A FRAMEWORK FOR SELECTING STRATEGIES TO IMPACT THE SUCCESS OF HIGH VOLUME ROADWAY PROJECTS

A Thesis

by

CLAYTON C. CHABANNES

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2006

Major Subject: Civil Engineering

A FRAMEWORK FOR SELECTING STRATEGIES TO IMPACT THE SUCCESS OF HIGH VOLUME ROADWAY PROJECTS

A Thesis

by

CLAYTON C. CHABANNES

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Approved by:

Chair of Committee, Stuart Anderson
Committee Members, David Trejo
Christopher Mathewson
Head of Department, David Rosowsky

May 2006

Major Subject: Civil Engineering

ABSTRACT

A Framework for Selecting Strategies to Impact the Success of High Volume Roadway Projects. (May 2006)

Clayton C. Chabannes, B.S., Texas A&M University

Chair of Advisory Committee: Dr. Stuart Anderson

State Highway Agencies (SHAs) are being forced to focus more on rehabilitation, resurfacing, and reconstruction of existing roadways rather than the construction of new facilities. These activities can create several challenges when they must be conducted on roadways with high traffic volumes. This research identified numerous strategies that can be implemented by SHAs that have the potential to influence the overall success of roadway projects with high traffic volumes. This research also created a framework for when to implement these different strategies. These strategies were identified through an in-depth literature review and through case studies conducted on highway projects that were under construction. Through the case studies the different strategies were documented within the context that warranted their use. Information from the case studies was collected and documented through interviews and site visits. The strategies identified through this research were used to create four matrices that summarize the research findings. A general matrix was created to show the motivating project conditions that warrant the use of each strategy. A public relations matrix was created to display the influence the impacted road user groups have on public relations and information strategies. A traffic management matrix was created to show different types of traffic management strategies and the potential impact they will have on the project. Finally, an interdependency matrix was created to show groups of strategies that are related to each other or require the use of other strategies to be able to influence the success of the project. These matrices could be further developed to create a set of guidelines that could be used by a SHA during the planning phases of a roadway project.

TABLE OF CONTENTS

LIST OF FIGURES

FIGURE Page

CHAPTER I

INTRODUCTION

The United States' interstate system is a vital part of its economic and social welfare. Construction on the interstate system commenced in 1957. This transportation system has been mostly completed and has greatly contributed to the growth of the US economy (Levinson 2004). Due to excess demand on this transportation system as well as its age, State Highway Agencies (SHAs) have been forced to focus more on restoration, resurfacing, and reconstruction of existing roadways than construction of new roadways (Anderson et al. 2002, Darter 1991, Herbsman et al. 1995, ACPA 1993a, Herbsman 1995).

Restoration, resurfacing, and reconstruction work creates additional challenges when conducted in urbans area where there are high traffic volumes (Secmen et al. 1996). This challenge is compounded by the fact that motorists are becoming less tolerant of frequent delays caused by road construction (APCA 2000, ACPA 1997, Anderson et al. 2000).

BACKGROUND

The Texas Transportation Institute (TTI) was contracted by the Federal Highway Administration (FHWA) to perform a research project to identify factors that contribute to the success of concrete pavement restoration, resurfacing, and reconstruction projects under high traffic volume conditions. The research project is entitled "Traffic Management Studies for High-Volume Roadways." The project's primary objective is to identify and document successful practices for preservation, rehabilitation, and/or reconstruction of concrete pavements under high traffic volumes. The research is designed to document and analyze the use of traffic, construction management, and

---

This thesis follows the style of the *Journal of Construction Engineering and Management.*

public relations or information strategies that can limit the temporary disruption to highway users and local businesses that results from construction activities on these types of roadways.

PROBLEM STATEMENT

Restoration, resurfacing, and reconstruction of rigid concrete pavements with high traffic volumes can have a large impact on road users and the local community (Herbsman 1995, Herbsman 1998). These impacts are experienced by the road users such as daily commuters, recreation traffic, and trucking groups as well as businesses and residences that are located near the construction. Construction may increase travel times or require motorists to use alternate routes to reach their destination. Construction activities may decrease accessibility to businesses or increase nose pollution or cut-through traffic in nearby residential areas. Research is needed to identify successful construction, public relations, and traffic management strategies for roadways under high traffic volumes. Identified strategies could be implemented on future projects to potentially reduce the negative impacts on the construction activities on the roadway users. For this research success is defined as the ability to meet projects objectives. Strategies that are considered successful are those that have a positive influence on meeting the project objectives. Only rigid concrete roadways will be investigated in this project.

Information has been published on strategies that can impact the success of construction projects such as contracting strategies and the use of different construction methods but the publications often neglect to discuss how these strategies should be used in relation to other possible strategies. The proposed research will provide project characteristic that warrant the use of a certain strategy, identify the possible benefits and drawbacks from using each strategy, and discuss how the use of one strategy might influence the use of another. The research will present a large amount of information in a concise format that can be utilized by SHAs during the planning phases of a project to increase the potential for overall success of the project. This information would allow

SHAs and contractors to learn from other SHA's past experiences. Impacts on the road users could also possibly be reduced by implementing the strategies identified through this research.

The purpose of this thesis is to identify factors related to construction, public relations, and traffic management that have the potential to influence overall project success. These factors were documented through literary sources and actual projects that are under construction. The research also created a framework for selecting appropriate strategies based on project conditions. This framework can be adopted and expanded by future research efforts and developed into a guide or tool. The research identifies the various factors that influence the need to implement a certain strategy. These factors are related to the project site, the motorist groups impacted, and the level of impact the motorists experience due to the construction. Each strategy has a certain cost associated with it (monetary or otherwise), so strategies should not be applied to all projects. This research identified both what is gained and lost from using each of the strategies. In addition, there are groups of strategies that create synergistic benefits when used together. It is the purpose of this research to also identify the potential relationships or interdependencies that exist between different strategies.

RESEARCH TASKS

In order to address the above stated research problem, the following research tasks were preformed for this project:

1. Identify possible strategies through literature review
2. Observe and document key strategies used in practice
3. Determine key reasons for implementation of each strategy
4. Determine interdependencies between strategies
5. Determine advantages and drawbacks to implementation of each strategy.
6. Create a framework to present the strategies and the context for their use.

Each of these research tasks is discussed in more detail in the section below.

Task 1: Identify Possible Strategies Through Literature Review

A literature review was conducted to identify different project areas that can influence the overall success of a project. The three primary project areas considered in the literature review were:

- Construction practices and management
- Traffic management and traffic control
- Public relations and information.

There are numerous different construction related categories that can influence project success. These include contracting strategies, constructability reviews, project planning and scheduling, construction methods, and decision making techniques. Traffic management and control includes lane closure strategies, demand reduction strategies, and strategies to improve traffic flow and safety through the workzone. Public relations and information includes any strategies implemented to inform motorists of the construction project. The details of the literature review are discussed in Chapter II.

Task 2: Observe and Document Key Strategies Used in Practice

SHAs were contacted to identify potential projects to observe and document in support of this research. The SHAs were provided information on the research project and the scope of the case study process. From these contacts, potential case study projects will be identified.

Case studies were initialized on projects that fit the scope of the research. Information will be gathered through the case studies by conducting interviews with the SHA, contractors, and/or consultants. Information was also gathered through site visits to document the construction procedures. Project related documents such as construction drawings, the project schedule, and/or specifications were also requested. More information on the methodology used to conduct the case studies can be found in Chapter III. The information collected from the case studies can be found in Chapter IV.

Task 3: Determine Key Reason for Implementation of Each Strategies

Because of the uniqueness of each construction project, factors contributing to the success of one project may not impact the success of another project. As a result, the research will relate the identified success factors to project characteristics. This allows the users of the research results to know when it may be helpful to implement certain success factors.

Many of the reasons related to implementing certain success factors were gathered through the interviews with SHA and contractor personnel. To determine the project characteristic influencing success factors that were not covered in interviews, information gathered from the case studies was analyzed and interpreted. This information in discussed in Chapter V and presented in matrix form in Chapter VI.

Task 4: Determine Interdependencies Between Strategies

Groups of strategies can be used in conjunction with each other to create synergistic benefits when used together. The use of one strategy may rely on the implementation of another strategy or may be more successful when used with another strategy.

To determine the interdependencies between different strategies the group of strategies used on each of the different projects will be analyzed to determine which strategies were used in conjunction with others. Some of the interdependencies will also be gathered in the interview process. The discovered interdependencies are discussed in Chapter V and presented in matrix form in Chapter VI.

Task 5: Determine Advantages and Drawbacks to Implementation of Each Success Factor

Each of the strategies identified brings the possible advantage of helping meet the project objectives that increases the opportunity for projects success. There are numerous different project objectives used on different projects including, but not limited to:

- Minimizing local user impacts
- Minimizing overall project costs
- Minimizing project schedule
- Maintaining a certain level of quality
- Maintaining a high level of project safety.

Each strategy has certain costs associated with its implementation. These costs can be monetary, such as the additional cost required to have additional signing on and around the construction site. The costs can be in terms of space, such as the additional space needed to place a concrete batch plant on the construction site. The costs can also be in the form of expertise or know how, such as the knowledge required to smoothly implement certain construction procedures. SHAs should consider the potential costs and benefits associated with each of the different strategies based on the specific characteristics of the project. This is discussed in detail in Chapter V.

Task 6: Create a Framework to Present the Strategies and the Context for Their Use

This research creates a framework for presenting strategies and the project conditions that warrant their use. This framework takes the form of a series of matrices. These matrices are presented in Chapter VI of this thesis.

Because of the limitations of this research, some areas of the matrices lack information. Future research efforts can further develop the framework into a guide or tool that can be used by an SHA.

EXPECTED BENEFITS

Due to the aging interstate system, SHAs are being forced to focus more and more on restoration, resurfacing, and reconstruction of existing roadways than on the construction of new roadways. Road users are becoming more and more intolerant of the delays caused by construction activities on these roadways. This research will also allow SHAs and contractors to learn from the success of previous projects and will provide guidance on when to implement different strategies based on the project's unique characteristics. This will help SHAs minimize the impact on the road users and increase the efficiency of the construction procedures used on the project.

In addition, this research will identify potential areas for further research. Due to the limited sample of projects considered in this research, additional research should be conducted to further explore the strategies identified in this research or to identify new strategies that complement the work contained in this thesis.

ORGANIZATION OF THE STUDY

In the following chapters of this thesis, the literature review, research methodology, data collection, data analysis, matrix development, and conclusions are discussed. Chapter II discusses the information gathered through a literature review on the research topics. The information gathered in this review relates to construction practices and management, traffic control and management, and public information and relations. This literature review includes information gathered prior to the start of this thesis effort through the FHWA research project.

Chapter III describes the methodology followed in the completion of this research. The chapter describes the triangulation and case study theory that this research utilizes. It then describes the procedures used in conducting the case studies and in the creation of the different matrices that summarize the research findings.

Chapter IV contains information on the four case studies documented in support of this research. General information as well as the scope of the work is provided for each project. This section describes how the data were collected and the success factors identified through each case study.

Chapter V contains the results of the data analysis. This chapter lists each of the success factors identified through this research, the project conditions that warranted their use, any relationship with other success factors or project areas, and the benefits and drawbacks of implementing each success factor.

Chapter VI introduces the matrices created to summarize the research findings. The four matrices created for this research are a general matrix of success factors and motivating conditions, a public relations matrix, a traffic management matrix, and a interdependency matrix. This section describes several observations made from these matrices. This section also describes the completion of the triangulation method with the inclusion of expert opinion concerning the research findings.

Chapter VII is the conclusion to the research report. This section summarizes the major research findings. It describes the validation of the research conclusions. It also discusses the limitations to the study and recommendations for future research.

CHAPTER II

LITERATURE REVIEW

INTRODUCTION

A literature review was conducted in support of this research. The purpose of the review was to:

- Identify project areas that influence success
- Identify specific strategies that can influence success
- Help validate research findings as one of three data collection methods as part of a triangulation approach.

The triangulation approach is discussed in the chapter entitled "Research Methodology." This review considered concrete paving practices on a variety of different types of projects but it focused mainly on high traffic volume situations. Projects with high traffic volumes often lead to construction scenarios where the project schedule is a critical objective. These types of projects may require the use of different strategies than concrete construction on lower volume roadways. Several different sources of information were consulted for this literature review including publications from the American Concrete Paving Association (ACPA), the American Society of Civil Engineers (ASCE), the Innovative Pavement Research Foundation (IPRF), and the National Cooperative Highway Research Program (NCHRP).

PREVIOUS FHWA RESEARCH

Work conducted under the FHWA research project "Traffic Management Studies for High Volume Roadways" prior to the start of the research for this thesis effort was considered in the literature review. This work included a literature review and three case studies that documented success factors on concrete paving projects. These case studies were performed in the US 23 and I-496 projects in Michigan and the I-10 Precast Paving Panel project in California. A short description of these projects is provided in Appendix A. More detailed information on these projects can be found in the reports created as part of this FHWA research (Anderson et al. 2003a, Anderson et al. 2003b, Anderson et al. 2004a). The findings from this work have been included in the discussion below.

BACKGROUND INFORMATION

There are three main challenges often associated with rigid concrete paving: 1) the long curing time, 2) the final quality and road smoothness, and 3) inefficiencies relating to short, small scale repairs (Steward 1992). The concrete paving industry has been working to overcome these challenges through the use of new materials, equipment, procedures, and techniques.

In order to address the challenges of increasing traffic volumes on local roadways and increasing public impatience with roadway construction, fast-track concrete pavement construction methods have been created. Fast-track concrete pavement construction involves numerous different methods used to accelerate construction times and minimize the impact on local users (ACPA 1994a). Some examples of fast-track methods include the use of incentives and disincentives, allowing night construction, use of different mixture designs and admixtures, use of strength criteria for traffic opening, and allowing the contractor to use innovative methods or equipment (ACPA 1994a).

Strategies

There are three different concrete pavement rehabilitation strategies: concrete pavement restoration (CPR), resurfacing, and reconstruction (ACPA 1993a). The appropriate strategy is a function of the level of deterioration of the pavement. This can be seen in Figure 1.

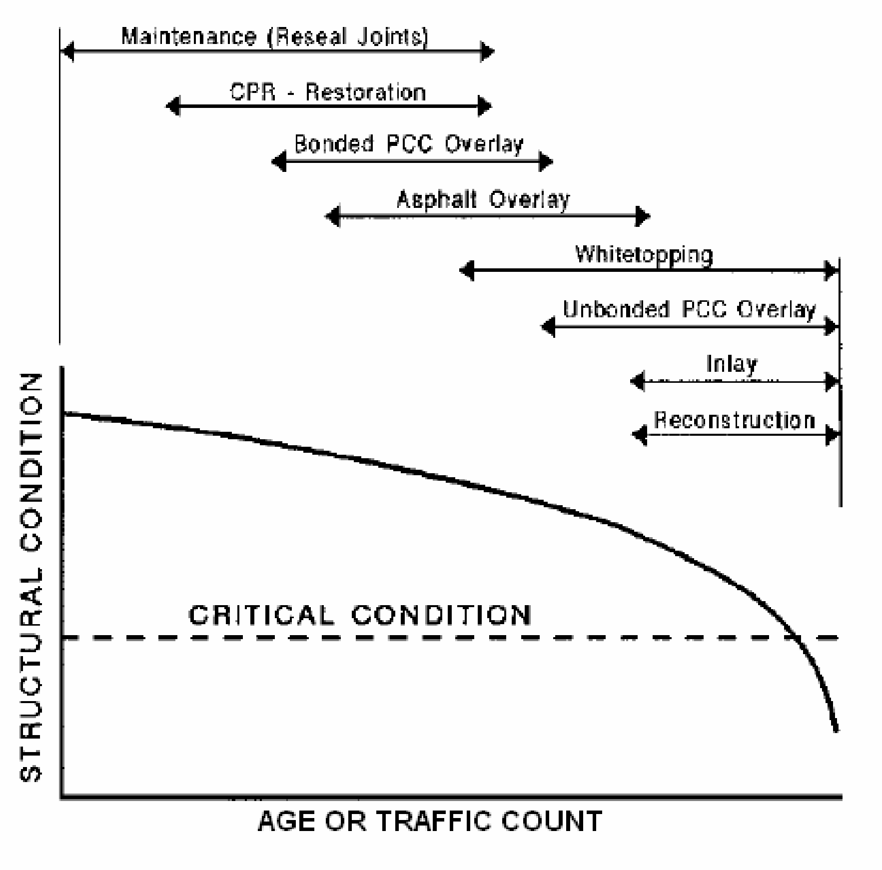


Fig. 1. Life cycle diagram showing pavement rehabilitation strategies (adapted from ACPA 1993a)

Concrete Pavement Restoration

Concrete pavement restoration is used to bring the structural condition and ridability of a pavement to an acceptable level (ACPA 1993a). Concrete restoration activities include full- and partial-depth concrete repairs, joint and crack sealing, slab stabilization, cross-stitching, diamond grinding, load transfer restoration, retrofitting of rigid concrete shoulders, longitudinal crack and joint repair, and grooving (ACPA 1993a, ACPA 1998a).

Full-depth repair is a corrective restoration technique. Cracked slabs and deteriorated joints are fixed by removing part or the entire existing slab and replacing it with new concrete (ACPA 1998b). Typical patch areas are a lane wide and at least a half of a lane long (ACPA 1998b).

Partial-depth repairs are another corrective technique used to fix surface distress such as joint and crack deterioration in the top of the concrete (ACPA 1998a). When the deterioration extends deeper than the top one-third to one-half of the concrete's depth, the use of a full-depth repair is warranted (ACPA 1998a, ACPA 1998b). The size of partial-depth repair is typically smaller than that of a full-depth repair. The area of the repair is often less than a square yard and only a few inches deep (ACPA 1998b). Partial-depth repairs are often used to fix moderate spalling or areas with severe scaling (ACPA 1998b).

Resealing joints and cracks in order to minimize the infiltration of water and other incompressible materials into the pavement is a preventative CPR technique (ACPA 1995, ACPA 1998b, Lynch et al. 2000). Infiltration of water into the pavement can cause several problems such as subbase or subgrade softening and erosion or pumping of the subgrade or subbase (ACPA 1995). Sealing joints and cracks can minimize the problems caused by water infiltrating the pavement such as loss of structural support, pavement settlement, or faulting (ACPA 1998b). When incompressibles enter the joint and cracks of a pavement, spalling or even "blow-ups" can occur from the large pressures that build up as the pavement expands in hot weather (ACPA 1995).

Retrofitting concrete shoulders is a preventative technique that ties the existing concrete roadway to a new concrete shoulder. This decreases the stresses in the edges and corners of the slab and reduces the potential for transverse cracking, pumping, and faulting (ACPA 1995). The retrofitted shoulder is tied to the existing concrete that decreases outside pavement deflections (ACPA 1995).

Another preventative CPR technique is adding a longitudinal drainage system to the pavement to quickly remove water. This can reduce pumping, faulting, and durability distress in the concrete (ACPA 1998b). When placing an edge drain on an existing pavement, the type of soil under the pavement should be taken into account. Pavements on clayey or silty soils may not be ideal candidates for edge drains because of the possibility of an accelerated loss of fines from beneath the pavement (ACPA 1998b).

A corrective CPR technique that improves a pavements surface is diamond grinding. This technique creates a smooth and uniform pavement surface by removing surface distress and unevenness (ACPA 1998b, ACPA 2002a). This technique reduces the impact loadings caused from the uneven riding surface and can increase the pavements life (ACPA 1998b, ACPA 2002a). Some of the benefits of diamond grinding are a reduction in road noise, a smoother riding surface, and increased skid resistance (ACPA 2002a). Diamond grinding does not significantly impact the fatigue life or material durability of a pavement (ACPA 2002a). Another advantage of this technique is that it can be performed during off peak traffic times such as on weekends (ACPA 2002a).

Dowel bar retrofitting is a corrective technique that improves the load transfer at transverse cracks and joints (ACPA 1998b). This is accomplished by cutting a series of slots in the pavement accoss the joint or crack and then placing dowel bars in the slots. New concrete is then placed over the dowels (ACPA 1998b). The improved load transfer reduces the tensile stresses in concrete, reduces corner deflections, and reduces differential deflections (ACPA 1997).

Another corrective CPR technique is slab stabilization. Voids under the concrete can cause a loss in structural support (ACPA 1998b). These voids can be caused by pumping, consolidation, subgrade failure, or by the washout of fill material (ACPA 1998b). This CPR technique fills these voids in order to restore support to the concrete. Slab stabilization is often used in conjunction with other CPR techniques such as diamond grinding or patching (ACPA 1994b).

Cross-stitching is a CPR technique used to repair low-severity longitudinal cracks by adding reinforcing steel to hold the crack together and limit its movement (ACPA 1998b). This technique should not be used on cracks that are severely deteriorated or cracks that are acting at joints in the concrete (ACPA 1998b). If the crack is acting as a joint, a dowel bar retrofit would be more appropriate because it will still allow the concrete to expand and contract while maintaining load transfer (ACPA 1998b).

A final corrective CPR technique is grooving. This technique creates small longitudinal or transverse channels that increase skid resistance and channel water from underneath the tire (ACPA 1998b).

Concrete Pavement Resurfacing

Resurfacing concrete pavements can be used to improve ridability, safety, and skid resistance as well as to correct cross sections and surface defects (ACPA 1993a). Concrete resurfacing includes bonded overlays, unbonded overlays, and whitetopping (ACPA 1993a).

An unbonded concrete overlay is a resurfacing technique appropriate for pavements in poor conditions such as those with severe D-cracking (ACPA 1990b). A separation layer is placed between the existing concrete and the overlay to prevent reflective cracking in the overlay. This separation often consists of a bituminous material (ACPA 1990b). This technique has the advantage of being able to maintain traffic on adjacent lanes while construction takes place (ACPA 1990b). The joints in the overlay slab should be placed on the approach side of the joints in the existing pavement. This prevents sudden deflections that can lead to pumping (ACPA 1990b). An unbonded overlay resurfacing strategy was used on the US 23 case study conducted under the FHWA research project "Traffic Management Studies for High Volume Roadways". This approach was chosen to preserve the routes infrastructure and to increase the load carry capacity for projected traffic increases in future years (Anderson et al. 2003b).

A bonded overlay is a resurfacing technique that is similar to an unbonded overlay expect that they separation layer is removed (ACPA 1990a). This creates a monolithic slab between the existing and overlayed pavement. A bonded overlay can improve the load carrying capacity, ridability, and skid resistance of the roadway (ACPA 1990a). Pre-overlay repairs may be needed to bring the existing pavement to an adequate condition for a bonded overlay (ACPA 1990a).

Whitetopping is another resurfacing technique that involves an overlay of rigid concrete over an existing asphalt pavement. The three primary variations of whitetopping are conventional whitetopping, concrete inlay, and ultra-thin whitetopping. Conventional whitetopping involves the placement of a 8-inch or thicker layer of rigid concrete on an existing asphalt pavement (Rasmussen et al. 2004). The concrete inlay variation involves milling out a section of the existing asphalt pavement and placing the overlay in the excavated area (ACPA 1993b). Thin whitetopping is between 4 and 8 inches in thickness (Rasmussen et al. 2004). Ultra-thin whittopping (UTW) is a 4 inch or thinner overlay placed on an existing asphalt concrete that has been prepared to enhance the bond between the existing pavement and the overlay (ACPA 1998c). Ultra-thin whitetopping is typically used with a substantially thick layer of asphalt. Whitetopping has the benefits of improving the life of the pavement, improving safety, reducing maintenance, and having a low life-cycle cost (ACPA 1998c).

Concrete Pavement Reconstruction

Reconstruction work is typically reserved for pavements that have reached the end of their service life. Reconstruction involves the complete removal of the existing concrete and often the base structures and then replacing them (ACPA 1993a). Two reconstruction strategies are concrete inlays and recycling (ACPA 1993a). Reconstruction can involve the removal of all the lanes, removal of selected lanes, or the removal of selected portions of individual lanes.

A concrete inlay is a reconstruction strategy that replaces the concrete pavement without significantly changing the elevation of the pavement. This strategy has the benefits of not having to make changes to the existing lanes or shoulders and being able to be lane-specific based on the deterioration of the pavement (ACPA 1993a). This strategy is good for pavements with uneven deterioration between the different lanes (ACPA 1993a). Uneven deterioration is often caused by truck traffic traveling on the outside lanes.

Recycling is another reconstruction strategy where the old pavement is used as the material to construct the new roadway. This strategy involves the removal and crushing of existing concrete and then removing any dowels and reinforcing steel. Recycling of existing concrete may be advantageous in areas where quality aggregates are not locally available (ACPA 1993a). This strategy has the advantages of conserving resources and eliminating the costs to dispose of the old materials (ACPA 1993a). It also has the potential to reduce truck traffic on and off site.

PROJECT AREAS INFLUENCING SUCCESS

The scope of this thesis covers three primary project areas: 1) construction practices and management, 2) traffic control and management, and 3) public relations and information. Information in these three primary project areas was considered when conducting the literature review.

From the literature several different construction related project areas were identified as potentially influencing the success of a project. These areas are:

- Constructability
- Contract Administration
- Planning and Scheduling
- Traffic Management and Control
- Public Relations and Information
- Construction Methods
- Decision Making.

Specific strategies from each of these areas are discussed below.

Constructability

Constructability efforts start during the planning phases of a project but can have a large influence on the construction phase. The following sections describe constructability reviews as well as an innovative computer program being developed by the University of California at Berkeley.

Constructability Review

Constructability involves the optimum use of construction knowledge and experience into a project's planning, design, and execution in order to meet the project's objectives (Anderson et al. 1999, Anderson et al. 2000). In order to maximize the benefits of strategy, constructability needs to be implemented at the beginning of the design phase instead of waiting until shortly before the project is let for bid (Hancher 2000, Anderson et al. 1999). During the beginning phases of a project changes can be made with minimal difficulty. Almost all SHAs perform a constructability review but it is usually an informal process (Anderson et al. 2000). Constructability issues commonly considered by SHAs are scheduling of construction activities, maintenance of traffic, project phasing, and specific design features (Anderson et al. 2000). By incorporating construction related experience and knowledge into the design and planning of a project the project's duration can sometimes be shortened and the construction operations made more efficient.

Construction Analysis Program

The University of California at Berkeley developed a construction simulation program called Construction Analysis for Pavement Rehabilitation Strategies (CA4PRS) that is being used on projects associated with the California Department of Transportation's (Caltrans) Long-Life Pavement Rehabilitation Strategies program (LLPRS) (Lee et al. 2005). The program considers several factors to determine the optimized distance and duration of highway rehabilitation projects (Lee et al. 2005). The program considers the following factors (Lee et al. 2005):

- Rehabilitation strategy
- Interface between different schedule activities
- Contractor's resource constraints

- Roadway design
- Material properties
- Lane closure strategy.

The program can be used with a traffic simulation program to consider the user impacts of each of the different strategies to determine the optimal strategies (Lee et al. 2005). The program has been tested on several different projects in California. These projects included the I-710 Long Beach Project, the I-10 Pomona Project, and the I-15 Devore project.

Contract Administration

The literature review yielded a great deal of information concerning contract information. The primary source of information for this information was the *Journal of Construction Engineering and Management* published by the American Society of Civil Engineers (ASCE). The sections below describe the strategies identified in the literature.

Incentives and Disincentives

Numerous different contracting methods have been created in order to increase cooperation between the contractor and the owner and to motivate the contractor to meet the project objectives. One common contracting strategy implemented to motivate the contractor and produce alignment of the project objectives is the use of incentives and disincentives (I/D) (Bower et al. 2002). The use of incentives ties the contractor directly to success of the project through the project objectives. This also transfers some of the owner's risk onto the contractor in exchange for the contractor having a chance to earn a bonus for timely completion (Arditi et al. 1998). This contracting strategy can be used on both fixed price contracts for meeting certain project objectives or on cost-reimbursable contracts for meeting certain targets such as schedule or cost targets (Bower et al 2002). Specific uses of I/D provisions in the construction contract include reducing contract cost, minimizing contract duration, as well as maintaining the safety, quality, progress, and efficiency of the construction effort (Arditi et al. 1998).

The three primary categories used for I/D is cost incentives, schedule incentives, and technical incentives (Bower et al. 2002). Cost incentives involve a target cost agreed upon by the owner and the contractor, a target fee which is how much profit is payable if the target cost is met, and a share formula that describes how any difference between actual and planned cost will be distributed between the contractor and the owner.

Schedule incentives typically involve a premium for completing construction early and a penalty, sometimes in the form a liquidated damages, for failing to meet certain schedule related milestones that is often used to reduce the overall schedule of the project (Bower et al. 2002, Jaraiedi et al. 1995). The disincentives can be calculated as a road user delay costs plus liquidated damages (Arditi et al. 1998). The use of schedule related I/D was documented on the I-496 and US 23 case studies conducted under the FHWA research project. These projects implemented I/D clauses in the contracts because of the stringent construction schedules and to motivate the contractor to meet certain project milestones (Anderson et al. 2003a, Anderson et al. 2003b).

There are several advantages to the implementation of I/D contracts. In a study conducted on the Illinois Department of Transportation project, over 90 percent of the projects were completed on time or sooner and only about 7 percent of projects had to pay disincentives (Arditi et al. 1998). Because the contractor typically receives some amount of incentive payment, the relationship between the contractor and the owner tend to be much less adversarial (Herbsman et al. 1995). Some of the drawbacks to this type of contacting strategy is the increase in administration to determine if the objectives are met, possible increase in claims by the contractor, and possible pressure from outside organizations such as the press believing the amount of bonuses are too high (Jaraiedi et al. 1995). One of the challenges of schedule-based incentives is creating reasonable benchmark times (Jaraiedi et al. 1995). If the times are not accurate, the contractor may receive a bonus for conducting the construction operation in the same manner as usual (Herbsman et al. 1995). Project schedule reductions may be possible on projects by simply reducing the engineer's time estimate. The Florida Department of Transportation decreased time estimates by 20 percent without any major delays to project completion (Herbsman et al. 1995).

Another type of I/D contract is performance or technical incentives which are incentives tied to performance measures other than cost and schedule (Bower et al. 2002). An example is the rideability of the pavement.

Multiparameter Bidding

Multiparameter bidding involves bidding on the project cost (A) and on time (B) and is often referred to as A+B. The project cost is bid just like a conventional bid. The time parameter is determined by the value of a unit of time to the owner (Herbsman 1995). This unit of time can be a day, hour, week, etc and the cost associated with this time is called the road user cost (RUC). The RUC is determined by travel delays and agency costs (Herbsman 1995). The time (B) parameter is calculated by multiplying the time by the RUC. The bids are evaluated by the combined cost and time parameters.

Implementation of multiparameter bidding can substantially reduce the contract time of a project when compared to conventional contracting methods and is appropriate for rehabilitation projects and projects that must be completed quickly (Herbsman 1995, Hancher 2000). Research also indicates that A+B contracts do not cost significantly more than traditional contracts on similar work (Herbsman et al. 1995, Herbsman 1995). Multiparameter bidding is often used in conjunction with incentives and disincentives in order to further motivate the contractor to complete the project as quickly as possible. This contracting method allows the contractor to control the time portion of contract that is appropriate because often the contractor can best determine the reasonable duration of a project better than the SHA or owner (Shr et al. 2004). Care should be taken when conducting a bid with A+B that the engineer's time estimate on the project is not released. If the time factor is released, contractors may use this time without doing their own calculations even though they may be able to complete the construction faster. An additional challenge that can arise with the use of A+B contracting is if the contractor underestimates the project duration to win the job. If the contractor cannot meet the overly optimistic completion date, quality may be sacrificed in order to avoid penalties (Herbsman et al. 1995). The contractor may also look to claims against the owner or change order to make up for lost earnings due to penalties (Herbsman et al. 1995). This can result in a more adversarial relationship between the contractor and the owner. To overcome this challenge, the contract documents should give the owner the power to reject any bids with unreasonable schedules (Herbsman et al 1995).

