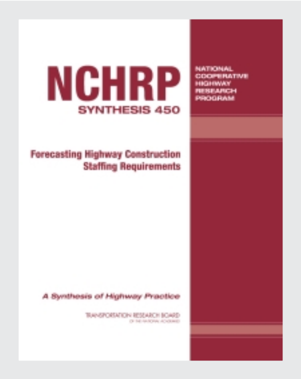

Forecasting Highway Construction Staffing Requirements

DETAILS

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 450

Forecasting Highway Construction Staffing Requirements

A Synthesis of Highway Practice

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Academies was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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FOREWORD

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Jon M. Williams
Program Director
Transportation Research Board

Adequate construction staffing is critical for performance of highway construction projects. The variable nature of these projects, however, can make it difficult to estimate construction staff requirements for both the short and long term. This study gathered information on the methods being used at highway transportation agencies to forecast staffing requirements. These methods are diverse and range from simple heuristics based on generic project types to multi-variate regression models developed from historical project data.

Information for this study was acquired through a literature review, surveys of state transportation agencies, and site visits to non-state agencies.

Timothy R.B. Taylor and William F. Maloney, University of Kentucky Department of Civil Engineering, Lexington, Kentucky, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable with the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

FORECASTING HIGHWAY CONSTRUCTION STAFFING REQUIREMENTS

SUMMARY

State transportation agencies (STAs) across the country continue to face many challenges to repair and enhance roadway infrastructure. One of these challenges is the selection of agency staff. Data collected in the current work shows that between 2000 and 2010 the total lane-miles in the systems managed by these agencies increased by an average of 4.1%, whereas the in-house STA personnel available to manage these systems decreased by an average of 9.78% over the same time period. By any measure STAs are doing more work with fewer agency employees than they were 10 years ago. Some of these agency employees have been replaced with consultant personnel; however, 86.1% of the respondents to this synthesis survey indicated that they were "doing more with fewer people than [they] were 10 years ago." Additional information on staffing levels and demographics from the responding states are described in chapter two. These statistics indicate that the allocation of human resources is critical in maintaining and improving the nation's roadway infrastructure system. This is especially true for agency employees in the area of construction, because construction projects represent a significant portion of a transportation agencies' total budget.

Adequate construction staffing is critical to the cost, schedule, quality, and safety performance of highway construction projects. However, the variable nature of construction project volume, construction project type, and construction project location can make estimating staffing requirements for both the short and long term difficult. The focus of this synthesis is on identifying factors influencing construction staffing levels required for highway construction and what systems are currently being used to forecast highway construction project staff. The synthesis was carried out using a combination of an on-line survey distributed to the 50 STAs, a review of existing tools and methods to forecast construction in use at these agencies, and site visits with non-state transportation agency transportation organizations (such as municipal planning authorities) to collect data on construction staffing.

Of the 40 STAs that responded to requests for information, only seven reported having some formal method or tool for estimating construction staffing needs for future projects. These methods and tools were diverse in their approach, ranging from simple construction staffing heuristics based on project type to complex forecasting models developed through multi-variate regression analysis of historic project data, and taking into account seasonal fluctuations in staffing requirements. Validation effort to verify the accuracy of these systems was either nonexistent or not reported.

In addition to the identification of construction staff forecasting methods in current use, the project also identified poor quality plans, specifications, and cost estimates as the most frequently cited factors in increasing the construction staffing requirements of a given project. This is consistent with previous research on the impact of design errors on construction project performance. The work also found that 88% of respondents to the survey reported using consultants to perform construction staffing functions, representing a significant increase over values reported in previous studies of the use of consultant construction labor by STAs. Additional details on the factors identified that affected construction staffing requirements are described in more detail in chapter three.

The results of this synthesis offer a number of significant general findings related to STA construction staffing for highway construction projects:

- *The types of construction staff forecasting methods employed by STAs are diverse and widespread in their methodology.* The forecasting methods range from simple staffing heuristics based on generic project types to multi-variate regression models developed from historical project data. The methods were also varied in the processes used to estimate staffing numbers with some using work type and others using total project cost to estimate staff requirements.
- *The two most cited factors by responding STAs for increasing construction staffing requirements for a project were poor quality plans, specifications, and cost estimates and an accelerated construction schedule.* Other factors that increased staffing requirements for construction administration and construction engineering personnel differed from those for construction inspection. Construction engineering and construction administration staffing requirements were increased by increased third party coordination efforts. Construction inspection personnel requirements were supplemented by increased environmental mitigation requirements.
- *Few factors were identified that tended to decrease construction staffing requirements for highway construction projects.* The lone exception was that increased experience for construction inspectors and contractors reduced the amount of construction inspection personnel required. However, it is important to note that the survey tool did not specifically collect data on factors that could decrease construction staffing requirements.
- *Outsourcing of construction personnel is much more common now than reported in previous studies.* Ninety-six percent of survey respondents indicated they used consultant personnel to meet staffing needs in construction administration, engineering, and inspection. The most common reason cited for the use of consultant labor was a lack of quantity of in-house construction staff.
- *The adoption of mobile information technology within STAs' construction organizations appears to be limited and the impact of those technologies used is also limited.* Less than 30% of responding agencies reported smart phone use among their field personnel and less than 15% reported using a tablet computer. Of those using mobile information technologies, 60% reported no increase in user productivity from the mobile devices.

For STAs that are interested in developing a construction staff forecasting system for their own agency, the systems examined in the current work share a number of common characteristics that could be considered when developing a new system. Details on each of the systems examined are described in chapter four.

- *A timeline for the construction staffing forecast.* Although the timelines for the systems differ, all the systems examined in the current work base their staffing estimate on a specified analysis period. It can be noted from the systems examined in the current work that the longer the analysis timeline the more complex the system, and likely the more resources required to develop and maintain.
- *Some form of project schedule is needed to estimate staffing needs.* None of the examined forecasting systems reported developing a formal critical path schedule as part of their methodology. However, each system used some formal or informal method to estimate project duration, with several systems including some generic type of activity.
- *Some type of connection between staff requirements and the work performed is needed.* Although most of these systems use some type of historical data or published standard for staffing levels, the synthesis panel cautions that these data should not be used without taking into account the current project or project portfolio. Relying on historical data can lead to a self-fulfilling prophecy, where because a project provided a certain level of staff that staff is used regardless of whether more or fewer people are needed on the project.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

In recent years, state transportation agencies (STAs) have experienced evolutions in their traditional business models for the development of highway construction projects. These evolutions have been driven by several influences including fluctuations in funding levels (e.g., lean periods of state funding followed by the influx of federal stimulus funding), dynamic sources of funding (i.e., changes in how projects are funded) across STA project portfolios (e.g., local vs. state vs. national, public–private partnerships, or any combination of funding agencies), alternative contracting methods [e.g., design-build, quality assurance/quality control (QA/QC) practices, and warrantee contracts], changes in traditional job responsibilities (e.g., integration of construction and maintenance departments), increased use of consultant services to augment in-house personnel (e.g., design outsourcing, construction inspection outsourcing), changes in project requirements (e.g., increased environmental mitigation requirements for planning and construction), and advances in design and construction technology [e.g., Global Positioning System (GPS) machine control, three-dimensional (3D) design] among others. This evolution also comes at a time when STAs are experiencing staff turnover. Experienced personnel are leaving STAs through retirement and are being replaced by less-experienced individuals who are encountering more rapid increases in responsibility earlier in their careers than their predecessors. These changes have affected all divisions of STA personnel, particularly those tasked with the construction of highway infrastructure.

The current work aggregates staffing for highway construction into three main categories; construction administration, construction engineering, and construction inspection.

- *Construction administration* is the day-to-day planning, scheduling, and oversight of construction project operations. This would involve budget management, contract management, change order initiation, preconstruction meetings, project closeout, etc.
- *Construction engineering* entails the functions of estimation, site design, falsework design, conflict resolution, site issue resolution, traffic control design, etc.
- *Construction inspection* is overseeing the work for conformance to plans, specifications, and material requirements; erosion control and environmental conformance; safety standard conformance; traffic control conformance, etc.

The aggregation of construction functions into these categories does not imply that overlap does not exist between them nor does it imply that a single person could not perform two or more of the categories.

