;
3) Evaluate perceived performance of the method in terms of adopted performance measures such as cost reduction potential, schedule, safety, and quality. The methods' information sheets provided in Appendix I can be used as a foundation for discussion of the potential effects of the methods on the project performance; and
4) Consider the method for implementation. This step requires additional analysis of the impact of the methods as well as potential risks associated with their implementation.

[Figure 13](#) illustrates the overall implementation process based on a four-step evaluation in each milestone review point. In the following section, the milestone points are described in more detail.

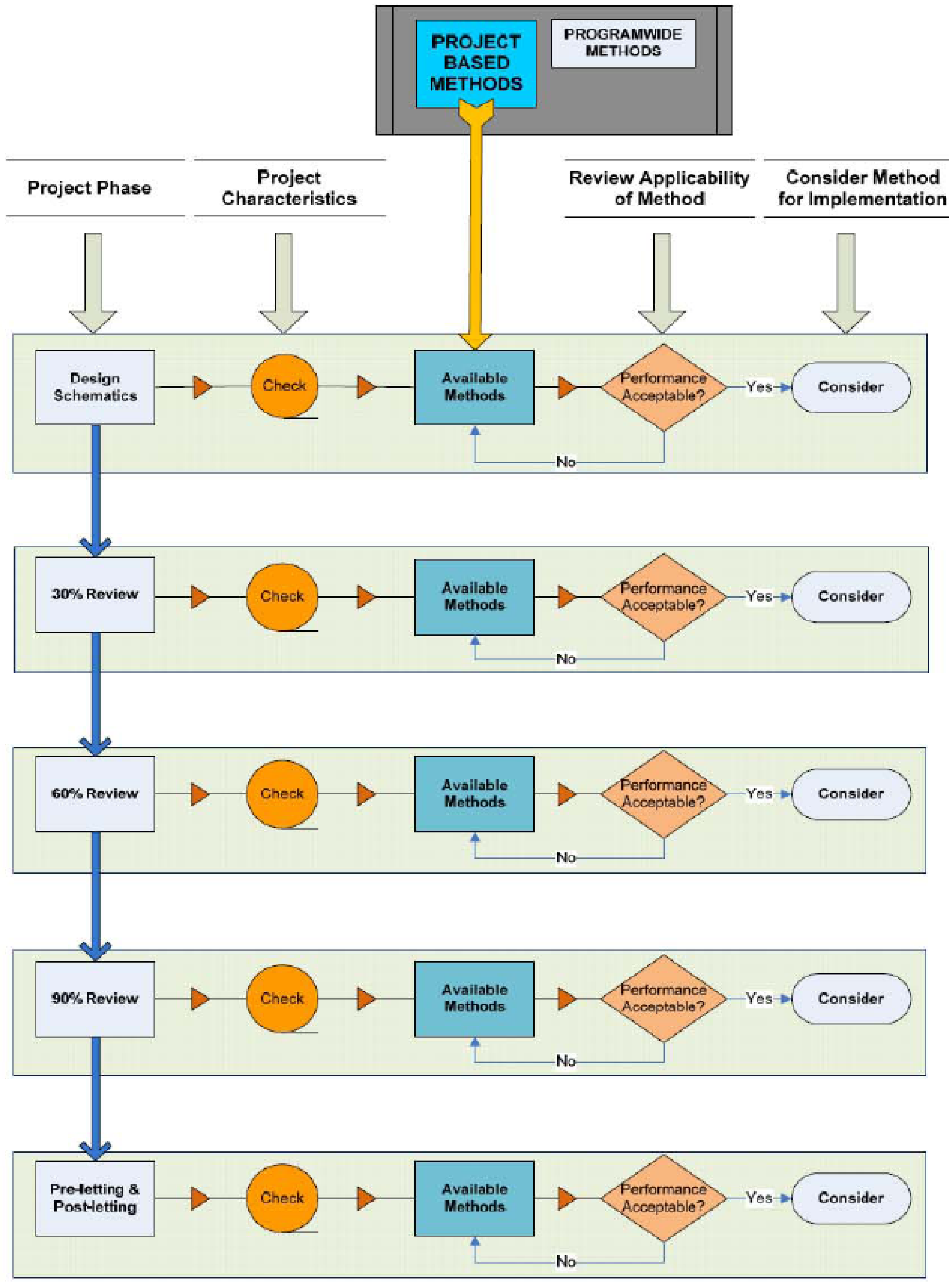


**Figure 13. Method Selection Process.**

### 6.1.1 Milestone Review Points

*Design Concept Conference*

The design concept conference results in schematic designs and geometric plans. The plans include existing features of the location and schematics for proposed development. This step is essential to the environmental approval process, particularly when an environmental impact statement is necessary (TxDOT, 2007). TxDOT conducts compliance with applicable environmental regulations in consultation and coordination with local, state, and federal agencies. The environmental design process involves identification of exclusions, where project activities do not significantly impact environment. For all other cases an environmental impact study needs to be done. The design kickoff also defines the preliminary right of way (TxDOT, 2007). This phase involves a public hearing for feedback on preliminary layouts. The design kickoff process also considers social impacts of the project.

*30% Review*

The 30 percent review essentially involves review of the preliminary designs and right of way. This is the correct time during the preliminary design stage for the application of value engineering. The cost reduction methods applicable to designs can be identified and applied during the next 30 percent of design completion. In the 30 percent review phase, right of way acquisition is planned considering existing and proposed utilities. The information regarding type, size, location, and nature of the utilities is crucial for design development. At a later stage, utility information is useful to contractors for construction. Accurate information regarding right of way and associated existing utilities can result in better bids to TxDOT.

*60% Review*

Detailed design is reviewed in this phase. The detailed designs start with a design conference to review the project requirements and basic design criteria. More information about the project is collected in terms of traffic data, right of way, as-built construction plans, and other site information (TxDOT, 2007). The design criteria are finalized considering project features and applicable regulations. Concurrence is obtained from the other concerned agencies and stakeholders as may be required. The design summary report (DSR) is then updated. The layouts and detailed designs are subsequently conducted.

*90% Review*

In this phase specifications and estimates are prepared based on nearly completed designs. The specification development generally involves use of standard specifications, special provisions as modifications of standard specifications, and proposed special specifications (TxDOT, 2007). Alternative special provisions and proposed special specifications require approval from a competent authority. Advancements in material manufacturing and new project requirements often introduce special materials to the project.

The next step is preparation of the estimate. This results in a tabulated listing of the bid items which reflect the estimated cost of the project. The list includes the description, quantity, and unit bid price of each bid item for the project (TxDOT, 2007). The estimate provides an opportunity to the engineer to review the costs and go back to the previous phases and explore cost reduction methods.

*Post-letting*

Depending upon funding, either federal or state, the relevant letting procedures and corresponding forms are used in letting by TxDOT. Federal funding follows the Federal Project Authorization and Agreement (FPAA), while state funding follows the state Letter of Authority (SLOA) process (TxDOT, 2007). Each process has its own requirements for advertisement, selection, and award processes. Letting is the last phase before that has potential for application of cost reduction methods. The post-letting phase involves the construction.

## 6.2 Consideration of Methods for Implementation

The process described earlier identifies the methods for given project review milestones and project characteristics. Method summary information sheets are developed to guide the engineers in discussion of the potential impacts of the methods and making sound decisions. The detailed method info sheets are presented in Appendix I as part of a standalone guideline for the implementation of this research. The method information sheet contains the following information:

**Method description:** Describes in detail the proposed method and how it affects the project cost.

**Project milestone:** The milestone review point in which the method should be considered.

**Project characteristics:** The type of project that would be suitable for application of the method.

**Factor addressed:** The method addresses one or more cost reduction factors. A detailed description allows the user to understand what factors are addressed and how they affect the cost, in the process of applying the given method.

**Perceived advantages and disadvantages:** Each method has advantages and possible disadvantages with respect to its implementation. The listed advantages and disadvantages will guide the design engineer in decision making with respect to integrating the method into the existing project design or project construction process.

**Cost impact evaluation:** The evaluation of a method by the Delphi group of experts is indicated in brackets. The score is determined by multiplying the number of responses in each of the "no," "low," "medium," "high," and "very high" categories by factors 0 to 4, respectively, and then dividing the total by the number of respondents. The cost evaluation score out of possible maximum 4.00 points indicates the method's potential to reduce the cost. The pie-chart indicates the distribution of the method cost reduction effectiveness from Delphi analysis.

**Performance impact indicator:** The Delphi group evaluated possible impact of the method on additional performance measures: quality, schedule and safety. Green light indicates that the method has no significant impact on the considered performance measure. Yellow light indicates possible impact of the method, while red light indicates that the Delphi group is of opinion that the method can potentially have a severe effect on the considered performance measure. In such cases, extra caution should be exercised when considering the method for implementation.

**Quality impact:** The Delphi group evaluated the impact of each method on quality. This information may be useful to the design engineer in decision making, particularly where the method has a potential adverse impact on quality. A method having an adverse quality impact may be considered with additional caution.

**Schedule impact:** The Delphi group evaluated the impact of a method on project schedule. This information may be useful to the design engineer in decision making, particularly where a method has a potential adverse impact on schedule. Depending upon project requirements the method may be rejected if accelerated schedule completion is critical to project success. For example, for projects in urban environment, schedule may be a more important performance measure than cost.

**Safety impact:** The Delphi group evaluated the impact of a method on construction safety. The methods having a possible adverse impact on safety need careful evaluation before implementation.

# 7 CONCLUSIONS AND RECOMMENDATIONS

## 7.1 OVERVIEW OF THE RESEARCH

The problem of increased construction costs and reduced purchasing power is facing many state transportation agencies. While this problem is not endemic only to the transportation sector, transportation agencies are among the agencies that are the most affected. In fact, the deficit in short-term cash flow has already affected many projects. As a result, projects are delayed and programs are reduced. The purpose of this research is to identify factors affecting increases in highway construction costs and propose methods that can reduce or contain these costs.

### *7.1.1 Research Objectives*

The goal of this research report is to present a set of guidelines that can assist TxDOT in an attempt to reduce contracting costs and control cost increases. More specifically, the objectives pertaining to this research goal are:

1. Identify factors that affect increases in costs of bid items and identify methods and strategies that can help reduce the costs.
2. Develop recommendations that could result in cost reduction and develop more comprehensive guidelines on how to modify projects to reduce initial construction costs while maintaining equal or better performance.
3. Assess how TxDOT can improve its project development and contracting procedures or processes to increase competition.

### *7.1.2 Research Methodology*

The research was based on four sequential steps. First, a survey of the experience TxDOT and other DOTs with increases in construction costs and methods for cost reduction and containment was conducted. This task was achieved through an extensive literature review. The literature review was followed by a series of fact-finding workshops where TxDOT and other DOT engineers participated in brainstorming sessions. The purpose of the brainstorming sessions was to identify factors affecting cost increases and generate ideas to how to reduce them. The active involvement of TxDOT engineers resulted in a comprehensive list of methods that have potential to control construction costs. Contractors' feedback was also obtained on the issue of method applicability and is included in this report. The Delphi process was used to rank the cost reduction methods and to obtain feedback on the effect of these methods on performance measures. The Delphi study resulted in a consensus among the participating experts regarding the effectiveness of the methods. Finally, similar methods were combined and then classified based on their application: at the program vs. the project level. The data sheet for each method developed as an end result will provide engineers the guidelines for use and implementation of individual methods based on project stage and project characteristics.

## 7.2 RESEARCH FINDINGS AND RECOMMENDATIONS

A key finding of this study is that the rise in the cost of crude oil is not the sole factor contributing to the increase in cost of construction. In fact, a confluence of a number of factors is contributing to the observed trends in cost of construction including competition, contract requirements, and other factors discussed in this report. Fact-finding workshops reveled that these factors can be both internal and external. While TxDOT can try to eliminate some of the internal factors, eliminating external factors would a difficult if not impossible task. The result from the Delphi study indicates that the cost reduction methods considered in this study can both address the internal and hedge negative effects of external factors. It is important to note that the methods applied in earlier phases of project development are perceived to have higher impact than those applied at the later stages.

This research identified 56 methods that impact cost increase factors; some of these methods have program-wide application and the rest have project-specific application. Such classification of methods is useful for implementation. The program-wide applicable methods need some decision-making and policy-level changes and impact a wider number of projects. The project-specific methods are effective in addressing specific issues known to exist in the project development process.

The study makes the following recommendations to TxDOT:

1. While this research effort has identified a total of 56 cost reduction methods, only 35 methods are applicable on a project-based level. Out of 56 methods, 21 methods have applicability at the program level. TxDOT management should consider making arrangements for implementing these program-wide methods. In such settings, TxDOT procedures should be flexible enough to adopt recommended methods.

2. Since the methods employed at the early stages of project development yield better cost reduction results, management should consider pursuing implementation of methods in planning and programming phase with more focus.

3. The methods which have adverse effects on other performance measures should be considered with caution. Further, since the results show only perceived performance, engineers should exercise their best judgment in consideration of the methods. The information sheets developed to describe the methods should be a starting point in evaluating their applicability.

## 7.3 RECOMMENDATIONS FOR FUTURE RESEARCH

Due to their strategic nature and lack of data, the performance of the methods identified in this research has been assessed using the Delphi process where experts ranked the effectiveness of the methods to reduce the cost. To fully assess the possible impact of the methods on the performance measures, a more quantitative analysis is needed. The analysis would provide estimated value of the method, in contrast to the perceived value of the method implementation considered in this study. However, it is important to note that these qualitative analyses would require data to calibrate the developed model. While data availability could be a limiting factor for some of the methods proposed in this study, for the other methods such data should be available.

Cost reduction and containment issues deserving further attention of the researchers include:

1. Analysis of the effects of public-private partnerships (PPP) in procurement of highway construction. In particular, the type of PPP arrangement referred to as "availability fee" might be able to reduce the cost and help in budget planning. Further studies are needed to determine what the effects of this arrangement would be.

2. Development of a comprehensive cost risk management process at both project and program level. By implementing such process TxDOT management would be able to identify cost risk components and manage them as they are introduced, as well as providing to policy makers needed information to make sound policy decisions.

3. Assessment of the effects of long-term performance-based outsourcing maintenance contracts on the total costs of the maintenance programs. A long-term experimental analysis of two similar portfolios of roadway maintenance projects would provide evidence if outsourcing maintenance work would be cost effective to TxDOT. Similar studies conducted abroad indicate that performance-based outsourcing of maintenance work can significantly reduce the cost of maintenance programs.

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# APPENDIX A

## TxDOT TASK FORCE COST CONTROL IDEAS

| Idea | |
|---|---|
| **Pavement Maintenance** | |
| 1 | For preventive maintenance, seal rural roadways with less than 5000 ADT and strongly consider sealing roadways with over 5000 ADT. |
| 2 | Don't seal shoulders every cycle. |
| 3 | Use spot level-up with seals. |
| 4 | Spot and strip-seal main lanes and shoulders. |
| 5 | Use rut boxes and scratch microsurface passes to address rutting in the wheel path. |
| 6 | Use fog seals on main lanes and shoulders. |
| 7 | Engineer the seal coat. Select the appropriate asphalt aggregate and precoat requirements. Consider reduced requirements for underseals and shoulders. |
| 7a | Select the appropriate asphalt grade for the application and for competition. |
| 7b | Select aggregate for underseal understanding need for grade and SAC. |
| 7c | Select appropriate material for precoat or whether to precoat. Precoat may be needed for hot applied asphalt but not needed for emulsions. |
| **Alternative Pavement Design** | |
| 8 | Consider alternative designs. |
| 8a | Ultra Thin Bonded Wearing Course (Novachip) versus an underseal with PFC, all with lane rental. |
| 8b | Hot in Place Recycling with virgin material overlay in same pass (Cutler) versus Dustrol followed by an overlay versus mill and overlay with 30 percent RAP, all with lane rental. |
| 8c | Thin Bonded PFC versus an underseal with PFC, all with lane rental. |
| 8d | Reflective Crack Relief Interlayer (Strata) versus rich bottom layer. |
| 8e | Concrete pavement versus flexible pavement. |
| 8f | Look at alternative pavement designs such as lime, lime-fly ash, cement, ASB, emulsion stabilizations, and combinations thereof. |
| 8g | Recycling pavement versus virgin design to restore surfaces. |
| 8h | Set up Type A flex base with an alternate Type B with lime. |
| 9 | Use RAP and crushed concrete for construction. |
| 9a | Blend up to 50% RAP with virgin materials for driveways, crossovers, other miscellaneous areas, shoulders, underlying layers, and bond breaker for rejuvenated RAP and RAP blended in ACP. |
| 9b | Use RAP in base. |
| 9c | Allow for the use of crushed concrete for flex base. |

| Idea | |
|---|---|
| 10 | Consider alternatives to 4 inch ACP as bond breaker under concrete pavement. Rigid Pavement Design allows 3 possible layer combinations (bond breaker and non-erodable material) which could be bid as alternatives. |
| 10a | 4 in. of ACP |
| 10b | 4 in. of ASB |
| 10c | 1 in. ASB over 6 in. of CSB |
| 11 | Engineer ride and schedule application. Know existing ride for overlays. |
| 12 | Consider flex base with 2 course surface treatment (CST) as an option to flex base with ACP. |
| 13 | Apply 60 and 70 degree pavement temperature restrictions for ACP placement using good judgment. |
| **Materials, Material Allowances, and Requirements** | |
| 14 | Reuse MBGF rail that is determined to be in good condition. |
| 15 | SGT on off-system bridges. |
| 16 | Reconsider requirements for certification for concrete plants and trucks, including structural concrete. |
| 17 | Proper requirements for PG binder. |
| 17a | Reduce use of restrictive specification requirements. |
| 17b | Specify higher grade PG binder only when needed. |
| 18 | Provide for alternative materials and construction methods in PS&E. For certain materials, haul limits the competition severely and the more options you can give, the better prices we can get from a contractor. |
| 18a | Provide AEP, PCE, EAP&T as an option to MC-30 |
| 18b | Use emulsions as alternatives for prime coat. (Item 310 versus Item 314 and CSS-1 and SS-1.) |
| 18c | Alternative binders for seal coat. |
| 18d | Concrete pipe and plastic pipe alternates. |
| 18e | Hardie pipe alternates to concrete pipe. |
| 19 | Allow for Class 5 or Class 8 for concrete joint seal. Used for joint sealer for concrete pavement or bridge joint sealant. |
| **Structure and structure aesthetics** | |
| 20 | Aesthetics Bridges |
| 20a | Example of steel traps versus I-beams. |
| 20b | Minimize wall panel unique designs. |
| 20c | Ask locals to participate in the aesthetic cost. |
| 20d | Standardize design and repetition. In regard to repetition, address competition. |
| 20e | Address consultant designs not in agreement with TxDOT standards or practice. |
| 20f | Reduce painted concrete. |

| Idea | |
|---|---|
| 21 | Design foundations to the appropriate depth. |
| 22 | Reduce intensive landscape that requires high maintenance, hand mowing, and bed maintenance. Execute agreements with locals to perform maintenance. Let landscape along a corridor. |
| 23 | Mowing start dates need to be more flexible. Do in a way that encourages competition. |
| 24 | Maintenance related. Mowing when not needed. Mowing 8 inch grass to 4 inches. |
| 25 | Increase use of prison labor. Contract with prisons to clean, repaint, service equipment, etc. |
| **Markings** | |
| 26 | Reduce RPM spacing to 80 feet everywhere. It is further proposed that routine placements not exceed the standard. |
| 27 | Use the latest formulation of water base paint to stripe previous year seal coat. |
| 28 | Reconsider use of in-house striping. |
| 29 | Don't remove reflective tabs on roads without buttons and low volume roads. Tab suppliers may be able to design durability. |
| **Competition** | |
| 30 | Use delayed time start and flexible start date provisions. Allows smaller contractors to bid and adds efficiency opportunities. |
| 31 | Give more time for Contractor's plan review prior to letting. |
| 31a | Web site with preliminary plans. More than one month; 6 to 8 weeks. Stamped with EPA requirements if needed, on Web. |
| 31b | Consider release proposal and plans 2 weeks earlier. |
| 32 | Create an "open for business" air. |
| 32a | Call contractors on release date to encourage bidders. |
| 32b | Call contractors after the letting to determine why they didn't bid. |
| 32c | Discuss plans and proposal with contractors to determine if there are issues with the contract that create difficulties or barriers to bidding. |
| 32d | Issue addenda as needed. |
| 32e | Welcome bidders in showing jobs. Be available for showing jobs. |
| 32f | For unique work, such as special forms, discuss future projects. |
| 33 | Consider waiving prequalification on construction projects. (Waiver of prequalification is the default for construction projects less than $300,000 and all RMCs.) |
| 34 | Reconsider implementation of Value Engineering (VE) for the construction phase. |
| 35 | Use additive and deductive alternates. Must award on base bid or predetermined budget amount. |
| 36 | Reduce contract duration and scope, so risk is less. Even though long term may reduce cost. In some cases, with highly volatile items and resources, contractors have to put in more risk. |

| Idea | |
|---|---|
| 37 | Consider project size to increase competition. |
| 37a | Economy of scale, bundling or splitting projects. |
| 37b | Area contractor capacity. |
| 37c | Consider material source influences on competition. |
| 37d | Consider subcontractor cost when bundling so odd work is not included. |
| 38 | Provide state yard and plant locations on-ROW or lease space off-ROW. Consider acquisition of yard sites for TxDOT that contractors could use for construction yards, etc. |
| 39 | Update estimates. Use addenda to address barriers to bidding. |
| 40 | Quality of plans and information needed by contractors including available materials, yard, water, and base sources. Include photographs. |
| 41 | Consider appropriate time for project completion. |
| 42 | Evaluate restrictive work hours and the effect of time to set up traffic control on production for daily operations. |
| **Project Scope** | |
| 43 | Appropriate Design for Projected Capacity |
| 43a | Ensure that divided 4 lanes are being built that design year capacity justifies added lanes or divided facility. Designs can be phased in over time. This may address several rural connectivity projects. |
| 44 | Use minimums versus desirable when safety or the future improvements to the transportations system is not compromised. |
| **Other** | |
| 45 | Use HES funding to offset the cost of Rehabilitation projects either through scheduling sequential projects like some other states or through the combination of funding. |
| 46 | Return to the use of more 2R (Restoration) projects. |
| 47 | Need district carryover for 105 and 144 each year. Will allow a district to manage their work so they are not forced to let work or buy materials they don't necessarily need. |
| 48 | Eliminate individual transfer fees for NOIs, etc., and do one for the entire state. |
| 49 | Consider elimination of subsidiary work that is essential to the bid item. |

# APPENDIX B

## FACTORS AFFECTING CONSTRUCTION COSTS

| No | Factors | Description |
|---|---|---|
| **I.** | **MATERIALS** | |
| 1. | Increase in price of fuel oil | An upward trend in the price of fuel oil has created an upward trend in prices of construction materials. In the last couple of years, prices of materials have increased significantly. This increase is proportional to the energy requirements of production operations. |
| 2. | Increase in global demand for construction materials | Construction materials are a commodity that is influenced by global demand and supply. In the last decade, the capability of material sources has not increased as much as demand has increased. This gap in the supply-demand equilibrium has resulted in increases in material prices. Steel, asphalt, cement, and aggregates are some of the most strongly affected commodities. |
| 3. | Limited capacity of material producers | The availability of material sources is falling short of the market demand. Some of the materials which are affected by this gap in demand and supply are cement, asphalt, steel, aggregates, and concrete pipes, among others. Material producers design the capability of their production facilities based on a prediction of future demand. If there is a large uncertainty in future demand, material producers typically design their production facilities short of expected demand. |
| 4. | Limited storage facilities | The lack of adequate storage capacity forces material producers to limit production quantities. In many cases the material producers do have required storage capacity, but often demand is not uniform, e.g., for asphalt. When producers do not have adequate storage capacity, production cannot be carried out at full capacity. |
| 5. | Limited capacity of refineries to supply asphalt in peak periods | Capability of refineries to produce asphalt is restricted. Since most asphalt-related jobs are conducted during summer periods, due to temperature restrictions related to placing asphalt pavements, refineries must adjust to variable production volumes. This variability creates shortages during some |

| No | Factors | Description |
|---|---|---|
| | | construction periods (mainly summer) due to limited capability and underutilization of resources during off-peak periods. |
| 6. | Limited local, in-state availability of cement | According to a 2007 U.S. Geological Survey report, there is a 24% shortfall in cement production in the U.S. which is met by importing. While Texas is a top cement producing state in the country, the overall demand for cement in the state exceeds the installed capacity. To bridge this gap between needed and available quantities, contractors are forced to obtain concrete from geographically more distant locations. This additional transportation cost increases the cost of concrete. |
| 7. | Availability of material with respect to project location | If materials are not available close to a construction site, material transportation costs will increase. The distance of material sources from the project site determines the inventory and transportation costs. The prices of materials vary from project to project based on accessibility and distance of the material source from the project site. |
| 8. | Federal and local restrictions on truck movement | Both federal and local (city) restrictions on truck movement for specific time periods can affect the cost of construction. For example, congestion-related restrictions on truck movements during the day time and noise pollution restrictions at night can affect project schedules, and ultimately the cost of construction in such areas. The restricted work windows often do not allow contractors to complete projects in an efficient manner. To mitigate their risks, contractors incorporate this inefficiency in construction operations in their bid prices. |
| 9. | Overuse of standard drawings | Overuse of standard drawings leads to higher demand for limited types of materials. For example, use of concrete pipes for all cross-drainage work increases the demand for concrete pipes. |
| 10. | Federal restrictions on importing materials | Import of certain materials is governed by federal regulations. The regulations relate to the quantity, type, or source of the materials. |
| 11. | Repetitive inspection of materials | Contractors incur a significant cost for testing and certification of materials. |

| No | Factors | Description |
|---|---|---|
| | | There is a duplication of effort, as inspection is carried out by both the contractor and TxDOT. |
| 12. | Effect of specifications on cost of producing concrete | Specifications for concrete production affect cost and schedule. A typical example production requirement is temperature of asphalt concrete mix. More stringent specifications in the case of asphalt concrete result in higher production costs and a reduced construction season. |
| 13. | Multiple design specifications and standards | Designers adopt multiple specifications, leading contractors to assume higher grades of materials in estimates. When designers adopt multiple specifications for similar work, contractors are not able to explore economy of scale due to increased variation in type of materials to perform the same function. Furthermore, material waste also increases due to variation in type of materials. |
| 14. | Restrictive specifications, limited or sole material sources | Restrictive specifications limit contractors' choices of materials and methods. Limited or sole sources for materials affect the price of materials, increasing demand for those materials and hence increasing price. Contractors cannot shop for economical materials due to restrictive specifications. Contractors also loose flexibility in execution. |
| **II.** | **COMPETITION, MARKET CONDITION, AND PROCEDURES** | |
| 1. | Time of lettings | Typically accumulation of job lettings occurs toward the end of the financial year. This can result in reduced competition as contractors choose to bid for those projects that have higher profit margins and a higher probability of winning. Further, sometimes due to limited availability of estimators for bid preparation, contractors choose to bid on selected projects only. |
| 2. | Unbalanced distribution of job lettings for similar projects within state | Job lettings occurring at the same time for similar types of projects (bridge, highway, etc.) can affect competition in those categories of projects. Since contractors specialize in a certain type of work, when similar works are let |