Lane Rental

The lane rental contracting method involves charging the contractor for each time the construction activities interfere with the traveling public (Herbsman et al. 1998). The cost to rent lanes is incorporated into the contractors cost estimate. The purpose of lane rental is to motivate the contractor to complete construction as quickly as possible resulting in reduced impacts to the traveling public (Herbsman et al. 1998). A fee schedule must be created for the different time periods and included in the bidding documents so that all participants can use the same rates in the creation of their bids. The fee structure may vary based on time of day or specific lanes that are being rented. Lane rental, especially on projects where the rental fees are high, can increase the resource intensiveness of a project (Herbsman et al. 1998). Contractors may use shift work, night construction, or continuous construction to avoid large rental fees. This approach has the potential to cause problems such as fatigue in the workers affecting safety and production (Herbsman et al. 1998). Despite these challenging conditions, research has shown the final quality of the product is as good as a conventional project (Herbsman et al. 1998). One challenge to this contracting method is if the lane rental charges are not set high enough there will likely be little change in contractor’s work plan (Herbsman et al. 1998). When used correctly, lane rental has the highest potential to reduce lane occupancy when compared to A+B and I/D contracting methods (Anderson et al. 2000). Lane rental has been shown to reduce construction schedules by approximately 25 percent (Herbsman et al. 1995).

Partnering

Partnering is a proactive strategy used to increase cooperation between the different project parties by recognizing and attempting to accommodate the expectation and objectives of the different parties (Grajek et al. 2000). This requires a shift from the normal adversarial role between the contractor and the owner to one of mutual trust and team building. Partnering is a resource and commitment intensive process that requires all participating parties to meet prior to starting construction to establish specific management procedures for the project (Glagola et al. 2002). A study conducted by the Construction Industry Institute found that partnered projects outperformed non-partnered projects in the areas of total project cost, schedule, safety, quality, claims, rework, and job satisfaction (Glagola et al. 2002). It is important that subcontractors be involved in the partnering process (Glagola et al. 2002). This guideline is reinforced by the findings of the I-496 case study performed for the FHWA research project. The earthwork and paving contractors were not included in the partnering effort on this project. Due to the numerous communication problems between the prime contractor and the subcontractors, the prime contractor stated that on future jobs they would partner with the paving and earthwork subcontractors (Anderson et al. 2003a). Partnering has been used by the Texas Department of Transportation (TxDOT) since the late 80's. During that time TxDOT has completed numerous partnering projects with an overall positive effect on the completion time, dispute resolution, and project team relations (Grajek et al. 2000). A final observation on partnering is that the level of success the partnering effort achieves is largely determined by the level of commitment the participants have in the process (Grajek et al. 2000).

Electronic Bidding

Electronic bidding allows contractors to access information on bids and allows contractors to submit bids via the SHA's webpage. The use of this system could potentially increase the number of bids on a project by making the bidding process more accessible to contractors that are not located near the SHA office. This could lead to more competitive bidding. One challenge of adopting an electric bidding system is providing a secure system (Hancher 2000).

Contractor Prequalification

Prequalification is used to screen out contractors that represent a risk to the project. A contractor can be screened based on numerous criterion such as bonding capacity or prior work performed. One innovative approach to contractor prequalification being implemented by the Ontario Ministry of Transportation is to evaluate contractors based on past performance (Hancher 2000). Contractors are given a weighted score based on the quality, safety, timeliness, and contract execution of projects performed within the past three years (Hancher 2000). The weighted score is used to determine the amount of work a contractor can be awarded (Hancher 2000).

Design-Build

Under the design-build contracting strategy, the design and construction of a project is awarded to a single contractor or joint venture that provides a single source of responsibility for the entire project (Hancher 2000). Three methods used to award design-build projects are low-bid design-build, adjusted score design-build, and best value design-build (Gransberg et al. 1999). Under the low-bid method, bids are collected at the specified day and time and the lowest bid is analyzed to determine if the preliminary design is comprehensive and meets the requirements in the request for proposal (RFP) (Gransberg et al. 1999). If the lowest bid does not meet the requirements, the next lowest bid will be considered. Under the adjusted-score method, the technical proposals are evaluated based on the criteria in the RFP without consideration of the price. The price of each bid is then divided by the score to determine an adjusted score (Gransberg et al. 1999). The bids are then evaluated based on the adjusted score with the lowest being the most favorable (Gransberg et al. 1999). The best-value design-build method is similar to the adjusted-score method except the bid price is considered in the scoring process. An analysis is then conducted over the cost and technical tradeoffs of each bid. Using a more expensive bid must be justified by the value being added to the project (Gransberg et al. 1999). Design-build contracts have been successfully implemented in numerous states and many SHAs are considering the use of this contracting approach in the future (Gransberg et al. 1999, Hancher 2000). Possible benefits of this contracting method are reduced overall project time and improved design on complex projects resulting from interaction between the designer and builder (Hancher 2000).

Transfer of Quality Control

Due to shrinking staffs and increased cost, many SHAs are transferring quality control responsibilities to the contractor (Hancher 2000). This allows SHAs to have a smaller staff, which can reduce costs. Some staff must be maintained to perform quality assurance tests. This also gives the contractor more freedom over material quality and workmanship that can be used by the contractor to lower costs (Hancher 2000). Some of these cost savings are offset by the additional need for additional workers to handle quality control activities. This strategy is often implemented with incentives and disincentives on the quality based on spot checks performed by SHA representatives.

Warranties

Warranties ensure that the work performed on the project will perform as expected over some time duration. The current practice for government funded projects is to have a performance bond that coveres the project for the first year. The implementation of long-term warranties has been met with stiff resistance from contractors, surety companies, and contracting agencies (Hancher 2000). Warranties reduce the bonding capacity of companies and may prevent many small contractors from competing for contracts.

Flexible Notice to Proceed

Under the flexible notice to proceed contracting method, the contractor is given a option of starting the project within a specified period. This approach allows the contractor more time prior to starting the project to plan and coordinate its equipment and manpower (Anderson et al. 2000). This has the possible benefits of reducing impacts to the traveling public and increasing the chances that the project will be completed within the allowed schedule (Anderson et al. 2000).

Planning and Scheduling

Life Cycle Cost Analysis

During the design phase several different alternatives may be available that meet the project objectives. One way to compare these different objectives is a life cycle cost analysis. Life cycle cost analysis involves an economic analysis of each alternative that considers all significant initial and future costs associated with each alternative expressed in equivalent dollars (ACPA 2002b). The equivalent dollars can be expressed as a present value where all future costs and benefits are discounted to account for the time value for money (ACPA 2002b). Another comparison method is to convert all the costs and benefits to an equivalent uniform annual cost (ACPA 2002b). This method is advantageous because it can be used to compare alternatives with different expected lives (2002b). Factors that should be included in the analysis include (ACPA 2002b):

- Initial cost
- Operation and maintenance costs
- Rehabilitation costs
- Salvage value
- Delay-of-use costs for the road users
- User cost due to roadway deterioration
- Accident costs
- Discount rate

- Inflation rate
- Analysis period for each alternative.

Construction Window

The construction window for a project may be constrained by weather or seasonal changes in traffic patterns. On the US 23 project, the construction window was critical to the project schedule (Anderson et al. 2003b). US 23 is a major tourism route connecting northern and southern Michigan. Because of the tourist traffic, the route needed to be open by the Memorial Day weekend (Anderson et al. 2003b). The construction lane closures were expected to take approximately 45 days resulting in a start date of March 31, 2001. The weather was constantly monitored and the schedule adjusted to ensure the project could be completed by Memorial Day weekend. As a contingency plan against bad weather, the contractor planned to implement a double shift (Anderson et al. 2003b). Because of the tight schedule, construction and paving took place during cold weather conditions, patches of snow, and light rain. Working in these conditions, though undesirable, allowed the contractor to complete the project by the Memorial Day weekend deadline.

Traffic Management and Control

Numerous traffic related strategies were identified through the literature review. These include strategies related to the type of workzone, workzone safety, demand reduction, and improving traffic flow through the workzone. These strategies are discussed next.

Work Zone Types

There are numerous different work zone types that can be implemented when performing construction on a roadway. These types include (ACPA 2000):

- Lane Constriction
- Lane Closure

- Shared Right of Way
- Temporary Bypass
- Intermittent Closure
- Crossover
- Use of Shoulder or Medians
- Detour.

The following information concerning construction workzone types was obtained from the American Concrete Pavement Association (ACPA) publication entitled “Traffic Management – Handbook for Concrete Pavement Reconstruction and Rehabilitation” (ACPA 2000). The lane constriction workzone type involves reducing the width of one or more lanes in order to preserve the same number of preconstruction lanes. This method is the least disruptive to motorists but is only applicable when a majority of the construction work takes place outside the normal traffic lanes. The lane closure workzone type involves closing one or more of the normal lanes to traffic. This reduces the capacity of the roadway so a capacity analysis on the roadway may be warranted before implementing this workzone type. The shared right of way method involves using one lane to accommodate traffic from both directions. Signing and signaling is typically used to coordinate traffic flow through the workzone. The temporary bypass method allows the total closure of part or all of the roadway by diverting traffic onto a temporary roadway constructed within the highway right of way. The intermittent closure workzone type involves a complete closure of the roadway for a short period of time. This workzone type is typically only used on low traffic volume roadways. The crossover workzone type involves moving a portion or all of the traffic in one direction across the median. This involves the creation of temporary roadways and may involve the use of shoulders to maintain the same number of preconstruction lanes. When traffic is transferred over, the median separation between traffic lanes is often reduced. This can increase the chances for head-on collisions. For this reason safety measures should be considered such as a temporary median and the use of channelization devices. Workzones can sometimes utilize the shoulder or median as a temporary traffic lane.

When implementing this scheme it is important that the strength of the median or shoulder be sufficient to handle the increased loadings. The detour scheme involves a full closure of traffic in one or both directions and rerouting traffic onto alternate roadways.

The full closure scheme was adopted on the I-496 case study. During one of the phases of construction, the entire roadway was closed and traffic rerouted to designated alternate routes (Anderson et al. 2003a). Improvements were made on the alternate routes to handle the increase in traffic. The full closure allowed construction to be completed within one construction season.

On the US 23 case study project, temporary shoulders were constructed and traffic was moved onto the temporary shoulders and part of the outside lane reducing the number of lanes in each direction to one (Anderson et al 2003b). Once construction was completed on the outside of the roadway, traffic was moved onto the newly constructed lanes and construction took place on the inside lanes.

On the I-10 Concrete Paving Panel Demonstration project performed by Caltrans, a lane closure scheme was adopted (Anderson et al 2004). The eastbound lanes were reduced from four to two lanes in each direction. Because of the high traffic volumes during the day, this work was performed completely at night.

Demand Reduction Strategies

There are several demand reduction strategies that can be implemented in order to reduce traffic volumes through the workzone. One common demand reduction strategy is through alternate routes. Alternate routes played a critical role in the success of the I-496 case study project (Anderson et al. 2003a). Prior to construction, the Michigan Department of Transportation (MDOT) used a macroscopic traffic simulation model to assess different potential alternate routes. As a result of the simulation, several arterials were designated as alternate routes. The alternate routes were also planned in order to minimize neighborhood cut-through traffic and limit overuse of the roadways. The traffic signals on the alternate routes were monitored and updated in order to maximize the efficiency of the roadway. The alternate routes were widely publicized and motorists started using them prior to the start of the construction. MDOT's alternate route planning, improving, and monitoring played a key role in the success of the I-496 project (Anderson et al. 2003a).

Several other demand reduction strategies were implemented by MDOT on the I-496 project. This included providing free bus fares, enhancing bus routes, and approaching local businesses and state agencies to encourage carpooling, staggered work hours, and telecommuting. Post-construction surveys showed that even though many people were aware of the free bus services, few changed their travel mode during the construction (Anderson et al. 2003).

Workzone Safety

Several strategies were identified concerning workzone safety in the report created to summarize the findings of Task 1.01 of the FHWA research project "Traffic Management Studies for High Volume Roadways" (Anderson et al. 2004b). The information on workzone safety described below was obtained from this report.

One common strategy used to enhance the safety of the workzone was to have an incident management program in place. The specifics of the plan varied from project to project but these plans typically include a dedicated towing service that could quickly clear traffic accidents. The Connecticut Department of Transportation (CDOT) used closed circuit television cameras on the I-95 reconstruction project in Bridgeport to quickly identify and clear traffic accidents.

Police enforcement is another common strategy implemented to improve the safety of the workzone. Often the speed limit through the workzone is reduced to increase safety. Many SHAs use police enforcement to ensure motorists obey traffic laws through the workzone.

Many SHAs close ramps in and around the workzone. Closing the ramps is beneficial because it reduces traffic demand on the roadway through the workzone and because it improves safety. This strategy was implemented on I-70 reconstruction in Colummbus, Ohio (Anderson et al. 2004b).

The use of signing is important in the communication of project related information to the motorists. SHAs often use both static and dynamic message signs (DMS) to convey information to motorists. On the I-465/70 Design-Build project in Indianapolis, DMS was used to provide up to date detour and traffic information to motorists (Anderson et al. 2004b).

Barriers are a common safety feature used in construction workzones. The barriers are usually made of concrete and are used to separate traffic flowing in different directions and to separate traffic from the construction area. An innovative type of barrier being used on projects is a quick-change barrier system. This type of system allows the barrier to be moved into place quickly by a specialized piece of equipment. This type of barrier system was used on the I-10 Pomona project in California and on the concrete paving panel demonstration project performed by Caltrans (Anderson et al. 2004a, Lee et al. 2002).

Improving Traffic Through Workzone

One way to improve traffic flow through the workzone is to provide motorists with information so they can adjust there travel patterns. Signing and highway advisory radio are commonly used to convey information to motorists. Static signing is commonly used around workzones no matter how much the construction is impacting motorists. The signs make motorists aware of the construction zone, lane closures, speed reduction, and lane shifts. Extensive signing was used on the I-95 Reconstruction Program in Bridgeport, Connecticut. The signs were used to inform motorists of the varying access ramp closures in and around the construction zone (Anderson et al. 2004b).

Another type of signing is changeable message signs (CMS). The messages on these signs can be changed to reflect current construction and traffic conditions or to provide information on alternate routes or closures. Changeable message signs were documented as being used on the Hillside Bottleneck project in Chicago, the I-95

Reconstruction program in Bridgeport, the I-465/70 Design-build project in Indianapolis, I-710 Long Beach Freeway rehabilitation project in Los Angeles, the I-95 bridge restoration project in Richmond, the I-15 reconstruction project in Salt Lake City, and the I-10 Long Life Pavement in Pomona, California (Anderson et al. 2004b).

Highway Advisory Radio (HAR) is another strategy used to convey construction and traffic related information to motorists. HAR transmitters that are placed around a project can provide motorists with up to date information concerning impacts from construction activities or incidents on the roadway. HAR was implemented on the I-710 Long Beach Freeway project and the I-10 Long Life Pavement project (Anderson et al. 2004b).

Closed Circuit Television (CCTV) monitoring is sometimes used on projects with high traffic impacts to motor traffic conditions in and around the construction zone as well as traffic conditions on alternate routes. CCTV can be used in combination with an incident management programs to quickly identify traffic incidents and dispatch an appropriate response. This application of CCTV was used on the I-95 reconstruction program in Bridgeport (Anderson et al. 2004b). The CCTVs were also used to provide real-time traffic information to the changeable message signs and the project webpage (Anderson et al. 2004b).

Public Relations and Information

SHAs use numerous different strategies to gain public support for projects and to inform the public of construction related issues such as closures and alternate routes. This section describes the public relation strategies identified through the case studies and literature review previously conducted for the FHWA research project.

Webpage

A project oriented webpage is a common technique utilized by SHAs to disseminate project related information to the public. On the I-95 reconstruction program project in

Bridgeport, the project webpage was updated with information detailing road closures (Anderson et al. 2004b). On the Springfield Interchange improvement project in Springfield, Virginia, a comprehensive webpage was created with information on all aspects of the project including closures and alternate routes as well as links to resources for commuters (Anderson et al. 2004b). The website created for the I-496 project in Lansing, Michigan and the I-15 reconstruction project in Salt Lake City, Utah included real-time traffic information through video feeds and pictures (Anderson et al. 2003a, Anderson et al. 2004b). A webpage was also utilized on the Hillside Bottleneck project in Chicago, the I-496/70 Design-build project in Indianapolis, the I-710 Long Beach Freeway project in Los Angeles, the I-10 Long Life Pavement project in Pomona, California, and the US 75/I-635 “High Five” Interchange project in Dallas, Texas (Anderson et al. 2004b).

Press Releases

Press releases are a common tool used by SHAs to convey project related information to impacted groups and the public as a whole. Press releases are sometimes held in anticipation of a ramp or lane closure to notify the public of the change as used on the I-465/70 Design-build project in Indianapolis (Anderson et al. 2004b). Press releases were also used on the I-95 Reconstruction Program project in Bridgeport, Connecticut, the I-70 Reconstruction project in Columbus, Ohio, and the I-10 Long Life Pavement project in Pomona, California (Anderson et al 2004b).

Advertising

Project related information can be distributed through mass media such as television, radio, and newspaper advertising. On the I-496 project in Lansing, Michigan, TV and radio commercials featured a fictional character called “Bob” who failed to plan his alternative routes and, as a result, was stuck in traffic (Anderson et al. 2003a). Based on public surveys, these advertisements were the public’s favorite way to receive updates on the project (Anderson et al. 2003a). On the Hillside Bottleneck project in Chicago, the public received continuing construction bulletins through media outlets such as television, radio, and newspaper (Anderson et al. 2004b). On the I-95 Reconstruction Program project in Bridgeport, Connecticut, newspaper articles were provided twice a week providing the details of the construction plan and road closures (Anderson et al. 2004b). The Springfield Interchange improvement project in Springfield, Virginia, the I-15 reconstruction project in Salt Lake City, Utah, and the I-285 reconstruction project in Atlanta, Georgia also utilized mass media to disseminate information concerning the projects (Anderson et al. 2004b).

E-mail and Fax Distribution

E-mail and fax mailing lists can be set up to periodically send out project updates to those that sign up for the service. This approach was used on the I-70 Reconstruction project in Columbus and I-10 Long Life Pavement project in Pomona (Anderson et al. 2004b).

Project Hotline

Many SHAs set up a telephone hotline where motorists can obtain up to date information on construction activities and motorist impacts. This approach was used on the Hillside Bottleneck project, The I-465/70 Design-build project, and the I-15 project in Salt Lake City (Anderson et al. 2004b).

Informational Videos

Informational videos were used on the I-95 Reconstruction program project in Bridgeport and the I-15 reconstruction project in Salt Lake City. The videos were used to provide a general overview of the project to interested parties (Anderson et al. 2004).

Brochures

Brochures were utilized on the I-496 project in Michigan, the Hillside Bottleneck in Chicago, and the I-95 Reconstruction program project in Bridgeport (Anderson et al.

2003a, Anderson et al. 2004b). The printed material targeted several groups including municipalities, businesses, and other local agencies (Anderson et al. 2004b).

Detour Maps

On the I-70 reconstruction project in Columbus, Ohio, detour maps were created to inform motorists on how to avoid the delays caused by the construction activities (Anderson et al. 2004b). The maps were made available at shopping malls and stores around the center of the city.

Newsletters

Another method used by SHAs to relay project information is through newsletters. Some SHAs such as CDOT on the I-95 Reconstruction Program project created their own newsletter specifically for the project (Anderson et al. 2004b). Other SHAs, such as Caltrans on the I-710 Long Beach Freeway project, provide articles for existing newsletters (Anderson et al. 2004b).

Project Logo

A project logo can be used so that the public can quickly associate other public outreach efforts with the project. A logo was created for the I-496 project in Michigan (Anderson et al. 2003a). The logo included the slogan “Putting the fix on 496”.

Billboards

Billboards were created for the I-496 project featuring “Bob,” a motorist that did not plan his alternate routes and as a result was stuck in traffic (Anderson et al 2003a). The billboards encouraged motorists to plan alternates routes if they did not wish to end up like the exasperated “Bob” on the billboard. Billboards were also used once the project was completed to convey a thank you message to motorists (Anderson et al 2003a).

Preconstruction Surveys

The Utah Department of Transportation (UDOT) performed a large public survey to determine the expectations of the different stakeholders in the project. As a result of the pre-construction surveys and other efforts, UDOT determined that the public favored a higher traffic disruption for a shorter period of time than a lower level of disruption over a long period of time (Anderson et al 2004b). Understanding the motorists' expectations helped UDOT gain public support by being able to meet those expectations.

Ribbon Cutting Ceremony

Once the I-496 project was completed, motorists were invited to a ribbon cutting and public walkthrough of the completed project (Anderson et al 2003a). This allowed motorists to walk and see the reconstructed roadway prior to opening it back up to traffic.

Information Partnership

On the I-70 Reconstruction project, the Ohio Department of Transportation (ODOT) initiated an information partnership with community and business groups. These groups aided in disseminating project information and also provided feedback on traffic management issues (Anderson et al. 2004). The Virginia Department of Transportation (VDOT) adopted a similar strategy on the I-95 bridge restoration project. VDOT worked with the large employers in the area to relay project related information. The employers then passed the information on the their employees (Anderson et al. 2004).

Discouraging Cut-through Traffic

The I-496 project in Lansing, Michigan impacted numerous nearby neighborhoods. In order to minimize traffic trying to cut-through neighborhoods, one of the key messages in the public relations and information campaign was "don't go through neighborhoods" (Anderson et al 2003a). This message was considered one of the most effective messages of the campaign (Anderson et al. 2003a).

Direct Mailing

Direct mailing is sometimes utilized by SHAs to disseminate project related information to nearby residents and local businesses. CDOT mailed information to local businesses and citizens in an entire zip code impacted by the construction activities on the I-95 reconstruction program project in Bridgeport (Anderson et al. 2004b). Direct mailing was also used on the Long Life Pavements project in Pomona, California and the I-285 Reconstruction Project in Atlanta, Georgia (Anderson et al. 2004b).

Public Meetings

Public meetings were used in several of the projects documented in the literature review for the FHWA research project. These meetings were often targeted to specific impacted groups. On the I-496 and I-15 projects a speaker's bureau was set up to distribute project information at these meetings (Anderson et al. 2003a, Anderson et al. 2004b). Groups targeted for public meetings includes local residents, local merchants, community organizations, trucking companies and trucking associations, neighborhood associations, politicians, and local emergency response agencies (Anderson et al. 2003a, Anderson et al. 2004b).

Flyers and Door Hangers

The I-496 project had a significant impact on the neighborhoods located around the construction zone. Door hangers were used in order to communicate information to local residents concerning changes in construction activities (Anderson et al. 2003a). The weekly contractor meetings were attended by public relations staff to ensure the information was correct and up to date. MDOT found that providing more information to residents resulted in more positive reaction, even if the information was concerning a negative impact (Anderson et al. 2003a).

Flyers are also used to inform local residents of construction activities. On the Hillside Bottleneck project in Chicago, flyers were provided to residents around the construction zone to provide information concerning the project (Anderson et al. 2004b).

This approach was also adopted on the I-710 Long Beach Freeway pavement rehabilitation project in Los Angeles (Anderson et al. 2004b).

Night Construction Noise Considerations

The noise from nighttime construction operations can have a significant negative impact on nearby residents. On the I-496 project, MDOT originally obtained noise waivers to allow the contractor to work 24 hours a day, seven days a week. The waivers were changed after meeting with residents to only allow the contractor to perform "light" work after 9:00 PM (Anderson et al. 2003a). The contractor appealed the decision but was denied.

Construction Practices and Management

In addition to the concrete rehabilitation, resurfacing, and reconstruction strategies discussed in the sections above, the literature review identified information pertaining to specific construction practices and management strategies that contribute to project success. These strategies are discussed in the sections below.

Dowel Bar Inserter Paver

The dowel bar inserter (DBI) paver eliminates the need for a dowel basket by inserting the dowels as the pavement is placed. When using a traditional paver, the dowel baskets can be dislodged during the paving operation (Landburg 1993). The DBI paver eliminates this problem as well as eliminating the labor costs associated with the construction of the baskets (Landburg 1993). This piece of equipment also has the advantage of allowing trucks to travel on the grade in front of the paver (Landburg 1993). With a traditional paver, this area could not be driven on once the dowel baskets are placed. One contractor related challenge associated with the DBI paver is that the cost is much higher than that of a traditional paver (Stewart 1992). Paving equipment is a long term and costly investment. As a result, contractors with equipment that is still in good working condition may be hesitant to purchase a new piece of equipment (Landburg 1993).

A DBI paver was implemented on the US 23 unbonded overlay project that was documented as a case study under the FHWA research project. The advantages of using the DBI paver identified in this case study were reduced crew size, increased safety from removing dowel placing crew, improved quality as dowels were placed at the correct depths, and the ability to move end-dump trucks in front of the paver (Anderson et al. 2003b). The combination of these factors has the potential to result in an overall higher productivity rate than a traditional concrete paver (Anderson et al. 2003b). One drawback of using the BDI paver identified in the case study was the placement of the dowels produced a lower quality surface ride (Anderson et al. 2003b).

Exclusive Onsite Batch Plant

Another construction related strategy implemented on the US 23 project was the use of an exclusive batch plant located within the project boundaries. The plant was provided because it was likely that local concrete providers could not provide the large quantities of concrete required for this project (Anderson et al. 2003b). The onsite plant was also provided because the paving contractor desired to have more control over the quality of the concrete (Anderson et al. 2003b). One challenge associated with an on-site batch plant is ensuring that there is adequate room for material laydown. Because of the limited room on the US 23 project for material laydown, the aggregates did not have time to completely dry. A second mixing drum was used to handle this challenge. Concrete would be mixed in the first drum and the slump then tested. Corrective action would be taken in the second drum before it was hauled to the construction area (Anderson et al. 2003b). Locating the batch plant within the project's boundaries was advantageous as it reduced haul times and costs and it minimized impact on local traffic (Anderson et al. 2003b). A disadvantage of using an exclusive batch plant is that project delays can occur in the event of an equipment break down. The batch plant on the US 23 project broke down during the paving operations. The concrete paving operations were completely halted during the two days that were required to repair the facility (Anderson et al. 2003b).

Precast Concrete Paving Panels

A construction method being tested by several SHAs involves the use of precast concrete paving panels. This approach was used by Caltrans on a section of I-10 in El Monte, California (Anderson et al. 2004a). The precast concrete panels were used to replace the outside two lanes and the shoulder of a 250 foot segment of roadway. Because of the large daytime traffic volumes, the construction took place at night. An advantage of using precast concrete paving panels is the speed in which the roadway can be opened to traffic (Anderson et al. 2004a). Another advantage is that the paving can be broken up into short segments that allow off peak traffic construction such as at night or over a weekend (Anderson et al. 2004a). A disadvantage of this method is that the in-place concrete cost is more than traditional or fast setting concrete (Anderson et al. 2004a). Also, a lane must be provided for trucks to pull up to the job site with the panels (Anderson et al. 2004a).

Decision Making

Decision making strategies can be implemented on a project to accelerate the construction schedule. The next section discusses one decision making strategy identified through the literature review.

Site Located Agency Representative

On the US 23 case study project documented for the FHWA research project, project communication and decision making was considered very important to maintain the accelerated schedule. The contractor created a site office accessible by MDOT staff where all key project information could be found. Having all the information in a central location helped expedite the communication process (Anderson et al. 2003b). In addition, MDOT placed a senior supervisor at the site that had authority over most decisions (Anderson et al. 2003b). This allowed approximately 75 percent of the decisions to be made quickly in the field.

SUMMARY

The literature review conducted for this research identified several different project areas that can potentially impact the overall success of a project. The review also identified several different specific strategies that could potentially impact the success of a project. The different identified project areas and strategies were used to create a general discussion topic interview tool for the case studies. The next section includes the detailed methodology of how this research was conducted including the case studies.

CHAPTER III

RESEARCH METHODOLOGY

The proposed research is considered qualitative research and will follow a triangulation approach. Triangulation involves the use of multiple data sources, multiple data collection methods, or both (Crabtree et al. 1992). This method is beneficial because it helps ensure the trustworthiness of the data collected. Three different data collection methods will be considered in the proposed research: 1) existing literature on concrete paving projects and methods; 2) case studies on current concrete paving projects fitting the scope of the research; and 3) expert opinion (Figure 2). For the purposes of this research, strategies are considered fully supported by the agreement in the findings from all three data collection methods.

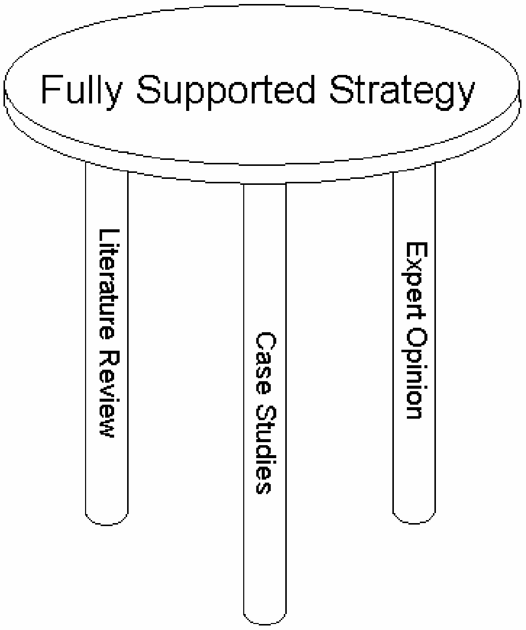


Fig. 2. Triangulation between three different data collection methods

For example, the use I/D is considered a fully supported strategy. The use of this strategy was first documented through the literature review. Several different journal articles were written on the use of I/D. This strategy was also documented in the US 23 and I-496 case studies which were studied as part of the literature review. Because I/D was found in several literature sources, it was included in the general topics which were discussed with the SHA when conducting the case studies (Appendix C). The use of this contracting strategy was then documented through three of the case studies. The I-85 project, the only case study project not to include both incentives and disincentives, supported the need to use both incentives and disincentives together. The information collected through the literature review and case studies was then analyzed and compared to determine why the strategy was applied, what were the benefits of applying the strategy, and any interdependencies with other strategies. This information was then reviewed by expects in the areas pertaining to this research to ensure that it did not contradict the current body of knowledge on the subject. The experts consulted were researchers which the Texas Transportation Institute that have knowledge and experience in the areas of construction, traffic management, and public relations. This provided the final support for the triangulation analysis.

Some strategies were documented in either the literature review or the case studies but not both. If there was significant information from the one collection method concerning the strategy it would be moved foreword and given the consideration of experts. These strategies are only supported by two of the three legs of the triangulation analysis. There were also sources identified through the literature review that identified possible strategies but did not provide in-depth information on the use strategy. Because of the lack of information on these strategies, they were not reviewed by experts. These last two categories are not considered fully supported because they are not supported by each of the data collection methods. Further research would be needed to confirm that these strategies can influence the overall success of the project.