In most STAs, construction personnel are concentrated in field offices throughout the state, with construction support staff located in central or regional offices. STAs are tasked not only with ensuring that construction staffing levels are adequate to meet the state's current construction needs but also forecasting future construction personnel staffing levels. Forecasting construction personnel needs is challenging as a result of many factors primarily related to the dynamic nature of highway infrastructure construction. Total state construction volume can vary from year to year, which adds uncertainty to personnel requirements at the central and field office level. However, construction volume within state districts can also fluctuate from year to year, which can require adjustments to field personnel. Construction staff forecasting is further complicated by variations in personnel experience levels in identical positions across the state, variations in construction staff productivity, variations in contractor quality, variations in project type and complexity, variations in local government requirements, changes in construction technology, and changes in construction staff responsibilities.

PROJECT SCOPE

For the current work, *construction* will be defined as those activities performed by construction personnel related to the physical construction of highway infrastructure (e.g., construction supervision, construction inspection), contract administration (e.g., payment approval, change order management), construction planning (e.g., constructability reviews, pre-bid meetings), and project closeout (e.g., organizing final inspections, final documentation). Activities that support highway construction but are not typically performed by construction personnel and are therefore *not* considered within the scope of this project include highway infrastructure design, payment processing, specialized final inspections (e.g., traffic signals, trees, and seeding), off-site material testing, and disadvantaged business entity administration. For the current work, *construction personnel* will be defined as those persons in both field, regional, and central offices assigned to the administration and inspection of construction of highway infrastructure. This definition would include positions such as project engineer, project inspector, and construction technician, but would *not* include positions such as design engineer, offsite materials testing technician, and maintenance inspector. Although specific positions for materials testing technician and maintenance inspector are outside the scope of the report, it is acknowledged that staff within included positions (e.g., project inspector) may sometimes perform the duties of positions considered outside the scope of the project (e.g., materials testing). Finally, some STAs are integrating construction and maintenance divisions at the field level, which can lead to a blurring of the lines between construction and maintenance operations. The current work will distinguish between construction and maintenance operations by defining construction activities as those that are procured through a formal bidding and selection process. However, the impact of assigned maintenance responsibilities on construction personnel is considered within the scope of the project.

STUDY METHODOLOGY

This synthesis used a combination of an on-line survey, site visits, and literature reviews to collect data on construction personnel demographics and staffing forecasting models currently in place at STAs. The survey tool was developed with input from the topic panel and was designed to collect information on the demographics of the construction staffing at STAs, factors that affect construction staffing needs for transportation infrastructure construction, and to identify tools used by STAs to forecast future construction staffing needs. A copy of the survey tool is included in Appendix A.

The survey was distributed to members of the AASHTO Subcommittee on Construction from all 50 STAs and the District of Columbia. In addition, the survey was distributed to transportation construction elements within the following non-STA transportation organizations, selected with input from the topic panel:

- San Diego Association of Governments (SANDAG),
- City of Atlanta,
- City of New York,
- Central Federal Lands Highway Division, and
- Florida Turnpike Authority.

The survey was administered using an online survey tool. Responses to the survey were received from STAs from the following 40 states of the 51 surveyed:

- California
- Colorado
- Connecticut
- Delaware
- Florida
- Georgia
- Hawaii
- Idaho
- Illinois
- Iowa
- Kansas
- Kentucky
- Louisiana
- Maine
- Maryland
- Massachusetts
- Michigan
- Minnesota
- Missouri
- Montana
- Nebraska
- Nevada
- New Hampshire
- New Jersey
- New Mexico
- New York
- North Carolina
- North Dakota
- Oklahoma
- Oregon
- Pennsylvania
- Rhode Island
- Tennessee
- Utah
- Vermont
- Virginia
- Washington
- West Virginia
- Wisconsin
- Wyoming.

The raw data and descriptive statistics collected from the survey are included in Appendix B.

Site visits were conducted with construction personnel at the following organizations:

- SANDAG,
- Los Angeles County Metropolitan Transportation Authority,
- San Francisco Municipal Transportation Agency, and
- San Francisco Bay Area Rapid Transit District.

Finally, a review of construction staffing policies and procedures was performed by searching STA websites for published information.

The remainder of the report presents the findings from the study effort. Chapter two presents the results of the general construction staffing data analysis. Chapter three provides the data related to the factors that impact construction staffing requirements for projects. Chapter four presents construction staffing forecasting systems that are currently in place at STA and non-STA transportation agencies. Chapter five draws conclusions from the current work, identifies commonalities between construction staff forecasting systems used within STAs, and identifies potential areas of future research.

CHAPTER TWO

GENERAL CONSTRUCTION INFORMATION FOR RESPONDING STATES

This chapter examines the demographics of construction staffing at STAs, including general agency information (e.g., budget, state populations, average vehicle-miles traveled), types of projects performed (e.g., average project size, construction staff assigned), project delivery methods (e.g., public–private partnerships, design-build), and information on construction staff demographics (e.g., average age, average experience). This builds foundational knowledge for the current state of construction staffing across STAs. Data from this section were obtained primarily from the survey, but also include published data from FHWA, the U.S. Census Bureau, and the National Academy of Sciences.

GENERAL TRANSPORTATION SYSTEM INFORMATION BY STATE

From 2000 to 2010, of the 40 STAs that responded to the survey, 39 states (97.5% of respondents) experienced an increase in population, 38 (95% of respondents) experienced an increase in total lane-miles within their road systems, 33 states (82.5% of respondents) experienced an increase in the number of highway bridges, and 35 (87.5% of respondents) experienced an increase in total annual vehicle-miles traveled (AVMT). Detailed information for each state is available in Appendix B. On average, from 2000 to 2010, state population from responding states increased by 9.47%, with only one state (Michigan) experiencing a population decrease. State managed lane-miles reported to FHWA increased by 4.10% during this time, with only two responding states (Nevada and Oregon) reporting a decrease in lane-miles, which may be the result of changes in reporting methods. The average number of state-managed highway bridges increased by 3.17%, with only seven responding states (Kansas, Louisiana, Nebraska, New York, North Dakota, Washington, and Wyoming) reporting a decrease. The average AVMT in the responding states increased by 8.25%, with only five states (Michigan, Oregon, Pennsylvania, Rhode Island, and West Virginia) reporting a decrease in AVMT between 2000 and 2010. To calculate the volume of construction performed within each STA the capital outlays for each state's transportation system is used by the U.S.DOT (n.d.), from reports of STAs to FHWA. The "Capital Outlay" category includes federal, state, and local funding spent on acquisition of right-of-way, preliminary and construction engineering, highway construction, and system preservation for each STA. State disbursements of capital outlay for roads and bridges in state highway systems increased by an average of 52.31% between 2000 and 2010 (taking inflation into consideration). A significant portion of this substantial increase was the result of stimulus funds released through the American Recovery and Reinvestment Act in 2009 and 2010. When 2009 and 2010 capital outlays are not considered, the inflation adjusted average increase in capital outlays between 2000 and 2008 was 9.15%. Table 1 shows the distribution of frequencies for the increases in state population, total lane-miles, number of highway bridges, AVMT, and disbursement on capital outlay for the responding states.

Of the 40 STAs that responded to the survey, 26 reported at least some information on the number of full-time equivalent (FTE) positions within their respective transportation agencies. It is important to note that to improve the response rate of survey participants, the respondents were asked to report on the number of FTEs within the entire transportation agency, rather than asking the participants to collect data on the number of construction FTEs. The synthesis assumes that changes in FTEs across STAs can serve as a proxy with changes in construction FTEs during the same time period.

Table 2 shows the change in FTE levels reported between 2000 and 2010. During this time, 15 states reported FTE levels for 2000, 2005, and 2010. Of these states, one (North Dakota) reported an increase in agency FTEs, three (Nebraska, Oklahoma, and Wyoming) reported no change in FTEs, and 11 (Georgia, Illinois, Kansas, Kentucky, Maine, Michigan, North Carolina, Oregon, Utah, West Virginia, and Florida) reported a decrease in FTEs. The average percent change in FTEs between 2000 and 2010 for the responding states was –9.68%, with six states reporting a decrease in FTEs greater than 10%. Table 2 also shows the change in FTEs per million dollars of disbursement on capital outlay by the respective STA, with all 15 of the responding states reporting a decrease. The average percent change in FTEs per million dollars of disbursement on capital outlay in the responding states is –37.26%, with ten states reporting changes in excess of 30%.

The respondents to the survey were asked if they were "doing more with fewer people than [they] were 10 years ago"; 86.1% responded "yes" and 13.9% "no" (36 total responses).