| No | Factors | Description |
|---|---|---|
| | | simultaneously, contractors choose to bid on those projects where they foresee a higher probability of winning. The overall effect is reduction in competition. |
| 3. | Competing markets (local/state/national/global) | Other construction projects such as residential, commercial, and industrial construction impact availability and costs of material, labor, subcontractors, machinery, and other highway construction resources. Following Hurricane Katrina, an increase in commercial and residential projects decreased competition and affected availability of construction materials, labor, machinery, and other highway construction resources. |
| 4. | Long project duration | Projects with longer durations are adversely affected by volatility in material prices. As duration of project increases, the risk premium charged by contractor increases to account for expected volatility in material prices and market conditions. Contractors fail to negotiate lower prices for material for the entire project duration, making material supplies vulnerable to inflation on projects with longer durations. |
| 5. | Size of the project in terms of dollar value | Contractor's overhead on smaller projects are higher. The contractors loose economy of scale and incur higher material wastage. Larger projects offer economy of scale to contractors; they also are typically longer, which has a negative effect on bid prices. The availability of qualified contractors to carry out the construction is not assessed in deciding the size of the project. Sometimes for a very big project numbers of qualified contractors are limited. |
| 6. | Specialty items on contracts | Specialty items require specialized materials, equipment, or agency for execution. This work is frequently subcontracted to a specialty contractor, resulting in a double mark-up for specialty items. Specialty items often require dependence on outside experts and create delays in schedules. |
| 7. | Availability of Disadvantaged Business Enterprises (DBE) | The Surface Transportation Assistance Act of 1982 emphasizes a DBE participation target of 10% for federal-aid highway and transit projects. |

| No | Factors | Description |
|---|---|---|
| | | Contractors may become ineligible for a project if they fail to meet the goal or to demonstrate "good faith effort" to meet the DBE goal. The availability of DBEs with specific expertise and their distribution within the state often makes contractors fall short of the DBE participation requirement and hence limits their participation in bidding. |
| 8. | Prequalification requirements for contractors | Currently TxDOT requires contractor prequalification for projects exceeding $300,000. Contractors incur significant costs in preparation and submission of prequalification documents. Further, the prequalification process eliminates some contractors from bidding, reducing the competition as a result. |
| 9. | Performance bond requirements | Contractors are required to obtain performance bonds for contracts that exceed $100,000. There is a cost associated with acquiring a performance bond, which increases with increasing project cost. Surety companies issue performance bonds considering the capacity of the contractor. Thus, each contractor possesses a limited capacity of bonding which restricts them from bidding for more projects. |
| 10. | Type of contracting method | The traditional project delivery method utilized by TxDOT is a design-bid-build (DBB) method. While this contracting method assures that the lowest bidder is selected for the job, it does not offer contractors flexibility to use materials, machinery, and schedules which are economical to them and satisfy design specifications. The DBB method often creates issues of design coordination, constructability, and change orders. |
| 11. | Fast-tracked and accelerated projects | Fast-tracked and accelerated project delivery reduces project duration. Short contract duration reduces the flexibility that contractors may have in mobilizing resources. Accelerated project delivery increases the cost and sometimes results in lower efficiency due to congestion on site. (On the positive side, short contract duration mitigates the effect of inflation.) |
| 12. | Lack of contractor inputs | Contractor input is important for design, specifications, constructability, |

| No | Factors | Description |
|---|---|---|
| | | construction staging, estimating, and planning of traffic control. Lack of contractor input can result in conflicts and change orders. Typically issues that arise due to lack of contractor input are design conflicts, utility conflicts, and schedule conflicts. |
| 13. | Lack of communication of business opportunities | Lack of communication and publicity about business opportunities reduces the number of bidders. For complex and unique projects, additional effort is needed to attract more bidders. There is lack of effort to evaluate reasons for poor response to previous lettings to improve the future letting response. |
| 14. | Contract restrictions | Restrictions in the contract increase difficulty and create pressure on schedule and cost of construction. Contract restrictions limit competition by introducing unnecessary features or capabilities, e.g., unnecessary requirements for plants, machinery, and inspections. |
| 15. | Outdated estimates | Estimates based on periodic fixed percentage increases to account inflation may not be realistic. When contractor’s estimates exceed engineer’s estimates beyond the threshold for which projects need to be re-let, contractors may choose not to bid again, as their bidding strategies might be exposed. Ultimately this can result in decreased competition. |
| 16. | Unnecessary completion milestones | The number of project milestone points can affect bid prices. These milestones prevent contractors from using their resources in an optimal manner. Due to the presence of milestone points, contractors are more focused on meeting the milestone deadlines, rather than most efficient utilization of their resources. |
| 17. | Lack of contractor interest in small and isolated jobs | Contractors may not be interested in small and isolated jobs. Isolated jobs cause problems of acquiring resources in an economical manner. The contractor’s overhead also increases on isolated work. Contractors loose economy of scale. Competition is reduced, as only local contractors are interested in such work. |
| 18. | Risk associated with acquisition of yard and | The risk associated with acquiring yard and plant sites within or near right |

| No | Factors | Description |
| --- | --- | --- |
| | plant sites | of way increases the risk premium charged by contractors. There are wide fluctuations in the rate of yard sites based on location, particularly in urban areas. Contractors prefer yard sites close to project locations, preferably on right of way. Urban sites pose more problems of site acquisition and higher costs associated with acquisition. |
| 19. | Lack of cost estimate consistency and accuracy over the project development process and throughout the districts | Lack of cost estimate consistency and accuracy over the project development process and throughout the districts results in disparity in estimates between districts for similar work. |
| **III.** | **DESIGN ISSUES** | |
| 1. | Traffic control planning | The cost of designing and implementing traffic control constitutes a significant cost component of the contractor's estimate. Traffic control design causes coordination problems in traditional design-bid-build contracts, as the contractor needs to manage the project schedule considering traffic control requirements designed by other entities. Lack of consideration of traffic control costs in estimates results in lower estimates. |
| 2. | Length of detours/diversions | While traffic detours are necessary, detours and diversions only add to the cost of the project without adding any value. Planning of detours and diversions is done considering the comfort of the users, with least concern for the cost of detours and diversions. |
| 3. | Standardization of design and drawings | Lack of standardized designs affects the ability of contractors to explore economies of scale. It increases procurement efforts and variation in type of resources. Excessive use of prototype drawings results in lack of clarity on site-specific details, which can result in change orders. The site-specific details include ground water level, soil types, and storm drainage. |
| 4. | Reluctance to use design exceptions | Designers hesitate to use design exceptions and engineering judgment. The perception that design exceptions are not acceptable leads to less-than- |

| No | Factors | Description |
|---|---|---|
| | | optimal designs. |
| 5. | Selection of federal standards versus state standards | Federal standards are perceived to be more stringent in some categories. For projects with federal funding, these standards must be met. This can result in less-than-optimal designs. |
| 6. | Lack of design experience | Lack of design experience can lead to overdesign. A designer's lack of knowledge about the construction process can result in constructability issues and design conflicts. This may also lead to conflicts related to scope and delays during construction. |
| 7. | Lack of pavement evaluation data for rehabilitation | Lack of detailed evaluation of pavement structural condition results in untimely or more frequent scheduling of maintenance actions. Falling weight deflectometer (FWD) data, as available with FHWA, is not being utilized effectively for maintenance decisions. |
| 8. | Insufficient site information | Inadequate site information such as hydrology, drainage conditions, and physical features can lead to less-than-optimal designs. The information regarding existing structures, subsurface utilities, and right of way acquisition is critical for cost and schedule point of view for highway projects. |
| 9. | Inadequate geotechnical investigations | Lack of adequate geotechnical investigations can lead to overdesign. Inadequate investigations also result in differing site conditions. The differing site conditions cause change orders during construction, increasing the overall cost. |
| **IV** | **OTHER FACTORS** | |
| 1. | Environmental restrictions | Environmental restrictions applicable to construction in certain geographic regions and areas including forests, watersheds, and urban residential areas impact project schedule, material handling, disposal of construction waste, use of machinery, etc. Un-intended violation of laws is possible during construction; however, fines and penalties associated |

| No | Factors | Description |
|---|---|---|
| | | with the violation of laws can be excessive and affect the overall project cost. |
| 2. | Local or municipal regulations | Local municipality regulations can affect project schedule. Local regulations restrict working hours. The disposal of waste, borrow-pits, and use of certain class of machinery is governed by local regulations, which are often stringent. |
| 3. | Project aesthetics requirements | Unique aesthetics design requirements can reduce the repetition of forms, complicate the fabrication process, and increase the construction time. Typically bridge columns, wall panels, railings, and other precast works require specialized forms, adding to cost of fabrication. |
| 4. | Scope creep | Accumulation of small changes in a project's scope can significantly increase the overall project cost. Such additions in scope often do not significantly add to the functionality or performance of the facility. A mechanism for controlling project scope by competent and accountable authority is needed. |
| 5. | Impact of night work | Night work is essential to timely delivery of urban projects. For such projects, minimum interruption of traffic is of great importance to reducing congestion and costly delays. While night work may require higher salary compensations, it can reduce hauling time. |
| 6. | Traffic handling constraints | TxDOT's construction contracts are more restrictive on closure of traffic during construction. At times, the allotted windows for work including night work may not be sufficient to complete the project in timely manner. There are penalties for not opening lanes on time, hence risk increases and sometimes contractors choose not to bid on projects with such constraints. |
| 7. | Limited information for complex projects | Complex projects involve unique designs or specialized methods for construction. Contractors need more time and information to understand the project complexities to prepare bids. In absence of adequate |

| No | Factors | Description |
| --- | --- | --- |
| | | information, contractors overprice the bid items. |
| 8. | Lack of contractor motivation for cost savings | Contractors are not motivated to reduce project costs. The initiatives of contractors in cost reduction are not rewarded by sharing savings. |
| 9. | Lack of documentation and sharing | The lessons learned from implementing cost control ideas are not shared with a larger group. The results from value engineering studies are not well-documented. |

# APPENDIX C

## METHODS FOR REDUCING OR CONTAINING PROJECT COSTS

| Sr. # | Method | Description | Factor addressed |
|---|---|---|---|
| **BUSINESS OPERATIONS, PROCEDURES, AND POLICIES STRATEGY** | | | |
| 1 | Plan ahead and communicate requirements to material suppliers in advance | Inform material producers and suppliers of upcoming projects and key quantities. Begin procurement process early. Early information may help suppliers plan their production better. | Inadequate capacity of sources and storage capacity<br>Effect of competing markets (local/state/national/global) on resources |
| 2 | Evaluate local market conditions for availability of resources to effectively plan construction lettings | Evaluate the local market conditions in terms of availability of workforce, materials, and machinery for improved estimation and planning of construction lettings. Plan lettings with consideration of material requirements and the capacity of material producers in the region. | Effect of competing markets (local/state/national/global) on resources<br>Time of letting and number of construction projects in the market |
| 3 | Evaluate restrictions on imported materials | Evaluate import of materials from other countries. In a 2007 U.S. Geological Survey report, reliance on imported Portland cement in the U.S. is approximated to be 24% of consumption. Presently, higher global demand for cement and a lower number of supplier countries has led to increased prices. | Limited sources of cement within the state |
| 4 | Create material sources by TxDOT | Develop TxDOT owned material sources for materials such as asphalt and aggregates. TxDOT sources can help combat material shortages. | Limited material sources |

| Sr. # | Method | Description | Factor addressed |
|---|---|---|---|
| 5 | Utilize owner buying power | Consider purchasing large quantities of construction materials. TxDOT can use its buying power to achieve economy of scale. TxDOT can then supply items to contractors and reimburse the cost from periodic progress payments. This can reduce the impact of inflation as contractors obtain materials supplied at a fixed price throughout construction. | Increase in price of oil, steel, aggregate, cement, etc.<br>Pressure on asphalt supply due to limited capacity of refineries and increased demand during asphalt season |
| 6 | Purchase commitments to suppliers by TxDOT with option for buying | Negotiate and make purchase commitments to material producers, which can motivate producers to expand plant capacity. Purchase commitments can also include buying options from material suppliers. | Increase in price of oil, steel, aggregate, cement, etc. |
| 7 | Provide state yards | Provide space for plants and yards, and manage the speculative component related to cost of acquisition of plant and yard sites. This may include sites for borrow area and waste disposal. | Risk and cost associated with acquisition of yard and plant sites |
| 8 | State-owned batch plants and crews | Set up state-owned batch and asphalt plants, and carry out jobs using state forces where enough competition does not exist. | Lack of contractor interest in some isolated jobs |
| 9 | Evaluate alternate contracting methods including design-build (D-B) and construction manager at risk (CM @ Risk) | Consider design-build contracts. D-B contracts may offer more flexibility to contractors as compared to traditional design-bid-build (D-B-B) contracts. On design-build contracts, contractors can potentially use resources that are more cost effective for them. This can impact resource planning and constructability. Also, there is a higher integration of design and construction in design-build contracts. D-B contracts may also result in reduced number of change orders. Other contractual methods like CM @ Risk with a guaranteed maximum price (GMP) may constrain overall project cost. | Type of contract (traditional D-B-B versus other contracts) |

| Sr. # | Method | Description | Factor addressed |
|---|---|---|---|
| 10 | Update construction cost estimates based on experience and analysis of construction components (labor, materials, equipment, etc.) | Use a cost-based bottom-up approach to estimate preparation. Cost estimates should be based on feedback from the contractors, experience, and understanding of the project conditions rather than on historical data adjusted for inflation increases over each year. Contractors may choose not to bid if they anticipate that their own cost estimates are likely to be significantly higher than DOT estimates and their bid will be rejected. | Outdated estimates |
| 11 | Share cost savings with the contractors | Accept cost saving proposals from contractors during bidding and construction. The contractors may be more motivated to submit such proposals when potential cost savings are shared. | Lack of contractor motivation for cost savings |
| 12 | Reduce cost of inspection (consider use of supplier and contractor test results) | Consider accepting supplier and contractor test certificates to reduce the cost of inspection and testing. This method can also be applied to reduce plant and truck DOT inspection requirements for non-structural concrete and non-bridge class culverts. | Lack of consideration of material inspection costs in engineer's estimate |
| 13 | Add price adjustment clause to contracts | Consider incorporating price adjustments or escalation clauses in construction contracts. For longer contract durations, such clauses have a potential to reduce the contractor's risk premium. This risk premium is added by contractors to bid item prices to account for the expectation of future increase in prices of materials due to inflation. | Increase in price of oil, steel, aggregate, cement, etc. |

| Sr. # | Method | Description | Factor addressed |
|---|---|---|---|
| 14 | Consider material advance for projects having longer duration | Include in construction contracts an ‘advance payment clause’ for materials procured in advance of construction. This may allow the contractor to buy large quantities at lower cost per unit and hence achieve economy of scale while mitigating the effect of inflation. Using a material advance provision, contractors get paid for materials procured even before the materials are consumed. This may favorably affect the contractor’s cash-flow and thereby increase its bid capacity. | Effect of project duration on risk premium |
| 15 | Provide owner-controlled bonding for small contractors | Waive bond requirements for small contractors. Consider providing bonds to small contractors to increase competition. | Performance bond requirement |
| 16 | Reduce bond cost over project time | Consider reducing the bond amount on a *pro rata* basis according to the progress of the work. Reducing the bond requirement can increase the financial capacity of the contractors for bidding, which in turn can increase competition. | Performance bond requirement |
| 17 | Relax prequalification requirements for certain projects | Relax prequalification requirements based on project type and cost to reduce contractors’ overhead related to the prequalification effort. Contractors incur costs in preparation and submission of prequalification documents. It may also increase competition on those contracts where prequalification requirements are relaxed. | Prequalification requirements for contractors |
| 18 | Increase bid preparation time | Giving contractors more time to bid projects may result in more realistic bid prices. Contractors have increased time to review plans, and obtain quotes from a number of suppliers and subcontractors in preparation of bids. Contractors may choose not to bid when the time available for bidding is too short. | Lack of contractor inputs<br>Effect of competing markets (local/state/national/global) on resources |

| Sr. # | Method | Description | Factor addressed |
|---|---|---|---|
| 19 | Control scope creep by accountable authority | Avoid unnecessary additions to the project scope that do not add value to the performance or functionality of the construction component or element. Ensure scope control mechanisms are in place and that project staff are accountable for controlling scope. | Scope creep |
| 20 | Increase flexibility in traffic control planning | Give more flexibility to contractors to plan traffic control. This can lead to more effective construction staging plans which are consistent with the contractor's construction schedule. | Traffic control |
| 21 | Ease contracting requirements with TxDOT | Make contracting with TxDOT more appealing by making contracting simpler and easier. | Effect of competing markets (local/state/national/global) on resources |
| 22 | Change evaluations of TxDOT districts | Change evaluations from production driven. Change the evaluation of TxDOT districts based on the fiscal year total dollar amount let. | Time of letting and number of construction projects in the market |
| **MATERIAL MANAGEMENT STRATEGY** | | | |
| 23 | Consider locally available materials in design | Make resource mapping data available to design personnel for selection of materials based on the location of the project and availability of the material source. | Availability of material with respect to project location |
| 24 | Reuse and recycle materials | Consider utilizing recycled materials such as crushed concrete aggregate, which can reduce pressure on material supply. Consider recycled pavement versus new. Reuse materials like Metal Beam Guard Fence (MBGF) rail which is determined to be in good condition. Reuse of salvaged materials in repairs will also create better compatibility of materials. Consider use of blended cements and optimum use of fly-ash to reduce cement consumption. | Increase in price of oil, steel, aggregate, cement, etc. Limited sources of cement within the state |

| Sr. # | Method | Description | Factor addressed |
|---|---|---|---|
| 25 | Change mode of transport | Use rail transport when available or reasonable. | Restriction on truck movement by federal and local regulations |
| 26 | Minimize mobilization | Minimize mobilization to reduce the impact of transportation. Bundle the projects to reduce the mobilization, where it makes sense to do so. | Restriction on truck movement by federal and local regulations |
| **DESIGN AND VALUE MANAGEMENT STRATEGY** | | | |
| 27 | Coordinate lettings based on the availability and capacity of contractors in the region | Plan yearly lettings with consideration of construction projects in other districts and other competing markets. Consider bid capacity of the contractors in the region and their availability throughout the year to decide an appropriate time for letting. Non-critical projects can be rescheduled to a time when there is a potential for improved competition. | Time of letting and number of construction projects in the market<br>Unbalanced distribution of job lettings within state |
| 28 | Time the projects to avoid environmental restrictions | Time projects to avoid environmental restrictions. Better timing of the project may help deal with the seasonal environmental restrictions such as migratory birds, wild-life restrictions, and others. | Environmental restrictions |
| 29 | Provide alternative materials in PS&E | Expand the number of material choices on a given project. Consider allowing alternate materials by providing flexibility in specifications. For example, a shortage of certain materials, such as concrete pipes, can be dealt with by providing flexible specifications or by allowing other material options to the contractors. | Increase in price of oil, steel, aggregate, cement, etc.<br>Limited material sources |
| 30 | Evaluate specifications and select materials that would allow relaxation of asphalt concrete temperature restrictions | Expand the construction period and relax the requirements for which asphalt concrete pavement (ACP) can be constructed. Select materials that can permit construction at lower asphalt temperatures. | Pressure on asphalt supply due to limited capacity of refineries and increased demand during asphalt season |

| Sr. # | Method | Description | Factor addressed |
|---|---|---|---|
| 31 | Consider warm mix asphalts | Consider adopting warm mix (heated well below 300$^{o}$ F) in place of hot mix asphalt. Warm mix asphalt can potentially reduce emissions, reduce fuel requirements, lengthen the asphalt construction season, and permit longer trucking distances and, hence, offers the potential for overall reduction in the cost of production. This may also result in reduced rejection of asphalt due to low temperature at the time of placing and allow more time for placing. | Effect of specifications on cost of producing materials |
| 32 | Consider alternative designs | Consider alternative designs that offer more flexibility in selection of materials to the contractors. Consider alternative materials such as lime, lime-fly ash, cement, aggregate subbase (ASB), and emulsion stabilization in pavement design. | Limited material sources |
| 33 | Apply correct design criteria | Identify and use the correct design criteria. Follow sound design judgment and principles. Select appropriate design criteria that can impact construction cost without compromising performance requirements. | Impact of overuse of standard drawings on material demand |
| 34 | Understand and manage the differences between federal and state standards | Understand the differences between state and federal standards and their impact on quality and costs. For state funded projects, relax those design criteria which do not add any value. | Selection of federal standards versus state standards |
| 35 | Check cost effectiveness of specialty items at early stage | Study the cost impact of specialty items early in the design phase and select items accordingly. A specialty item may require unique material, machinery, or expertise for construction (e.g., retaining walls, noise barriers, utility relocation, hazardous waste mitigation, environmental mitigation, and erosion control). | Specialty items on contracts |

| Sr. # | Method | Description | Factor addressed |
|---|---|---|---|
| 36 | Standardize designs and provide more design repetition | Standardize designs to ensure more design repetition, which may reduce waste and allow contractors to explore economy of scale. Non-complex designs and repetitive elements may decrease construction costs. | Project aesthetics requirement Standardization of design and drawings |
| 37 | Minimize detours and diversions | Minimize the use of detours and other traffic diversions to reduce potential cost impacts. Detours and other traffic diversions may be necessary but their value to the construction project should be carefully evaluated. | Length of detours/diversions |
| 38 | Obtain pavement evaluation data | Obtain pavement evaluation data. The data may include FWD, GPR, DCP [define?], visual distress, ride quality, and rut depth information; such information can be used when generating the optimum pavement design. | Lack of pavement evaluation data for rehabilitation |
| 39 | Provide more utility information using subsurface utility engineering | Provide more information regarding utilities located within the boundary limits of the construction project. Improve the definition of utility relocation requirements using subsurface utility engineering. Improved utility information may lower bid prices. | Not enough site information |
| 40 | Conduct more geotechnical investigations | Increased geotechnical investigations can improve designs by providing more realistic site conditions; this may reduce the number of change orders during construction. | Inadequate geotechnical investigations |

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| **CONTRACT MANAGEMENT AND PROJECT DELIVERY STRATEGY** | | | |
| 41 | Understand and manage environmental restrictions | Provide more information regarding utilities located within the boundary limits of the construction project. Improve the definition of utility relocation requirements using subsurface utility engineering. Improved utility information may lower bid prices by reducing the risk premium anticipated by the contractor. This may also result in reduced number of change orders during construction. | Environmental restrictions |
| 42 | Recognize cost of inspections as a hidden cost | Incorporate cost of material inspection in the estimates. While this method may not reduce construction cost, improved accuracy of cost estimates may help to understand the impact of material inspection on bid prices. Contractors may choose not to bid when they find that their own cost estimates are much higher than DOT estimates. Hence, more accurate cost estimates may increase competition. | Lack of consideration of material inspection costs in engineer’s estimate |
| 43 | Review specifications for their applicability to the given project | Review and evaluate specifications for their applicability to a given project. Adopt “must have” versus “good to have” approach, where possible. | Limited material sources |
| 44 | Use performance or end product specifications | Provide flexibility in specifications to give contractors the freedom to shop for more economical materials. Allow contractors to use methods and equipment that are more economical for them. This may reduce life-cycle costs. | Restrictive specifications |
| 45 | Bundle construction projects for exploring economies of scale | Bundle small projects into one larger project. This may offer contractors economy of scale in their operations and attract more contractors to bid on a project. | Size of the project in terms of dollar value |

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| 46 | Split construction projects | Split one large project into two or more smaller projects to increase potential competition. This approach may be particularly useful when there are an insufficient number of qualified contractors in the region to bid on a large project. A decision to split a large project may be based on the number of contractors in a region, their bidding capacity, and expertise. | Size of the project in terms of dollar value |
| 47 | Group specialty items into a separate package | Group specialty items into a separate bid package. This separate package can be let to a specialist contractor (e.g., utility relocation work can be isolated to form a new contract to let it to a specialist contractor). | Specialty items on contracts |
| 48 | Add alternate package for aesthetics | Develop a separate or alternate package for the aesthetics component of a construction project. Let this component to a specialist contractor. | Project aesthetics requirement |
| 49 | Provide design-build lump-sum contract for traffic control | Separate the traffic control component from other construction components and bid this component under a separate design-build lump-sum contract. As a separate contract, a single lump sum bid may be obtained to design, implement, and maintain the traffic control for a given construction contract. This method may also reduce requirements for field inspection (the level of paperwork). | Traffic control |
| 50 | Control project duration using A+B bidding without incentives/disincentives | Adopt A+B bidding to include a time element for contractor selection. This may result in reduced project duration. Since project duration is proposed by the contractor based on their own resources and assessment of project conditions, A+B bidding may provide more realistic construction duration. A+B bidding can aid when projects require restrictions, lane closures, or traffic detours that are likely to significantly contribute toward higher user costs. | Pressure on asphalt supply due to limited capability of refineries and increased demand during asphalt season |

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| 51 | Reject non-competitive bids and re-advertise | Reject non-competitive bids when bids received are substantially higher than the engineer's estimate. Competition may be increased by re-letting. The causes for higher bids can be analyzed and addressed prior to re-letting (e.g., changes in the design can be made). | Effect of competing markets (local/state/national/global) on resources |
| 52 | Improve design change procedure to increase responsiveness to change (fast and simple) | The design change procedure should be fast and responsive to the impact local site conditions have on designs. Simplify the design change procedure to accommodate constructability issues and location-specific issues. Reduce time to review. | Standardization of design and drawings |
| 53 | Consider multiple project completion dates | Provide multiple project completion dates in the construction contract. For example, provide a primary completion date based on the traffic operation requirements and a secondary completion date for non-critical tasks like landscaping, walkways, etc. Multiple completion dates provides the contractor flexibility, which can potentially reduce the cost as they can more efficiently utilize their resources. | Unnecessary milestones |
| 54 | Provide flexible project start time | Provide a flexible start time to allow contractors to plan and schedule their resources better. This may reduce the impact of competition on material costs, particularly when many projects are let simultaneously. Consider flexible start dates on projects that involve offsite preparatory work that can be accomplished prior to the starting date. Contractors may be able to bid for more projects with flexible start times. | Inadequate production capacity of sources and storage capacity<br>Time of letting and number of construction projects in the market |
| 55 | Provide schedule flexibility to contractors | Contractors may use the schedule flexibility to more efficiently utilize resources as per availability of resources rather than based on project schedule and milestone requirements. With schedule flexibility, contractors may be able to bid on more projects. | Inadequate capacity of sources and storage capacity<br>Effect of competing markets (local/state/national/global) on resources |