Four case studies were conducted on concrete paving project with high traffic volumes that were currently under construction. A case study research approach is appropriate for this research because of the focus on the "how" and "why" questions (Yin 1994). Examples of "how" and "why" questions that relate to this research include:

- Why were specific strategies implemented on a project?
- How did the project character impact the selection of different strategies?
- Why were certain strategies considered successful?

The procedure used to conduct the case studies in this research followed the principles discussed in *Case Study Research: Design and Methods* by Robert K. Yin (Yin 1994). A case study approach is helpful in investigating current methods and strategies being used by SHAs within the context of the individual project conditions and driving forces. Yin encourages the use of triangulation when conducting case studies to make the conclusions drawn from the case studies more convincing (Yin 1994).

Figure 3 illustrates the methodology that will be followed in this research. Information on key project success factors was gathered through a literature review (Task 1) and through case studies on roadway projects that met the scope of this research project (Task 2). The data were analyzed and conclusions were then drawn on the motivations for using each strategy, the advantages and drawbacks to using each strategy, and relationships with other strategies (Tasks 3, 4, and 5). The results of the data analysis were used to create a series of matrices the summarize the research findings. These matrices also provide a framework for future research (Task 6). The results of the research were presented to experts in the subject areas pertaining to this project to gather expert opinion and to help validate the project's conclusions.

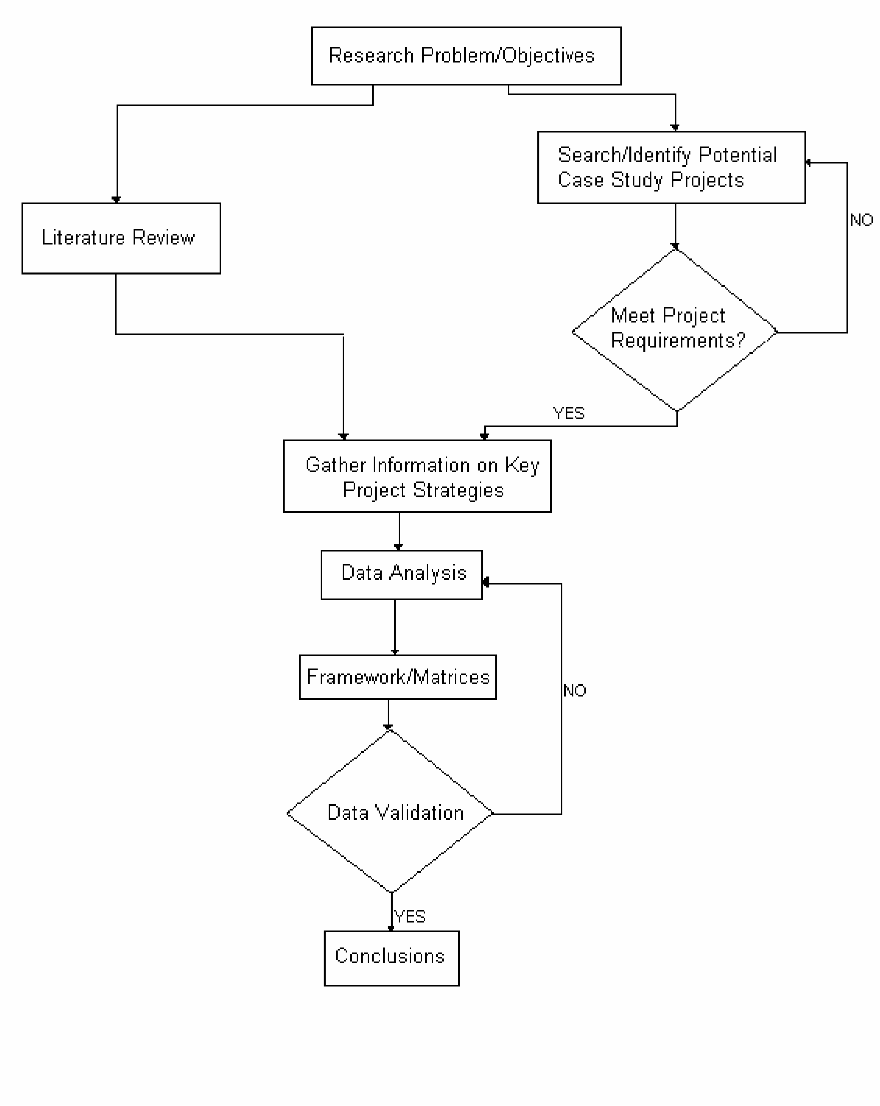


Fig. 3. Research plan

LITERATURE REVIEW

The literature review was used to identify possible success factors to look for when conducting the case studies. The literature review also was conducted to aid in validating and supporting the findings of the case studies. Several different sources of information were utilized in the literature review including library resources, American Concrete Pavement Association (ACPA) publications, American Society of Civil Engineers (ASCE) publications, Transportation Research Information Services (TRIS), and web-based search engines. Also included in the literature review was information collected during the initial phases of the FHWA research project prior to the start of this thesis effort. This information included information from three case studies conducted on concrete paving projects with high traffic volumes and information on traffic management and public relation efforts on completed concrete paving projects.

There are several project areas that the researcher examined to determine key success factors. These areas were:

- General project information and scope
- Constructability
- Contract Administration
- Planning and Scheduling
- Construction Practices
- Traffic Control and Management
- Public Relations
- Decision Making strategies.

Based on the findings of the literature review, these areas encompass all the major project areas that can lead to project success. The literature review was used to help determine if there were other project areas that needed to be considered as contributing to project success.

General project information included information on the project's location, the type of work being performed, and the number of lanes. This will also include information on the traffic volumes and groups impacted by the construction operations. This information was used to determine what made the implementation of certain practices for the project import to the overall success of the project.

There are four primary parties that are affected by the success of a project: the owner (usually the SHA), consultants, the contractor, and the general public. How successful a project is perceived to be depends on which party is questioned. A project that the contractor considers successful may not be considered successful by the owner or road users.

The project owner initiates the project. This is usually the SHA or a City's public works department. These groups are given funds to manage and maintain the existing infrastructure as well as to build new infrastructure. As a result, it is the goal of these groups to provide a "service." This service is provided to the road users. Often, the funds available to these SHAs and public works departments are less than the cost to complete all the needed work. As a result, these groups must manage funds in order to provide the best value for the funds spent. Success from an owner's perspective involves increasing project value and reducing the impact on the road users. The owner has the ability to impact the success of a project through project planning, contracting, and public outreach (Bower et al. 2002, Grajek et al. 2000).

Consultants are often used in roadway work to provide experience and expertise in the areas of design, traffic management, project management, and program management. Some areas where consultants can impact the success of a project are through scope development, constructability reviews, and management practices. Success from the consultant's perspective involves making a profit off the project and maintaining or improving the company's image.

The contractor accepts the owner's contract to build the project. These companies are funded by the profits made from projects. As a result, a major factor that influences success from a contractor perspective is the ability to make a profit on the project. The contractor is also concerned with its company image. If the project is considered to be successful by the owner and/or the general public, it will help give the company a good image. Some of the areas that impact success from a contractor's perspective are contracting, construction methods, and project planning and management (Anderson et al. 2004).

Concrete paving projects on roadways with high traffic volumes can have a large impact on the road users and sometimes local businesses. Many SHAs have started considering the impact on road users in their contracting methods. Minimizing the impact of construction on the users can involve maximizing traffic flow and minimizing the construction schedule. Road users can influence the success of a project by providing input to the SHA during the project planning process. This feedback process is made possible when an SHA starts the public information campaign prior to the beginning of the project. As a result, road users' ability to impact the success of a project is dependent on the SHA's willingness to listen and incorporate the road users' needs into the project.

This research focuses primarily on success from the SHA's point of view. Representatives from the contractors and the design consultants were also interviewed to determine the project's success for their perspective. Although important, this research was not designed to identify the public's perception of success.

CASE STUDIES

Short case studies were conducted on concrete paving projects that fit the scope of the research project to collect data related to this research topic. Concrete paving projects including restoration, resurfacing, or reconstruction work were considered for this research. The four case studies performed for this research involved restoration and reconstruction. Two of the case studies performed prior to the start of this research effort were resurfacing projects. Information on these projects was captured using interviews with SHA personnel and contractor representatives, photographs, and video documentation. The third case study documented prior to the start of this research involved reconstruction using precast concrete paving panels.

To identify potential projects for the research project, letters explaining the research project and the case studies were sent to each SHA's construction engineer. A document further explaining the research project and the case studies was attached with the letter. A copy of the letter and scope document can be found in Appendix B. Letters were also sent to members of the ACPA's subcommittee on construction. This research conducted four case studies on current roadway projects. Three case studies that were previously performed under the FHWA research project were also considered in the literature review. Two of these projects were conducted under MDOT and one was conducted under Caltrans.

When conducting the case studies, the researcher gathered general information on the project's scope and general characteristics. This will include the project's location, the type of work that was accomplished, and the impacted road users. This information was used to determine the project characteristic or driving forces that trigger the use of different strategies. Information on the eight project categories discussed in the literature review section above were gathered through observation of the construction and through interviews with SHA personnel and contractor representatives. In addition to gathering information on the different aspects of the project, the following questions were discussed during the interview process:

- What were the original traffic, construction, and public relations plans for the project?
- What was actually done on the project and why?
- What worked on the project and why?
- What lessons can be learned from the project?
- What were the key strategies for the project that impacted the overall success?

These questions were used to determine the specific strategies that contributed to project's success and will identify the reasons those strategies were implemented. Asking about the lessons learned identified project areas critical to the overall success of the project.

Once a project was identified as a possible candidate for a case study, a meeting was arranged with representatives of the SHA. Contractor representatives were also encouraged to attend the initial meeting as well. The contractor was present at the initial meeting of the I-85 project. A contractor representative was not present at any of the other initial meetings. The purpose of this meeting was to gather information on the project scope, work completed to date, and potential success factors. A list of general topics that were covered in the initial meeting can be seen in Appendix C.

Some time after the initial meeting, site visits were planned to document the construction practices on the project. The site visits were planned in order to capture critical information concerning the major construction and traffic management operations. When needed, more than one site visit was conducted. The information from the site visits was documented using video and photographs.

Additional interviews were conducted as needed. The information from the initial meeting and the interviews was recorded and/or documented.

DATA ANALYSIS

Once the data from the case studies and literature review were collected, it was organized by the project areas discussed in the literature review. The case studies and the literature review data collection methods represent the first two legs of the triangulation analysis. Key project participants from the case studies were asked to identify success factors. Once the success factors were determined, they were organized into one of the key project area categories identified through the literature review.

Through the case studies, the critical project driving forces and the key project characteristics were identified. This information was gathered through the general project questions asked in the interview process. The information obtained by asking why certain practices and success factors were implemented aided in this analysis. The driving forces and characteristics were compared to the success factors to identify similarities between projects. The researcher used data collected from the case studies and information collected in the literature review to determine which success factors were a direct result of the project specific driving forces and characteristics. This research created a matrix that matches each of the success factors to the project characteristics. Because of the limited number of case studies that were conducted, the matrices do not necessarily show all the relationships between strategies and motivating conditions or project characteristics. Future research should be conducted based on the framework created through the matrices to create a tool that could be used by SHAs.

When conducting the research, varying levels of effort were seen in the implementation of different success factors, especially in the areas of traffic management and public relations. The research examined the varying levels of effort exerted in each of the different project levels to determine how they were influenced by the specifics of the project. The research examined the intensity of the public relations campaign compared to the impact the construction was having on the road users. The research also documented the different groups that were impacted by the construction efforts. This approach determined if certain strategies were used primarily because of a specific impacted group. The research determined what characteristics of a project trigger the need for increased levels of effort in the different success factor areas. The use of multiple data sources under the triangulation analysis was used to identify the varying levels of traffic management and public relations strategies.

The research determined if there were any interdependencies between the different success factors. This research determined what success factors were results of the project and what success factors were used because they were related to other success factors. This was accomplished by analyzing the groups of success factors implemented on different projects. Information from the interview process on why certain success factors were implemented aided in determining interdependencies. The results of this process are displayed in an interdependency matrix. Differing perceived relationship strengths were discovered as the data from the literature review and case studies were analyzed. The research identified the perceived strength of interdependencies between the different strategies.

SUMMARY

This research follows the triangulation approach. The three different data collection methods are comprised of case studies, information from literature sources, and input from experts in the areas roadway construction, traffic management, and public relations. The data from these different data collection methods were used to create a framework for selecting different strategies based on specific project conditions. The next section describes the four case studies that were documented in support of this research effort. This included a description of the projects and the different strategies that were successfully implemented on each project.

CHAPTER IV

DATA COLLECTION

Case studies were performed on concrete paving projects involving high traffic volumes that were currently under construction. These case studies involved collecting data through interviews and through observing and documenting the construction procedures implemented. Each case study involved multiple interviews and site visits to adequately capture the various aspects of the project.

Four different case studies were documented in support of this research. Each project was considered to have high traffic volumes by the SHA. Each of the projects involved reconstruction work. Rehabilitation work was documented on the I-15 Devore project and the I-85 project. This chapter describes the case studies, how the data were collected, and the success factors identified.

LAMAR BOULEVARD UTILITIES AND RECONSTRUCTION PROJECT

General Project Information and Scope

Lamar Boulevard, located in downtown Austin, Texas, is a four lane road with a two-way left turn lane. This project involved the reconstruction of approximately 1.7 miles of the roadway. The scope of this project included water and wastewater improvements, pedestrian amenities, and full-depth roadway reconstruction. The wastewater improvements included new wastewater lines, a new water line, and numerous storm drain inlets. The pedestrian amenities included a new sidewalk, sidewalk repairs, new ramps, a raised pedestrian island, and a new pedestrian crossing. Most of the project was reconstructed using asphalt concrete but three intersections and a stretch of the road were reconstructed with portland cement concrete because of the high traffic volumes.

Figure 4 shows the average daily traffic (ADT) for 5th Street and 6th Street and the section of Lamar Boulevard that was reconstructed with concrete.

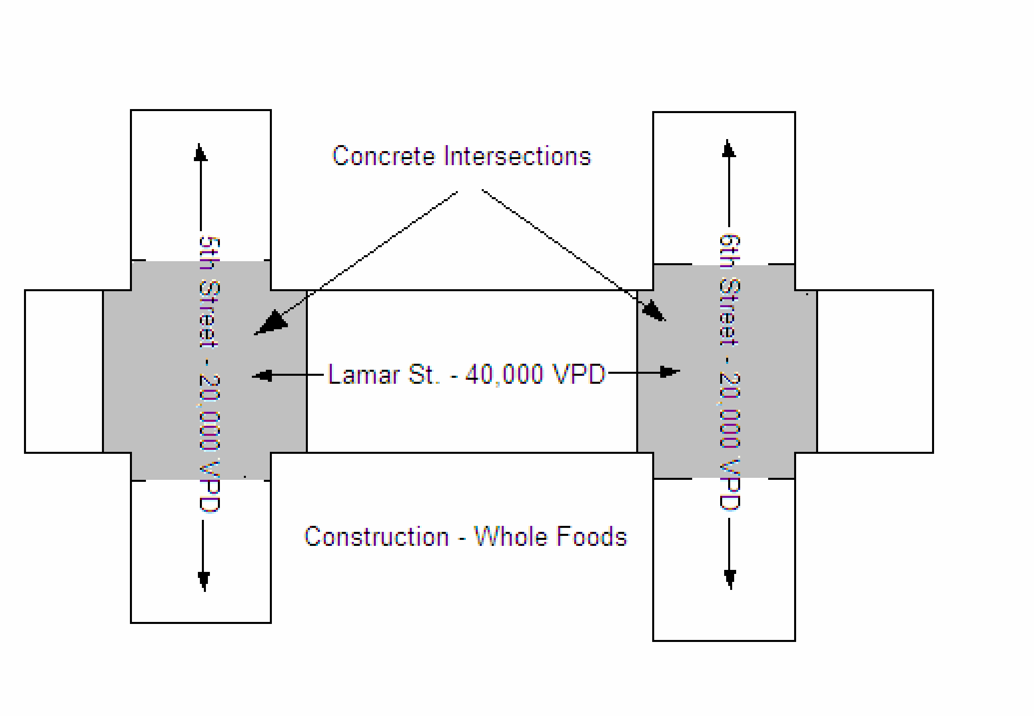


Fig. 4. Traffic counts for Lamar Boulevard between 5th Street and 6th Street

A unique feature of this project was that numerous businesses were impacted by the construction work (Figure 5). The businesses were considered the primary impacted group on this project and much of the project's planning and scheduling was influenced by the impact to the businesses.

The contractor started the reconstruction and utility work on March 1, 2004 with an anticipated completion date of June 2005. The original construction schedule included a 6-week break during the holiday season to give the public easy access to the local businesses. The City of Austin and the contractor's efforts to further accelerate the project schedule resulted in the project being substantially complete by September 10,

2004. The contractor worked seven days a week, 12 hours per day to complete the project.

Because of the large impacts the reconstruction efforts would have on local businesses and commuters, stricter requirements for contractor participation were defined through a screening process. The rigorous screening process resulted in only two contractors bidding on the project. The contract on this project included I/D. Incentives were placed on the major project milestones. Disincentives were placed on the opening time for the intersection reconstruction.

Fig. 5. Intersection reconstruction efforts close to local businesses

The City of Austin worked with the design consultant to create the Accelerated Design and Construction Process (ADCP). This was a teamwork driven process that focused on completing the project with minimal impact to the local businesses. This process streamlined all the major project areas including design, bid, and construction. The ADCP greatly increased the speed of the Request for Information (RFI) process. Under the ADCP, the contractor would bring issues up at the daily construction meetings. The design engineer would create a solution and it would be ready for approval by the next morning. This helped minimize construction interruptions created from lag time between redesign and construction.

Daily construction meetings were held at the contractor's on-site office and were attended by decision makers from all of the major project participants including the City of Austin, the contractor, the design consultant, and utility companies. This allowed decisions concerning to project to be made on a daily basis as issues arose.

The concrete intersections were reconstructed in quadrants. The reconstruction of each quadrant took place over a weekend. This allowed the intersection to remain functional during the reconstruction. An accelerating admixture was used in the concrete mixture to ensure adequate strength was achieved by the time the roadway was opened to traffic. The concrete was placed early Sunday morning at approximately 4:00 am to ease truck movement through and around the construction site. The trucks were routed through commercial areas because these were typically closed and not impacted by the traffic or noise. The contractor took measures to reduce the noise created from the nighttime construction operations to minimize the impact on the local residents.

Case Study Methodology

An initial interview was conducted with the project manager to gather general information on the project's scope and to collect project information as it pertained to the different areas of the research project. A list of general topics was created to guide the discussion during the interview.

A site visit was conducted to observe and document the weekend reconstruction of one quadrant of the 12th Street intersection. The construction operations were documented with photographs and video footage. Additional photographs documenting the reconstruction of the 12th Street intersection as well as some of the other construction operations were obtained from the project manager.

A site visit was conducted to observe one of the daily construction meetings that greatly influenced the overall success of the project. After the meeting, a group interview was conducted with representatives of the City of Austin and the contractor.

Phone interviews were conducted with traffic management and public relation representatives from the project. Information was also collected on the design consultant's participation in the project through the different phases of project execution. Construction drawings and project specifications were also collected on this project

Documented Success Factors

The Lamar Boulevard reconstruction project was considered a success by the City of Austin, the contractor, the design consultant, and the numerous businesses impacted by the construction. There are several strategies implemented on this project that impacted the overall success of the project. These strategies are discussed below.

Construction Practices and Management

The City of Austin performed a rigorous screening process prior to the formal bidding process. The contractors were screened based on:

- Experience with similar types of projects (size, scope, traffic conditions, etc)
- Adequate staffing and equipment
- Ability to work 12-hour days, seven days a week with fourteen days on and two days off
- Ability to meet accelerated schedule milestones and deadlines
- Backlog of work that might impair ability to complete project
- Willingness to attend daily construction meetings.

The screening process helped ensure the contractor that received the contract for the project could handle the project's complexity, accelerated schedule, and daily commitment to attend project meetings. The screening process did, however, cause lower levels of interest in the project from contractors and only two bids were received.

The City of Austin worked with the design consultant to create the ADCP. The ADCP greatly increased the speed of the RFI process. The turnaround time for RFIs on the Lamar project was typically less than 24 hours. Under the ADCP, any issues that the contractor had would be brought up at the daily construction meetings. The design engineer would then initiate a solution or redesign at the work site and then e-mail the information to the design consultant's office. The design engineer would pick up the completed drafting design at the office in time for approval during the next construction meeting. The redesign would then be given to the contractor. This process helped minimize construction interruptions created from the lag time between redesign and construction.

The contract for this project included incentives for the early completion of major milestones as well as penalties for failing to open the roadway to users by a certain time. The incentives were used to motivate the contractor to maintain and exceed the accelerated schedule for the project. The project was completed in six months, ten days. This was significantly faster than the already accelerated schedule of 16.5 months originally planned for the project. As a result of the contractor's efforts, the contractor received the maximum incentives possible.

There were penalties related to the intersection reconstruction work. Each intersection was reconstructed in quadrants. The contractor was given 93 hours to complete the reconstruction of each quadrant. A penalty of $20,000 was in place if the contractor needed an additional day to complete the work. The contractor was able to complete all the intersection work without incurring any penalties.

Because of the highly accelerated schedule, daily construction meetings were held at the contractor's site office. These meetings were attended by decision-making representatives from all the major parties involved in the project and attendance was mandatory. This allowed decisions to me made quickly when challenges or problems arose.

The primary groups impacted by this construction were the local merchants and weekday commuters. In order to minimize the impact of the construction on these groups, the reconstruction of the concrete intersection was scheduled on the weekends.

There are several nearby neighborhood impacted by the construction on Lamar Boulevard. When construction took place at night, noise reduction strategies were implemented to reduce the impact on the nearby residents. The concrete trucks were routed through commercial areas that were typically closed at night. The pump trucks or conveyor trucks were strategically positioned near buildings that would reduce the noise resulting from the construction operations (Figure 6). The back-up alarms on some of the pieces of equipment were also temporarily disabled.

Fig. 6. Concrete paving at night at the intersection of 12th Street and Lamar Blvd.

The utility work on the Lamar project was a major challenge because many of the original utilities installed in the 1930's were still in place and their exact locations were not well documented. The majority of the utility work was completed early in the project. During the utility work, the locations of the new utilities were clearly documented. This approach will be beneficial when future utility work is necessary. In addition, utility representatives attended the daily construction meetings when utility work was taking place.

A concrete accelerating admixture was used on the intersection reconstruction. The admixture used was an anti-corrosion admixture used at one third its normal dose. This mixture design was used to ensure adequate strength gain had taken place before the newly constructed roadway was opened back up to motorists. The admixture was significantly less expensive than an accelerator but has not been well tested in concrete paving applications. The admixture was also very susceptible to temperature changes. The admixture did allow the concrete to gain adequate strength by the time it was opened to traffic. It is uncertain how the pavement will perform long-term.

Public Relations and Information

An extensive outreach effort was targeted towards the numerous local merchants impacted by the construction efforts. Weekly meetings were held to inform local businesses of project information and to give them options concerning lane closures. The original construction phasing maintained a turn lane into the local business entrances at all time. Because of the outreach efforts, the local businesses allowed for the removal of the turn lane to further accelerate the construction efforts. In response to the removal of the turn lane, the City of Austin provided signs clearly showing access points for each of the businesses (Figure 7). Flaggers were also provided to help direct traffic through the construction zone (Figure 8).

Fig. 7. Business access signs

Fig. 8. Access to businesses signing with a flagger to direct traffic

The public outreach to the local businesses and impacted communities started almost a year before the construction efforts began. Weekly meetings were held with merchants and nearby residents. For those unable to attend the meetings, project information was available through the project webpage and through an e-mail information distribution system. Information was disseminated in written form through news releases and hand delivered updates. In addition, traditional media such as television, radio, and newspaper were used to communicate information on the project.

Traffic Management

During the construction efforts, the traffic management plan was updated regularly to accommodate local resident and merchant concerns and changes in construction sequencing required to keep the project schedule on track. The City of Austin maintained an on-site traffic control technician to approve minor changes to the traffic management plan. Larger changes would be approved during the construction meetings.

Because of the intense nature of this project due to the accelerated and constantly changing schedule, the work load of the Traffic Control Supervisor was drastically reduced from 15 projects to only two projects. This allowed him to focus more of his attention to this constantly changing project.

Several alternative routes were planned for this project but were not extensively publicized due to the merchant concerns. Traffic on Lamar Street as well as alternative routes was constantly monitored. The traffic signals on these roadways were adjusted to improve traffic flow.

Rather than only allowing the contractor to work during off peak hours, permanent lane closures were used when possible. It was estimated that this approach reduced the project's duration by several months.

I-15 DEVORE PAVEMENT REHABILITATION PROJECT

General Project Information and Scope

The I-15 Devore project involved a 3.4 mile stretch of roadway that carries over 80,000 vehicles per day during the week with a high percentage of trucks. The roadway also has a large percentage of weekend traffic as a result of motorists traveling to from the Las Vegas area. Figure 9 shows the location of the project.

Fig. 9. I-15 project location

This $15 million project focused on construction efforts focused on the outside two lanes. The far outside lane was completely reconstructed. Parts of the other lanes showing distress were removed and replaced (Figure 10). Caltrans originally wanted to reconstruct the entire roadway but was limited due to inadequate funds. The new concrete was constructed to have a life of 30 years and consisted of unreinforced concrete with dowels.

The project was divided into two segments. Segment 1 has four lanes in each direction and segment 2 has three lanes in each direction (Figure 11). Figure 12 illustrates the location of the reconstruction efforts.

Fig. 10. Damaged concrete slabs in the outside lanes (left) and the beginning of construction workzone, southbound (right)

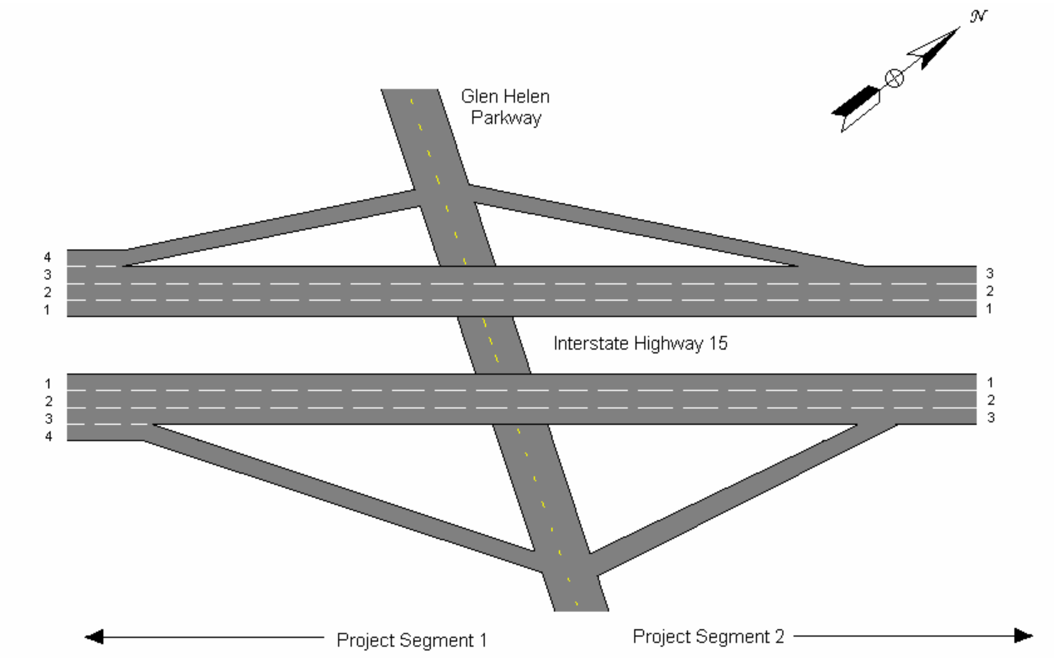


Fig. 11. Lane configuration of I-15 at Glen Helen Parkway

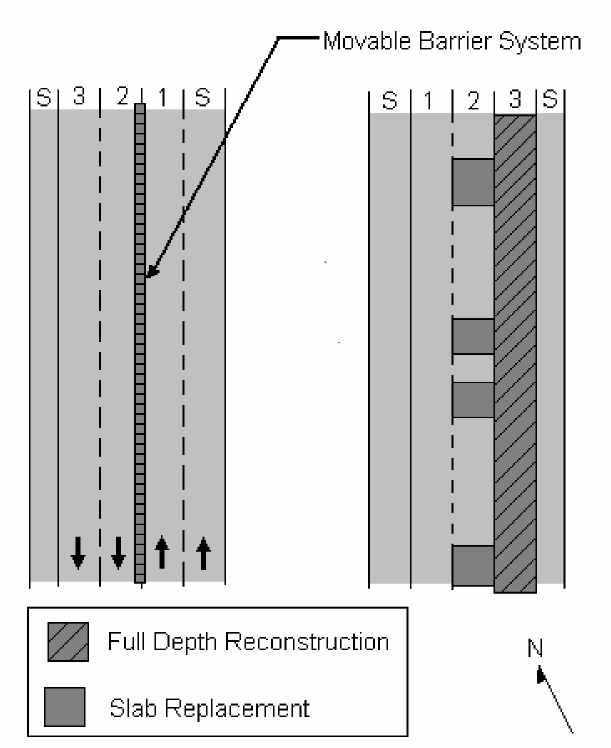


Fig. 12. Lane configuration during segment 2 construction efforts

The I-15 project started in August 2004 with an expected completion date of February 2005. The original construction schedule included a six week period of weekday construction. Caltrans did not hold outreach meetings during the planning stages of the project. When the public found out that the weekend travelers were not sharing the inconveniences of the construction they were outraged. As a result, Caltrans slowed the project in an effort to gain more public buy-in of the project.

The project resumed on October 3, 2004 with an expected completion date of the reconstruction efforts of November 12, 2004. The 96 hour weekday closures started Sunday night. The roadway had to be reopened to traffic by 5:00 am Friday morning. After the second week of construction, the contractor was allowed to work through the weekend to complete the northbound lanes even though the original schedule allowed only for weekday work. The start of construction on the southbound lanes was delayed from the intended October 18th (Monday) to October 22nd (Friday) because of the unusually large amounts of rainfall received during that period. The contractor was again allowed to work through the weekend. Work continued into following week. The contractor was able to complete the reconstruction work in only four weeks.

This project was intentionally scheduled to avoid the summer time peak periods and finish paving operations and extended lane closures before the start of the holiday season marked by the Thanksgiving holiday. Caltrans re-opened all lanes on I-15 from Sierra Avenue in Fontana to the I-15/I-215 junction in Devore on November 3, 2004. Guardrail and sign replacement, grinding, and lane re-striping continued under traditional short-term nighttime closures through February 2005.

Study Methodology

Two site visits were conducted to document Caltrans' efforts on this project. During the site visits the construction operations were observed and documented using photographs and video footage. Also accomplished during the site visits were a series of interviews with Caltrans and construction personnel.

