SCHEMATIC APPROACH TO IMPROVE TIME PERFORMANCE OF HIGHWAY CONSTRUCTION CONTRACTS

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ABSTRACT : This paper presents incentive application strategies and delay prevention strategies as schematic approaches to improve time performance of highway construction contracts. This research recognizes the importance of improving time performance during highway construction. Strategic solutions of the most core issues on time performance incentive contracting are identified. The suggested incentive application strategies develop criteria for applying time classification to projects, for assigning project time classifications to contractors and designers, and for determining appropriate incentive values in A (cost) + B (time cost) and other performance incentive contracts. The suggested delay prevention strategies develop criteria for determining the appropriate subsurface utility engineering (SUE) level and to develop best practices for avoiding utility relocation delays. A schematic approach for each strategy is developed. This paper also introduces current incentive contracting practices in Florida. The researchers obtained the information from experienced persons in the highway construction industry, including key highway contractors, designers, and Department of Transportation (DOT) and Federal Highway Administration (FHWA) personnel. The major focus of this research is to develop strategies and suggest approaches to improve time performance of highway construction contracts. For future study, practical tools to facilitate implementation of the suggested strategies should be developed, so that the criteria, implementation processes, and best practices developed may contribute to the current industry-wide effort to improve time performance.

Key words : Highway Construction, Time Performance, A+B, Incentive Contracting

1. INTRODUCTION

The time performance of highway construction contracts is increasingly becoming an issue of national concern. While it is true that completed construction projects add to the value of the transportation system, the construction process itself can adversely affect the traveling public and local businesses. Consequently, there is a growing recognition that attention must be given to minimizing the negative effects of transportation construction projects. In general, reducing the project construction time will reduce the inconveniences caused by the construction.

The objective of this study is to develop strategies and suggest approaches to improve highway construction contract time performance. The research was performed by conducting interviews with and administrating surveys to experienced persons from the highway construction industry, including a key highway contractor, a designer, and DOT and FHWA personnel.

1.1 Impacts of incentive contracting methods

The current state highway agencies (SHAs) utilize incentive contract methods aiming for early completion of highway construction projects. Substantial improvement of project time performance has been reported [1]. Construction time data recently obtained from District 6 in Florida also show time savings by contract methods, as shown in Table 1. Average time savings using incentive methods was approximately 14.7% in the district. However, average time overruns of conventional contract methods used during the same periods was about 7.1%. Comparing the two methods, incentive contracts showed improved time savings of approximately 21.8%.

Table 1. Time savings by contract types

Contract type	No. of projects	Average time savings (+) / overrun (-)
Bonus	17	14.37 %
A+B with Bonus	20	7.61 %
Liquidated Savings	12	21.73 %
Incentive/Disincentive	20	18.34 %
Conventional methods	42	-7.1 %

1.2 Avoiding delay during construction phase

It is important to avoid delays during highway construction. The root causes of the most common delays were identified using a recent survey of SHA and highway contractors who provided a ranking of construction delay causes [2]. As might be expected, the two groups have slightly different views. However, both SHAs and contractors ranked utility relocation delays as the number one cause of delays.

Subsurface utility engineering (SUE) technology has significantly improved the precision of subsurface utility location during the project design phase. Using the appropriate SUE technology has been shown to significantly reduce utility conflicts resulting from inaccurate location information [3]. Additionally, some SHAs, such as the Florida Department of Transportation (FDOT), are making SUE resources available to construction teams. If a construction team believes that additional location information is needed at any time during construction, FDOT has the budget and resources available to help. This has proven to be a valuable failsafe feature, allowing the construction team to proactively identify conflicts before they result in delays.

2. CURRENT PRACTICE IN FLORIDA

In order to improve time performance of highway construction, the SHAs has used such incentive contracting methods as A (cost) + B (time cost), Bonus, Incentive and Disincentive (I/D), Liquidated Savings, and the like. The FDOT is one of the leading SHAs using these innovative contracting methods. Thus, the researchers studied the current practice of awarding incentive contracts in Florida.

2.1 Incentive project selection procedures

The FDOT allows the districts flexibility to manage their business using methods with which they feel most comfortable. Thus, the districts do not all have the same system. The incentive contract method has been frequently and actively used in Florida, generating many success stories. The researcher interviewed district engineers in Florida to ask their experience in relation to incentive projects. Generally speaking, the district management controls the selection of incentive projects. The incentive contract requests can come from a number of sources including district construction, district production, local city, local county, district secretary, and so on. Next, it is entered into the Work Program. Different districts operate differently, but they all use a Work Program. Finally, the recommended projects obtain approval from their district management so that the projects are eligible for incentive money. The reasons for the requests depend on various situations:

- Whether a project is highly visible and important,
- Whether a project has a high priority,
- What the impacts of construction on the project will be,
- What the economic impacts might be,
- What the financial impacts to the department and/or the public,
- What the events in this area are.