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| 56 | Understand impact of night work | Consider permitting night work after evaluating the schedule benefits versus cost of night work. This may help manage the impacts of federal and local requirements on truck use during night time construction. | Restriction on truck movement by federal and local regulations |
| 57 | Reduce construction durations | Consider shortening project durations to reduce the effect of inflation. Where feasible, longer duration projects can be shortened by splitting projects into multiple construction contracts. This method may be particularly effective for construction involving highly volatile material items such as concrete and resources, where contractors have a higher risk. | Effect of project duration on risk premium |
| 58 | Remove contract restrictions | Remove those contract restrictions that do not add value to the project. For example, TxDOT expects the same level of sampling and testing and corresponding paperwork for asphalt used on traffic level A and B facilities that it did on limited access interstate highways. Removing such restrictions may affect the bid price, e.g., reducing sampling and testing or paperwork requirements may reduce the bid price. | Contract restrictions |
| 59 | Schedule projects considering federal trucking requirements | Schedule projects after careful evaluation of the project conditions with respect to federal requirements on trucking. Maximize the hours during which truck drivers could operate and make less aggressive contract times where not necessary to reduce the number of drivers. Less aggressive contract times may reduce surcharges applied to hauling/delivery costs. | Restriction on truck movement by federal and local regulations |
| 60 | Plan adequate oversight for accelerated projects | For accelerated project development, plan effectively. Consider the cost impact of accelerated development. | Acceleration of project |

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| 61 | Contractor evaluation/grading | Grade contractor's performance. Use contractor evaluation not as a substitute for prequalification, rather as an element of prequalification process. | Prequalification requirements for contractors |
| 62 | Implement comprehensive approach to cost estimating | Develop systematic and structured approach to cost estimating for all levels of estimate development including the necessary tools to support estimate preparation. Include in estimate environmental factors, permitting ordinances, surcharges, and market conditions at the time of estimating, effect of unique design features on estimate, and recognition that limiting onsite evaluations of project site during development increases the risk of higher bid prices. | Outdated estimates |
| **INFORMATION AND TRAINING STRATEGY** | | | |
| 63 | Increase knowledge of design guidance and use of engineering judgment for design exceptions | Study design exceptions early in the design phase. Use of engineering judgment in design decisions may lead to more economical designs. | Reluctance to use design exceptions |
| 64 | Increase knowledge about the contractors and their capacities | Increase knowledge about the bidding capacity of the contractors, their expertise, and preferences to work in certain geographical locations. This knowledge can facilitate decisions regarding whether to bundle or split the projects. | Size of the project in terms of dollar value |
| 65 | Cross-district sharing of lessons learned | Share lessons learned from implementation of cost control methods across the state. Post-construction reviews can provide helpful ideas for controlling cost of future projects. | Lack of documentation and sharing |
| 66 | Understand and manage federal requirements for Disadvantaged Business Enterprise (DBE) | Understand federal requirements for DBE use, the availability of DBE companies within the state, and their location within the state. | Federal requirements for participation of DBE in projects |

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| 67 | Educate and train designers | Educate and train designers to develop sound, easy to construct, and rational designs.<br>-Educate and train designers not to be overly cautious, overly safe, or overly conservative when preparing designs;<br>-Educate designers to utilize data when making pavement rehabilitation decisions;<br>-Train designers to modify standard designs to suit project-specific requirements and help deal with the issue of overstandardization; and<br>-Educate and train designers to develop better understanding of application of standards. | Lack of design experience |
| 68 | Update design manuals | Update design manuals more frequently and incorporate the lessons learned from previously completed projects. | Standardization of design and drawings |
| 69 | Educate and train consultants and contractors on new/different design criteria | Train consultants and contractors for utilization of appropriate design criteria. This reduces the risk of errors by designers and construction inspection staff, as well as contractors by having multiple design specifications and standards. | Multiple design specifications and standards |
| **STAKEHOLDER INPUT STRATEGY** | | | |
| 70 | Conduct pre-bid meetings | Use pre-bid meetings to respond to the queries and concerns that contractors may have with designs and other contract documents. In pre-bid meetings contractor feedback on design, specifications and contract conditions can be obtained. Prompt response to the pre-bid queries is important to achieve realistic bids. | Lack of contractor input |

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| 71 | Provide for contractor input when developing drawings, specifications, and the construction schedule | Involve contractors early in the project design phase to better address constructability issues with plans and specifications and local and environmental restrictions. Contractors can suggest materials based on availability, construction methods, and construction staging approaches. Involve contractors in the development of preliminary schedules and setting milestones. This may result in more realistic contract durations. | Lack of contractor input<br>Environmental restrictions<br>Pressure on asphalt supply due to limited capacity of refineries and increased demand during asphalt season |
| 72 | Involve contractor in the design process | Involve contractors in developing designs. Contractors can better understand the impact of design on resource management and constructability. | Standardization of design and drawings |
| 73 | Conduct constructability reviews | Incorporate contractor expertise and experience when reviewing designs, estimates, construction methods, traffic control plans, and construction staging approaches. Constructability reviews can be in the form of internal, external, and post-construction reviews. Involve suppliers, contractors, and subcontractors when developing plans and specifications. This can result in easy to implement designs which are cost effective and reduce potential conflicts during execution. | Lack of contractor input<br>Multiple design specifications and standards |
| **PROJECT MARKETING AND ADVERTISING STRATEGY** | | | |
| 74 | Market new projects aggressively | Market new project opportunities aggressively, particularly on a large or complex project. This may be useful to attract more bidders. Develop working models, 3-D CAD views, walk-throughs, and special presentations in this regard. | Difficult, complex, or large projects |

| ADDITIONAL METHODS PROPOSED BY DELPHI EXPERTS IN ROUND-1 OF SURVEY | | | |
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| 75 | Avoid lumping too many work items together | Avoid lumping too many work items together. Itemizing work gives clarity to the contractor regarding the extent of work and scope. Also it prevents them from charging for unforeseen items and quantities. For example, ROW preparation is an initial item involving too many different types of work items and requiring additional startup money. Another example where work lumped together can be avoided is box culvert concrete extension where work is lumped together by linear foot item replacing different work items. | Improper scope definition |
| 76 | Take more time during design to get it right in the first place | Cost overruns, delays, and safety problems often arise due to defective designs. Also, contractors include contingency costs in their bids when designs appear flawed. | Defective designs |
| 77 | Do a more thorough job of determining and optimizing the scope of the project before design begins | Once design begins, do not allow changes in scope unless there is a relaxation of the letting date. This would allow the scope change to be incorporated into the plan set carefully, to avoid design errors and conflicts. | Improper scope definition |
| 78 | Better utilize inspectors | Stop measuring every square foot or cubic yard of material used. Instead use the schedule to progress the project. Daily work reports only generate an estimate. They actually reduce the amount of time our inspectors spend inspecting. | DOT engineers' time not effectively utilized |

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| 79 | Do away with Material-on-Hand (MOH) | Allow contractors to bid all of their materials into mobilization. Put a MOH bid item and pay a percentage for each estimate. Do not track MOH extensively as is done now. It is too costly and it even results in supplemental estimates, when there are mistakes in estimates. Recordkeepers spend at least 10 hours per estimate on MOH. Instead, MOH could be added to contractor's mobilization payment using suitable mechanism. | DOT engineers' time not effectively utilized |
| 80 | Implement formal risk identification and management program | Identifying the potential risk and providing project managers an opportunity to manage these risks out of the project can result in a significant cost savings. | Lack of formal risk management practices |
| 81 | Develop selection tools for contracting methods based on past performance of alternative contracts | Develop selection tools for contracting methods to be used for alternative contracting methods. The past experience of the alternative contracts performance may be useful. | Lack of use of knowledge on past performance of alternative contracting methods |