PROJECT DELIVERY METHODS

The survey requested information on a number of different project development, funding, and delivery systems including design-build, public–private partnerships (PPPs), and

TABLE 1
DISTRIBUTION OF INCREASE IN STATE POPULATION, TOTAL LANE-MILES, HIGHWAY BRIDGES, AVMT, AND DISBURSEMENT ON CAPITAL OUTLAY FOR RESPONDING STAs

% Increase	Population	Lane-miles	Bridges	AVMT	Disbursement on Capital Outlay
<0	1	2	7	5	3
0–5%	12	25	24	7	4
5%–10%	12	11	8	14	0
10%–15%	8	1	0	8	1
15%–20%	4	0	0	5	1
>20%	3	1	1	1	31
Total	40	40	40	40	40

TABLE 2
FULL-TIME EQUIVALENT POSITIONS FROM RESPONDING STAs

State	FTE Positions			% Change	FTE Positions per $ Million Disbursement on Capital Outlay			% Change
	2000	2005	2010		2000	2005	2010	
California	23,444	21,035	20,796		9.1	8.65	3.73	
Colorado								
Connecticut								
Delaware								
Florida	10,354	7,579	7,443	–28.11%	4.28	2.2	1.72	–59.81%
Georgia	5,895	5,807	4,950	–16.03%	6	5.91	3.14	–47.67%
Hawaii								
Idaho								
Illinois	8,000	5,750	5,270	–34.13%	4.96	3.49	1.96	–60.48%
Iowa								
Kansas	3,304	3,247	2,916	–11.74%	5.61	5.41	4.84	–13.73%
Kentucky	5,972	5,108	4,814	–19.39%	6.55	7.1	3.82	–41.68%
Louisiana								
Maine	2,396	2,390	2,260	–5.68%	11.11	10.98	6.83	–38.52%
Maryland			3,181				3.36	
Massachusetts								
Michigan	3,244	2,872	2,863	–11.74%	2.84	2.57	2.1	–26.06%
Minnesota								
Missouri			6,000				4.52	
Montana			1,377				2.85	
Nebraska	2,200	2,200	2,200	0.00%	5.76	6.71	5.72	–0.70%
Nevada								
New Hampshire								
New Jersey		3,973				2.69		
New Mexico								
New York			9,000				3.24	
North Carolina	14,457	14,544	13,957	–3.46%	9.87	8.26	7.02	–28.88%
North Dakota	1,040	1,044	1,055	1.44%	6.62	4.32	3.17	–52.11%
Oklahoma	2,350	2,350	2,350	0.00%	3.01	5.79	1.91	–36.54%
Oregon	4,727	4,559	4,550	–3.74%	13.21	7.43	6.04	–54.28%
Pennsylvania			11,000				2.66	
Rhode Island		200	230			1.28	0.94	
Tennessee			4,800				4.2	
Utah	1,920	1,820	1,753	–8.70%	2.78	4.48	1.49	–46.40%

TABLE 2
(*continued*)

State	FTE Positions			% Change	FTE Positions per $ Million Disbursement on Capital Outlay			% Change
	2000	2005	2010		2000	2005	2010	
Vermont			1,200				5.85	
Virginia			7,000				7.26	
Washington			7,000				4.15	
West Virginia	5,100	5,000	4,900	–3.92%	7.57	8.75	6.56	–13.34%
Wisconsin								
Wyoming	2,000	2,000	2,000	0.00%	8.45	8.81	5.14	–39.17%
Average					**6.73**	**5.82**	**4.01**	**–37.26%**

warranty projects. Of the STAs responding to the survey, 27 (75%) indicated that their agencies have utilized design-build delivery systems for their projects, while 9 STAs (25%) indicated that their agencies did not use design-build delivery systems. Of the STAs utilizing design-build delivery systems, 16 (59.3% of respondents) indicated that they expect their agencies use of design-build contracts to increase over the next 10 years, 10 (37%) expected their use of design-build delivery systems to remain at the current level, and one (3.7%) expected its use of design-build contracts to decrease over the next 10 years. The survey did not collect data on the percent breakdown of total construction volume between delivery methods.

Contractor-supplied warranties on highway construction projects were less common among the survey respondents than design-build contracts, with 14 STAs (38.9%) indicating that their agencies used warranties on previous projects, while 22 (61.1%) indicated that their agencies did not use warranty contracts. Of the 14 STAs that used warranties, ten noted that they employed Construction Administration and Construction Inspection personnel to monitor warranty enforcement, and eight that they also use Construction Engineering personnel to monitor the warranty.

The use of PPPs on highway construction projects was also rare among the STAs responding to the survey. Seven states (19.4% of respondents) indicated that their agencies had used PPPs for highway construction, while 29 states (80.6%) reported not using PPPs. Of the seven states that use PPPs, five expected their use to increase, while two expected the use of PPPs to remain at current levels.

TABLE 3
REPORTED AGE RANGE OF CONSTRUCTION STAFF

Age Range (years)	Count	Percentage
30–40	15	39.5
40–50	23	60.5
50–60	0	0
60–70	0	0

CONSTRUCTION PERSONNEL DEMOGRAPHICS

Table 3 shows the reported average age range for construction personnel within the responding agencies. The highest frequency range for average age was 40 to 50 years old. This range corresponds to a median age of 42 years for engineers employed in the general civil/architectural field (Abt. Associates 2004).

Figure 1 shows the distribution of the average experience range of construction staff for the survey respondents. The largest concentration of construction personnel experience for the responding STAs was in the 10 to 15 year range (43%).

The survey also queried agencies concerning the union status of their construction staff; 24 states (63.2% of respondents) indicated their agency staff was represented by a union, whereas 14 states (36.8%) reported no union involvement. Of

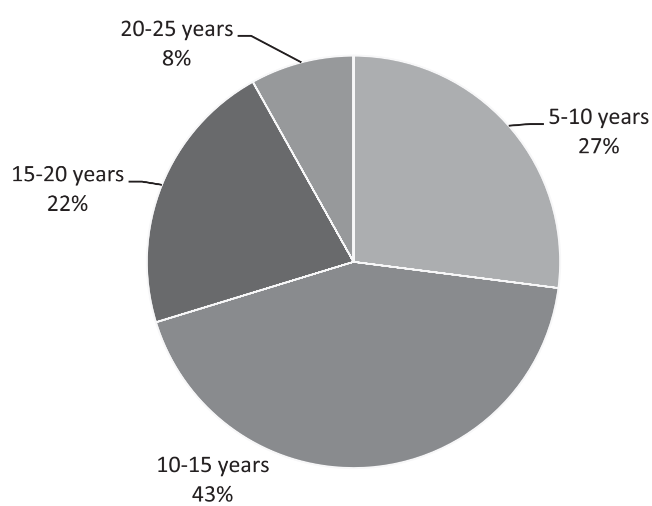

FIGURE 1 Average years of experience for construction staff.

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Are employees of your agency represented by a union?	1	1.712801	1.71280	0.4887
Error	24	84.117337	3.50489	
C. Total	25	85.830138		

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
No	11	4.30818	0.56447	3.1432	5.4732
Yes	15	3.78867	0.48338	2.7910	4.7863

Std Error uses a pooled estimate of error variance

FIGURE 2 Analysis of variance for union and non-union FTEs per million dollars of disbursement on capital outlay.

the 24 states with union representation, none reported that their union contracts specified minimum staffing levels for highway construction projects. To examine the impact of union contracts on STA staffing levels, an analysis of variance was performed comparing FTEs per million dollars of disbursement on capital outlay between union and non-union states using the JMP version 9 software package. Making comparisons based on FTEs per million dollars of disbursement on capital outlay normalizes the data for managed system size across STAs. Figure 2 shows the output of a one-way analysis of variance. The analysis demonstrated that the average FTEs per million dollars of disbursement on capital outlay is slightly lower for union STAs (3.79) than for non-union STAs (4.31). However, as shown in this figure, the difference is not statistically significant (Prob > *f* is much larger than 0.05).

TYPICAL PROJECT SIZE AND CONSTRUCTION STAFFING LEVELS

Survey respondents were also questioned concerning the average project cost and construction staffing level for a typical project within their agency. Ten states supplied information on average project size and staffing levels. To ensure consistency among answers, the respondents were asked to categorize projects according to the generic descriptions of typical roadway construction projects as shown in Table 4. Although a basic description for each project type is provided, it is important to acknowledge that survey respondents may differ in how they classify a specific project. Figure 3 shows the average project size (in $ million) for the responding agencies by project type. Figure 4 shows the average FTE staffing level for different project types. Figure 5 shows the construction volume managed by one FTE by project type.

The average project data reported shows that "reconstruction limited access" and "new route" are the two largest project types in terms of both project size ($ million) and in terms of construction staff. Across project types, construction inspection staff comprises the largest percentage of the overall construction project staff. There is some variation in construction volume managed per FTE across project type, with "bridge rehabilitation" showing the lowest construction volume per FTE.

