Louisiana Transportation Research Center

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Synthesis on the Best Practices for State DOTs to Determine Project Delivery Time, Project Management, and Ratio of Consultant to In-House Design

by

Amirhosein Jafari, Ph.D., Louisiana State University
Sharareh Kermanshachi, Ph.D., the University of Texas at Arlington
Elnaz Safapour, the University of Texas at Arlington
Arash Taghinezhad, Ph.D., Louisiana State University

4101 Gourrier Avenue | Baton Rouge, Louisiana 70808
(225) 767-9131 | (225) 767-9108 fax | www.ltrc.lsu.edu

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2. Author(s)

Amirhosein Jafari, Ph.D.
Sharareh Kermanshachi, Ph.D.
Elnaz Safapour
Arash Taghinezhad, Ph.D.

3. Performing Organization Name and Address

Bert S. Turner Department of Construction Management
Louisiana State University
3319 Patrick F. Taylor Hall
Baton Rouge, LA 70810

4. Sponsoring Agency Name and Address

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13. Abstract

Transportation agencies are experiencing unprecedented pressure to deliver projects successfully. An obvious response to this pressure is to improve the project delivery process through the implementation of available successful project management practices. Also, with increasing restraints upon budgets and large workloads, transportation agencies are contracting out portions of their project design and delivery. Understanding these practices plays a vital role in the successful delivery of transportation projects. The overall objective of this project was to synthesize the best practices for departments of transportation (DOTs) project delivery processes by looking at all factors of project delivery, including time estimation, project management, and suggested ratios of in-house versus consultant for project delivery. This study

focused on tools, techniques, and processes required to deliver a transportation project effectively, and investigated the impact of design outsourcing on project schedule and cost. To achieve the objectives of this project, the research team first performed a literature review pertaining to transportation project delivery to discover project management dimensions in transportation projects. Then, they designed a survey to identify general project management practices in the DOTs' delivery process. The research team piloted the survey and then distributed it among state transportation agencies via an online platform. The online survey was performed, followed by a series of interviews, to collect the perspectives of the experts and professionals in state DOT agencies across the nation. The research team analyzed the results of the survey and performed follow-up interviews to confirm the results. A total of 96 completed surveys and 6 follow-up interviews were conducted to collect the required information. Finally, the research team developed a matrix to document their recommendations for the best practices for DOT project delivery processes. The results highlighted 12 project management dimensions in transportation projects including time management, cost management, quality control and inspection, environmental process, right-of-way and utilities, safety, outsourcing, value engineering, change orders, type of contracting, workforce qualification, and operation and maintenance. The results showed that although there is no publicly available manual or guideline for every identified project management dimensions in every state DOT agency, most of the agencies implement them in their transportation projects. In addition, although the results proved that DOT projects use around 40% of the project budget for contracting out some part of the projects and using consultants, this value significantly depends on the project's characteristics. For example, state DOT agencies prefer to use more outsourcing in larger and more complex projects, especially ones located in an urban area. The results also indicated that the main reasons for state DOT agencies to contract out parts of the projects are (1) insufficient in-house personnel, (2) lack of required particular expertise within the agencies, and (3) time constraints of the project activities.

Project Review Committee

Each research project will have an advisory committee appointed by the LTRC Director. The Project Review Committee is responsible for assisting the LTRC Administrator or Manager in the development of acceptable research problem statements, requests for proposals, review of research proposals, oversight of approved research projects, and implementation of findings.

LTRC appreciates the dedication of the following Project Review Committee Members in guiding this research study to fruition.

LTRC Administrator/Manager

Kirk Zeringue

Special Studies Research Manager

Directorate Implementation Sponsor

Christopher P. Knotts, P.E.

DOTD Chief Engineer

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Bert S. Turner Department of Construction Management
Louisiana State University
3319 Patrick F. Taylor Hall
Baton Rouge, LA 70810

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Abstract

Transportation agencies are experiencing unprecedented pressure to deliver projects successfully. An obvious response to this pressure is to improve the project delivery process through the implementation of available successful project management practices. Also, with increasing restraints upon budgets and large workloads, transportation agencies are contracting out portions of their project design and delivery. Understanding these practices plays a vital role in the successful delivery of transportation projects. The overall objective of this project was to synthesize the best practices for departments of transportation (DOTs) project delivery processes by looking at all factors of project delivery, including time estimation, project management, and suggested ratios of in-house versus consultant for project delivery. This study focused on tools, techniques, and processes required to deliver a transportation project effectively, and investigated the impact of design outsourcing on project schedule and cost. To achieve the objectives of this project, the research team first performed a literature review pertaining to transportation project delivery to discover project management dimensions in transportation projects. Then, they designed a survey to identify general project management practices in the DOTs' delivery process. The research team piloted the survey and then distributed it among state transportation agencies via an online platform. The online survey was performed, followed by a series of interviews, to collect the perspectives of the experts and professionals in state DOT agencies across the nation. The research team analyzed the results of the survey and performed follow-up interviews to confirm the results. A total of 96 completed surveys and 6 follow-up interviews were conducted to collect the required information. Finally, the research team developed a matrix to document their recommendations for the best practices for DOT project delivery processes. The results highlighted 12 project management dimensions in transportation projects including time management, cost management, quality control and inspection, environmental process, right-of-way and utilities, safety, outsourcing, value engineering, change orders, type of contracting, workforce qualification, and operation and maintenance. The results showed that although there is no publicly available manual or guideline for every identified project management dimensions in every state DOT agency, most of the agencies implement them in their transportation projects. In addition, although the results proved that DOT projects use around 40% of the project budget for contracting out some part of the projects and using consultants, this value significantly depends on the project's characteristics. For example, state DOT agencies prefer to use more outsourcing in larger and more complex projects, especially ones located in an

urban area. The results also indicated that the main reasons for state DOT agencies to contract out parts of the projects are (1) insufficient in-house personnel, (2) lack of required particular expertise within the agencies, and (3) time constraints of the project activities.

Acknowledgments

Over 100 people from 25 different state DOTs participated in this study, including Alabama, Arizona, Colorado, Connecticut, Florida, Idaho, Iowa, Kentucky, Louisiana, Maine, Maryland, Minnesota, Nebraska, New Mexico, North Carolina, Ohio, Oklahoma, Oregon, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, and Washington. We would like to thank everyone for supporting this project by responding to our survey, participating in our interviews, and providing us with valuable information.

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Implementation Statement

The project synthesis can be used as a reference document for the identification of successful project management practices and design outsourcing options.

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Introduction

Delivering a successful outcome of a transportation construction project requires overcoming the overwhelming risks that are inherent in these types of projects. One of the primary concerns of project managers is delivering project outcomes on time and within budget [1] [2] [3]. In general, construction projects frequently fail to meet owners' expectations in terms of cost, schedule, and quality performance [4]. Thomsen et al. [5] performed a study and reported that between 40% and 50% of construction projects consistently fall behind the baseline schedule. When a construction project is delayed, it is either accelerated or is extended beyond the scheduled completion date, causing cost overruns.

Over the past years, there has been an inexorable increase in the number of transportation projects in the United States [6]. On any given day, a state Department of Transportation (DOT) has hundreds of small-to-large projects underway, with the common purpose of assuring that millions of individual travelers experience a transportation network that works smoothly [7]. Therefore, transportation agencies are experiencing unprecedented pressure to deliver projects successfully. An obvious response to this pressure is to improve the project delivery process through the implementation of available successful project management practices, as well as through contracting out the work to private sector companies and even to other levels of government, such as county transportation agencies. Contracting out, of course, is not new, and many state DOTs have been engaged in it for years [8]. Understanding these practices plays a vital role in the successful delivery of transportation projects.

Researchers and practitioners have conducted several studies to improve project delivery of construction of transportation projects [9]. Alias et al. [10] stated that successful project delivery greatly depends on how the project has been managed and controlled. In this respect, Barners [11] argued that cost, schedule, and output (i.e., quality and scope) are the triple constraints of project management. Alias et al. [10] mentioned that the common major challenges with project management are planning, scoping, project implementation, quality design and construction, risk assessment and management, change orders mitigation, cost, and schedule. Kermanshachi et al. [12] developed a generic project scoping process model to achieve on-time and on-budget delivery of transportation projects. Thus, the selection of an appropriate project management approach is required to meet the essential facets of delivery success [13] [14]. As construction project management has evolved at a fast rate in recent years, many

researchers and practitioners have made an effort to find the most appropriate project management approach for the construction of transportation projects. An appropriate project management approach involves the following stages: (1) initiation, (2) planning and design, (3) execution, (4) monitoring and controlling systems, and (5) completion.

Using innovative tools and methods to manage time, cost, and quality are crucial to the successful delivery of projects [15]. Many factors can affect the successful delivery of transportation projects, but not all of them impact every project. Environmental issues, right-of-ways (ROW) and utilities, outsourcing ratios, operation and maintenance (O&M), and the number of users are a few examples of factors that impact the project management process in transportation projects more than any other type of construction projects. Due to the unique nature of management activities of transportation projects, each state DOT has developed specific guidelines to highlight project management processes, based on their local regulations and conditions. Therefore, understanding the project management practices and their successful tools and methods is very important for project managers and stakeholders in transportation agencies. The ratio of consultant to in-house design and project delivery varies from one state DOT to another, and there are also many differences in how delivery times are determined and how projects are managed. Comparing the project success and performance management of in-house services to those of outside suppliers can produce valuable information, even when the decision is not to outsource the services in question [16].

To deliver a construction project successfully, there is the debated question of whether it is more cost-effective for the design to be conducted in-house or to be contracted out. Several researchers and practitioners conducted studies in an effort to find the answer to this question [17] [18]. Griffis and Choi [19] claimed that many state transportation agencies target a design workload of 25% in-house and 75% contracted out to accomplish their programs and in-house training goals. Additionally, these authors investigated the underlying issues that should be considered in making the decision of whether the design is conducted in-house or contracted out: policy, staffing capacity, schedule constraints, availability of special expertise, the need for innovation, better risk management, enhancement of quality, and cost-effectiveness [19].

The decision of whether or not to outsource activities in projects requires narrowing the subject area and investigating the best practices for project delivery and management thoroughly and in great detail. Accordingly, this project targeted the best practices for state DOT project delivery processes, and focused on different project delivery factors

such as time estimation, project management, and suggested ratios of in-house versus consultant design.

Objective

The overall objective of this project was to synthesize the best practices for project delivery processes of departments of transportation (DOTs) by looking at all factors of project delivery including time estimation, project management, and suggested ratios of in-house versus consultant design.

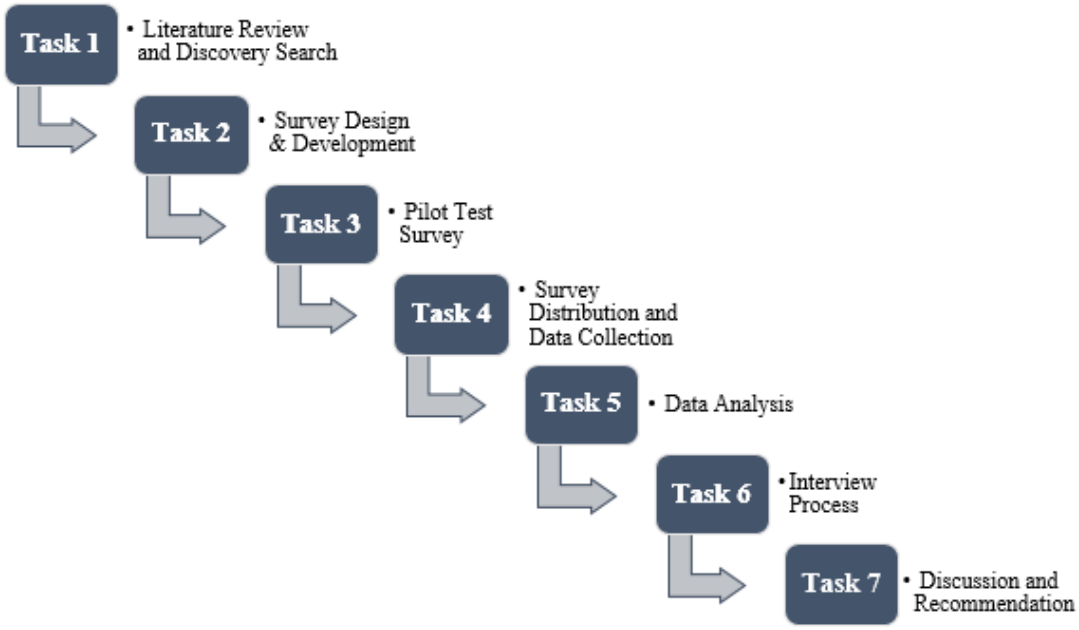
Scope

The scope of this project was limited to identifying effective strategies and best practices to accurately estimate the cost and schedule of transportation projects during the planning, scoping, and design phases of the project. This study focused on tools, techniques, and processes required to deliver a transportation project effectively and investigated the impact of design outsourcing on project quality, schedule, and cost.

Methodology

Figure 1 presents the list of major tasks for accomplishing the objectives of this project.

Figure 1. Research Approach



These tasks are described in the following sections.

Task 1: Literature Review and Discovery Search

The objective of Task 1 was to perform a literature review that focuses on published information regarding all factors of project delivery, including time estimation, project management, and suggested ratios of in-house versus consultant design for project delivery. In conducting the literature search, the research team focused on project development phases in both the highway industry and other non-highway industry sectors, such as the Construction Industry Institute's (CII) front-end planning process. Two types of reviews were conducted:

(1) A literature review of publications relevant to the subject areas of interest, and

(2) A review of state transportation agency (STA) websites, with the intent of finding current practices and tools for various aspects of successful project delivery.

First, the research team performed a literature review of published materials pertaining to project management practices for project success, as well as available processes and tools. The scope of this literature review was focused on all phases of project delivery, from pre-design to post-construction, for the transportation industry and other sectors of the construction industry. Only literature published within the United States was considered in this study. The most repeated project management dimensions in the literature were identified and selected to form the final list of project management best practices for transportation projects.

Second, the research team collected the state DOTs' guidelines and manuals, which provided a wide variety of information on different aspects of project management success. These documents included different project management practices, but not all of them were comprehensive. Although the sources are easily accessible through the state DOT websites, finding the states with relevant manuals on project management success factors was a complex process. The research team collected all of the project management manuals and guidelines that were available from the 50 states, and added the District Columbia and Puerto Rico to them. Then, they mapped the collected information, based on the agency's location, to provide a comparative analysis of the availability of guidelines in the various states. Such information may help policymakers better understand the gaps in project management, and future needs.

As a result of Task 1, an annotated bibliography of relevant publications and an evaluation of STA project development processes found on STA websites are presented in this report.

Task 2: Survey Design and Development

Concurrently with the literature review, the research team used an online platform, Qualtrics, to develop a survey that was designed to identify the general practices of state transportation agencies. Qualtrics is LSU's web-based survey platform, which the institute has used for a variety of research applications across many projects. Prior to conducting the online survey, the research team submitted the list of survey questions to STC and revised it based on their reviews and comments. The survey included three primary sections: (1) a description of the project summary and goal for the participants;

(2) a description of the participants' general information such as job position, level of expertise, and DOT location, etc.; and (3) a collection of technical responses to both open- and close-ended questions targeting project management approaches, time estimation tools and techniques, cost estimation methods, management practices, and design outsourcing status and its relationship to project success (in-house vs. consultant). Terminologies used in the survey instrument were clearly defined for the participants, to ensure that accurate and precise data was collected.

Task 3: Pilot Test Survey

The research team tested the survey with a pilot distribution to targeted experts in the Louisiana and Texas DOTs. Four experts participated in the pilot study, and their detailed comments and feedback were collected and integrated into the survey. The goal of this pilot test was to refine the survey instruments before collecting the primary data from the targeted population.

Task 4: Survey Distribution and Data Collection

The research team invited more than 300 representatives to participate in this study. The invited experts were from 50 states' DOTs, the District of Columbia, the Federal Highway Administration (FHWA), and the Transportation Research Board (TRB). The research team used a generated list of relevant engineers and experts in state agencies, as well as an updated list of representatives from relevant AASHTO committees to develop the list of experts with the required expertise and experience

Task 5: Data Analysis

After collecting the required data from the survey instrument in Task 4, the research team analyzed the data, using quantitative and qualitative analysis methods. The results of this task will be presented in this report, using demographic data, data analysis, and discovered information.

Task 6: Interview Process

The research team designed an interview guide to use while conducting structured follow-up interviews to confirm the survey results and obtain additional information, where appropriate. The survey results enabled the research team to identify a sample of STAs, with a focus on states that have established and documented different aspects of successful project delivery. The research team conducted a set of six telephone interviews with these STAs to discuss lessons learned, best practices, and documentation of practices.

Task 7: Discussion and Recommendations

The research team prepared this final report, documenting the entire research effort and providing the impacts and benefits of the findings. This final report summarizes all of the research tasks accomplished. It also presents a matrix of recommendations that summarizes the findings, discoveries, and lessons learned.

Literature Review and Discovery Search

This section is organized as follows. The project success criteria and project management process are described first, followed by the results of the comprehensive literature review, including the 12 identified project management dimensions. Finally, the results of exploring and analyzing the U.S. state agencies' manuals and guidelines regarding project management practices are mapped and discussed.

Project Success Criteria

To successfully deliver any project, the project success criteria needs to be identified and evaluated carefully. Traditionally, the main concern of project managers was to deliver the project within the expected time, budget, and quality defined during the design process [1] [2]. The three main criteria of time, budget, and quality in the project delivery process, called the "iron triangle," were traditionally linked with the project success [20] [21]. However, in the last decade, researchers have gone beyond the traditional iron triangle definition, and have added other factors for project success such as commitment, coordination, and competence [22]; client satisfaction; benefits to organization; end-user's satisfaction; benefits to stakeholders; benefits to project personnel [1]; safety, efficiency, and effectiveness [23]; ethics [24]; sustainability [25]; environmental impacts; safety; and site disputes [26]. There was no consensus on project success criteria in recent studies. The recently proposed criteria primarily emphasize increasing efficiency, decreasing the impacts of the project on humans and the environment and stakeholder satisfaction. The large scale and complexity of transportation projects have been the impetuses for the number of studies that have been conducted to investigate their project success factors (e.g., [27] [28] [7] [12] [29]).

Project Management Practices

The project management process is defined by the project management body of knowledge (PMBOK) as "a five-stage process, including initiation, planning, executing, monitoring and controlling, and closing" [30]. One of the challenges in the project management process is to understand the activities and practices that are required for each stage [31]. The required activities for the PMBOK phases include integration, scope, time, cost, quality, human resources, communications, risk, and procurement [32]. Each

of these activities might require different tools, based on the project goals. For example, computer-based tools such as Primavera, MS Project, Geographic Information System (GIS), and building information modeling (BIM), among others, have been widely used as comprehensive tools for project management recently.

Successful implementation of project management and project controlling practices is essential for project success [10], and transportation projects have unique characteristics that might require practices that are different from those of other construction projects. Although project success criteria have been studied by other researchers, there is still a lack of understanding about the relationship between project management practices and project success criteria, specifically in transportation projects.

Transportation Project Management Dimensions

The research team performed a comprehensive literature review to identify the project management dimensions in the published literature. Table 1 summarizes the existing literature in this regard. Based on the literature review, the research team selected 12 main project management dimensions for further investigation, including time management, cost management, quality control and inspection, environmental process, ROW and utilities, safety, outsourcing, value engineering, change orders, types of contracting, workforce qualifications, and operation and maintenance. These dimensions are discussed in detail in the following sections. The most repeated project dimensions are presented in Table 1.

Table 1. Transportation Project Management Dimensions

No.	Sample References	Dimension	Description
1	[33] [34] [20] [35] [21] [22] [36] [37] [38] [23] [39] [24] [10] [40] [25] [32] [26]	Time Management	Process of estimating and managing the project schedule efficiently and making necessary adjustments in the project timeline
2	[33] [27] [20] [21] [41] [42] [39] [24] [25] [43] [10] [26] [44] [45]	Cost Management	Process of cost estimation and cost control to ensure that a project remains within budget while meeting its scope

No.	Sample References	Dimension	Description
3	[33] [20] [21] [46] [22] [1] [23] [24] [25] [26]	Quality Control and Inspection	Process of managing quality of the project to ensure that the project has been built or implemented correctly
4	[47] [20] [21] [24] [25] [26]	Environmental Process	Process of managing the potential environmental impacts of the project on nature and the human environment
5	[48] [49] [7] [38]	Right-of-Way and Utilities	Process of managing the access to the project and route the utilities to it
6	[33] [50] [51] [52] [53] [23] [54] [24] [55] [26]	Safety	Process of identifying hazards and managing risks related to the project workplace, workers, etc.
7	[56] [41] [27] [17] [28]	Outsourcing	Process of using consultants or contractors outside of the agency to help with a project
8	[7] [57] [58] [59]	Value Engineering	Process of providing all necessary functions of a project at the lowest possible cost
9	[60] [12] [2] [61] [62]	Change Orders	Process of preparation and support changes in the scope of work that is agreed to by the project's involved parties
10	[61] [63]	Type of Contracting	Process of selecting the contract type, including project delivery and procurement system
11	[7] [64] [61] [65] [66]	Workforce Qualification	Process of selecting and/or training the employees to ensure that they acquire needed skills
12	[67] [61] [68] [69]	Operation and Maintenance	Process of assuring that the project performs the functions for which it is designed and constructed.

Time Management

Time management allows the project manager and project team to manage the project schedule efficiently and make necessary adjustments in the project timeline, based on the project requirements [2]. The first step is time estimation, which determines the duration of the project delivery process. The duration of each task in project delivery is usually estimated based on available resources and historical data from similar projects [70]. The activity sequence and scheduling design are required to perform the time estimation for scheduling [71]. In most projects, the expected duration from beginning to end is stated in

the project contract. In most types of contracts, the financial management of projects relies on the project adhering to the project scheduling. Therefore, any delays in accomplishing the scheduled milestones might lead to tremendous problems in project budgeting due to cost overruns, and consequently result in the dissatisfaction of project owners and stakeholders.

Schedule delays are one of the main issues in the project management process [10]. According to Thomsen et al. [5], between 40% and 50% of all construction projects in the U.S. consistently fall behind the baseline schedule. There have been numerous studies to investigate the reasons for schedule delays, including change in scope, faulty execution, design defects and delays, planning defects and delays, procurement issues, subcontractor productivity defects and delays, utility relocations, differing site conditions, unforeseen field conditions, utility conflicts, local issues, permitting issues, unexpected environmental conditions (e.g., weather), environmental planning delays, and poor communication between stakeholders (e.g., [60] [72] [73] [74]).