# APPENDIX D

## DELPHI GROUP RESPONSE IN FIRST AND SECOND ROUND

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **BUSINESS OPERATIONS, PROCEDURES, AND POLICIES STRATEGY** | | | | | | | | | | |
| 1 | **Plan ahead and communicate requirements to material suppliers in advance** | No | Low | Med | High | Very High | No | Low | Med | High | Very High |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 16.7% | 66.7% | 12.5% | 4.2% | 0.0% | 22.2% | 55.6% | 18.5% | 3.7% |
| | | Positive | Neutral | Negative | | | Positive | Neutral | Negative | | |
| | What is anticipated impact of this method on Quality? | 50.0% | 50.0% | 0.0% | | | 48.1% | 51.9% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 91.7% | 8.3% | 0.0% | | | 88.9% | 11.1% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 12.5% | 87.5% | 0.0% | | | 14.8% | 85.2% | 0.0% | | |
| | | Yes | No | | | | Yes | No | | | |
| | Is there a legal or institutional barrier to implement this method? | 8.3% | 91.7% | | | | 15.4% | 84.6% | | | |
| 2 | **Evaluate local market condition for availability of resources to effectively plan construction lettings** | No | Low | Med | High | Very High | No | Low | Med | High | Very High |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 12.5% | 62.5% | 20.8% | 0.0% | 3.7% | 22.2% | 48.1% | 18.5% | 7.4% |
| | | Positive | Neutral | Negative | | | Positive | Neutral | Negative | | |
| | What is anticipated impact of this method on Quality? | 50.0% | 50.0% | 0.0% | | | 55.6% | 44.4% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 91.7% | 4.2% | 4.2% | | | 85.2% | 7.4% | 7.4% | | |
| | What is anticipated impact of this method on Safety? | 20.8% | 79.2% | 0.0% | | | 18.5% | 81.5% | 0.0% | | |
| | | Yes | No | | | | Yes | No | | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 7.7% | 92.3% | | | |
| 3 | **Evaluate restrictions on imported materials** | No | Low | Med | High | Very High | No | Low | Med | High | Very High |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 16.7% | 50.0% | 29.2% | 0.0% | 3.7% | 18.5% | 40.7% | 25.9% | 11.1% |
| | | Positive | Neutral | Negative | | | Positive | Neutral | Negative | | |
| | What is anticipated impact of this method on Quality? | 20.8% | 58.3% | 20.8% | | | 22.2% | 51.9% | 25.9% | | |
| | What is anticipated impact of this method on Schedule? | 50.0% | 45.8% | 4.2% | | | 55.6% | 37.0% | 7.4% | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on Safety? | 20.8% | 62.5% | 16.7% | | | 18.5% | 63.0% | 18.5% | | |
| | | Yes | No | | | | Yes | No | | | |
| | Is there a legal or institutional barrier to implement this method? | 87.5% | 12.5% | | | | 77.8% | 22.2% | | | |
| 4 | **Create material sources by TxDOT** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 25.0% | 33.3% | 37.5% | 0.0% | 7.4% | 22.2% | 29.6% | 37.0% | 3.7% |
| | What is anticipated impact of this method on Quality? | 50.0% | 45.8% | 4.2% | | | 48.1% | 48.1% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 70.8% | 16.7% | 12.5% | | | 63.0% | 22.2% | 14.8% | | |
| | What is anticipated impact of this method on Safety? | 25.0% | 75.0% | 0.0% | | | 25.9% | 70.4% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 47.8% | 52.2% | | | | 52.0% | 48.0% | | | |
| 5 | **Utilize owner buying power** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 20.8% | 54.2% | 20.8% | 0.0% | 7.4% | 25.9% | 37.0% | 18.5% | 11.1% |
| | What is anticipated impact of this method on Quality? | 8.3% | 87.5% | 4.2% | | | 14.8% | 77.8% | 7.4% | | |
| | What is anticipated impact of this method on Schedule? | 54.2% | 37.5% | 8.3% | | | 48.1% | 37.0% | 14.8% | | |
| | What is anticipated impact of this method on Safety? | 12.5% | 87.5% | 0.0% | | | 11.5% | 88.5% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 52.2% | 47.8% | | | | 52.0% | 48.0% | | | |
| 6 | **Purchase commitments to suppliers by TxDOT with option for buying** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 12.5% | 33.3% | 50.0% | 4.2% | 0.0% | 11.1% | 29.6% | 40.7% | 14.8% | 3.7% |
| | What is anticipated impact of this method on Quality? | 8.3% | 87.5% | 4.2% | | | 14.8% | 74.1% | 11.1% | | |
| | What is anticipated impact of this method on Schedule? | 54.2% | 45.8% | 0.0% | | | 51.9% | 44.4% | 3.7% | | |
| | What is anticipated impact of this method on Safety? | 0.0% | 100.0% | 0.0% | | | 3.7% | 96.3% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 59.1% | 40.9% | | | | 58.3% | 41.7% | | | |
| 7 | **Provide state yards** | | | | | | | | | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 12.5% | 45.8% | 25.0% | 16.7% | 0.0% | 14.8% | 37.0% | 25.9% | 22.2% | 0.0% |
| | What is anticipated impact of this method on Quality? | 25.0% | 75.0% | 0.0% | | | 33.3% | 63.0% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 45.8% | 54.2% | 0.0% | | | 48.1% | 48.1% | 3.7% | | |
| | What is anticipated impact of this method on Safety? | 8.3% | 87.5% | 4.2% | | | 25.9% | 66.7% | 7.4% | | |
| | Is there a legal or institutional barrier to implement this method? | 22.7% | 77.3% | | | | 29.2% | 70.8% | | | |
| 8 | **State owned batch plants and crews** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 25.0% | 20.8% | 29.2% | 20.8% | 4.2% | 25.9% | 22.2% | 25.9% | 18.5% | 7.4% |
| | What is anticipated impact of this method on Quality? | 50.0% | 33.3% | 16.7% | | | 48.1% | 33.3% | 18.5% | | |
| | What is anticipated impact of this method on Schedule? | 41.7% | 37.5% | 20.8% | | | 37.0% | 33.3% | 29.6% | | |
| | What is anticipated impact of this method on Safety? | 25.0% | 50.0% | 25.0% | | | 25.9% | 44.4% | 29.6% | | |
| | Is there a legal or institutional barrier to implement this method? | 39.1% | 60.9% | | | | 40.0% | 60.0% | | | |
| 9 | **Evaluate alternate contracting methods including design-build (D-B) and construction manager at risk (CM @ Risk*)** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 8.3% | 62.5% | 25.0% | 0.0% | 3.7% | 18.5% | 48.1% | 29.6% | 0.0% |
| | What is anticipated impact of this method on Quality? | 29.2% | 45.8% | 25.0% | | | 29.6% | 37.0% | 33.3% | | |
| | What is anticipated impact of this method on Schedule? | 100.0% | 0.0% | 0.0% | | | 96.3% | 3.7% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 25.0% | 70.8% | 4.2% | | | 25.9% | 70.4% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 47.8% | 52.2% | | | | 48.0% | 52.0% | | | |
| 10 | **Update construction cost estimates based on experience and analysis of construction components (labor, materials, equipment, etc.)** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 25.0% | 54.2% | 12.5% | 8.3% | 0.0% | 33.3% | 40.7% | 14.8% | 11.1% | 0.0% |
| | What is anticipated impact of this method on Quality? | 12.5% | 87.5% | 0.0% | | | 14.8% | 81.5% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 12.5% | 83.3% | 4.2% | | | 18.5% | 77.8% | 3.7% | | |
| | What is anticipated impact of this method on Safety? | 4.2% | 95.8% | 0.0% | | | 3.7% | 96.3% | 0.0% | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Is there a legal or institutional barrier to implement this method? | 8.3% | 91.7% | | | | 18.5% | 81.5% | | | |
| 11 | **Share cost savings with the contractors** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 33.3% | 54.2% | 12.5% | 0.0% | 0.0% | 37.0% | 44.4% | 18.5% | 0.0% |
| | What is anticipated impact of this method on Quality? | 12.5% | 75.0% | 12.5% | | | 22.2% | 66.7% | 11.1% | | |
| | What is anticipated impact of this method on Schedule? | 41.7% | 58.3% | 0.0% | | | 44.4% | 51.9% | 3.7% | | |
| | What is anticipated impact of this method on Safety? | 4.2% | 87.5% | 8.3% | | | 3.7% | 88.9% | 7.4% | | |
| | Is there a legal or institutional barrier to implement this method? | 50.0% | 50.0% | | | | 57.7% | 42.3% | | | |
| 12 | **Reduce cost of inspection (consider use of supplier and contractor test results)** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 25.0% | 58.3% | 12.5% | 4.2% | 0.0% | 29.6% | 51.9% | 14.8% | 3.7% | 0.0% |
| | What is anticipated impact of this method on Quality? | 0.0% | 25.0% | 75.0% | | | 0.0% | 22.2% | 77.8% | | |
| | What is anticipated impact of this method on Schedule? | 33.3% | 58.3% | 8.3% | | | 33.3% | 59.3% | 7.4% | | |
| | What is anticipated impact of this method on Safety? | 4.2% | 62.5% | 33.3% | | | 3.7% | 55.6% | 40.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 29.2% | 70.8% | | | | 37.0% | 63.0% | | | |
| 13 | **Add price adjustment clause to contracts** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 33.3% | 54.2% | 8.3% | 4.2% | 3.7% | 29.6% | 48.1% | 14.8% | 3.7% |
| | What is anticipated impact of this method on Quality? | 4.2% | 91.7% | 4.2% | | | 14.8% | 77.8% | 7.4% | | |
| | What is anticipated impact of this method on Schedule? | 12.5% | 79.2% | 8.3% | | | 18.5% | 70.4% | 11.1% | | |
| | What is anticipated impact of this method on Safety? | 0.0% | 95.8% | 4.2% | | | 0.0% | 92.6% | 7.4% | | |
| | Is there a legal or institutional barrier to implement this method? | 45.8% | 54.2% | | | | 48.1% | 51.9% | | | |
| 14 | **Consider material advance for projects having longer duration** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 37.5% | 37.5% | 16.7% | 4.2% | 7.4% | 33.3% | 37.0% | 18.5% | 3.7% |
| | What is anticipated impact of this method on Quality? | 20.8% | 79.2% | 0.0% | | | 22.2% | 70.4% | 7.4% | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on Schedule? | 70.8% | 29.2% | 0.0% | | | 63.0% | 37.0% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 16.7% | 83.3% | 0.0% | | | 14.8% | 85.2% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 16.7% | 83.3% | | | | 26.9% | 73.1% | | | |
| 15 | **Provide owner controlled bonding for small contractors** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 8.3% | 75.0% | 16.7% | 0.0% | 0.0% | 7.4% | 77.8% | 14.8% | 0.0% | 0.0% |
| | What is anticipated impact of this method on Quality? | 12.5% | 66.7% | 20.8% | | | 14.8% | 51.9% | 33.3% | | |
| | What is anticipated impact of this method on Schedule? | 12.5% | 75.0% | 12.5% | | | 14.8% | 74.1% | 11.1% | | |
| | What is anticipated impact of this method on Safety? | 0.0% | 91.7% | 8.3% | | | 0.0% | 92.6% | 7.4% | | |
| | Is there a legal or institutional barrier to implement this method? | 73.9% | 26.1% | | | | 65.2% | 34.8% | | | |
| 16 | **Reduce bond cost over project time** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 56.5% | 39.1% | 4.3% | 0.0% | 3.8% | 50.0% | 38.5% | 7.7% | 0.0% |
| | What is anticipated impact of this method on Quality? | 4.3% | 91.3% | 4.3% | | | 3.8% | 84.6% | 11.5% | | |
| | What is anticipated impact of this method on Schedule? | 13.0% | 82.6% | 4.3% | | | 19.2% | 73.1% | 7.7% | | |
| | What is anticipated impact of this method on Safety? | 4.3% | 95.7% | 0.0% | | | 3.8% | 96.2% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 72.7% | 27.3% | | | | 65.2% | 34.8% | | | |
| 17 | **Relax prequalification requirements for certain projects** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 75.0% | 20.8% | 0.0% | 0.0% | 11.5% | 69.2% | 19.2% | 0.0% | 0.0% |
| | What is anticipated impact of this method on Quality? | 4.2% | 8.3% | 87.5% | | | 3.8% | 15.4% | 80.8% | | |
| | What is anticipated impact of this method on Schedule? | 12.5% | 58.3% | 29.2% | | | 11.5% | 50.0% | 38.5% | | |
| | What is anticipated impact of this method on Safety? | 4.2% | 62.5% | 33.3% | | | 3.8% | 61.5% | 34.6% | | |
| | Is there a legal or institutional barrier to implement this method? | 66.7% | 33.3% | | | | 65.2% | 34.8% | | | |
| 18 | **Increase bid preparation time** | | | | | | | | | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 12.5% | 4.2% | 62.5% | 20.8% | 0.0% | 11.1% | 18.5% | 51.9% | 18.5% | 0.0% |
| | What is anticipated impact of this method on Quality? | 41.7% | 58.3% | 0.0% | | | 48.1% | 51.9% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 41.7% | 54.2% | 4.2% | | | 48.1% | 48.1% | 3.7% | | |
| | What is anticipated impact of this method on Safety? | 20.8% | 79.2% | 0.0% | | | 25.9% | 74.1% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 13.0% | 87.0% | | | | 25.0% | 75.0% | | | |
| 19 | **Control scope creep by accountable authority** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 25.0% | 54.2% | 12.5% | 8.3% | 3.7% | 29.6% | 44.4% | 18.5% | 3.7% |
| | What is anticipated impact of this method on Quality? | 8.3% | 83.3% | 8.3% | | | 18.5% | 74.1% | 7.4% | | |
| | What is anticipated impact of this method on Schedule? | 75.0% | 25.0% | 0.0% | | | 63.0% | 37.0% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 4.2% | 91.7% | 4.2% | | | 3.7% | 92.6% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 3.8% | 96.2% | | | |
| 20 | **Increase flexibility in traffic control planning** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 25.0% | 50.0% | 12.5% | 8.3% | 3.8% | 30.8% | 42.3% | 15.4% | 7.7% |
| | What is anticipated impact of this method on Quality? | 29.2% | 58.3% | 12.5% | | | 30.8% | 53.8% | 15.4% | | |
| | What is anticipated impact of this method on Schedule? | 87.5% | 8.3% | 4.2% | | | 84.6% | 11.5% | 3.8% | | |
| | What is anticipated impact of this method on Safety? | 16.7% | 37.5% | 45.8% | | | 23.1% | 34.6% | 42.3% | | |
| | Is there a legal or institutional barrier to implement this method? | 26.1% | 73.9% | | | | 34.6% | 65.4% | | | |
| 21 | **Ease contracting requirements with TxDOT** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 12.5% | 54.2% | 33.3% | 0.0% | 0.0% | 14.8% | 48.1% | 29.6% | 7.4% | 0.0% |
| | What is anticipated impact of this method on Quality? | 4.2% | 58.3% | 37.5% | | | 3.7% | 55.6% | 40.7% | | |
| | What is anticipated impact of this method on Schedule? | 25.0% | 66.7% | 8.3% | | | 18.5% | 66.7% | 14.8% | | |
| | What is anticipated impact of this method on Safety? | 4.2% | 75.0% | 20.8% | | | 3.7% | 66.7% | 29.6% | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Is there a legal or institutional barrier to implement this method? | 36.4% | 63.6% | | | | 37.5% | 62.5% | | | |
| 22 | **Change evaluations of TxDOT districts** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 43.5% | 43.5% | 13.0% | 0.0% | 0.0% | 42.3% | 38.5% | 15.4% | 3.8% | 0.0% |
| | What is anticipated impact of this method on Quality? | 21.7% | 78.3% | 0.0% | | | 34.6% | 57.7% | 7.7% | | |
| | What is anticipated impact of this method on Schedule? | 8.7% | 78.3% | 13.0% | | | 19.2% | 65.4% | 15.4% | | |
| | What is anticipated impact of this method on Safety? | 4.3% | 95.7% | 0.0% | | | 11.5% | 84.6% | 3.8% | | |
| | Is there a legal or institutional barrier to implement this method? | 18.2% | 77.3% | | | | 39.1% | 60.9% | | | |
| | MATERIAL MANAGEMENT STRATEGY | | | | | | | | | | |
| 23 | **Consider locally available materials in design** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 16.7% | 54.2% | 20.8% | 4.2% | 7.4% | 22.2% | 37.0% | 29.6% | 3.7% |
| | What is anticipated impact of this method on Quality? | 20.8% | 50.0% | 29.2% | | | 25.9% | 44.4% | 29.6% | | |
| | What is anticipated impact of this method on Schedule? | 83.3% | 16.7% | 0.0% | | | 77.8% | 22.2% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 8.3% | 87.5% | 4.2% | | | 11.1% | 85.2% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 7.7% | 92.3% | | | |
| 24 | **Reuse and recycle materials** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 16.7% | 62.5% | 8.3% | 8.3% | 7.4% | 18.5% | 51.9% | 14.8% | 7.4% |
| | What is anticipated impact of this method on Quality? | 8.3% | 54.2% | 37.5% | | | 11.1% | 55.6% | 33.3% | | |
| | What is anticipated impact of this method on Schedule? | 41.7% | 58.3% | 0.0% | | | 48.1% | 51.9% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 8.3% | 91.7% | 0.0% | | | 7.4% | 92.6% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 7.7% | 92.3% | | | |
| 25 | **Change mode of transport** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 20.8% | 41.7% | 25.0% | 0.0% | 12.5% | 25.9% | 33.3% | 29.6% | 0.0% | 11.1% |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on Quality? | 12.5% | 87.5% | 0.0% | | | 11.1% | 88.9% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 25.0% | 62.5% | 12.5% | | | 25.9% | 55.6% | 18.5% | | |
| | What is anticipated impact of this method on Safety? | 25.0% | 75.0% | 0.0% | | | 25.9% | 74.1% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 8.3% | 91.7% | | | | 11.5% | 88.5% | | | |
| 26 | **Minimize mobilization** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 12.5% | 20.8% | 54.2% | 8.3% | 4.2% | 14.8% | 25.9% | 40.7% | 14.8% | 3.7% |
| | What is anticipated impact of this method on Quality? | 12.5% | 87.5% | 0.0% | | | 14.8% | 81.5% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 70.8% | 25.0% | 4.2% | | | 66.7% | 25.9% | 7.4% | | |
| | What is anticipated impact of this method on Safety? | 20.8% | 79.2% | 0.0% | | | 22.2% | 77.8% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 8.3% | 91.7% | | | | 15.4% | 84.6% | | | |
| | **DESIGN AND VALUE MANAGEMENT STRATEGY** | | | | | | | | | | |
| 27 | **Coordinate lettings based on the availability and capacity of contractors in the region** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 12.5% | 50.0% | 29.2% | 4.2% | 3.7% | 25.9% | 44.4% | 22.2% | 3.7% |
| | What is anticipated impact of this method on Quality? | 41.7% | 58.3% | 0.0% | | | 40.7% | 55.6% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 70.8% | 16.7% | 12.5% | | | 55.6% | 18.5% | 25.9% | | |
| | What is anticipated impact of this method on Safety? | 12.5% | 87.5% | 0.0% | | | 14.8% | 85.2% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 12.5% | 87.5% | | | |
| 28 | **Time the projects to avoid environmental restrictions** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 8.3% | 50.0% | 33.3% | 4.2% | 4.2% | 11.1% | 44.4% | 29.6% | 7.4% | 7.4% |
| | What is anticipated impact of this method on Quality? | 12.5% | 87.5% | 0.0% | | | 14.8% | 81.5% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 50.0% | 20.8% | 29.2% | | | 44.4% | 22.2% | 33.3% | | |
| | What is anticipated impact of this method on Safety? | 16.7% | 83.3% | 0.0% | | | 18.5% | 81.5% | 0.0% | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 7.4% | 92.6% | | | |
| 29 | **Provide alternative materials in PS&E** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 12.5% | 58.3% | 25.0% | 4.2% | 0.0% | 22.2% | 44.4% | 25.9% | 7.4% |
| | What is anticipated impact of this method on Quality? | 12.5% | 70.8% | 16.7% | | | 14.8% | 66.7% | 18.5% | | |
| | What is anticipated impact of this method on Schedule? | 62.5% | 37.5% | 0.0% | | | 55.6% | 44.4% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 8.3% | 87.5% | 4.2% | | | 7.4% | 88.9% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 7.7% | 92.3% | | | |
| 30 | **Evaluate specifications and select materials that would allow relaxation of asphalt concrete temperature restrictions** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 12.5% | 58.3% | 25.0% | 0.0% | 4.2% | 14.8% | 51.9% | 29.6% | 0.0% | 3.7% |
| | What is anticipated impact of this method on Quality? | 4.2% | 20.8% | 75.0% | | | 7.4% | 22.2% | 70.4% | | |
| | What is anticipated impact of this method on Schedule? | 50.0% | 50.0% | 0.0% | | | 51.9% | 44.4% | 3.7% | | |
| | What is anticipated impact of this method on Safety? | 12.5% | 83.3% | 4.2% | | | 14.8% | 77.8% | 7.4% | | |
| | Is there a legal or institutional barrier to implement this method? | 20.8% | 79.2% | | | | 26.9% | 73.1% | | | |
| 31 | **Consider warm mix asphalts** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 8.3% | 62.5% | 16.7% | 12.5% | 0.0% | 11.1% | 51.9% | 22.2% | 14.8% | 0.0% |
| | What is anticipated impact of this method on Quality? | 8.3% | 41.7% | 50.0% | | | 7.4% | 48.1% | 44.4% | | |
| | What is anticipated impact of this method on Schedule? | 54.2% | 45.8% | 0.0% | | | 59.3% | 40.7% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 16.7% | 79.2% | 4.2% | | | 25.9% | 70.4% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 12.5% | 87.5% | | | | 19.2% | 80.8% | | | |
| 32 | **Consider alternative designs** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 25.0% | 50.0% | 25.0% | 0.0% | 3.7% | 22.2% | 44.4% | 29.6% | 0.0% |
| | What is anticipated impact of this method on Quality? | 16.7% | 79.2% | 4.2% | | | 22.2% | 66.7% | 11.1% | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on Schedule? | 54.2% | 45.8% | 0.0% | | | 51.9% | 48.1% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 12.5% | 83.3% | 4.2% | | | 14.8% | 81.5% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 8.3% | 91.7% | | | | 19.2% | 80.8% | | | |
| 33 | **Apply correct design criteria** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 16.7% | 58.3% | 25.0% | 0.0% | 3.8% | 23.1% | 42.3% | 30.8% | 0.0% |
| | What is anticipated impact of this method on Quality? | 70.8% | 25.0% | 4.2% | | | 57.7% | 38.5% | 3.8% | | |
| | What is anticipated impact of this method on Schedule? | 66.7% | 33.3% | 0.0% | | | 53.8% | 42.3% | 3.8% | | |
| | What is anticipated impact of this method on Safety? | 45.8% | 54.2% | 0.0% | | | 46.2% | 50.0% | 3.8% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 8.0% | 92.0% | | | |
| 34 | **Understand and manage the differences between federal and state standards** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 66.7% | 29.2% | 4.2% | 0.0% | 0.0% | 63.0% | 25.9% | 11.1% | 0.0% |
| | What is anticipated impact of this method on Quality? | 12.5% | 79.2% | 8.3% | | | 14.8% | 74.1% | 11.1% | | |
| | What is anticipated impact of this method on Schedule? | 25.0% | 75.0% | 0.0% | | | 33.3% | 66.7% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 8.3% | 91.7% | 0.0% | | | 11.1% | 77.8% | 11.1% | | |
| | Is there a legal or institutional barrier to implement this method? | 8.3% | 91.7% | | | | 18.5% | 81.5% | | | |
| 35 | **Check cost effectiveness of specialty items at early stage** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 8.7% | 17.4% | 52.2% | 17.4% | 4.3% | 15.4% | 15.4% | 42.3% | 23.1% | 3.8% |
| | What is anticipated impact of this method on Quality? | 21.7% | 73.9% | 4.3% | | | 23.1% | 73.1% | 3.8% | | |
| | What is anticipated impact of this method on Schedule? | 47.8% | 47.8% | 4.3% | | | 46.2% | 46.2% | 7.7% | | |
| | What is anticipated impact of this method on Safety? | 13.0% | 87.0% | 0.0% | | | 11.5% | 84.6% | 3.8% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 8.0% | 92.0% | | | |
| 36 | **Standardize designs and provide more design repetition** | | | | | | | | | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 12.5% | 50.0% | 25.0% | 8.3% | 3.7% | 14.8% | 44.4% | 22.2% | 14.8% |
| | What is anticipated impact of this method on Quality? | 58.3% | 41.7% | 0.0% | | | 63.0% | 37.0% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 83.3% | 16.7% | 0.0% | | | 85.2% | 14.8% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 45.8% | 54.2% | 0.0% | | | 51.9% | 48.1% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 7.4% | 92.6% | | | |
| 37 | **Minimize detours and diversions** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 25.0% | 29.2% | 37.5% | 4.2% | 7.7% | 19.2% | 26.9% | 42.3% | 3.8% |
| | What is anticipated impact of this method on Quality? | 29.2% | 58.3% | 12.5% | | | 29.6% | 51.9% | 18.5% | | |
| | What is anticipated impact of this method on Schedule? | 58.3% | 29.2% | 12.5% | | | 55.6% | 25.9% | 18.5% | | |
| | What is anticipated impact of this method on Safety? | 37.5% | 41.7% | 20.8% | | | 40.7% | 37.0% | 22.2% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 7.4% | 92.6% | | | |
| 38 | **Obtain pavement evaluation data** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 8.3% | 29.2% | 50.0% | 8.3% | 4.2% | 7.4% | 33.3% | 44.4% | 7.4% | 7.4% |
| | What is anticipated impact of this method on Quality? | 75.0% | 25.0% | 0.0% | | | 70.4% | 29.6% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 29.2% | 70.8% | 0.0% | | | 33.3% | 66.7% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 25.0% | 75.0% | 0.0% | | | 25.9% | 74.1% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 3.7% | 96.3% | | | |
| 39 | **Provide more utility information using subsurface utility engineering** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 29.2% | 41.7% | 16.7% | 8.3% | 3.7% | 33.3% | 33.3% | 14.8% | 14.8% |
| | What is anticipated impact of this method on Quality? | 45.8% | 54.2% | 0.0% | | | 44.4% | 55.6% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 91.7% | 8.3% | 0.0% | | | 88.9% | 11.1% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 66.7% | 33.3% | 0.0% | | | 59.3% | 40.7% | 0.0% | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 7.4% | 92.6% | | | |
| 40 | **Conduct more geotechnical investigations** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 41.7% | 29.2% | 25.0% | 4.2% | 0.0% | 37.0% | 29.6% | 29.6% | 3.7% |
| | What is anticipated impact of this method on Quality? | 83.3% | 16.7% | 0.0% | | | 77.8% | 22.2% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 75.0% | 16.7% | 8.3% | | | 77.8% | 14.8% | 7.4% | | |
| | What is anticipated impact of this method on Safety? | 37.5% | 62.5% | 0.0% | | | 44.4% | 55.6% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 3.7% | 96.3% | | | |
| | **CONTRACT MANAGEMENT AND PROJECT DELIVERY STRATEGY** | | | | | | | | | | |
| 41 | **Understand and manage environmental restrictions** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 8.3% | 45.8% | 29.2% | 12.5% | 4.2% | 11.1% | 40.7% | 25.9% | 18.5% | 3.7% |
| | What is anticipated impact of this method on Quality? | 29.2% | 70.8% | 0.0% | | | 40.7% | 59.3% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 70.8% | 25.0% | 4.2% | | | 63.0% | 22.2% | 14.8% | | |
| | What is anticipated impact of this method on Safety? | 16.7% | 83.3% | 0.0% | | | 14.8% | 81.5% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 7.4% | 92.6% | | | |
| 42 | **Recognize cost of inspections as a hidden cost** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 34.8% | 56.5% | 4.3% | 4.3% | 0.0% | 34.6% | 53.8% | 3.8% | 7.7% | 0.0% |
| | What is anticipated impact of this method on Quality? | 8.7% | 91.3% | 0.0% | | | 11.5% | 84.6% | 3.8% | | |
| | What is anticipated impact of this method on Schedule? | 4.3% | 95.7% | 0.0% | | | 3.8% | 88.5% | 7.7% | | |
| | What is anticipated impact of this method on Safety? | 4.3% | 95.7% | 0.0% | | | 7.7% | 92.3% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 13.0% | 87.0% | | | | 16.0% | 84.0% | | | |
| 43 | **Review specifications for their applicability to the given project** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 62.5% | 29.2% | 4.2% | 0.0% | 7.4% | 55.6% | 25.9% | 11.1% | 0.0% |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on Quality? | 50.0% | 41.7% | 8.3% | | | 44.4% | 40.7% | 14.8% | | |
| | What is anticipated impact of this method on Schedule? | 58.3% | 41.7% | 0.0% | | | 51.9% | 48.1% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 12.5% | 83.3% | 4.2% | | | 19.2% | 76.9% | 3.8% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 7.4% | 92.6% | | | |
| 44 | **Use performance or end product specifications** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 41.7% | 50.0% | 4.2% | 4.2% | 3.7% | 40.7% | 40.7% | 11.1% | 3.7% |
| | What is anticipated impact of this method on Quality? | 37.5% | 54.2% | 8.3% | | | 37.0% | 48.1% | 14.8% | | |
| | What is anticipated impact of this method on Schedule? | 78.3% | 21.7% | 0.0% | | | 73.1% | 23.1% | 3.8% | | |
| | What is anticipated impact of this method on Safety? | 8.3% | 87.5% | 4.2% | | | 7.4% | 88.9% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 37.5% | 62.5% | | | | 40.7% | 59.3% | | | |
| 45 | **Bundle construction projects for exploring economies of scale** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 25.0% | 50.0% | 25.0% | 0.0% | 0.0% | 29.6% | 44.4% | 25.9% | 0.0% |
| | What is anticipated impact of this method on Quality? | 33.3% | 66.7% | 0.0% | | | 37.0% | 63.0% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 70.8% | 12.5% | 16.7% | | | 59.3% | 22.2% | 18.5% | | |
| | What is anticipated impact of this method on Safety? | 16.7% | 83.3% | 0.0% | | | 18.5% | 81.5% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 7.7% | 92.3% | | | |
| 46 | **Split construction projects** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 12.5% | 58.3% | 12.5% | 16.7% | 0.0% | 14.8% | 51.9% | 22.2% | 11.1% | 0.0% |
| | What is anticipated impact of this method on Quality? | 12.5% | 79.2% | 8.3% | | | 18.5% | 70.4% | 11.1% | | |
| | What is anticipated impact of this method on Schedule? | 29.2% | 29.2% | 41.7% | | | 29.6% | 29.6% | 40.7% | | |
| | What is anticipated impact of this method on Safety? | 8.3% | 83.3% | 8.3% | | | 7.4% | 81.5% | 11.1% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 7.4% | 92.6% | | | |
| 47 | **Group specialty items into a separate package** | | | | | | | | | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 16.7% | 45.8% | 25.0% | 8.3% | 4.2% | 14.8% | 44.4% | 22.2% | 14.8% | 3.7% |
| | What is anticipated impact of this method on Quality? | 54.2% | 41.7% | 4.2% | | | 48.1% | 48.1% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 33.3% | 33.3% | 33.3% | | | 33.3% | 29.6% | 37.0% | | |
| | What is anticipated impact of this method on Safety? | 8.3% | 91.7% | 0.0% | | | 7.4% | 92.6% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 3.7% | 96.3% | | | |
| 48 | **Add alternate package for aesthetics** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 25.0% | 50.0% | 12.5% | 8.3% | 4.2% | 25.9% | 44.4% | 14.8% | 11.1% | 3.7% |
| | What is anticipated impact of this method on Quality? | 45.8% | 45.8% | 8.3% | | | 44.4% | 44.4% | 11.1% | | |
| | What is anticipated impact of this method on Schedule? | 33.3% | 37.5% | 29.2% | | | 29.6% | 33.3% | 37.0% | | |
| | What is anticipated impact of this method on Safety? | 8.3% | 91.7% | 0.0% | | | 11.1% | 77.8% | 11.1% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 11.1% | 88.9% | | | |
| 49 | **Provide design-build lump-sum contract for traffic control** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 45.5% | 22.7% | 22.7% | 9.1% | 0.0% | 44.0% | 24.0% | 24.0% | 8.0% | 0.0% |
| | What is anticipated impact of this method on Quality? | 22.7% | 50.0% | 27.3% | | | 20.0% | 48.0% | 32.0% | | |
| | What is anticipated impact of this method on Schedule? | 31.8% | 40.9% | 27.3% | | | 28.0% | 44.0% | 28.0% | | |
| | What is anticipated impact of this method on Safety? | 13.6% | 54.5% | 31.8% | | | 12.0% | 52.0% | 36.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 31.8% | 68.2% | | | | 30.4% | 69.6% | | | |
| 50 | **Control project duration using A+B bidding without incentives/disincentives** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 34.8% | 30.4% | 26.1% | 4.3% | 4.3% | 28.0% | 32.0% | 28.0% | 8.0% | 4.0% |
| | What is anticipated impact of this method on Quality? | 17.4% | 73.9% | 8.7% | | | 19.2% | 73.1% | 7.7% | | |
| | What is anticipated impact of this method on Schedule? | 78.3% | 21.7% | 0.0% | | | 76.9% | 23.1% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 8.7% | 82.6% | 8.7% | | | 11.5% | 80.8% | 7.7% | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Is there a legal or institutional barrier to implement this method? | 13.0% | 87.0% | | | | 19.2% | 80.8% | | | |
| 51 | **Reject non-competitive bids and re-advertise** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 16.7% | 45.8% | 25.0% | 8.3% | 4.2% | 25.9% | 33.3% | 29.6% | 7.4% | 3.7% |
| | What is anticipated impact of this method on Quality? | 8.3% | 87.5% | 4.2% | | | 7.4% | 85.2% | 7.4% | | |
| | What is anticipated impact of this method on Schedule? | 4.2% | 45.8% | 50.0% | | | 7.4% | 44.4% | 48.1% | | |
| | What is anticipated impact of this method on Safety? | 4.2% | 95.8% | 0.0% | | | 3.7% | 92.6% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 14.8% | 85.2% | | | |
| 52 | **Improve design change procedure to increase responsiveness to change (fast and simple)** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 58.3% | 29.2% | 4.2% | 4.2% | 7.4% | 48.1% | 29.6% | 11.1% | 3.7% |
| | What is anticipated impact of this method on Quality? | 25.0% | 66.7% | 8.3% | | | 25.9% | 66.7% | 7.4% | | |
| | What is anticipated impact of this method on Schedule? | 83.3% | 16.7% | 0.0% | | | 85.2% | 14.8% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 20.8% | 70.8% | 8.3% | | | 22.2% | 70.4% | 7.4% | | |
| | Is there a legal or institutional barrier to implement this method? | 8.3% | 91.7% | | | | 22.2% | 77.8% | | | |
| 53 | **Consider multiple project completion dates** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 8.3% | 62.5% | 29.2% | 0.0% | 0.0% | 11.1% | 51.9% | 33.3% | 3.7% | 0.0% |
| | What is anticipated impact of this method on Quality? | 4.2% | 95.8% | 0.0% | | | 3.7% | 96.3% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 66.7% | 29.2% | 4.2% | | | 66.7% | 25.9% | 7.4% | | |
| | What is anticipated impact of this method on Safety? | 16.7% | 83.3% | 0.0% | | | 18.5% | 77.8% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 12.5% | 87.5% | | | | 22.2% | 77.8% | | | |
| 54 | **Provide flexible project start time** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 25.0% | 58.3% | 16.7% | 0.0% | 0.0% | 29.6% | 55.6% | 14.8% | 0.0% |
| | What is anticipated impact of this method on Quality? | 45.8% | 54.2% | 0.0% | | | 40.7% | 59.3% | 0.0% | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on Schedule? | 58.3% | 12.5% | 29.2% | | | 59.3% | 14.8% | 25.9% | | |
| | What is anticipated impact of this method on Safety? | 20.8% | 79.2% | 0.0% | | | 22.2% | 77.8% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 8.3% | 91.7% | | | | 14.8% | 85.2% | | | |
| 55 | **Provide schedule flexibility to contractors** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 58.3% | 29.2% | 12.5% | 0.0% | 0.0% | 51.9% | 37.0% | 11.1% | 0.0% |
| | What is anticipated impact of this method on Quality? | 12.5% | 70.8% | 16.7% | | | 14.8% | 66.7% | 18.5% | | |
| | What is anticipated impact of this method on Schedule? | 25.0% | 12.5% | 62.5% | | | 33.3% | 7.4% | 59.3% | | |
| | What is anticipated impact of this method on Safety? | 12.5% | 66.7% | 20.8% | | | 14.8% | 66.7% | 18.5% | | |
| | Is there a legal or institutional barrier to implement this method? | 26.1% | 73.9% | | | | 32.0% | 68.0% | | | |
| 56 | **Understand impact of night work** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 12.5% | 58.3% | 16.7% | 12.5% | 0.0% | 11.5% | 53.8% | 23.1% | 11.5% | 0.0% |
| | What is anticipated impact of this method on Quality? | 4.2% | 75.0% | 20.8% | | | 3.7% | 74.1% | 22.2% | | |
| | What is anticipated impact of this method on Schedule? | 79.2% | 16.7% | 4.2% | | | 77.8% | 18.5% | 3.7% | | |
| | What is anticipated impact of this method on Safety? | 41.7% | 16.7% | 41.7% | | | 33.3% | 18.5% | 48.1% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 7.4% | 92.6% | | | |
| 57 | **Reduce construction durations** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 66.7% | 20.8% | 4.2% | 4.2% | 7.4% | 51.9% | 25.9% | 11.1% | 3.7% |
| | What is anticipated impact of this method on Quality? | 12.5% | 54.2% | 33.3% | | | 11.1% | 59.3% | 29.6% | | |
| | What is anticipated impact of this method on Schedule? | 58.3% | 25.0% | 16.7% | | | 55.6% | 25.9% | 18.5% | | |
| | What is anticipated impact of this method on Safety? | 12.5% | 66.7% | 20.8% | | | 14.8% | 59.3% | 25.9% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 7.4% | 92.6% | | | |
| 58 | **Remove contract restrictions** | | | | | | | | | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 58.3% | 33.3% | 4.2% | 0.0% | 7.4% | 55.6% | 33.3% | 3.7% | 0.0% |
| | What is anticipated impact of this method on Quality? | 4.2% | 25.0% | 70.8% | | | 7.4% | 22.2% | 70.4% | | |
| | What is anticipated impact of this method on Schedule? | 37.5% | 58.3% | 4.2% | | | 33.3% | 55.6% | 11.1% | | |
| | What is anticipated impact of this method on Safety? | 8.3% | 58.3% | 33.3% | | | 7.4% | 55.6% | 37.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 20.8% | 79.2% | | | | 33.3% | 66.7% | | | |
| 59 | **Schedule projects considering federal trucking requirements** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 17.4% | 56.5% | 21.7% | 4.3% | 0.0% | 23.1% | 50.0% | 23.1% | 3.8% | 0.0% |
| | What is anticipated impact of this method on Quality? | 4.3% | 87.0% | 8.7% | | | 3.8% | 88.5% | 7.7% | | |
| | What is anticipated impact of this method on Schedule? | 21.7% | 56.5% | 21.7% | | | 26.9% | 46.2% | 26.9% | | |
| | What is anticipated impact of this method on Safety? | 21.7% | 69.6% | 8.7% | | | 23.1% | 65.4% | 11.5% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.3% | 95.7% | | | | 7.7% | 92.3% | | | |
| 60 | **Plan adequate oversight for accelerated projects** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 29.2% | 41.7% | 20.8% | 8.3% | 0.0% | 33.3% | 33.3% | 22.2% | 11.1% | 0.0% |
| | What is anticipated impact of this method on Quality? | 45.8% | 41.7% | 12.5% | | | 37.0% | 48.1% | 14.8% | | |
| | What is anticipated impact of this method on Schedule? | 83.3% | 16.7% | 0.0% | | | 70.4% | 25.9% | 3.7% | | |
| | What is anticipated impact of this method on Safety? | 33.3% | 62.5% | 4.2% | | | 29.6% | 66.7% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 7.4% | 92.6% | | | |
| 61 | **Contractor evaluation/grading** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 29.2% | 37.5% | 33.3% | 0.0% | 0.0% | 33.3% | 33.3% | 29.6% | 3.7% | 0.0% |
| | What is anticipated impact of this method on Quality? | 75.0% | 25.0% | 0.0% | | | 77.8% | 18.5% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 45.8% | 50.0% | 4.2% | | | 48.1% | 44.4% | 7.4% | | |
| | What is anticipated impact of this method on Safety? | 41.7% | 58.3% | 0.0% | | | 44.4% | 51.9% | 3.7% | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Is there a legal or institutional barrier to implement this method? | 34.8% | 65.2% | | | | 42.3% | 57.7% | | | |
| 62 | **Implement comprehensive approach to cost estimating** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 20.8% | 45.8% | 25.0% | 8.3% | 0.0% | 25.9% | 37.0% | 25.9% | 11.1% | 0.0% |
| | What is anticipated impact of this method on Quality? | 16.7% | 79.2% | 4.2% | | | 22.2% | 74.1% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 33.3% | 66.7% | 0.0% | | | 34.6% | 61.5% | 3.8% | | |
| | What is anticipated impact of this method on Safety? | 12.5% | 87.5% | 0.0% | | | 14.8% | 85.2% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 91.7% | | | | 15.4% | 84.6% | | | |
| | **INFORMATION AND TRAINING STRATEGY** | | | | | | | | | | |
| 63 | **Increase knowledge of design guidance and use of engineering judgment for design exceptions** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 8.3% | 37.5% | 33.3% | 20.8% | 0.0% | 11.1% | 37.0% | 29.6% | 18.5% | 3.7% |
| | What is anticipated impact of this method on Quality? | 33.3% | 66.7% | 0.0% | | | 37.0% | 59.3% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 50.0% | 45.8% | 4.2% | | | 48.1% | 48.1% | 3.7% | | |
| | What is anticipated impact of this method on Safety? | 25.0% | 75.0% | 0.0% | | | 33.3% | 59.3% | 7.4% | | |
| | Is there a legal or institutional barrier to implement this method? | 8.3% | 91.7% | | | | 18.5% | 81.5% | | | |
| 64 | **Increase knowledge about the contractors and their capacities** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 8.3% | 45.8% | 37.5% | 8.3% | 0.0% | 11.1% | 48.1% | 25.9% | 14.8% | 0.0% |
| | What is anticipated impact of this method on Quality? | 45.8% | 54.2% | 0.0% | | | 44.4% | 55.6% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 62.5% | 37.5% | 0.0% | | | 55.6% | 44.4% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 37.5% | 62.5% | 0.0% | | | 37.0% | 63.0% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 7.4% | 92.6% | | | |
| 65 | **Cross-district sharing of lessons learned** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 8.3% | 37.5% | 37.5% | 16.7% | 0.0% | 7.4% | 37.0% | 29.6% | 25.9% | 0.0% |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on Quality? | 83.3% | 16.7% | 0.0% | | | 81.5% | 18.5% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 87.5% | 12.5% | 0.0% | | | 77.8% | 22.2% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 79.2% | 20.8% | 0.0% | | | 74.1% | 25.9% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 3.7% | 96.3% | | | |
| 66 | **Understand and manage federal requirements for Disadvantaged Business Enterprise (DBE)** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 45.8% | 45.8% | 4.2% | 4.2% | 0.0% | 46.2% | 34.6% | 15.4% | 3.8% | 0.0% |
| | What is anticipated impact of this method on Quality? | 4.2% | 95.8% | 0.0% | | | 3.8% | 96.2% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 12.5% | 87.5% | 0.0% | | | 15.4% | 80.8% | 3.8% | | |
| | What is anticipated impact of this method on Safety? | 8.3% | 91.7% | 0.0% | | | 7.7% | 92.3% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 7.7% | 92.3% | | | |
| 67 | **Educate and train designers** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 16.7% | 50.0% | 29.2% | 4.2% | 3.7% | 22.2% | 37.0% | 22.2% | 14.8% |
| | What is anticipated impact of this method on Quality? | 87.5% | 12.5% | 0.0% | | | 77.8% | 22.2% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 87.5% | 12.5% | 0.0% | | | 74.1% | 25.9% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 79.2% | 20.8% | 0.0% | | | 66.7% | 33.3% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 3.7% | 96.3% | | | |
| 68 | **Update design manuals** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 62.5% | 25.0% | 4.2% | 4.2% | 7.7% | 50.0% | 26.9% | 7.7% | 7.7% |
| | What is anticipated impact of this method on Quality? | 83.3% | 16.7% | 0.0% | | | 73.1% | 26.9% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 70.8% | 29.2% | 0.0% | | | 57.7% | 42.3% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 70.8% | 29.2% | 0.0% | | | 61.5% | 38.5% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | 7.7% | 92.3% | | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 69 | **Educate and train consultants and contractors on new/different design criteria** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.2% | 41.7% | 37.5% | 8.3% | 8.3% | 7.4% | 40.7% | 25.9% | 14.8% | 11.1% |
| | What is anticipated impact of this method on Quality? | 91.7% | 8.3% | 0.0% | | | 85.2% | 14.8% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 75.0% | 20.8% | 4.2% | | | 70.4% | 25.9% | 3.7% | | |
| | What is anticipated impact of this method on Safety? | 66.7% | 33.3% | 0.0% | | | 63.0% | 37.0% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | 14.8% | 85.2% | | | |
| | **STAKEHOLDER INPUT STRATEGY** | | | | | | | | | | |
| 70 | **Conduct pre-bid meetings** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 8.3% | 62.5% | 16.7% | 12.5% | 0.0% | 11.1% | 55.6% | 14.8% | 18.5% | 0.0% |
| | What is anticipated impact of this method on Quality? | 66.7% | 29.2% | 4.2% | | | 63.0% | 33.3% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 66.7% | 25.0% | 8.3% | | | 59.3% | 33.3% | 7.4% | | |
| | What is anticipated impact of this method on Safety? | 66.7% | 29.2% | 4.2% | | | 59.3% | 37.0% | 3.7% | | |
| | Is there a legal or institutional barrier to implement this method? | 12.5% | 87.5% | | | | 25.9% | 74.1% | | | |
| 71 | **Provide for contractor input when developing drawings, specifications, and the construction schedule** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 33.3% | 41.7% | 20.8% | 4.2% | 0.0% | 34.6% | 38.5% | 26.9% | 0.0% |
| | What is anticipated impact of this method on Quality? | 83.3% | 12.5% | 4.2% | | | 81.5% | 14.8% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 87.5% | 8.3% | 4.2% | | | 88.9% | 7.4% | 3.7% | | |
| | What is anticipated impact of this method on Safety? | 54.2% | 45.8% | 0.0% | | | 55.6% | 44.4% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 13.0% | 87.0% | | | | 23.1% | 76.9% | | | |
| 72 | **Involve contractor in the design process** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 54.2% | 29.2% | 12.5% | 4.2% | 0.0% | 48.1% | 25.9% | 22.2% | 3.7% |
| | What is anticipated impact of this method on Quality? | 70.8% | 25.0% | 4.2% | | | 66.7% | 29.6% | 3.7% | | |