The Work Program is developed by the districts, working with local governments and metropolitan planning organizations [4]. Four production phases are included in a Five-Year Work Program: environmental and engineering, design, right of way, and construction. Generally speaking, within a twelve-month period prior to the finalization of contract documents, incentive projects are selected, although it can be closer to the construction phase.

Thus, the process for selecting and programming incentive methods is delegated to each district. The district management determines the selection of incentive projects to be able to minimize those impacts to those they serve, the traveling public and business owners.

2.2 Success of incentive contract methods

Generally speaking, the district engineers who were interviewed emphasized two things that make construction projects successful. They are *quality of contract documents* and *appropriate choice of incentives*. For the issues of quality of contract documents, several items are necessary:

- A high quality set of plans and specifications,
- A well prepared construction schedule,
- Well coordinated utility relocation schedules,
- Verified quantities and pay items.

According to the interviews with district engineers, incentive projects would rarely increase the budget of the project if there is a good set of plans. With poorly prepared contract documents, incentives only aggravate problems. For example, the department needs to clearly describe what the incentives are based on and include this in the contract document. If a district incentive says that the district will give the contractor $5000 incentive money for opening three lanes of traffic, it is important that the department be very clear what the criteria are for achieving that incentive. For instance, it should be clearly stated in the contract what is meant by open lanes of traffic because it may require a permanent seal coat or permanent pavement markings.

It is also important to have a good working relationship between the construction and the production departments within a district. In District 6, the production and construction departments work as a team. The production department assigns quality of plans the highest priority in the design process.

2.3 Appropriate choice of incentives

Appropriate incentives are usually based on user cost analysis. The user cost used to be calculated using the *MicroBENCOST* or the *Quewz* computer program [5]. However, the fact is that the user cost can become a very high number. The daily incentive amount may rise to $100,000 a day if there are 100,000 vehicles a day going through a point on an interstate. In this instance, the district engineers review the project to decide what a reasonable amount will be. Thus, they have to justify what the maximum amount of incentive will be and often use their judgment to decide what would be the reasonable amount. For example, District 6 has used incentives and disincentives many times, usually very successfully. Construction time and cost analyses by the district engineers to indicate that the department does not need to offer an exorbitant amount of incentive in order to attract a contractor’s interest. Relatively low amount such as $100,000 or $200,000, often will serve to motivate contractors to accelerate project time schedule and earn the bonus.

2.4 Analysis of time performance on incentive methods

The researchers investigated the impacts of incentive contract methods on construction time performance using construction project time data obtained from District 6 in

Florida during the fiscal years of 2000 through 2004. Data for 111 projects have been received and consist of 69 projects using incentive contracting methods and 42 projects using conventional contracting methods. Time performance index (TPI) of each project was evaluated based on the following formula:

$$TPI = \frac{Original\ Contract\ Days - Days\ Used}{Original\ Contract\ Days} \quad (1)$$

where a positive value of *TPI* means time savings and a negative value of *TPI* means time overruns. For example, a value of 0.10 means a 10 percent time savings, while a value of -0.10 means a 10 percent time overrun.

Statistical analyses were performed to investigate the possible difference in time performances between incentive contracting methods and conventional contracting methods. A two-sample *t*-test was used to test if there was a significant difference between the means of the two groups. The *t*-test was conclusive at the 0.05 level and the test results showed sufficient evidence that the average time performances from the two groups were not the same. In particular, incentive contracting methods are more efficient to improve project time performance than conventional contracting methods. Summary statistics of samples and the *t*-test results with *p*-value and significance levels are shown in Appendix I.