Information on much of the traffic management and public information activities was available on the Caltrans District 8 project website or through various newspaper media articles describing the project's progress. More detailed information on the traffic management and public information activities was collected through e-mail correspondence with the project's public information officer and the project's design engineer.

The University of California at Berkeley, provided additional information concerning the project's website the Automated Work Zone Information (AWZI) System used to help determine the closure scheme.

Documented Success Factors

Construction Practices and Management

The contract for this project included incentives and disincentives. Incentives were available for early completion and disincentives were in place for not opening the lanes to motorists by a certain time. Caltrans paid the contractor a total of approximately $600,000 in incentives. There was a "late-opening" penalty that resulted in the contractor being fined $200,000. This fine was eventually dropped because of the numerous changes to the project's schedule and because of the contractor's efforts to reduce the impacts of the construction operation of the road users. The use of incentives and disincentives was used in this contract to motivate the contractor to use less than the original contract schedule and to motivate the contractor to have lanes open to the public by the specified time periods.

The construction work took place on the outside two lanes. The far outside lane was completely reconstructed and selected portions of the other lane were reconstructed. The contractor used a two-lane slip-form paver that allowed both lanes, the lane that was completely reconstructed and the lane with selected slab replacements, to be paved simultaneously (Figure 13). This increased the speed of the paving operation. The concrete was transported to the construction site in dump trucks. The concrete was dumped in front of the paving equipment and then spread with a front end loader. A similar method was used on the I-85 project, however, the Georgia Department of Transportation (GDOT) preferred having the concrete dumped into spreader equipment because of the risk of segregation.

The contractor used 12-hour and 24-hour mix designs which included Type III and Type II cements, respectively. The 12-hour mix design was used at the end of construction segments or on segments paved the day before they would be opened to traffic. Concrete specimens were prepared and tested on-site for slump and flexural strength.

Fig. 13. Paving with a two lane slip-form paver

Public Relations and Information

The original construction schedule for this project was comprised of six construction periods that would reduce the roadway to two lanes in each direction. Because of the large weekend traffic volumes, the closures were scheduled from Monday to Thursday of each week. Due to public outcry from weekday commuters who felt that weekend travelers should share the inconvenience of the construction, the project schedule was slowed to perform more public relations actvitites. Although not the original plan, Caltrans did allow the contractor to work on some of the weekends to further accelerate the schedule and to make up for delays caused by large rainfalls.

The nation's largest amphitheater is located near the construction zone. Caltrans worked with this venue as well as others in the area to coordinate the construction schedule. The normal concert season runs from April to October. Because the construction started during the concert season, Caltrans felt that coordinating with this venue was a high priority.

Caltrans started the public information campaign early to ensure all effected parties were informed on the impending construction. Caltrans met with groups including the Legislators, City/County Staff, the San Bernadino Police Department, and the Chamber of Commerce in surrounding cities.

Traditional broadcast and print media agencies as well as other impacted transportation agencies were provided weekly press releases with the latest project information. The press releases were also available through a fax distribution system.

Traffic Management

The traffic conditions on I-15 were highly directional based on the time of day. In order to maximize the capacity of the roadway Caltrans used a quick-change barrier system. The barrier would be moved to allow peak hour traffic to have three lanes while the other direction would have only one. The barrier system could be moved quickly to accommodate the directional traffic conditions. A picture of the movable barrier can be seen in Figure 14.

Fig. 14. Movable barrier system separating traffic lanes

During non-peak traffic time, the contractor would close additional lanes in an effort to complete the paving operations as quickly as possible. This accelerated the schedule and helped minimize the impact of the construction on the road users.

Caltrans utilized the California Highway Patrol to assist with traffic control and construction zone speed enforcement. The highway patrol ticketed motorists who failed to obey the construction zone speed limit at various times during the project. The highway patrol also helped with lane closures and shifting traffic. When crossing traffic over onto the other side of the roadway, the highway had to be temporary closed to setup the crossover and restripe the roadway. When reopened, the highway patrol lead motorists through the construction zone.

Several tow operators were stationed at different points along the project. Their purpose was to remove disabled vehicles quickly from the construction zone in order to minimize traffic impacts. The average time to clear an accident from the construction zone was reported to be six minutes.

Traffic conditions on the site were monitored using closed circuit television cameras (CCTV) from a "command post" located near the project (Figure 15). The CCTVs allowed Caltrans to assess and respond quickly to traffic incidents. The CCTVs were monitored 16 hours a day. The information collected from the command post would be used to update changeable message signs with real-time traffic information. The information would also be used to update the traffic map available online. The temporary traffic management center created for this project can be seen in Figure 15.

Fig. 15. Tempory traffic management center

Several alternate routes were designated for this project. Motorists were encouraged to use the alternate routes, especially during peak periods each day. Changeable message signs were used to inform motorists of alternate routes. The signs would designate an alternate route based on real-time traffic information on travel times through the workzone and travel conditions on alternate routes. This approach helped balance congestion on I-15 and the alternate routes.

To minimize demand on I-15, Caltrans worked with local groups such as the California Trucking Associating and the Nevada Convention Bureau prior to the start of construction to encourage the use of alternate routes and to encourage off-peak travel. Trucks were encouraged not to travel during peak travel times and travelers going to or from the Las Vegas area were encouraged to fly. The demand reduction strategies implemented by Caltrans including the use of alternate routes and encouraging non-peak traveling resulted in an 18 to 20 percent observed decrease in traffic volumes on I-15 through the project limits.

I-85 ATLANTA RECONSTRUCTION PROJECT

General Project Information and Scope

The I-85 reconstruction project in Atlanta, Georgia consists of a 6.9 mile stretch of roadway with four lanes in each direction. The older outer lanes constructed in the 1960's were reconstructed and the newer inner lanes were rehabilitated. The roadway includes an existing barrier wall and drainage structures in the median (Figure 16). The median barrier wall was heightened by two feet to reduce the glare from oncoming traffic at night. The total project cost was estimated to be $37.9 million.

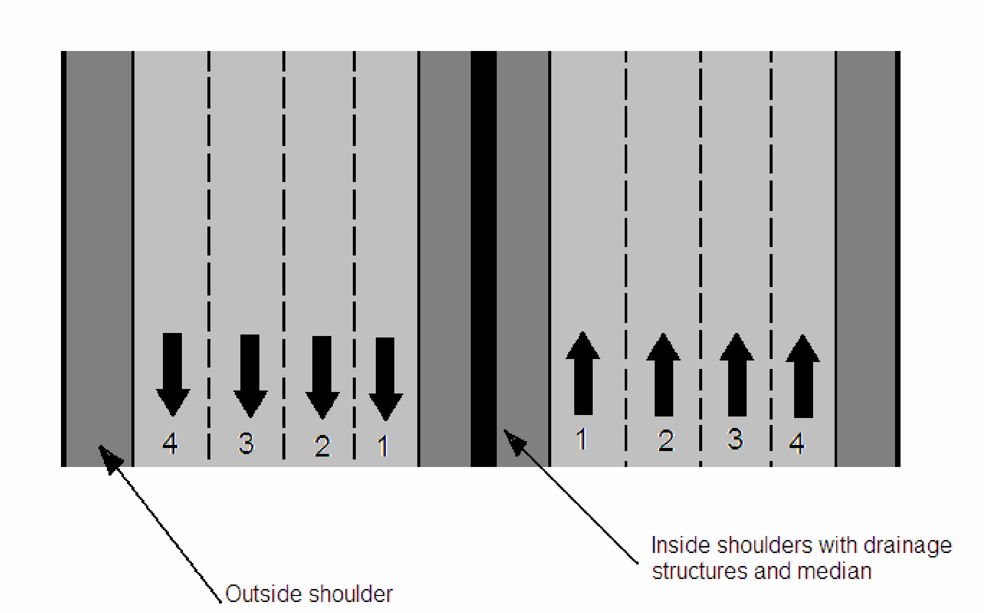


Fig. 16. I-85 lane configuration

The ADT on this roadway is 131,000 vehicles per day. Because weekday commuters are the primary road user, the reconstruction efforts were conducted on the weekends. Each weekend, approximately one half of a mile of roadway was reconstructed. The reconstruction efforts were expected to take 27 weekends and the contractor could pick the weekends to work with some limitations such as holidays or special events. Penalties were included in the contract for not having the roadway open by a certain time on Monday morning and for needing more than 27 weekends to complete the reconstruction. A moveable concrete barrier system was used to quickly establish a safe workzone. An on-site batch plant was utilized to minimize haul times.

Nighttime construction took place during the week between 9:00 pm and 5:00 am. The contractor used this time to work on the shoulders, pre-cut the concrete slabs in anticipation for the weekend construction, perform rehabilitation work on the inside lanes, and diamond grind newly placed concrete. Approximately 700 square yards of rehabilitation work was needed for the inside lanes. Disincentives were in place to motivate the contractor to have the roadway open to traffic by 5:00 am Monday morning.

The contract for this project included disincentives only. There were disincentives on the lane opening times to ensure morning commuters were not impacted by the weekend or night construction activities. There were also disincentives on the number of available weekends. If additional weekends were needed to complete the reconstruction of the outside lanes they had to be purchased from GDOT at $100,000 per weekend. There was a $450,000 penalty if the project exceeded the allowed schedule. The contractor believed that this project would have benefited from having incentives instead of solely disincentives. They believed that they could have completed the project ahead of schedule. They also believed that implementing incentives on the project would have made the relationship between the owner and the contractor less adversarial.

Case Study Methodology

An initial meeting interview was conducted with the GDOT and with representatives from the contractor to gather general information on the scope of the project and to gather specific information on topic that pertain to the research project.

A site visit was conducted to document the weekend reconstruction efforts. The site visit involved observing and documenting the reconstruction efforts using photographs and video footage. Follow-up contact was maintained with GDOT to keep up with the progress on the project and to determine if there were any major changes in the project and why they occurred.

Another site visit was conducted after the contractor had completed the southbound lanes and had started construction on the northbound lanes. Interviews with GDOT and the contractor yielded valuable information concerning construction operations conducted during the week, the intensity of the planning and scheduling process, and problems that arose during construction. During the second site visit the reconstruction operations were documented with still photography as well as video footage.

Documented Success Factors

Several success factors were documented during the reconstruction of I-85 in Atlanta. These factors are discussed in the section below.

Construction Practices and Management

Because the primary road user for this project is weekday commuters, the contract specified that the reconstruction efforts take place on the weekend. The contractor was given 27 weekends to complete the reconstruction work with some stipulations on certain weekends such as holiday weekends or weekends with special events. The construction operations stopped for most of winter and resumed again in the spring. A detailed hourly schedule was created for the weekend reconstruction efforts. Construction efforts took place day and night.

Each weekend, approximately a half of a mile of concrete pavement was reconstructed. During the first weekends that the reconstruction was attempted the contractor fell short of the half-mile goal. After resuming construction in the spring, the contractor was able to pave 3,600 feet, well over half of a mile. The contractor expected to be able to pave close to 4000 feet as the project neared the on-site construction office and batch plant. The A movable concrete barrier was used to separate the construction operations from traffic. The movable concrete barrier, as shown in Figure 17, was beneficial because it could be quickly moved into place and it provided safety to the workers in the workzone. The workers on the project preferred working behind the movable concrete barrier over traffic barrels because if the increased safety. Prior to the site visit to document the weekend construction the barrier was struck by a truck. The barrier moved slightly and was damaged but it protected the workers.

Fig. 17. Movable barrier system

An on-site batch plant was utilized for this project. The concrete supplier had materials dedicated to the I-85 project in order to prevent delays from concrete shortages. The on-site batch plant also helped minimize haul times. The contractor also utilized a batch plant located near the project limits that was being used for another project during the week. Approximately the last third of the concrete placed over each weekend included an accelerating admixture that allowed adequate strength gain so the roadway could be opened by 5:00 am on Monday.

The weekend reconstruction efforts required a larger amount of workers than the weekday work. The contractor moved workers from another job on the weekends to ensure the project was completed on time. Managing labor was challenging on this project. Hours were intentionally withheld from workers in anticipation for the weekend work. If the weekend reconstruction operations had to be cancelled due to rain, the contractor had to respond quickly to redistribute the workers onto other tasks. Canceling the weekend reconstruction work also required coordination with the batch plant and the trucking companies. The contractor stated that the planning and scheduling requirements on this project were much higher than traditional construction projects.

The concrete was pre-sawed during the week to expedite the removal of the concrete slabs during the weekend. This work was conducted at night by closing the outside two lanes. Pre-sawing the slabs allowed them to be removed quickly. The excavator was mounted with a special bucket suited for removing the slabs (Figure 18). This excavation method also minimizes damage to the base and subbase layers.

Fig. 18. Removing the pre-sawed slabs with an excavator

A GDOT representative was onsite each weekend for the entire duration of the construction activities to make decisions and answer contractor questions. This was important because the accelerated schedule could not afford a lengthy decision making process. GDOT inspectors were also on the site throughout the weekend construction operations.

The contractor used a two lane slip-form paver to pave both of the lanes at once (Figure 19). This was more efficient than using a single lane paver. The contractor planned the construction segments so that overpasses did not restrict the use of the two lane paver. The pavement under overpasses that could not be paved using the slip-form paver was paved using formwork.

Fig. 19. Paving operations on the I-85 project

Public Relations and Information

The public relations campaign on this project was carried out by GDOT. The public relations efforts included utilizing media and the news on Thursdays and Fridays to inform motorists about the construction. Traditional advertising, a project website, and the use of changeable message signs were also used. GDOT also worked with the Trucking Association to distribute flyers at rest stops to inform the trucking community of the construction work on I-85.

Traffic Management

During the weekend reconstruction efforts, the roadway was reduced to two lanes in each direction (Figure 20). A traffic officer was present at the construction site throughout the weekend to slow down traffic as it entered the workzone. Signs were set to inform motorists of the construction activities. Police officers were present on the site throughout the weekend construction to encourage motorists to obey traffic laws and not speed through the workzone. Towing services were available in the instance of a traffic accident or breakdown.

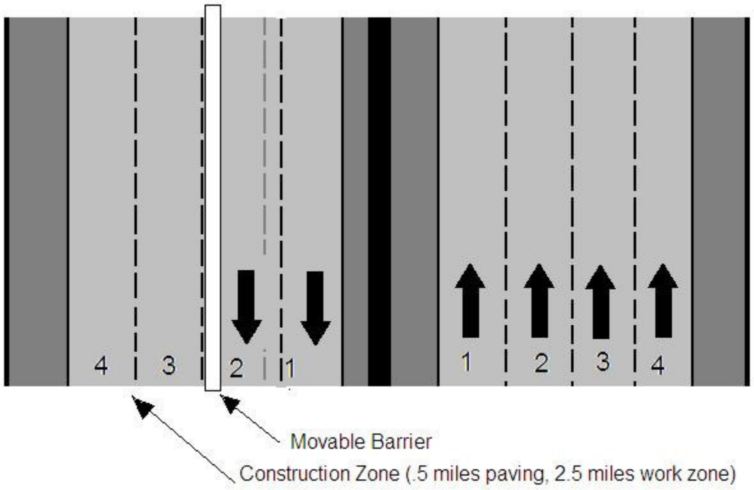


Fig. 20. Traffic flow and the location of the movable concrete barrier for construction on the southbound lanes

The construction contract for this project included increasing the height of the median barrier to reduce the glare created from oncoming traffic at night. Work on the anti-glare barrier was accomplished by closing the inner lane in each direction with traffic barrels. GDOT specified that this work could not take place within two miles of the reconstruction operations.

I-65 RECONSTRUCTION PROJECT

General Project Information and Scope

Interstate Highway 65 in Nashville, Tennessee is a six lane roadway (three in each direction) that is being widened to five lanes in each direction. The ADT in 2000 was 117,000 vehicles per day, almost twice the ADT in 1986. It is estimated that the ADT will continue to rise to 177,000 vehicles per day. The roadway also has a high percentage of truck traffic (Figure 21).

Fig. 21. High percentage of truck traffic through the workzone

The original lanes are being reconstructed simultaneously with the construction of the new lanes to keep the roadway on the same life cycle. In addition to the new lanes, 12-foot outside shoulders will be constructed. The majority of the project is located within the existing right-of-way (ROW). The project also includes the reconstruction of one interchange and one overpass as well as the installation of intelligent transportation systems (ITS) and sounds walls. A conservative pavement design is being used on this project that is expected to last approximately 50 years. In order to minimize the impact of the construction efforts, three lanes remained open to motorists during peak travel times. Because of the high volumes of concrete required for this project, an exclusive on-site batch plant was utilized for this project.

The reconstruction and expansion of I-65 was separated into three segments with a total project cost of $102.8 million. This budget only covers the construction of Sections 1 and 2. The construction of Section 3 will require additional funding. The information collected through this case study was on Section 2 that extends from Old Hickory Boulevard to Vietnam Veterans Boulevard.

Construction on the I-65 project began in April 2002 and was originally scheduled to be completed by October 2004. Due to numerous project delays, the project is expected to be completed some time in late 2005 or early 2006. The delays were the result of a combination of factors including weather, right-of-way acquisition, permitting, and contractor qualifications. Despite the numerous schedule delays, the project is currently only $1.5 million over budget. The primary source of the overruns is the barrier rails that are being used on the project.

The contract on this project included I/D. Because of the numerous delays, the contractor lost all opportunities to earn incentives. At the time of the site visit, the contractor was negotiating with the Tennessee Department of Transportation (TDOT) to determine the magnitude of the penalties that would be incurred by the contractor.

Case Study Methodology

The documentation of this project started with a meeting with the TDOT to gather information on the project's scope and to gather information on aspects of the project that pertain to this research project. A second site visit was made to conduct interviews with the contractor and with members of the project design consultant and project manager. During the site visit, the concrete paving operations were documented with still photographs and video footage. Also during the visit, member of the research team visited TDOT's traffic management center for the City of Nashville.

Documented Success Factors

Several success factors were documented through this case study. These factors are discussed below.

Construction Practices and Management

Because of the high paving volumes on the project, an exclusive, on-site batch plant was utilized (Figure 22). This batch plant was located by the site offices. The plant had a single mixing drum and provided adequate space for aggregate laydown. Locating the batch plant on-site minimized haul distances allowing dump trucks to be used.

Fig. 22. Exclusive on-site batch plant located near the contractor's office

The haul routes for the concrete trucks were designed to minimize the impact on traffic. On one portion of the project, the truck route was changed to ensure the trucks had adequate room to cross the three lanes of traffic and enter the construction site. This improved safety for the motorists.

Public Relations and Information

Because of the relatively low impact of the construction activities on the motorists, very little was needed in the area of public relations and information. Some information on the project was released by TDOT concerning major changes in the construction such as lane changes.

Traffic Management

Nashville has a city-wide ITS system that is channeled to a central traffic management center (Figure 23). Information from CCTVs was used to update an on-line traffic map for the city and to update messages on changeable message signs. The traffic management center has dispatchers that can contact the appropriate emergency response vehicles in the occurrence of an accident of stall. This system was used to monitor traffic through the I-85 workzone. The location of the different ITS devices in the City of Nashville can be seen in Figure 24.

Fig. 23. Traffic management center for the City of Nashville

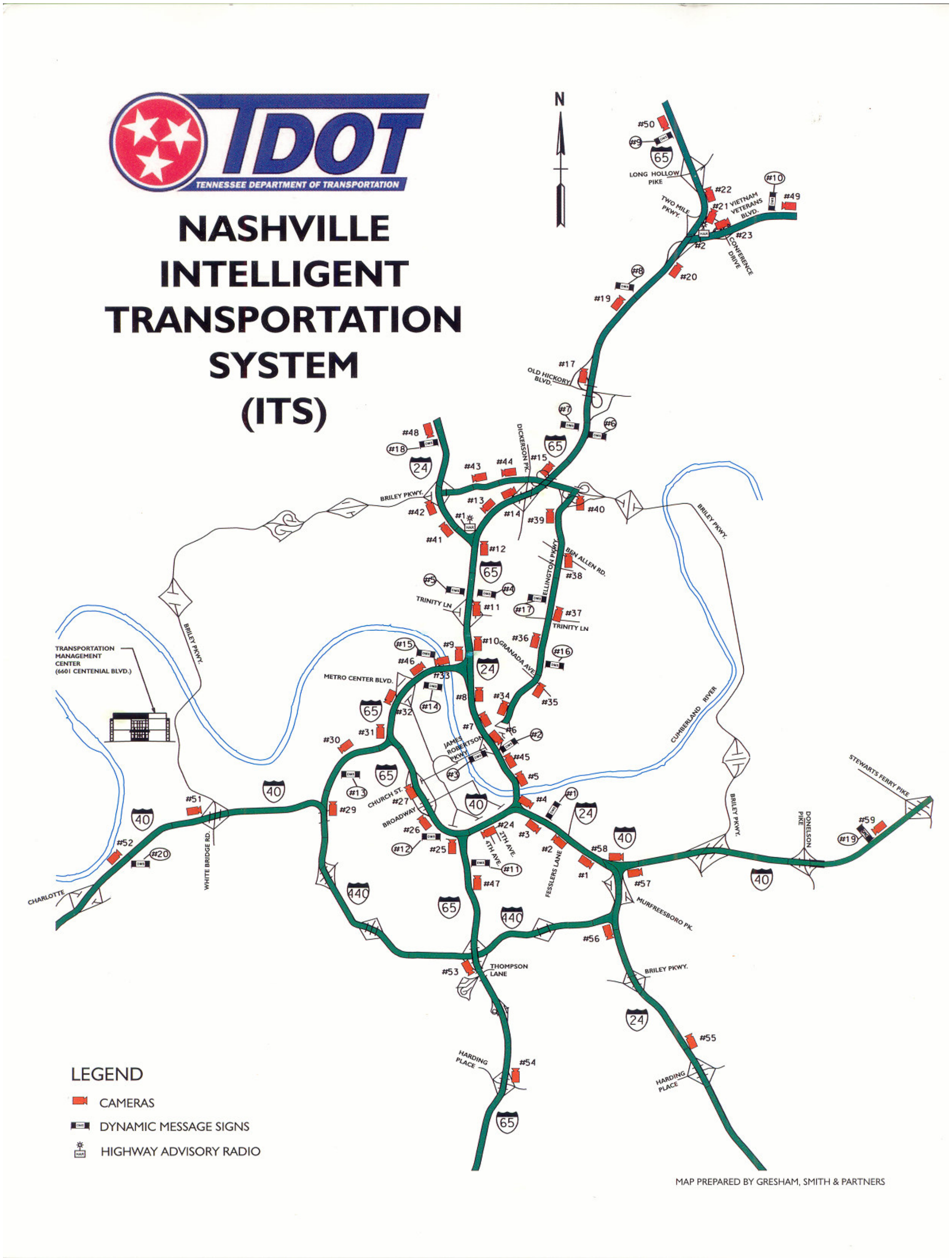


Fig. 24. ITS map for the City of Nashville

SUMMARY

Four case studies were conducted in support of this research. Each of the case studies was documented through interviews and site visits. Through the case studies numerous strategies were identified that can potentially impact the overall success of a project. The strategies identified through the case studies are discussed in relation to the finding of the literature review in the next section. Each strategy is discussed based on the motivations for its use as well as potential benefits and drawbacks of implementing each strategy. Each strategy is also discussed in the context of the number of data collection methods under the triangulation analysis that support that strategy.

CHAPTER V

DATA ANALYSIS

This section describes the information gathered through the analysis of the case studies and the literature review. For each identified perceived success factor or strategy, the motivating conditions for the implementation of that factor or strategy has been identified. This section also discusses the advantages and drawbacks to implementing different strategies as well as perceived relationships with other strategies. The strategies have been organized into the different major project areas identified through the literature review.

The different strategies are organized based on the data sources that identified the strategy. Under the triangulation approach used for this research, fully supported strategies are those that were identified through the case studies, the literature review, and expert opinion. Strategies that were only identified through one or two data collection methods are also included but more research is needed to confirm these strategies ability to influence project success.

FULLY SUPPORTED STRATEGIES

This section includes the strategies that are fully supported by the triangulation analysis. These strategies were documented in both the literature review and in the case studies and were then verified by expert opinion.

Contract Administration

Contractor Screening

Contractor screening was observed and attributed to the success of the Lamar Boulevard case study project. The City of Austin screened contractors based on there experience, staff and equipment, ability to meet the stringent schedule, backlog, and willingness to participate in the daily construction meetings. Contractor screening was implemented on this project because of the resource intensiveness of the project and the City of Austin’s desire to work with the contractor to minimize the impact of the construction on the local merchants.

Prequalification can also be evaluated on the basis of the quality and the past performance of the contractor as implemented by the Ontario Ministry of Transportation. This system assigns contractors a score based primarily on quality but also on safety, timeliness, and contract execution. The scores are used to determine the amount of work a contractor can be given.

The result of the contractor screening process on the Lamar Boulevard project was that the contractors that bid on the job had the resources and equipment to handle the complexity and accelerated schedule of this project. This helped reduce the chances of failing to meet the project objectives. The drawback to contractor screening is that less bids may be received possibly resulting in a higher overall contract price. On the Lamar Boulevard project, only two bids were received as a result of the rigorous screening process. Although this drawback was not recorded in regards to the screening process used by the Ontario Ministry of Transportation, a similar result could be expected.

Partnering

A formal partnering program was used on the I-496 case study conducted under the FHWA research project. Informal partnering was used on the I-15 Devore case study project and the Lamar Boulevard project. The use of partnering was also documented in several literature sources. Partnering is ideal on projects where alignment of the owner’s and contractor’s objectives is important. Partnering should also be used when cooperation between the owner and the contractor is important. This is supported by the I-15 and the Lamar Boulevard case studies. On the Lamar Boulevard project, the City of Austin informally partnered with the contractor to work towards minimizing the impact of the construction operations on the local merchants. On the I-15 project, Caltrans worked with the contractor to minimize the impacts of the construction operations on the motorists. On the I-496 project, a formal partnering program was created because of the need to have constant and efficient communication channels in order to maintain the accelerated schedule. This suggests that partnering may be appropriate on complex or resource intensive projects. Had partnering not been in place, the contractor may have been more concerned with their profit than the impact of the road users.

The success of the partnering program is largely dependant on the commitment of the different parties to the partnering process. It is beneficial in a partnering agreement for there to be clearly defined team objectives and roles. This literature also suggested that a partnering program may require the participants to go beyond the contract requirements. This was evident on the Lamar Boulevard project. The contractor worked to complete the project as quickly as possible even when no additional incentives could be earned.

Partnering is advantageous because it increases teamwork, communication, trust, and collaboration between the owner and the contractor. A partnering relationship has the potential to reduce claims and aid in dispute resolution. The partnering process can increase decision making efficiency that is beneficial on projects with accelerated schedules. Partnering can also help maintain repeat business between the contractor and the SHA.

Despite the numerous advantages to implementing a partnering program, there are also several drawbacks. Some believe that partnering can cause contract requirements to be relaxed to enhance the relationship between the partnering team. This can impact the overall quality of the completed project. Although mentioned in the literature review this drawback was not observed through the case studies. Many contractors do not believe the partnering with a SHA improves the relationships between suppliers and subcontractors. This was evident on the I-496 project in Michigan. There were numerous communication problems between the prime contractor and the subcontractors on the project despite the partnering between the prime contractor and the SHA. In the future, the prime contractor stated that they would consider including the subcontractors in the partnering process to avoid such problems (Anderson et al. 2003a). Partnering may not be cost effective if all the parties involved are not committed to the process (Grajek et al. 2000).

Incentives/Disincentives

The use on I/D as a contracting technique is heavily supported by both the case studies and the literature as a strategy that can be implemented to influence the overall perceived success of a project. Incentives and disincentives were included in the contracts of the Lamar Boulevard, I-15, and I-65 case study projects. I/D provision were included in the US 23 and I-496 case studies conducted under the FHWA research project "Traffic Management Studies for High Volume Roadway" (Anderson et al. 2003a, Anderson et al. 2003b). The incentives and disincentives for each of the projects were schedule based.

I/D contracting provisions are commonly used to motivate the contractor to meet certain schedule milestones. The incentive and disincentive structure on the Lamar, I-65, and I-15 projects involved incentives for completing the milestones ahead of schedule. On the I-15 project, the contractor was allowed 6 weeks to complete the reconstruction efforts. The contractor was offered an incentive of $300,000 for each week that the project was completed early. The contractor was able to complete the project in only 4 weeks and as a result earned the maximum possible incentives.

Disincentives on these projects are used to encourage timely completion of the overall project as well as to motivate the contractor to complete segments of the project on time so they could be reopened to the traveling public. On the I-85 project in Atlanta, disincentives were in place to motivate the contractor to have the roadway open to commuters by 5:00 am on Monday morning. Similar disincentives were used on the Lamar project on the weekend reconstruction of the intersection and on the I-15 project to ensure the roadway was open to traffic by Friday morning because of the heavy weekend traffic. The only case study project were disincentives were recorded was on the I-15 project due to opening the roadway a few hours late on Friday morning. These penalties were eventually dropped because of the numerous changes in the project schedule and because of the contractors work in minimizing the impact the construction had on traffic.

The literature suggests that the use of I/D can increase cooperation and alignment between the contractor and the SHA (Bower et al. 2002, Herbsman et al. 1995). This is supported by the finding of the Lamar and I-15 case studies. In both cases the contract included large incentives and disincentive to encourage timely project completion and to minimize the impact the construction efforts had on motorists. On both projects, the contractor worked with the SHA and was willing to accept changes in the project schedule. On the Lamar project, the City of Austin worked to reduce the impact of construction on local businesses. This was accomplished through a drastic reduction of the already accelerated schedule. Contractor decision making representatives attended daily construction meetings to discuss the constantly changing construction and traffic phasing on the project. Because of the alignment between the contractor and the City of Austin to minimize the impact of the construction on the local merchant, the overall project schedule was reduced from 16½ months to just over 6 months. Similar cooperation between the contractor and SHA can be seen on the I-15 project.

The use of I/D is advantageous on projects where the schedule is critical to the overall success of the project. Research has shown that a vast majority of project with incentives and disincentives included in the contract are completed on time or ahead of schedule (Arditi et al. 1998). Of the three case studies that were conducted on projects with I/D provisions, two of them were completed ahead of schedule. The I-65 project, which at the time when this thesis is being written, was still under construction and has encountered numerous delays. Negotiations are taking place concerning the amount of disincentive penalties the contractor would face. From the SHA’s perspective, the use of I/D can be advantageous because it transfers some of the risk associated with schedule overruns to the contractor in exchange for the chance to earn a bonus for early completion (Arditi et al. 1998).

One challenge associated with using I/D provisions that are tied to the project schedule is establishing reasonable benchmarks (Jaraiedi et al. 1995). If the schedule is estimated too conservatively, the contractor will not have to work any differently than normal to receive incentives (Herbsman et al. 1995). Other possible disadvantages of using I/D contracting is the possibility of the project costing more because of bonuses earned by the contract and the challenge of accurately gauging road user impact costs. Another challenge of using I/D encountered on the I-496 project is that the public or the media may focus on disincentives the contractor is required to pay instead of the overall success of the project (Anderson et al. 2003a).

Incentives and disincentives are often used in conjunction with cost (A) plus time (B) contracts (Herbsman et al. 1995). Incentives and disincentives are set based on the proposed schedule of the winning bid. Based on research, projects with A+B plus I/D contracts are usually completed ahead of schedule (Herbsman et al. 1995). Although not require, I/D is incorporated into most A+B contracts (Herbsman et al. 1995).