| Sr. # | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on Schedule? | 79.2% | 16.7% | 4.2% | | | 81.5% | 14.8% | 3.7% | | |
| | What is anticipated impact of this method on Safety? | 62.5% | 37.5% | 0.0% | | | 59.3% | 40.7% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 20.8% | 79.2% | | | | 29.6% | 70.4% | | | |
| 73 | **Conduct constructability reviews** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 16.7% | 62.5% | 16.7% | 4.2% | 0.0% | 29.6% | 51.9% | 14.8% | 3.7% |
| | What is anticipated impact of this method on Quality? | 83.3% | 16.7% | 0.0% | | | 81.5% | 18.5% | 0.0% | | |
| | What is anticipated impact of this method on Schedule? | 91.7% | 8.3% | 0.0% | | | 92.6% | 7.4% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 75.0% | 25.0% | 0.0% | | | 70.4% | 29.6% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 12.5% | 87.5% | | | | 18.5% | 81.5% | | | |
| | **PROJECT MARKETING AND ADVERTISING STRATEGY** | | | | | | | | | | |
| 74 | **Market new projects aggressively** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 50.0% | 37.5% | 8.3% | 4.2% | 3.7% | 48.1% | 33.3% | 11.1% | 3.7% |
| | What is anticipated impact of this method on Quality? | 29.2% | 66.7% | 4.2% | | | 29.6% | 66.7% | 3.7% | | |
| | What is anticipated impact of this method on Schedule? | 54.2% | 45.8% | 0.0% | | | 48.1% | 51.9% | 0.0% | | |
| | What is anticipated impact of this method on Safety? | 29.2% | 70.8% | 0.0% | | | 33.3% | 66.7% | 0.0% | | |
| | Is there a legal or institutional barrier to implement this method? | 8.3% | 91.7% | | | | 14.8% | 85.2% | | | |
| | | | | | | | | | | | |
| **Sr. #** | **Please evaluate following additional methods proposed by Delphi experts in Round-I** | | | | | | | | | | |
| 75 | **Avoid lumping too many work items together.** | | | | | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 8.3% | 37.5% | 33.3% | 16.7% | 4.2% | | | | | |
| | What is anticipated impact of this method on Quality? | 41.7% | 58.3% | 0.0% | | | | | | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 |
|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on Schedule? | 37.5% | 54.2% | 8.3% | | | |
| | What is anticipated impact of this method on Safety? | 20.8% | 79.2% | 0.0% | | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | |
| 76 | **Take more time during design to get it right in the first place.** | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 12.5% | 41.7% | 37.5% | 8.3% | |
| | What is anticipated impact of this method on Quality? | 91.7% | 8.3% | 0.0% | | | |
| | What is anticipated impact of this method on Schedule? | 75.0% | 12.5% | 12.5% | | | |
| | What is anticipated impact of this method on Safety? | 41.7% | 58.3% | 0.0% | | | |
| | Is there a legal or institutional barrier to implement this method? | 0.0% | 100.0% | | | | |
| 77 | **Do a more thorough job of determining and optimizing the scope of the project before design begins.** | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 26.1% | 34.8% | 26.1% | 13.0% | |
| | What is anticipated impact of this method on Quality? | 91.3% | 8.7% | 0.0% | | | |
| | What is anticipated impact of this method on Schedule? | 65.2% | 30.4% | 4.3% | | | |
| | What is anticipated impact of this method on Safety? | 47.8% | 52.2% | 0.0% | | | |
| | Is there a legal or institutional barrier to implement this method? | 8.7% | 91.3% | | | | |
| 78 | **Better utilize inspectors.** | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 16.7% | 62.5% | 8.3% | 12.5% | 0.0% | |
| | What is anticipated impact of this method on Quality? | 29.2% | 33.3% | 37.5% | | | |
| | What is anticipated impact of this method on Schedule? | 33.3% | 62.5% | 4.2% | | | |
| | What is anticipated impact of this method on Safety? | 16.7% | 70.8% | 12.5% | | | |
| | Is there a legal or institutional barrier to implement this method? | 4.2% | 95.8% | | | | |
| 79 | **Do away with Material-on-Hand (MOH).** | | | | | | |

| | Evaluate Methods for Cost Reduction or Containment and its Impact on Performance | Group response Round-2 | | | | | Group response Round-1 |
|---|---|---|---|---|---|---|---|
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 16.7% | 50.0% | 25.0% | 4.2% | 4.2% | |
| | What is anticipated impact of this method on Quality? | 0.0% | 91.7% | 8.3% | | | |
| | What is anticipated impact of this method on Schedule? | 12.5% | 83.3% | 4.2% | | | |
| | What is anticipated impact of this method on Safety? | 0.0% | 95.8% | 4.2% | | | |
| | Is there a legal or institutional barrier to implement this method? | 36.4% | 63.6% | | | | |
| 80 | **Implement formal risk identification and management program.** | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 0.0% | 29.2% | 50.0% | 16.7% | 4.2% | |
| | What is anticipated impact of this method on Quality? | 58.3% | 41.7% | 0.0% | | | |
| | What is anticipated impact of this method on Schedule? | 62.5% | 37.5% | 0.0% | | | |
| | What is anticipated impact of this method on Safety? | 33.3% | 66.7% | 0.0% | | | |
| | Is there a legal or institutional barrier to implement this method? | 8.7% | 91.3% | | | | |
| 81 | **Develop selection tools for contracting methods based on past performance of alternative contracts** | | | | | | |
| | What is anticipated impact of this method on reduction in total cost of construction (either on bid price, or escalation of cost during construction)? | 4.3% | 56.5% | 13.0% | 26.1% | 0.0% | |
| | What is anticipated impact of this method on Quality? | 56.5% | 43.5% | 0.0% | | | |
| | What is anticipated impact of this method on Schedule? | 45.5% | 50.0% | 4.5% | | | |
| | What is anticipated impact of this method on Safety? | 26.1% | 73.9% | 0.0% | | | |
| | Is there a legal or institutional barrier to implement this method? | 21.7% | 78.3% | | | | |

# APPENDIX E

## CONSOLIDATED LIST OF METHODS WITH SCORES

| Rank | Sr. # | Method | Score (out of 4.00) | Remark |
|---|---|---|---|---|
| 1 | 76 | Take time to develop sound designs using appropriate design criteria and technical information. Incorporate pavement evaluation, geotechnical, and utility data in designs. | 2.42 | Merged 33, 38, 39, 40, 34 |
| 2 | 29 | Provide alternative materials in PS&E. | 2.21 | |
| 3 | 36 | Standardize designs and provide more design repetition | 2.21 | |
| 4 | 67 | Educate and train designers, consultants, and contractors. | 2.21 | Merged 69 |
| 5 | 27 | Coordinate lettings based on the availability and capacity of contractors in the region. | 2.17 | Merged 64 |
| 6 | 19 | Better define and optimize the project scope initially and subsequently control scope creep by accountable authority. | 2.17 | Merged 77, 75 |
| 7 | 37 | Minimize detours and diversions. | 2.13 | |
| 8 | 9 | Evaluate alternate contracting methods including design-build (D-B) and construction manager at risk (CM @ Risk*). | 2.08 | |
| 9 | 73 | Use contractor inputs in the development of design, specifications, and schedule. Involve contractors in constructability review process. | 2.08 | Merged 72, 71 |
| 10 | 1 | Plan ahead and communicate requirements to material suppliers in advance. | 2.04 | |
| 11 | 3 | Evaluate restrictions on imported materials. | 2.04 | |
| 12 | 23 | Consider locally available materials in design. | 2.04 | |
| 13 | 4 | Create material sources by TxDOT. | 2.04 | |
| 14 | 2 | Evaluate local market condition for availability of resources to effectively plan construction lettings. | 2.00 | |
| 15 | 24 | Reuse and recycle materials. | 2.00 | |
| 16 | 32 | Consider alternative designs. | 2.00 | Merged 31 |
| 17 | 45 | Bundle construction projects for exploring economies of scale. | 2.00 | |
| 18 | 20 | Increase flexibility in traffic control planning. | 1.96 | |
| 19 | 80 | Implement formal risk identification and management program. | 1.96 | |

| Rank | Sr. # | Method | Score (out of 4.00) | Remark |
|---|---|---|---|---|
| 20 | 18 | Increase bid preparation time and conduct pre-bid meetings. | 1.92 | Merged 70 |
| 21 | 5 | Utilize owner buying power. | 1.92 | |
| 22 | 54 | Provide flexible project start time. | 1.92 | |
| 23 | 35 | Check cost effectiveness of specialty items at early stage. | 1.83 | |
| 24 | 13 | Add price adjustment clause to contracts. | 1.83 | |
| 25 | 11 | Share cost savings with the contractors. | 1.79 | |
| 26 | 26 | Minimize mobilization. | 1.71 | |
| 27 | 44 | Use performance or end product specifications. | 1.71 | |
| 28 | 63 | Increase knowledge of design guidance and use of engineering judgment for design exceptions. | 1.67 | |
| 29 | 74 | Market new projects aggressively. | 1.67 | |
| 30 | 65 | Cross-district sharing of lessons learned. | 1.63 | |
| 31 | 8 | State-owned batch plants and crews. | 1.58 | |
| 32 | 41 | Understand and manage environmental restrictions. | 1.58 | Merged 28 |
| 33 | 81 | Develop selection tools for contracting methods based on past performance of alternative contracts. | 1.54 | |
| 34 | 6 | Purchase commitments to suppliers by TxDOT with option for buying. | 1.46 | |
| 35 | 7 | Provide state yards. | 1.46 | |
| 36 | 52 | Improve design change procedure to increase responsiveness to change (fast and simple). | 1.46 | |
| 37 | 16 | Reduce bond cost over project time. | 1.42 | |
| 38 | 68 | Update design manuals. | 1.42 | |
| 39 | 47 | Group specialty items into a separate package. | 1.38 | |
| 40 | 51 | Reject non-competitive bids and re-advertise. | 1.38 | |
| 41 | 58 | Remove contract restrictions. | 1.38 | |
| 42 | 57 | Reduce construction durations. | 1.38 | |
| 43 | 43 | Review specifications for their applicability to the given project. | 1.33 | |
| 44 | 46 | Split construction projects. | 1.33 | |
| 45 | 56 | Understand impact of night work. | 1.29 | |
| 46 | 62 | Implement comprehensive approach to cost estimating. | 1.21 | Merged 10 |
| 47 | 21 | Ease contracting requirements with TxDOT. | 1.21 | |

| Rank | Sr. # | Method | Score (out of 4.00) | Remark |
|---|---|---|---|---|
| 48 | 53 | Consider multiple project completion dates. | 1.21 | |
| 49 | 48 | Add alternate package for aesthetics. | 1.17 | |
| 50 | 78 | Better utilize inspectors and recognize cost of inspections in the estimates. | 1.17 | Merged 42 |
| 51 | 17 | Relax prequalification requirements for certain projects. | 1.17 | |
| 52 | 60 | Plan adequate oversight for accelerated projects. | 1.08 | |
| 53 | 59 | Schedule projects considering federal trucking requirements. | 1.08 | |
| 54 | 15 | Provide owner-controlled bonding for small contractors. | 1.08 | |
| 55 | 61 | Contractor evaluation/grading. | 1.04 | |
| 56 | 49 | Provide design-build lump-sum contract for traffic control. | 0.88 | |

# APPENDIX F

## PROGRAM-BASED METHODS

| Rank | Sr. # | Method | Score (out of 4.00) |
|---|---|---|---|
| 1 | 29 | Standardize designs and provide more design repetition. | 2.21 |
| 2 | 53 | Educate and train designers, consultants, and contractors. | 2.21 |
| 3 | 7 | Evaluate restrictions on imported materials. | 2.04 |
| 4 | 4 | Create material sources by TxDOT. | 2.04 |
| 5 | 33 | Evaluate local market condition for availability of resources to effectively plan construction lettings. | 2.00 |
| 6 | 61 | Implement formal risk identification and management program. | 1.96 |
| 7 | 2 | Utilize owner buying power. | 1.92 |
| 8 | 13 | Add price adjustment clause to contracts. | 1.83 |
| 9 | 55 | Cross-district sharing of lessons learned. | 1.63 |
| 10 | 6 | State-owned batch plants and crews for small and isolated jobs. | 1.58 |
| 11 | 56 | Develop selection tools for contracting methods based on past performance of alternative contracts. | 1.54 |
| 12 | 3 | Purchase commitments to suppliers by TxDOT with option for buying. | 1.46 |
| 13 | 30 | Improve design change procedure to increase responsiveness to change (fast and simple). | 1.46 |
| 14 | 16 | Reduce bond cost over project time. | 1.42 |
| 15 | 54 | Update design manuals. | 1.42 |
| 16 | 51 | Implement comprehensive approach to cost estimating. | 1.21 |
| 17 | 59 | Ease contracting requirements with TxDOT. | 1.21 |
| 18 | 17 | Relax prequalification requirements for certain projects. | 1.17 |
| 19 | 15 | Provide owner-controlled bonding for small contractors. | 1.08 |
| 20 | 50 | Contractor evaluation/grading. | 1.04 |
| 21 | 57 | Provide design-build lump-sum contract for traffic control. | 0.88 |

# APPENDIX G

## PROJECT-BASED METHODS

| Cost Rank | Sr. # | Method | Score (out of 4.00) |
|---|---|---|---|
| 1 | 28 | Take time to develop sound designs using appropriate design criteria and technical information. Incorporate pavement evaluation, geotechnical and utility data in designs. | 2.42 |
| 2 | 22 | Provide alternative materials in PS&E. | 2.21 |
| 3 | 32 | Coordinate lettings based on the availability and capacity of contractors in the region. | 2.17 |
| 4 | 19 | Better define and optimize the project scope initially and subsequently control scope creep by accountable authority. | 2.17 |
| 5 | 31 | Minimize detours and diversions. | 2.13 |
| 6 | 8 | Evaluate alternate contracting methods including design-build (D-B) and construction manager at risk (CM @ Risk). | 2.08 |
| 7 | 58 | Use contractor inputs in the development of design, specifications, schedule, and in constructability review process. | 2.08 |
| 8 | 1 | Plan ahead and communicate requirements to material suppliers in advance. | 2.04 |
| 9 | 23 | Consider locally available materials in design. | 2.04 |
| 10 | 21 | Reuse and recycle materials. | 2.00 |
| 11 | 35 | Bundle construction projects for exploring economies of scale. | 2.00 |
| 12 | 27 | Consider alternative designs. | 2.00 |
| 13 | 45 | Increase flexibility in traffic control planning. | 1.96 |
| 14 | 18 | Increase bid preparation time and conduct pre-bid meetings. | 1.92 |
| 15 | 44 | Provide flexible project start time. | 1.92 |
| 16 | 37 | Check cost effectiveness of specialty items at early stage. | 1.83 |
| 17 | 62 | Share cost savings with the contractors. | 1.79 |
| 18 | 49 | Minimize mobilization. | 1.71 |
| 19 | 25 | Use performance or end product specifications. | 1.71 |
| 20 | 52 | Increase knowledge of design guidance and use of engineering judgment for design exceptions. | 1.67 |
| 21 | 60 | Market new projects aggressively. | 1.67 |
| 22 | 34 | Understand and manage environmental restrictions. | 1.58 |
| 23 | 5 | Provide state yards. | 1.46 |
| 24 | 38 | Group specialty items into a separate package. | 1.38 |
| 25 | 47 | Remove contract restrictions. | 1.38 |
| 26 | 42 | Reject non-competitive bids and re-advertise. | 1.38 |

| Cost Rank | Sr. # | Method | Score (out of 4.00) |
|---|---|---|---|
| 27 | 41 | Reduce construction durations. | 1.38 |
| 28 | 24 | Review specifications for their applicability to the given project, e.g., relaxation of asphalt concrete temperature restrictions. | 1.33 |
| 29 | 36 | Split construction projects. | 1.33 |
| 30 | 46 | Understand impact of night work. | 1.29 |
| 31 | 43 | Consider multiple project completion dates. | 1.21 |
| 32 | 39 | Add alternate package for aesthetics. | 1.17 |
| 33 | 10 | Better utilize inspectors and recognize cost of inspections in the estimates. | 1.17 |
| 34 | 12 | Plan adequate oversight for accelerated projects. | 1.08 |
| 35 | 48 | Schedule projects considering federal trucking requirements. | 1.08 |

# APPENDIX H

## METHODS APPLICABLE AT DIFFERENT DESIGN REVIEW MILESTONES

| No. | Method | Design Concept Conference | 30% Review | 60% Review | 90% Review | Post-letting | SR. # |
|---|---|---|---|---|---|---|---|
| 1 | Take time to develop sound designs using appropriate design criteria and technical information. Incorporate pavement evaluation, geotechnical and utility data in designs. | 2.42 √ | | | | | 76 |
| 2 | Better define and optimize the project scope initially and subsequently control scope creep by accountable authority. | 2.04 √ | | | | | 19 |
| 3 | Evaluate alternate contracting methods including design-build (D-B) and construction manager at risk (CM @ Risk). | 2.17 √ | | | | | 9 |
| 4 | Bundle construction projects for exploring economies of scale. | 2.00 √ | | | | | 45 |
| 5 | Market new projects aggressively. | 1.67 √ | | | | | 74 |
| 6 | Understand and manage environmental restrictions. | 1.58 √ | | | | | 41 |
| 7 | Split construction projects. | 1.33 √ | | | | | 46 |
| 1 | Consider locally available materials in design. | | 2.08 √ | | | | 23 |

| No. | Method | Design Concept Conference | 30% Review | 60% Review | 90% Review | Post-letting | SR. # |
|---|---|---|---|---|---|---|---|
| 2 | Consider alternative designs. | | 2.00 √ | | | | 32 |
| 3 | Increase knowledge of design guidance and use of engineering judgment for design exceptions. | | 1.67 √ | | | | 63 |
| 4 | Add alternate package for aesthetics. | | 1.17 √ | | | | 48 |
| 1 | Provide alternative materials in PS&E. | | | 2.21 √ | | | 29 |
| 2 | Minimize detours and diversions. | | | 2.13 √ | | | 37 |
| 3 | Reuse and recycle materials. | | | 2.00 √ | | | 24 |
| 4 | Increase flexibility in traffic control planning. | | | 1.96 √ | | | 20 |
| 5 | Check cost effectiveness of specialty items at early stage. | | | 1.83 √ | | | 35 |
| 6 | Minimize mobilization. | | | 1.71 √ | | | 26 |

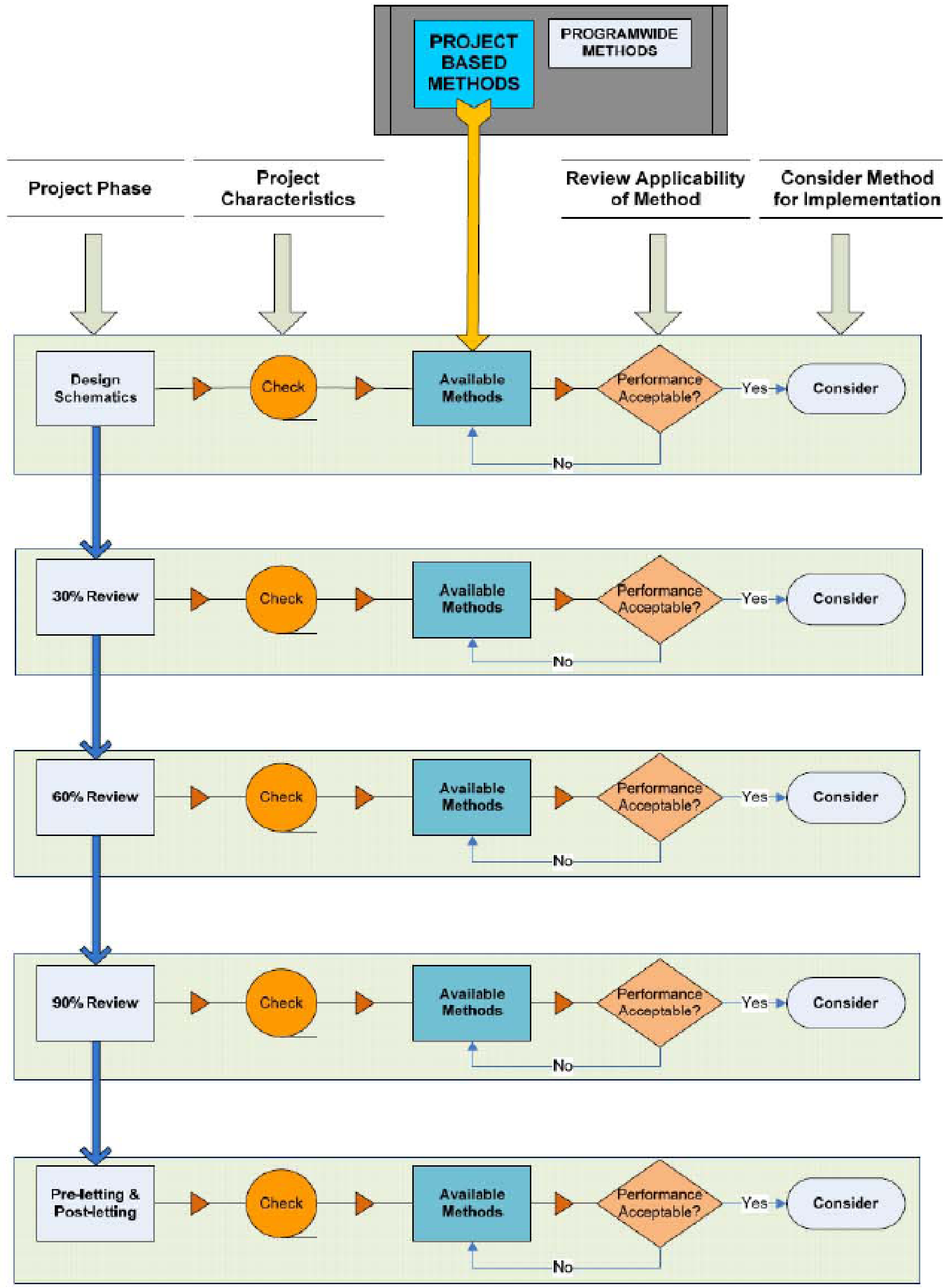
| No. | Method | Design Concept Conference | 30% Review | 60% Review | 90% Review | Post-letting | SR. # |
|---|---|---|---|---|---|---|---|
| 7 | Use performance or end product specifications. | | | 1.71 √ | | | 44 |
| 8 | Group specialty items into a separate package. | | | 1.38 √ | | | 47 |
| 9 | Remove contract restrictions. | | | 1.38 √ | | | 58 |
| 10 | Review specifications for their applicability to the given project, e.g., relaxation of asphalt concrete temperature restrictions. | | | 1.38 √ | | | 43 |
| 11 | Understand impact of night work. | | | 1.29 √ | | | 56 |
| 1 | Coordinate lettings based on the availability and capacity of contractors in the region. | | | | 2.17 √ | | 27 |
| 2 | Use contractor inputs in the development of design, specifications, schedule, and in constructability review process. | | | | 2.08 √ | | 73 |
| 3 | Plan ahead and communicate requirements to material suppliers in advance. | | | | 2.04 √ | | 1 |
| 4 | Increase bid preparation time and conduct pre-bid meetings. | | | | 1.92 √ | | 18 |

| No. | Method | Design Concept Conference | 30% Review | 60% Review | 90% Review | Post-letting | SR. # |
|---|---|---|---|---|---|---|---|
| 5 | Provide flexible project start time. | | | | 1.92 √ | | 54 |
| 6 | Provide state yards. | | | | 1.46 √ | | 7 |
| 7 | Reduce construction durations. | | | | 1.38 √ | | 57 |
| 8 | Consider multiple project completion dates. | | | | 1.21 √ | | 53 |
| 9 | Plan adequate oversight for accelerated projects. | | | | 1.08 √ | | 60 |
| 10 | Schedule projects considering federal trucking requirements. | | | | 1.08 √ | | 59 |
| 1 | Share cost savings with the contractors. | | | | | 1.79 √ | 11 |
| 2 | Reject non-competitive bids and re-advertise. | | | | | 1.38 √ | 51 |
| 3 | Better utilize inspectors and recognize cost of inspections in the estimates. | | | | | 1.17 √ | 78 |

# APPENDIX I

## GUIDELINES FOR SELECTION OF COST REDUCTION METHODS IN PROJECT DEVELOPMENT PROCESS

This appendix summarizes the cost reduction selection process for methods that do not require changes in department policies, and it can be used as a stand-alone guidebook for method selection and review. The methods described in this appendix can be considered for implementation during different phases of project development, starting with the design concept conference and ending with the post-letting phase. The systematic process for evaluation of the methods throughout the project development process is illustrated below:




The method application process starts with a design concept conference and continues until the post-letting decision point. Each step considers three important action points: 1) *check project characteristics*, to confirm if the project is suitable for implementation of cost reduction methods, 2) *review available methods*, to select methods that are applicable to considered milestone review points (or implementation steps), and 3) *evaluate performance*, to review if the reported cost reduction effectiveness (from Delphi study) satisfies criteria set for the considered project. In this stage it is also necessary to check if the method will negatively affect quality, safety, and schedule. The methods data sheets at the end of this guidebook contain this information for each method. Further, it is important to note that the effectiveness of the methods in this study is evaluated from a generalized perspective through the process of surveying expert opinions. In practice, methods may not always perform as expected; hence, during the review process, TxDOT engineers should consider the method expected results but also exercise their best judgment, as the effects might differ from the experts' perceptions.

*Design Concept Conference*

The design concept conference results in schematic designs and geometric plans. The plans include existing features of the location and the scheme for proposed development. This step is essential to the environmental approval process, particularly when an environmental impact statement is necessary. TxDOT complies with applicable environmental regulations in consultation and coordination with local, state, and federal agencies. The environmental design process involves identification of exclusions where project activities do not significantly impact environment. In all other cases, an environmental impact study needs to be done. The design kickoff also defines the preliminary right of way. This phase involves a public hearing for feedback on preliminary layouts. The design kickoff process also considers social impacts of the project.

*30% Review*

The 30 percent review essentially involves review of the preliminary designs and right of way. This is the correct time during the preliminary design stage to apply value engineering. Cost reduction methods applicable to designs can be identified and applied during the next 30 percent of design completion. In the 30 percent review phase, right of way is planned considering existing and proposed utilities. Information regarding type, size, location, and nature of the utilities is crucial for design development. At a later stage, utility information is useful to contractors for construction. Proper information regarding right of way and associated existing utilities can result in more accurate bids to TxDOT.

*60% Review*

The detailed design is reviewed in this phase. The detailed design starts with a design conference to review the project requirements and basic design criteria. More information about the project is collected in terms of traffic data, right of way, as-built construction plans, and other site information. The design criteria are finalized considering project features and applicable regulations. Concurrence is obtained from other concerned agencies and stakeholders as may be required. The design summary report (DSR) is then updated. The layouts and detailed designs are subsequently carried out.