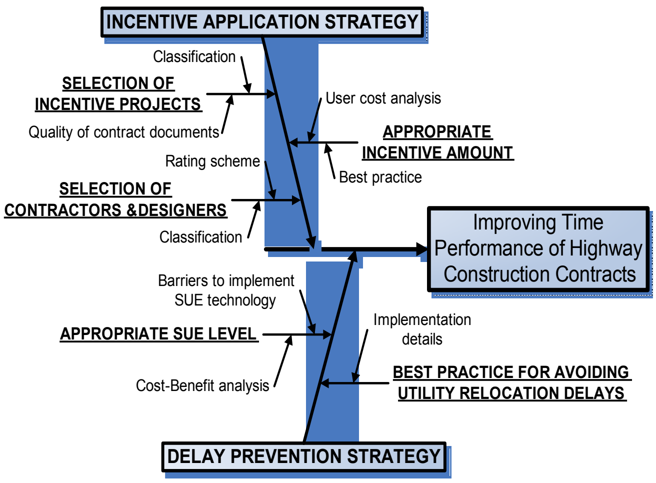

Figure 1. Fishbone diagram to improve time performance

3. SCHEMATIC STRATEGIES

Through the interview, survey, and data analysis two main strategies were developed to improve time performance of highway construction contracts. They are the *Incentive application strategy* and the *Delay prevention strategy*. Under the incentive application strategy, three substrategies were developed to use incentive methods effectively with regard to: selection of incentive project, selection of contractors and designers, and appropriate incentive amount. Under the delay prevention strategy, two substrategies are developed related to: appropriate SUE level and best practice for avoiding utility relocation delays.

Figure 1 identifies the possible ways to improve time performance of highway construction contracts. A detailed approach for the implementation of each strategy is described in the following subsection.

3.1 Time classification for projects

An indispensable recommendation brought out during the interviews and surveys was to develop a project time classification scheme. The suggested time classification categories are shown in Appendix II. The projects with greatest priority relate to reducing the time the public is inconvenienced. They are designated as Class 1 projects. The practices and procedures applied to Class 1 projects are different from those applied to other less-sensitive projects, thus preserving the fundamental principle of priority. In a resource-constrained environment, the highest priority projects should receive the most resources.

Each Class 1 projects should be treated as unique, as the objective of minimizing time is paramount. Every person in the SHA, the designer, and the contractor should know that this project has been given the highest priority relative to time, thereby promoting effective communication. A limited number of projects should have this designation, the actual number depending upon available resources. The number of projects should be consistent with the resources available to the district or region. The classification should be a part of the program planning process, meaning that the selection would be made during the planning stage. However, more detailed guidance is needed with regard to the process of assigning time categories to projects for the future study.

3.2 Time classification for contractors and designers

In reinforce the fundamental principles of accountability and rewards, only contractors and designers who can perform to the highest standard should be allowed to participate in the highest-priority (Class 1) projects. This rating restricts the number of participants much in the way that work classifications, i.e., bridges, signalization, earthwork, etc., restrict the type of work a contractor may undertake. Restricting the number of participants and tying the classification to time performance would create a team environment. The risk of losing a top rating might be sufficient encouragement for contractors and designers to work together to quickly resolve problems and this necessitates a planning horizon that is greater than one or two weeks. The incentive can spur people to identify and resolve issues before they become problems that lead to time extensions.

Analysis of historical time performance of contractors and designers could provide baseline information for determining appropriate classification criteria. The rating schemes should be developed to supplement, not replace, current prequalification schemes.

3.3 Appropriate incentive values in incentive contracts

Many state DOTs are utilizing various incentive contracts tied to time performance. DOT planners would like to provide sufficient incentive to achieve the desired time performance, but do not want to overpay for that performance. The problem is that there is no clear guidance available to assist planners in determining the appropriate incentive level for different project situations.

For example, A + B contracting has become a common strategy to improve project time performance on time-sensitive projects. However, the bid results and overall project outcomes greatly depend upon the choice of the B value. An inappropriate choice for B may not produce the desired performance objectives. Early attempts at B estimates followed procedures similar to the development of liquidated damages values. However, there are significant differences. What is needed is a comprehensive review and development of best contracting practices for determining B values in A + B contracting. Therefore, people can use time performance data on incentive-type contracts to develop clear guidelines and criteria for setting the B value in A + B contracting and for determining appropriate incentive values for other types of time incentive contracts.

3.4 Determination of the appropriate SUE level

Utility locations are a source of major concern, causing delays on highway construction. The technology is available to determine the x, y, and z coordinates of most utilities. The field of services provided is called subsurface utility engineering (SUE). SUE has been promoted for a number of years by FHWA, but primarily institutional barriers have limited its use. Designers are generally aware of the SUE technologies and benefits. However, there is no clear guidance available on where to use SUE and on what level to employ it. Appropriate guidelines should be produced for when and where to utilized SUE technologies, and what levels are appropriate for each representative situation. In addition, the barriers to the use of SUE should be addressed. Some have already been identified, as cited in the NCHRP 20-24(12) report, and these are provided in Appendix II in order of importance.