Several tools and methods are available to provide a managing tool to track the timeline of construction projects, and their implementation is vital due to the enormous number of tasks and activities that must be performed for both simple and complex projects [75]. The three most common scheduling methods in construction projects are Gantt charts, the critical path method (CPM), and the program evaluation and review technique (PERT). The Gant Chart is the simplest method and is usually used in presentations to show the main stages of project deliveries that stakeholders can perform to control their projects. The CPM and PERT are most often used for project time and resource management in construction projects. Project activities in CPM and PERT methods are connected based on the determined critical path, which is a sequence of activities that delay in each of them causes delays in the entire project delivery process. The critical path is essential for understanding the impact of project activities on the overall project time. Several computer-based time management tools, including Primavera, Microsoft (MS) Project, and open-source project management tools, are also available to accelerate the scheduling process [34] [35] [46] [32] [76].

Cost Management

Delivering a transportation project within the estimated budget is one of the most critical aspects of the project's success [12], as the project budget can affect other elements of a project such as time, quality, and safety [26]. Turochy et al. [77] performed a comprehensive study of different methods that are used by state DOTs for highway

project cost estimation, and they concluded that the essential elements of cost estimation for highway projects are the cost of preliminary engineering, ROW, and construction cost. The cost estimates for construction projects are performed in two stages: the initial and the final cost estimations. The initial cost estimation is performed in the feasibility stage of projects to understand the overall required budget for completing the projects. The final cost estimation is performed after completion of the design work to enable the project manager to allocate the resources to each project task accurately and control the project cost. The initial cost estimation can be performed by generalized models, using data from previous similar projects. Many research studies confirmed that statistical prediction models, such as multiple linear regression and neural networks, can successfully perform the initial cost estimates for transportation projects (e.g., [77] [42] [41] [78]). However, after completion of the design work, a more detailed cost estimation (e.g., unit cost) must be performed to manage the project cost more accurately.

Cost overruns are an important issue in transportation projects, as approximately 50% of the heavy transportation projects in the U.S. exceed their initial cost estimations [79]. A cost overrun is an increase in the cost of project tasks that is not predicted in the project budget and detailed cost estimation for project planning. Numerous researchers have investigated the reasons for cost overruns, including changes in scope, schedule delays or changes, different site conditions, unforeseen field conditions, utility conflicts, cost estimation defects, faulty execution, unexpected environmental conditions (e.g., weather), procurement issues, design defects or delays, earned value management defects, engineering or construction complexities, contract issue, local issues or permitting issues, and ROW costs ([36] [79] [38] [43] [80]).

Quality Control & Inspection

Having a robust quality control system is essential to achieve overall success in project delivery of transportation projects. Quality control and inspection systems mitigate the mistakes and rework in the projects and help projects to deliver on time and on budget [81] [82].

Before construction begins, the owner should be assured of the quality of the design work. Then a systematic procedure must be established by the project manager to review and confirm the quality of materials and technical specifications according to the codes, standards, and design specifications [83]. Quality control should be monitored continually at the job site by the project manager [84]. All project plans and documents should be reviewed carefully and compared with performed works at the job site. Also,

the material test on the job site or in the laboratories must be performed whenever it is required.

To have a successful quality control system, it is necessary to set standards and implement educational training and measuring tools for each project task [85]. New technologies such as computer visualization, data management, and reporting tools can also be used to enhance quality control and inspections of transportation projects [86] [87].

Environmental Process

To successfully deliver a transportation project, the project manager must be aware of all regulations and required authorizations and permits for the project's environmental process. The potential environmental impacts of the project on nature and humans' environment should be studied before the implementation of any construction activities. The project manager should cooperate with governmental agencies to avoid any issues related to environmental concerns. Having a good document management system helps to expedite environmental studies of transportation projects; therefore, the availability of the plans, aerial photographs, topographical maps, justification studies, previous environmental impact studies, and previous public hearings documents are recommended [47].

Right-of-Way and Utilities

One of the factors that impacts the success of infrastructural projects is the ROW [48] [49] [7]. Transportation construction projects require thousands of utilities to be installed within the ROW of transportation routes. Delays in acquiring the land and/or permits for the ROW may lead to schedule delays and cost overruns. According to Crossett and Hines [7], it is important to acquire ROW permits before starting the construction process. Involving the owners in the design phase, conducting in-depth interviews, providing educational programs for professional staff, and facilitating effective communication between the transportation agencies and utility departments are among the successful practices for ROWs in transportation projects [48]. In addition, according to Quiroga and Pina [49], the application of a geographic information system (GIS) with a utility data inventory model can assist the project managers in managing the ROW of utilities within the highway networks in a timely and efficient manner.

Safety

Due to the hazardous conditions that are inherent in construction works, it is important to implement safety practices to mitigate potential injuries and fatalities at the job site during construction, as well as afterwards and during the project maintenance period. Road construction projects need special safety requirements due to the moving equipment and the workers' exposure to passing vehicles in work zones.

The Occupational Safety and Health Administration (OSHA) handbook explains the safety practices and requirements that should be followed for all construction works [88]. Additionally, the Federal Highway Administration (FHWA) developed the National Highway Work Zone Safety Program (NHWZSP) to improve safety in construction work zones for highway projects. Numerous research studies have investigated the best practices for construction safety (e.g., [52] [53] [89]). However, for reaching the highest standards in construction safety, most practices can be categorized inside the activities for improving safety education (e.g., [55] [90]), safety equipment (e.g., [51] [91] [92] [93]), safety workplace enforcement (e.g., [94]), and owner's and management's roles (e.g., [93] [95] [54]).

Outsourcing

Outsourcing refers to the use of contractors who are not employed by the state's DOT design, construction, and maintenance offices. It can be one of the most important factors for on-time and on-budget delivery of transportation projects [96]. Because transportation projects demand a high level of resources during a limited time period for project delivery, many state DOTs are using outsourcing to facilitate the delivery of their projects [97]. It can be used in seven main project delivery stages: administration, planning, design, construction, maintenance, operation, and ROW [18]. Based on a study by Moore et al. [17], 34 U.S. state transportation agencies use outsourced services for design, construction, maintenance, and other related services. Warne [18] showed that the requirements of special skills, staffing, and equipment are the main motivations for DOTs using outsourcing; cost-effectiveness is rarely considered as the main motivation.

The benefits of outsourcing have been confirmed by many studies (e.g., [27] [17] [18] [61]). Some potential benefits include improvement of quality, accommodation of peak demand, enhancement in project delivery speed, broader access to expertise, improvement of efficiency, decreased costs, and better innovation and risk management [17]. A survey study by Warne [18] approved the overall satisfaction of outsourcing

practices adopted by state DOTs which help them to successfully deliver projects, fulfill their schedule commitments, provide the ability to bring complex projects to fruition, and meet legal requirements. Although benefits like accommodation of peak demand and broader access to expertise are supported by most studies, some of the other benefits, like cost efficiency and quality improvement, are challenged by others. Several studies were conducted to understand the cost efficiency of DOT projects when they use in-house resources versus when they use outsourcing. Moore et al. [17] noted that DOTs using consultants for design services experienced less cost growth than those performing the services in-house. Fanning [98] reported that the DOTs using a successful ratio of in-house to consultant services achieved the lowest design cost. Other studies, however, showed that, on average, consultant design is more expensive than in-house design (e.g., [16] [99]). Wilmot [99] reported that due to an increase in the cost of contract preparation and supervision of consultant design, the cost to DOTs for consultant design is about 20% more than for in-house design. Table 2 summarizes the cost-efficiency investigations for in-house versus consulting design services from the mentioned studies.

Table 2. Summary of Previous Studies on Cost Efficiency of In-House vs. Consulting Services

Ref	Outsourcing Activity	Research Method	Results
[56]	Design	Survey study	In-house cheaper than consultants
[98]	Design	A survey from the Federal Highways Administration (FHWA) of 50 states	Consultants cheaper than in-house with 50%~70% outsourcing
[100]	Design	A survey from 10 states	In-house cheaper than consultants
[97]	Design	Literature review from past studies	In-house cheaper about 20% in comparison to consultants
[99]	Design	Louisiana DOT case study	In-house cheaper than consultants
[16]	Design	Simulation	In-house cheaper about 17% to 19% in comparison to consultants
[101]	Design	Literature review from case studies	In-house cheaper than consultants

Most studies noted that it is very difficult to fairly compare the design costs of projects utilizing in-house with those using consultant services. However, the majority of studies

concluded that regardless of the wide variety of outsourcing benefits, it is less expensive to utilize in-house services than to use consultants.

Decision-making for outsourcing can be a complicated process. Deis et al. [28] suggested five factors to consider for outsourcing: (1) economic impact, (2) vendor service, reliability and service quality, (3) legal ramifications, (4) impact on strategic core competencies, and (5) sociological factors. Warne [18] stated that the DOTs typically consider the types of contractors needed, prequalification procedures, the contract management process, the selection process, and payment methodologies. Another concern for outsourcing is the correct ratio of in-house to consultant services. According to McMinimee et al. [61], the consultant design ratio can vary between 20% in Missouri to more than 80% in Arizona, Florida, and Utah. For instance, for the preconstruction process, the Colorado DOT prefers to perform the projects with 45% in-house and 55% outsourcing [102]. Fanning [98] reported that the states with less than 20% outsourcing in their engineering design have the highest design cost, and states with outsourcing between 50% and 70% have the lowest design cost. According to Warne [18], the need for special skills, staffing, and equipment are the main reasons that DOTs use outsourcing.

Value Engineering

Value engineering requires a systematic technical review process to closely match the engineering design to the value that the owner expects from the design. The main reason for value engineering is to decrease the project cost without sacrificing quality [103]. It can also decrease project delivery time. A value engineering analysis should be conducted during the planning or preliminary engineering phase of the project. If the updated cost estimate for the preliminary and design phase of the project meets or approaches the value engineering threshold, a value engineering analysis must be conducted to control the project budget. For most federally funded transportation projects, value engineering is obligatory.

Change Orders

Change orders occur when construction work is added or deleted from the original scope of work stipulated in the contract [104]. Avoiding or minimizing change orders protects projects from schedule delays and cost overruns [105]. Change orders can be issued by the owner, designer, and contractor, and alter the amount of work, time, and/or requirements stated in the original contract between the owner and the contractor.

Changes occur most often in complex projects, and are directly related to an increase in the total number of joint venture partners in a project the number of funding phases from concept to project completion, and the number of executive oversight entities above the project management level [2].

Project managers should always be prepared to minimize the consequences of change orders, since they are unavoidable in most construction projects [106]. According to the Louisiana Department of Transportation and Development (DOTD), change orders are classified into seven categories that are based on specific conditions during the construction: (1) quantity errors or omissions, (2) differing site conditions, (3) DOTD convenience, (4) third-party accommodations, (5) contractor convenience, (6) untimely ROW/utilities, and (7) design error.

Types of Contracting

Another important factor in project management is the decision pertaining to the type of contract. Types of contracting determine the responsibilities of the stakeholders (e.g., the owner, the design department). The common types of used by DOTs are design-bid-build (DBB), multi-prime (MP), construction management at risk (CMR) or construction management general contractor (CMGC), design-build (DB), and integrated project delivery (IPD). The benefits and drawbacks of each contracting method were investigated in previous studies (e.g., [63]). The owner has the most responsibility and control over a project with the multi-prime method, and the lowest responsibility and control over a project with the design-build method. However, the projects that allocate more responsibility to the owners are more likely to face adversities due to the low level of communication between designers and contractors [107].

Workforce Qualification

Using a trained or high-skilled workforce is one of the main criteria for increasing productivity in construction projects, and leads to on-time and on-budget delivery of projects [64] [108]. The quality of the workforce is directly related to project success [66], and can be measured by workforce health; absenteeism; and levels of commitment, empowerment, skill and experience, familiarity with the job, staff turnover, and involvement [65].

Operation and Maintenance (O&M)

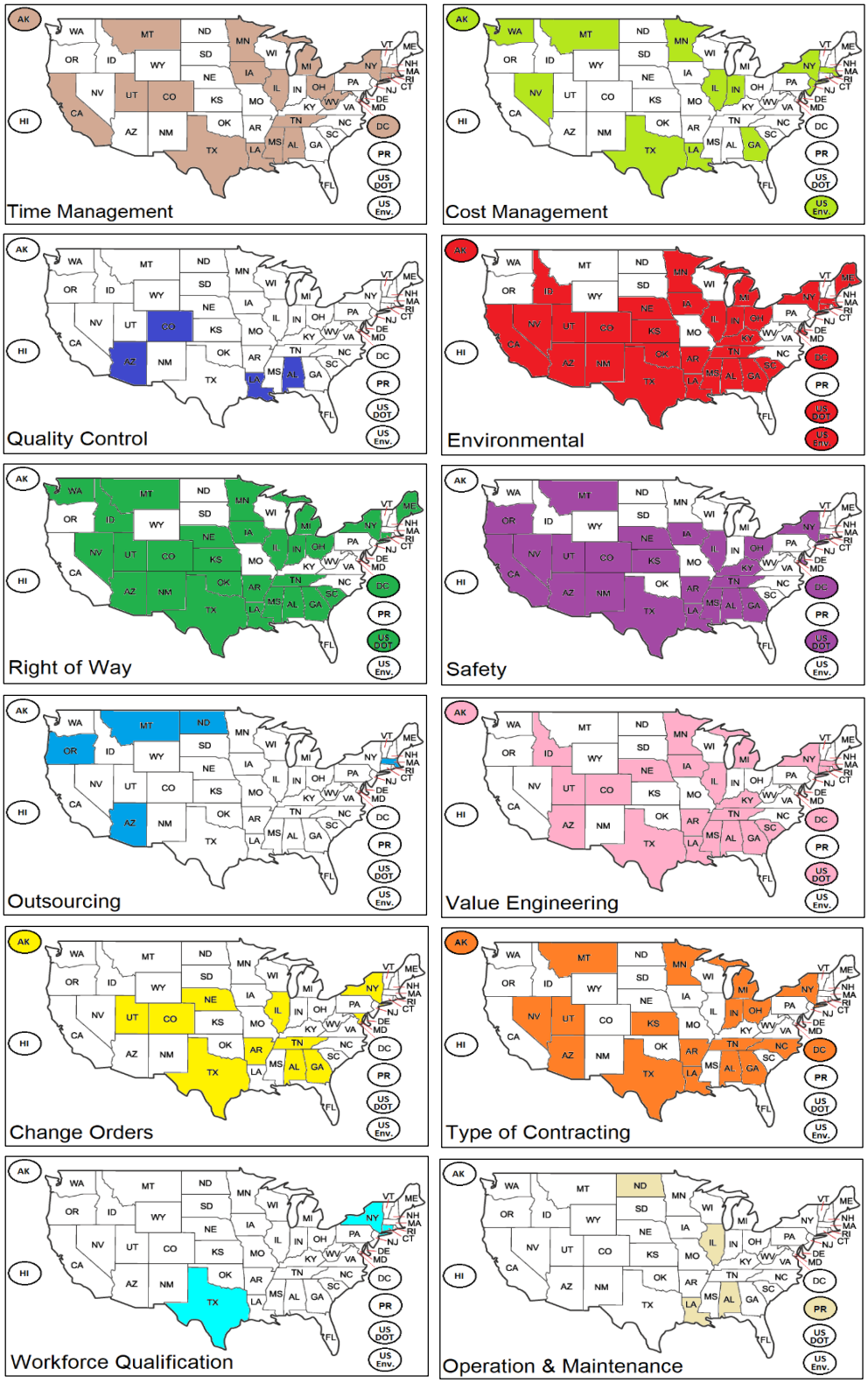
It is vital that the systems that support the infrastructure, such as utility systems, parking lots, roads, and drainage systems be able to meet their intended function during the project's designated useful life. O&M plays an important role in ensuring that projects function at the level for which they were designed. A systematic approach to regular maintenance activities must be employed to ensure the effectiveness of designed systems and networks during their useful life period [109] [110]. Preventive repair and maintenance activities should be planned, and the project manager verify the accuracy of the documents and execute procedures for activities and tasks related to O&M. Many studies have been conducted in recent years performed on the benefits of using new technologies, such as building information modeling (BIM) and intelligent monitoring systems for O&M (e.g., [86] [98] [111]).

Project Management Dimensions at State DOTs

Many DOTs have their own project management manuals and guidelines, and the research team collected and reviewed 87 of them to see whether the identified project management dimensions were addressed. A list of these manuals and guidelines are provided in Appendix A. The research team mapped the documents based on the geographical locations for each identified project management dimension, and the results are shown in Figure 2.

Various documents in most of the DOTs pertain to time and cost management; however, the in-house software or methods for these practices differ from state to state. There are fewer manuals for implementing quality control practices than for time and cost management, implying that quality control is a lower priority for the stakeholders than time and cost management.

Figure 2. Project Management Dimensions in State DOT Documents



Since transportation projects are usually large, are located in diverse areas, and have a considerable impact on their surrounding environment, many manuals are available that pertain to the environmental process. Special attention must be paid also to the acquisition of the land and the ROWs of utilities within the transportation routes. The construction of ROWs is one of the specialized construction activities in transportation projects; therefore, many guidelines have been developed by state DOTs to ensure their proper construction. Safety manuals are also among those most available for transportation projects because of the danger of moving vehicles and big equipment on the job sites.

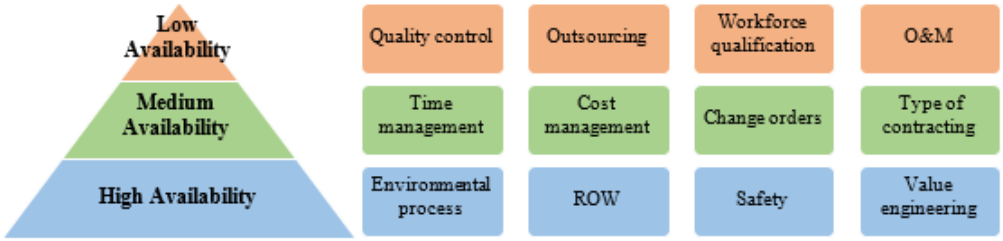
A limited number of studies have been conducted on the various aspects of outsourcing, such as the proper construction activities or the recommended ratio of in-house to outsourcing, and there is no or little agreement on how to determine its benefits. Therefore, few manuals are available to guide agencies in their outsourcing of specific parts of projects. On the other hand, value engineering is a very important aspect of project management. Transportation projects are massive and expensive, and there is a limited budget for each project. Even a small enhancement in projects can make millions of dollars difference in the project cost.

The subject of workforce qualification in the manuals is mostly limited to reviewing federal and state regulations for hiring; the qualifications needed for the workforce for project success are not discussed. Finally, few manuals exist for O&M because these tasks are usually performed after the project's completion and are outsourced by some agencies.

Based on the availability and frequency of project management dimensions in the collected documents, three categories are defined as low availability (less than six state guidelines), medium availability (between 6 and 21 state guidelines), and high availability (more than 21 state guidelines). The project management dimensions in each category are presented in Figure 3.

Project management practices with fewer formal guidelines include project management dimensions of quality control, outsourcing, workforce qualification, and O&M. Project management practices with a medium number of formal guidelines include project management dimensions of time management, cost management, change orders, and type of contracting. Project management practices with a high number of formal guidelines include project management dimensions of the environmental process, ROW, safety, and value engineering.

Figure 3. Project Management Dimensions based on Availability



It should be mentioned that it is possible that some state DOTs have these documents, but have not made them publicly available. However, publishing these documents can be very beneficial to a project's success because the documents enable the outsourced contractors and other stakeholders to perform their duties more efficiently. Keeping the documents updated enables agencies to utilize the material for project management practices and for providing guidelines on new technologies (e.g., data management, data visualization systems, and automation technologies).

Based on the collected and reviewed documents, it can be concluded that most DOTs lack manuals for project management dimensions of quality control, outsourcing, workforce qualifications, and O&M. It was observed that the states of Alabama, Arizona, and Illinois have more manuals available for their users. This information can help state DOTs focus on providing needed manuals in their agencies.

Survey Results and Discussion

This section presents the development, distribution, and results of an online survey conducted in the fall of 2019. First, the survey development, distribution, and data collection procedures are summarized, then the results (organized by topics) are presented. Finally, the key findings are summarized.

This study, including the survey instrument, was reviewed by the Louisiana State University Institutional Review Board (IRB), and since it constituted no more than minimal risks to the participants, it was approved for IRB exemption. A copy of the approval letter is accessible in Appendix B.

Survey Data Collection Procedure

Survey Design

In the first step, the research team identified potential questions associated with the project's objectives. Next, they categorized the potential questions. Through an exclusion procedure, the non-useful or repeated questions were excluded from the survey, and the answer options for each question were suggested and finalized through a comprehensive study on probable responses. Finally, the classified questions were drafted as a document.

Survey Development

After designing the survey, the research team organized a draft of the questions and put them into a web-based survey platform called "QUALTRICS" (Qualtrics Website). (Louisiana State University provides its researchers with a license for this software.) Next, the research team asked four experts and professionals to pilot-test the survey. After receiving their feedback and suggestions, the research team imposed the final modifications, deleted the irrelevant questions, and finalized the online version of the survey. The final version of the survey questions is accessible in Appendix C.

The final questions of the survey were classified into six sections, including "General Information," "Project Delivery," "Cost Management," "Time Management," "Project Management," and "Best Practices."

Survey Distribution

After developing the survey, the research team identified the potential respondents from different state DOT agencies and invited them by email to participate in the survey and to share their points of view. A copy of the invitation letter is accessible in Appendix D.

The research team listed more than 300 experts and contacted them multiple times for this study. After multiple follow-up emails, a total of 96 completed surveys were collected from experts working for different DOTs.

Survey Respondents' Profile

The 96 completed surveys were collected from experts and professionals from 25 different DOT agencies, including Alabama, Arizona, Colorado, Connecticut, Florida, Idaho, Iowa, Kentucky, Louisiana, Maine, Maryland, Minnesota, Nebraska, New Mexico, North Carolina, Ohio, Oklahoma, Oregon, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, and Washington. The demographic information of the respondents is presented in Table 3.