*90% Review*

In this phase specifications and estimates are prepared based on nearly completed designs. Specification development generally involves use of standard specifications, modification of standard specifications, and alternative special specifications (TxDOT, 2007). Modification of standard specifications and alternative special specifications requires approval from a competent authority. Advancements in material manufacturing and new project requirements often introduce special materials to the project.

The next step is plans estimate preparation. This results in a tabulated listing of the bid items which reflect the estimated cost of the project. The list includes the description, quantity, and unit bid price of each bid item for the project. The plans estimate provides an opportunity to the engineer to review the costs and go back to the previous phases and explore cost reduction methods.

*Post-letting*

Depending upon funding, either federal or state, the relevant letting procedures and forms are used in letting by TxDOT. Federal funding follows the Federal Project Authorization and Agreement (FPAA), while state funding follows state Letter of Authority (LOA) process. Each process has its own requirements for advertisement, selection, and award processes. Letting is the last phase before the construction phase that has potential for application of cost reduction methods. The post-letting phase involves the construction.

*Consideration of Methods and Review of their Applicability*

After selecting the review milestone point and reviewing project characteristics implementation of cost-saving methods, a short list of applicable methods is considered. Available methods during each of the project review milestones are given in the table on the next page. The team conducting the cost reduction process checks method applicability to the given project. The info sheets for methods may be useful in reviewing methods. These data sheets include cost increase factors addressed by the method, as well as Delphi group evaluation scores for cost reduction effectiveness and other performance measures. Info sheets for individual methods are provided at the end of this appendix.

| No. | Method | Design Concept Conference | 30% Review | 60% Review | 90% Review | Post-letting |
|---|---|---|---|---|---|---|
| 1 | Take time to develop sound designs using appropriate design criteria and technical information. Incorporate pavement evaluation, geotechnical, and utility data in designs. | 2.42 √ | | | | |
| 2 | Better define and optimize the project scope initially and subsequently control scope creep by accountable authority. | 2.04 √ | | | | |
| 3 | Evaluate alternate contracting methods including design-build (D-B) and construction manager at risk (CM @ Risk). | 2.17 √ | | | | |
| 4 | Bundle construction projects for exploring economies of scale. | 2.00 √ | | | | |
| 5 | Market new projects aggressively. | 1.67 √ | | | | |
| 6 | Understand and manage environmental restrictions. | 1.58 √ | | | | |
| 7 | Split construction projects. | 1.33 √ | | | | |
| 1 | Consider locally available materials in design. | | 2.08 √ | | | |
| 2 | Consider alterative designs. | | 2.00 √ | | | |
| 3 | Increase knowledge of design guidance and use of engineering judgment for design exceptions. | | 1.67 √ | | | |
| 4 | Add alternate package for aesthetics. | | 1.17 √ | | | |
| 1 | Provide alternative materials in PS&E. | | | 2.21 √ | | |

| No. | Method | Design Concept Conference | 30% Review | 60% Review | 90% Review | Post-letting |
|---|---|---|---|---|---|---|
| 2 | Minimize detours and diversions. | | | 2.13 √ | | |
| 3 | Reuse and recycle materials. | | | 2.00 √ | | |
| 4 | Increase flexibility in traffic control planning. | | | 1.96 √ | | |
| 5 | Check cost effectiveness of specialty items at early stage. | | | 1.83 √ | | |
| 6 | Minimize mobilization. | | | 1.71 √ | | |
| 7 | Use performance or end product specifications. | | | 1.71 √ | | |
| 8 | Group specialty items into a separate package. | | | 1.38 √ | | |
| 9 | Remove contract restrictions. | | | 1.38 √ | | |
| 10 | Review specifications for their applicability to the given project, e.g., relaxation of asphalt concrete temperature restrictions. | | | 1.38 √ | | |
| 11 | Understand impact of night work. | | | 1.29 √ | | |
| 1 | Coordinate lettings based on the availability and capacity of contractors in the region. | | | | 2.17 √ | |
| 2 | Use contractor inputs in the development of design, specifications, schedule, and in constructability review process. | | | | 2.08 √ | |
| 3 | Plan ahead and communicate requirements to material suppliers in advance. | | | | 2.04 √ | |

| No. | Method | Design Concept Conference | 30% Review | 60% Review | 90% Review | Post-letting |
|---|---|---|---|---|---|---|
| 4 | Increase bid preparation time and conduct pre-bid meetings. | | | | 1.92 √ | |
| 5 | Provide flexible project start time. | | | | 1.92 √ | |
| 6 | Provide state yards. | | | | 1.46 √ | |
| 7 | Reduce construction durations. | | | | 1.38 √ | |
| 8 | Consider multiple project completion dates. | | | | 1.21 √ | |
| 9 | Plan adequate oversight for accelerated projects. | | | | 1.08 √ | |
| 10 | Schedule projects considering federal trucking requirements. | | | | 1.08 √ | |
| 1 | Share cost savings with the contractors. | | | | | 1.79 √ |
| 2 | Reject non-competitive bids and re-advertise. | | | | | 1.38 √ |
| 3 | Better utilize inspectors and recognize cost of inspections in the estimates. | | | | | 1.17 √ |

The process described earlier identifies the applicable methods for given project review milestones and project characteristics. A method information summary sheet has been generated for each method to guide the engineer in decision making. The following information explains the type of information provided in method info sheets:

The process described earlier identifies the methods for given project review milestones and project characteristics. Method summary information sheets are developed to guide the engineers in discussion of the potential impacts of the methods and making sound decisions. The detailed method information sheets are presented below as part of a standalone guideline for the implementation of this research. The method info sheet contains the following information:

**Method description**: Describes in detail the proposed method and how it affects the project cost.

**Project milestone:** The milestone review point in which the method should be considered.

**Project characteristics:** The type of project that would be suitable for application of the method.

**Factor addressed:** The method addresses one or more cost reduction factors. A detailed description allows the user to understand what factors are addressed and how they affect the cost, in the process of applying the given method.

**Perceived advantages and disadvantages:** Each method has advantages and possible disadvantages with respect to its implementation. The listed advantages and disadvantages will guide the design engineer in decision making with respect to integrating the method into the existing project design or project construction process.

**Cost impact evaluation:** The evaluation of a method by the Delphi group of experts is indicated in brackets. The score is determined by multiplying the number of responses in each of the "no," "low," "medium," "high," and "very high" categories, respectively, with factors 0 to 4 and then dividing the total by the number of respondents. The cost evaluation score out of possible maximum 4.00 points indicates the method's potential to reduce the cost. The pie-chart indicates the distribution of the method cost reduction effectiveness from Delphi analysis.

**Performance impact indicator**: The Delphi group evaluated possible impact of the method on additional performance measures: quality, schedule and safety. Green light indicates that the method has no significant impact on the considered performance measure. Yellow light indicates possible impact of the method, while red light indicates that the Delphi group is of opinion that the method can potentially have a severe effect on the considered performance measure. In such cases, extra caution should be exercised when considering the method for implementation.

**Quality impact:** The Delphi group evaluated the impact of each method on quality. This information may be useful to the design engineer in decision making, particularly where the method has a potential adverse impact on quality. A method having an adverse quality impact may be considered with additional caution.

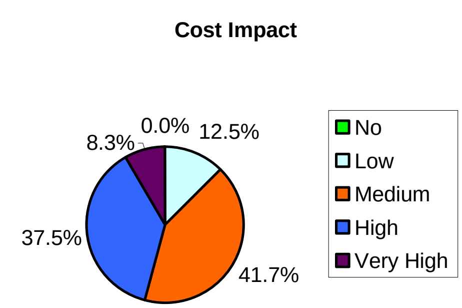
**Schedule impact:** The Delphi group evaluated the impact of a method on project schedule. This information may be useful to the design engineer in decision making, particularly where a method has a potential adverse impact on schedule. Depending upon project requirements the method may be rejected if accelerated schedule completion is critical to project success. For example, for projects in urban environment, schedule may be a more important performance measure than cost.

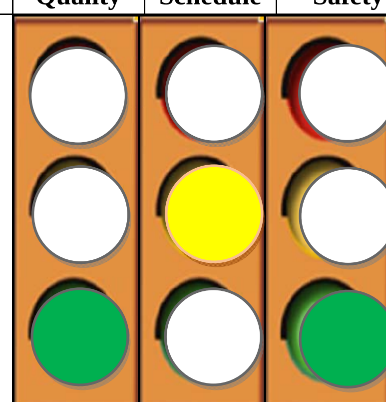
**Safety impact:** The Delphi group evaluated the impact of a method on construction safety. The methods having a possible adverse impact on safety need careful evaluation before implementation.

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Take time to develop sound designs using appropriate design criteria and technical information. Incorporate pavement evaluation, geotechnical, and utility data in designs.** |
| **Description** | Take adequate time for designs to do it right first time. Select appropriate design criteria that can impact construction cost without compromising performance requirements. Obtain pavement evaluation data. The data may include FWD, GPR, DCP, visual distress, ride quality, and rut depth information; such information can be used when generating the optimum pavement design. Provide more information regarding utilities located within the boundary limits of the construction project. Improve the definition of utility relocation requirements using subsurface utility engineering. Improved utility information may lower bid prices by reducing the risk premium anticipated by the contractor. This may also result in reduced number of change orders during construction. |
| **Project Milestone** | Design Concept Conference |
| **Project Characteristics** | Large highway projects |
| **Factor Addressed** | Inadequate site information such as hydrology, drainage conditions, and physical features can lead to less-than-optimal designs. Information regarding existing structures, subsurface utilities, and right of way acquisition is critical for cost and schedule point of view for highway projects. Lack of adequate geotechnical investigations can lead to overdesign. Inadequate investigations also result in differing site conditions. Lack of detailed evaluation of pavement structural condition results in untimely or more frequent scheduling of maintenance actions. |
| **Perceived Advantages** | ▪ Reduces change orders<br>▪ Reduces owner coordination efforts with respect to utility<br>▪ Leads to optimal designs<br>▪ Reduces design conflicts |
| **Perceived Disadvantages** | ▪ More detailed investigations may increase the project cost |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 2.42/4.00 | **Quality** | **Schedule** | **Safety** |



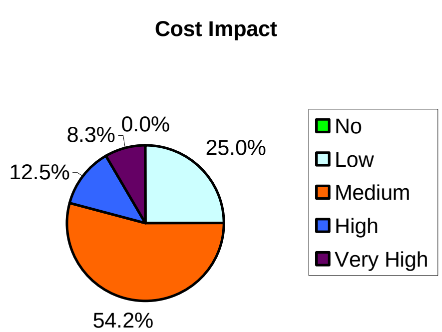
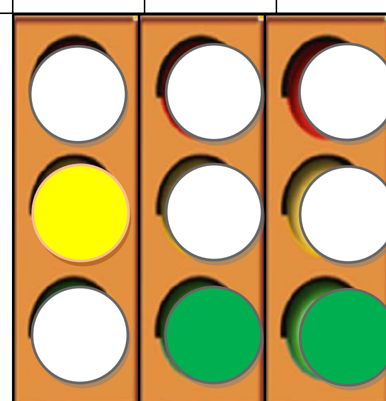



LEGEND

| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Better define and optimize the project scope initially and subsequently control scope creep by accountable authority** |
| **Description** | Define and optimize scope once design begins, and do not allow changes in scope subsequently. This would allow the scope change to be incorporated into the plan set carefully, to avoid design errors and conflicts. Avoid unnecessary additions to the scope that do not add value to the performance or functionality of construction component or element. Ensure scope control mechanisms are in place and that project staff are accountable for controlling scope. As far as individual items are concerned, do not lump too many work items together. Itemizing work gives clarity to the contractor regarding the extent of work and scope. Also it prevents them from charging for unforeseen items and quantities. For example, ROW preparation is an initial item involving too many different types of work items, requiring additional startup money. |
| **Project Milestone** | Design Concept Conference |
| **Project Characteristics** | All projects |
| **Factor Addressed** | Lack of definition of project scope from the beginning results in additions and change orders. The accumulation of small changes in project's scope can significantly increase the overall project cost. Such additions in scope often do not significantly add to the functionality or performance of the facility. A mechanism for controlling project scope by competent and accountable authority is needed. |
| **Perceived Advantages** | ▪ Reduces change orders<br>▪ Reduces design errors and conflicts<br>▪ Results in better initial estimates<br>▪ Contractors have ranked this method to have a very high impact |
| **Perceived Disadvantages** | ▪ Requires more time for initial designs<br>▪ Gets harder funding smaller scope projects |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 2.04/4.00 | **Quality** | **Schedule** | **Safety** |
|  |  | | |



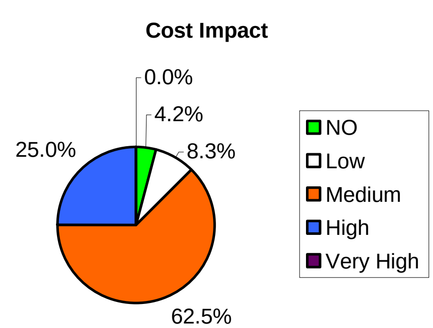
LEGEND

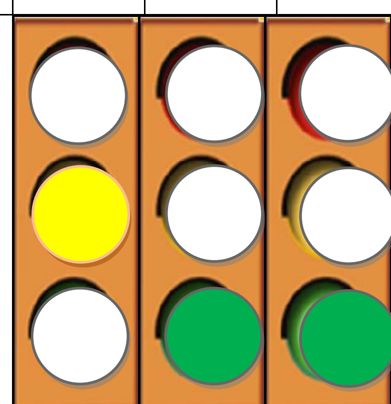
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Evaluate alternative contracting methods (design-build (D-B) and construction manager at risk (CM @ Risk))** |
| **Description** | Consider design-build contracts. D-B contracts may offer more flexibility to contractors as compared to traditional design-bid-build (D-B-B) contracts. In D-B contracts, contractors can better utilize resources that are cost effective. There is a higher integration of design and construction in design-build contracts. Thus, D-B contracts can positively impact resource planning and constructability. D-B contracts may also result in reduced number of change orders during construction. Other contractual methods like construction manager at risk (CM @ Risk) with a guaranteed maximum price (GMP) may constrain overall project cost. |
| **Project Milestone** | Design Concept Conference |
| **Project Characteristics** | Large contract size, complex projects |
| **Factor Addressed** | Type of contract (traditional D-B-B versus other contracts). The traditional project delivery method utilized by TxDOT is a design-bid-build method. While this contracting method assures that the lowest bidder is selected for the job, it does not offer contractors flexibility to use materials, machinery, and schedules which are economical to them and satisfy design specifications. The D-B-B method often creates issues of design coordination, constructability, and change orders. |
| **Perceived Advantages** | ▪ Reduces owner coordination requirements<br>▪ Reduces change orders<br>▪ Integrates design and construction better<br>▪ Results in better constructability<br>▪ Reduces time duration<br>▪ Contractors have ranked this method to have a medium impact |
| **Perceived Disadvantages** | ▪ Owner loses control over design process<br>▪ Legislative restricts other form of contracts<br>▪ Quality may be compromised |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 2.84/4.00 | **Quality** | **Schedule** | **Safety** |



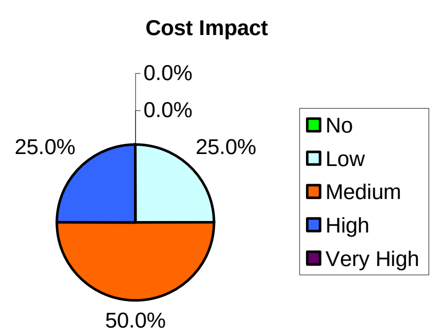
LEGEND

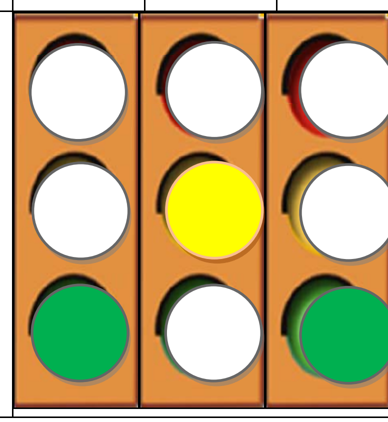
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

# COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Bundle construction projects for exploring economies of scale** |
| **Description** | Bundle small projects into one larger project. This may offer contractors economy of scale in their operations and attract more contractors to bid on a project. |
| **Project Milestone** | Design Concept Conference |
| **Project Characteristics** | Small dollar value projects |
| **Factor Addressed** | Contractor's overhead on smaller sized projects are higher. The contractors loose economy of scale and incur higher material wastage. The larger projects offer economy of scale to the contractors; they also are typically of longer duration, which has a negative effect on bid prices. The availability of qualified contractors to carry out the construction is not assessed in deciding the size of the project. Sometimes for a very big project numbers of qualified contractors are limited. |
| **Perceived Advantages** | ▪ Results in economy of scale for contractors<br>▪ Requires less effort in contract administration<br>▪ Contractors have ranked this method to have a very high impact |
| **Perceived Disadvantages** | ▪ Competition may be reduced, if availability of contractors having higher bidding capacity is low<br>▪ Longer project duration may increase the risk premium |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 2.00/4.00 | **Quality** | **Schedule** | **Safety** |



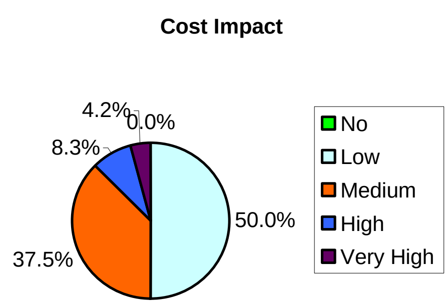
LEGEND

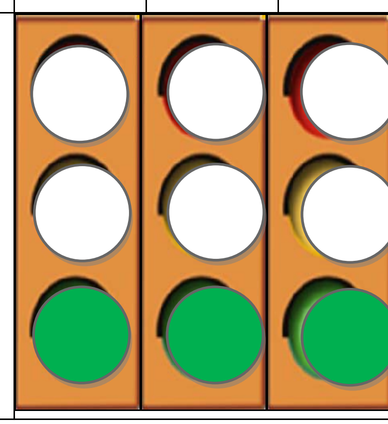
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Market new projects aggressively** |
| **Description** | Market new project opportunities aggressively, particularly on a large or complex project. This may attract more bidders. Develop working models, 3-D CAD views, walk-throughs, and special presentations in this regard. |
| **Project Milestone** | Design Concept Conference |
| **Project Characteristics** | Large and complex projects |
| **Factor Addressed** | Lack of communication and publicity about the business opportunities reduces the number of bidders. For complex and unique projects additional effort is needed to attract more bidders. There is lack of effort to evaluate reasons for poor response to previous lettings to improve future letting response. Complex projects involve unique designs or specialized methods for construction. Contractors need more time and information to understand the project complexities to prepare bids. In the absence of adequate information, contractors overprice the bid items. |
| **Perceived Advantages** | ▪ Increases the competition by attracting more bidders<br>▪ Results in more accurate bids by the contractors |
| **Perceived Disadvantages** | ▪ Contractors have ranked this method to have no impact |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.67/4.00 | **Quality** | **Schedule** | **Safety** |



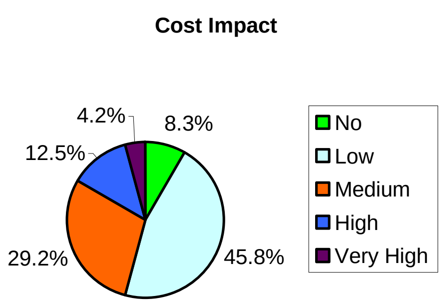
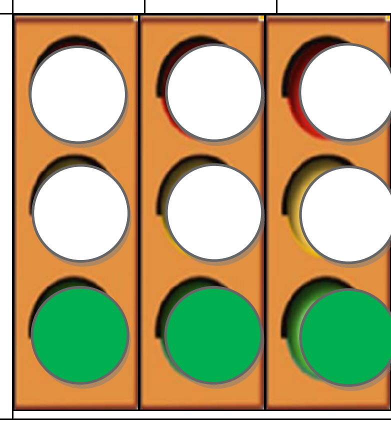



LEGEND

| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Understand and manage environmental restrictions** |
| **Description** | Understand the environmental restrictions in terms of air pollution, clean water act, solid waste disposal, flood plains and wetlands, endangered and threatened species protection, and other laws and their applicability to a given project. In particular, understand and manage the monetary and schedule impact of the restrictions and accommodate these issues in cost estimates and project schedules. Environmental restrictions may necessitate the use of different construction methodologies at potentially higher costs. One way of managing the environmental restrictions is to time the projects to avoid environmental restrictions. Better timing of the project may help deal with the seasonal environmental restrictions such as migratory birds, wild-life restrictions, and others. |
| **Project Milestone** | Design Concept Conference |
| **Project Characteristics** | Highway projects |
| **Factor Addressed** | There are environmental restrictions applicable to construction in certain geographic regions and areas including forests, watersheds, and urban residential areas. These restrictions impact the project schedule, material handling, disposal of construction waste, use of machinery, etc. Unintended violation of laws is possible during construction; however, fines and penalties associated with the violation of laws can be excessive and affect the overall project cost. |
| **Perceived Advantages** | ▪ Reduces the risk and uncertainties related to environmental aspects<br>▪ Impacts schedule positively<br>▪ Results in more accurate bids by the contractors<br>▪ Contractors have ranked this method to have high impact |
| **Perceived Disadvantages** | ▪ None |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.58/4.00 | **Quality** | **Schedule** | **Safety** |
|  |  | | |



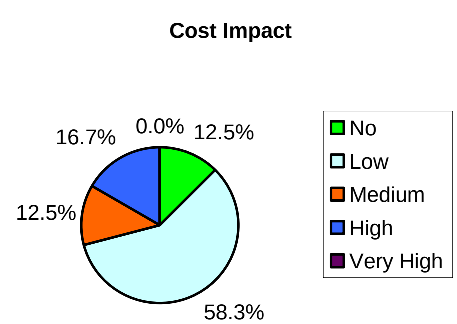
LEGEND

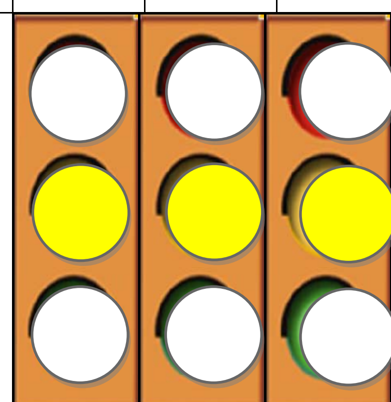
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

# COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Split construction projects** |
| **Description** | Split one large project into two or more smaller projects to increase potential competition. This approach may be particularly useful when there is an insufficient number of qualified contractors in the region to bid on a large project. A decision to split a large project may be based on the number of contractors in a region, their capacity, and expertise. |
| **Project Milestone** | Design Concept Conference |
| **Project Characteristics** | Large projects, maintenance projects |
| **Factor Addressed** | Competing markets results in reduced competition. The availability of big contractors who can handle large dollar value projects is less as compared to smaller contractors in general. Project duration is typically longer for big projects. As the duration of the project increases, the risk premium charged by the contractors increases to account for expected volatility in material prices and market conditions. Contractors fail to negotiate lower prices for material for an entire project duration, making material supplies vulnerable to inflation on projects with longer durations, e.g., maintenance projects of longer durations. |
| **Perceived Advantages** | ▪ Increases the competition<br>▪ Reduces the risk premium charged by contractors |
| **Perceived Disadvantages** | ▪ Impacts quality and schedule of construction negatively<br>▪ Increases the owner's effort in contract administration<br>▪ Contractors have ranked this method to have no impact |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.33/4.00 | **Quality** | **Schedule** | **Safety** |



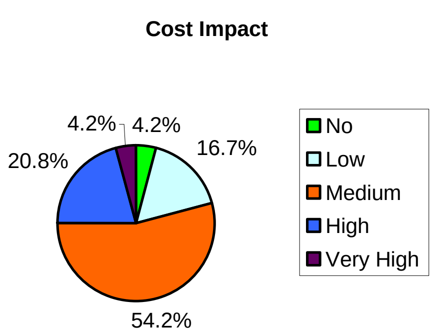
LEGEND

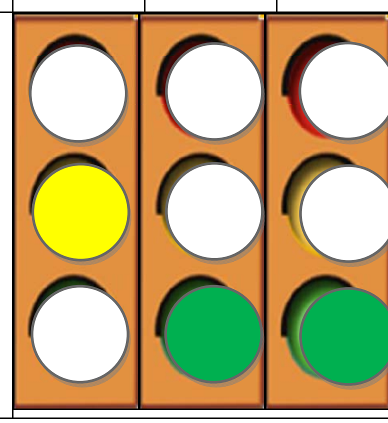
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

# COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Consider locally available materials in design** |
| **Description** | Make available resource mapping data to the design personnel for selection of materials based on the location of the project and availability of the materials source. Select materials that are locally available in sufficient quantity. |
| **Project Milestone** | 30% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | If materials are not available close to the construction site, it increases the material transportation cost. The distance of material sources from the project site determines the inventory and transportation costs. The prices of material vary from project to project based on accessibility and distance of the material source from the project site. |
| **Perceived Advantages** | ▪ Reduces the hauling distances and hence transportation costs<br>▪ Reduces the inventory costs<br>▪ May impact schedule positively due to short hauling distances<br>▪ Contractors have ranked this method to have very high impact |
| **Perceived Disadvantages** | ▪ Quality of locally available material may be questionable in some cases |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 2.08/4.00 | **Quality** | **Schedule** | **Safety** |



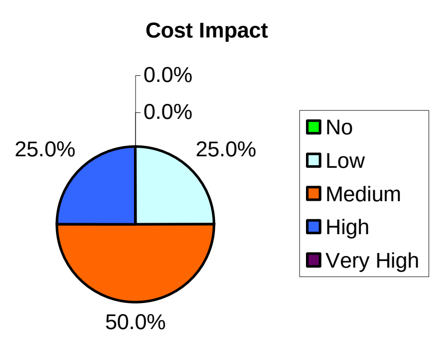
LEGEND

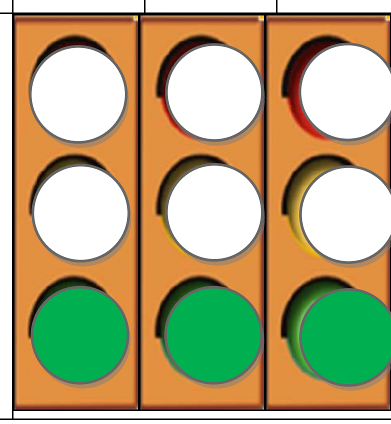
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Consider alterative designs** |
| **Description** | Consider alternative designs that offer more flexibility in selection of materials to the contractors. Consider alterative materials such as lime, lime-fly ash, cement, aggregate subbase (ASB), and emulsion stabilization in pavement design. Another example of alternative designs is use of warm mix asphalt. Consider adopting warm mix (heated well below 300° F) in place of hot mix asphalt. Warm mix asphalt can potentially reduce emissions, reduce fuel requirements, increase duration of the asphalt construction season, and permit longer trucking distances and, hence, offers the potential for overall reduction in the cost of production. This may also result in reduced rejection of asphalt due to low temperature at the time of placing and allow more time for placing. |
| **Project Milestone** | 30% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | The specification for concrete production affects cost and schedule. A typical example production requirement is temperature of asphalt concrete mix. More stringent specifications in the case of asphalt concret, results in higher production costs and reduced construction season. |
| **Perceived Advantages** | ▪ Offers more flexibility in material selection to the contractors<br>▪ Reduces the rejection rate in the case of warm mix asphalts<br>▪ Increases the asphalt construction season duration<br>▪ Contractors have rated this method to have a very high impact |
| **Perceived Disadvantages** | ▪ Increases design efforts and costs |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 2.00/4.00 | **Quality** | **Schedule** | **Safety** |