Incentives and disincentives can also be used on contracts lengths that are based on productivity rates. On the I-85 project in Atlanta, GDOT based the overall project duration on productivity levels for accelerated projects. To encourage the contractor to meet these productivity levels, disincentives were placed in the contract for needing more than the allowed time.

Planning and Scheduling

Accelerated Schedule

An accelerated project schedule was used on three of the case study projects conducted in support of this thesis as well as on projects documented through the literature review. The accelerated schedules were created in response to the large impact the construction was expected to have on motorists and local groups. On the I-65 case study project, the schedule was not accelerated because the original number of lanes were maintained throughout the duration of the project. This resulted in only small traffic impacts from construction operations.

There are several strategies identified by this study that can be implemented to compliment an accelerated schedule. Contracting strategies can be implemented to encourage the contractor to complete the project quickly such as lane rental, cost-plus-time, and incentives/disincentives. Partnering can be useful on projects with accelerated schedules to ensure that all the participating parties share schedule related objectives such as the unofficial partnering on the Lamar Boulevard project. Contractor screening can be used to ensure that bids are only received from qualified contractors that can meet the project's demands. Production rates from previous accelerated projects can be used help create the accelerated schedule such as on the I-85 case study project. These contracting methods were discussed in more detail earlier.

Planning and scheduling can also play an important role in successfully implementing an accelerated schedule. A contingency plan can be created to help protect again the risk of project delays and overruns. Contingency plans were part of the accelerated schedules on the I-15 Devore case study project and the US 23 project (Anderson et al. 2003b). Completing the utilities early on a project, especially when the utilities are expected to be a challenge, can help reduce delays caused by utility complications. This approach was successfully implemented on the Lamar Boulevard project. As a lesson learned on the I-496 project, the use of joint schedule review meetings has the potential to reduce the time it takes to create an accurate construction schedule. This practice would also allow issues related to the schedule to be openly discussed and resolved quickly (Anderson et al. 2003a).

An accelerated construction schedule is appropriate for a project where the construction effort will result in high user impacts. Accelerating the construction schedule can help reduce these impacts. The drawback of implementing an accelerated schedule is that this type of schedule is usually more resource intensive than a traditional construction schedule. More preparation may be needed in the contracting documents, especially if a non-traditional contracting strategy is being used. The contractor may be required to use more equipment and manpower as well as increased planning to complete the construction operations within the allotted time period. This can increase the overall cost of a project.

Detailed Hourly Schedule

The contractor on the I-85 project created a detailed hourly schedule for the weekend reconstruction efforts. This level of planning detail was important on this project because of the large disincentives that the contractor would incur if the roadway was not open by the specified time on Monday morning. For this project a bar chart schedule was created in Microsoft Excel. To create a detailed hourly schedule, the contractor must have detailed knowledge on production rates for different activities as well as information concerning equipment availability and crew sizes.

The use of a detailed hourly schedule is also appropriate for accelerated intersection construction. The FHWA report, “Accelerated Construction Method for Concrete Pavement at Intersections,” gives guidelines for the reconstruction of intersections in a 72 hour period (Secmen et al. 1996). A detailed hourly schedule was created for the Red Bluff intersection project documented in this report.

Weekend Construction

Weekend reconstruction efforts took place on the I-85 and Lamar Boulevard case studies. This approach was also documented as being used on the I-10 Pomona project in California (Lee et al. 2002). On all of the projects weekend construction was chosen because of the large traffic volumes on the weekdays. Performing major construction operations on the weekends can minimize the impact the construction operations have on the primary road users.

On the I-85 project, the primary user of the highway is weekday commuters. Although some construction efforts took place during the week, the majority of the reconstruction efforts took place on the weekend while traffic volumes are lower. On the Lamar Boulevard project, the major groups that were impacted by the construction operations were the local businesses, weekday commuters, and local residents. The reconstruction of the intersections took place on the weekends because of the lower traffic volumes on the roadway. Only a quarter of the intersection was reconstructed each weekend which allowed the intersection to remain functional.

On all of the projects the weekend reconstruction efforts were accompanied by disincentives on the opening time. This helped ensure the construction efforts did not continue into Monday morning and impact the weekday commuters.

Because of the short construction window that weekend work allows, operations often take place around the clock. The I-85 and the I-10 projects worked continuously to complete the required reconstruction length. On the Lamar Boulevard project, the concrete paving activities took place at night. This was primarily because it was easier for the concrete trucks to deliver the concrete at night while traffic volumes were lower.

Weekend construction can be used to quickly replace intersections in urban areas such as on the Lamar Boulevard project. This concept is discussed in the FHWA report "Accelerated Construction Methodology for Concrete Pavements at Urban Intersections" (Secmen et al. 1996). This report gives guidelines for reconstructing an intersection in 72 hours such as over an weekend. Weekend intersection reconstruction often leads to increases costs because of the use of weekend work, night work, and concrete admixtures (Secmen et al. 1996).

Weekend construction is advantageous on projects where traffic volumes are higher during the week than the weekend. Weekend construction can also allow for higher productivity than night construction because it allows the contractor to work for a longer period of time before having to demobilize.

One possible disadvantage of implementing weekend construction is that a continuous construction schedule can cause safety issues, especially when working at night. Weekend reconstruction also requires the contractor to mobilize and then demobilize each weekend. This may result in lower productivity than if the contractor was allowed to work continuously and not just on the weekends.

Night Construction

Night construction work was used on the I-15 Devore project and the I-85 project documented through the case studies. The use of night construction was also documented on the I-10 precast concrete paving panel demonstration project and the I-10 Pomona project, both conducted by Caltrans (Anderson et al. 2004a, Lee et al. 2002). Night construction was conducted because of the large volumes of daytime traffic on the roadway. Performing the construction operations at night reduced the impact of the activities on the road users.

Night construction is best suited to construction work that can be separated into short segments. On the I-10 Pomona project, night construction was used to replace selected pavement slabs. Fast setting concrete had to be used in order to ensure proper strength was gained by the time the roadway was reopened to traffic (Lee et al. 2002). On the I-10 precast concrete paving panel project, night construction was feasible because placed panels did not require curing before being opened traffic (Anderson et al. 2004a).

There are drawbacks to performing construction at night. A relatively large percentage of the nighttime construction schedule may be needed for mobilization and demobilization. This leaves less time to perform construction activities. There also may be reductions in quality from working at night.

Contingency Plan

Contingency plans can be created to help guard against schedule delays. Maintaining the project schedule is important on projects with high user impacts. Several different types of contingency plans were documented through the case studies and the literature review.

On the US 23 project, up to three contingency work plans were in place at any given time (Anderson et al. 2003b). These plans would be executed in the instance that the original schedule could not be carried out. The contingency plans were in place to ensure the construction work would be completed within the strict 45 days allocated for lane closures. On the I-15 Devore case study project, a contingency plan was created based on possible project risk scenarios. The plan addressed the specific actions that were to be taken if one of the scenarios occurred. The contingency plan included brush fires, inclement weather, accidents within the project boundaries, increased traffic congestion, a shut down of contractor operations, material shortages, and an accident on the major alternative route for the project. The plan discussed the risks associated with each scenario, the planned response actions, and who was responsible for each of the response actions.

Another type of contingency plan provided on some projects was the availability of backup equipment. On the I-65 project, the contractor had spare parts for all the major components of the paving machines. The schedule on the I-65 project was important in the sense that the project was already well past the original completion date. The contractor had lost all incentives and was working quickly to avoid incurring any disincentives.

Back-up equipment was used on the I-85 project. The contractor placed a batch plant on-site to provide concrete to the project. If the plant had to shut-down unexpectedly, the contract planned to utilize a batch plant located near the northern project boundary that was normally being used for another project. Back-up paving equipment was also available in the event that the primary equipment had mechanical problems. The back-up batch plants and equipment were provided on this project because of the extremely stringent weekend reconstruction schedule. The contractor had to ensure the roadway was open by the specified time on Monday morning to avoid incurring the large late opening penalties.

Back-up equipment was also used on the I-10 Pomona project documented through the literature review (Lee et al. 2002). In addition to the primary batch plant, a secondary batch plant was available. During the paving operations, the primary batch plant experienced a 4-hour electrical breakdown. The secondary batch plant was able to supply a limited amount of concrete until the primary batch plant was once again operational. Because of the back-up batch plant could only provide a limited amount of concrete, there were still project delays associated with the equipment breakdown.

The use of back-up equipment as part of a contingency plan is advantageous on projects with very strict schedules, especially when there are financial penalties if the work is not completed on time. The back-up equipment helps guard the contractor and the owner against the risk of the project overrunning the schedule. This can help prevent increased user impacts caused by schedule delays. This strategy does, however, tie up equipment that could be potentially used on another project. The equipment may end up being idle for most or all of the project duration.

Decision Making Strategies

Effective Contractor Communication

The importance of effective contractor communication was a lesson learned on the I-496 project (Anderson et al. 2003a). There were several communication issues that arose between the joint venture acting as the prime contractor and the paving contractor. The paving contractor encountered several problems over the course of the project which were not communicated to the joint venture. When bridgework problems arose, the joint venture did not relay the resulting changes in the construction sequence in a timely manner. As a result the paving contractor did not have time to accommodate for the changes. Because of the lack of communication between the different contractors, the paving operations started falling behind almost immediately. One way to increase communication between the different contractors is to include partnering on the project with all the contractors. Partnering was used on the I-496 project but it only included the SHA and the prime contractor (Anderson et al. 2003a).

Effective contractor communication is also very important on short construction segments with stringent schedules such as weekend work. The reconstruction of urban intersections over a weekend can require close interaction and effective communication with the contractor to ensure the design is successfully implemented (Secmen 1996).

Effective contractor communication is important on accelerated projects with stringent or complicated schedule such as on the I-496 project. Effective communication between the prime contractor and the subcontractors could have reduced the project delay by giving the subcontractors more time to react and plan for changes in the project's schedule. Effective communication may require a higher level of effort between contractors than what is considered normal.

On-site Agency Representative

One decision making strategy that can be implemented to speed up the decision making process on low impact decisions is having on-site agency representatives. On the US 23 case study, a Michigan Department of Transportation senior supervisor who had authority over most decisions was constantly on the site (Anderson et al. 2003b). Being able to make decisions on the job site was much quicker than requesting authorization from high-level project members.

On the I-40 bridge reconstruction project performed by the Oklahoma Department of Transportation (ODOT), completing construction as quickly as possible was a key project objective (Wimmer 2004). Because the speed of completion was so important on this project, a temporary office was set up near the job site that was staffed with 10 ODOT engineers and 3 retired ODOT employees that were working with consulting firms. A resident engineer was on the construction site 24 hours a day to make decisions and answer contractor questions.

On the Lamar Boulevard project, a City of Austin traffic control technician was always on the construction site. This representative has the authority to approve minor traffic control changes. Larger changes to the traffic control plan were made on a daily or weekly basis by the City of Austin's Department of Public Works.

Having a site located agency representative is appropriate for projects where the schedule is a primary objective. On-site representatives can typically make decisions much faster than if authorization for a change must be requested through SHA management. This can help prevent or reduce project delays associated with seeking approval for project changes.

The primary drawback to this strategy is the resource commitment to a single project. On projects where the schedule is not as important, having an on-site agency representative may not be cost effective.

Responsive Adverse Weather Plan

Weather conditions duration construction can pose potential risks in the timely completion of a project. Weather conditions played an important role on the I-15 and I-85 case study projects as well as the US 23 case study project (Anderson et al. 2003b). On the I-15 Devore project, one factor that influenced the project's start date was the more stable weather conditions during the month of October. The project did, however, receive unusually high rainfalls during construction. Caltrans and the contractor reacted to the weather by changing the construction schedule to allow the contractor to work over the weekend. The quick reaction to the adverse weather conditions prevented any major completion delays. On the I-85 project, the contractor was given a set number of weekends to work which was more than the number of weekends projected to complete the project. The contractor had to monitor and react quickly to the weekend weather projections when deciding to begin construction on one of the 0.5 mile weekend construction segments.

Because of the stringent project schedule on the US 23 project, adverse weather constituted a significant project risk. The contractor constantly monitored weather conditions via a dedicated computer. Information for local weather forecasts was used to plan construction activities for the following days. There were periods when the project received snow but the contractor had to work in these conditions to complete the project on time (Anderson et al. 2003). During these periods of adverse weather, the contractor worked on ramp paving instead on paving the main lanes. The contractor's attentiveness to the weather and their willingness to work in adverse weather conditions helped keep the project on schedule.

Weather can cause significant project delays. Creating a responsive adverse weather plan can help minimize weather related project impacts. This type of strategy requires the resources to constantly monitor the weather and react to adverse conditions.

Construction Practices

Concrete Mix Design

The use of different concrete mix designs can allow the roadway to be opened to traffic more quickly than traditional concrete. On the Lamar Boulevard project, each intersection quadrant was reconstructed over a weekend. The newly constructed pavement had to reach adequate strength by Monday morning when it was reopened to traffic. An anti-corrosion admixture was included in the mix design which acted as an accelerator. This approach was chosen because the admixture did not adversely impact the handlability of the concrete. The admixture was also less costly than the cost of a superplasticizer.

On the I-15 Devore project, the contractor used a 12 hour and a 24 hour mix design. The 12 hour mix design would be used on project segments that would be opened to traffic within a day. The 12 hour mix design used high early strength Type III Portlant Cement Concrete.

An accelerating admixture was used on some of the concrete placed on the I-85 case study project. The accelerator was used on the last third of concrete placed during a weekend to ensure the concrete reached the required strength before opening to traffic.

The use of an accelerated concrete mix design can help support an accelerated schedule. Accelerating admixtures are also appropriate on projects where the new concrete pavement must be opened to traffic quickly. One drawback to using accelerated concrete mix designs is that they often cost more than traditional concrete mixes. They may also require more planning to ensure the concrete can be placed before it starts to set.

Batch Plant

A construction related strategy that can be implemented to influence the overall success of a project is the use of an exclusive, on-site batch plant. An exclusive batch plant was provided by the contractor on the I-85 case study project, the I-65 case study project, the US 23 project, and the I-496 project. All these plants were provided because of the large amounts of concrete that needed to be prepared for the project. There was concern that local concrete providers would not be able to provide enough concrete. On the I-496 and the US 23 projects, the contractors provided a batch plant for the projects to have more control over the quality of the concrete (Anderson et al. 2003a, Anderson et al. 2003b).

Based on these projects, the use of an exclusive, on-site batch plant would be appropriate for projects with high paving volumes and/or projects where control over the concrete's quality is critical to the overall project objectives. In order to place a batch plant within the project limits, there must be adequate space for the equipment as well as room for aggregate laydown.

Placing the batch plant within the project limits can have several advantages. The haul times for the concrete trucks are reduced, which can increase productivity. Shorter haul times can be very beneficial on projects that are using fast setting concrete. On the I-10 Pomona project, a batch plant was provided near the construction to reduce the haul distance because fast setting hydraulic cement concrete was being used (Lee et al. 2002). Placing the batch plant within the project boundaries also helps keep the concrete trucks off other roadways. One drawback to using an exclusive on-site batch plant is that the equipment may not easily accessible for other projects.

Quickchange Movable Concrete Barrier

The use of a quickchange movable concrete barrier was studied in the Atlanta, I-85 case study and the I-15 case study. The use of a movable concrete barrier system was also used on Caltrans I-10 Pomona project, which was studied through the literature review (Anderson et al. 2004, Lee et al. 2002). The use of a movable concrete barrier system allows a construction zone to be quickly closed off and later reopened to traffic. The barrier provides safety to the construction workers. On the I-85 project, the barrier was struck by a large truck while construction was taking place. The barrier sustained damage but stayed in place. The use of a movable concrete barrier system is ideal for short construction segments that need to be quickly reopened to motorists such as the half mile weekend reconstruction segments on the I-85 and I-10 projects.

On the I-15 project near Devore, California, a movable concrete barrier system was used as a traffic control device to maximize the capacity of the roadway. The traffic on this roadway is highly direction based on the time of day and the day of the week. A movable concrete barrier was used to separate the northbound and southbound traffic. This allowed the contractor to change the number of lanes in the northbound and southbound quickly to respond to the changing traffic conditions. The movable barrier was also used to quickly change the lane configuration for a median crossover. This would not have been possible with traditional concrete barriers. The movable concrete barrier also provided additional safety through the workzone by separating northbound and southbound traffic.

The use of a movable concrete barrier system is advantageous on projects with short construction segments. The speed that the barrier can be deployed makes it ideal for nighttime or weekend reconstruction efforts. Another advantage of this system is that the equipment that moves the barrier only requires only one lane for the shifting process.

The major disadvantage of using this type of system is that currently there is only one vendor, Barrier System, Inc. A quickchange movable barrier system is also much more expensive than the traditional concrete barriers used for construction applications.

Noise Reduction Strategies

Noise reduction strategies were implemented on the Lamar Boulevard case study project and the I-496 project. On both of these projects, noise reduction strategies were put in place to minimize the impact of the construction operations on the local residents. On the Lamar Boulevard case study, some of the construction operations, such as placing the concrete, took place at night. In order to minimize the impact of the construction operations, trucks were routed through commercial areas which were typically closed at night. The contractor also positioned the concrete paving equipment near buildings to help baffle the noise.

On the I-496 project, noise restrictions between 9:00 pm and 6:00 am prevented construction during this time. The contractor could obtain permission to conduct minimal noise during these hours but were not given permission to work 24 hour per day because of the noise impacts (Anderson et al. 2003a).

Noise reduction strategies are ideal for projects located close to residential areas. This helps reduce the impact of the noise created by the construction efforts on this group. This approach can help increase public support of the project. A disadvantage of this approach is that the noise reduction strategies may prevent certain construction operations from taking place at night as on the I-496 project. This may have a negative impact on the overall duration of the project schedule.

Traffic Control and Management

Traffic Management Center

A project oriented traffic management center was created for the I-15 Devore project. The traffic management center was set up in a conference room in the Caltrans District 8 office. The traffic management center included life feeds from closed circuit television cameras (CCTV), several computers, and drawings of the project. Information collected in the traffic management center was used to provide updated information to changeable message signs as well as an on-line traffic map of the area.

On the I-65 project, the traffic management center for the City of Nashville was used to monitor traffic conditions within the project limits. The traffic management center included dispatchers that could contact the appropriate emergency response service in the instance of a traffic accident or a stalled vehicle.

A project oriented traffic management center was also used on the I-496 project (Anderson et al. 2003a). Temporary ITS was deployed to monitor real-time traffic conditions throughout the designated alternative routes. The system was comprised of CCTV cameras, microwave traffic counters, portable changeable message signs (PCMS), portable queue detectors, remote video monitoring stations, and a web server. The traffic management center allowed MDOT to monitor real-time traffic conditions throughout the designated alternate routes. Information on the traffic conditions on the alternate routes was then transmitted to the driving public through the PCMS and the project website so they could make informed decisions concerning what alternative route to take. The information relayed to motorists included closures, contractor activities that could cause delays, traffic backups, advice on alternate routes, and accidents or incidents on freeways or alternate routes. The website include real-time traffic footage from various locations around the construction site. The traffic management center provided MDOT with a tool that could be used to communicate to motorists.

A traffic management center is beneficial on projects where real-time traffic information is needed. This included projects with high traffic impacts through the construction zone or alternate routes. A traffic management center can be used to gather traffic information and adjust the messages being transmitted to the public. This allows motorists to make informed decisions based on up-to-date information. A traffic management center can also be used to help clear accidents quickly. In order for a traffic management center to be feasible, it must have access to real-time traffic information such as through the use of CCTV or queue detectors.

Traffic Pattern Analysis

Understanding the traffic patterns of road users is important when devising the project schedule, construction staging, and traffic management plan. On the US 23 project, the Michigan Department of Transportation (MDOT) spent considerable time and resources to better understand motorist traffic patterns on the roadway (Anderson et al. 2003b). This allowed MDOT to cater to the needs of the primary impacted group on this project, vacation travelers. The project was scheduled to be completed by Memorial Day so that US 23 would be available to vacation traffic. This analysis also identified issues concerning the reconstruction of a bridge that links a residential area to a school. In response MDOT rescheduled the bridge reconstruction until after the school year.

Understanding motorist traffic patterns also played an important role in the construction scheduling of the I-85 project. The primary user of this roadway is weekday commuters. To minimize the impact on the weekday commuters, the reconstruction activities were scheduled on the weekends with only minor construction work taking place during the week.

Traffic pattern analysis was important in the alternative route planning on the I-496 project. The proposed full closure scheme during the first project phase would displace a large volume of traffic. The SHA performed an assessment of the traffic conditions that would result from the full closure of the roadway. This analysis helped identify a number of roadways as alternate routes for the project.

Understanding motorist traffic patterns is important on roadway projects that are expected to have a large roadway user impact. Adjusting the construction and traffic management plans to accomidate the primary road users' needs can help mitigate the impacts of construction operations. The drawback of using this strategy is the time and resources that it takes to conduct the analysis of traffic conditions. This strategy is best implemented during the planning stages before the construction and traffic management plans have been decided on and when there is more flexibility in making changes to the project scope.

Alternative Route Planning and Information

Alternative route planning can be very important on projects that have significant impacts on motorists. On the I-496 project in downtown Lansing, Michigan, alternate route planning played a critical role in the success of the project because of the full closure scheme implemented during the first phase of the project (Anderson et al. 2003a). Traffic modeling software was used to determine the impacts the full closure would have on surrounding roadways. Money was allocated to upgrade the signals on several of the state trunk lines that were designated as alternate routes. Only state trunk lines were designated as alternate routes in an attempt to limit the amount of neighborhood cut-through traffic.

In order for alternate route planning to be successful, it is important the information concerning the alternate routes be conveyed to the public. On the I-496 project, the different alternate routes were widely publicized prior the closure of the roadway. Motorists started using the alternate routes up to a month in advance of the start of construction (Anderson et al. 2003a).

Alternate routes were also important on the I-15 Devore case study project. Several different alternate routes were identified and promoted to the public. Motorists were encouraged to use the alternate routes; especially during peak traffic periods. Information concerning the alternate routes was relayed to the public through changeable message signs. The changeable message signs were updated based on real-time traffic information. Motorists would be encouraged to use an alternate route if the travel time through the workzone was greater than a certain threshold value. This helped balance the traffic congestion through the workzone with the traffic congestion of the alternate routes.

The use of alternate routes is beneficial on projects where large volumes of traffic are impacted by the construction operations. Making the public aware of the alternate routes can help reduce traffic demand through the workzone. Implementing alternate routes may require significant resources to be successful. Traffic modeling may be warranted to determine traffic impacts on alternate routes. If the impact on the alternate routes is significant, improvements to the alternate routes may be required. The alternate routes may need to be supported by a traffic management center. Also, resources must be expended to inform the public of the alternate routes and to encourage their use.

Use of Local Police

To increase the motorist safety through the workzone, some SHAs utilize local law enforcement agencies. On the I-15 Devore case study project, local police were used to enforce the reduced speed limit through the workzone. Periods of heavy ticketing resulted early on in the project because of motorists' failure to obey the reduced speed limit. Police were also used on this project during lane closures and openings. During a lane switch police stopped traffic. Once the roadway was restriped, police then guided traffic through the newly configured workzone. Local police was also utilized on the I-95 Reconstruction project in Bridgeport, Connecticut, the I-15 reconstruction project in Salt Lake City, Utah, the I-710 Long Beach Freeway pavement rehabilitation project in Los Angeles, California, the I-95 Bridge Restoration Program project in Richmond, Virginia, and the Springfield Interchange Improvement Project in Springfield, Virginia (Anderson et al. 2004b). The primary disadvantage of utilizing local police is the cost of hiring them to patrol the project.

Incident Management Plan

Implementing an emergency response plan can increase motorist safety and traffic flow through the workzone in the event of a traffic accident. The specifics of the incident management program may vary from project to project. On the I-65 case study project in Nashville, Tennessee, the project is monitored from a city-wide traffic management center that is equipped with emergency response dispatchers. When an incident is observed, the appropriate emergency response agency would be dispatched to the site. On the I-15 Devore case study project, a fleet of Freeway Service Patrol tow operators were positioned in close proximity to workzone to respond quickly in the case of a stalled vehicle or traffic accident. On the Hillside bottleneck project in Chicago, Illinois incident management was provided by an emergency traffic patrol (Anderson et al. 2004b). On the I-95 Bridge Restoration Program project in Richmond, Virginia a contracted wrecker service was provided for incident management (Anderson et al. 2004). The incident management program on the Springfield Interchange project in

Springfield, Virginia included a state-of-the-art police mobile command vehicle located near the interchange that could coordinate communication and respond to major incidents. The incident management program on this project also included a fire foam truck to assist in hazardous material situations (Anderson et al. 2004). An incident management program is beneficial because it minimizes the impact of traffic accidents on the travel time through the workzone. The primary disadvantage to implementing an incident management program is the cost of maintaining patrol vehicles around the project.

Public Information

Public Relations Service Based on Project Conditions

This research observed the successful use of a contracted and in-house public relations service. On the I-496 project, MDOT hired a local public relations firm to help develop the communications program for this project. The public relations firm helped develop the extensive, multifaceted public relations campaign that was critical to the overall success of the project (Anderson et al. 2003a). The extensiveness of this public relations campaign encouraged MDOT to seek additional expertise in its planning and execution.

On the Lamar Boulevard project, initial thoughts of using an outside public relations firm were rejected because the City of Austin did not think an outside firm could adequately bridge the communication gap between engineering and construction personnel and the public. The City of Austin did not think a private public relations firm would be able to adequately communicate the advantages and disadvantages of different construction and traffic scenarios, and they would not be aware of the political implications of a public works project of this size. Conducting the public relations activities internally also proved to be more cost effective. This approach was able to increase the level of public relations services.

Although the public information services were important to the success of both of these projects, more research is needed to determine specific project characteristics or motivating conditions that warrant contracting a public relations firm or conducting these services in-house.

Slogans/Logo

Slogans and logos can be useful on projects involving a large public relations campaign. On the I-496 project, a project logo and slogan “Putting the Fix on 496” was created and used in conjunction with other public relation activities (Anderson et al. 2003a). A series of slogans were also created for the I-15 Devore project. These slogans encouraged motorists to sign up to receive fax updates on project conditions, check traffic conditions through the workzone via the project website, to use alternative routes, and consolidate the number of trips they need to take in and around the workzone. These slogans provided information in short, easy to remember phases.

Community/Public Meetings

Holding community and/or public meetings prior to and during construction is a common strategy implemented by SHAs to disseminate project information to groups impacted by the construction activities and solicit support for the project (Anderson et al. 2004b). The local merchants were the primary group impacted on the Lamar Boulevard project. To keep this group informed of potential impacts of construction activities, weekly meetings were held which were attended by all members of the project management team. The meetings also gave the merchants a chance to give feedback on the different traffic control decisions and allowed the management team to give the merchants options concerning traffic management. The original traffic management plan maintained a center turn lane to ease motorist access into the local businesses. As a result of the outreach to the local merchants, the merchants allowed for the removal of the turn lane in the original traffic control plan to further accelerate the project.

Public meetings can be used to reach the general public as on the I-15 project or a specific impacted group such as that on Lamar. If conducted during the early project phases, public concerns and needs can be considered in the development of the project.

Conducting public meetings requires time and resources. Representatives of the SHA need to have an understanding of the project and must be able to communicate project information to the public. On the I-496, a speakers bureau was created that was comprised of SHA employees who could present project information at the over 200 outreach meetings that were conducted in support of the project (Anderson et al. 2003a). Public meetings were also used on the I-70 reconstruction project in Ohio, the Hillside Bottleneck project in Illinois, I-465/70 Design-build project in Indiana, the I-710 Long Breach Freeway project in California, the I-10 Pomona Project in California, and the I-285 Reconstruction project in Georgia (Anderson et al. 2004b).

Electronic E-mail/Fax Database

An electronic e-mail or fax distribution system was created for the I-15 Devore and Lamar case study projects as well as the I-10 Pomona project documented through the literature review (Anderson et al. 2004b). Interested parties could subscribe to this distribution system to receive project updates. On the Lamar Boulevard project, the distribution list was comprised of all the merchants and business owners located on Lamar Boulevard in or around the construction area, 29 different neighborhood associations, and various individuals that signed up for the information. This distribution method was found to be useful because the businesses and neighborhood groups would forward the information to their customers or members. This approach allows large numbers of people to be reached with relatively little effort from the SHA. The SHA needs to be committed to producing regular updates for the distribution system for this to be successful.

Website

Many SHAs use a project oriented webpage to disseminate project related information to the general public. Several projects studied in the literature review had project webpages including the US 75/I-635 “High-Five” interchange project in Texas, the I-10 Pomona Project in California, the Springfield Interchange Improvement Project in

Virginia, the I-710 Long Beach Freeway Project in California, the I-465/70 Design-build Project in Indiana, the Hillside Bottleneck Project in Illinois, the I-70 Reconstruction Project in Ohio, and the I-95 Reconstruction Project in Connecticut (Anderson et al. 2004b). Project oriented websites or webpages were also created for all the case study projects. On the I-65 project, which had a relatively low impact on traffic, only general information of the project was provided on a webpage that was not updated as construction progressed. The webpage provided for the I-85 project includes general project information as well as updates on closures and construction operations. This project also had a relatively low impact on traffic because a majority of the construction efforts took place during non-peak traffic times. The Lamar Boulevard project website provided general project information, links to press and news releases regarding traffic impacts and lane closures, and responses to frequently ask questions. This project had a significant impact on the local businesses, weekday commuters, and local residents. The I-15 project had the most information rich website which provided real-time traffic information via CCTV and an updated traffic map. This site provided information concerning the project to the numerous weekday commuters, weekend travelers, and truck traffic impacted by the reconstruction efforts. These case studies suggest a general trend to provide more information through a website on projects with high impacts on local traffic.

The I-496 case study conducted under the FHWA research project also implemented a project oriented web site. This site included real-time traffic information of the different alternative routes through CCTV as well as other up-to-date project information. The website was part of a multifaceted outreach campaign created because of the high visibility of the project which run though the heart of downtown Lansing and the large impact the project had on motorists through the full closure of the roadway (Anderson et al. 2003a).

Providing a project oriented webpage can be beneficial on projects with a dynamic traffic control plan so that motorists can have a source of up-to-date information on road closures such as that used on the Lamar Boulevard project.

Media Advertising

Many SHAs utilize media such as television, radio, and newspaper to advertise the project and its impacts. On the I-496 case study, a fictional motorist named “Bob” was created for the media campaign (Anderson et al. 2003a). Television and radio advertisements were created that featured Bob being stuck in traffic because he did not plan his alternative routes. Media advertising was also utilized on the I-15 Reconstruction project in Salt Lake City Utah, the I-285 Reconstruction project in Georgia, and the Lamar Boulevard project in Austin, Texas (Anderson et al. 2004b).

Media advertising has the advantage of being able to provide project information to a large number of people. This can help make people aware of traffic impacts so they can make educated decisions concerning their traffic routes. The drawback of media advertising is the relatively high cost. As a result, this strategy may be appropriate for projects with very large traffic impacts such as the I-496 project or projects where the groups impacted are decentralized making other public outreach methods less feasible.