TABLE 4
DESCRIPTION OF GENERIC PROJECT TYPES FOR HIGHWAY CONSTRUCTION

Project Type	Description
Reconstruction Limited Access	A project that utilized the existing alignment but may revise the profile, number of lanes, or drainage issues on a restricted access roadway (e.g., Interstate system).
Reconstruction Open Access	A project that utilized the existing alignment but may revise the profile, number of lanes, or drainage issues on an open access roadway (e.g., a road with signaled intersections and numerous access points).
New Route	A project that allows a new road system to be constructed on a new alignment (e.g., "greenfield" construction).
Relocation	A project that relocates a portion of an existing road onto a new alignment and grade.
Bridge Rehabilitation	A project that involves repairing an existing bridge (e.g., lane resurfacing, bridge widening).
Bridge Replacement	A project that involves the construction of a new bridge.

Hancher and Werkmeister (2000).

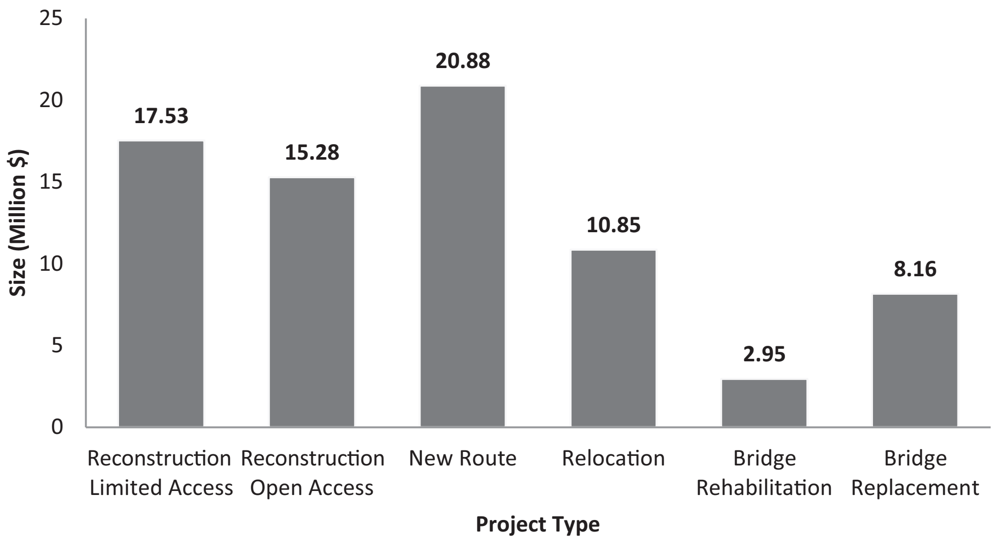

FIGURE 3 Average project size by project type (in $ million).

STRATEGIES FOR ADDRESSING CONSTRUCTION STAFF SHORTFALLS

To identify strategies that are most commonly used to meet staffing shortfalls, the survey asked the STAs to identify strategies that their state had used in recent years to address staffing issues (Figure 6).

This figure shows that the most common strategy to address a staffing shortfall was the use of outsourced construction personnel to perform construction duties. Thirty states (88.2%) reported using contract personnel (i.e., non-STA employees) to augment their permanent construction staff, whereas only four states (11.8% of respondents) reported not using consultants. When compared with the reported 59% of responding STAs using consultant construction personnel in *NCHRP Synthesis 146* (Newman 1989) and the 60% in *NCHRP Synthesis 246* (Witheford 1997), this represents a significant increase in the number of STAs using consultant services for construction personnel.

Figure 7 shows the construction staffing functions in which consultant personnel are typically employed. As would be expected, given the high levels of construction inspection staffing requirements for a typical project (Figure 4), construction inspection was reported as the most commonly outsourced function.

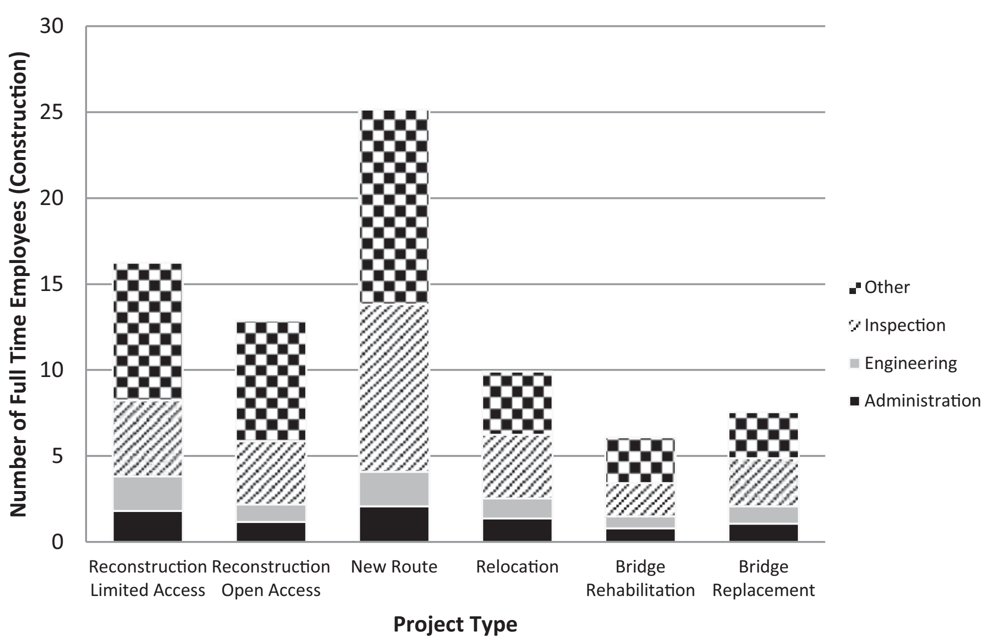

FIGURE 4 Average FTE construction staffing for a typical project.

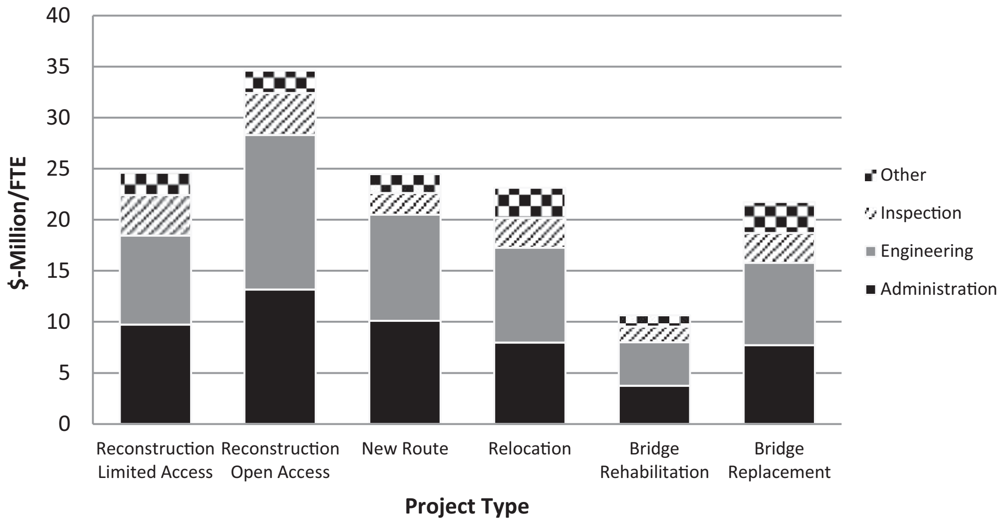

FIGURE 5 $ million/FTE by project type.

When examining the factors that contribute to the decision to use consultant construction personnel, the vast majority of respondents cited the lack of available personnel in-house to meet the staffing needs, followed by the lack of qualifications of in-house staff (Table 5).

USE OF INFORMATION TECHNOLOGY BY CONSTRUCTION STAFF

In recent years, information technology (IT) such as smart phones and tablet computers has seen increased use in the general business world. However, as Table 6 shows, the adoption of these technologies among responding agencies has been low. Table 7 shows that of those agencies using smart phones and tablet computers the most cited function for their use is smart phones for communication.