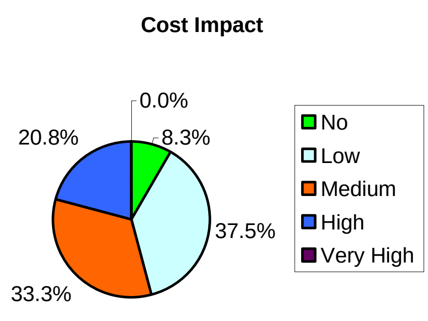
LEGEND

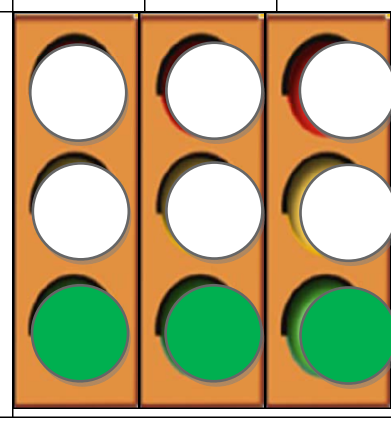
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Increase knowledge of design guidance and use of engineering judgment for design exceptions** |
| **Description** | Study design exceptions early in the design phase. Use of engineering judgment in design decisions may lead to more economical designs. |
| **Project Milestone** | 30% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | Designers hesitate to use design exceptions and engineering judgment. The perception that design exceptions are not acceptable leads to less than optimal designs. |
| **Perceived Advantages** | ▪ Results in optimal designs<br>▪ Results in better constructability<br>▪ Contractors have rated this method to have a very high impact |
| **Perceived Disadvantages** | ▪ None |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.67/4.00 | **Quality** | **Schedule** | **Safety** |



LEGEND

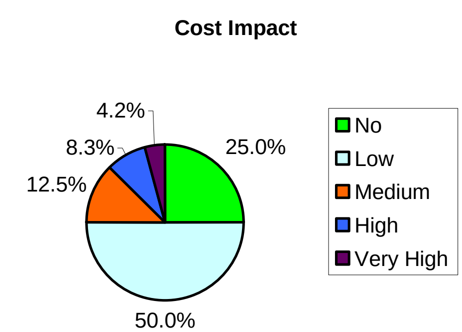
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Milestones** | Design | | 30% | | 60% | | 90% | | Post Letting | |

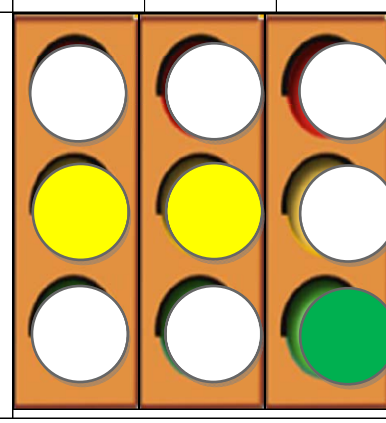
| | | | | | | |
|---|---|---|---|---|---|---|
| **Performance Impact** | Positive | | Neutral | | Negative | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Add alternate package for aesthetics** |
| **Description** | Develop a separate or alternate package for the aesthetics component of a construction project. Let this component to a specialist contractor. Provide more design repetitions. |
| **Project Milestone** | 30% Review |
| **Project Characteristics** | Bridge projects |
| **Factor Addressed** | Unique aesthetics design requirements can reduce the repetition of forms, complicate the fabrication process, and increase the construction time. Typically bridge columns, wall panels, railings, and other precast works require specialized forms, adding cost of fabrication. |
| **Perceived Advantages** | ▪ Results in better quality work due to use of specialist contractor [Quality yellow below, correct?]<br>▪ More repetition of forms results in economy to the contractor |
| **Perceived Disadvantages** | ▪ Contractors have rated this method to have no impact<br>▪ Increases the contract administration efforts for owner<br>▪ Aesthetics may get compromised in effort to reduce cost |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.17/4.00 | **Quality** | **Schedule** | **Safety** |



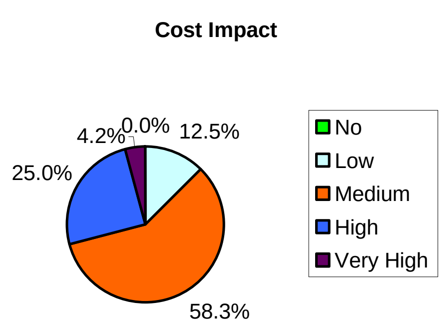
LEGEND

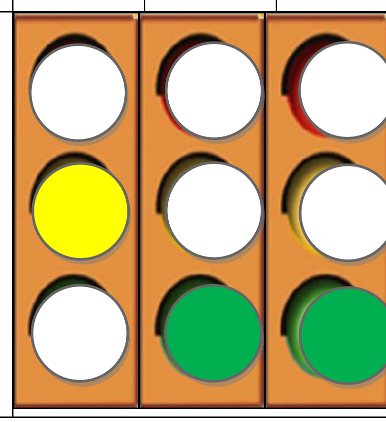
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

# COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Provide alternative materials in PS&E** |
| **Description** | Expand the number of material choices on a given project. Consider allowing alternate materials by providing flexibility in specifications. For example, a shortage of certain materials, such as concrete pipes, can be dealt with by providing flexible specifications or by allowing other material options to the contractors. |
| **Project Milestone** | 60% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | The capacity of available material sources is falling short of market demand. According to a 2007 U.S. Geological Survey report, there is a 24% shortfall in cement production in the U.S. which is met by importing. Capacity of refineries to produce asphalt is also restricted. Refineries are faced with the problem of variable production volumes. Some of the materials in short supply are cement, asphalt, steel, aggregates, and concrete pipes. |
| **Perceived Advantages** | ▪ Provides more options of material selection to the contractors<br>▪ Reduces or eases the shortage of certain materials<br>▪ Improves the schedule due to options of materials<br>▪ Contractors have ranked this method to have very high impact |
| **Perceived Disadvantages** | ▪ May have negative impact on quality |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 2.21/4.00 | **Quality** | **Schedule** | **Safety** |



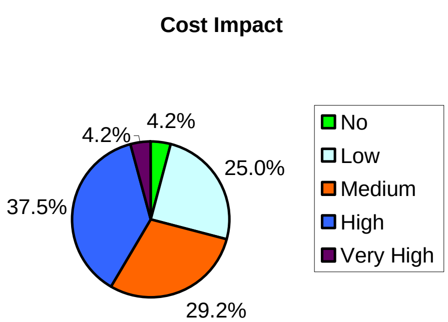
LEGEND

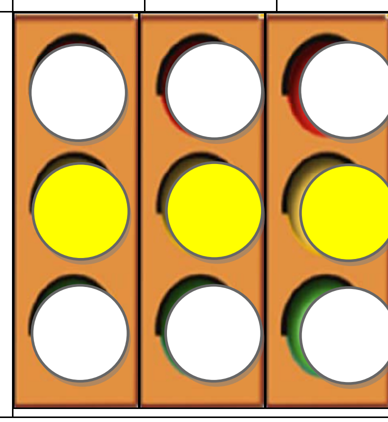
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Minimize detours and diversions** |
| **Description** | Minimize the use of detours and other traffic diversions to reduce potential cost impacts. Detours and other traffic diversions may be necessary but their value to the construction of the project should be carefully evaluated. |
| **Project Milestone** | 60% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | While traffic detours are necessary, detours and diversions add to the cost of the project without bringing any value. Planning of detours and diversions is done considering the comfort of the users, with least concern for the cost of detours and diversions. |
| **Perceived Advantages** | ▪ Reduces the cost including user costs<br>▪ Increases the user convenience and time<br>▪ Contractors have ranked this method to have very high impact |
| **Perceived Disadvantages** | ▪ Contractors have ranked this method to have no impact<br>▪ Poses a concern for safety |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 2.13/4.00 | **Quality** | **Schedule** | **Safety** |



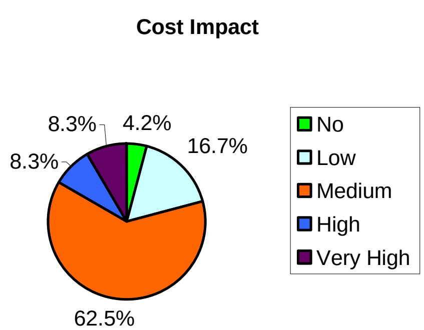
LEGEND

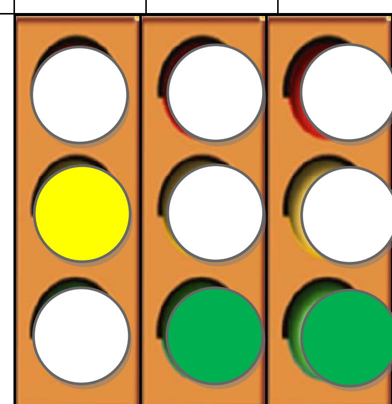
| | |
|---|---|
| **Milestones** | Design, 30%, 60%, 90%, Post Letting |
| **Performance Impact** | Positive, Neutral, Negative |

# COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Reuse and recycle materials** |
| **Description** | Consider utilizing recycled materials such as crushed concrete aggregate, which can reduce pressure on material supply. Consider recycled pavement versus new. Reuse materials like Metal Beam Guard Fence (MBGF) rail which is determined to be in good condition. Reuse of salvaged materials in repairs will also create better compatibility of the materials. Consider use of blended cements and optimum use of fly-ash to reduce cement consumption. |
| **Project Milestone** | 60% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | The capacity of available material sources is falling short of the market demand. According to a 2007 U.S. Geological Survey report, there is a 24% shortfall in cement production in the U.S. which is met by importing. Capacity of refineries to produce asphalt is also restricted. Refineries are faced with the problem of variable production volumes. The limited capacity of aggregate sources is a perennial problem. |
| **Perceived Advantages** | ▪ Reduces the wastage generation and promotes greener environment<br>▪ Reduces or eases the shortage of certain materials<br>▪ Contractors have ranked this method to have very high impact |
| **Perceived Disadvantages** | ▪ May have negative impact on quality<br>▪ Some designers may not prefer to use ‘old’ materials |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 2.00/4.00 | **Quality** | **Schedule** | **Safety** |



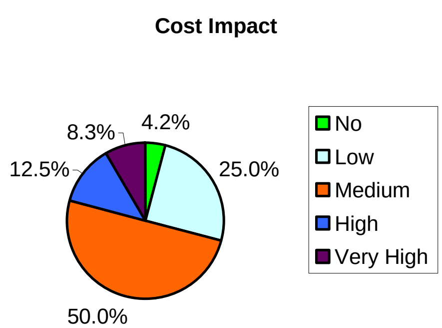
LEGEND

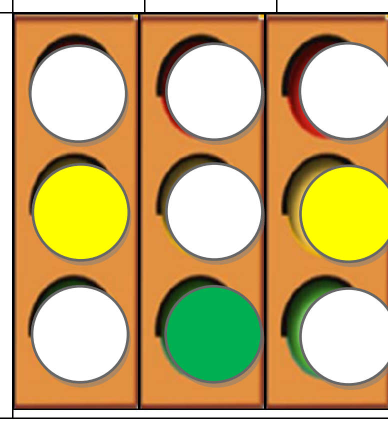
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Increase flexibility in traffic control planning** |
| **Description** | Give more flexibility to contractors to plan traffic control. This can lead to more effective construction staging plans which are consistent with the contractor's construction schedule. |
| **Project Milestone** | 60% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | The cost of designing and implementing traffic control constitutes a significant cost component on the contractor's estimate. Traffic control design causes coordination problems in traditional design-bid-build contracts, as the contractor needs to manage the project schedule considering traffic control requirements designed by other entities. Lack of consideration of traffic control cost in estimate results in lower estimate. |
| **Perceived Advantages** | ▪ Reduces the coordination efforts<br>▪ Results in more accurate bids by the contractors<br>▪ Impacts project schedule positively |
| **Perceived Disadvantages** | ▪ May have negative impact on quality and safety<br>▪ Transfers the risk to the contractors<br>▪ The contractors have ranked this method to have no impact |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.96/4.00 | **Quality** | **Schedule** | **Safety** |



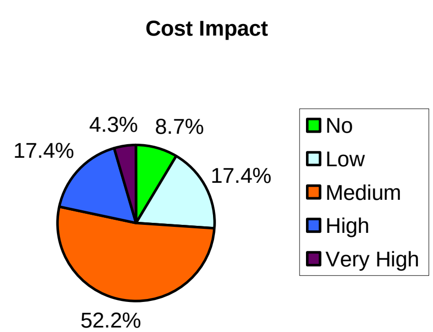
LEGEND

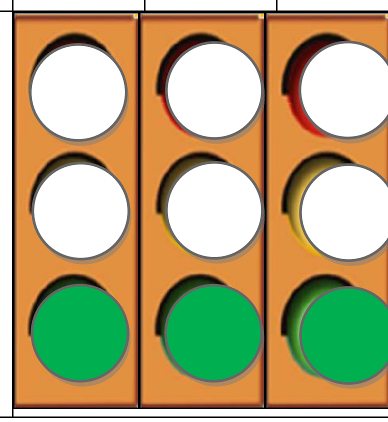
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Check cost effectiveness of specialty items at early stage** |
| **Description** | Study the cost impact of specialty items early in the design phase and select items accordingly. A specialty item may require unique material, machinery, or expertise for construction (e.g., retaining walls, noise barriers, utility relocation, hazardous waste mitigation, environmental mitigation, and erosion control). |
| **Project Milestone** | 60% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | Specialty items require specialized materials, equipment, or agency for execution. This work is frequently subcontracted to a specialty contractor. This results in a double markup for specialty items. Specialty items often require dependence on outside experts. The specialty items create delay in schedule. |
| **Perceived Advantages** | ▪ Reduces the dual markups<br>▪ Results in more accurate bids by the contractors<br>▪ The contractors have ranked this method to have very high impact |
| **Perceived Disadvantages** | ▪ Increases contract administration efforts when separate package is floated |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.83/4.00 | **Quality** | **Schedule** | **Safety** |



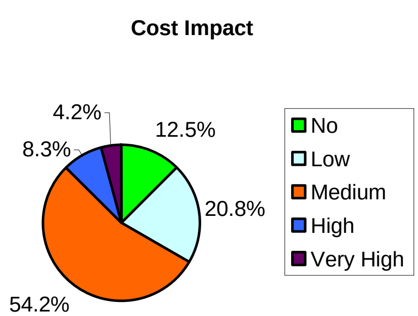
LEGEND

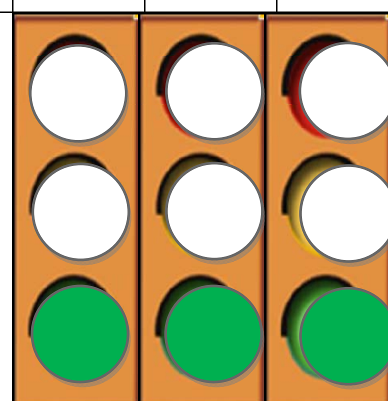
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Minimize mobilization** |
| **Description** | Minimize mobilization to reduce the impact of transportation. Bundle projects to reduce the mobilization, where it makes sense to do so. |
| **Project Milestone** | 60% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | Both federal and local (city) restrictions on truck movement during specific time periods can affect the cost of construction. For example, congestion-related restrictions on truck movements during day time and noise pollution restrictions during night time can affect project schedules, and ultimately the cost of construction in such areas. The restricted windows for work often do not allow contractors to complete the work in an efficient manner. To mitigate their risks, contractors incorporate this inefficiency in construction operations in their bid prices. |
| **Perceived Advantages** | ▪ Reduces the transportation cost and ease the material logistics<br>▪ Impacts project schedule positively<br>▪ The contractors have ranked this method to have a medium impact |
| **Perceived Disadvantages** | ▪ None |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.71/4.00 | **Quality** | **Schedule** | **Safety** |



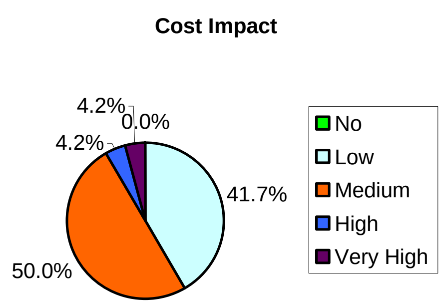
LEGEND

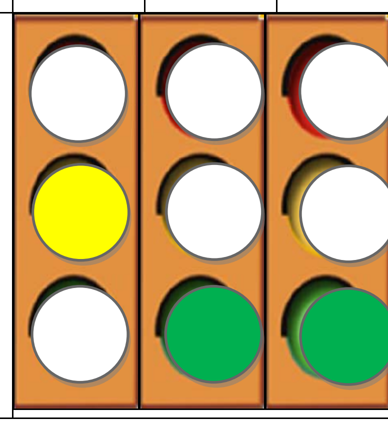
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Use performance or end product specifications** |
| **Description** | Provide flexibility in specifications to give contractor freedom to shop for more economical materials. Allow contractors to use methods and equipment that are more economical for them. This may reduce life-cycle costs. |
| **Project Milestone** | 60% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | Restrictive specifications limit contractors' choices of materials and methods. Limited or sole source for materials affects the price of materials. It increases the demand for those materials and hence price. Contractors cannot shop for economical materials due to restrictive specifications. Contractor also looses flexibility in construction. |
| **Perceived Advantages** | ▪ Gives more flexibility to contractors to shop for more economical materials<br>▪ Results in more accurate and lower bids by the contractors<br>▪ Impacts project schedule positively<br>▪ The contractors have ranked this method to have very high impact |
| **Perceived Disadvantages** | ▪ May have negative impact on quality<br>▪ On conventional projects contractors may prefer testing to performance responsibility |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.71/4.00 | **Quality** | **Schedule** | **Safety** |



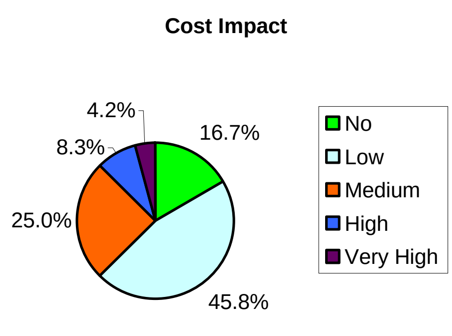
LEGEND

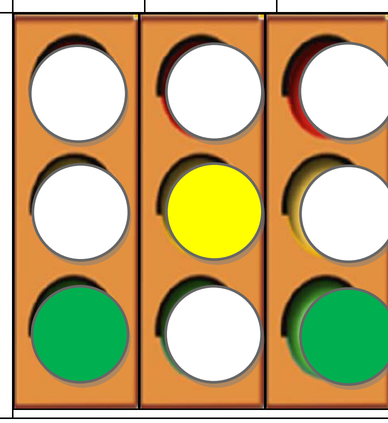
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Group specialty items into a separate package** |
| **Description** | Group specialty items into a separate bid package. This separate package can be let to a specialist contractor (e.g., utility relocation work can be isolated to form a new contract to let it to a specialist contractor). |
| **Project Milestone** | 60% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | Specialty items require specialized materials, equipment, or agency for execution. This work is frequently subcontracted to a specialty contractor. This results in a double markup for specialty items. |
| **Perceived Advantages** | ▪ Results in better quality due to specialist agency<br>▪ Eliminates the dual markups by the contractor<br>▪ May be effective for selected items<br>▪ May improve schedule due to involvement of a specialist [Schedule yellow below, correct?] |
| **Perceived Disadvantages** | ▪ The contractors have ranked this method to have low impact<br>▪ Increases the contract administration efforts for the owner |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.38/4.00 | **Quality** | **Schedule** | **Safety** |



LEGEND

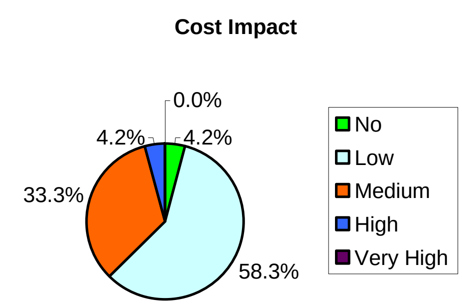
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Milestones** | Design | | 30% | | 60% | | 90% | | Post Letting | |

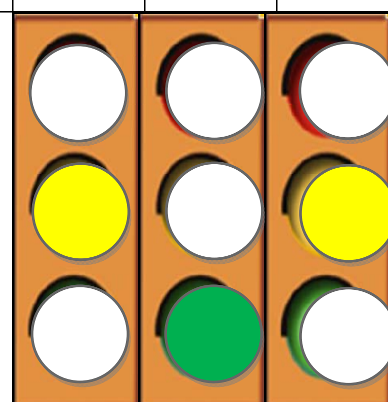
| | | | | | | |
|---|---|---|---|---|---|---|
| **Performance Impact** | Positive | | Neutral | | Negative | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Remove contract restrictions** |
| **Description** | Remove those contract restrictions that do not add value to the project. For example, a DOT may expect the same level of sampling and testing and corresponding paperwork for asphalt used on traffic level A and B facilities that it did on limited access interstate highways. Removing such restrictions may affect the bid price, e.g., reducing sampling and testing or paperwork requirements may reduce the bid price. |
| **Project Milestone** | 60% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | The restrictions in the contract increase the difficulty and create pressure on schedule and cost of construction. Contract restrictions limit competition by introducing unnecessary features or capabilities, e.g., unnecessary requirements for plants, machinery, and inspections. |
| **Perceived Advantages** | ▪ Increases the competition<br>▪ Results in cost reduction for contractor<br>▪ Reduces the administrative cost for owner<br>▪ The contractors have ranked this method to have very high impact |
| **Perceived Disadvantages** | ▪ May have negative impact on quality and safety |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.38/4.00 | **Quality** | **Schedule** | **Safety** |



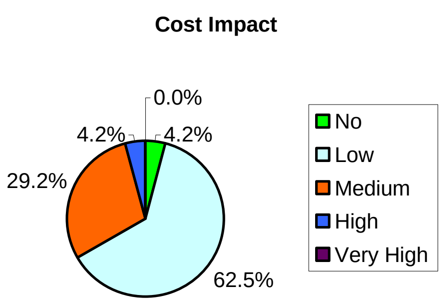
LEGEND

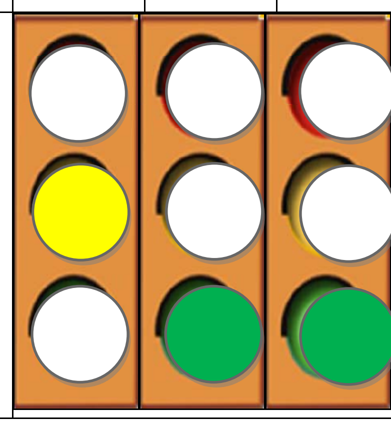
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

# COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Review specifications for their applicability to the given project, e.g., relaxation of asphalt concrete temperature restrictions** |
| **Description** | Review and evaluate specifications for their applicability to a given project. Adopt "must have versus good to have" approach, where possible. |
| **Project Milestone** | 60% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | The specification for concrete production affects cost and schedule. A typical example of a production requirement is temperature of asphalt concrete mix. More stringent specifications in the case of asphalt concrete result in higher production costs and reduced construction season duration. |
| **Perceived Advantages** | ▪ Results in cost reduction for contractor<br>▪ Impacts schedule positively<br>▪ The contractors have ranked this method to have very high impact |
| **Perceived Disadvantages** | ▪ May have negative impact on quality |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.38/4.00 | **Quality** | **Schedule** | **Safety** |



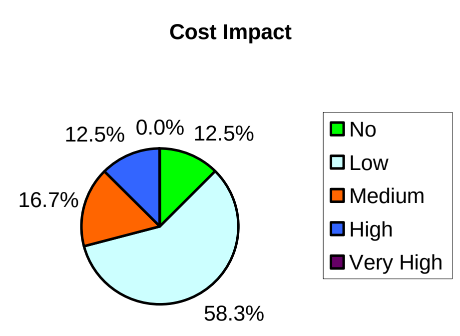
LEGEND

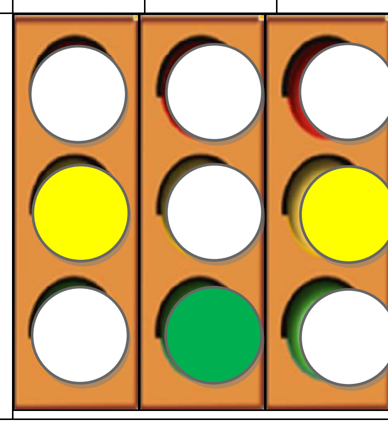
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

# COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Understand impact of night work** |
| **Description** | Consider permitting night work after evaluating the schedule benefits versus cost of night work. This may help manage the impacts of federal and local requirements on truck use during night time construction. |
| **Project Milestone** | 60% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | Federal, state, and local (city) restrictions on truck movement during specific time periods can affect the cost of construction. For example, congestion-related restrictions on truck movements during day time and noise pollution restriction during night time can affect project schedule, and ultimately the cost of construction in such areas. The restricted windows for work often do not allow contractors to complete the work in an efficient manner. To mitigate their risks, contractors incorporate this inefficiency in construction operations in their bid prices. Night work results in an overall increase in the costs. |
| **Perceived Advantages** | ▪ Results in cost reduction for contractor<br>▪ Impacts schedule positively<br>▪ Day work results in better quality of work<br>▪ The contractors have ranked this method to have very high impact |
| **Perceived Disadvantages** | ▪ May have negative impact on traffic operations |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.29/4.00 | **Quality** | **Schedule** | **Safety** |