Telephone Hotline

A telephone hotline can be used to provide up to date information concerning road closures, impacts arising from construction operations, and traffic conditions. The use of a telephone hotline was implemented on the I-496 project, the I-15 Devore project, the Springfield Interchange Improvement Project, the I-15 Reconstruction project, the I-465/70 Design-build project, and the Hillside Bottleneck project (Anderson et al. 2003a, Anderson et al. 2004b). In order for a telephone hotline to be useful, the information must be kept up to date and the public must be made aware of the hotline. As a result, a telephone hotline can compliment other aspects of a public relations campaign such a printed material by providing the audience with a phone number they can call to receive more information on the project.

Ribbon Cutting Ceremony

A ribbon cutting ceremony was used on the Lamar Boulevard case study and the I-496 case study to allow motorists to walk the roadway prior to its opening (Anderson et al. 2003a). Both of these projects had a large impact on motorists, local residents, and local businesses. Both of these projects were also high visibility projects located near the downtown area. The ribbon cutting ceremony celebrated the quick completion of the projects and acted as a way to express thanks to impacted groups for there patience during the construction.

A ribbon cutting ceremony can act as a press event that can give the SHA and the contractor positive publicity for their efforts in minimizing the construction impacts on impacted groups. The possible drawbacks of a ribbon cutting ceremony are the time, money, and resources needed to plan the event and the possible delay in opening the roadway to motorists.

STRATEGIES SUPPORTED BY TWO DATA COLLECTION METHODS

This section includes strategies that were documented through either the literature review or through the case studies. These strategies were submitted to experts for verification because significant amounts of information were collected on the use of these strategies. Even though these strategies are supported by two data collection methods, more research is needed to fully understand the potential impact these strategies can have on a project's success.

Contract Administration

Multiparameter (A+B) Bidding

Cost plus time or A+B contracting was not documented in any of the case studies performed for this research, but it was used on the I-496 case study project conducted under the FHWA research plan (Anderson et al. 2003a). The use of A+B contracting is also well supported by the literature.

A+B contracting is appropriate on projects where accelerating the project schedule is important to minimize the impact of the construction operations on road users. On the I-496 project, the cost-plus-time approach was used because of the set construction window and the need to open the roadway to motorists as quickly as possible. Diverting traffic through a construction zone can cause safety risks to the motorists. A+B contracting can reduce these risks by shortening the overall duration of the schedule.

This contracting strategy is often used with incentives and disincentives. The disincentives are placed on the completion date set in the awarded contract. The contractor needs to be familiar with its production rates to produce an accurate time estimate. A review clause should be considered with the contract when using A+B to protect the owner against project overruns. This clause allows the owner to review estimates that are more than a certain percent from the engineering estimate (Herbsman 1995).

This contracting method is advantageous because it typically results in a shorter project duration which helps minimize the impact on motorists and local groups. This contracting method works well on rehabilitation projects where a quick turn around is required. The use of A+B is well tested on road rehabilitation projects and the potential benefits of this method are documented in several research studies (Anderson et al. 2000, Anderson et al. 2003a, Hancher 2000, Herbsman 1995, Herbsman et al. 1995, Shr 2004).

The use of this contracting method has the potential to cause a slight increase in the total project cost over traditional contracting methods. The actual time savings associated with using this contracting method tend to be higher when the contractor has experience using the method. Another challenge with implementing this contract type is that user impact costs can be hard to determine (Hancher 2000). It is suggested that when implementing this strategy the project be free of right-of-way problems and the utilities are already completed. Meetings these requirements can help prevent schedule-based claims against the SHA based on interference from these activities (Anderson et al. 2000).

Lane Rental

Based on NCHRP Synthesis 293, lane rental is rated by SHAs as having the largest potential to reduce and mitigate the impacts of lane occupancy during construction and maintenance (Anderson et al. 2000). This contracting method is appropriate for projects with high traffic volumes, projects where alternate routes are limited or unavailable, or projects where minimizing the overall construction duration is important.

The use of lane rental as a contracting method is not well documented through the case studies but is well supported through the literature. In order to successfully implement this contracting strategy, the rates for each of the lanes and the different time period must be established. It is important that all work is clearly defined and shown on plans before the project is bid (Anderson et al. 2000). The project specifications need to clearly state when the lane rental times begin and end. The SHA also needs to determine how weather impacts and delays will be considered.

Implementing a lane rental contracting strategy can be very resource intensive. Special care needs to be taken to consider the human aspects of the project (Herbsman et al. 1998). The lane rental charges can cause the contractor to place large amounts of workers and equipment in close proximity which can cause safety issues. The safety issues can be compounded when operations take place at night. As a result the SHA needs to determine when lane rental will be used.

This contracting method is advantageous because it reduces the time the contractor spends occupying lanes which reduces the impact the construction operations have on the road users. Because of the different rental charges, the contractor is encouraged to conduct construction operations during non-peak traffic periods. The lane rental charges may cause the contractor to be more organized and efficient in executing the construction plans in order to minimize the costs of occupying lanes. Also, research has shown the quality of the work on these projects is typically as good as that conducted under traditional contracting strategies (Herbsman et al. 1998).

Lane rental contracting methods can create challenges because of the pressure on the resources of all the parties involved (Herbsman et al. 1995). This pressure is a result of the increased resources needed to create and execute the contract. Allowing construction to take place at night can cause productivity and safety issues. Also, if the lane rental charge is too small, it will not influence the contractor's decisions concerning what lanes to close and when to close them.

Production Rate-based Contract Length

The engineer's schedule estimate for the I-85 project was based on historical production rates on accelerated projects with similar scope. This allowed the SHA to create a feasible project schedule for this accelerated project. In order to meet the stringent schedule, the contractor created a detailed hourly schedule for each of the construction segments. Backup equipment was available to ensure the schedule was met.

During the beginning weeks of the project, the contractor had a difficult time meeting the 0.5 mile reconstruction segment per weekend required by the SHA. Once the contractor gained experience with the construction methods, they were able to increase the production significantly beyond what the engineer's estimate required. As a result, it may be appropriate to consider the contractors' experience when evaluating the bids on a project with a production rate-based contract length.

For this type of contracting strategy to be successfully implemented, the SHA needs to have access to production rate information on similar projects and conditions. Using generic production rates or rates from projects that are not significantly similar can result in an inaccurate or unreasonable engineers estimate.

Planning and Scheduling

Joint Schedule Review Meetings

A lesson that was learned on the I-496 project involved the use of schedule review meetings. The construction schedule created by the joint venture for the project was submitted to the SHA for review and approval but at no time did the SHA meet with the joint venture to discuss the schedule. The SHA believed that a schedule review meeting would have beneficial because it would have provided an opportunity to discuss and resolve issues regarding the schedule to the satisfaction of all the involved parties. The SHA also believed this would have produced a comprehensive and accurate schedule in less time (Anderson et al. 2003a).

Dynamic Project Schedule

On the Lamar Boulevard and I-15 Devore case study project, the project schedule was changed to adapt to changing project conditions to maintain the accelerated schedule. On the Lamar Boulevard project, the original traffic control plan was abandoned to further reduce the already accelerated schedule in an effort to minimize the impact of the construction operations on the local merchants. The project schedule changed on a daily basis based on current progress. This type of construction schedule was made possible by the daily construction meetings that were attended by decision making representatives from all of the key project participants. This allowed decisions concerning changes in the project schedule to be made quickly and efficiently.

It was noted on the Lamar Boulevard project that implementing a dynamic project schedule requires a high level of familiarity with the construction corridor such as lane widths, the locations of curb cuts, and access requirements. This was provided by the City of Austin’s public works department.

The primary advantage of implementing a dynamic project schedule is the ability to maintain an accelerated construction schedule by reacting quickly to changes in project condition and progress. The use of this approach allowed the Lamar Boulevard project to be completed drastically ahead of schedule. The primary drawback to this approach is resource commitment required from the different project participants to make decisions quickly. Because the schedule was constantly changing, the contractor could not easily share resources between the Lamar Boulevard project and any other projects that might be ongoing. The daily construction meetings also required a large commitment of time and resources. The use of daily construction meetings is discussed in more detail in the section entitled “Decision Making Strategies.”

Early Utility Completion

The existing utilities on the Lamar Boulevard project were constructed in the 1930’s and their exact locations were unknown. In order to maintain the accelerated schedule, the utilities were completed early in the construction process. The locations of the old utilities and the newly replaced utilities were recorded during this process and could then be used in the planning of the construction activities. On accelerated projects where problems or challenges are expected with utility work, it may be beneficial to complete this work early in the project to ensure that it does not cause conflicts with other construction operations. Even though early utility completion was critical to the overall success of the Lamar Boulevard project, this strategy was not verified on another case study or through the literature.

Rest Days

On projects with stringent schedules, rest days may be beneficial in maintaining a safe working environment. On the US 23 project, the contractor expressed concern because of the lack of rest days included in the stringent schedule. Adding rest days may result in safer project condition but may increase the overall duration of the project (Anderson et al. 2003b).

Rest days were also used on the I-496 project (Anderson et al. 2003a). Several days were included in the contract where the contract was not allowed to work. These days had to be included in the contractors’ bids and these days could not be used to claim incentives. The use of rest days helped ensure the laborers were not overworked.

Decision Making Strategies

Daily Construction Meetings

Daily construction meetings were implemented on the Lamar Boulevard case study project. These meetings were attended by decision makers from key project areas including representatives from the City of Austin, the contractor, the design consultant, and utility companies.

The use of daily construction meetings made the drastically accelerated and dynamic project schedule possible. Because the meetings were attended by decision makers, changes in the project such as changes in the traffic control plan or construction schedule could usually be made within one to two days.

Daily construction meetings were also used at the beginning of the I-15 Devore project. The meetings helped promote a team environment between the contractor and the owner. The meetings also allowed project decisions to be made quickly. The meeting were less frequent as the project neared completion.

One of the challenges associated with this strategy is the large commitment of resources and time to attend the daily meetings. On the Lamar Boulevard project the meetings were held every day and participation was mandatory. To ensure the contractor would be willing to commit the resources to the meetings every day, the requirement to attend daily construction meetings was included in the contractor screening process.

Construction Practices

Two-lane Slip-form Paver

On projects where more that one lane of concrete is being placed, it may be beneficial to use a two-lane slip for paver. On the I-15 Devore project, the outside lane was replaced along with selected slabs from the adjacent inside lane. Even though only selected slabs were being replaced, the contractor used a two-lane slip-form paver that could pave both lanes at the same time. This increased productivity. A two-lane slip-form paver was also used on the I-85 project in Atlanta to repave the two outside lanes that were being reconstructed. The use of a two-lane slip-form paver can increase productivity but requires that the contractor own or have access to the equipment. Adequate space must also be available on the site for this piece of equipment.

Precast Concrete Paving

The use of precast concrete paving panels was documented on the I-10 case study (Anderson et al. 2004a). The concrete panels were used to reconstruct the outside two lanes and the shoulder of a short stretch of the roadway. Because of the high daytime traffic volumes, the construction efforts took place at night. Based on the findings of this project, the use of precast concrete paving panels is ideal for short construction segments that need to be quickly opened to motorists. This includes night construction similar to the I-10 project (Anderson et al. 2004a). Because the pavement panels are precast, all cure time is eliminated. Another potential advantage of using precast concrete paving panels is its improved quality since the panels are constructed in a controlled environment. The disadvantages of using precast concrete paving panels in the high initial cost and the delivery space needed to move the panels onto or near the work location. A large crane is required to move the precast slabs from the flatbed truck to their destination duration construction (Anderson et al. 2004a).

Dowel Bar Inserter Paver

A dowel bar inserter paver was documented on the US 23 case study as well as through the literature (Anderson et al. 2003b, Stewart 1992). This type of paver can increase productivity and reduce labor costs by eliminating the need to place dowel baskets. Traditional paving equipment can dislodge or move the dowel baskets as the equipment passes over them. The DBI paver can eliminate this problem. This makes the DBI ideal on projects where the concrete quality is critical to the overall success of the project. It is also appropriate on projects with large paving quantities such as the US 23 project which involved 4 lanes of paving for 5 miles.

The primary drawback to using this type of equipment is that many SHAs have to change their specifications to allow this piece of equipment to be used. Another potential drawback to this piece of the equipment is that it is very expensive to purchase. Paving equipment has a relatively long life and contractors may be weary to invest in such an expensive piece of equipment if there current piece of equipment still has several years of life left. A final possible disadvantage of this type of equipment is that the dowel placement operation can have a negative impact on the smoothness of the finished roadway (Anderson et al. 2003b).

Traffic Control and Management

Dynamic Traffic Control Plan

On the Lamar Boulevard case study project, the original traffic control plan was abandoned to accelerate the project as much as possible. The traffic control plan changed constantly to accommodate project conditions and progress. This approach allowed the construction schedule to be further accelerated in an effort to minimize the construction impacts on the local merchants and motorists.

The dynamic traffic control plan was made possible by the decision making strategies implemented on this project. The daily construction meetings allowed decisions and changes to be made quickly and challenges or problems could be addressed and solved in an effort to maintain the accelerated schedule. As a result, changes to the traffic control plan were made on a daily basis as needed. A traffic control technician was located on the job site at all times who had decision making authority over small changes in the traffic control plan. This allowed low impact decisions to be made within a matter of minutes instead of a day or even days.

The use of a dynamic traffic control plan should be considered on projects where completing the construction as quickly as possible is very important to the overall success of the project. Implementing a dynamic traffic control plan is much more resource intensive than a static plan. Mechanisms must be in place to be able to respond to changing project conditions and make decisions quickly. A dynamic traffic control plan requires a high level of familiarity with the roadway corridor. Having knowledge of curb cuts, access requirement, and lane widths allowed reliable decisions to be made based on the actually project conditions. This knowledge was provided on the Lamar Boulevard project by the City of Austin's Department of Public Works. This strategy may also cause additional traffic weaving through the workzone which is generally considered to negatively impact workzone safety. On the Lamar Boulevard project, despite the additional traffic weaving and dynamic nature of the traffic control plan, not a single vehicular, pedestrian, or on-the-job accident occurred as a result of the construction operations.

Full Roadway Closure

The I-496 project located in downtown Lansing, Michigan implemented a full roadway closure during the first phase of construction. This approach was chosen because of the high traffic volumes, the two bridges located within the construction segment, and the desire to complete the project within a single construction season (Anderson et al. 2003a).

In order for the full closure to be successful, alternate route planning and information was imperative. Motorists were informed well in advance of the closure of what alternative routes should be used. Improvements were also made on the alternate routes to accommodate the increased traffic volumes.

Public relations efforts are also very important because of the large impact the closure would have on motorists. MDOT conducted an extensive public relations campaign that commenced well in advance of the start of the project. This campaign included billboards, a project logo, mass media advertising campaign, printed promotional material, a project website, a speakers bureau to conduct outreach meetings, neighborhood oriented outreach, a telephone hotline, and a ribbon cutting ceremony once the project was completed. This campaign informed motorists of the imminent traffic impacts and helped them prepare accordingly. Despite the large impact of the full closure scheme, the project was considered a success by MDOT as well as a vast majority of the motorists polled in a post-project survey.

A full closure scheme is advantageous because it allows construction operations to take place without being hindered by onsite traffic (FHWA 2003). This can increase productivity and allow the project to be completed in a shorted amount of time (FHWA 2003). This may be beneficial because motorists tend to prefer a higher level of traffic disruption for a shorter period of time as long as they are adequately warned of the impending construction impacts (Anderson et al. 2004b). Using a full closure strategy may also result in cost savings, a safer working environment, a better quality final product, and increased flexibility in project staging (FHWA 2003). In order for this strategy to be successful, significant resources must be dedicated to alternate route planning and public relations (FHWA 2003). Construction operations may take place around the clock to complete the construction as quickly as possible. The noise impacts from nighttime construction on local residents need to be considered (FHWA 2003). It is also important the project meet the completion deadline as full closure projects are often highly publicized (FHWA 2003)

Permanent Lane Closures

On the Lamar Boulevard project the City of Austin required the contractor to use permanent lane closures. Normally the contractor would not be allowed to start working until 9:00 am and would be required to return the street to drivable condition by 4:00 pm. Removing this restriction allowed the contractor to work for longer periods of time each day. It was estimated by the City of Austin that implementing this strategy reduced the project duration by several months. This strategy increased the disruption to the weekday commuters but decreased the overall duration of this disruption.

Business Access

For the Lamar Boulevard project, minimizing the impact from construction operations on the local merchants was a key objective for the City of Austin and the contractor. One way this was accomplished was by maintaining access to the local businesses throughout the construction zone. The entrances to the businesses were clearly marked with signs provided by the City of Austin. Access to local businesses was also enhanced by the use of flaggers in certain areas of the project to direct traffic.

The use of business access signs and flaggers was important on this project because of the lack of a turn lane throughout the project limits. The original construction phasing had provisions for a turn lane but local merchants allowed the City of Austin to remove the turn lane in favor of a more accelerated schedule and a shorter period of disruption. The business access signs and the flaggers were used to reduce the impact of removing the turn lane.

Working with the local businesses to maintain access helped maintain merchant buy-in of the construction activities and helped minimize the impact of the construction activities on the local merchants. This approach does require the additional funds for the creation of the signs as well manpower in the way of the flaggers.

Public Information

Elected Official/Community Leader Buy-in

Elected official or community leader buy-in was an influencing factor on the Lamar Boulevard project and the I-15 Devore project. On the Lamar Boulevard project, the City of Austin targeted neighborhood association representatives as part of the public relations campaign. The neighborhood associations acted as channels passing information from the City of Austin to local residents. Delegating the responsibility of keeping residents informed to the neighborhood associations reduced the SHA resources that were needed for this task.

The impact of not seeking community leader buy-in was documented on the I-15 Devore project. That lack of project support resulted in Caltrans having to slow the project schedule to gain public buy-in before proceeding. This may have been avoided had meetings with local communities been held in advance. The primary drawback of this strategy is the time and resources needed to hold the meetings with the various impacted groups.

Billboards

Billboards were used on the I-496 case study as part of the public information efforts (Anderson et al. 2003a). The billboards were used to encourage drivers to use alternate routes by showing the potential negative results of failing to do so. The billboards were also used once the roadway was reopened to thank motorists for there patience during the construction. The billboards were used to target general motorists and had the potential to impact a large number of motorists because of the visibility of the signs. The use of billboards was only documented on this one project. More research is needed to determine the specific advantages and disadvantages of using this public relations technique.

Informational Brochures/Flyers

Printer brochures and flyers were created as part of the public relations campaign for the I-496 project, the I-95 Reconstruction Program, and the Hillside Bottleneck project (Anderson et al. 2003a, Anderson et al. 2004b). The flyers can be intended for the general public or for a specific targeted group such as local municipalities or businesses.

STRATEGIES SUPPORTED BY ONE DATA COLLECTION METHOD

There were several strategies identified through the literature that lacked detailed information such as advantages and drawbacks for using the strategy or interdependencies with other strategies. Because these strategies were only documented in the literature review and only included limited information, they were not submitted to experts for verification. These strategies are:

- Electron bidding
- Design-build
- Transfer of quality control
- Warranties
- Flexible notice to proceed
- Life cycle cost analysis
- Preconstruction surveys
- Direct mailing
- Discouraging cut-through traffic.
- Constructability reviews
- Construction analysis program

These strategies are discussed in the chapter entitled "Literature Review". More research is needed to determine the impact these strategies can have on roadway projects with high traffic volumes.

SUMMARY

Specific strategies were identified in each of the different project areas. The results of this data analysis were used to create a series of matrices that summarize the findings of the data analysis. The next section introduces the matrices, describes how they were made, and discusses some observations and conclusions based on the interpretation of the information contained in the matrices.

CHAPTER VI

MATRIX DEVELOPMENT

MATRICES METHODOLGY

A series of matrices were created to summarize the research findings in concise format that could be utilized by SHAs. This section describes the methodology used to create each of the different matrices. The information contained in the matrices is from the case studies and literature.

The information presented in the matrices represents the findings of this research effort but are not to be considered a complete comprehensive list of strategies that can influence project success. The matrices provide a framework that can guide and provide a foundation for future research.

General Matrix Methodology

A general matrix was created based on the individual strategies observed in each of the case studies or documented through the literature and the project characteristics that warranted the use of that specific strategy. The first step used to organize the strategies documented in each of the case studies and from the literature review was to organize them into different categories. The categories used for this matrix are:

- Contract Administration
- Planning and Scheduling
- Decision Making Strategies
- Constructability
- Construction Practices and Management
- Traffic Control and Management
- Public Information.

Based primarily on the literature review, these are major project areas that can influence the overall success of a project. Once each of the strategies was sorted into the correct category, the project conditions that facilitated the use of the strategy were identified. Many of these project conditions were identified through the interviews conducted in conjunction with the case studies. For strategies where a related project condition was not identified, the motivating project condition was identified through a synthesis of the information collected during the case study and from expert opinion.

Once the project conditions for each of the success factors were identified, it was observed that these characteristics fall into two primary categories: traffic related motivating conditions and construction related motivating conditions. The motivating conditions shown in the matrix reflect this observation.

Symbols were used to denote the number of data collection methods under the triangulation analysis that supported each of the identified strategies. Fully supported strategies are identified with a dark circle. Strategies supported by two out of the three data collection methods are identified by a half circle. Strategies that were only identified through the literature review are identified with a hollow circle.

Public Relation Matrix Methodology

The public relations matrix summarizes the information captured relating to public relations and information strategies. After analyzing the information gathered through the case studies and literature review on public relations and information strategies, it was observed that the type of strategies implemented are related to the user groups that are impacted by construction. The user groups identified in the research are:

- General traffic
- Weekday commuters
- Weekend traffic
- Truck traffic
- Special event traffic

- Local residents
- Local businesses.

The general traffic category is used to capture the numerous public relations and information strategies that are implemented regardless of the specific group impacted. These types of activities include a project website, brochures, and media advertising. The weekday commuter group is made up of people that are traveling to and from work. Traffic volumes from weekday commuters are typically highest during morning and evening rush hours. Weekday commuters made up a large portion of the traffic on the I-85 project and the Lamar Boulevard project. Weekend traffic may consist of tourist traffic such on the I-15 Devore project. The high traffic volumes were a result of motorists traveling to and from the Las Vegas area on the weekends. The highway system is heavily utilized by the trucking industry in many areas. Each of the documented public relation success factors was categorized based on the local group that facilitated the need to implement each strategy. The I-85 and I-15 case study projects both recognized the trucking community as an import group that was impacted by the construction operations. The trucking community was also important on the I-95 bridge restoration project and the I-710 project in California (Anderson et al. 2004b). Special event traffic was a concern on the I-15 Devore case study project. The nation's largest amphitheater is located near the project. Caltrans coordinated its construction schedule with this venue to minimize the impact on special event traffic. On the Lamar Boulevard project and the I-496 project, the impact of the construction efforts of the local residents was a concern (Anderson et al. 2003a). Special efforts were made to target this group and keep them informed. The execution of the Lamar Boulevard project was driven by a large presence of local merchants. Numerous activities targeted this specific group.

It was also observed that public relation and information activities are related the level of impact the strategies can potentially have on each specific group. Three levels of perceived impact were used in the creation of this matrix: high impact, medium impact, and low impact. Only three categories were used because of the limited number of projects from which information could be extracted.

Strategies with low impact are those in which implementing the public relations strategy will have a minimal impact on the user group. These types of strategies typically provide general project information and may require the motorist to seek the information out. They are also typically the least costly types of strategies. An example of this type of strategy is a project oriented web page that provides general project information to users.

High impact strategies are those that have the greatest potential in disseminating project information to road users. These types of strategies often require real-time traffic information and as a result are more labor intensive and more costly.

In support of the different public relation strategies project examples have been given. The project example column states either the case study or the project from the literature that implemented the different success factors.

Traffic Management Matrix Methodology

The traffic management matrix is similar to the public relations matrix. This matrix summarizes the different traffic control and management strategies documented through the research efforts. The traffic control and management strategies were first divided into the following categories:

- General traffic management
- Improving traffic through the workzone
- Demand reduction
- Workzone safety.

The general traffic management category captures strategies that when implemented can influence the strategies in other categories. An example is the implementation of a pre-construction traffic analysis. This type of analysis can be used to design the construction and traffic phasing in a way so as to minimize the impact on the primary road users.

Conducting a traffic analysis can impact strategies such as the planning of alternate routes. Some strategies were implemented to improve traffic flow through the workzone. An example of this is the use of the movable concrete barrier on the I-15 Devore project. The barrier was used to change the number of lanes to increase the capacity of the roadway. Demand reduction strategies are strategies that reduce the traffic volumes in and around the workzone. A common example of a demand reduction strategy is the use of alternate routes. Alternate routes divert some or all of the traffic away from the workzone to another roadway. Several traffic management strategies were implemented to increase the safety of the workzone. An example of this type of strategy is to have an incident management program that quickly responds to traffic accidents or automobile breakdowns.

The different strategies were categorized based on the level the impact strategies could potentially have on improving traffic flow through the workzone, decreasing demand, or improving safety. Because of the limited number of projects, three categories were used to classify the level of perceived impact: high impact, medium impact, and low impact.

This matrix does not give guidance on lane closure strategies. It assumes that a lane closure strategy is already in place and the use of different strategies is based on the impact the lane closure strategy is expected to create. The University of California at Berkeley developed a program called CA4PRS that can be used to help determine the ideal lane closure strategy for a specific project. This software takes into account scheduling constraints, rehabilitation strategy, pavement design, lane closure tactics, and contractor logistics to determine optimized distances and durations of highway rehabilitation projects. This software can be used with traffic modeling software to determine the user costs associated with each lane closure strategy. CA4PRS has been used on several different Catrans projects with overall positive results.

Interdependency Matrix Methodology

It was observed that there were numerous interdependencies that exist between the different strategies. There are groups of strategies that create synergistic benefits when used together. In order to display these apparent relationships, an interdependency matrix was created that shows relationships between each strategy in the General Matrix.

The groups of success factors implemented on each project were analyzed to determine the relationships between different strategies. This can be illustrated with the I-496 project. The full closure scheme led to the success of the project because it minimized the duration of the construction impact on the motorists. This factor, however, would not have been as successful if used alone. Extensive alternate route planning and improvements were implemented to handle the traffic displaced from the closed highway. The public relations efforts provided information on the closure and alternate routes that motorists should use. The combination of these different factors used together increased the overall success of the project.

The matrix also considered the relative linkage between the different success factors. These are represented by a dark circle for a high relationship level, a half circle for a medium relationship level, and a hollow circle for a low relationship level. These relative linkages represent how important it is that the strategies be used together in order to influence the overall success of the project. On projects where implementing strategies together might be helpful a low level was assigned. When factors must be used together to be successful, a high level was assigned.

MATRICES DISCUSSION

This section presents the different matrices created to summarize the results of the research in support of this thesis. Four different matrices were created: a general summary matrix, a traffic management matrix, a public relations matrix, and an interdependency matrix. These matrices are discussed in more detail in the sections below.

These matrices are based on the information collected through the case studies and the literature review. Linkages or relationships may exist that are not represented on the matrices simply because these were not observed through the research.

Summary Matrix

The general summary matrix displays identified strategies for concrete paving under high traffic volumes and the motivating conditions behind those factors. For ease of viewing this matrix has been split into two smaller matrices as seen in Figure 24 and Figure 25. The undivided matrix can be seen in Appendix D. The general project areas of construction management and practices, traffic management, and public relations were further organized into the seven project areas identified through the literature review and the case studies. The motivating conditions identified for each of the success factors are organized into two categories: 1) traffic related and 2) construction related.

This matrix shows that traffic related motivating conditions have the greatest influence on traffic control and public relation strategies. Traffic related factors include the traffic volumes on the roadway and the type of road users, the visibility of the project, nearby areas influenced by the construction, traffic safety, alternate route availability, and emergency service provisions. This observation lead to the creation of the public relations matrix based on impacted groups and to the creation of the traffic control matrix showing different project areas that fall under traffic management.

This matrix also shows that construction related strategies and decision making strategies are generally related to construction related motivating conditions. These conditions include the working relationship between the different project participants, minimizing the impact of construction on local traffic, schedule related issues such as a set construction window or early completion, the size of the construction segments, the complexity of the project, and issues related to concrete paving productivity and quality.

Planning and Scheduling and Contract Administration are influenced by both construction- and traffic-related motivating conditions. Contract Administration is influenced by both categories because contracts can be used to influence a project in many ways including establishing an accelerated schedule, minimizing the impact on road users, and influencing the working relationship between project participants. Although planning and scheduling is influenced by both construction and traffic related conditions, the primary construction related condition is minimizing the impact the construction operations have on local traffic. Because of this, planning and scheduling is more heavily influenced by traffic related issues.

The information collected on the implementation of constructability strategies was limited. Constructability needs to be implemented during the planning phases of a project to have the greatest benefit. This research focused on strategies that are implemented during the construction process. More research needs to be accomplished to identify project factors that relate to constructability issues.