Of the respondents reporting the use of smart phones or tablet computers, 60% indicated that the use of these devices has not affected the productivity of the construction personnel. Forty percent of the respondents noted that the technology resulted in an increase in productivity, with a 10% productivity increase being the most frequently cited. There are several potential hindrances to the impact of new IT on staff productivity. There may be the limited availability of IT infrastructure at the project site. Discussions with several STAs indicated a resistance by their central office IT groups of allowing the use of wireless technology owing to concerns about data security. The limited availability of mobile applications specific to the transportation construction industry may also contribute to the low acceptance of IT. Finally, different levels of compatibility between current tablet operating systems and existing STA IT systems may prohibit the use of certain tablets.

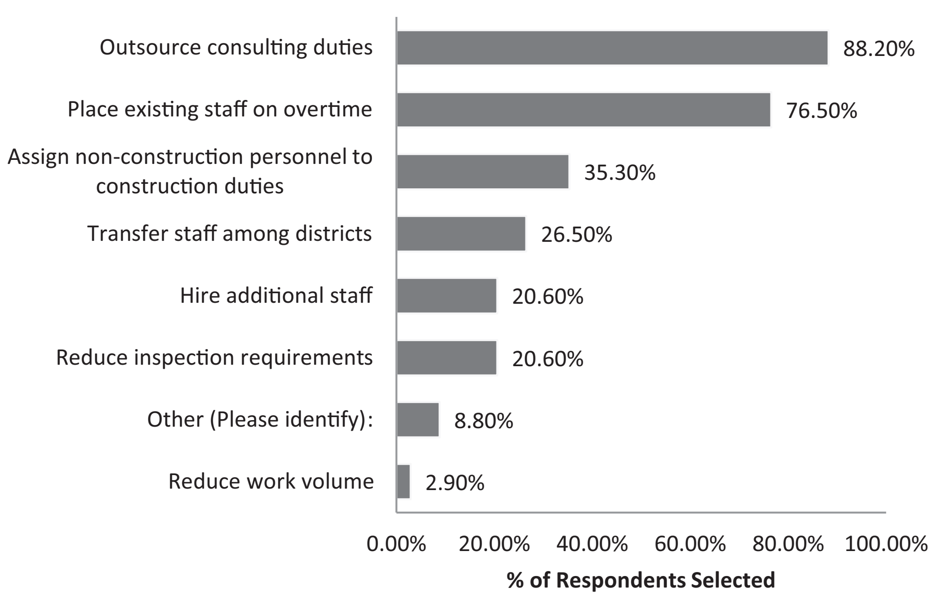

FIGURE 6 Strategies to address staffing shortfalls.

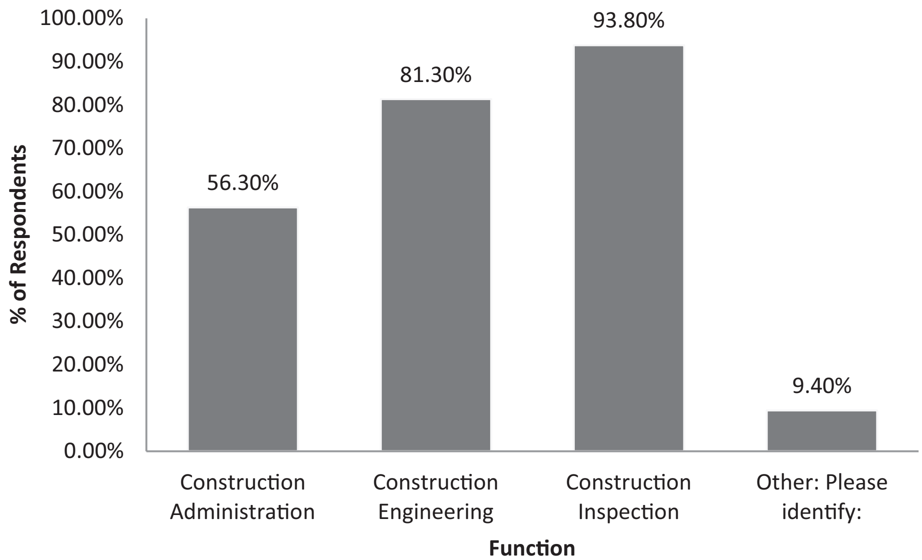

FIGURE 7 Use of consultant labor by construction function.

INTEGRATED CONSTRUCTION AND MAINTENANCE PERSONNEL

Some STAs have recently reorganized and combined some (or all) of their construction and maintenance personnel into a single district or regional organization in which personnel perform both construction and maintenance duties. The results of the survey indicated that this type of reorganization is not widespread (Figure 8). Colorado, Illinois, Iowa, Kansas, North Carolina, Oklahoma, and Utah report fully integrated construction and maintenance divisions. Oregon does not have a specified maintenance division. Kentucky and New Jersey have organizations that have separate construction and maintenance divisions at the central office level, but have integrated construction and maintenance divisions at the district level.

INVOLVEMENT OF CONSTRUCTION PERSONNEL IN THE PROJECT DEVELOPMENT PROCESS

To determine the involvement of construction personnel in the project development process, respondents were asked to identify which of the project develop phases (Design, Bid, Contract Award Construction, and Project Closeout) their construction administration, construction engineering, and construction inspection personnel were involved with. The results are displayed in Figure 9. This figure shows that on average, construction administration staff has the highest percent involvement across the entire development process, whereas construction engineering and construction inspection involvement peaks during the construction phase. It can be noted that the low indicated level of construction inspection involvement could indicate confusion concerning the question, as it would be expected that inspection personnel would be heavily involved with the construction process.

TABLE 5
FACTORS CITED IN MAKING THE DECISION TO OUTSOURCE CONSTRUCTION DUTIES

Factor	Count	Percent of Responses
Lack of Availability of In-house Personnel	31	96.9
Cost	12	37.5
Qualifications Lacking In-house	22	68.8
Other	2	6.3

OWNER-PERFORMED WORK

STAs reported that 69.4% of the agencies do not self-perform construction work, while 30.6% reported some level of self-performed work. Of the states that do self-perform construction work, seven of eight respondents reported that self-performed work requires less oversight from construction administration, engineering, and inspection personnel, whereas only one reported that self-performed work requires more oversight. One STA noted that there are reduced construction supervision and inspection requirements on self-performed work because there is less need for workforce oversight. A different STA noted that its materials testing requirements are not as extensive on self-performed work.

CHAPTER SUMMARY

The data presented in this chapter demonstrate that, on average, by any reported measure, the transportation systems managed by the responding states experienced increases in both the size and use of the road system managed between 2000 and 2010. The data also demonstrate that, on average, the responding states are managing these larger, more frequently

TABLE 6
USE OF INFORMATION TECHNOLOGY BY CONSTRUCTION FUNCTION

Information Technology (IT)	Respondents Functions Using IT		
	Construction administration	Construction engineering	Construction inspection
Smart Phone	25%	27.5%	17.5%
Tablet Computer	15%	10%	15%

TABLE 7
RESPONDENT USES FOR INFORMATION TECHNOLOGY

Information Technology (IT)	Respondents Using IT for:				
	Communication	Inspection	Plans and specs	Daily work report	Change orders
Smart Phone	32.5%	10%	7.5%	5%	5%
Tablet Computer	12.5%	12.5%	15%	15%	12.5%

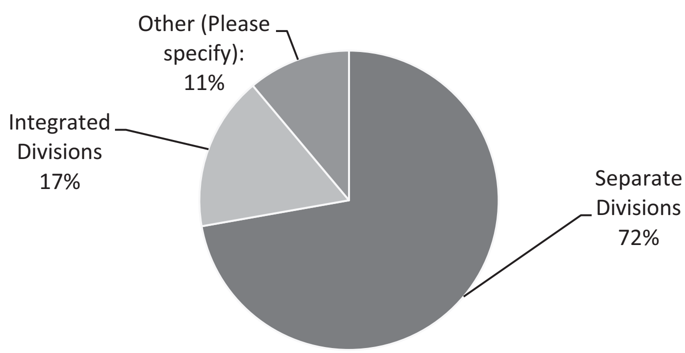

FIGURE 8 Construction and maintenance division organization.