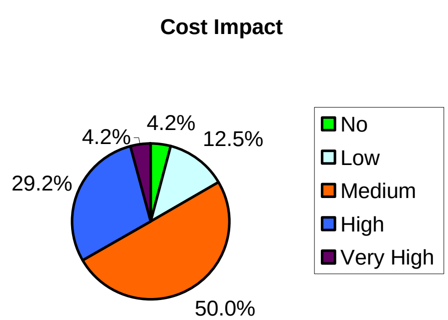
LEGEND

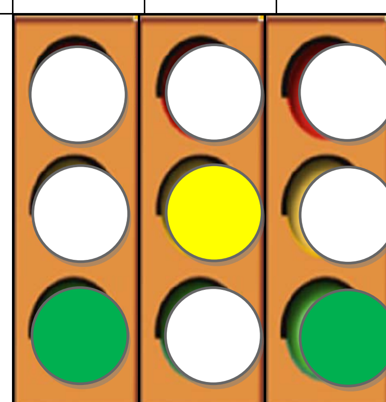
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Coordinate lettings based on the availability and capacity of contractors in the region** |
| **Description** | Plan yearly lettings with consideration of construction projects in other districts and other competing markets. Increase knowledge about the capacity of the contractors, their expertise, and preferences to work in certain geographical locations. This knowledge can facilitate decisions regarding whether to bundle or split the projects. Consider bid capacity of the contractors in the region and their availability around the year to decide appropriate time for letting. Non-critical projects can be deferred to a time when there is a potential for improved competition. |
| **Project Milestone** | 90% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | Typically accumulation of job lettings occurs toward the end of the financial year. This can result in reduced competition. Job lettings occurring at same time for similar types of projects (bridge, highway, etc.) can affect competition in those categories of projects. Since contractors specialize in certain types of work, when similar works are let simultaneously, the contractor selects those projects for bidding where they foresee a higher probability of winning. The overall effect is reduction in competition. |
| **Perceived Advantages** | ▪ Increases the competition<br>▪ Improves quality and schedule due to balancing [Schedule yellow below, correct?]<br>▪ Distributes the lettings uniformly |
| **Perceived Disadvantages** | ▪ The contractors have ranked this method to have no impact<br>▪ May have negative impact on overall letting efficiency<br>▪ Difficult to manage on larger scale |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 2.17/4.00 | **Quality** | **Schedule** | **Safety** |



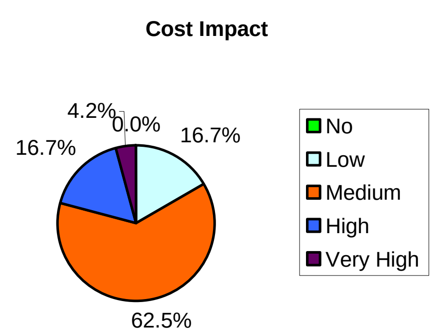
LEGEND

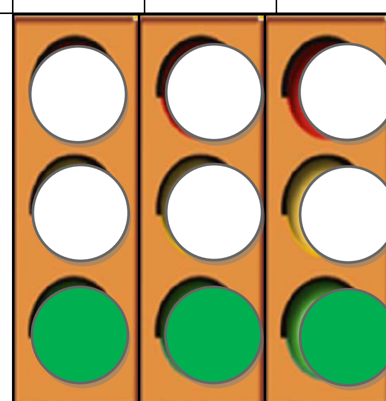
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Use contractor inputs in the development of design, specifications, schedule, and in constructability review process** |
| **Description** | Incorporate contractor expertise and experience when reviewing designs, estimates, construction methods, traffic control plans, schedule, and construction staging approaches. Involve contractors early in the project design phase to better address constructability issues with plans and specifications and local and environmental restrictions. Contractors can suggest materials based on availability, construction methods, and construction staging approaches. Involve contractors in the developing preliminary schedules and setting milestones. This may result in more realistic contract durations. Involve suppliers, contractors, and subcontractors when developing plans and specifications. This can result in easy to implement designs which are cost effective and reduce potential conflicts during execution. |
| **Project Milestone** | 90% Review |
| **Project Characteristics** | Large projects |
| **Factor Addressed** | Contractor input is important for design, specifications, constructability, construction staging, estimating, and planning of traffic control. Lack of contractor input can result in conflicts and change orders. Typically issues that arise due to lack of contractor input are design conflicts, utility conflicts, and schedule conflicts. |
| **Perceived Advantages** | ▪ Improves the constructability<br>▪ Reduces the design conflicts<br>▪ Reduces the cost for contractor<br>▪ Improves the estimates<br>▪ The contractors have ranked this method to have very high impact |
| **Perceived Disadvantages** | ▪ May increase the design development time |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 2.08/4.00 | **Quality** | **Schedule** | **Safety** |



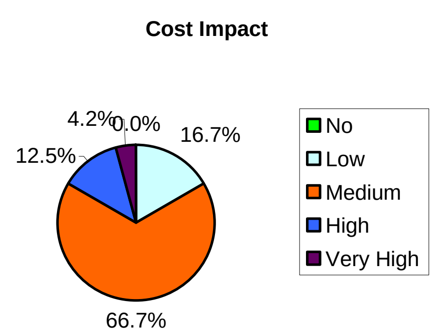
LEGEND

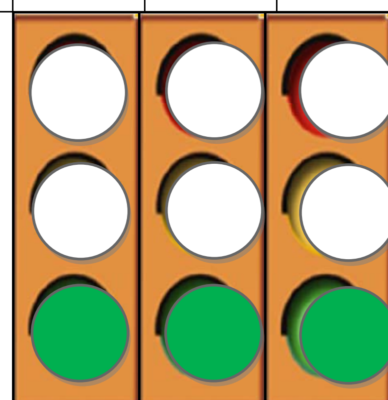
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Plan ahead and communicate requirements to material suppliers in advance** |
| **Description** | Inform material producers and suppliers of upcoming projects and key quantities. Begin the procurement process early. Early information may help suppliers plan their production better. Stockpiling materials improves the contractor's resource utilization. |
| **Project Milestone** | 90% Review |
| **Project Characteristics** | Large projects |
| **Factor Addressed** | The capacity of available material sources is falling short of the market demand. According to a 2007 U.S. Geological Survey report, there is a 24% shortfall in cement production in the U.S. which is met by importing. Capacity of refineries to produce asphalt is also restricted. Refineries are faced with the problem of variable production volumes. Some of the materials in short supply are cement, asphalt, steel, aggregates, and concrete pipes. |
| **Perceived Advantages** | ▪ Reduces or eases the shortage of certain materials<br>▪ Better consistency of materials<br>▪ Contractor can better manage resources due to stockpiled materials<br>▪ Impacts schedule positively |
| **Perceived Disadvantages** | ▪ The contractors have ranked this method to have no impact |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 2.04/4.00 | **Quality** | **Schedule** | **Safety** |



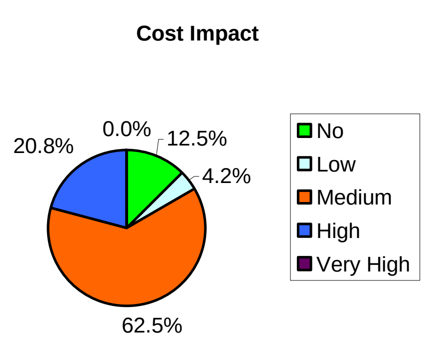
LEGEND

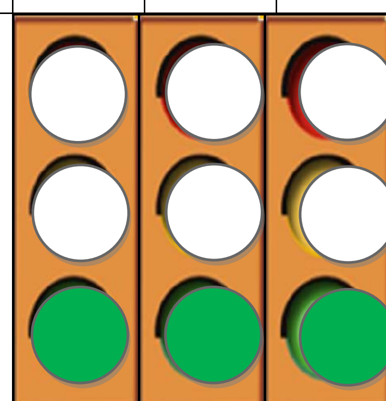
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

# COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Increase bid preparation time and conduct pre-bid meetings** |
| **Description** | Giving contractors more time to bid on projects may result in more realistic bid prices. The contractor has increased time to review plans and obtain quotes from a number of suppliers and subcontractors in preparation of bids. Contractors may choose not to bid when the time available for bidding is too short. Use pre-bid meetings to respond to queries and concerns that contractors may have about designs and other contract documents. In pre-bid meetings contractor feedback on design, specifications, and contract conditions can be obtained. Prompt response to the pre-bid queries is important to achieve realistic bids. |
| **Project Milestone** | 90% Review |
| **Project Characteristics** | Large projects |
| **Factor Addressed** | Inadequate time given to contractors for bidding may result in lack of interest from contractors. Contractors may choose not to bid when they are overloaded and less time is available. It may result inaccurate bids. When pre-bid meetings are not conducted, it results in lack of contractor inputs. Contractors may not get chance to clarify doubts if a pre-bid meeting is not conducted. |
| **Perceived Advantages** | ▪ Increases the competition<br>▪ Reduces change orders when doubts are cleared in pre-bid meeting<br>▪ Results in more accurate bids by the contractors |
| **Perceived Disadvantages** | ▪ Increases the time of letting process<br>▪ More time may lead to conflict with forthcoming lettings<br>▪ Contractors do not utilize more time given for bidding<br>▪ The contractors have ranked this method to have no impact |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.92/4.00 | **Quality** | **Schedule** | **Safety** |



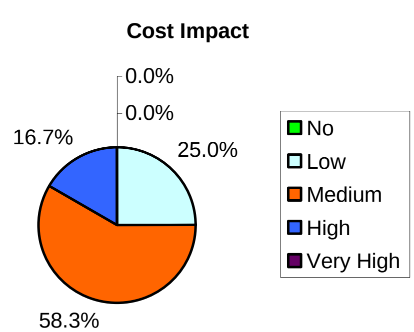
## LEGEND

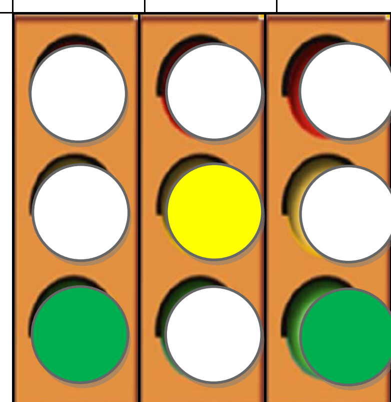
| | |
|---|---|
| **Milestones** | Design, 30%, 60%, 90%, Post Letting |
| **Performance Impact** | Positive, Neutral, Negative |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Provide flexible project start time** |
| **Description** | Provide flexible start time to allow contractors to plan and schedule their resources better. This may reduce the impact of competition on material costs, particularly when many projects are let simultaneously. Consider flexible start dates on projects that involve offsite preparatory work that can be accomplished prior to the starting date. Contractors may be able to bid for more projects with flexible start times. |
| **Project Milestone** | 90% Review |
| **Project Characteristics** | Large projects |
| **Factor Addressed** | Typically accumulation of job lettings occurs toward the end of the financial year. This can result in reduced competition as contractors choose to bid for those projects that have higher profit margins and higher probability of winning. Job lettings occurring at same time for similar types of projects (bridge, highway, etc.) can affect competition in those categories of projects. Since contractors specialize in certain types of work, when similar works are let simultaneously, the contractor selects those projects for bidding where they foresee a higher probability of winning. The overall effect is reduction in competition. |
| **Perceived Advantages** | ▪ Increases the competition<br>▪ Reduces the cost of materials, contractors can procure materials at favorable time<br>▪ The contractors have ranked this method to have a very high impact |
| **Perceived Disadvantages** | ▪ May impact the project schedule negatively |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.92/4.00 | **Quality** | **Schedule** | **Safety** |



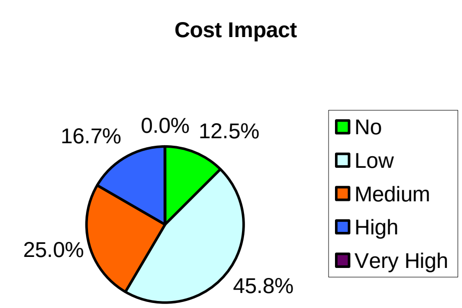
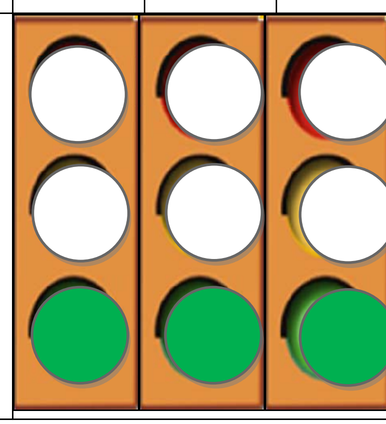



LEGEND

| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Provide state yards** |
| **Description** | Provide space for plants and yards, and manage the speculative component related to cost of acquisition of plant and yard sites. This may include sites for borrow area and waste disposal. |
| **Project Milestone** | 90% Review |
| **Project Characteristics** | Large projects |
| **Factor Addressed** | The risk associated with acquiring yard and plant sites within or nearby right of way increases the risk premium charged by contractors. There are wide fluctuations in the rate of yard sites based on location, particularly in urban areas. Contractors prefer yard sites close to project locations and preferably on the right of way. Urban sites pose more problems of site acquisition and higher costs associated with acquisition. |
| **Perceived Advantages** | ▪ Reduces the risk and cost related to acquisition of yard sites<br>▪ Reduces the transportation cost, when site is provided in or near to right of way<br>▪ Improves quality due to proximity to site |
| **Perceived Disadvantages** | ▪ Increases the State liability<br>▪ Borrow/disposal area may create problem for project clearing environmentally<br>▪ The contractors have ranked this method to have no impact |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.46/4.00 | **Quality** | **Schedule** | **Safety** |
|  |  | | |



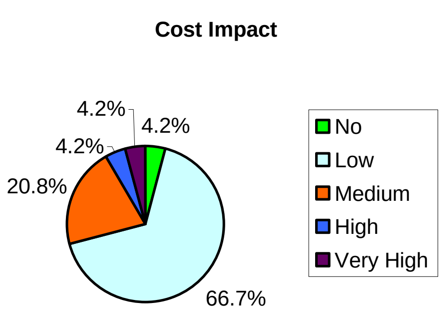
LEGEND

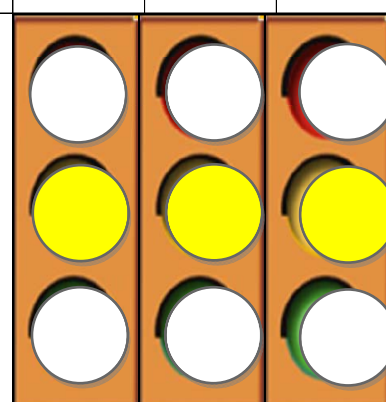
| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Milestones** | Design | | 30% | | 60% | | 90% | | Post Letting | |
| **Performance Impact** | Positive | | Neutral | | Negative | | | | | |

# COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Reduce construction durations** |
| **Description** | Consider shortening project durations to reduce the effect of inflation. Where feasible, longer duration projects can be shortened by splitting projects into multiple construction contracts. This method may be particularly effective for construction involving highly volatile material items such as concrete and resources, where contractors have a higher risk. |
| **Project Milestone** | 90% Review |
| **Project Characteristics** | Large projects |
| **Factor Addressed** | Projects with longer project durations are adversely affected by the volatility in material prices. As the duration of a project increases, the risk premium charged by contractors increases to account for expected volatility in material prices and market conditions. Contractors fail to negotiate lower prices for material for entire project duration, making material supplies vulnerable to inflation on projects with longer durations. |
| **Perceived Advantages** | ▪ Reduces the effect of inflation and risk premium<br>▪ Increases the contract administration efforts for owner |
| **Perceived Disadvantages** | ▪ Contractors may bid high if duration is too short<br>▪ May impact quality, schedule, and safety negatively<br>▪ The contractors have ranked this method to have no impact |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.38/4.00 | **Quality** | **Schedule** | **Safety** |



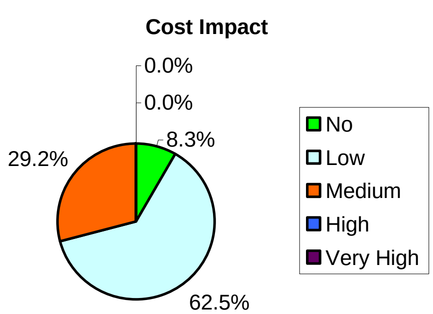
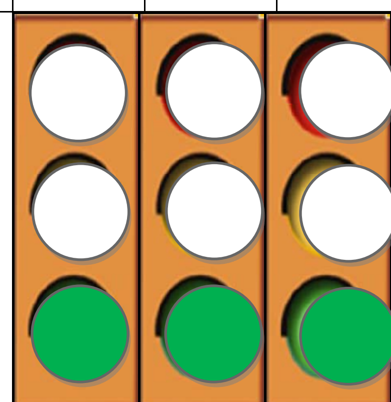



LEGEND

| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Consider multiple project completion dates** |
| **Description** | Provide multiple project completion dates in the construction contract. For example, provide a primary completion date based on the traffic operation requirements and a secondary date for non-critical tasks like landscaping, walkways, etc. Multiple completion dates provide the contractor flexibility which can potentially reduce the cost, as they can more efficiently utilize their resources. |
| **Project Milestone** | 90% Review |
| **Project Characteristics** | Large projects |
| **Factor Addressed** | The number of project milestone points can affect the bid prices. These milestones prevent contractors from using their resources in an optimal manner. Due to the presence of milestone points, contractors are more focused on meeting the milestone deadlines, rather than most efficient utilization of their resources. |
| **Perceived Advantages** | ▪ Gives flexibility to contractor in project completion<br>▪ Eliminates unnecessary milestones<br>▪ The contractors have ranked this method to have high impact |
| **Perceived Disadvantages** | ▪ May increase the paperwork and associated cost<br>▪ May increase overall project completion time [negative impact on schedule (green below)?] |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.21/4.00 | **Quality** | **Schedule** | **Safety** |
|  |  | | |



LEGEND

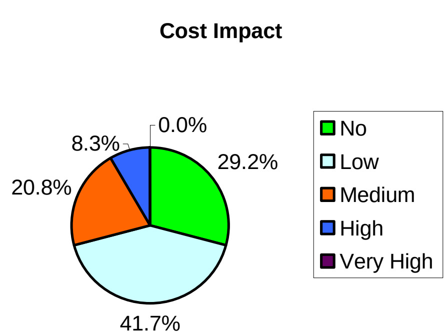
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |

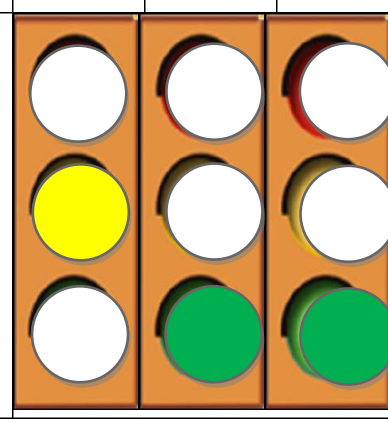
| | | | |
|---|---|---|---|
| **Performance Impact** | Positive | Neutral | Negative |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Plan adequate oversight for accelerated projects** |
| **Description** | For accelerated project development, plan effectively. Consider the cost impact of accelerated development. |
| **Project Milestone** | 90% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | Fast-tracked and accelerated project delivery reduces project duration. Short contract duration reduces the flexibility that contractors may have in mobilizing resources. Accelerated project delivery increases the cost and sometimes results in lower efficiency due to congestion on site. (On the positive side, short contract duration mitigates the effect of inflation.) |
| **Perceived Advantages** | ▪ Reduces the adverse impact of accelerated development<br>▪ Increases the project performance<br>▪ The contractors have ranked this method to have high impact |
| **Perceived Disadvantages** | ▪ None |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.08/4.00 | **Quality** | **Schedule** | **Safety** |



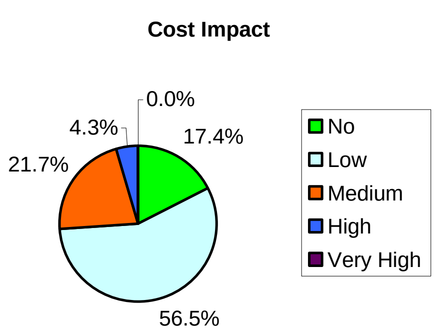
LEGEND

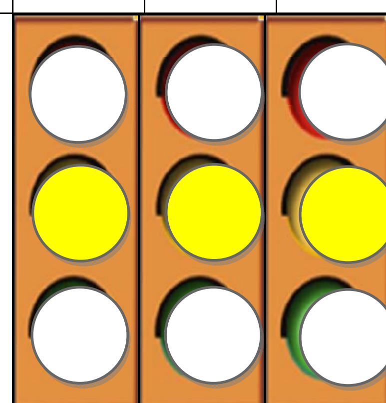
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Schedule projects considering federal trucking requirements** |
| **Description** | Schedule projects after careful evaluation of project conditions with respect to federal requirements on trucking. Maximize the number of hours in which truck drivers could operate and that make less aggressive contract times where not necessary to reduce the number of drivers. Less aggressive contract times may reduce surcharges applied to hauling/delivery costs. |
| **Project Milestone** | 90% Review |
| **Project Characteristics** | All projects |
| **Factor Addressed** | Both federal and local (city) restrictions on truck movements during specific time periods can affect the cost of construction. For example, congestion-related restrictions on truck movements during day time and noise pollution restrictions during night time can affect project schedule, and ultimately the cost of construction in such areas. The restricted windows for work often do not allow contractors to complete the work in an efficient manner. To mitigate their risks, contractors incorporate this inefficiency in construction operations in their bid prices. |
| **Perceived Advantages** | ▪ Improves the logistics and reduces the cost for contractor<br>▪ Provides more working time |
| **Perceived Disadvantages** | ▪ The contractors have ranked this method to have no impact<br>▪ May increase the traffic exposure |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.08/4.00 | **Quality** | **Schedule** | **Safety** |



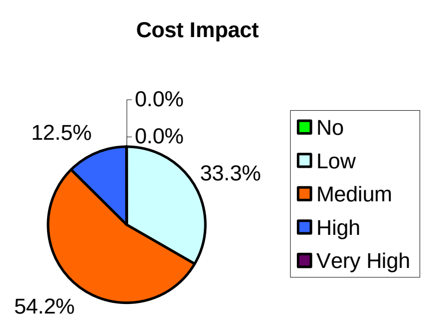
LEGEND

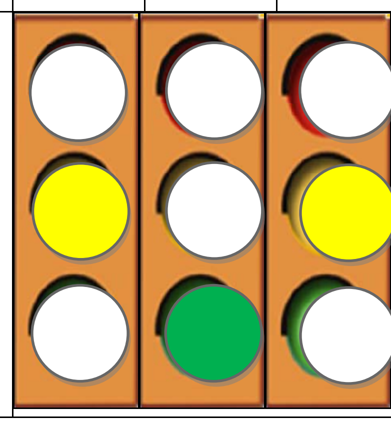
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Share cost savings with the contractors** |
| **Description** | Accept cost saving proposals from contractors during bidding and construction. Contractors may be more motivated to submit such proposals when potential cost savings are shared. |
| **Project Milestone** | Post-letting |
| **Project Characteristics** | All projects |
| **Factor Addressed** | Contractors are not motivated to reduce the project cost. The initiatives of contractors in cost reduction are not rewarded by sharing savings. |
| **Perceived Advantages** | ▪ Increases contractor involvement in the cost reduction process |
| **Perceived Disadvantages** | ▪ May have negative impact on quality, safety, and bidding process<br>▪ May be applied to limited areas<br>▪ The contractors have ranked this method to have no impact |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.79/4.00 | **Quality** | **Schedule** | **Safety** |



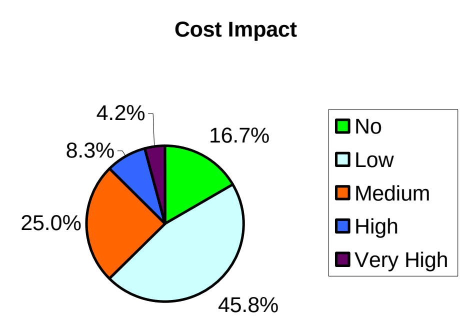
LEGEND

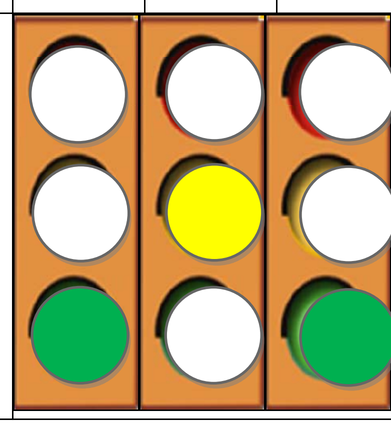
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Reject non-competitive bids and re-advertise** |
| **Description** | Reject non-competitive bids when bids received are substantially higher than the engineer's estimate. Competition may be increased by re-letting. The causes for higher bids can be analyzed and addressed prior to re-letting (e.g., changes in the design can be made). |
| **Project Milestone** | Post-letting |
| **Project Characteristics** | All projects |
| **Factor Aaddressed** | Competing markets affect the competition on highway projects. The influence of other construction projects such as residential, commercial, and industrial construction impacts availability and costs of material, labor, subcontractors, machinery, and other highway construction resources. Following Hurricane Katrina, an increase in commercial and residential projects has decreased competition and affected availability of construction materials, labor, machinery, and other highway construction resources. |
| **Perceived Advantages** | ▪ Increases the competition<br>▪ Provides chance for changing design or project features affecting cost<br>▪ The contractors have ranked this method to have medium impact |
| **Perceived Disadvantages** | ▪ May delay the project<br>▪ Does not guarantee reduction in prices<br>▪ May result in additional expenses related to re-letting administration |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.38/4.00 | **Quality** | **Schedule** | **Safety** |



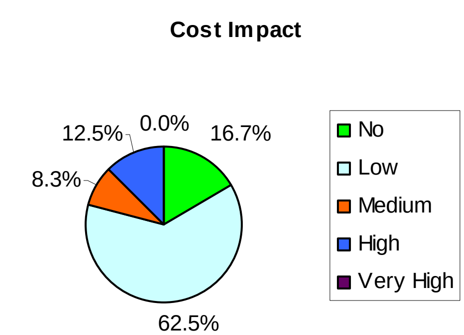
LEGEND

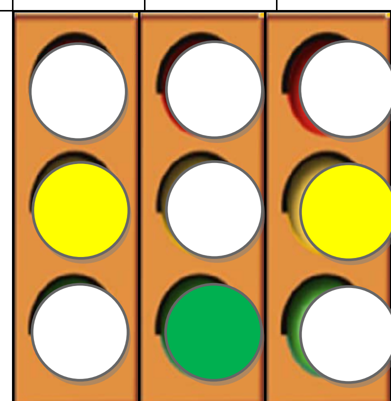
| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |

## COST REDUCTION METHOD INFORMATION SHEET

| | |
|---|---|
| **Method** | **Better utilize inspectors and recognize cost of inspections in the estimates.** |
| **Description** | Stop measuring every square foot or cubic yard of material used. Instead use the schedule to monitor progress of the project. Daily work reports only generate an estimate and actually reduce the amount of time inspectors spend inspecting. Incorporate inspection costs in the estimates to have more realistic estimates. Contractors refrain from bidding when engineer's estimate is lower than their own estimates. |
| **Project Milestone** | Post-letting |
| **Project Characteristics** | All projects |
| **Factor Addressed** | Contractors incur a significant cost for testing and certification of materials. There is a duplication of efforts, as inspection is carried out by both contractor and TxDOT. |
| **Perceived Advantages** | ▪ Reduces the owner inspection costs<br>▪ Results in better estimates and more accurate bids by contractors |
| **Perceived Disadvantages** | ▪ May impact project quality and safety negatively |

| **Cost Impact Evaluation** | **Performance Impact Indicator** | | |
|---|---|---|---|
| Cost Evaluation Score 1.17/4.00 | **Quality** | **Schedule** | **Safety** |



LEGEND

| | | | | | |
|---|---|---|---|---|---|
| **Milestones** | Design | 30% | 60% | 90% | Post Letting |
| **Performance Impact** | Positive | Neutral | Negative | | |