CONSTRUCTION STRATEGIES		MOTIVATING CONDITIONS FOR STRATEGY SELECTION																									
		TRAFFIC												CONSTRUCTION													
		High Visibility Project	High Traffic Volumes	Weekday Commuters	Weekend Traffic	Directional Traffic	Local Residents	Local Businesses	Adequate Alternate Routes	Safety of Diverted Traffic	Provision of Emergency Services	Collect Real Time Traffic Information	Minimized Traffic Impacts	Enhanced Owner/Contractor Cooperation	Common Owner/Contractor Objectives	Safety of Workers	Early Project Completion	Set Construction Window	Short Construction Segments	Resource-intensive, Complex Project	High Concrete Production Rates	High Concrete Quality	Eliminate Risky Contractors from Bid Process	Reduce Project Costs	Comparison of Alternatives with Different Expected Live	Minimized Concrete Haul Times	Increase Number of Project Bids
CONTRACT ADMINISTRATION																											
CA1	Contractor Screening																			◑			●				
CA2	Partnering													●	●					●							
CA3	Incentives/Disincentives	●		●	●			●		●	●						●	●									
CA4	A+B Contracting			◑				◑		◑								●									
CA5	Lane Rental		◑	◑	◑			◑																			
CA6	Production Rate-based Contract Length												◑														
CA7	Elctronic Bidding																										○
CA8	Design-Build																			○							
CA9	Transfer of Quality Control																							○			
CA10	Warrenties																					○					
CA11	Flexable Notice to Proceed												○														
PLANNING AND SCHEDULING																											
PS1	Joint Schedule Review Meetings												◑														
PS2	Accelerated Schedule			●	●		●	●					●														
PS3	Detailed Hourly Schedule																	●									
PS4	Dynamic Project Schedule												◑														
PS5	Weekend Construction			●																							
PS6	Night Construction			●																							
PS7	Early Utilities Completion																◑										
PS8	Contingency Plan												●														
PS9	Anticipating Weather Window												●														
PS10	Rest Days															◑											
PS11	Life Cycle Cost Analysis																								○		
DECISION MAKING STRATEGIES																											
DM1	Daily Construction Meetings													◑	◑												
DM2	Effective Contractor Comminication																			●							
DM3	On-site Agency Representatives												●				●										
DM4	Responsive Adverse Weather Plan																	●									
CONSTRUCTABILITY																											
CA1	Lane Closure Program (UC Berkley)		○										○					○		○							
CA2	Formal Constructability Review		○										○					○		○							

LEGEND

○	Fully supported strategy
◑	Strategy supported by two data collection methods
●	Strategy supported by one data collection method

Fig. 25. General matrix of contract administration, planning and scheduling, decision making, and constructability strategies and motivating conditions

CONSTRUCTION STRATEGIES		MOTIVATING CONDITIONS FOR STRATEGY SELECTION																									
		TRAFFIC												CONSTRUCTION													
		High Visibility Project	High Traffic Volumes	Weekday Commuters	Weekend Traffic	Directional Traffic	Local Residents	Local Businesses	Adequate Alternate Routes	Safety of Diverted Traffic	Provision of Emergency Services	Collect Real Time Traffic Information	Minimized Traffic Impacts	Enhanced Owner/Contractor Cooperation	Common Owner/Contractor Objectives	Safety of Workers	Early Project Completion	Set Construction Window	Short Construction Segments	Resource-intensive, Complex Project	High Concrete Production Rates	High Concrete Quality	Eliminate Risky Contractors from Bid Process	Reduce Project Costs	Comparison of Alternatives with Different Expected Live	Minimized Concrete Haul Times	Increase Number of Project Bids
CONSTRUCTION PRACTICES																											
CP1	Concrete Accelerator Admixture												●														
CP2	On-site Batch Plant																									●	
CP3	Exclusive Batch Plant																				●	●					
CP4	Two-lane Slip Form Paver												◑														
CP5	Precast Concrete Paving																		◑								
CP6	Dowel Bar Inserter Paver												◑								◑						
CP7	Backup Equipment												◑														
CP8	Movable Concrete Barrier															●			●								
CP9	Noise Reduction Strategies						●																				
TRAFFIC CONTROL AND MANAGEMENT																											
TC1	Dynamic Traffic Control Plan												◑														
TC2	Traffic Management Center	●		●				●		●																	
TC3	Traffic Pattern Analysis			●	●																						
TC4	Alternate Route Planning & Information		●																								
TC5	Full Roadway Closures		◑																								
TC6	Permenant Lane Closures								◑																		
TC7	Movable Concrete Barrier					◑				◑																	
TC8	Business Access							◑																			
TC9	Business Signs and Flaggers							◑								◑											
TC10	Use of Local Police									●																	
TC11	Incident Management Program									●																	
TC12	Ramp Closures									○																	
TC13	Construction Barriers									●						●											
TC14	Highway Advisory Radio		●																								
TC15	Closured Circuit Telivision Monitoring		●									●															
PUBLIC INFORMATION																											
PI1	Public Relations Service based on Project Conditions																										
PI2	Slogans/Logo	●																									
PI3	Elected Official/Community Leader Buy-in	◑																									
PI4	Community/Public Meetings						●																				
PI5	Electronic Email/Fax Database			●			●	●																			
PI6	Website	●	●	●	●		●	●																			
PI7	Billboards			◑	◑																						
PI8	Informational Brochures/Flyers/Videos						◑	◑																			
PI9	Media Advertising	●	●	●	●																						
PI10	Telephone Hotline		●	●																							
PI11	Press Release / News Release	●	●																								
PI12	Preconstruction Surveys	○	○																								
PI13	Information Partnership						●	●																			
PI14	Direct Mailing						○	○																			
PI15	Discouraging Cut-Through Traffic						○																				
PI13	Ribbon-cutting Ceremony						●	●																			

LEGEND

○ Fully supported strategy
◑ Strategy supported by two data collection methods
● Strategy supported by one data collection method

Fig. 26. General matrix of construction practices, traffic control and management, and public information strategies and motivating conditions

Public Relation Matrix

The public relation matrix created displays the observed or anticipated public information impact (high, medium, or low) to the various strategies discovered through this research. For easier viewing this matrix is presented in two parts as seen in Figures 26 and 27. Based on the research, public information strategies are influenced by the unique road users that are impacted by the project.

High impact strategies often involve the use of technology to provide real-time information to road users. An example of this is the use of CCTV to provide real-time traffic information to changeable message signs or a project oriented webpage. The strategies listed in this category have the greatest potential to influence the success of the public relations campaign but are often labor and/or technology intensive making them more expensive than lower level strategies.

Low impact level strategies typically involve providing general information to roadway users and may require the motorist to actively seek out the information. Examples of strategies in this category include static and changeable message signs, project webpage, and printed materials such as brochures.

More research is needed to determine the strategies used to target specific groups such as truck traffic, special event traffic, and weekend traffic when the level of impact is high. Several strategies have been identified for local residents and businesses with high level of impact through the Lamar Boulevard and I-496 case studies.

	IMPACTED GROUP					
	General Traffic		Weekday Commuters		Weekend Traffic	
	Strategy	Project Examples	Strategy	Project Examples	Strategy	Project Examples
Low Impact	Project Webpage	US 75/I-635	Changeable Message Signs	I-85	Changeable Message Signs	I-85
	Press Releases	I-95, I-70				
Medium Impact	Slogan	I-15	Radio Advertising	I-15	Scheduled Media Announcements	I-85
	Press Conference	I-15, Springfield, I-15 SLC	Public Meetings	I-15	Radio Advertising	I-15
	Radio Advertising	I-15, I-496, Hillside, I-95 Bridge, Springfield, I-15 SLC	Real-Time Changeable Message Signs	I-15	Real-time Changeable Message Signs	I-15
	Newspaper Advertising	I-15, I-95, Hillside, I-95 Bridge, Springfield, I-15 SLC				
	Announcements at City Council Meetings	I-15				
	Information via Fax	I-15, I-10 Pomona				
	Newsletters	I-95, I-710, Springfield, I-15 SLC				
	Information distribution at nearby centers (e.g. malls, libraries, etc)	Springfield, I-15 SLC, I-70, I-95 Bridge				
	Highway Advisory Radio (HAR)	I-15 SLC				
	Detour Maps	I-70, I-10 Pomona				
	Informational Brochures	1-95, Hillside				
	Informational Meetings or Seminars	I-10 Pomona, I-15 SLC, I-710				
	Informing Traffic Reporters	I-10 Pomona				
	Informational Videos	I-95, I-15 SLC				
	Information via Email	I-70, Lamar				
	Website with Real-time Traffic Information & Traffic Updates	I-15, I-70, Hillside, Springfield, I-15 SLC, I-10 Pomona				
High Impact	Pre-construction (up to one year) Campaign	I-496, Lamar, I-95, I-10 Pomona	Pre-construction Motorist Surveys	I-496, 1-15 SLC	Pre-construction Motorist Surveys	I-496
	Speaker's bureau, oral presentations	1-15 SLC, I-10 Pomona	Ribbon-cutting Ceremony, Public Walk-through	I-496, Lamar		
	Logo	I-496	Partner with mass transit, ridesharing, vanpooling	Springfield		
	TV Advertising	I-496, Hillside, I-95 Bridge, Springfield, I-15				
	Telephone Hotline	I-496, Hillside, I-465/70, Springfield, I-15 SLC				
	Billboards	I-496, Hillside, I-496/70,Springfield, I-15 SLC				
	Special feature articles for newspaper	I-10 Pomona				
	Contact nearby SHAs, MPOs, police, emergenies services	I-10 Pomona				

Fig. 27. Public information matrix based on user group impacted (general traffic, weekday commuters, and weekend traffic) and the level of impact

	IMPACTED GROUP							
	TruckTraffic		Special Event Traffic		Local Residents		Local Businesses	
	Strategy	Project Examples	Strategy	Project Examples	Strategy	Project Examples	Strategy	Project Examples
Low Impact	Brochures/Flyers at Rest Stops	I-85					Brochures/Flyers	I-496
Medium Impact	Information to Local Trucking Groups	I-85	Information to Significant Local Venues	I-15	Public Meetings	I-15, I-496	Public Meetings	I-15
	Meetings with trucking groups	I-95 Bridge	Meetings with tourism groups	I-95 Bridge	Additional Speed Limit Compliance Signing	Lamar	Information via Email	Lamar
			Meetings with visitor bureaus	I-10 Pomona	Announcements to Discourage Cut-through Traffic	I-496	Targeted Outreach Meetings	I-496
					Information partnership	I-70	Information Partnership	I-70
					Information via flyers	Hillside, I-710		
High Impact	Encourage Off-peak Travel for Trucks	I-15			Targeted Outreach Meetings	I-496	Information via Hand-delivery	Lamar
	Real-time Changeable Message Signs	I-15			Ribbon-cutting Ceremony, Public Walk-through	Lamar	Merchant Buy-in on Closure Schemes	Lamar
	Partnership with trucking associations	I-710			Information via "Doorhangers"	I-496	Business Access Signs	Lamar
					Limited Noise Impact from Night Construction	I-496, Lamar	Signs to Encourage Business Patronage	Lamar
					Direct Mailing to affected areas	I-95, I-10 Pomona	Pre-construction (up to one year) Campaign	Lamar
					Pre-construction (up to one year) Campaign	I-70, Hillside	Ribbon-cutting Ceremony, Public Walk-through	I-496, Lamar

Fig. 28. Public information matrix based on user group impacted (truck traffic, special event traffic, local residents, and local businesses) and the level of impact

Traffic Management Matrix

The traffic management matrix relates different identified traffic management strategies to the anticipated or observed impact they have on the success of the overall traffic management plan of project. For ease of viewing this matrix is displayed as two matrices as seen in Figure 28 and Figure 29. The undivided matrix can be seen in Appendix D. The matrix has been further organized by the type of traffic management strategy.

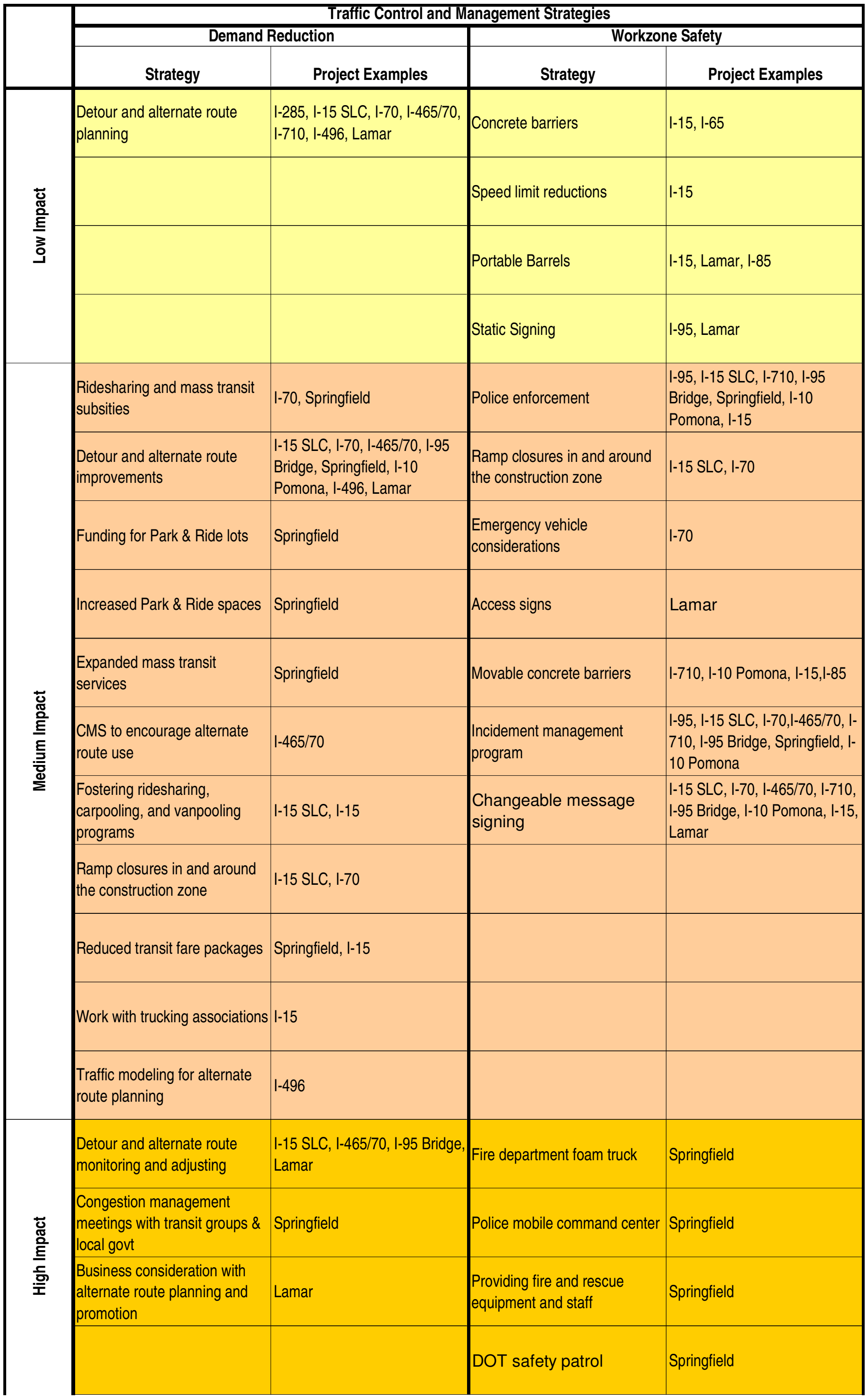
Several strategies have been identified for each of the categories with the exception of the "General Traffic Management" category. This category contains traffic management strategies that could influence the focus or selection of other strategies. For example, conducting a pre-construction traffic analysis will help determine the primary groups being impacted by the construction operations. It can also help determine if alternative routes are needed and available. The results of this analysis can be used to guide the decisions concerning the selection of other traffic management strategies.

High impact strategies have the greatest potential to reducing and improving traffic flow through the workzone and improving motorist safety. These strategies often involve the use of real-time traffic information. High impact strategies also are typically the more resource intensive than medium or low impact strategies. Low impact strategies are typically passive in nature and have only a small impact. These strategies are also often less resource intensive and typically cost less than high impact strategies. Examples of strategies in this category include static signing and speed limit reductions through the workzone.

This matrix does not provide guidance on lane closure strategies. The University of California at Berkley has created a program called CA4PRS (Construction Analysis for Pavement Rehabilitation Strategies) that can be used to help determine an ideal lane closure strategy for a specific project. This software takes into account scheduling constraints, rehabilitation strategy, pavement design, lane closure tactics, and contractor logistics to determine optimized distances and durations of highway rehabilitation projects. This software can be used with traffic modeling software to determine the user costs associated with each lane closure strategy. This software has been used on several different Caltrans projects with generally positive results.

	Traffic Control and Management Strategies			
	General Traffic Management		Improving Traffic Through Workzone	
	Strategy	Project Examples	Strategy	Project Examples
Low Impact			Static signing, Lamar	I-95, I-15 SLC, I-95 Bridge
Medium Impact	Pre-construction traffic analysis	I-95, I-496	Changeable message signing	I-15 SLC, I-70, I-465/70, I-10 Pomona, I-15, Lamar
	Coordination with other roadway projects in impacted area	Lamar, I-496	Closing nearby ramps	I-15 SLC, I-70
	Signing in nearby neighborhoods	Lamar	Project Hotline	I-15
	Traffic calming techniques around residential areas	I-496	Consider local venues in traffic and construction staging	I-15
			Access signs for local businesses	Lamar
			Flaggers to help motorists identify and use business access points	Lamar
			Highway Advisory Radio (HAR)	I-10 Pomona
High Impact			CCTVs to supply real time traffic information	I-95, I-15 SLC, I-95 Bridge, I-15, Lamar
			Project specific traffic management center	I-15
			CMS updated with real-time traffic information	I-10 Pomona, I-15
			On-site traffic engineer to make traffic related decisions	Lamar
			Movable barrier for dirrectional traffic	I-15

Fig. 29. Traffic management matrix based on type of traffic control strategy (general traffic management and improving traffic through the workzone) and the level of user impact caused by traffic control plan or lane closure scheme



	Traffic Control and Management Strategies			
	Demand Reduction		Workzone Safety	
	Strategy	Project Examples	Strategy	Project Examples
Low Impact	Detour and alternate route planning	I-285, I-15 SLC, I-70, I-465/70, I-710, I-496, Lamar	Concrete barriers	I-15, I-65
			Speed limit reductions	I-15
			Portable Barrels	I-15, Lamar, I-85
			Static Signing	I-95, Lamar
Medium Impact	Ridesharing and mass transit subsities	I-70, Springfield	Police enforcement	I-95, I-15 SLC, I-710, I-95 Bridge, Springfield, I-10 Pomona, I-15
	Detour and alternate route improvements	I-15 SLC, I-70, I-465/70, I-95 Bridge, Springfield, I-10 Pomona, I-496, Lamar	Ramp closures in and around the construction zone	I-15 SLC, I-70
	Funding for Park & Ride lots	Springfield	Emergency vehicle considerations	I-70
	Increased Park & Ride spaces	Springfield	Access signs	Lamar
	Expanded mass transit services	Springfield	Movable concrete barriers	I-710, I-10 Pomona, I-15,I-85
	CMS to encourage alternate route use	I-465/70	Incidement management program	I-95, I-15 SLC, I-70,I-465/70, I-710, I-95 Bridge, Springfield, I-10 Pomona
	Fostering ridesharing, carpooling, and vanpooling programs	I-15 SLC, I-15	Changeable message signing	I-15 SLC, I-70, I-465/70, I-710, I-95 Bridge, I-10 Pomona, I-15, Lamar
	Ramp closures in and around the construction zone	I-15 SLC, I-70		
	Reduced transit fare packages	Springfield, I-15		
	Work with trucking associations	I-15		
	Traffic modeling for alternate route planning	I-496		
High Impact	Detour and alternate route monitoring and adjusting	I-15 SLC, I-465/70, I-95 Bridge, Lamar	Fire department foam truck	Springfield
	Congestion management meetings with transit groups & local govt	Springfield	Police mobile command center	Springfield
	Business consideration with alternate route planning and promotion	Lamar	Providing fire and rescue equipment and staff	Springfield
			DOT safety patrol	Springfield

Fig. 30. Traffic management matrix based on type of traffic control strategy (demand reduction and workzone safety) and the level of user impact caused by traffic control plan or lane closure scheme

Interdependency Matrix

The interdependency matrix (Appendix D) identifies groups of strategies that demonstrate synergistic benefits when used together instead of alone. The perceived linkage between the strategies has been represented by a darkened circle for a high or significant perceived relationship, a half-filled circle for medium or moderate perceived relationship, and a hollow circle for low perceived relationship.

There are several relationships between Contract Administration and Planning and Scheduling. This is logical since the type of contract used on a project can be used to influence the overall schedule and completion date. This is especially true on accelerated projects. Likewise on projects specifying I/D, lane rental, or cost (A) plus time (B) contracting, planning and scheduling plays a key role in influencing project success. Planning and scheduling is important with contracts with I/D to ensure project milestones are met and liquidated damages are avoided. Planning any scheduling is also important on I/D contracts to analyze the possibility of early completion to earn incentives. On contracts specifying A+B or lane rental planning and scheduling is important in order to create a project bid that is the optimum combination of project costs and user impact costs.

There are several relationships between Planning and Scheduling and Construction related strategies. There are several schedule types that require the use of certain construction practices to be successful. For example, weekend or night construction will often require the use of special concrete admixtures to ensure the lanes can be open to motorists immediately after the construction window. Short construction windows require more detail in the planning and scheduling such as the use of a detailed hourly schedule to ensure the construction operations can be completed within the allocated time. A contingency plan and having backup equipment may also be helpful in order to maintain the project schedule in the event of an equipment breakdown or other problem. When conducting night construction in the vicinity of residential areas, noise mitigation strategies may be appropriate to minimize the impact of the construction activities.

There are also relationships between traffic control and public relation activities. The traffic control strategies and lane closure plan will influence the level of impact the construction has on the road users and surrounding areas. As seen in the public relations matrix, this level of impact will influence the types of public relation and information strategies that should be considered on project.

MATRIX CONFIRMATION

The results of this research were sent to experts for review. The experts specialized in the areas of concrete materials, roadway construction, traffic management, and public relations. The comments and expert opinions provided ensure that the results of this research do not contradict the current body of knowledge concerning concrete paving. The agreement between the literature review, the information gathered through the case studies, and expert opinions completes the triangulation between different data collection methods.

The results were further confirmed as reasonable through the use of multiple data sources for each of the different data collection methods. Four new case studies were conducted in support of this research. Literature from several different sources was considered including the previous work completed under the FHWA research project. Opinions from several different experts were also gathered. The use multiple data collection sources and multiple data sources confirmed that the findings of this research were reasonable.

SUMMARY

The information from the data analysis was used to create four matrices. These matrices summarize the finding of the research. From the matrices, several conclusions were drawn regarding the conditions that trigger the use of different strategies. The independency matrix was created to show groups of strategies that can or should be used together to potentially increase the overall success of the project. The information presented in the matrices was verified by the use of different data sources and collection methods.

CHAPTER VII

CONCLUSIONS

The primary goal of this research was to identify strategies that contribute to the perceived success of concrete roadway rehabilitation projects with high traffic volume conditions. In support of this objective the motivating conditions that triggered the use of each success factor were documented. The research also identified groups of success factors that can create additional benefits to the project when used together rather than alone. Based on an evaluation of the work completed for this research project, the research tasks have been achieved.

1. Specific factors that contribute to project success were also identified.
2. Four case studies were conducted on roadway projects with high traffic volume conditions. Three of these projects involved the partial or complete reconstruction of a highway. The other project involved the reconstruction of a downtown city street that had a large impact on local businesses. A series of factors were produced from the case studies.
3. The individual factors documented in the case studies or collected through the literature review were organized into the different project areas and the motivating conditions for using each factor were identified. The factors were analyzed to reveal groups of factors that were used together because of the greater benefits of doing so. The possible advantages and drawbacks of different factors and strategies were also documented.

The following general conclusions can be drawn from the information analyzed from the four case studies and the literature review:

1. The implementation of different strategies should be based on the specific conditions of the project. Each construction project is unique and a blanket application of the identified strategies will not guarantee the overall success of the project. During the planning phases the project objectives should be

evaluated and compared to the characteristics and conditions of the project to determine which strategies or groups of strategies should be used to increase the overall success of the project.

2. Public relations and traffic management activities are largely driven by the specific groups impacted by the project. While in the planning phases SHAs should make sure they have information on the different groups that will be impacted by the impending construction. This will allow them to tailor the specifics of the traffic management and public relations campaign to the specific needs of the impacted groups.
3. Non-traditional contracting strategies should be considered on projects where schedule considerations are critical to the overall success of the project. These contracting strategies can help motivate the contractor to complete the work in a minimal time period, help reduce lane occupancy of construction activities, and encourage cooperation and alignment of project objectives between the different parties involved.
4. Contract administration strategies are often linked to planning and scheduling strategies. There are several linkages between strategies in these two projects areas. Using contract administration strategies in conjunction with planning and scheduling strategies can increase the overall project benefits versus using these strategies individually.
5. Drastically accelerated projects may require the use of a combination of strategies from all of the different identified project areas. Accelerated projects can reduce the impact of the construction activities but are more resource intensive for both the SHA and the contractor.

LIMITATIONS

There are several limitations to the conclusions drawn from this study. These limitations are:

1. This research was limited to only four case study projects. Each construction project is unique and it would therefore be beneficial to document more projects. This would aid in identifying more strategies and conditions and would validate the strategies identified through this research.
2. The projects documented in the case studies were primarily reconstruction projects. Case studies were not conducted on projects that were driven by restoration or resurfacing of the roadway. The strategies that influence the success of these types of projects may be slightly different than those appropriate for reconstruction projects.
3. This research did not consider success from the point of view of the impacted road user groups or the general public. Because the objectives and needs of the SHA and the contractor are different from the general public, perceived success may also be different.
4. The research conducted in support of this thesis is qualitative and as a result is subjective by nature. The information collected was influenced by the different points of view of those interviewed. To help minimize this bias, representatives from SHA, contractor, and when possible the project consultant were interviewed to gather different perspectives on projects. A triangulation approach was used to confirm that the findings of the research were reasonable by supporting the different strategies through different data collection methods or sources.
5. The results and conclusions drawn from this thesis were influenced by the researcher’s personal interpretation of the data. The researcher’s interpretations were needed in the analysis of the different strategies and in the creation of the different matrices. To minimize bias in the research findings, input was regularly

obtained from members of the FHWA research project team. This helped minimize bias and helped verify that the research findings were reasonable.

6. This study only considered the impact of the different success factors over the duration of the construction activities. The research does not consider the impact of the different activities on the long term quality of the completed project. To do this the completed projects would need to be revisited in the future to determine if quality issues arose and what strategies were linked to the quality issues. Unfortunately the time frame of this study does not permit such an analysis.
7. The matrices created to summarize the findings of this research consider only the information documented in the study. This means that there may be motivating conditions or linkages between factors that are not shown on the matrices. More research would be needed to make the matrices more comprehensive and more applicable to any high traffic volume concrete rehabilitation project.

FUTURE RESEARCH

Future research should be conducted to compliment and enhance the findings of this research effort. It would be beneficial to document more case studies of concrete rehabilitation projects under high traffic volume conditions. Projects with similar conditions could be used to confirm the strategies identified in this research. This would provide the more in-depth validation required to develop a tool usable by SHAs from the matrices. Projects with different or unique project conditions could be used to identify more success factors or general project areas that influence the overall project success. Also, this research could be expanded on by seeking a broader range of expert opinion using survey research and/or the salphic technique.

This research did not identify the project characteristics or motivating condition that trigger the use of constructability activities such as a formal constructability review or a program that helps optimize lane closures. Further research is needed to determine when these activities should be used and if they are related to the implementation of other factors.

It would also be beneficial for the results of this research to be tested on projects that are currently in the planning phases. Different strategies or groups of strategies could be chosen based on the project conditions or objectives. During construction, the impact of the different strategies could be documented.

REFERENCES

American Concrete Pavement Association (ACPA). (1990a). "Guidelines for Bonded Concrete Overlays." *TB-007P*, American Concrete Pavement Association, Skokie, Illinois.

American Concrete Pavement Association (ACPA). (1990b). "Guidelines for Unbonded Overlays." *TB-005P*, American Concrete Pavement Association, Skokie, Illinois.

American Concrete Pavement Association (ACPA). (1993a). "Pavement Rehabilitation Strategy Selection." *TB-015.P*, American Concrete Pavement Association, Skokie, Illinois.

American Concrete Pavement Association (ACPA). (1993b). "Reconstruction Optimization Through Concrete Inlays." *TB-013.0*, American Concrete Pavement Association, Skokie, Illinois.

American Concrete Pavement Association (ACPA). (1994a). "Fast-Track Concrete Pavements." *TB004.02P*, American Concrete Pavement Association, Skokie, Illinois

American Concrete Pavement Association (ACPA). (1994b). "Slab Stabilization Guidelines for Concrete Pavements." *TB018P*, American Concrete Pavement Association, Skokie, Illinois.

American Concrete Pavement Association (ACPA). (1995). "Joint and Crack Sealing and Repair for Concrete Pavements." *TB012P*, American Concrete Pavement Association, Skokie, Illinois.

American Concrete Pavement Association (ACPA). (1997). "Concrete Pavement Rehabilitation: Guide for Load Transfer Restoration." *FHWA No. FHWA-SA-97-103*, and *JP001P*, American Concrete Pavement Association, Washington, D.C.

American Concrete Pavement Association (ACPA). (1998a). "Guidelines for Partial-Depth Spall Repair." *TB0003.02P*, American Concrete Pavement Association, Skokie, Illinois.

American Concrete Pavement Association (ACPA). (1998b). "The Concrete Pavement Restoration Guide." *TB020.02P*, American Concrete Pavement Association, Skokie, Illinois.

American Concrete Pavement Association (ACPA). (1998c). "Whiteopping – State of the Practice." *EB210.02P*, American Concrete Pavement Association, Skokie, Illinois.

American Concrete Pavement Association (ACPA). (2000). "Traffic Management – Handbook for Concrete Pavement Reconstruction and Rehabilitation." *EB213P*, American Concrete Pavement Association, Skokie, Illinois.

American Concrete Pavement Association (ACPA). (2002a). "Diamond Grinding and Concrete Pavement Restoration." *TB008.01P*, American Concrete Pavement Association, Skokie, Illinois.

American Concrete Pavement Association (ACPA). (2002b). "Life Cycle Cost Analysis: A Guide for Comparing Alterative Pavement Designs." *EB220P*,American Concrete Pavement Association, Skokie, Illinois.

Anderson, Lee L., Brookshire, James K., and Gudelski, Paul J. (2004). "A Partnering Success Story At the Woodrow Wilson Bridge." *Leadership and Management in* Engineering, 4(1), American Society of Civil Engineers, 38-45.

Anderson, Stuart, de las Casas, Rodrigo, and Daniels, Ginger. (2003a). "Michigan Department of Transportation I-496 Concrete Reconstruction Project." US Department of Transportation Federal Highway Administration (FHWA) Cooperative Agreement No. DTFH61-03-H-00101.

Anderson, Stuart D., Chabannes, Clayton, and Mehta, Mihir. (2004a). "Caltran's I-10 Concrete Paving Panel Demonstration Project," US Department of Transportation Federal Highway Administration (FHWA) Cooperative Agreement No. DTFH61-03-H-00101.

Anderson, Stuart D., de las Casas, Rodrigo, and Daniels, Ginger. (2003b). "Michigan Department of Transportation US 23 Unbonded Overlay Project." US Department of Transportation Federal Highway Administration (FHWA) Cooperative Agreement No. DTFH61-03-H-00101.

Anderson, Stuart D., Fisher, Deborah J., and Rahman, Suhel P. (1999). "Constructability Issues for Highway Projects." *Journal of Management in Engineering*, 15(3), American Society of Civil Engineers, 60-68.

Anderson, Stuart D. and Ullman, Gerald L. (2000). "NCHRP Synthesis 293 – Reducing and Mitigating the Impacts of Lane Occupancy During Construction and Maintenance." Transportation Research Board, National Research Council, Washington, D.C.

Anderson, Stuart D., Ullman, Gerald L., and Blaschke, Byron C. (2002). "NCHRP 10-50A – A Process for Selecting Strategies for Rehabilitation of Rigid Pavements." Transportation Research Board, National Research Council, Washington, D.C.

Anderson, Stuart D., Ullman, Gerald, and Goodin, Ginger. (2004b). “Summery Report for Study Task 1.01: Identify Motorist and Resident Perceptions.” US Department of Transportation Federal Highway Administration (FHWA) Cooperative Agreement No. DTFH61-03-H-00101.

Arditi, David, and Yasamis, Firuzan. (1998). “Incentive/Disincentive Contracts: Perceptions of Owners and Contractors.” *Journal of Construction Engineering and Management*, 124(5), American Society of Civil Engineers, 361-373.

Bower, D., G. Ashby, K. Gerald, and Smyk, W. (2002). “Incentive Mechanisms for Project Success.” *Journal of Management in Engineering*, 18(1), American Society of Civil Engineers, 37-43.

Crabtree, Benjamin F., and Miller, William L. (1992). *Doing Qualitative Research*, Sage Publications, Newberry Park, California.

Darter, Michael I. (1991). “Portland Cement Concrete Pavement: Rehabilitation Challenges and Recommendataions.” *Public Roads*, <www.highbeams.com> (accessed January 2005).

Federal Highway Administration (FHWA). (2003). “Full Road Closures for Work Zone Opertions: A Cross-Cutting Study,” *Report No. FHWA-OP-04-009*, U.S. Department of Transportation Federal Highway (FHWA), Washington, D.C, <http://www.ops.fhwa.dot.gov/wz/resources/publications/FullClosure/CrossCutting/its.htm> (accessed August 2005).