Table 3. Demographic Information of the Participants

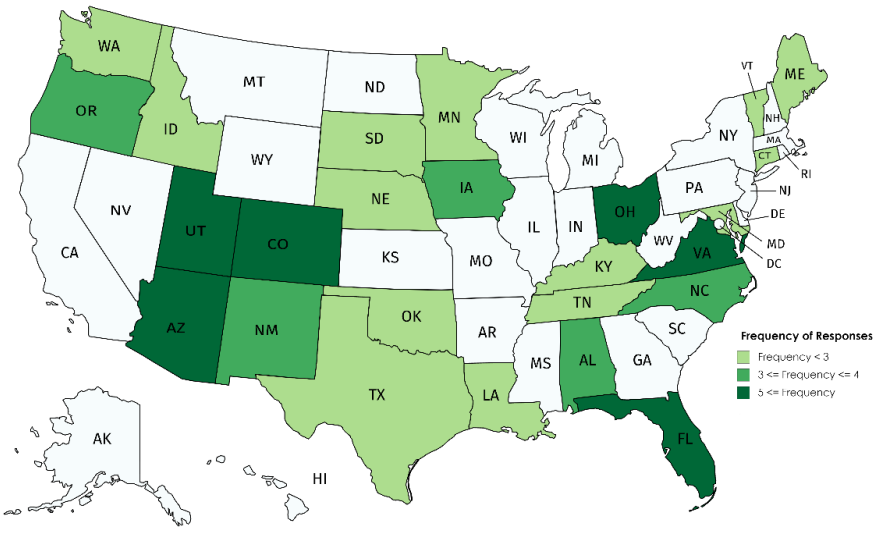
Position	Experience	Percentage
Construction Engineer	More than 10 Years	20%
Construction Manager	More than 10 Years	7%
Chief Construction Officer	More than 10 Years	7%
Administration Director	More than 10 Years	6%
Assistant Construction Engineer	More than 10 Years	3%
Construction Supervisor	More than 10 Years	1%
Contract Manager	More than 10 Years	1%
Deputy Director	More than 10 Years	1%
Field Engineer	Less than 5 Years	3%
Field Engineer	Between 5 and 10 Years	1%
Field Engineer	More than 10 Years	1%
Project Manager	More than 10 Years	13%
Project Manager	Between 5 and 10 Years	3%

Position	Experience	Percentage
Staff Engineer	More than 10 Years	4%
Staff Engineer	Between 5 and 10 Years	1%
Superintendent	More than 10 Years	1%
Others	More than 10 Years	24%
Others	Less than 5 Years	1%

As Table 3 shows, 89% of the respondents had related experience of more than 10 years, and 20% and 16% of the respondents were working as construction engineers and project managers, respectively.

The regions and the associated frequency of the survey responses are presented in Figure 4, which shows that one or two surveys were completed by respondents located at 14 different DOT agencies in Washington, Idaho, South Dakota, Nebraska, Minnesota, Oklahoma, Texas, Louisiana, Kentucky, Tennessee, Maine, Vermont, Maryland, and Connecticut. Three or four respondents were from DOT agencies in Oregon, Iowa, North Carolina, Alabama, and New Mexico, and more than five responses were from DOT agencies in Florida, Arizona, Utah, Colorado, Virginia, and Ohio.

Figure 4. Frequency of Responses



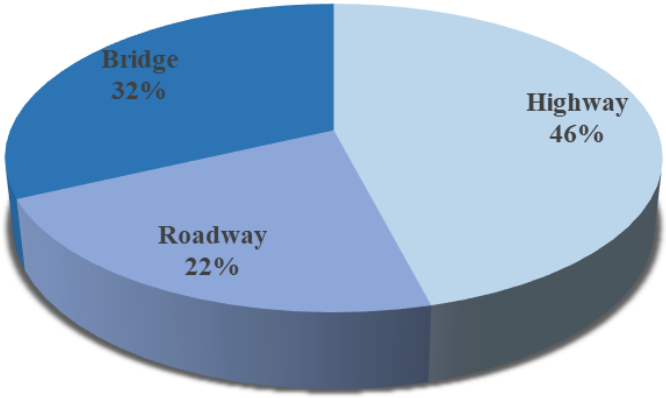
Survey Results Regarding Project Information

The survey participants were asked to select a project in which they were involved that was completed since the year 2015 and to answer the survey questions based on that project. The information resulting from the survey was as follows.

Project Type

The respondents were asked to name the type of project that their responses were based upon. The majority of them (46%) selected a highway project, 32% selected a bridge project, and 22% selected a roadway project. The project type results are shown in Figure 5.

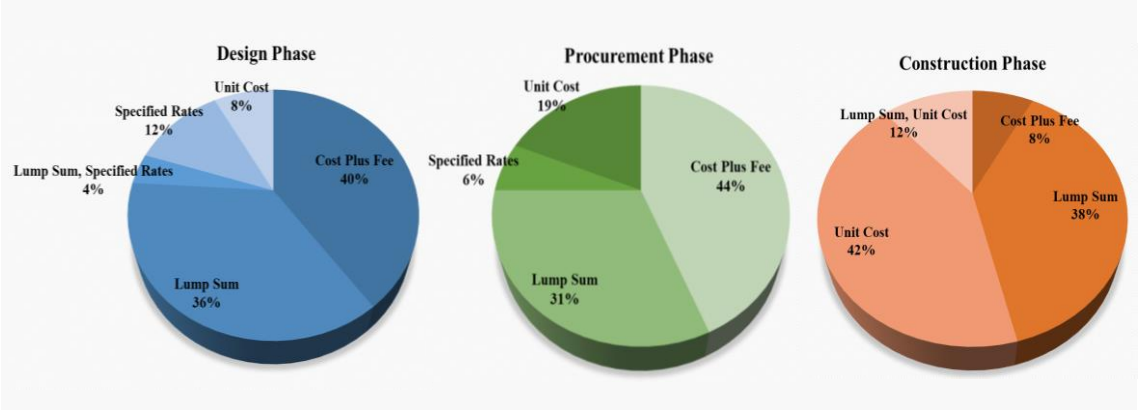
Figure 5. Project Type



Contract Type

A construction contract is a legally binding agreement between two parties that specifies the amount of compensation that the executed job receives and how the compensation is distributed. The respondents were asked about the contract type used in the design, procurement, and construction phases of their projects, and the results are shown in Figure 6.

Figure 6. Contract Type

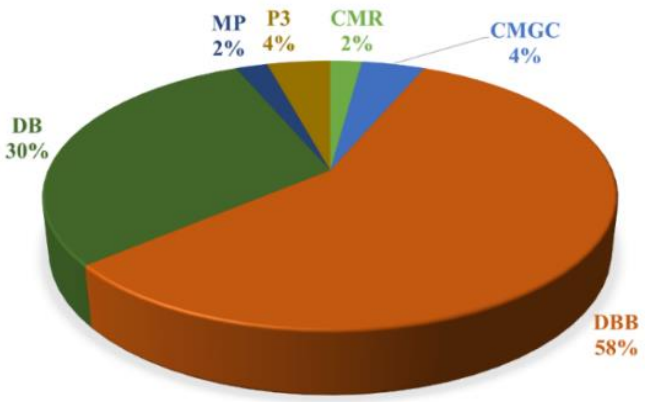


As Figure 6 shows, the design phase was mostly under the cost plus fee and lump sum contract types (40% and 36%, respectively). Similarly, the procurement phase was mostly under the cost plus fee and lump sum contract types (44% and 31%, respectively). For construction contract types, unit cost (42%) and lump sum (38%) received the highest percentages among the various contract types.

Delivery Method

A project delivery method is a system used by an owner for organizing and delivering design, construction, operation, and maintenance services for a structure or facility by entering into legal agreements with one or more entities or project parties. The survey participants were asked about the delivery method used in their selected project, and the results are shown in Figure 7.

Figure 7. Delivery Method



As presented in Figure 7, the respondents mentioned six different delivery methods used in their projects, including design-bid-build (DBB), design-build (DB), construction management at risk (CMR), multiple primes (MP), construction manager general contractor (CMGC), and public-private partnerships (P3). According to the survey results, DBB (58%) and DB (30%) received the highest percentages among the mentioned delivery methods.

Survey Results Regarding Outsourcing in Projects

The survey participants were asked to determine which activities in their project's service life (i.e., administration, planning, design, construction, maintenance, and operation) were outsourced and to estimate the weight of in-house versus outsourced services. They were also asked to highlight the reasons for contracting out some part of the project. The results of the survey regarding outsourcing in projects are presented in this section.

In-house Versus Outsourced Services

The survey participants were asked to determine the activities that were contracted out or outsourced in their selected project, and the results are shown in Table 4. This table illustrates that state DOT agencies mostly prefer to outsource some or most of the design and construction works for their projects.

For roadway projects, the average percentage of outsourced services for the DOT agencies of Colorado, Kentucky, Texas, and Utah was between 60% and 80%. Interestingly, this number for the Arizona DOT was between 0 and 20%.

Table 4. Outsourced Activities and Ratios

Project Type	State	Administration Phase	Planning Phase	Design Phase	Construction Phase	Maintenance Phase	Operation Phase	Right-Of-Way Phase	Environmental Phase	Ratio In-house/Outsource
Roadway	Arizona			√					√	0%-20%
Roadway	Colorado				√	√	√	√	√	60%-80%
Roadway	Florida			√	√	√				20%-40%
Roadway	Idaho			√	√				√	20%-40%

Project Type	State	Administration Phase	Planning Phase	Design Phase	Construction Phase	Maintenance Phase	Operation Phase	Right-Of-Way Phase	Environmental Phase	Ratio In-house/Outsource
Roadway	Kentucky		√	√	√					60%-80%
Roadway	New Mexico			√	√					20%-40%
Roadway	Ohio			√	√					20%-40%
Roadway	Texas			√	√					60%-80%
Roadway	Utah			√	√		√			60%-80%
Bridge	Arizona			√	√				√	0%-20%
Bridge	Colorado			√	√	√	√	√	√	40%-60%
Bridge	Connecticut		√	√	√				√	60%-80%
Bridge	Florida	√	√	√	√	√	√	√	√	0%-20%
Bridge	Main			√	√		√		√	20%-40%
Bridge	Maryland			√	√				√	20%-40%
Bridge	Ohio			√	√				√	40%-60%
Bridge	Oklahoma			√	√				√	60%-80%
Bridge	Vermont			√	√					60%-80%
Bridge	Washington				√					80%-100%
Highway	Arizona			√	√			√	√	20%-40%
Highway	Colorado		√	√	√			√	√	60%-80%
Highway	Kentucky			√	√			√	√	20%-40%
Highway	Main			√						20%-40%
Highway	North Carolina	√	√	√	√	√	√		√	0%-20%
Highway	Ohio		√	√	√			√	√	0%-20%
Highway	Oregon		√	√					√	20%-40%
Highway	Utah	√		√	√		√			40%-60%

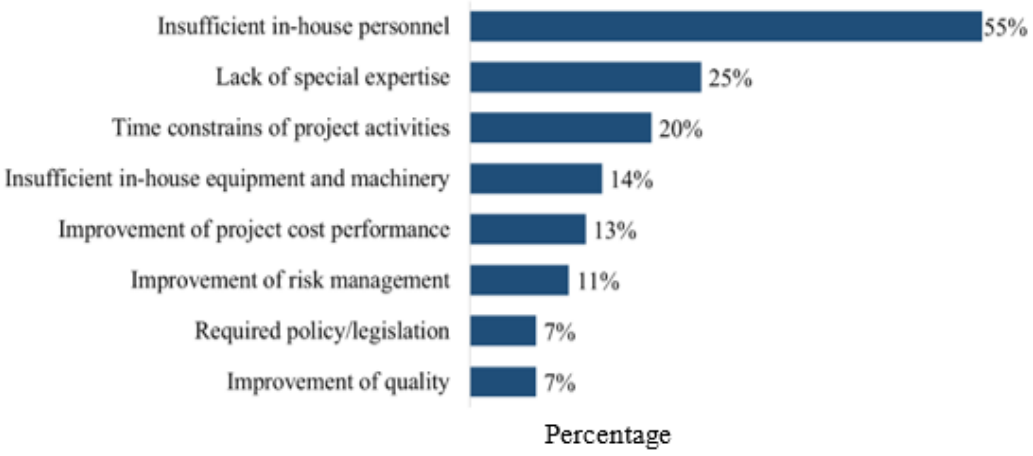
Table 4 also indicates that, although the Florida DOT outsourced all of the phases of its bridge projects (administration, planning, design, construction, maintenance, operation, right of way, and environmental), the average percentage of outsourced services was between 0 and 20%, the same as the Arizona DOT. On the other hand, the Washington State DOT conducted most phases and activities of bridge projects in-house. As shown

in Table 4, North Carolina and Ohio DOT agencies mostly outsourced their highway projects, and the average percentage of outsourced services was between 0 and 20%.

Reasons for Outsourcing the Projects

The survey participants were asked to identify the reasons that they contracted out or outsourced activities in their selected project, and a summary of their reasons is presented in Figure 8.

Figure 8. Reasons for Outsourcing



The results show that 55% of the respondents believed that insufficient in-house personnel was one of the main reasons for outsourcing their project activities. A lack of required particular expertise was the primary reason for outsourcing the projects for 25% of the respondents, and time constraints were given as the third most important reason (20%) for outsourcing activities in a project.

Survey Results Regarding Cost Estimation and Management

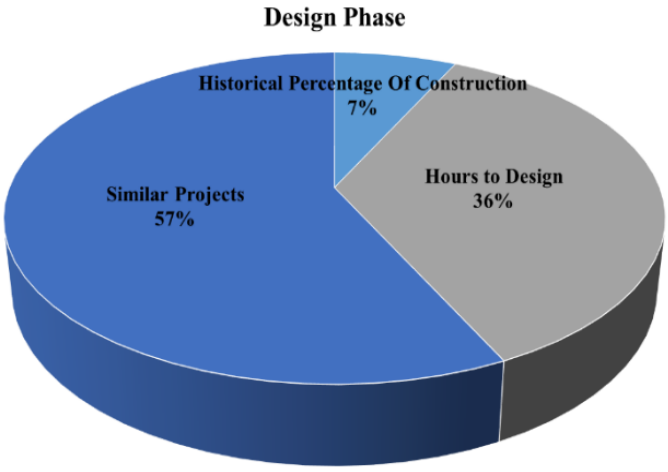
Construction cost estimating is the process of forecasting the cost of a construction project. For accurate cost estimating, construction estimators need to conduct related research and craft and present a comprehensive cost analysis of a construction project. Creating a detailed cost estimate is a time-consuming and laborious process.

The survey participants were asked to determine some of the project management practices that were applied in their selected projects, including cost estimation, cost management, communication, and use of technology. In this section, the results of the survey regarding these project management practices are presented.

Cost Estimation Method

The survey participants were asked about the design and construction cost estimation methods used in their selected projects. As shown in Figure 9, three different estimation methods were used for cost estimation in the design phase: similar projects, hours to design, and historical percentage of construction. Among them, similar projects was ranked first (57%), and hours to design was ranked second (36%).

Figure 9. Cost Estimation Method



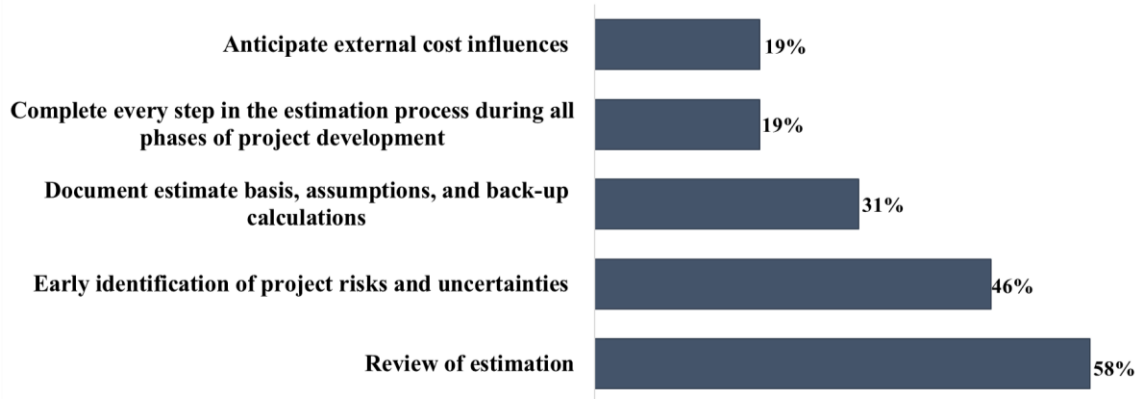
Cost Estimation Practices

The research team conducted a literature review to identify the most beneficial cost estimation practices, which were determined as follows:

- Review of estimation
- Early identification of project risks and uncertainties
- Documentation of estimate basis, assumptions, and back-up calculations
- Completion every step in the estimation process during all phases of project development
- Anticipation of external cost influences

The respondents were asked to identify the implementation level of the aforementioned cost estimation practices by their DOT agencies in their projects. The results are presented in Figure 10.

Figure 10. Implementation of Different Cost Estimation Practices

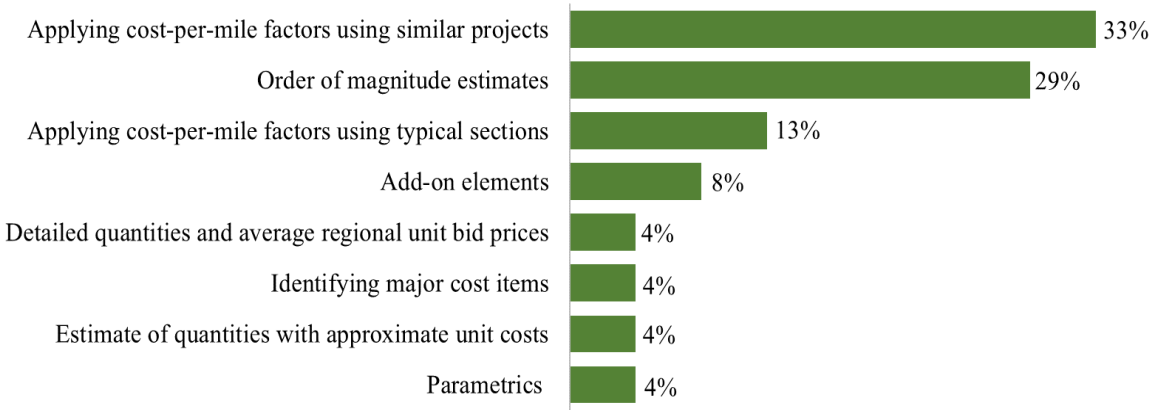


As shown in Figure 10, 58% of respondents mentioned that their DOT agencies adopted the strategy of review of estimation as a cost estimation practice for transportation infrastructure projects. Approximately 45% of respondents replied that the early identification of project risks and uncertainties was implemented by their DOT agencies in highway, bridge, and roadway projects.

Inaccurate cost estimation can have negative consequences on construction projects. There is always some uncertainty when estimating the cost of a construction project, but accuracy can be improved by using different practices during the planning phase or programming and preliminary design phases.

The *planning phase* of a construction project involves details of the development of the project that are designed to meet the project's objectives. In the planning phase, the project team identifies all of the tasks to be conducted, the resources needed to complete them, and a strategy for procuring them. The respondents provided data about the cost estimating practices and activities during the planning phase, and the results are presented in Figure 11.

Figure 11. Cost Estimate Practice in Planning Phase

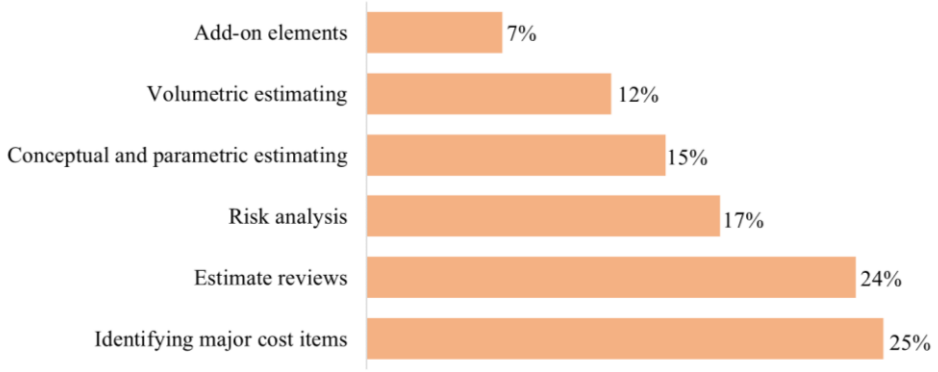


The results showed that eight cost estimation practices are used in the planning phase, with applying cost-per-mile factors using similar projects being the most repeated practice (33%). The order of magnitude estimates was the second most repeated practice (29%) among the mentioned cost estimating practices in the planning phase.

Through the *programming and preliminary design phase* of a construction project, the project criteria are developed in greater detail, which allows the design process to proceed with the development of alternative concepts and the design summary. The respondents were asked about the cost estimating practices used in their programming and preliminary design phase, and the results are shown in Figure 12.

The results showed that six cost estimation practices were used in this phase. Among these practices, identifying major cost items was the most repeated practice (25%). Estimate reviews (24%) and risk analysis (17) were the second and third most repeated practice.

Figure 12. Cost Estimate Practice in Programming & Preliminary Phase



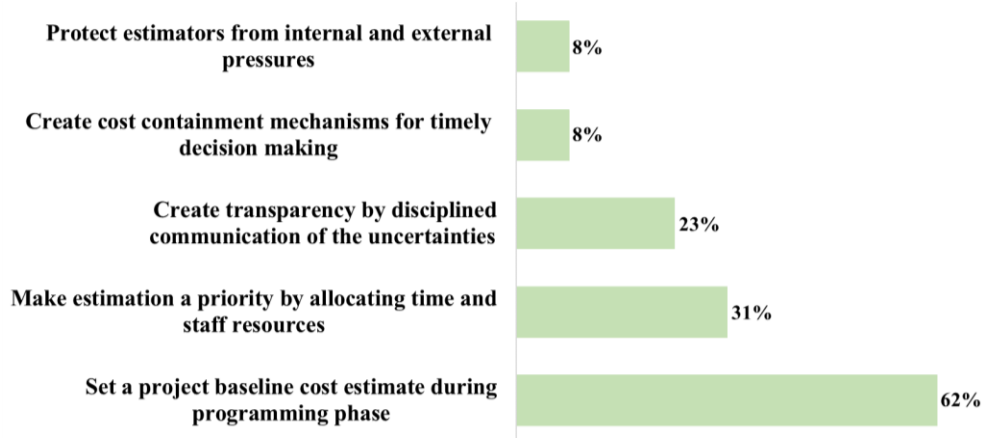
Management of Cost Estimation

Through conducting a comprehensive literature review, the research team identified multiple beneficial management practices through cost estimating, as listed below:

- Protect estimators from internal and external pressures
- Create cost containment mechanisms for timely decision making
- Create transparency by disciplined communication of the uncertainties
- Make estimation a priority by allocating time and staff resources
- Set a project baseline cost estimate during the programming phase

The research team designed a question in the survey related to strategies that can be used to manage cost estimation. As shown in Figure 13, 62% of respondents stated that the strategy of setting a project baseline cost estimate during the programming phase was implemented by their DOTs in transportation infrastructure projects.