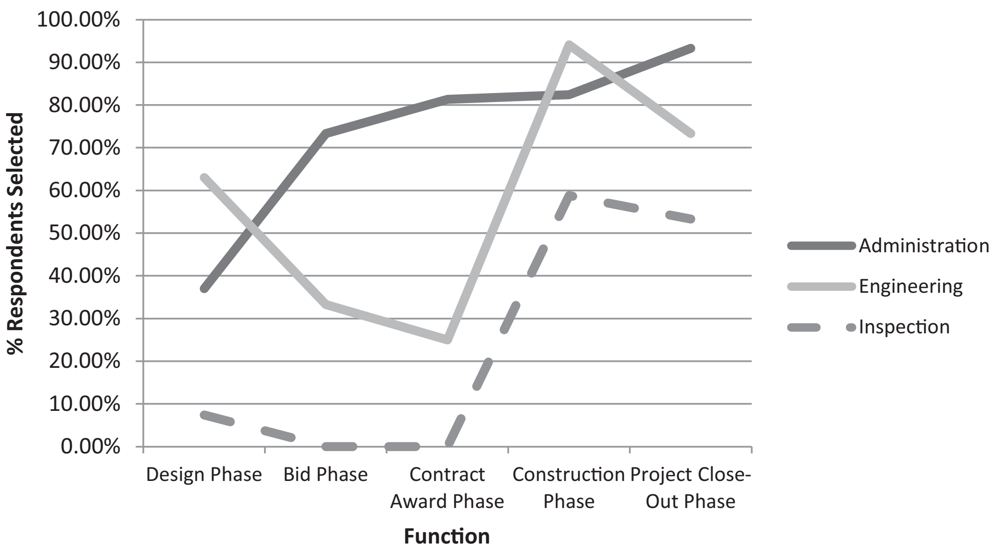

FIGURE 9 Involvement of construction personnel in project development phases.

used road networks with fewer in-house FTEs than they were 10 years ago. The use of outsourcing among responding agencies to augment construction staff is significantly higher than was reported 15 years ago. However, the data collected in the synthesis does not provide insight as to how the combined number of FTEs of STA in-house personnel and consultant personnel compares with in-house personnel levels from 15 years ago. The majority of respondents indicated that their agencies employ design-build project delivery systems for some of their projects, whereas the use of warranties and PPPs was less common. Personnel at the majority of respondent agencies were represented by unions, although no state reported minimum staffing requirements specifications in union contracts, and the difference in staffing levels between union and non-union agencies was not statistically significant when normalized to the size of the road network. Limited access reconstruction and new route construction were the largest types of projects executed, with construction inspection comprising the greatest staffing requirements. Finally, the adoption of smart phones and tablet computers by construction personnel has been slow, with those who are using the technology reporting only modest gains in productivity.

CHAPTER THREE

FACTORS THAT INFLUENCE CONSTRUCTION STAFFING REQUIREMENTS FOR PROJECTS

This chapter focuses on identifying the factors that influence construction staffing requirements for highway construction projects. The data for this chapter are from the survey responses.

SELECTED FACTOR IMPACT ON STAFFING NEEDS FOR A TYPICAL PROJECT

The study team and the topic panel developed the list of factors shown in Table 8 that could influence STA staffing requirements for highway construction projects.

The intent of the list was to succinctly describe conditions that could be encountered on a project to allow the STA respondents to report their opinions on how each factor would affect staffing requirements. The purpose of the list is to identify factors that influence staffing requirements, not to quantify the magnitude of the impact for each factor. To this end, the respondents were asked to note whether the specific factor would tend to "increase staff requirements," "decrease staff requirements," or result in "no change" in staff requirements for a typical project for construction administration, engineering, and inspection staff. Thirteen STAs provided their estimates on the impact of each factor on construction staffing. The following figures display the percentages of the STAs that selected each category for each factor (vertical axis) for construction administration (Figure 10), construction engineering (Figure 11), and construction inspection staff (Figure 12). The factor number shown along the horizontal axis corresponds to the factor number in Table 8.

Figures 10–12 identify several key factors that require increased construction staffing needs. Table 9 shows the rank order of identified factors that tend to increase construction staffing requirements for highway construction work. This table shows that the expectation of a poor set of plans, schedules, and estimates is the top ranked factor for increasing staffing requirements for construction engineering and is the fourth ranked factor for construction administration and construction inspection. Expected poor plans, specifications, and estimates, and an accelerated construction schedule are the only factors that appear in the top four reported factors across the construction staffing type. The assertion by the survey respondents that poor quality plans, schedules, and estimates can increase construction staffing needs is consistent with previous research related to the impact of design errors on construction. In a statistical analysis of change orders on Kentucky Transportation Cabinet construction projects, one of the high risk causes of change orders was design errors and omissions (Taylor et al. 2012). Another work on analyzing the causes of change orders at the Kentucky Transportation Cabinet identified guardrails as a high change order risk work item (Goodrum et al. 2010). Research in the Australian construction industry found that design errors increased project cost between 6.9% and 7.4% (Lopez and Love 2012). These studies indicate that increased agency personnel requirements for projects with high levels of change orders could also be attributed (at least in some part) to design errors.

Table 9 also shows a noticeable difference between the types of factors that tend to affect administration and engineering (early project development activities) and those that affect inspection (construction phase activities).

Figures 10 and 11 show little support for factors that can decrease construction administration and construction engineering staffing requirements. However, Figure 12 shows that increases in construction staff experience can reduce construction inspection personnel requirements. It is important to note that the list of factors shown in Table 8 focus heavily on factors that would be expected to increase staffing requirements and does not include factors that would be expected to decrease staffing requirements.

IMPACT OF PROJECT DELIVERY AND FUNDING SYSTEMS ON STAFFING REQUIREMENTS

As described in chapter two, Project Delivery Methods, a majority of STAs are utilizing design-build project delivery systems on some projects, whereas PPPs and warranty projects are less common. Of the states using design-build contracts, 12 (44.4%) reported that less construction staff is required, 14 (51.9%) reported no change in staffing requirements, and one (3.7%) reported that more construction staff is required for these types of contracts. Of the seven states using PPPs, five (71.4%) reported that PPPs require less construction staff and two (28.6%) that there is no difference in construction staffing requirements for these types of projects. Of the 14 states that have used warranties for highway construction, 12 (85.7%) reported no change in construction staffing requirements, one (7.1%) reported a decrease in staffing requirements, and one (7.1%) reported an increase in staffing requirements for warranty projects.

TABLE 8
FACTORS THAT COULD INFLUENCE STA STAFFING REQUIREMENTS FOR HIGHWAY CONSTRUCTION PROJECTS

Factor Number	Factor Description
1	Accelerated construction schedule
2	Expected increase in contractor quality
3	Expected poor plan, specifications, and estimate quality
4	Inclement weather
5	Increased average daily traffic count
6	Increased environmental mitigation
7	Increased utility relocation/coordination requirements
8	Increased construction staff experience
9	Increased contractor experience
10	Increased coordination with other agencies
11	Increased funding
12	Limited material availability
13	Project located in a large metropolitan area
14	Project located in a rural area

IMPACT OF PROJECT EXPEDITING ON STAFFING REQUIREMENTS

The decision to expedite a project (i.e., a project that receives more attention because of external circumstances that drive the project to a faster completion) increases the overall construction staffing requirements for a project. Of the 36 STAs that provided data on expedited projects, 25 (69.4%) indicated that these types of projects increase construction staffing requirements, while 11 (30.6%) indicated that expedited projects resulted in no change in staffing requirements.

IMPACT OF FHWA OVERSIGHT INSPECTIONS ON STAFFING REQUIREMENTS

As part of FHWA's oversight agreement on highway construction projects with federal funding, the agency can provide input on construction staffing levels to STAs. The STAs surveyed were asked for information on the number of FHWA communications on issues related to staffing on their projects over the past five years because of understaffing (Figure 13). Of the 36 respondents to the question, only 10 indicated that they had communication with FHWA because of understaffed projects. Discussions with several officials from these states revealed

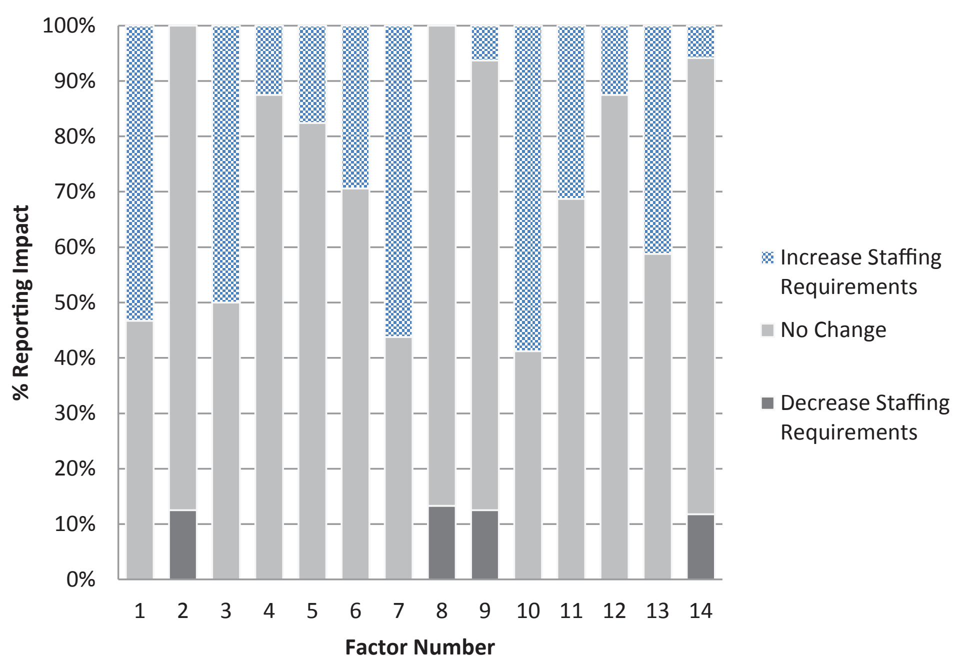

FIGURE 10 Impact of selected factors on construction administration staffing requirements.