Glagola, Charles R., and Malcolm, William. (2002). “Partnering on Defense Contracts.” *Journal of Construction Engineering and Management*, 128(2), American Society of Civil Engineers, 127-138).

Grajek, Kenneth M., Gibson Jr., G. Edward, and Tucker, Richard L. (2000). “Partnered Project Performance in Texas Department of Transportation.” *Journal of Infrastructure Systems*, 6(2), American Society of Civil Engineers, 73-79.

Gransberg, Douglas D., Sanjaya P. Senadheera. (1999). “Design Build Contract Award Methods For Transportation Projects.” *Journal of Transportation Engineering*, 125(6), American Society of Civil Engineers, 565-567.

Hancher, Donn E. (2000). “Contracting Methods for Highway Construction.” TRB Committee A2F05, Washington, D.C.

Herbsman, Zohar J. (1995). "A+B Bidding Method – Hidden Success Story for Highway Construction," *Journal of Construction Engineering and Management*, 121(4), American Society of Civil Engineers, 430-437.

Herbsman, Zohar J., Chen, Wei Tong, and Epstein, William C. (1995). "Time is Money: Innovative Contracting Methods in Highway Construction." *Journal of Construction Engineering and Management*, 121(3), American Society of Civil Engineers, 273-261.

Herbsman, Zohar J., and Charles R. Giagola. (1998). "Lane Rental – Innovative Way to Reduce Road Construction Time," *Journal of Construction Engineering and Management*, 124(5), American Society of Civil Engineers, 411-417.

Jaraiedi, Majid, Plummer, Ralph W., and Aber, Mary S. (1995). "Incentive/Disincentive Guidelines for Highway Contracts." *Journal of Construction Engineering and Managemen*t, 121(1), American Society of Civil Engineers, 112-120.

Landberg, Lynn. (1993). "Concrete Pavers Change with Demands: Smaller Urban Jobs and Exacting Specifications Launch a New Breed of Paver." *Construction Equipment*, <www.highbeams.com> (accessed January 2005).

Lee, Eul-Bum, Harvey, John T., and Samadian, Michael M. (2005). "Knowledge-based Scheduling Analysis Software for Highway Rehabilitation and Reconstruction Projects." Submitted to TRB Construction Management Committee AFH10 for TRB 84th Annual Meeting, Washington D.C.

Lee, Eul-Bum, Roesler, Jeff, Harvey, John T., and William, C. (2002). "Case Study of Urban Concrete Pavement Reconstruction on Interstate 10." *Journal of Construction Engineering and Management*, 128(1), American Society of Civil Engineers, 49-56.

Levinson, Herbert S. (2004). "Highways, People, and Places: Past, Present, and Future," Journal of Transportation Engineering, 130(4), American Society of Civil Engineers, 406-411.

Lynch, Larry, Steffes, Robert, Chehovits, James, Voigt, Gerald, Evens, Lynn, and Al-Qadi, Imad L. (2000). "Joint and Crack-Sealing Challenges." TRB Committee A3C13, Washington, D.C.

Rasmussen, Robert Otto, and Rozycki, Dan K. (2004). "NCHRP Synthesis 338 – Thin and Ultra-Thin Whitetopping." Transportation Research Board, National Research Council, Washington, D.C.

Secmen, Serhan, Schwarz, James, Anderson, Stuart, and Zollinger, Dan. (1996). "Accelerated Construction Methodology for Concrete Pavements at Urban Intersections." U.S. Department of Transportation Federal Highway Administration (FHWA) Research Study Number 0-1454.

Shr, Jin-Fang, Ran, Bin, and Sung, Chiu Wei. (2004). "Method to Determine Minimum Contract Bid for A+B+I/D Highway Projects." *Journal of Construction Engineering and Management*, 130(4), American Society of Civil Engineers, 509-516.

Stewart, Larry. (1992). "Concrete Adapts to Rebuilding Roads," *Construction Equipment*, <www.highbeams.com> (accessed January 2005).

Wimmer, Sandra J. (2004). "Bridge Reconstruction Project Triumphs Over Time Constraints: When a Tragic Accident Crippled a Major Highway Route Two Years Ago, The Oklahoma Dept. of Transportation Drove Hard to Get Traffic Moving in Record Time." *Government Procurement*, <www.highbeams.com> (accessed January 2005).

Yin, Robert K. (1994). *Case Study Research: Design and Methods,* 2nd Edition, Sage Publications, Thousand Oaks, California.

APPENDIX A

FHWA RESEARCH PROJECT CASE STUDY DESCRIPTIONS

Literature Review Case Studies

Three case studies were conducted as part of the FHWA research project "Traffic Management Studies for High Volume Roadways" prior to the start of this research project. Information was collected on these projects as part of the literature review and these projects are referenced throughout this thesis. A short description of these projects is provided below.

I-496 Concrete Reconstruction Project

The information contained is this description was taken from the report entitled "Michigan Department of Transportation I-496 Concrete Reconstruction Project" (Anderson et al. 2003a).

The I-496 project in downtown Lansing, Michigan involved work on 32 bridges, 3.7 miles of pavement reconstruction, and 4.9 miles of pavement rehabilitation. This $42 million project involved a full roadway closure for one of the project phases to facilitate much of the bridge work. The pavement rehabilitation took place under lane closures. The estimated traffic on this 4-lane divided highway was estimated to be 65,800 vehicles per day. Prior to the full closure, extensive alternate route planning and public relations activities took place. During the full-closure, the alternate routes were monitored and efforts were made the keep traffic on these routs moving.

Michigan Department of Transportation US 23 Unbonded Overlay Project

The information contained is this description was taken from the report entitled "Michigan Department of Transportation US 23 Unbonded Overlay Project" (Anderson et al. 2003b).

US 23 is a 4-lane divided highway that links tourist areas in northern Michigan to the urban areas located in the southern end of the state. Because the primary road users were tourists, the project was scheduled to be completed before the Memorial Day weekend. The construction work involved a 10-inch unbonded overlay over 5.15 miles. The construction was accomplished under a daytime part-width traffic management strategy. The contractor used an on-site batch plant to supply concrete for the project and a dowel bar inserter paver was used to place the concrete. The contractor had to constantly monitor weather patterns and adjust construction activities to ensure the project was completed by the deadline.

Caltrans I-10 Concrete Paving Panel Demonstration Project

The information contained is this description was taken from the report entitled "Caltrans I-10 Concrete Paving Panel Demonstration Project" (Anderson et al. 2004a).

This case study involved once portion of the I-10 widening project between Baldwin Avenue and the San Gabriel River Freeway. This project widened I-10 from eight lanes to ten lanes by adding two new High Occupancy Vehicle (HOV) lanes. The case study focused on a 250 foot segment of the project where precast concrete paving panels were used. Each panel was 37 feet wide and 8 feet long. The panels were transported to the site on the back of a flatbed truck and moved into place with a crane. Once in place the panels were tensioned together. The construction efforts took place at night to minimize the impacts on daytime traffic.

APPENDIX B

LETTER AND SCOPE DOCUMENT

February 28, 2005

Dear Sir/Madam,

The Texas Transportation Institute has a cooperative agreement with the Federal Highway Administration (FHWA) to conduct the study, "Traffic Management Studies for High-Volume Roadways". The main focus of this study is the integration of both traffic and construction management practices.

The attached document briefly describes the project study scope. This document defines the research objectives, benefits, and the methodology. It further describes the research tasks. The work that will be accomplished under this project will result in products that can be implemented through the FHWA in support of its CPTP goals. The four goals of the CPTP are to reduce user delays, reduce costs, improve performance, and foster innovation.

As indicated in the attached "Brief Description of Project Scope," we are looking for projects that fit Task 1.02, *Document Key Factors for Successful Rehabilitation and/or Reconstruction of High-Volume Roadways*. The projects for Task 1.02 should be concrete paving projects that are now under construction or will be under construction this year. The study may be limited to just a segment of a construction project or some specific unique application of a method or technique. The project could reflect standard practice that is successful in completing a concrete paving project. Alternatively, an innovative idea applied on a concrete paving project could also be studied. Any high volume project including preservation, rehabilitation and/or reconstruction could be considered. Concrete paving projects involving local streets could be considered to evaluate the impact on local businesses. Since the research team is more interested in conducting shorter and less in-depth case studies than originally planned, it will not take much time or effort on the part of the State Highway Agency.

We now need your help in finding outstanding projects for this study! We will contact you within the next few weeks to find out more about potential projects that we can study. Meanwhile, if you have any questions or can provide the contact names for specific projects, please telephone me at (979) 845-2407, or send an email to me at s-anderson5@tamu.edu. We thank you in advance for your time and consideration.

Sincerely,

Stuart D. Anderson, PhD, PE
Manager, Construction Program

FEDERAL HIGHWAY ADMINISTRATION

TEXAS TRANSPORTATION INSTITUTE

Traffic Management Studies for High-Volume Roadways
Cooperative Agreement No. DTFH61-03-H-00101

Brief Description of Project Scope

Research Objective

Identify and document successful practices for preservation, rehabilitation, and/or reconstruction of concrete pavements under high volume roadways.

Expected Benefits of this Research

The utilization of effective traffic and construction management strategies for preservation, rehabilitation, and/or reconstruction of rigid pavements subjected to high traffic volumes will help limit the temporary disruption to highway users and the local community caused by these activities. In that way, agencies, contractors, and the public can benefit from past experiences. The work that will be accomplished in this research project will result in products that can be implemented by The Federal Highway Administration (FHWA) in support of the Concrete Pavement Technology Program (CPTP) goals. The four goals of the CPTP are as follows: 1) reduce user delays; 2) reduce costs; 3) improve performance; and 4) foster innovation.

Tasks Involved in this Research

The tasks for the research are:

- Task 1.01. Identify Motorist and Resident Perceptions
- Task 1.02. Documenting Key Factors for Successful Rehabilitation and/or Reconstruction of High-Volume Roadways
- Task 1.03. Identify and Recommend Projects for Conceptual Studies
- Task 1.04. Prepare Interim Report
- Task 1.05. Conduct Conceptual Studies
- Task 1.06. Develop Potential Format for Technology Transfer (includes Technical Briefs)
- Task 1.07. Prepare Final Report

The main focus of the information provided next is related to Task 1.02.

Task 1.02 Objective

Investigate, analyze, and document key factors that affect the success of concrete paving projects relative to traffic management and construction practices.

Research Methodology for Task 1.02

The research team plans to conduct many small case studies that investigate and document success factors for concrete pavement projects. The projects should be concrete paving projects that are now under construction or will be under construction this year. The study may be limited to just a segment of a construction project or some specific unique application of a method or technique. The project could reflect standard practice that is successful in completing a concrete paving project. Alternatively, an innovative idea applied on a concrete paving project could also be studied. Any high volume project including preservation, rehabilitation, and/or reconstruction could be considered. Concrete paving projects involving local streets could be considered to evaluate the impact on local businesses.

The research team plans on capturing the information from the case studies using interviews with key project participants, short video clips, still photos, and site visits. The deliverable for each case study would be a short report and a technical brief that would describe key findings of the case study. The technical briefs could also be used to bring exposure to new innovations in the area of concrete pavement reconstruction, rehabilitation, or preservation. The technical briefs as well as the short reports will be published on the Federal Highway Administration website.

Two case studies have been completed and draft reports prepared. The projects were an unbonded concrete overlay under part-width construction and reconstruction of a pavement under full closure. The Michigan Department of Transportation (DOT) sponsored both projects. The two case studies considered the entire project instead of only parts of the project and, as a result, were very time consuming and resource intensive. Even though these first two case studies provided valuable information, the research team believes a larger impact on the successful implementation and construction of concrete pavements can be achieved by conducting many smaller case studies as described above.

Benefits to Participating State Highway Agencies

The research from this project will collect successful practices and innovations from many different DOTs and publish the key results in a concise format such as through

FHWA technical briefs. The DOTs will have an opportunity to learn of successful practices of other DOTs that could possibly be implemented in their own state.

APPENDIX C

DISCUSSION TOPICS

Federal Highway Administration (FHWA) and Texas Transportation Institute (TTI)
Traffic Management Studies for High Volume Roadways
Protocol for Data Collection and Project Study-First Visit

Project:

I. General

1. Construction to be performed and general project scope (Number of existing lanes, additional lanes to be constructed, location of the project, project length, number of major intersections, traffic conditions, etc).
2. General project information (project duration, cost, contractors, etc.)

II. Constructability
1. Project phases where constructability analysis performed (e.g. planning, preliminary engineering, etc.)
2. Parties involved constructability analysis
3. Issues addressed during constructability analysis
4. Constructability review

III. Contracting Administration
1. Contracting strategy for the construction phase of this project (Traditional, A+B, lane rental, design-build) and reasoning.
2. Use of Incentives/Disincentives (I/D) clauses, reasoning, and structure of the clauses.
3. Use of Value Engineering clauses
4. Use of Partnering in the project

IV. Planning and Scheduling
1. Project schedule and plan development
    - 1.1 Scheduling logic that was used to develop the schedule and reasoning
    - 1.2 Other parties involved in developing the schedule and extent of involvement.
    - 1.3 Basis of the activity duration and logic
    - 1.4 Integration of resources into the development of the construction plan
    - 1.5 Critical constraints and restrictions

2. Established work schedule for the project and factors in the selection process (continuous day work, night work, weekends)
3. Phasing sequence development
4. Time restrictions on project

V. Construction Practices
1. Material Selection

2. Effect of the traffic management plan on construction
3. Selection of the concrete type
4. Source of concrete supply
5. Work accomplished to date and schedule performance
6. Unique project features

VI. Traffic Control and Management
1. Customers
2. Traffic Management Strategy
   2.1 Demand-oriented strategies
   2.2 Operational strategies
3. Traveler Information and Public Awareness
   3.1 Temporary CMS
   3.2 Permanent CMS
   3.3 Media
   3.4 Public Meetings
   3.5 Hotlines

VII. Public Relations (PR) Campaign
1. PR campaign description
2. Target audience of the PR campaign
3. Coordination of the PR campaign
4. PR campaign schedule

VIII. Summary
1. Key Factors that are critical to project success

IX. Items Requested

- Construction schedule
- Contract documents (specifications, project scope, etc)
- Construction drawings and plans
- List of contractors and subcontractors including areas of work
- Concrete mix designs for all areas
- Traffic management plan
- Public outreach plan

APPENDIX D

MATRICES

CONSTRUCTION STRATEGIES		MOTIVATING CONDITIONS FOR STRATEGY SELECTION																									
		TRAFFIC												CONSTRUCTION													
		High Visibility Project	High Traffic Volumes	Weekday Commuters	Weekend Traffic	Directional Traffic	Local Residents	Local Businesses	Adequate Alternate Routes	Safety of Diverted Traffic	Provision of Emergency Services	Collect Real Time Traffic Information	Minimized Traffic Impacts	Enhanced Owner/Contractor Cooperation	Common Owner/Contractor Objectives	Safety of Workers	Early Project Completion	Set Construction Window	Short Construction Segments	Resource-intensive, Complex Project	High Concrete Production Rates	High Concrete Quality	Eliminate Risky Contractors from Bid Process	Reduce Project Costs	Comparison of Alternatives with Different Expected Live	Minimized Concrete Haul Times	Increase Number of Project Bids
CONSTRUCTION PRACTICES																											
CP1	Concrete Accelerator Admixture												●														
CP2	On-site Batch Plant																									●	
CP3	Exclusive Batch Plant																				●	●					
CP4	Two-lane Slip Form Paver												◑														
CP5	Precast Concrete Paving																		◑								
CP6	Dowel Bar Inserter Paver												◑								◑						
CP7	Backup Equipment												◑														
CP8	Movable Concrete Barrier															●			●								
CP9	Noise Reduction Strategies						●																				
TRAFFIC CONTROL AND MANAGEMENT																											
TC1	Dynamic Traffic Control Plan												◑														
TC2	Traffic Management Center	●		●				●		●																	
TC3	Traffic Pattern Analysis			●	●																						
TC4	Alternate Route Planning & Information		●																								
TC5	Full Roadway Closures		◑																								
TC6	Permenant Lane Closures								◑																		
TC7	Movable Concrete Barrier					◑				◑																	
TC8	Business Access							◑																			
TC9	Business Signs and Flaggers							◑								◑											
TC10	Use of Local Police									●																	
TC11	Incident Management Program									●																	
TC12	Ramp Closures									○																	
TC13	Construction Barriers									●						●											
TC14	Highway Advisory Radio		●																								
TC15	Closured Circuit Telivision Monitoring		●									●															
PUBLIC INFORMATION																											
PI1	Public Relations Service based on Project Conditions																										
PI2	Slogans/Logo	●																									
PI3	Elected Official/Community Leader Buy-in	◑																									
PI4	Community/Public Meetings						●																				
PI5	Electronic Email/Fax Database			●			●	●																			
PI6	Website	●	●	●	●		●	●																			
PI7	Billboards			◑	◑																						
PI8	Informational Brochures/Flyers/Videos						◑	◑																			
PI9	Media Advertising	●	●	●	●																						
PI10	Telephone Hotline		●	●																							
PI11	Press Release / News Release	●	●																								
PI12	Preconstruction Surveys	○	○																								
PI13	Information Partnership						●	●																			
PI14	Direct Mailing						○	○																			
PI15	Discouraging Cut-Through Traffic						○																				
PI13	Ribbon-cutting Ceremony						●	●																			

LEGEND

○ Fully supported strategy

◑ Strategy supported by two data collection methods

● Strategy supported by one data collection method

	IMPACTED GROUP													
	General Traffic		Weekday Commuters		Weekend Traffic		TruckTraffic		Special Event Traffic		Local Residents		Local Businesses	
	Strategy	Project Examples	Strategy	Project Examples	Strategy	Project Examples	Strategy	Project Examples	Strategy	Project Examples	Strategy	Project Examples	Strategy	Project Examples
Low Impact	Project Webpage	US 75/I-635	Changeable Message Signs	I-85	Changeable Message Signs	I-85	Brochures/Flyers at Rest Stops	I-85					Brochures/Flyers	I-496
	Press Releases	I-95, I-70												
Medium Impact	Slogan	I-15	Radio Advertising	I-15	Scheduled Media Announcements	I-85	Information to Local Trucking Groups	I-85	Information to Significant Local Venues	I-15	Public Meetings	I-15, I-496	Public Meetings	I-15
	Press Conference	I-15, Springfield, I-15 SLC	Public Meetings	I-15	Radio Advertising	I-15	Meetings with trucking groups	I-95 Bridge	Meetings with tourism groups	I-95 Bridge	Additional Speed Limit Compliance Signing	Lamar	Information via Email	Lamar
	Radio Advertising	I-15, I-496, Hillside, I-95 Bridge, Springfield, I-15 SLC	Real-Time Changeable Message Signs	I-15	Real-time Changeable Message Signs	I-15			Meetings with visitor bureaus	I-10 Pomona	Announcements to Discourage Cut-through Traffic	I-496	Targeted Outreach Meetings	I-496
	Newspaper Advertising	I-15, I-95, Hillside, I-95 Bridge, Springfield, I-15 SLC									Information partnership	I-70	Information Partnership	I-70
	Announcements at City Council Meetings	I-15									Information via flyers	Hillside, I-710		
	Information via Fax	I-15, I-10 Pomona												
	Newsletters	I-95, I-710, Springfield, I-15 SLC												
	Information distribution at nearby centers (e.g. malls, libraries, etc)	Springfield, I-15 SLC, I-70, I-95 Bridge												
	Highway Advisory Radio (HAR)	I-15 SLC												
	Detour Maps	I-70, I-10 Pomona												
	Informational Brochures	1-95, Hillside												
	Informational Meetings or Seminars	I-10 Pomona, I-15 SLC, I-710												
	Informing Traffic Reporters	I-10 Pomona												
	Informational Videos	I-95, I-15 SLC												
	Information via Email	I-70, Lamar												
	Website with Real-time Traffic Information & Traffic Updates	I-15, I-70, Hillside, Springfield, I-15 SLC, I-10 Pomona												
High Impact	Pre-construction (up to one year) Campaign	I-496, Lamar, I-95, I-10 Pomona	Pre-construction Motorist Surveys	I-496, 1-15 SLC	Pre-construction Motorist Surveys	I-496	Encourage Off-peak Travel for Trucks	I-15			Targeted Outreach Meetings	I-496	Information via Hand-delivery	Lamar
	Speaker's bureau, oral presentations	1-15 SLC, I-10 Pomona	Ribbon-cutting Ceremony, Public Walk-through	I-496, Lamar			Real-time Changeable Message Signs	I-15			Ribbon-cutting Ceremony, Public Walk-through	Lamar	Merchant Buy-in on Closure Schemes	Lamar
	Logo	I-496	Partner with mass transit, ridesharing, vanpooling	Springfield			Partnership with trucking associations	I-710			Information via "Doorhangers"	I-496	Business Access Signs	Lamar
	TV Advertising	I-496, Hillside, I-95 Bridge, Springfield, I-15									Limited Noise Impact from Night Construction	I-496, Lamar	Signs to Encourage Business Patronage	Lamar
	Telephone Hotline	I-496, Hillside, I-465/70, Springfield, I-15 SLC									Direct Mailing to affected areas	I-95, I-10 Pomona	Pre-construction (up to one year) Campaign	Lamar
	Billboards	I-496, Hillside, I-496/70,Springfield, I-15 SLC									Pre-construction (up to one year) Campaign	I-70, Hillside	Ribbon-cutting Ceremony, Public Walk-through	I-496, Lamar
	Special feature articles for newspaper	I-10 Pomona												
	Contact nearby SHAs, MPOs, police, emergenies services	I-10 Pomona												

	Traffic Control and Management Strategies							
	General Traffic Management		Improving Traffic Through Workzone		Demand Reduction		Workzone Safety	
	Strategy	**Project Examples**	**Strategy**	**Project Examples**	**Strategy**	**Project Examples**	**Strategy**	**Project Examples**
Low Impact			Static signing, Lamar	I-95, I-15 SLC, I-95 Bridge	Detour and alternate route planning	I-285, I-15 SLC, I-70, I-465/70, I-710, I-496, Lamar	Concrete barriers	I-15, I-65
							Speed limit reductions	I-15
							Portable Barrels	I-15, Lamar, I-85
							Static Signing	I-95, Lamar
Medium Impact	Pre-construction traffic analysis	I-95, I-496	Changeable message signing	I-15 SLC, I-70, I-465/70, I-10 Pomona, I-15, Lamar	Ridesharing and mass transit subsities	I-70, Springfield	Police enforcement	I-95, I-15 SLC, I-710, I-95 Bridge, Springfield, I-10 Pomona, I-15
	Coordination with other roadway projects in impacted area	Lamar, I-496	Closing nearby ramps	I-15 SLC, I-70	Detour and alternate route improvements	I-15 SLC, I-70, I-465/70, I-95 Bridge, Springfield, I-10 Pomona, I-496, Lamar	Ramp closures in and around the construction zone	I-15 SLC, I-70
	Signing in nearby neighborhoods	Lamar	Project Hotline	I-15	Funding for Park & Ride lots	Springfield	Emergency vehicle considerations	I-70
	Traffic calming techniques around residential areas	I-496	Consider local venues in traffic and construction staging	I-15	Increased Park & Ride spaces	Springfield	Access signs	Lamar
			Access signs for local businesses	Lamar	Expanded mass transit services	Springfield	Movable concrete barriers	I-710, I-10 Pomona, I-15,I-85
			Flaggers to help motorists identify and use business access points	Lamar	CMS to encourage alternate route use	I-465/70	Incidement management program	I-95, I-15 SLC, I-70,I-465/70, I-710, I-95 Bridge, Springfield, I-10 Pomona
			Highway Advisory Radio (HAR)	I-10 Pomona	Fostering ridesharing, carpooling, and vanpooling programs	I-15 SLC, I-15	Changeable message signing	I-15 SLC, I-70, I-465/70, I-710, I-95 Bridge, I-10 Pomona, I-15, Lamar
					Ramp closures in and around the construction zone	I-15 SLC, I-70		
					Reduced transit fare packages	Springfield, I-15		
					Work with trucking associations	I-15		
					Traffic modeling for alternate route planning	I-496		
High Impact			CCTVs to supply real time traffic information	I-95, I-15 SLC, I-95 Bridge, I-15, Lamar	Detour and alternate route monitoring and adjusting	I-15 SLC, I-465/70, I-95 Bridge, Lamar	Fire department foam truck	Springfield
			Project specific traffic management center	I-15	Congestion management meetings with transit groups & local govt	Springfield	Police mobile command center	Springfield
			CMS updated with real-time traffic information	I-10 Pomona, I-15	Business consideration with alternate route planning and promotion	Lamar	Providing fire and rescue equipment and staff	Springfield
			On-site traffic engineer to make traffic related decisions	Lamar			DOT safety patrol	Springfield
			Movable barrier for directional traffic	I-15				

STRATEGY INTERDEPENDENCIES		CONTRACT ADMINISTRATION	CA1 Contractor Screening	CA2 Partnering	CA3 Incentives/Disincentives	CA4 A+B Contracting	CA5 Lane Rental	CA6 Production Rate-based Contract Length	PLANNING AND SCHEDULING	PS1 Joint Schedule Review Meetings	PS2 Accelerated Schedule	PS3 Detailed Hourly Schedule	PS4 Dynamic Project Schedule	PS5 Weekend Construction	PS6 Night Construction	PS7 Early Utilities Completion	PS8 Contingency Plan	PS9 Anticipating Weather Window	PS10 Rest Days	DECISION MAKING STRATEGIES	DM1 Daily Construction Meetings	DM2 Effective Contractor Communication	DM3 On-site Agency Representatives	DM4 Responsive Adverse Weather Plan	CONSTRUCTABILITY	CA1 Lane Closure Program (UC Berkley)	CA2 Formal Constructability Review	CONSTRUCTION PRACTICES AND MANAGEMENT	CP1 Concrete Accelerator Admixture	CP2 On-site Batch Plant	CP3 Exclusive Batch Plant	CP4 Two-lane Slip Form Paver	CP5 Precast Concrete Paving	CP6 Dowel Bar Inserter Paver	CP7 Backup Equipment	CP8 Movable Concrete Barrier	CP10 Noise Reduction Strategies	TRAFFIC CONTROL AND MANAGEMENT	TC1 Dynamic Traffic Control Plan	TC2 Traffic Management Center	TC3 Traffic Pattern Analysis	TC4 Alternate Route Planning & Information	TC5 Full Roadway Closures	TC6 Permanent Lane Closures	TC7 Movable Concrete Barrier	TC8 Business Access	TC9 Business Signs and Flaggers	TC10 Use of Local Police	TC11 Incident Management Program	TC13 Construction Barriers	TC14 Highway Advisory Radio	TC15 Closed Circuit Television Monitoring	PUBLIC INFORMATION	PI1 Contracted Public Relations Service	PI2 Slogans/Logo	PI3 Elected Official/Community Leader Buy-in	PI4 Community/Public Meetings	PI5 Electronic Email Database	PI6 Website	PI7 Billboards	PI8 Informational Brochures/Flyers	PI9 TV, Radio, Newspaper Advertising	PI10 Telephone Hotline	PI11 Ribbon-cutting Ceremony
CONTRACT ADMINISTRATION																																																																
CA1	Contractor Screening			○							○		○								○								◑										○																									
CA2	Partnering		○								○											◑																	◑																									
CA3	Incentives/Disincentives					◑		◑			◑																																																					
CA4	A+B Contracting				◑			○			◑																																																					
CA5	Lane Rental										◑	◑																																																				
CA6	Production Rate-based Contract Length				◑	○					◑																																																					
PLANNING AND SCHEDULING																																																																
PS1	Joint Schedule Review Meetings										◑																																																					
PS2	Accelerated Schedule		○	○	◑	◑	◑	◑		◑						○	○	○				◑							◑						◑				◑																									
PS3	Detailed Hourly Schedule						◑							●	●																																																	
PS4	Dynamic Project Schedule		○																		●																		●																									
PS5	Weekend Construction											●						●						●					●						◑	◑																												
PS6	Night Construction											●																	●	◑			○			◑	◑																											
PS7	Early Utilities Completion										○																																																					
PS8	Contingency Plan										○																																																					
PS9	Anticipating Weather Window										○			●																																																		
PS10	Rest Days																																																														
DECISION MAKING STRATEGIES																																																																
DM1	Daily Construction Meetings		○										●																										◑																									
DM2	Effective Contractor Communication			○							◑																												●																									
DM3	On-site Agency Representatives																																						◑																									
DM4	Responsive Adverse Weather Plan													●																																																		
CONSTRUCTABILITY																																																																
CA1	Lane Closure Program (UC Berkley)																																																															
CA2	Formal Constructability Review																																																															
CONSTRUCTION PRACTICES AND MANAGEMENT																																																																
CP1	Concrete Accelerator Admixture		○								◑			●	●															○																																		
CP2	On-site Batch Plant			◑											◑														○																																			
CP3	Exclusive Batch Plant																																																															
CP4	Two-lane Slip Form Paver																																																															
CP5	Precast Concrete Paving														○																																																	
CP6	Dowel Bar Inserter Paver																																																															
CP7	Backup Equipment										◑			◑																																																		
CP8	Movable Concrete Barrier													◑	◑																																																	
CP10	Noise Reduction Strategies														◑																																																	
TRAFFIC CONTROL AND MANAGEMENT																																																																
TC1	Dynamic Traffic Control Plan		○	◑							◑		●								◑	●	◑																	○	○																	◑	◑					
TC2	Traffic Management Center																																						○										◑			●												
TC3	Traffic Pattern Analysis																																						○			◑										○												
TC4	Alternate Route Planning & Information																																								◑		●									○							◑		◑	◑		
TC5	Full Roadway Closures																																									●												○	○	◑	◑	○	◑	○	◑	◑	○	○
TC6	Permanent Lane Closures																																																															
TC7	Movable Concrete Barrier																																																															
TC8	Business Access																																													◑																		
TC9	Business Signs and Flaggers																																												◑																			
TC10	Use of Local Police																																																															
TC11	Incident Management Program																																							◑																								
TC13	Construction Barriers																																																															
TC14	Highway Advisory Radio																																																															
TC15	Closed Circuit Television Monitoring																																							●	○	○																						
PUBLIC INFORMATION																																																																
PI1	Contracted Public Relations Service																																										○																					
PI2	Slogans/Logo																																										○																		◑	◑	◑		
PI3	Elected Official/Community Leader Buy-in																																										◑																					
PI4	Community/Public Meetings																																										◑																					
PI5	Electronic Email Database																																						◑				○																◑					
PI6	Website																																						◑			◑	◑															◑						
PI7	Billboards																																										○													◑								
PI8	Informational Brochures/Flyers																																									◑	◑													◑								
PI9	TV, Radio, Newspaper Advertising																																									◑	◑													◑								
PI10	Telephone Hotline																																										○																					
PI11	Ribbon-cutting Ceremony																																										○																					

LEGEND
○ Low relationship level
◑ Medium Relationship Level
● High Relationship Level

VITA

Name: Clayton C. Chabannes

Address: Jones & Carter, Inc., 8701 New Trails Drive, Suite 200,
The Woodlands, TX 77381

Email Address: ccchabannes@jonescarter.com

Education: B.S., Civil Engineering, Texas A&M University at College Station, 2003
M.S., Civil Engineering, Texas A&M University at College Station, 2006