Figure 13. Implementation of Cost Estimating Management



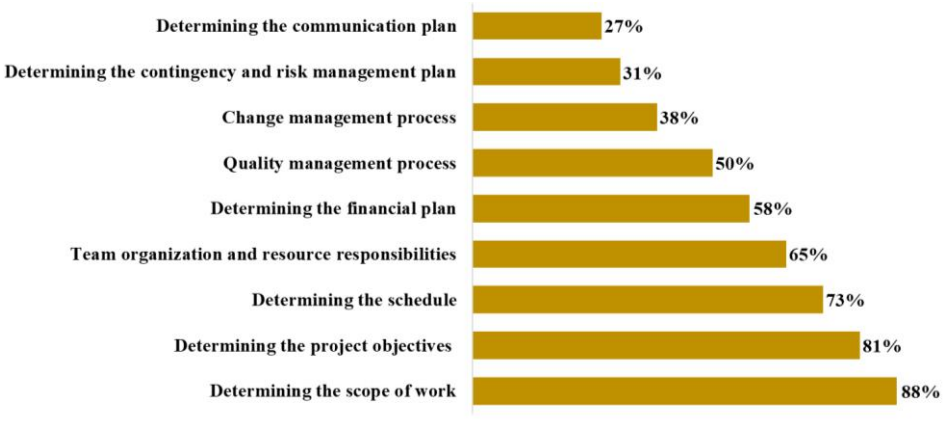
Survey Results Regarding Project Management Plan

Project Management Plan

The purpose of project management in a construction project is commonly to foresee or predict as many risks and problems as possible, and to plan, organize, and control activities so that the project will be completed successfully. The respondents were asked to name the key elements of a project management plan conducted in their project. As the

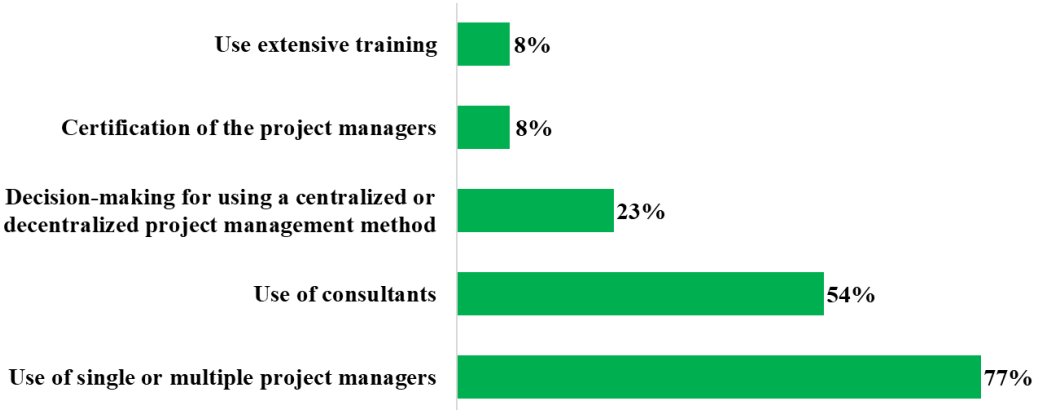
results show in Figure 14, 88% and 81% of respondents believed that determining the scope of work and defining the project objectives are the key elements of a project management plan, respectively.

Figure 14. Key Elements of the Project Management Plan



The respondents also provided information about the project management strategies adopted in their selected projects, and the results are presented in Figure 15. This figure indicates that 77% of the respondents replied that their agencies hired single or multiple project managers for their projects, and 54% of the respondents replied that their DOT agencies hired consultants for their projects. These numbers highlight the importance of outsourced services in the DOT project management strategies.

Figure 15. Project Management Strategies



One of the survey questions was designed to identify the most implemented project management principles in DOT projects. The results are shown in Table 5, which depicts

that 70% of the respondents indicated that their DOT agencies ensure that the project is fully defined, and an equal percentage indicated that the DOT agencies usually oversee consultants and contractors to ensure that their tasks are completed in a timely manner and meet quality standards and regular requirements. The survey participants also replied that 70% of the DOT agencies establish communication with DOT staff and develop an escalation process to resolve conflicts and issues that arise in their projects.

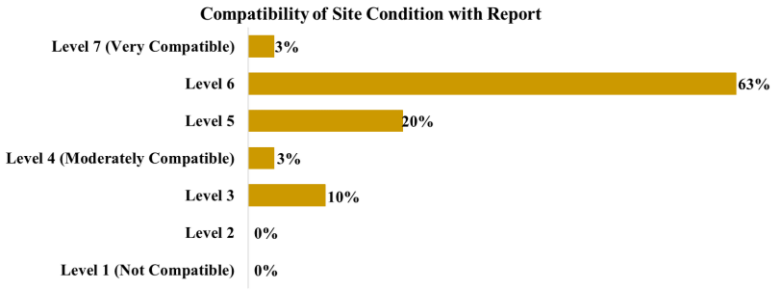
Table 5. Implementation of Project Management Principles

Principles	Percentage
Ensure that the project is fully scoped.	70%
Actively oversee consultants and contractors to ensure work is complete and timely and meets quality standards and regular requirements.	70%
Establish and maintain communication with DOT staff; develop an escalation process to resolve conflicts and issues.	70%
Participate in partnership meetings.	54%
Know and understand pertinent regulations.	50%
Begin work only after funding authorization has been obtained.	50%
Ensure that the project team has the required qualifications, certifications, and experience.	46%
Develop a project management plan and follow it.	42%
Manage the project to meet approved project plans and specifications in order to successfully pass inspections and complete the final acceptance process.	27%
Develop a succession plan that designates replacement staff for key positions.	15%
Establish and implement effective quality-management procedures.	15%
Accurately complete all paperwork, retain it for required time frames, and submit it on schedule to ensure full reimbursement for all eligible costs.	8%
Finish the project within the required time.	4%

Managerial Issues

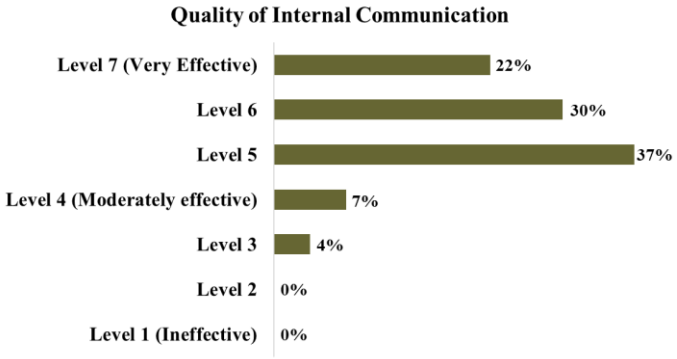
The respondents were asked to rank some of the managerial issues they faced in their selected project. First, the respondents were asked about the compatibility of site conditions with the report. This question consisted of seven options that present seven different levels of compatibility, from level 1 (the site condition was not compatible with the report or 0% of compatibility) to level 7 (the site condition was very compatible with the report or 100% of compatibility).

Figure 16. Compatibility of Site Condition with Report



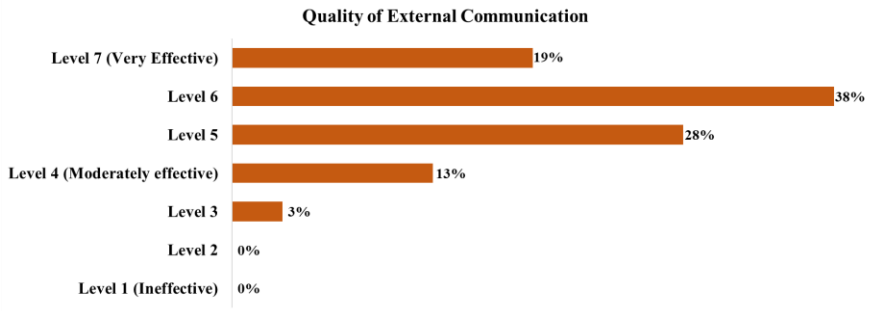
Second, the respondents were asked about the quality of internal communication within the project's entities. This question included seven options that present seven different levels of the quality of internal communication between the project's stakeholders, from level 1 (ineffective internal communication within the respondents' entities or 0% effective) to level 7 (very effective internal communication within the respondents' entities or 100% effective). As illustrated in Figure 17, 22% of respondents believed that the quality of internal communication within their entities was very (100%) effective, and 30% of the respondents described the quality of internal communication within their entities as mostly effective.

Figure 17. Quality of Internal Communication



Finally, the respondents were asked to provide information about the quality of external communication among the project's entities, from level 1 (ineffective internal communication within the respondents' entities or 0% effective) to level 7 (very effective internal communication within the respondents' entities or 100% effective). The results are presented in Figure 18, which shows that about 20% of respondents believed that the quality of external communication between their entities and other parties was very effective (100% effective), and roughly 40% of respondents believed that the quality of external communication of their entities was mostly effective.

Figure 18. Quality of External Communication



New Software/Technology

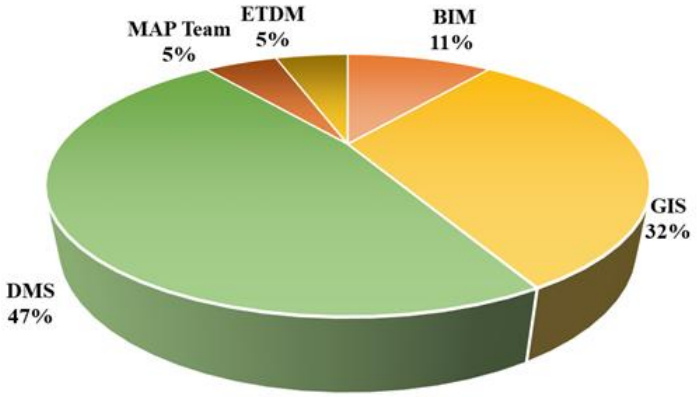
The utilization of new software and/or innovative technologies in a construction project has multiple benefits. Some of these benefits are as follows:

- More accurate cost estimation
- More efficient payroll and accounting

- Effective and efficient management of construction projects
- Single-entry integrated system
- Strong training and technical support

The respondents were asked to provide information about new software and technologies used in their projects. Six options were provided for respondents: building information modeling (BIM), geographic information system (GIS), data management systems (DMS), multi-agency permit team (MAP Team), efficient transportation decision making (ETDM), and an open-ended question. The results are presented in Figure 19, and show that 47% of respondents replied that DMS was used in their projects, and 32% of respondents' used GIS in the highway, roadway, and bridge projects.

Figure 19. Used Software and Technologies



Survey Results Regarding Project Management Implementation

The purpose of this project was to identify the best management practice strategies adopted by DOT agencies. For this purpose, multiple questions about the implementation level of different management practices were designed and included in the survey with a seven-scale rating, as follows:

- level 1: very low level of implementation
- level 2: low level of implementation
- level 3: moderately low levelof implementation
- level 4: moderate level of implementation

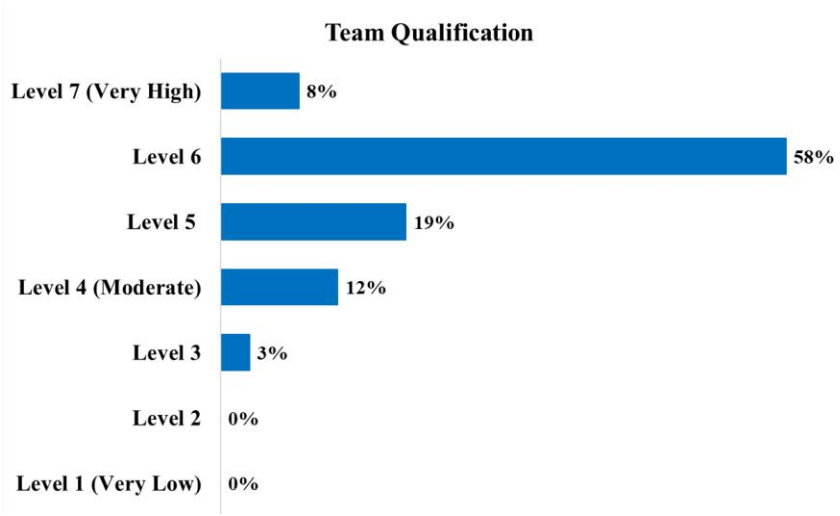
- level 5: moderately high level of implementation
- level 6: high level of implementation
- level 7: very high level of implementation

Team Qualification Strategy

The success of any project is highly related to the project team tasked with delivering it. Even the best-planned projects may fail to meet their objectives if the project team does not perform to the best of its ability. The effective development and integration of the project team are essential to the success of a construction project because the project team will be responsible for the delivery of the scope of the project throughout its lifecycle.

The respondents were asked to provide information about the implementation level of team qualification in their projects, and the results are presented in Figure 20.

Figure 20. Implementation Level of Team Qualification Strategy



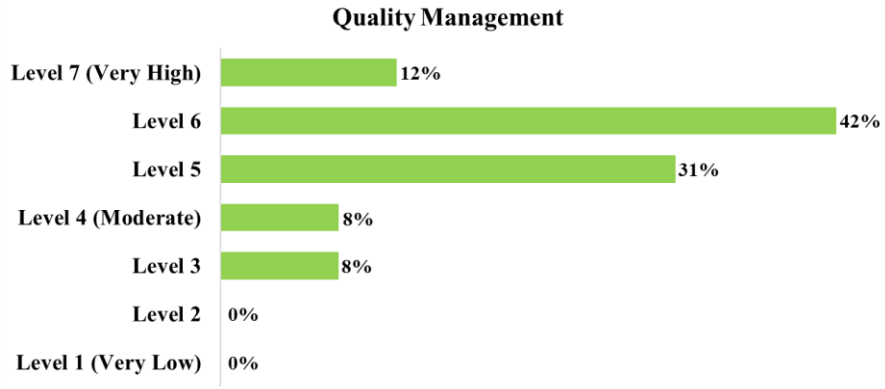
As shown in Figure 20, 58% of the survey participants responded that their DOT agencies highly implemented the strategy of team qualification in projects, and 19% believed that the team qualification strategy was moderately high level adopted in the projects in their DOT agencies.

Quality Management Strategy

Quality management strategy refers to the incorporation of all activities conducted to improve the efficiency, contract compliance, and cost-effectiveness of design,

engineering, procurement, quality assurance (QA) and/or quality control (QC), construction, and startup elements of construction projects. Accordingly, one of the survey questions was about the implementation level of quality management strategy in their projects. The results are presented in Figure 21.

Figure 21. Implementation Level of Quality Management Strategy



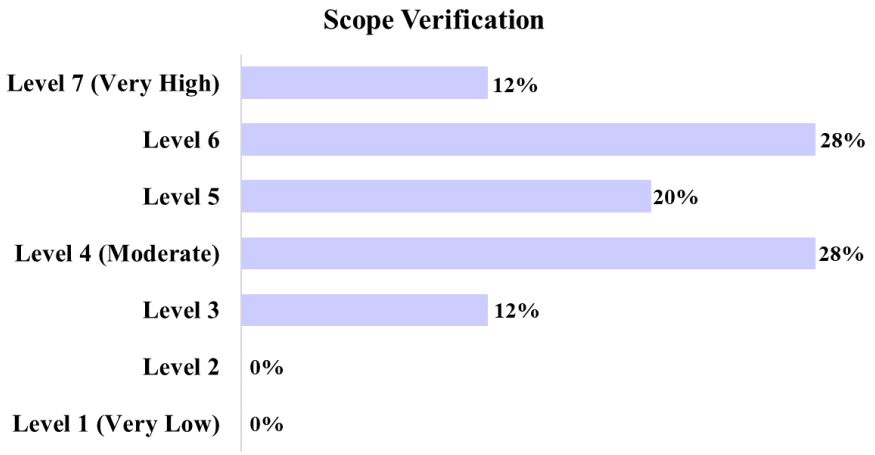
This figure shows that more than 40% of transportation agencies highly adopted quality management strategies in their projects, and more than 30% of the DOT agencies moderately high level implemented the mentioned strategies.

Scope Verification Strategy

Scope verification strategy refers to the process of formalizing acceptance of the project scope by the stakeholders. It requires reviewing work products and results to ensure that all were completed correctly and satisfactorily. Scope verification strategy commonly occurs at the end of each project phase, as part of the project closeout process.

A question pertaining to the implementation level of a scope verification strategy in the survey participant's project was included in the survey, and the results are shown as a chart in Figure 22.

Figure 22. Implementation Level of Scope Verification Strategy



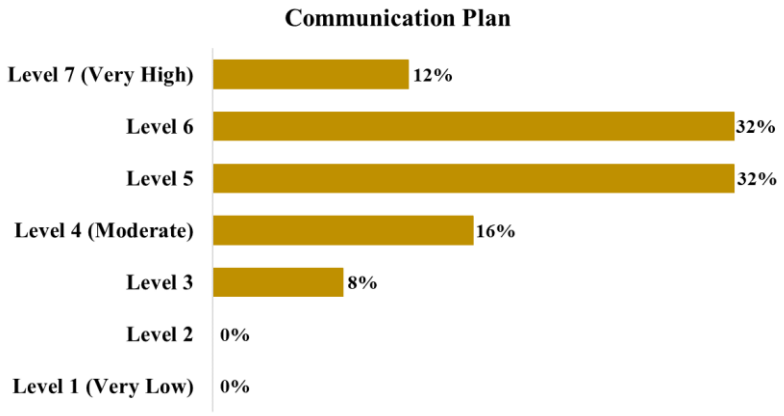
This figure presents that 28% of respondents indicated that a scope verification strategy was highly adopted, while 20% of the respondents indicated that their agency's level of adoption was moderately high level in the transportation infrastructure projects.

Communication Plan Strategy

The strategy of a communication plan is defined as the process of deriving alignment between the communications function and the organization's core objectives. This strategy should always include consideration of employees as a key audience.

Some of the information provided by respondents for this study pertained to the implementation level of communication plans in their projects by their DOT agencies. The results are shown in Figure 23.

Figure 23. Implementation Level of Communication Plan Strategy



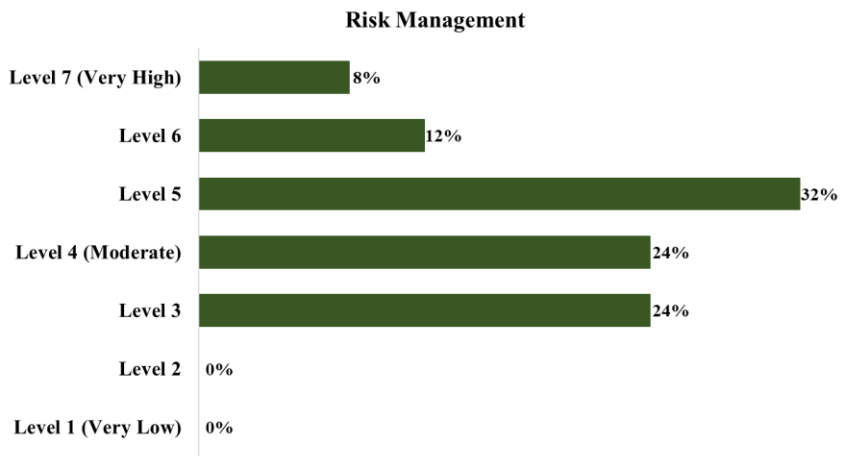
This figure illustrates that 32% of respondents believed that their agencies adopted a high level of communication plan strategy in their projects, and 32% of the respondents believed that their DOT agencies implemented the stated strategy moderately high level in transportation infrastructure projects.

Risk Management Strategy

A risk management strategy provides a structured and coherent approach to identifying, assessing, and managing risk. It builds in a process for regularly updating and reviewing the assessment based on new developments or actions taken.

The survey respondents were asked to provide information about the implementation level of risk management in their infrastructure transportation projects, and the results are shown in Figure 24.

Figure 24. Implementation Level of Risk Management Strategy



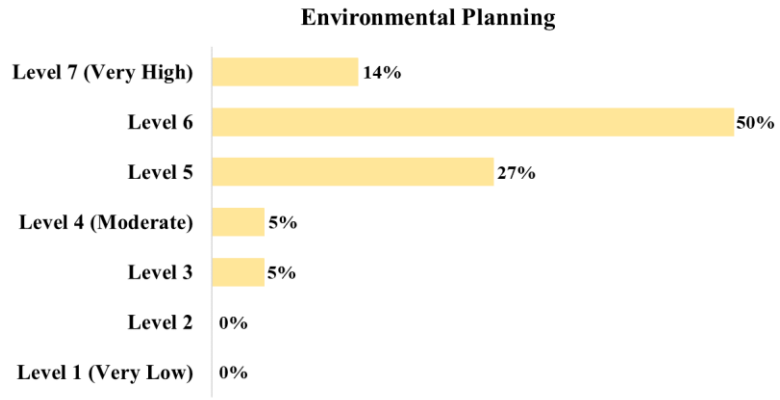
This figure illustrates that about 30% of the respondents indicated that a moderately high level of risk management best practices were adopted by their agencies. Accumulatively, 20% of respondents stated that their agencies implemented a high and very high level of risk management strategy in their projects.

Environmental Planning Strategy

The strategy of environmental planning refers to the process of facilitating decision making to carry out land development, with consideration given to the physical environment, alongside social, political, economic, and governance factors, and provides a framework for achieving favorable outcomes.

In this respect, the other information that the respondents provided was about the implementation level of environmental planning best practices by different transportation agencies in transportation infrastructure projects. The results are shown in Figure 25.

Figure 25. Implementation Level of Environmental Planning Strategy

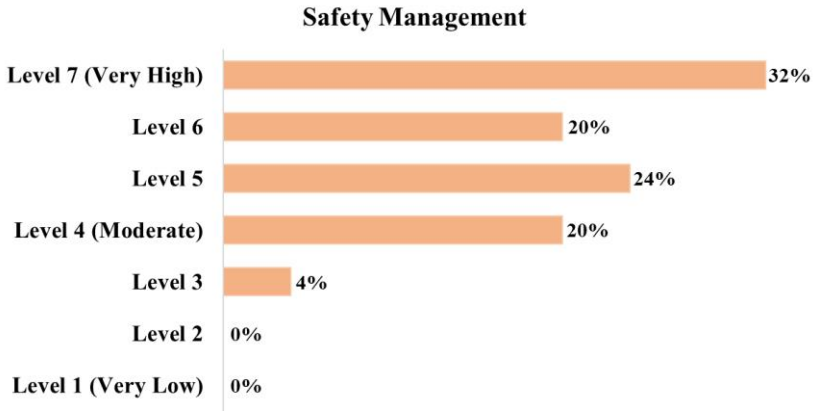


As indicated in this figure, half of the respondents indicated that the agencies that they worked for favorably adopted environmental planning strategies through the execution of transportation projects. Furthermore, 14% and 50% of the participants indicated that their DOT agencies most highly and highly implemented the mentioned strategy by their DOTs through execution of the transportation infrastructure projects, respectively.

Safety Management Strategy

The implementation of a safety management strategy is commonly considered one of the key project management strategies for the execution of construction projects. For instance, top project managers should assess the risk of injury by considering the hazards. Therefore, the research team asked the survey's participants how the stated strategy was adopted in their projects. The results are shown in Figure 26.