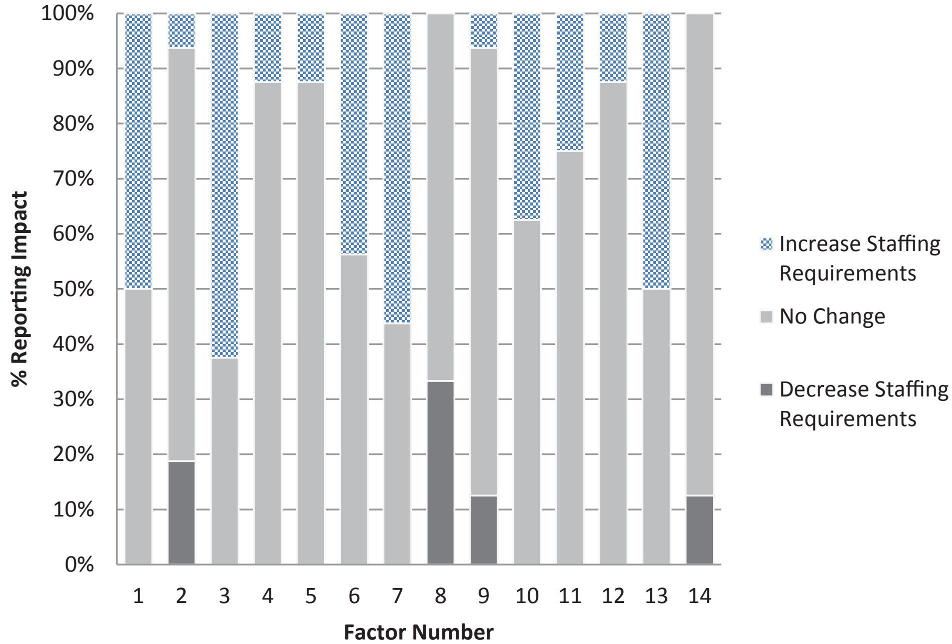

FIGURE 11 Impact of selected factors on construction engineering staffing requirements.

that FHWA minimum staffing requirements are subject to the interpretation of the FHWA inspector. STA staffing requirements during construction are specified in United States Federal Code 23 CFR 635.105(a) that states:

> The STD [State Transportation Department] has responsibility for the construction of all Federal-aid projects, and is not relieved of such responsibility by authorizing performance of the work by a local public agency or other Federal agency. The STD shall be responsible for insuring that such projects receive adequate supervision and inspection to insure that projects are completed in conformance with approved plans and specifications.

CHAPTER SUMMARY

The data presented in this chapter demonstrate that expected poor quality plans, specifications, and estimates, and accelerated construction schedules tend to increase construction staffing requirements across administration, engineering,

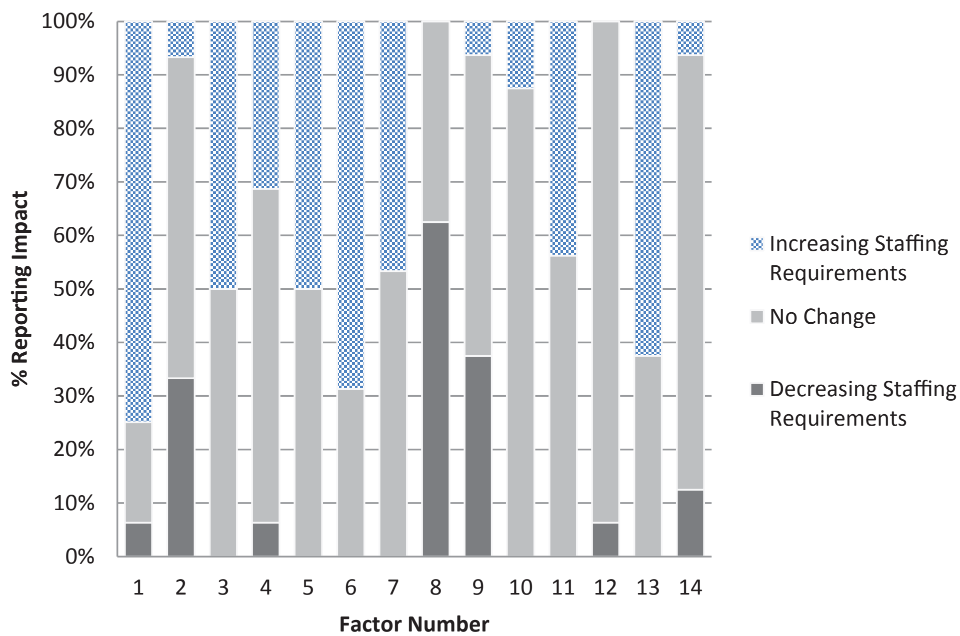

FIGURE 12 Impact of selected factors on construction inspection staffing requirements.

TABLE 9
FACTORS THAT TEND TO INCREASE CONSTRUCTION STAFFING REQUIREMENTS

Rank	Construction		
	Administration	Engineering	Inspection
1	Increased coordination with other agencies (#10)	Expected poor plan, specifications, and estimate quality (#3)	Accelerated construction schedule (#1)
2	Increased utility relocation/coordination requirements (#7)	Increased utility relocation/coordination requirements (#7)	Increased environmental mitigation (#6)
3	Accelerated construction schedule (#1)	Project located in a large metropolitan area (#13)	Project located in a large metropolitan area (#13)
4	Expected poor plan, specifications, and estimate quality (#3)	Accelerated construction schedule (#1)	Expected poor plan, specifications, and estimate quality (#3) and Increased ADT count (#5)

ADT = average daily traffic.

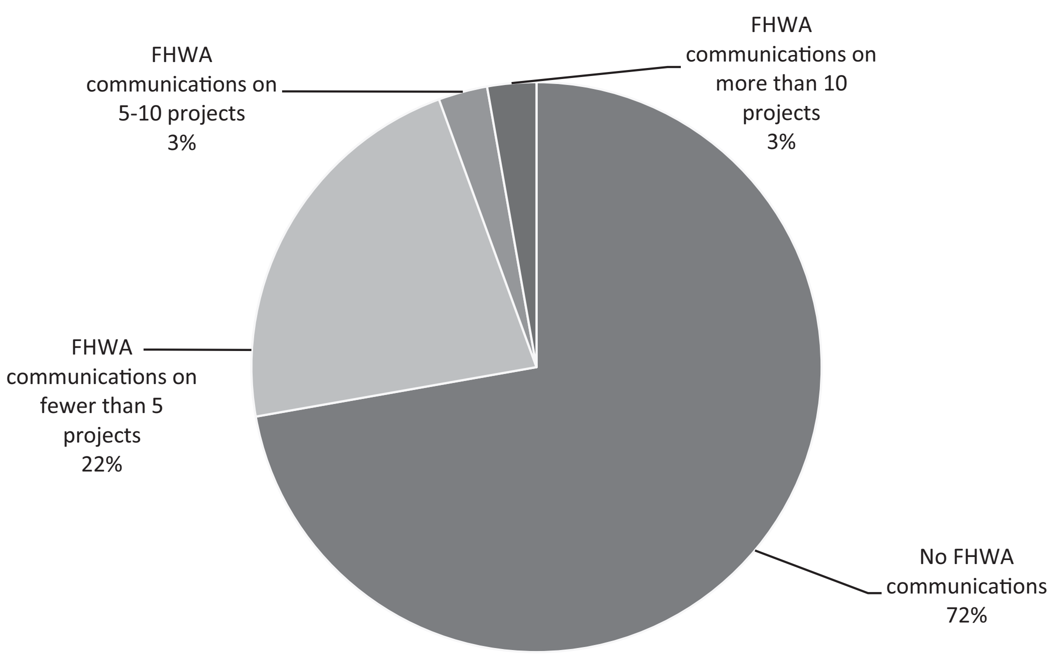

FIGURE 13 FHWA communications due to understaffing in the past 5 years.

and inspection. Increased coordination among utilities and other agencies can lead to increased staff requirements for construction engineering and construction administration, respectively. Construction inspection staffing requirements can be reduced through increased construction staff experience, increased contractor experience, and increased contractor quality. Alternative project delivery systems appear to have some reported reductions in STA construction staffing as demonstrated by the 44.4% reporting reduced staffing requirements for design-build projects and the 71.4% reporting reduced staffing requirements for PPPs. Expediting projects tends to increase construction staffing requirements for projects while the impact of FHWA oversight is minimal.