3.5 Best practices for avoiding utility relocation delays

While obtaining quality utility location information is obviously important, this does not address the entire utility delay issue. A significant portion of the utility-related delays occur because of delays in relocation activities. A major part of the difficulty appears to be related to the fact that the utility activities are often not a direct part of the highway construction contract. Utilities typically occupy DOT right-of-way space under some form of lease agreement, but having them perform the required relocations on schedule can be problematic. Some DOTs are making progress by developing innovative contractual and procedural practices to facilitate timely utility relocations. Thus, more details of these best practices should be obtained and implementation details should be addressed, including procedural, contractual, and legislative issues.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

A schematic approach to improve time performance of highway construction contracts is developed. Incentive application strategies and delay prevention strategies are identified. Strategic solutions of the most core issues of time performance incentive contracting are identified. The suggested incentive application strategies are to develop criteria for applying time classification to projects, for assigning project time classifications to contractors and designers, and for determining appropriate incentive values in A + B and other incentive contracts. The suggested delay prevention strategies are to develop criteria for determining the appropriate SUE level and develop best practices for avoiding utility relocation delays. A schematic approach for each strategy is developed.

In-depth procedures of current incentive project selection in Florida are introduced. The FDOT district engineers reported that the quality of contract documents and the appropriate choice of incentives are the most important aspects to make incentive projects successful. The construction project time analysis indicated that incentive contracting methods are more efficient in improving project time performance than conventional contracting methods.

4.2 Recommendations

Practical tools to facilitate implementation of the suggested strategies should be developed so that the criteria, implementation processes, and best practices developed may contribute to the current industry-wide effort to improve time performance.

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APPENDIX I

Two sample *t*-test results

Sample Summaries	**Incentive contract methods**	**Conventional contract methods**
Sample Size	69	42
Sample Mean	0.147	-0.071
Sample Std Dev	0.193	0.328
Hypothesis Test (Difference of Means)	**Equal Variances**	**Unequal Variances**
Hypothesized Mean Difference	0	0
Alternative Hypothesis	<> 0	<> 0
Sample Mean Difference	0.218	0.218
Std. Error of Difference	0.049	0.056
Degrees of Freedom	109	58
t-Test Statistic	4.423	3.925
p-Value	<0.0001	0.0002
Null Hypotheses at 5% Significance	Reject	Reject
Equality of Variances Test		
Ratio of Sample Var.	0.3481	
p-Value	0.0001	

APPENDIX II

Project Time Classifications

Category	Description
Class 1	A Class 1 project is one where timely completion is the overriding objective. The emphasis is not necessarily on the overall planning-designing-constructing time frame but rather on the time spent in the field where the public is inconvenienced. For Class 1 projects, delays in completion are not acceptable and certain management actions are to be taken to ensure timeliness. Limited resources do not allow these actions to be applied to a large number of projects. Public input may be desirable to determine if the public is willing to endure a higher level of disruption for a shorter period of time.
Class 2	A Class 2 project is very important relative to time issues, but not as important as a Class 1 project. Not all of the management actions applied to Class 1 projects are applied to Class 2. Nevertheless, changes that could benefit the public, but extend the duration of the project, would be very carefully evaluated.
Class 3	A Class 3 project is an ordinary project where it is not justified to expend the resources available to Class 1 or 2 projects. Nevertheless, some management actions that require few resources can be made available.

APPENDIX III

Barriers to implementation of SUE

Rank	Barriers to implementation
1	Why should we pay for better information when the utility owners don't/won't relocate their facilities accurately in time anyway?
2	There are not any local firms that can do SUE.
3	The utility company owns the facilities. They mark them for construction. That should be good enough. And if it isn't, let's make them mark them during design.
4	There is always a prominent disclaimer on the plans about existing conditions being the responsibility of the contractor.
5	Delays in the design process occur due to the time required to execute SUE contracts and perform the work.
6	The use of SUE provides a benefit to the utility at the DOT's expense.
7	The use of SUE increases the project costs.
8	Utilities occupy the right-of-way at little or no cost. They are required to move at their own expense. Conflicts between design and utilities are their problem.
9	The use of SUE is not the way "we have always done it."
10	We are basically a rural state. We don't need a big program.
11	Nobody has shown me that there are cost savings from using SUE.

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