Figure 26. Implementation Level of Safety Management Strategy



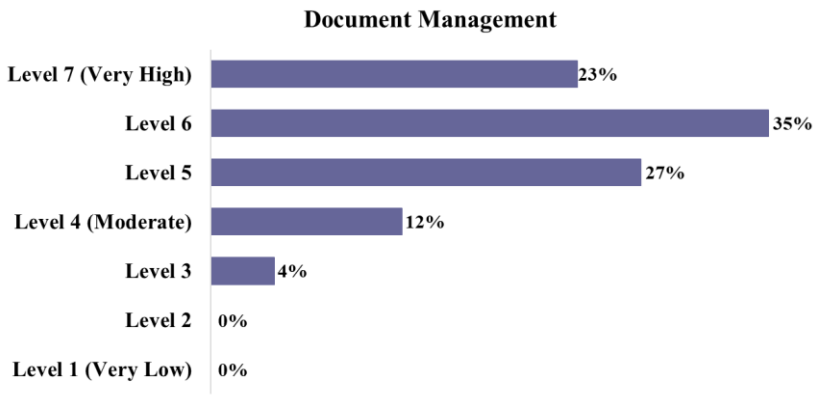
This figure indicates that 52% of DOT agencies highly and most highly adopted safety management strategies in their projects. Furthermore, 24% of respondents indicated that their DOTs moderately highly implemented the stated strategy in their transportation infrastructure projects.

Document Management Strategy

Document management is a critical element of coordination in an organization. Some examples of document management strategies are the availability of plans, aerial photographs, topological maps, justification studies, previous environmental impact studies, and previous public hearings documents.

In this respect, the respondents were asked to provide information about the implementation level of document management in their project by their DOT. The results are presented in Figure 27.

Figure 27. Implementation Level of Document Management Strategy



As shown in Figure 27, 35% of the survey participants believed that the strategy of document management was highly implemented through the execution of transportation infrastructure projects by their DOT agencies. Approximately 25% of the respondents indicated that the stated strategy was most highly adopted by their agencies.

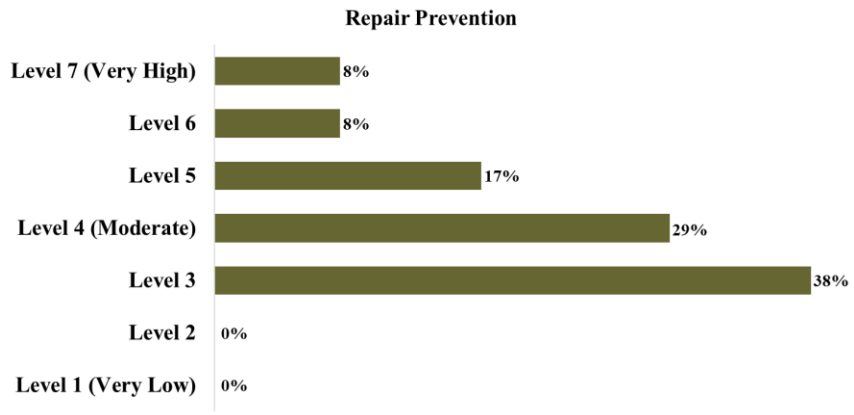
Repair Preventive Strategy

Repair, maintenance, and replacement of equipment, machinery, and systems during the execution of mega-scale transportation projects are usually costly. Accordingly, the adoption of repair preventive can be beneficial for completing a project on time and on

budget. Repair preventive refers to identifying any issues before equipment failure or downtime, through routinely scheduled maintenance. The purpose of the implementation of repair preventive is to maximize the lifespan and runtime of equipment.

The survey participants were asked to provide information about the implementation level of repair prevention strategies in their DOT agencies, and the results are shown in Figure 28.

Figure 28. Implementation Level of Repair Prevention Strategy

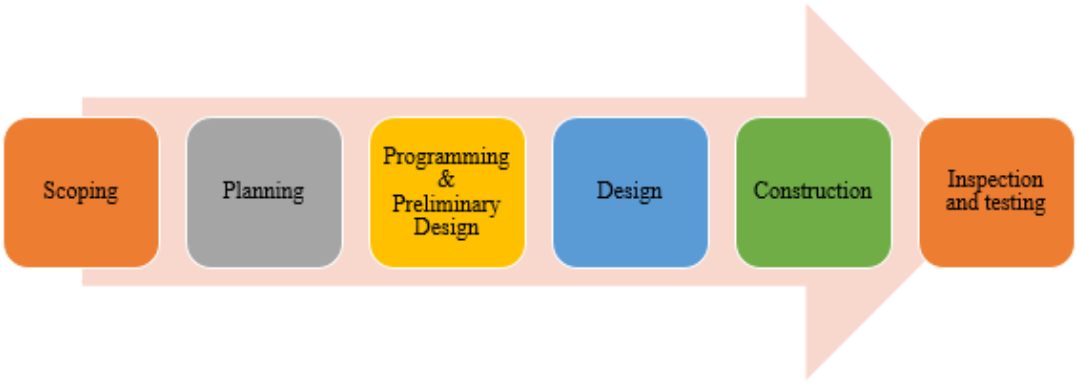


As shown in the figure above, only about 10% of the respondents believed that their agencies very highly adopted the repair prevention strategy in the transportation infrastructure projects. Approximately 10% of the respondents indicated that their DOT agency highly implemented the stated strategy in their projects.

Summary of Best Project Management Practices

Finally, the research team identified the project management practices and asked the respondents to identify the best and most frequently used strategies in their projects. To determine the best practices, the project team classified a transportation project lifecycle into the six main phases shown in Figure 29. The project management practices in each phase were identified and presented to the respondents, and they were asked to select the ones most frequently used. The results for each phase are presented in this section.

Figure 29. Project Lifecycle Phases



Scoping Phase

The scoping phase is the initial step in the project development process. A project manager is assigned after the project sponsor defines the project's purpose and needs, and determines the funding sources. The scoping phase duration depends on the project's complexity, and involves identifying stakeholders, establishing the project team, confirming the project purpose and need, initiating the environmental review process, determining the level of environmental documentation and required permits, performing the survey, identifying risks, considering context-sensitive solutions, and evaluating public involvement strategies. The scoping phase begins when the project manager assembles a multi-disciplinary project team, which includes other appropriate stakeholders, who evaluate the project and the available resource materials and proceeds to investigate the project's individual disciplines. The project team defines the required project deliverables, the working budget, and the schedule for designing and developing the project.

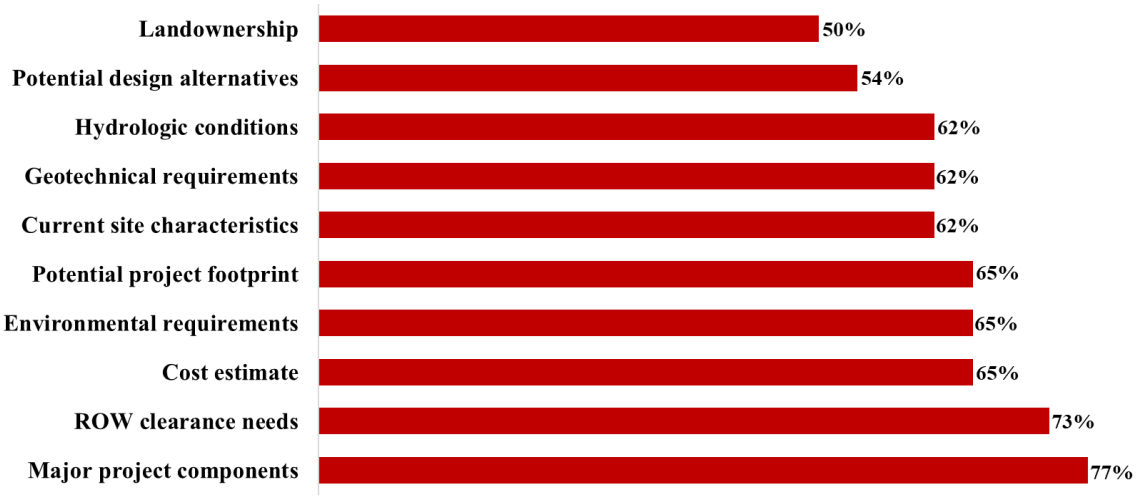
The research team reviewed related published articles and identified the most useful strategies for the scoping phase. The list of identified strategies are presented as follows:

- Major project components
- ROW clearance needs
- Cost estimate
- Environmental requirements
- Potential project footprint
- Current site characteristics
- Geotechnical requirements

- Hydrological conditions
- Potential design alternatives
- Landownership

The respondents were asked to provide information about the implementation level of the strategies mentioned above in the scoping phase of their selected project. The results are presented in Figure 30.

Figure 30. Implementation Level of Different Strategies in the Scoping Phase



As the results show, at least half of the respondents indicated that their DOT agency adopted all of the scoping strategies in their selected transportation infrastructure project. The strategy of major project components was recorded as the first rank (77%) among the above-mentioned useful strategies for the scoping phase of the highway, bridge, and roadway projects. The strategy of ROW clearance needs ranked second, with 73%.

Planning Phase

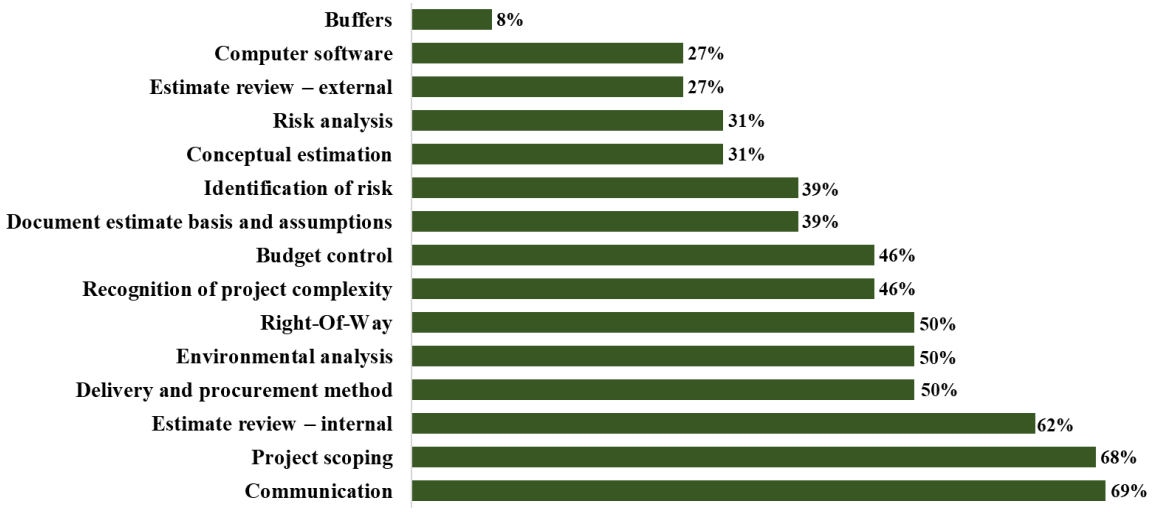
The primary purpose of a construction project planning phase is to: (1) establish the project requirements; (2) establish a baseline budget, schedule, list of deliverables, and delivery dates; (3) establish a resources plan; and (4) obtain management approval and proceed to the next phase. The planning phase of a construction project commonly refines the project's objectives that were determined during the initiation phase. It includes planning the steps necessary to meet those objectives by further identifying the specific activities and resources required to complete the project.

As successfully completing a planning phase is very important to delivering a mega-scale construction project, the respondents were asked to provide information on the implementation level of different strategies in the planning phase by their DOT for their selected project. The research team conducted a thorough literature review to identify potential strategies usually implementing during the planning phase. The list of potential strategies, which was presented in this question of the survey, is as follows:

- Budget control
- Buffers (A buffer gives project managers leeway when unforeseen events occur, and are often associated with scheduling in project management.)
- Communication
- Computer software (e.g., MS Project Management)
- Conceptual estimation (e.g., parametric estimating)
- Document estimate basis and assumptions
- Delivery and procurement methods
- Estimate review – external
- Estimate review – internal
- Environmental analysis
- Identification of risk
- Identification of off-prism issues (unexpected issues)
- Project scoping
- Recognition of project complexity
- Right-of-ways
- Risk analysis

Figure 31 depicts that at least half of the survey participants believed that the strategies of communication, project scoping, estimate review (internal), delivery and procurement, environmental analysis, and ROWs were adopted by their DOT agency during the planning phase of transportation infrastructure projects. Approximately 70% of the respondents indicated that the strategies of communication and project scoping were implemented by their DOT through the planning phase of the highway, bridge, and roadway projects.

Figure 31. Implementation Level of Different Strategies in Planning Phase



Programming & Preliminary Design Phase

During the programming and preliminary design phase of a construction project, the primary emphasis is upon the civil, mechanical, and architectural design. The design of all of the mechanical processes, such as the water systems, is completed during this phase to make sure that they are appropriately integrated into the structures, and all of the required site investigations are completed.

A preliminary design report is prepared with drawings that describe all of the structural components and mechanical processes of the facility and how they interrelate. The report should include an outline of materials and equipment specifications, which are used as a basis for revising earlier construction cost estimates. These can then be reduced from the plus or minus 25% accuracy of the schematic design to about 15% accuracy. Operating cost estimates and the construction schedule are also revised at this time. In addition, costs and scheduling revisions are compared with the original financial objectives and constraints to ensure that the project remains financially feasible.

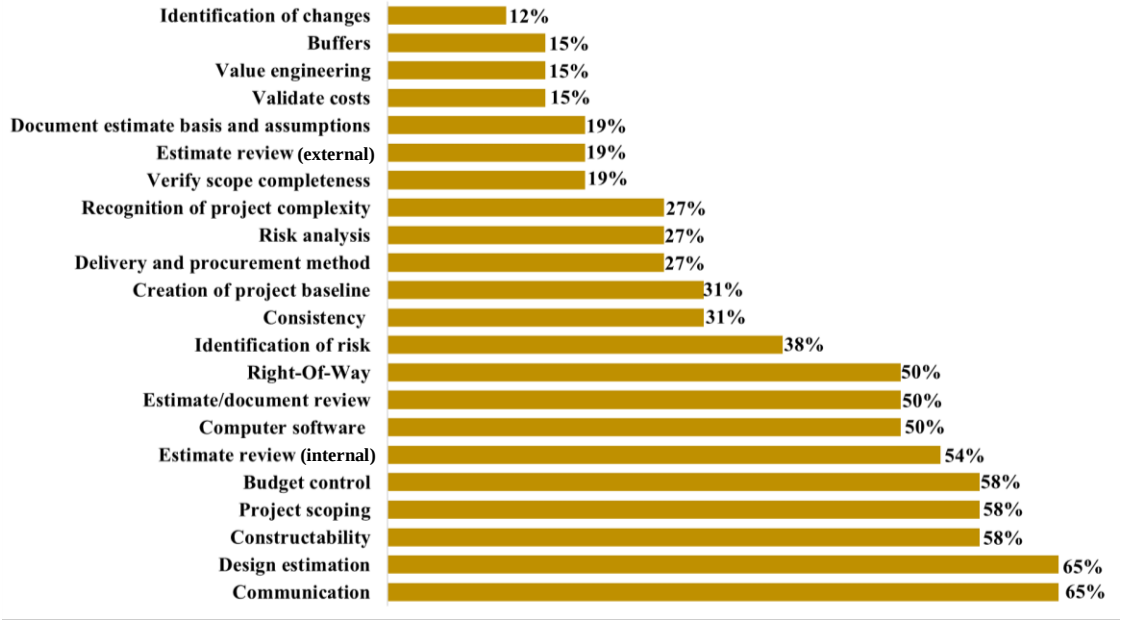
As the adoption of key strategies helps decision-makers successfully conduct the programming and preliminary design phase in large-scale transportation infrastructure projects, the team members designed a question in the survey based on the identified related strategies from the existing literature to investigate the implementation level of key strategies by different DOT agencies. These identified potential strategies are:

- Communication

- Design estimation
- Constructability
- Project scoping
- Budget control
- Estimate review (internal)
- Computer software
- Estimate/document review
- ROW
- Identification of risk
- Consistency
- Creation of project baseline
- Delivery and procurement method
- Risk analysis
- Recognition of project complexity
- Verification of scope completeness
- Estimate review (external)
- Document estimate basis and assumptions
- Validation of costs
- Value engineering
- Buffers
- Identification of changes

The results are presented in Figure 32 and show that at least half of the respondents indicated that their DOT agency implemented nine of the listed strategies through the programming and preliminary design phase in transportation infrastructure projects. These include communication, design estimation, constructability, project scoping, budget control, and estimate review (internal), computer software, estimate/document review, and ROW. Among the nine strategies, communication (65%) and design estimation (65%) were recorded as the first rank.

Figure 32. Implementation Level of Different Strategies in Programming & Preliminary Design Phase



Design Phase

Throughout the design phase, a project manager makes significant efforts to provide the details needed to create a set of drawings for the construction phase. Detailed drawings of layouts are generated to assure adherence to all applicable codes and standards. The function of the space is crucial to the design, but maintenance should also be considered. This phase of the project requires close coordination with several different parties — the physical plant, procurement, information technology, and safety.

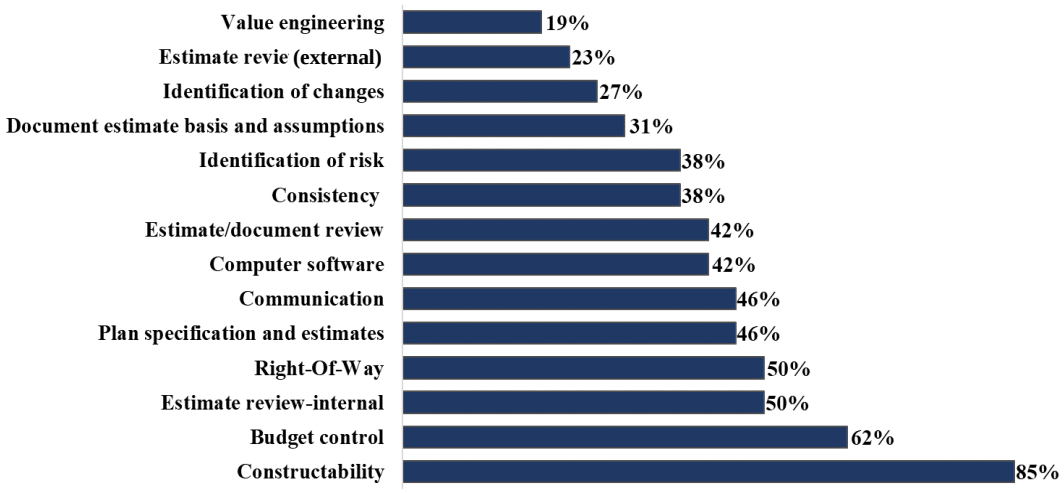
As the accuracy of completion of the design phase is very important for the success of large-scale transportation infrastructure projects, the research team identified the best practices cited most often in the literature. These best practices are as follows:

- Constructability
- Budget control
- Estimate review (internal)
- ROW
- Plan specification and estimates
- Communication
- Computer software

- Estimate/document review
- Consistency
- Identification of risk
- Document estimate basis and assumptions
- Identification of changes
- Estimate review (external)
- Value engineering

The survey participants were asked to describe the implementation level of the potential strategies in the design phase by their DOT agencies in highway, bridge, and roadway projects. The results are shown in Figure 33. This figure presents that at least half of the survey's participants believed that their DOT agency adopted four strategies during the design phase: constructability, budget control, estimate review (internal), and ROW. Among these strategies, constructability was ranked first.

Figure 33. Implementation Level of Different Strategies in Design Phase



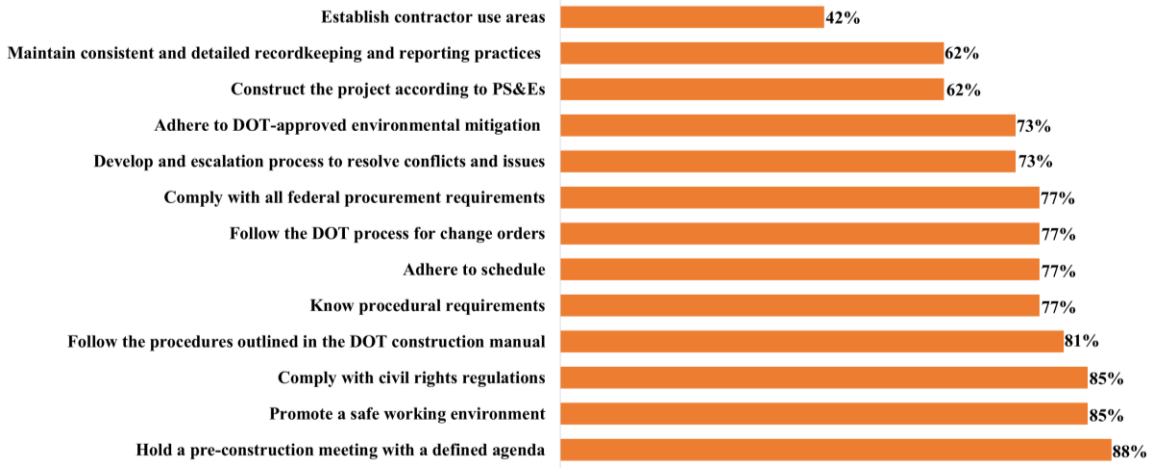
Construction Phase

The construction phase refers to the time when a project is put into performance mode. The successful delivery of the construction phase is the most critical phase in a construction project. In this regard, the research team identified and collected the most useful strategies that may be adopted by DOT agencies. These strategies are as follows:

- Hold a pre-construction meeting with a defined agenda
- Promote a safe working environment
- Comply with civil rights regulations
- Follow the procedures outlined in the DOT construction manual
- Know procedural requirements
- Adhere to schedules
- Follow the DOT process for change orders
- Comply with all federal procurement requirements
- Develop and escalate process to resolve conflicts and issues
- Adhere to DOT-approved environmental mitigation
- Construct the project according to plans, specifications, and estimate
- Maintain consistent and detailed recordkeeping and reporting practices
- Establish contractor use areas

The research team designed a survey question about the implementation level of identified potential strategies in the construction phase of projects, and the results are shown in Figure 34. As is shown, more than half of the respondents believed that their DOT adopted all of the strategies through the construction phase of the highway, bridge, and roadway projects (except establishing contractor use areas, which was selected by 42% of the survey's participants). Among the strategies, the strategy of holding a pre-construction meeting with a defined agenda was ranked first. The two strategies to promote a safe working environment and comply with civil rights regulations were ranked second.

Figure 34. Implementation Level of Different Strategies in Construction Phase



Inspection and Testing

Every project in the construction industry needs oversight, inspection, and testing to focus on ensuring that the project is built according to the plan and specifications. All materials and equipment shall be inspected and tested to ensure conformance with the project requirements before they are released for use. Verification that all items conform to specified requirements of the quality plan shall be documented and filed in the project QA and/or QC file. In determining the number and nature of inspections, consideration should be given to the control exercised at the manufacturing source, and documented evidence of quality conformance provided by the supplier.

The research team identified the following potential useful strategies for inspection and testing that were cited most often in literature:

- Review of past inspection documents and on-site records
- Assurance of safety conditions at the site
- Documentation of field activities and recordkeeping
- Inspection frequencies
- Inspection of ongoing construction activities
- Independent QA inspections and material testing
- Assurance of personnel certification training

Next, the research team designed a question for the survey to investigate the implementation level of the aforementioned strategies in inspection and testing procedures by different DOT agencies in highway, bridge, and roadway projects. The results are presented in Figure 35.

As illustrated in Figure 35, at least half of the respondents believed that all of the strategies were adopted by their DOT agency. Strategies of assurance of personnel certification training, independent QA inspections and material testing, and inspection of ongoing construction activities were ranked first. The strategy of inspection frequencies was ranked second.

Figure 35. Implementation Level of Different Strategies in Inspection & Testing

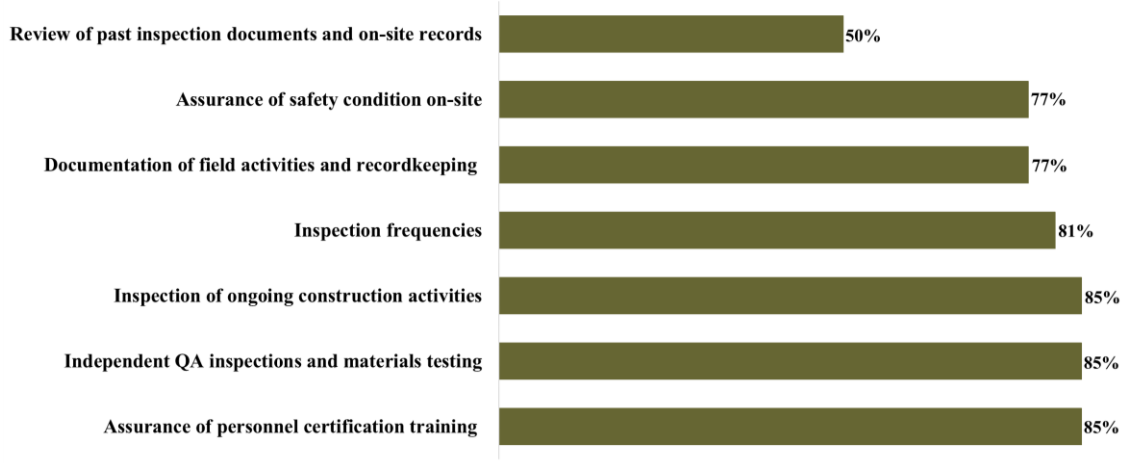


Table 6 summarizes the identified best project management practices in transportation projects based on the survey results. They are categorized into six different project phases.

Table 6. Best Project Management Practices

Phase	Best Practices
Scoping	• Major project components • ROW clearance needs
Planning	• Project Scoping • Communication plan
Programming & Preliminary Design	• Communication • Design estimation
Design	• Constructability • Budget control
Construction	• Holding a pre-construction meeting with a defined agenda • Promoting a safe working environment • Complying with civil rights regulations
Inspection and Testing	• Assurance of personnel certification training • Independent QA inspections and material testing • Inspection of ongoing construction activities

Interview Results and Discussion

This section presents the design of the interview conducted in the fall of 2019. The first section of this chapter summarizes the design of the interview protocol and the interview process. The interview results were organized by each interviewee's location, and the key findings are summarized.

Interview Conduction Process

In the first step, the research team designed a protocol to be used by during the interviews. This interview protocol included four main elements: (1) overview of the interview to highlight the general theme, (2) definitions to highlight the terminologies, (3) introductory protocol to highlight the purpose and objectives of the project, and (4) questions that need to be covered in each interview. The final version of the interview protocol is accessible in Appendix E.

The interview questions were selected based on two criteria:

1. The questions in the survey most important to achieving the objective of this project, and
2. The survey questions did not receive many responses.

The interview questions were also selected, based on the estimated response time, as each interview was to be completed within approximately 30 minutes.

Next, the research team identified the potential interviewees from the selected list of relevant experts. Some of the experts had participated or had been invited to participate in the survey. The research team sent out 15 invitations, using potential participants to engage in a telephone interview. A copy of the interview invitation letter is accessible in Appendix F. The research team conducted six interviews with DOTs of Ohio, Idaho, Virginia, Washington, Maryland, and Colorado.

The interviews were conducted by phone, each following the designated interview protocol over a period of about 30 minutes. The interviewees had different job positions in state DOT agencies, including office engineer, construction administrator, project manager, and program management director. The diverse positions were selected so that the project might reflect different points of view.

Interviewees' Responses

A summary of the demographics of the interviewees is presented in Table 7. In this section, the lessons learned from each interview are presented.

Table 7. Interviewee's Profile

Agency	Perspective	Experience
Ohio DOT	Construction Management	30 years
Idaho DOT	Design	5 years
Virginia DOT	Construction Management	14 years
Washington State DOT	Design	25 years
Maryland DOT	Construction Management	15 years
Colorado DOT	Design	25 years

Ohio DOT

The first interview was with two employees at an Ohio DOT: a construction administrator and a construction specialist with more than 30 years of experience who works at the construction administration central office. They stated that their office of construction administration houses around 10 specialists, and each of the specialists focus on a specific area, like pavement, traffic, structures, etc. Each of the specialists is also a specification chair, so they create specification documents as well as manual procedures for their inspectors. In general, the construction administration central office generates the policies and procedures for 12 districts, each of which has a separate construction administrator office. These offices have upwards from 100 staff in the field to administer projects, and the central office works with them closely. Since they both have worked in the construction administration central office and administered every project in Ohio, they have dealt with all kinds of projects (e.g., bridges, roadways, and highways).

They reported that they use consultants for a wide variety of activities, based on the size of the project. In the design and planning phase, consultants work on different projects; however, that was outside the scope of this interview since the interviewees were both from the construction administration office. However, they stated that they sometimes contract out activities from inspectors to construction administrators, and that they have contracts that districts can utilize for inspection and engineering services. They also

mentioned that they once had a public-private-partnership (P3) project where approximately 95% of the project was staffed with consultants.

On average, they indicated that they spend 15 to 20 percent of the project budget for consultants; however, it can vary greatly from project to project. They also added that they usually use more consultants in urban districts than in rural districts, and therefore the number might be higher for urban district projects.

They added that it could not be said that outsourcing is better than in-house activities. In the design phase, the Ohio DOT has used external consultants for many years; however, in the construction phase, it is becoming an acceptable alternative. They needed to work with more people, but did not want to hire new staff. When they need specific expertise on complex projects (e.g., cable segment bridges or tunneling projects), they hire a consultant to take advantage of the better qualifications; however, there are not many of those projects in their department.

They pointed out that outsourcing can be useful for DOT employees due to workforce training, and reported that many of the experts previously worked for the Ohio DOT, and went to work for consultant organizations after they retired. By using the expertise and many years of experience of those consultants, the Ohio DOT staff gets the benefits of working with them and learning from them. Of course, if the work is performed in-house, the DOT employees have more ownership in the project and can make important decisions.

The interviewees stated that the type of project management practices they use depends on the nature of the project. An engineering estimate and formal review are required for cost estimation, especially for design-build projects. The utilized project management practices vary by project, and are typically handled in the district office; however, the district follows the central office estimations on the design part. They noted that they do not have a formal tool for scheduling, and that it is handled by district engineering and is usually based on production rates, items of work, and similar types of projects. They use an online system to let the contractors provide plans, and then they update the schedule every time there is a schedule delay condition (e.g., rainfalls).

They also added that although they do not have a formal risk management process, they believe that it is an essential strategy for enhancing cost and time performance. For safety management, their contractors need to follow OSHA requirements or manual procedures that have been designed for the project. Regarding workforce training, they have training

programs for various topics, both internally and externally. They also stated that they use a prequalification method for selecting consultants for inspection and engineering staff, and have many requirements for inspection and engineering services personnel.

They estimated that 7 to 15% of their projects have time and cost overruns, with the lower number applying to larger projects and the smaller number applying to larger projects. Change orders were the main reason that they mentioned for the overruns. Then they added soil and subsurface issues, as well as utility issues related to the subsurface in urban areas (e.g., improperly located utilities), that can cause significant delays in a project. They also noted that climate issues might increase the delays in a project significantly. For example, their projects are usually planned to be completed at the end of the year, and if there are delays, they are unable to complete the project until spring since no construction can be done during the winter because of the cold weather in Ohio. Therefore, a two-week delay can postpone the completion of a project for more than three months.

As a final note, they added that their construction management strategies vary by project. Construction management is simple for small projects with few people involved. On the other hand, for larger projects, there are many management activities, such as coordination, scope definition, and risk management.

Idaho DOT

The second interview was with a staff engineer at the Idaho DOT, whose responsibilities include receiving the project plans (with around 10% of the design) from the planning and scoping department and running them through the design, modeling, analysis, plan sheets development, and environmental process all the way up to the construction phase. He also gets involved in the project's construction once it has been awarded to the construction bidder. He has worked in the field for around five years, and has been involved in structural and roadway design, and most notably, bridge and railroad projects. There are six districts in his region, and he works for one of the districts.

He reported that the number of consultants that are hired varies from project to project, but some are hired for almost every project. For example, in his district (and some others in his region), there is not a surveyor on the payroll, so they need to contract those services out for almost every project. He cited an example of a project that was contracted out to a consultant 100%; however, this was an exception to their normal practice of keeping the projects in-house as much as possible. On average, about 30% of

their work is contracted out to consultants, and around 70% of the work is kept in-house. He also added that larger and more complex projects usually require the hiring of more consultants, and that although contracting consultants is usually more expensive than using in-house staff, the consultants' experience and abilities can accelerate the completion of the project.

They have a system in place to establish the bid prices and estimates almost every year that can help them in cost estimation.

Although they have a few tools for risk management, the designers do not usually use them, especially for the smaller projects. Their contractors follow OSHA safety standards, and they have general safety policy guidelines for in-house employees, and hold safety meetings once a month.

They use a national guideline for workforce qualifications, and they can select any consultant for projects that are less than $100,000. If the cost is from $100,000 to $500,000, they have to request additional information. An agreement over $500,000 requires a proposal. They post the announcements requesting bids on their website so that all of the consultants can see it and submit their proposals. They also have a system that they use to invite experts from outside their region to review the proposals and provide input.

The time overruns for the projects vary from team to team and project to project. He mentioned that approximately one-quarter of their projects experience delays. Usually, big and complex projects are completed on time, while the small and relatively simple projects get delayed. Their goal is to keep each project's cost under 105% of the overall budget each year. Most of the time, they are a little over budget; however, the projects rarely exceed that number (one to two project per year in their district).

Their overruns are primarily caused by mistakes in the design plans, unforeseen changes in conditions, and risks that were not properly addressed during the design phase. Some of these not-addressed risks or mistakes have happened recently because of the high number of projects in the Idaho DOT that need acceleration in the design works.

Virginia DOT

The next interviewee was one of three assistant state construction engineers at the Virginia DOT, who has more than 14 years of experience in the construction engineering industry. He said that the duties of their construction division are divided between the

three assistant construction engineers. One of them handles pre-construction activities, such as monitoring for environmentally permitting, writing specifications, and doing constructability reviews; one of them handles all of the contract development and awards, putting the contracts together, receiving the bids, and awarding the contracts; and one (the interviewee) handles the actual construction. Therefore, everything that occurs after rewarding the contract until the completion of the project and payments falls under his purview. Four individuals report directly to him and help him with his endeavors: (1) a project controls engineer who handles the schedule changes, money changes, change orders and the quality program; (2) an administrative engineer who administers the consultant and design-build contracts; (3) an e-construction engineer, a new initiative for Virginia in the past 18 months, who handles the paperless construction administration delivery process, including electronic submission of all construction documentation, electronic document routing/approvals, and digital management of all construction documentation; and (4) a program manager who handles all of the local projects. He highlighted that they deal with all kinds and sizes of projects - from a sidewalk project to highway or bridge construction.

Regarding project delivery, he mentioned that they usually use a traditional design-bid-build project, where the low bidder wins the project and then they monitor that work to make sure they are getting the product that is contracted.

Regarding outsourcing, he highlighted that they sometimes contract out construction inspectors to monitor the contractor and make sure that they are doing the work correctly. The Virginia DOT has its own workforce that performs various jobs from construction managers to change order engineers. However, they do not have enough in-house workforce to perform all of the activities required by their construction contracts, so they contract out some of those activities to a consultant that works as an agent on behalf of the Virginia DOT. Approximately 60% of their project construction-related activities are outsourced, and 40% are performed in-house. In addition to inspectors, some of the other outsourced construction-related activities include reviewing complex schedules, risk analysis (potential claims review), technology activities (use of drones for progress photos), etc.

He also emphasized that since the consultant companies have more experienced engineers who are available to perform the work and have connections to engineering resources across the country, they can expedite the jobs. However, there is a premium that needs to be paid for that expedited service, and the cost for it is generally more expensive

than that for an in-house workforce. Sometimes contracting out some activities is inevitable since the specific expertise needed is not available in-house.

Based on the interviewee's knowledge, the Virginia DOT uses software called "Pre-Construction" that can help designers estimate the project time and cost before the bidding process.

According to this interviewee, holding a pre-construction meeting before the construction phase begins is the most essential element of a successful construction project. It can help review the contract expectations with the contractor and clarify precisely what part of the contracts are important, how the contract will be administered, how the contractor is going to be inspected for the work, what paperwork needs to be completed, how changes should be handled, how the payments to the contractor should be handled, etc. so that every party involved in the project is on the same page.

He added that risk management is another important aspect, especially for design-build or public-private-partnership projects, where they determine the probability and impact of the potential risks (including design, geotechnical, structure, environmental, etc.) to determine whether those risks need to be avoided entirely through engineering, or mitigated some way with the contract language, or whether they are going to accept the risk and put it on the contractor in the price of the project.

They also require the contractors to have safety plans for each project that detail what is required for them to perform the work. The safety plan is reviewed before construction begins to make sure that it follows all of the OSHA rules. The Virginia DOT also has its own administration safety plan for every single project.

He reported that all of the contractors have to complete a pre-qualification application process in the Virginia DOT. They also have a probationary status for new contractors or contractors with a bad performance record, and they can only work on one project at a time.

The Virginia DOT has an in-house maintenance crew for smaller construction works such as sign placement and replacement; however, for the majority of repair and maintenance activities (e.g., re-pavement or bridge reconstruction), they have specific contractors with specific specialty crews.

The interviewee indicated that, in his opinion, the Virginia DOT is one of the best as far as the performance metrics. They have been monitoring the on-time and on-budget

application of their construction projects for the past 15 years, and the information is publicly available (Virginia DOT Dashboard Website). Their current numbers show that 90% of their construction works are on budget, and 81% of their construction projects are on time. It is a tool that is used to prove to the citizens and the elected leaders that the performance level of the Virginia DOT in managing projects is high.

He stated that the biggest reason for overruns in construction projects is the lack of completed design plans, and that design errors that require change orders result in delays and cost overruns. They have a program that includes financial incentives for contractors, to motivate them to complete projects ahead of schedule, regardless of their design errors, weather, etc.

Washington State DOT

The next interviewee was a project engineer in the Washington State DOT field office. He is responsible for design work, plan specifications, work estimates, and contract administration for all project delivery methods for all kinds of projects. Although he has served as a project engineer for only four years, he has been with the Washington DOT for more than 25 years.

In Washington DOT, regarding outsourcing, he mentioned that they usually hire some consultants to do some of the design works for them, and the construction work is usually done by competitive bid and outsource contracts. He also highlighted that only around 10 to 15 percent of the design works are contracted out, and it depends on the type of projects. Also, since they hire high standard consultants, the service they provided in usually more efficient with high performance. On the other hand, hiring such consultants cost more in the projects. Sometimes contracting out some part of work is inevitable since there are not enough in-house crew or there are not enough crew with the required specialty. He added that they have an in-house data-driven tool to estimate the project performance based on the previous ones. They also use those estimates to justify the use of consultants in design works.

He reported that they use different levels of risk management, based on the project size. For example, larger projects incur more advanced risk management, based on managing the larger number of identified risks.

Washington State DOT has an environmental office that handles all of the environmental procedures, including environmental documentation and environmental permitting for the

design and construction of the projects. It also helps them to estimate the costs of the project more effectively.

They have a highway safety manual that is usually used during the design phase to input the features that need to go into the roadway design, course plans during the design and development, the course work zone strategies, type of closure, etc. Then it goes into the contract, and then into construction administration. They also work with communication offices to notify the public about changes in the uses of facilities, traffic, and safety.

Their procedure for hiring consultants begins with requesting a statement of their qualifications. If they are qualified, they can bid on specific types of projects.

For time or schedule overruns, the contracts are very clear about the damage and its costs. Cost overruns usually have a contingency budget (around 4% historically) to cover unforeseen items, since 3 to 4% of the Washington State DOT runs over budget in the construction phase. Delays in the design phase are much greater since there are many things that can go out of control such as ROW issues, environmental issues, etc. To deal with such issues, they have a risk management procedure that utilizes a risk matrix to identify and manage potential risks.

Maryland DOT

The next interviewee was a deputy director for the office of construction in the Maryland DOT field office. He is responsible for program management of all construction-related activities and fund management of DOT projects throughout the state of Maryland. He has been involved in many different transportation-related projects.

He reported that during the lifecycle of a project, they usually outsource 30% of the work, from design works all the way to the management of the construction phase. This involves the design, constructability, and contract management services because they don’t have enough in-house crews, and have a large number of state projects. They outsource around 90% of their construction management activities to a consultant for project management and inspection of the construction process. Approximately 70% of the design work activities are outsourced, while about 90% of the construction activities are outsourced. The in-house activities are usually related to smaller projects, while the larger projects (e.g., bridge construction) are primarily outsourced (e.g., design, project management, inspection, etc.).

He also highlighted that the level of performance of the outsourced services is usually related to many factors, e.g., the hiring time of consultants, the familiarity of the hired consultants to the agency's procedures and documentation management, and even the lack of a crew with a specific specialty. All of these could impact the project schedule significantly.

Regarding cost estimation, he stated that they have a crew to update the cost database to increase the accuracy of estimations based on the historical pricing of previous project financing. They also always perform a constructability analysis after the design phase.

For any large project (over $5 million), the contractors are required to build the schedule and be responsible for maintaining it. They are responsible for reviewing it and tracking it for time and cost performance of the project. The DOT is also implementing an E-construction system that would help better manage funds and track data for projects.

He also mentioned that they ask the contractors to follow OSHA or Maryland Occupational Safety and Health (MOSH), which is an OSHA-approved state plan.

The Maryland contractor selection process involves two steps. First, a shortlist of qualified consultants is developed, and then the best candidate is selected, based on the lowest reasonable bids (compared to their own engineer's estimates in the designer phase).

Approximately 85% of their projects are completed on time, and they average between 5 to 7 percent overruns on projects. Most of the cost and time overruns are on larger projects in excess of $5 million in more confined or urban locations, where there are constraints with environmental concerns, utilities, etc. He also highlighted that the main reasons for these overruns usually are design errors, environmental and utility issues, and inadequate plans made during the construction phase.

Colorado DOT

The last interview was with two employees at the Colorado DOT: a program management director and an engineer with about 25 years of experience who works in the program management office (PMO). The PMO office in the Colorado DOT is responsible for (1) supporting regional transportation project delivery by collaborating to establish standards and promulgate best practices, directing the elevation of concerns to the appropriate level for resolution, and streamlining communications with headquarters; (2) developing and supporting the implementation of consistent guidelines, processes, and tools to help

project managers implement a systematic approach for project planning, estimating, and execution; and (3) analyzing project and program data for tracking the agency's annual construction program and analyzing interconnected projects or programs designed to achieve the agency's broader objectives related to asset management, safety, and mobility.

Regarding outsourcing, they stated that on average, in their projects, consultants deliver about 70 percent of the pre-construction works and about 85 percent of the construction management works. They added that it is more common to use outsourcing in larger projects. For smaller projects, discipline groups (such as environmental or ROW) can access their own consultants, while for the larger projects, there is usually one contract for the project contractor and all of the services are acquired under that contract

For cost estimation and management, the Colorado DOT has developed and used a tool that leverages bid item-level data received from contractors daily. This tool has been established as the standard for the conceptual and scope level of cost estimation. It also considers potential risks, using a Monte Carlo simulation. More information about this tool can be found here: link to Colorado DOT cost management tool.

They have also developed and use a Risk Workbook for risk management. To develop a risk management plan, the project management and project team conduct: (1) a risk identification process to determine the risks that could affect the project; (2) a risk analysis, which is a qualitative assessment of the probability and impact associated with a risk; (3) risk response planning, which involves developing risk response strategies and assigning owners to monitor risks; and (4) risk monitoring and controlling for tracking risk status, implementing response strategies, and identifying new risks. More information about the risk management plan can be found here: link to Colorado DOT risk management tool.

They reported that around 95% of their project delivery is through the design-bid-build project delivery system. Approximately 95% of the contractors and consultants are selected based on the low bid, while around 5% is quality-based selection. Also, the consultants are usually selected using quality-based selection or a combination of qualification and cost. The Colorado DOT developed a new tool called "ProjectWise" for document management. They use a third-party tool called "PMWeb," which is a web-based platform designed to handle project management information.

They usually consider contract change order (e.g., design errors, ownership changes) percentages as a function of the bid prices, at about 5% of the project cost. Regarding time and cost performance, they highlighted that consultant and contractor performance, utility ROWs, and unforeseen conditions are the course of overruns.

Summary of Interview Findings

The key outputs of the interviews are presented in this section. The main three takeaways from the interviews include outsourcing, cost estimation, and project management criteria.

Outsourcing

One of the central parts of the interview pertained to the ratio of outsourced to in-house services. Although the interviewees highlighted many services performed during the planning, design, and pre-construction phases (e.g., design, environmental studies, and constructability analysis), sometimes the construction administration services were also outsourced (e.g., project management, and inspection). The main reasons for outsourcing include:

- Insufficient in-house crew
- Need for particular expertise (e.g., complex design), equipment, or technology (e.g., drone)
- Need for accelerating the project schedule

Table 8 summarizes the ratio of outsourced services to in-house activities. As is shown, these values vary from project to project, and agency to agency.

One of the critical factors in outsourcing service is the type, size, and complexity of the project. Most of the interviewees believed that larger and more complex projects, especially ones located in an urban area, require more consultants and contractors and, therefore, the number of outsourced services increases significantly for such projects.

Table 8. The Percentage of Outsourced Activities

Agency	Point of View	The % of Outsourced Activities
Ohio DOT	Construction Management	15-20%
Idaho DOT	Design	30%
Virginia DOT	Construction Management	60%
Washington State DOT	Design	10-15%
Maryland DOT	Construction Management	30-90%
Colorado DOT	Design	70-85%

Cost Estimation

Another important part of the interview concerned the cost estimation and management methods used by different agencies. As was mentioned in the previous section, every agency uses a different method or tool for cost estimation in the pre-construction stage; however, their methods are based on similar project data or historical bid prices. Most of the agencies also use a reward/penalty system for consultants and contractors to reduce the time overruns in projects.

Table 9 summarizes cost overrun estimates in projects, based on the interviews. As the interviewees stated, 80 to 95% of projects are completed on-budget, and there is sometimes a marginal budget to ensure that cost overruns are covered. As is shown in Table 9, the main reasons for these cost overruns were identified as:

- Change orders
- Weather conditions
- Unforeseen conditions
- Uncompleted design plans
- Design errors
- Utility ROW issues
- Environmental issues
- Contractor performance

Project Management Implementation

The last topic that was discussed with the interviewees was related to project management practices. The interviewees emphasized that the level of project management is different from project to project — the larger the project is, the more efforts are focused on project management activities. In addition to time and cost management, risk management, safety, and workforce qualifications were the main focus of the interviews.

Table 9. Cost Overruns

Agency	Point of View	Cost Overrun	Reasons for Overrun
Ohio DOT	Construction Management	7-15%	• Change Orders • Soil and subsurface issues • Utility issues • Weather condition
Idaho DOT	Design	5%	• Design errors • Change orders • Unforeseen conditions
Virginia DOT	Construction Management	3-5%	• Uncompleted design plans • Design errors • Change orders
Washington State DOT	Design	3-4%	• Utility ROW issues • Environmental issues
Maryland DOT	Construction Management	5-7%	• Design errors • Environmental issues • Utility ROW issues • Uncompleted design plans
Colorado DOT	Design	5%	• Contractor performance • Utility ROW issues • Unforeseen conditions

Most of the experts highlighted the importance of document management and the new web-based or electronic tools that state DOT agencies have adopted or are adopting to implement and enhance the efficiency of document management. Finally, some of the

interviews highlighted the importance of environmental studies in their agencies; however, others said that those services were outsourced in their agency.

Conclusions

The overall objective of this project was to synthesize the best practices of departments of transportations' project delivery processes by looking at all factors of project delivery. The study utilized a comprehensive literature review to determine the project management dimensions in transportation projects. Then, an online survey was conducted, followed by a series of interviews to collect the perspectives of the experts and professionals in state DOT agencies across the nation. A total of 96 survey participants completed the surveys, and 6 follow-up interviews were conducted to collect the required information.

Based on the literature review, the following 12 project management dimensions were identified.

1. **Time Management**: Process of estimating and managing the project schedule efficiently and making necessary adjustments in the project timeline
2. **Cost Management**: Process of cost estimation and cost control to ensure that a project remains within budget while meeting its scope
3. **Quality Control and Inspection**: Process of managing the quality of the project to ensure that the project has been built or implemented correctly
4. **Environmental Process**: Process of managing the potential environmental impacts of the project on nature and the human environment
5. **Right-of-Way and Utilities**: Process of managing the access to the project and routing the utilities to it
6. **Safety**: Process of identifying hazards and managing risks relating to the project workplace and workers
7. **Outsourcing**: Process of using consultants or getting help from contractors outside of the agency for a project
8. **Value Engineering**: Process of providing all necessary functions of a project at the lowest possible cost
9. **Change Orders**: Process of preparation and support changes in the scope of work that is agreed to by the project's involved parties
10. **Type of Contracting**: Process of selecting the contract type, including project delivery and procurement system
11. **Workforce Qualification**: Process of selecting and/or training the employees to ensure that they acquire needed skills

12. **Operation and Maintenance**: Process of assuring that the project performs the functions for which it was designed and constructed

A review of publicly available manuals and guidelines on state DOT websites revealed a lack of manuals or guidelines for project management dimensions in DOT agencies. No manual has guidelines for every identified project management dimension, and some agencies are greatly lacking in this area. Based on the collected and reviewed documents, most state DOTS have a dearth of manuals on the project management dimensions of quality control, outsourcing, workforce qualifications, and O&M.

The results of the surveys and interviews also revealed project management strategies that are widely implemented in state DOT projects, such as workforce qualifications, quality management, environmental planning, safety, and document management. On the other hand, strategies such as scope verification, risk management, and repair prevention strategies are not well-implemented in transportation projects, even though they have a significant impact on project performance.

Based on the survey results, the most frequent project management practices in transportation projects were identifying the major project components and ROW clearance needs in the *scoping phase*; developing the project scope and communication plan in the *planning phase*; enhancing communication and design estimation in the *programming and preliminary design phase*; analyzing constructability and budget control in the *design phase*; holding a pre-construction meeting with a defined agenda, promoting a safe working environment, and complying with civil rights regulations in the *construction phase*; and assuring personnel certification training, independent QA inspections and material testing, and inspections of ongoing construction activities in the *inspection and testing phase*.

Every state DOT agency uses many different tools and methods for cost estimation and management; however, the results of the survey and follow-up interviews demonstrated that these methods are usually based on similar projects and historical data. The review of estimates and early identification of project risks and uncertainties were identified as the best cost estimation practices in DOT projects.

Finally, regarding the outsourced services versus in-house activities in DOT projects, the results showed that estimating a single number would not be a good approach. Although the surveys and interviews proved that DOT projects use around 40% of the project budget for contracting out some parts of the projects and use consultants, this value

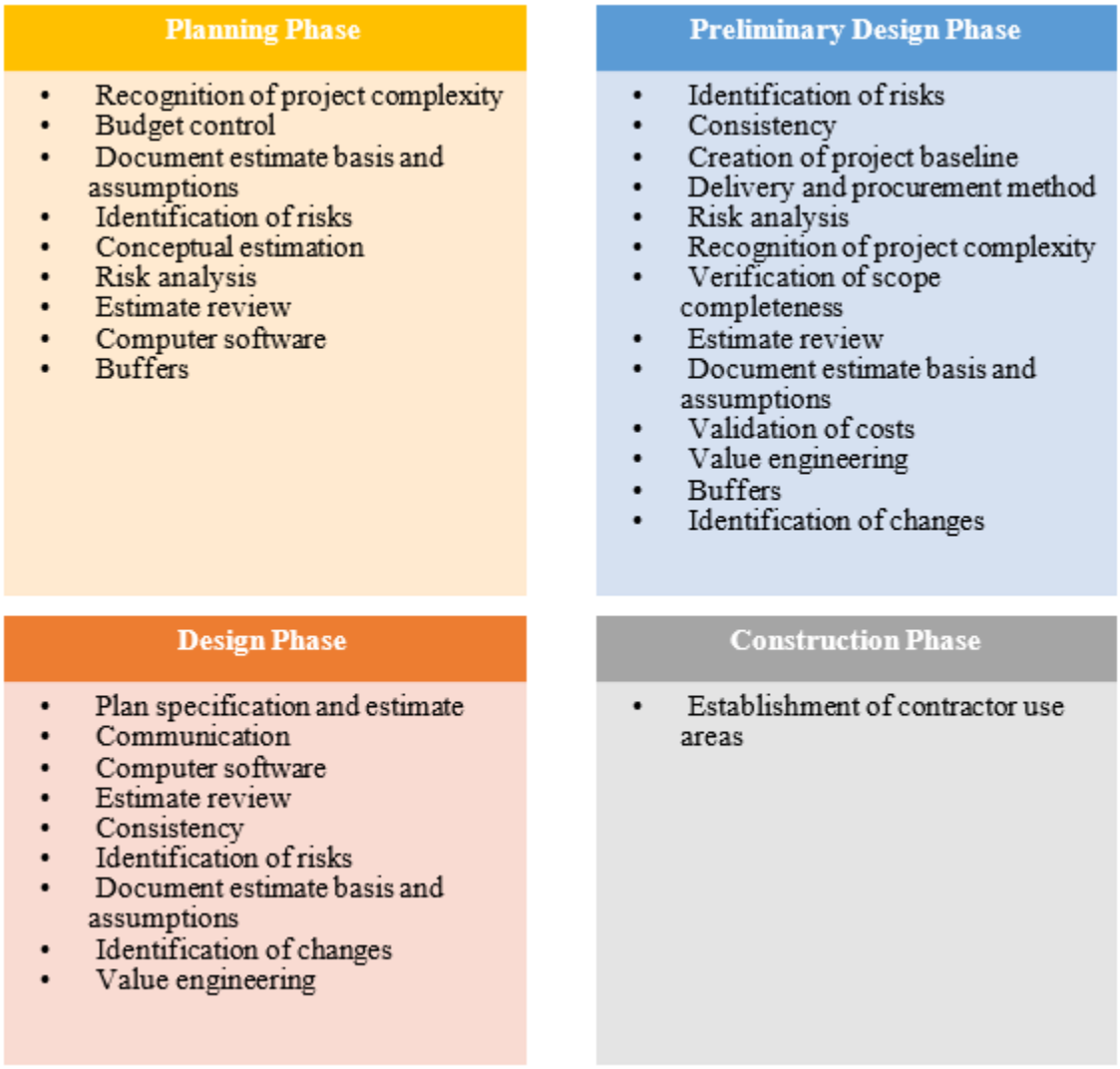
significantly depends on the project's characteristics. The collected data from both surveys and interviews illustrated that the outsourced to in-house ratios could be very different. For example, based on the survey results, the ratio of outsourced to in-house service is higher for bridge projects than for roadway and highway projects, and the ratio for highway projects is higher than it is for roadway projects. In addition, based on the collected information from the interviews, the DOT agencies prefer to use more outsourcing in larger and more complex projects, especially in ones located in an urban area. Last but not least, the results indicated that the main reasons for state DOT agencies to contract out parts of projects are (1) insufficient in-house personnel, (2) lack of required particular expertise in the agencies, and (3) time constraints of the project activities.

For further investigation, the best ratio of in-house versus consultant services should be calculated, based on the DOT workforce and project. Such analysis requires a data set of DOT agency's workforce and capabilities, type of project, and a budget review of the project to estimate outsourced activities. By using this information, a decision matrix can be developed to help DOT agencies expand their workforce if it is required, or use the matrix as a guideline for budget considerations regarding outsourced services.

Recommendations

Based on the results of this study, the research team developed a list of the best project management practices for DOT agencies to adopt for highway, bridge, and roadway projects. The list of best practices, which were mentioned by less than half of the respondents, are presented in Figure 36.

Figure 36. Recommendations of Best Practices for Construction Phases



In the *planning phase,* the adoption of strategies for recognizing project complexity will be beneficial for project managers, as they develop a proactive plan to identify, assess,

and analyze potential risks through the execution of a project. Therefore, the number and cost of unfavorable change orders will be mitigated. Another recommended strategy is the implementation of conceptual cost estimating through the planning phase. The conceptual cost estimate will provide the first check against the project budget, give the owner greater insight to managing the overall cost control program, and shed light on potential cost overruns at early stages. It will empower all project stakeholders with information and time to review designs for possible alternatives.

In the *preliminary design phase*, project consistency is one of the suggested critical elements in large-scale transportation infrastructure projects. Project consistency refers to the federal and state requirement that transportation projects must be described consistently in all applicable plans, programs, conformity documentation, and environmental documents with regard to the following elements:

- Design concept: project limits, location, facility type
- Design scope: project configuration (e.g., number of lanes and signalization)
- Project cost
- Estimated letting date

Therefore, all of the DOT agencies should ensure project consistency through the preliminary design phase of the highway, bridge, and roadway projects.

In *the design phase*, one of the recommended best practices is the establishment of communication. Communication in a construction project refers to the exchange of information and other resources such as ideas, knowledge, skills, and technology among team members and organizations. The quality of communication in a construction project is one of the most important factors contributing to its success because of the numerous parties involved and the number of issues that need to be addressed. The other recommended useful strategy is the timely identification of changes. Change orders due to design errors and modifications are common and almost inevitable in all types of construction projects. They affect the cost of a project, create scheduling delays, and decrease productivity. Therefore, changes play important roles in the success or failure of a project.

In the *construction phase*, adoption of the mentioned strategy prevents any conflict between owners and contractors. Therefore, implementation of this strategy works as a proactive activity to prevent schedule delays due to conflicts.

Acronyms, Abbreviations, and Symbols

Term	Description
AASHTO	American Association of State Highway and Transportation Officials
BIM	Building Information Modeling
CII	Construction Industry Institute
CMGC	Construction Management General Contractor
CMR	Construction Management at Risk
CPM	Critical Path Method
DB	Design-Build
DBB	Design-Bid-Build
DOT	Department of Transportation
FHWA	Federal Highway Administration
GIS	Geographical Information System
IPD	Integrated Project Delivery
IRB	Institutional Review Board
LADOTD	Louisiana Department of Transportation and Development
LTRC	Louisiana Transportation Research Center
MP	Multi-Prime
MS	Microsoft
NHWZSP	National Highway Work Zone Safety Program
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
P3	Public-Private Partnership
PERT	Program Evaluation and Review Technique
PMBOK	Project Management Body of Knowledge
PMO	Project Management Office
QA	Quality Assurance
QC	Quality Control
ROW	Right-Of-Way
STA	State Transportation Agency

Term	Description
STC	Southeast Transportation Consortium
TRB	Transportation Research Board

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Appendix

Appendix A. List of collected manuals and guidelines from state DOTs

Appendix B. IRB exemption record

Appendix C. Final copy of the designed survey instrument

Appendix D. Sample of invitation letter for survey participation

Appendix E. Final copy of the designed interview protocol

Appendix D. Sample of invitation letter for interview participation

Appendix A. List of collected manuals and guidelines from state DOTs

No	Document Name	Related Agency	Date
1	Maintenance Manual	Alabama DOT	1995
2	Project Management Guide	Utah DOT	1998
3	Highway Design Manual	South Carolina DOT	2003
4	Guidebook for Design-Build Highway Project Development	Alaska DOT	2005
5	Bureau of Local Roads and Streets Manual	Illinoise DOT	2005
6	Bridge Manual Part I & Part II	Massachusetts Highway Department	2005
7	Roadway Design Manual	Nebraska DOT	2006
8	Contract Administration Manual	Minnesota DOT	2007
9	Cost Estimation and Cost Management, Technichal Reference Manual	Minnesota DOT	2008
10	Design and Engineering Manual	District of Columbia DOT	2009
11	Design and Construction Manual	Illinoise DOT	2009
12	Construction Management Manual	District of ColumbiaDOT	2010
13	Right of Way Manual	Maine DOT	2010
14	Construction Manual	Connecticut DOT	2011
15	LPA Manual for Federal-Aid Project in Alabama	Alabama DOT	2011
16	Volum of I of III Maintenance Manual-Toll Road Concession Agreement for PR-22 and PR-5	Puerto Rico Highway and Transportation Authority	2011
17	Volum of II of III Operation & Procedure Manual- Toll Road Concession Agreement For PR-22 and PR-5	Puerto Rico Highway and Transportation Authority	2011
18	Delaware Traffic Calming Design Manual	Delaware DOT	2012
19	Project Management Handbook	Georgia DOT	2012
20	Project Development and Design Manual	DOT FHA	2012
21	Project Development Guide	Connecticut DOT	2012
22	Life-Cycle Cost Analysis Procedures Manual	California DOT	2013
23	State of North Carolina Contract Administration and Monitoring Guide	North Carolina DOT	2013
24	Project Development Process Manual- Guidelines for Implementing	Iowa DOT	2013
25	Project Delivery Manual	Louisiana DOT	2013
26	Local Public Agency Project Manual	Arizona DOT	2013
27	Delivering Beer Values for Money: Determining Outsourcing Feasibility and Standard Pricing Methods	Oregan DOT	2013
28	Planning Procedures Manual	New Mexico DOT	2013
29	Project Design Development- Part 1	Indiana DOT	2013
30	Risk-Based Construction Cost Estimating-Reference Guide	Texas DOT	2013
31	Roadway Design Manual	Idaho DOT	2013
32	CDOT Construction Manual	Colorado DOT	2014
33	Construction Manual	Kansas DOT	2014
34	Design Build Manual	District of ColumbiaDOT	2014
35	Bridge Design and Evaluation Manual	Louisiana DOT	2014
36	State of Michigan Project Management Methodology	DTMB	2014
37	Permit Manual, Maintenance Bureau	Alabama DOT	2014
38	Standard Specifications for Highway Construction	Arkansas DOT	2014

No	Document Name	Related Agency	Date
39	DESIGN-BUILD GUIDELINES AND PROCEDURES	Arkansas DOT	2015
40	Quality Control Training Manual for Construction Contract Administration	Colorado DOT	2015
41	Construction Contract Administration Manual	Texas DOT	2015
42	National Review of State Cost Estimation Practice	DOT FHA	2015
43	Cost Estimation Manual for Projects	Washington State DOT	2015
44	Innovative Construction Contracting Guide	Michigan DOT	2015
45	Project Cost Estimation Manual	Nevada DOT	2015
46	Consultant Administration Services Procedure Manual	North Dakota DOT	2015
47	UDOT Project Development Preformance Management-Teaming with the Regions for Project Delivery Succes	Utah DOT	2015
48	Acquisition Manual	South Carolina DOT	2016
49	Building Design and Construction Manual	Kansas DOT	2016
50	State of LA DOTD's Alternative Delivery Program	Louisiana DOT	2016
51	Construction Manual	Maryland DOT	2016
52	New Mexico Department of Transportation Manual Design	New Mexico DOT	2016
53	Construction Manaual	Nevada DOT	2017
54	Construction Administration Manual of Procedures	Ohio DOT	2017
55	Construction Contract Administration	Louisiana DOT	2017
56	Construction Manual	Mississippi DOT	2017
57	Bureau of Design and Environment Manual	Illinois DOT	2017
58	AASHTOWare Project Cost Estimation System (CES) Manual	State of New Jersy DOT	2017
59	Design-Build Standard Guidance	Tennessee DOT	2017
60	Design-Build Manual	Minnesota DOT	2017
61	Construction Site Best Management Practices(BMP)Manual	California DOT	2017
62	Professional Service Constract Administration Manual	Indiana DOT	2017
63	Project Development Process Manual	Texas DOT	2017
64	Bridge Design Manual -Delaware	Delaware DOT	2017
65	Professional Services Agreement (PSA) Manual	Alaska DOT	2018
66	Constraction Manager's Manual	Illinoise State Toll Highway Authority	2018
67	Illinois Construction Manual	Illinois DOT	2018
68	Consultant Service Manual	Montana DOT	2018
69	Design-Build Manual	Gorgia DOT	2018
70	Transportation Asset Management Plan	North Dakota DOT	2018
71	Design and Engineering Manual	District of Columbia DOT	2019
72	LRFD Bridge Design Manual	Iowa DOT	2019
73	Cost Estimation Guideline	New Jersey DOT	2019
74	Project Development Process	Oklahoma DOT	2019
75	Project Development Manual for Local Public Agencies	Mississippi DOT	2019

Appendix B. IRB exemption record

ACTION ON EXEMPTION APPROVAL REQUEST

Institutional Review Board
Dr. Dennis Landin, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu
lsu.edu/research

TO: Amirhosein Jafari
Construction Management

FROM: Dennis Landin
Chair, Institutional Review Board

DATE: May 8, 2019

RE: **IRB#** E11713

TITLE: Synthesis on the Best Practices for State DOTs to Determine Project Delivery Time, Project Management, and Ratio of Consultant to In-House Design

New Protocol/Modification/Continuation: New Protocol

Review Date: 5/7/2019

Approved X **Disapproved**

Approval Date: 5/8/2019 **Approval Expiration Date:** 5/7/2022

Exemption Category/Paragraph: 2c

Signed Consent Waived?: Yes

Re-review frequency: (three years unless otherwise stated)

LSU Proposal Number (if applicable): 47787-2

By: Dennis Landin, Chairman DLandin

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc. Approvals will automatically be closed by the IRB on the expiration date unless the PI requests a continuation.**

* *All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb*

Appendix C. Final copy of the designed survey instrument

Default Question Block

Study Title: Synthesis on the Best Practices for State DOTs to Determine Project Delivery Time, Project Management, and Ratio of Consultant to In-House Design

Greetings,

Thank you for participating in this survey. We have been contracted by the Louisiana DOTD, on behalf of the Southeast Transportation Consortium (STC), to conduct a research project that explores the best construction management practices for successful project delivery in state transportation agencies.

To conduct this research, we are distributing this survey to collect input from professional engineers and construction managers that are involved in transportation projects at state transportation agencies. Results of the study may be published, but no names or identifying information will be included in the publication. In this survey, no risk is involved. The survey can be done completely anonymous (inserting names and email address will be optional). Every effort will be made by the research team to maintain the confidentiality of the study records. The estimated time for answering the designed survey questions would be around 20 minutes of your time and the due date to answer the survey questions is November 15, 2019.

The following investigator are available for questions about this study, Dr. Amirhosein Jafari, ajafari1@lsu.edu, (225) 578-5496 and Dr. Sharareh (Sherri) Kermanshachi, sharareh.kermanshachi@uta.edu, (817) 272-6704.

The study has been discussed with me and all my questions have been answered. I may direct additional questions regarding study specifics to the investigators. If I have questions about subjects' rights or other concerns, I can contact Dennis Landin, Institutional Review Board, (225) 578-8692, irb@lsu.edu, or www.lsu.edu/research.

I agree with the above statement

I consent to voluntarily participate in the research by taking this survey

Position:

Years of experience at your current position:

Total years of professional experience:

Information about the transportation agency that you are working there:

Name:

Main office location city:

In which state your transportation agency is located?

Section 1: General Information

Please select one of your recently completed projects (since 2015) in which you were involved and answer the following questions.

You should have comprehensive information about the construction management aspects of this project to be able to answer the questions accurately.

1) What is the type of project?

Roadway

Highway

Bridge

Tunnel

Railway

Other: Please describe it

2) What is the level of project complexity?

Not Complex			Moderate			Very Complex
1	2	3	4	5	6	7
○	○	○	○	○	○	○

3)Did this project experience the scope changes?

Yes

No

4) If this project experienced the scope changes, please indicate the percentage of scope changes?

0%-20%	20%-40%	40%-60%	60%-80%	80%-100%

5) How do you rank the overall project success in terms of time?

Not Successful			Moderate			Very Successful
1	2	3	4	5	6	7
○	○	○	○	○	○	○

6) How do you rank the overall project success in terms of cost?

Not Successful			Moderate			Very Successful
1	2	3	4	5	6	7
○	○	○	○	○	○	○

7) How do you rank the overall project success in terms of quality?

Not Successful			Moderate			Very Successful
1	2	3	4	5	6	7
○	○	○	○	○	○	○

8) How do you rank the overall project success in terms of environmental impact/sustainability?

Not Successful			Moderate			Very Successful
1	2	3	4	5	6	7
○	○	○	○	○	○	○

Section 2: Project Delivery

1) Which of the following activities/phases was performed in-house or outsource (i.e., use consultants or get help from contractors outside of the agency) in this project?

	In-House	Outsource
Administration	○	○
Planning	○	○
Detailed Design/Engineering	○	○
Construction	○	○
Maintenance	○	○
Operation	○	○
Right-of-Way (ROW)	○	○
Environmental Studies	○	○

2) Which of the following items were considered as the main barriers that hindered your agency to use more outsourcing?
(You can select more than one option)

A. Legal/legislation Issues
B. Budget constrains
C. Lack of qualified contractors
D. Prequalification procedure
E. Contractor selection process
F. Contract management process
G. Payment methodologies

H. Others: Please describe it

3) What was the reason that the company used outsourcing for this project? (You can select more than one option)

A. Time constrains of project activities
B. Insufficient in-house personnel
C. Insufficient in-house equipment and machinery
D. Required policy/legislation
E. Lack of special expertise
F. Improvement of risk management
G. Improvement of quality
H. Improvement of project cost performance

I. Others: Please describe it

4) What is the average ratio of in-house to outsource projects in your agency?

0%-20% 20%-40% 40%-60% 60%-80% 80%-100%

5) Please select the project delivery method that most closely characterizes the delivery method used for this project:

Design-Bid-Build (DBB)
Design-Build (DB)
Construction Management at Risk (CMR)
Multiple Primes (MP)
Integrated Project Delivery (IPD)
Construction Manager General Contractor (CMGC)

Other: Please describe it

6) Did your project contract contain any of the following provisions?

	Yes	No
Liquidated damages	○	○
Penalties for late completion	○	○

7) Please mention the contract types/payment method used in this project:

	Lump Sum	Cost Reimbursable (Cost plus fixed fee)	Unit Cost	Specified Rates	Others
Detailed Design/Engineering	☐	☐	☐	☐	☐
Procurement	☐	☐	☐	☐	☐
Construction	☐	☐	☐	☐	☐

8) If you have selected others in previous question, please name the contract types/payment method used in this project in boxes below:

	Others
Detailed Design/Engineering	
Procurement	
Construction	

Section 3: Cost Management

1) Please complete the following table (in U.S. Dollar):
(Put N/A if you don't know the answer)

	Baseline Budget	Actual Cost	Don't Know
Total Project Cost			
Detailed Engineering/Design			
Procurement			
Construction			

2) If improvement of project cost performance was the reason for outsourcing the project, please indicate how much percentage of the cost performance increased in total project budget compared with similar projects?

0%-20% 20%-40% 40%-60% 60%-80% 80%-100%

3) How was the quality of communication between your agency and the consultants?

Poor			Moderate			Excellent
1	2	3	4	5	6	7
○	○	○	○	○	○	○

4) Did contractor/consultant in this project face financial difficulties?

Yes
No
I don't know

5) Which of the following methods was used for design cost estimation in this project?

Similar Projects
Hours to Design
Historical Percentage of Construction Cost (What is the percentage? ____%)

Other: Please describe it

6) What method was used to estimate the construction cost?

Similar Projects
Historical Bid Data

Other: Please describe it

7) What type of historical cost database was used to prepare the cost estimate?

In-House Database
Published Database (e.g., RS Means)
Both In-House and Published Databases
Cost Data from Similar Projects

Other: Please describe it

8) Which of the following cost estimation practices was conducted through planning phase?

Applying Cost-per-Mile factors using typical sections
Applying Cost-per-Mile factors using similar projects
Order of magnitude estimates

Add-on elements

Other: Please describe it

9) Which of the following cost estimation practices was conducted through programming and preliminary design estimates in this project?
(You can select more than one option)

A. Identifying major cost items
B. Conceptual and parametric estimating
C. Volumetric estimating
D. Risk analysis
E. Add-on elements
F. Estimate reviews

G. Others: Please describe

10) Which of the following methods was used for calculation of inflation rate in this project?

Estimate kept in current dollars, adjust annually
Adjusted project pricing when data become available
Construction inflation index applied quarterly to estimated cost

Others: Please describe

11) Which of the following methods was used for calculation of contingency factor in this project?

Percentage of estimated construction cost
General contingency fund for all projects
Adjustments made annually three years prior to the start
Contingencies not explicitly addressed
Revised when more data are available and during the construction phase

Other: Please describe it

12) If percentage of estimated construction cost was used for calculation of contingency factor, please select how much percentage:

0%-20% 20%-40% 40%-60% 60%-80% 80%-100%

13) Which of the following internal factors led to cost escalation in this project?
(You can select more than one option)

A.Delivery/procurement approach
B.Project schedule changes
C.Engineering and construction complexities
D.Scope changes
E. Poor estimating
F. Inconsistent application of contingencies
G. Faulty execution
H. Ambiguous contract provisions
I. Contract document conflicts
J. Other: Please describe it

14) Which of the following external factors led to cost escalation in this project?
(You can select more than one option)

A. Local concerns and requirements
B. Effects of inflation
C. Scope changes
D. Market conditions
E. Unforeseen events
F. Unforeseen conditions
G. Other: Please describe it

15) Did any error occur through ROW cost estimation process in this project?

Yes
No

Section 4: Time Management

1) Please complete the following table (in days):
(Put N/A if you don't know the answer)

	Baseline Schedule	Actual Schedule	Don't Know
Total Project Schedule			

	Baseline Schedule	Actual Schedule	Don't Know
Detailed Engineering/Design			
Procurement			
Construction			

2) What tool(s) was used to estimate the duration of this project?

A. Primavera

B. MS Project

C. Open Source Project Management Tools (e.g., dotProject, phpCollab, Allegra)

D. Others: Please describe it

Section 5: Project Management

1) Was the process of planning conducted accurately?

Not Accurate			Moderate			Very Accurate
1	2	3	4	5	6	7
○	○	○	○	○	○	○

2) Was the site condition compatible with report?

Not Compatible			Moderate			Very Compatible
1	2	3	4	5	6	7
○	○	○	○	○	○	○

3) Did this project experience permitting issues?

Yes

No

If yes, please indicate how many times?

4) Please complete the following table with respect to change orders after authorization.

(Put N/A if you don't know the answer)

	Design Phase ($)	Construction Phase ($)
Owner Driven		
Engineering Driven		
Contractor Driven		
Total Value		

5) Which of the new software/technology was used in this project for improving the project delivery process?
(You can select more than one option)

A. Building information modeling (BIM)
B. Geographic information system (GIS)
C. Data management systems
D. Multi-agency permit team (MAP Team)
E. Efficient transportation decision making (ETDM)
F. Other: Please describe it

6) What is the quality of internal communication within your entity in this project?

Very Low			Moderate			Very High
1	2	3	4	5	6	7
○	○	○	○	○	○	○

Block 1

Section 6: Best Practices

1) Which of the following key elements of a project management plan was conducted in this project?
(You can select more than one option)

A. Determining the project objectives
B. Determining the scope of work
C. Determining the schedule
D. Determining the financial plan

E. Team organization and resource responsibilities

F. Quality management process

G. Change management process

H. Determining the communication plan

I. Determining the contingency and risk management plan

2) Which of the following strategies was implemented for project management in this project?
(You can select more than one option)

A. Use of single or multiple project managers

B. Decision-making for using a centralized or decentralized project management method

C. Use extensive training

D. Certification of the project managers

E. Use of consultants

F. Others: Please describe

3) Which of the following principles of good project management was conducted in this project?
(You can select more than one option)

A. Ensure that the project is fully scoped

B. Develop a project management plan and follow it

C. Participate in partnership meetings

D. Begin work only after federal funding authorization has been obtained

E. Ensure that the project team has the required qualifications, certifications, and experience

F. Develop a succession plan that designates replacement staff for key positions

G. Establish and maintain communication with DOT staff; develop an escalation process to resolve conflicts and issues

H. Know and understand pertinent regulations

I. Actively oversee consultants and contractors to ensure work is complete and timely and meets quality standards and regulatory requirements

J. Establish and implement effective quality-management procedures

K. Manage the project to meet approved project plans and specifications in order to successfully pass inspections and complete the final acceptance process

L. Team selection (i.e., procedure for selection of the construction team)

M. Accurately complete all paperwork, retain it for required time frames, and submit it on schedule to ensure full reimbursement for all eligible costs

N. Finish the project within required time frames

O. Other: Please describe it

4) What was the level of project team qualification in this project?

Low			Moderate			High
1	2	3	4	5	6	7
○	○	○	○	○	○	○

5) What was the level of implemented quality management in this project? (Quality management refers to the act of overseeing all activities and tasks needed to maintain a desired level of excellence through execution of the project)

Not at all			Moderate			Fully Conducted
1	2	3	4	5	6	7
○	○	○	○	○	○	○

6) Was environmental planning implemented in this project?

Yes

No

7) If yes, what is the quality level of implemented environmental planning in this project?

No Quality			Moderate Quality			High Quality
1	2	3	4	5	6	7
○	○	○	○	○	○	○

8) What was the level of scope verification [i.e., scope definition and/or work break down structure (WBS)] implemented in this project?

Not at all			Moderate			Fully Applied
1	2	3	4	5	6	7
○	○	○	○	○	○	○

9) What was the level of implemented communication plan in this project?

Not at all			Moderate			Fully Implemented
1	2	3	4	5	6	7
○	○	○	○	○	○	○

10) What was the level of implemented risk management plan in this project?

Not at all			Moderate			Fully Conducted
1	2	3	4	5	6	7
○	○	○	○	○	○	○

11) What was the level of implemented safety practices in this project?

Not at all			Moderate			Fully Conducted
1	2	3	4	5	6	7
○	○	○	○	○	○	○

12) What was the level of performed preventive repair and maintenance activities in this project?

Not at all			Moderate			Fully Conducted
1	2	3	4	5	6	7
○	○	○	○	○	○	○

13) Which of the following best practices was implemented for maintenance & operation? (You can select more than one option)

A.Growth maintenance contracting

B. Public partnerships

C. Private partnerships

D. Reliability and life cycle analysis of the project components for predictive testing and inspection

E. Information technology solutions for real-time monitoring and system defects identification

F. Maintenance equipment with better technologies

G. Develop the manuals and guidelines

H. Other: Please describe it

14) Which of the following best practices was implemented for workforce qualification? (You can select more than one option)

A. Control the workforce health

B. Control the workforce absenteeism

C. Control the workforce commitment

D. Control the workforce ability and/or skill and/or experience

E. Control the workforce involvement

F. Control the staff turnover

G. Other: Please describe it

15) What is the level of implemented document management in this project? (Some examples of document management are the availability of the plans, aerial photographs, topological maps, justification studies, previous environmental impact studies, and previous public hearings document.)

Not at all			Moderate			Fully Documented
1	2	3	4	5	6	7
○	○	○	○	○	○	○

16) Which of the following strategies was conducted through planning phase in this project?
(You can select more than one option)

A. Budget control

B. Buffers (A buffer gives project managers a leeway when unforeseen events occur and is often associated with scheduling in project management)

C. Communication

D. Computer software (e.g., P6, MS Project Management)

E. Conceptual estimation (e.g., parametric estimating)

F. Document estimate basis and assumptions

G. Delivery and procurement method

H. Estimate review – external

I. Estimate review – internal

J. Environmental analysis

K. Identification of risk

L. Identifying off - prism issues (i.e., unexpected issues)

M. Project scoping

N. Recognition of project complexity

O. ROW

P. Risk analysis

Q. Other: Please mention its name

17) Which of the following strategies was performed through programming and preliminary design phase in this project?
(You can select more than one option)

A. Budget control
B. Buffers
C. Communication
D. Computer software
E. Consistency
F. Constructability
G. Creation of project baseline
H. Delivery and procurement method
I. Design estimation
J. Design to mandated budget
K. Document estimate basis and assumptions
L. Estimate/document review
M. Estimate review-external
N. Estimate review-internal
O. Gated process
P. Identification of changes
Q. Identification of risk
R. Identifying off-prism issues
S. Project scoping
T. Recognition of project complexity
U. ROW
V. Risk analysis
W. Validate costs
X. Value engineering
Y. Verify scope completeness

Z. Other: Please describe it

18) Which of the following strategies was performed through design phase in this project?
(You can select more than one option)

A. Budget control
B. Buffers
C. Communication
D. Computer software
E. Consistency

F. Constructability

G. Document estimate basis and assumptions

H. Estimate/document review

I. Estimate review-external

J. Estimate review-internal

K. Gated process

L. Identification of changes

M. Identification of risk

N. Identifying off-prism issues

O. Plan specification and estimates

P. ROW

Q. Value engineering

R. Other: Please mention its name

19) Which of the following cost estimation management activities was conducted in this project?
(You can select more than one option)

A. Make estimation a priority by allocating time and staff resources.

B. Set a project baseline cost estimate during programming or early in preliminary design and manage to it throughout project development.

C. Create cost containment mechanisms for timely decision making that indicate when projects deviate from the baseline.

D. Create estimate transparency with disciplined communication of the uncertainty and importance of an estimate.

E. Protect estimators from internal and external pressures to provide low cost estimates.

F. Other: please describe it

20) Which of the following cost estimation practices was conducted in this project?
(You can select more than one option)

A. Complete every step in the estimation process during all phases of project development.

B. Document estimate basis, assumptions, and back-up calculations thoroughly.

C. Identify project risks and uncertainties early and use these explicitly identified risks to establish appropriate contingencies.

D. Anticipate external cost influences and incorporate them into the estimate

E. Perform estimate reviews to confirm the estimate is accurate and fully reflects project scope.

F. Other: Please describe it

21) Was a formal estimate review conducted in this project?

Yes: Please explain that is there a set of formalized and institutionalized procedures for conducting such reviews? What are the milestones for these reviews?

No: Please explain how does your DOT verify an estimate?

22) Was there a systematic program to standardize estimating procedures in this project?

Yes

No

23) Were there established cost-reporting mechanisms to control changes?

Yes: Please describe it

No

24) Was project value or project complexity trigger conducted additional reviews?

Yes: If so, what are these trigger values?

No

25) What formal mechanisms were used for capturing and transferring knowledge?

Yes

No

26) Was there a reporting system for managing changes that provided traceable and visibility for all changes?

Yes

No

27) Was there an established reporting system that provided the necessary data to each level of management to track the cost, schedule, and scope of a project?

Yes

No

28) Which of the following best practices of scoping documents was provided in this project?
(You can select more than one option)

A. Current site characteristics
B. Potential project footprint
C. Major project components
D. Potential design alternatives
E. Environmental resource clearance requirements
F. ROW clearance needs
G. Landownership
H. Geotechnical investigation needs
I. Hydrologic conditions
J. Cost estimate

K. Other: Please describe it

29) Which of the following best practices was conducted through development/design phase in this project?
(You can select more than one option)

A. Develop the project according to applicable publications, policies, and standards such as those developed by AASHTO
B. Comply with AASHTO design standards and criteria
C. Identify the need for and obtain approval of any design exceptions as early as possible
D. Be aware of the technical or environmental constraints affecting a project
E. Understand and adhere to the approved consultant selection procedures
F. Establish a review and comment resolution process
G. Adhere to project schedule
H. Ensure project team members have appropriate technical certifications
I. Use submittal checklist for each design stage
J. Make submittals in a timely manner
K. Ensure that the bid and award process adheres to all applicable requirements
L. Provide contract modification request in a timely manner
M Follow the applicable guideline documents

N. Other: Please describe it

30) Which of the following best practices was conducted through construction phase in this project?
(You can select more than one option)

A. Know procedural requirements

B. Follow the procedures outlined in the DOT construction manual

C. Comply with all federal procurement requirements

D. Hold a pre-construction meeting that includes a partnering session and use a defined agenda

E. Develop and escalation process to resolve conflicts and issues

F. Adhere to DOT-approved environmental mitigation and special conditions

G. Construct the project according to approval plans, specifications, and estimates (PS&Es)

H. Maintain consistent, detailed recordkeeping and reporting practices in adherence with applicable requirements

I. Promote a safe working environment

J. Comply with civil rights regulations

K. Adhere to schedule

L. Follow the DOT process for change orders and submit requests in a timely manner

M. Establish contractor use areas

N. Other: Please describe it

31) Which of the following best practices was conducted through inspection and testing in this project?
(You can select more than one option)

A. Assurance of personnel certification training of staff

B. Inspection of ongoing construction activities

C. Review of past inspection finding documents and on-sire records for corrective actions

D. Independent quality assurance (QA) inspections and materials testing during construction

E. Inspection frequencies

F. Documentation of field activities and recordkeeping within the provided timetables and in accordance with the protocols for each activity

G. Assurance of safety condition on-site

H. Other: Please describe it

Personal information:

Full Name: (optional)

Email Address: (optional)

Appendix D. Sample of invitation letter for survey participation

Greetings,

You are receiving this letter because we are hoping that you will help us with a very important project. Your expertise and feedback would be valuable as we work to identify best construction management practices for successful project delivery in state transportation agencies. The sponsors of this project are the Louisiana DOTD and Southeast Transportation Consortium (STC).

Your participation is voluntary and your responses to the survey will be kept strictly confidential. If you have any questions or concerns about the study, please feel free to email the Principal Investigators Dr. Amir Jafari, ajafari1@lsu.edu, and Dr. Sharareh (Sherri) Kermanshachi at sharareh.kermanshachi@uta.edu.

We hope that you will take the time to answer the questions and return the results by October 31, 2019. Completing the survey should take no longer than 20 minutes. Thank you in advance for your help with this valuable study. To begin the survey, please click on the link below:

http://lsu.qualtrics.com/jfe/form/SV_ab2EGKYgy5VhjaR

Best Regards,

Appendix E. Final copy of the designed interview protocol

1. Overview of the interview (for the interviewer)

i. What we want to ask overall?
   a. What are the project management strategies you are using in your projects?
   b. What are the importance of project management?
   c. What are the reasons to use outsourcing in your agency?
   d. What are the tools you use for project management?

ii. The most important information we are trying to obtain:
   a. List of project management best practices in different project phase
   b. The ratio of in-house to outsourcing in your agency

iii. What are the key points we want to address throughout the interview?
   a. The project management & its necessity
   b. Project management tools and practices

iv. Remind to the interviewee about, purpose of the interview, what will happen to the information obtained, and any confidentiality concerns.
   a. Purpose: to explore the best construction management practices for successful project delivery in state transportation agencies
   b. Confidentiality of the information: your participation is voluntary, and your responses to the interview will be kept strictly confidential.

v. Discuss the interviewee somehow and avoid only yes/no answers. For example, you may ask him/her to describe more about his answer if the answer is very short.

2. Definitions (for the interviewer)

i. Outsourcing: using consultants or get help from contractors outside of the agency.
ii. Team selection: procedure for selection of the construction or execution team.
iii. Scope verification: scope definition and/or work break down structure (WBS)
iv. Project phases: includes planning phase, programming and preliminary design phase, design phase, construction phase, inspection and testing, and post-construction and maintenance
v. ROW: Right-of-Way for utilities

3. Introductory Protocol

We are conducting a study to explore the best construction management practices for successful project delivery in state transportation agencies and would like to ask you to participate in an interview. Your expertise and feedback would be valuable as we work to identify best construction management practices to help improve project management. We have been contracted by the Louisiana DOTD, on behalf of the Southeast Transportation Consortium (STC), to conduct this research project. To facilitate our note-taking, we would like to audio tape our conversations today. During this time, we have several questions that we would like to cover. If time begins to run short, it may be necessary to interrupt you in order to push ahead and complete this line of questioning.

Your participation is voluntary, and your responses to the interview will be kept strictly confidential. If you have any questions or concerns about the study, please feel free to email the Principal Investigator Amirhosein Jafari at ajafari1@lsu.edu. Any questions you may have about your rights as a research subject may be directed to Dennis Landin, Institutional Review Board, (225) 578-8692, irb@lsu.edu, or www.lsu.edu/research.

4. Questions

i. Interviewee Background
   - What DOT do you work for?
   - What is your current position in the project? Please briefly explain about it.
   - How many years of experience do you have in your field?
   - What type of project are you involved in?
     a) Highway
     b) Roadway
     c) Bridge
     d) Other Type

ii. Outsourcing
   - For what type of project do your agency usually use outsourcing?
     a) Highway
     b) Roadway
     c) Bridge
     d) Other Type

- What type of outsourcing do you usually use in your projects?
    a) Administration
    b) Planning
    c) Detailed Design/Engineering
    d) Construction, Maintenance
    e) Operation
    f) Right-of-Way (ROW)
    g) Environmental Studies
    h) Others
- What is the average ratio (in percent) of in-house to outsourcing projects?
- How the cost and schedule performance of the outsourced projects were different (decreased or increased) compared to similar in-house projects for each type of project?
    a) Cost Performance
    b) Schedule Performance

iii. Project Management

- What strategies your agency adopts to improve the accuracy of the cost estimation procedure for each type of project?
    a) What was the level of impact on cost and scheduleperformance?
    b) Systematic program to standardize cost estimating
    c) Formal estimate review
    d) Other strategies
- What strategies your agency adopts to improve the cost and schedule performance of the projects for each type of project?
    a) What was the level of impact on cost and schedule performance?
    b) Environmental planning
    c) Scope verification
    d) Communication plan
    e) Risk management
    f) Safety practices
    g) Repair and maintenance activities
    h) Workforce qualification
    i) Document management
    j) Other Strategies

- What are the average percentages for delays and cost overruns in each type of project?
    a) Cost overrun percentage
    b) Schedule delay percentage
- What are the potential reasons for these overruns?
    a) Process of planning conducted inaccurately
    b) Site condition incompatible with the report
    c) Permitting issues
    d) Other reasons
- What strategy do you suggest to adopt in order to improve cost and schedule performance?

Thank you for your time and input!

Appendix F. Sample of invitation letter for interview participation

Dear XXX,

I am writing to you to kindly remind you that I am still looking forward to hearing back from you regarding the following email.

We would like to invite you to participate in a phone interview since your expertise and feedback would be valuable for us and our work. The interview will include some general questions about identifying the best construction management practices to help improve project management and will take 15 to 25 minutes. During this time, I will ask several questions that I would like to cover.

Again, your valuable expertise and knowledge will help us to improve our research work significantly. If you agree, we can schedule the interview at any time of your convenience. Your participation is voluntary, and your responses to the interview will be kept strictly confidential.

If you have any questions or concerns about the study, please feel free to email me at ajafari1@lsu.edu or call me at work (225) 578-5496.

I am looking forward to hearing back from you.
Sincerely,
Amirhosein Jafari, Ph.D.
Assistant Professor
Bert S. Turner Department of Construction Management
Louisiana State University
3315K Patrick F. Taylor Hall, Baton Rouge, LA 70803
Office: 225-578-5496

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