CHAPTER FOUR

CONSTRUCTION STAFFING FORECASTING TOOLS

This chapter describes the construction staffing forecasting tools identified during the course of the project. This information was collected through the survey, interviews with non-STA transportation agencies, and workshops at the 91st Annual Meeting of the Transportation Research Board in January 2012.

USE OF FORECASTING TOOLS AND STAFFING METRICS WITHIN STATE TRANSPORTATION AGENCIES

To examine the use of construction staff forecasting tools across STAs data were collected through the survey on construction forecasting tools in use at STAs and specified staffing metrics at different state agencies. When asked if their agency had a method for forecasting construction staffing requirements, six of the 38 respondents (15.8%) (Michigan, North Carolina, North Dakota, Utah, California, and Virginia) indicated their agency did have a tool for forecasting construction staffing needs. In addition, information was received by e-mail on construction staff forecasting methods in use in Texas. The systems reported in use at these states are described in more detail in the following sections.

Survey respondents were also asked if their agencies had construction staffing metrics for their projects. A staffing metric describes the number and type of personnel needed for a given type of work. The responses are summarized in Table 10, with most STAs having no formal staffing metrics.

STAFFING METRICS AT STATE TRANSPORTATION AGENCIES

In addition to the information collected through the survey, 33 state highway construction manuals or standard specifications that were available online were also studied to determine how many states provided staffing metrics for their projects. Most manuals included information on the basic personnel organization of the STA, but did not provide detailed information on the number of personnel required for a given project or type of work. Of the available manuals, only Kentucky and Nevada provided what could be considered a staffing metric. The example here is taken from the Kentucky Transportation Cabinet's *Construction Guidance Manual* (Kentucky Transportation Cabinet 2009):

> **1100 Bituminous Concrete Pavement → Section Engineer Responsibilities → Assigning Personnel to Paving Operations**
> The section engineer (SE) assigns as a minimum the following personnel to each paving operation:
> □ One Paving Inspector
> □ One Ticket Taker (when available)
> The contractor's operations may require two or more paving inspectors. One inspector stays with each paving operation and additional inspectors may be necessary to aid in overseeing the operation. It may also be necessary to add additional ticket takers on projects where significant tonnage is laid each day.

This is a clearly stated minimum staffing requirement for bituminous concrete paving operations. However, no such clear requirements were found for other types of work in that construction guidance manual. Most staffing requirement information needed to be extracted from the context as demonstrated by the following example.

> **1300 Structure → Concrete → Investigating Low-Strength Concrete:**
> The district materials engineer (DME) shall automatically investigate any in-place concrete that is represented by a low-strength cylinder report.

From the previous statement readers can learn that a district materials engineer may be involved in the construction of concrete structures. Table 11 is a summary of staffing requirements that are mentioned in similar manners in the manual. By summarizing the staffing requirements for each type of work in a matrix, one can acquire a general idea of the *idealized* staffing level of a highway construction project in Kentucky. These staffing levels do not indicate the number of construction staff on the project everyday, rather the staff involved for various activities. Discussions with Kentucky Transportation Cabinet personnel revealed that the guidelines are not commonly used for planning or staffing purposes.

In response to the survey's request for staffing metric information, West Virginia provided the following metric for "typical personnel requirements for normal daily operations of a project" (Figure 14).

These types of staffing metrics may be useful for planning construction staff resource needs as they provide a foundation for the estimate of construction staffing requirements for projects.

TABLE 10
STAs WITH CONSTRUCTION STAFFING METRICS

Response	Construction Administration		Construction Engineering		Construction Inspection	
	Count	%	Count	%	Count	%
Yes	7	19.4	5	13.9	8	22.9
No	29	80.6	31	86.1	27	77.1

CONSTRUCTION STAFF FORECASTING AT MICHIGAN DEPARTMENT OF TRANSPORTATION

The construction staff forecasting system used at the Michigan Department of Transportation (MIDOT) calculated estimated man hour requirements for individual projects to estimate the manpower requirements for an entire division. The system operates in Microsoft Excel® with cells defined for user inputs and other protected cells that calculate total staffing needs. Each Transportation Service Center (TSC, similar to a district office in other DOTs) estimates monthly construction staff manpower requirements for each project in their entire project portfolio based on the following staffing titles:

- TSC Construction Engineer
- Assistant Construction Engineering
- Staffing Engineer
- Senior Construction Technician
- Construction Technician
- Office Technician

The user enters the projects that are scheduled to be ongoing during that month as shown in Figure 15. For each project the user enters the estimated monthly man hours by staff type required for each project (Figure 16). This information is then used by the system to calculate the available construction staff compared with the required construction staff for the TSC for an entire year. To balance staff requirements versus availability, users have the option to include the use of temporary positions and overtime in the calculations. An example of the output of the system is shown in Figure 17.

Conversations with MIDOT revealed that the system was developed within the last 10 years "due to funding concerns based on [MIDOT's] ability to match federal funds." The

TABLE 11
STAFFING REQUIREMENTS FOR A KENTUCKY TRANSPORTATION CABINET PROJECT

Section No.	Section Scope	Minimum Total Number of Personnel Involved	Central Office—Division of Construction	District Office—Project Delivery & Preservation	Section Engineer (SE)	Operator	District Materials Engineer (DME)	Project Inspectors	Ticket Taker	Superpave Mix Design Technologist (SMDT)	Superpave Plant Technologist (SPT)
200	Preconstruction Requirements	3	1	1	1						
300	Contract Administration	3	1	1	1						
400	Post-Construction Requirements	3	1	1	1						
600	Construction Surveying	1			1						
700	Environmental Protection & Landscaping	1			1						
800	Nuclear Density—Moisture Meters	4	1	1	1	1					
900	Grade & Drain Construction	2			1		1				
1000	Subgrade & Base Construction	4			1			3			
1100	Bituminous Concrete Pavement	6			1		1	1	1	1	1
1200	Jointed Plain Concrete Pavement	3			1		1				
1300	Structure	5	1	1	1		1				

PERSONNEL TYPE	PROJECT TYPE: Large Grade, Drain and Pave①	Small Grade, Drain and Pave②	Major Structure③	Small Structure or Miscellaneous Improvement	Resurfacing
Project Engineer/Supervisor	1	1	1	1	—
Assistant Project Engineer/Supervisor	1	—	—	—	—
Office Technician	1	1	1	—	—
Field Inspector	2	1	1	1	2
Structure Inspector	See Note ④	See Note ④	1	—	—
Traffic Inspector	1	—	—	—	—
Quality Assurance Inspector	1	1	—	—	—
Add for Double Shift	See Note ⑤	See Note ⑤	—	—	—
TOTAL PERSONNEL	≥7	≥4	4	2	2

Notes:

1. *Large — Over $15 million.*
2. *Small — $5 million to $15 million.*
3. *Major Structure — Over $4 million.*
4. *Add 1 Structure Inspector per bridge.*
5. *Add 1 Field Inspector for double shift.*

FIGURE 14 Project staffing matrix for a West Virginia DOT project.
Note: A dash means the type of personnel is not applicable to the project type.

original intent of the system was to balance technicians between TSCs. The system has been shared across all TSCs, with most adopting the program. The forecasts for staffing needs are updated annually and the user indicated that the system had not been formally validated, but the tool has improved their planning processes.

CONSTRUCTION STAFF FORECASTING AT NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Construction staff forecasting at the North Carolina DOT is based on staffing requirements for six generic project types (bridges, interstate, rural, urban, rest area, and safety). The forecasting tool is shown in Figure 18.

The tool focuses on estimating the number of construction inspectors and survey parties needed for a given type of project. Within the bridge, interstate, rural, and urban generic project types staff requirements are further differentiated based on contract amount and estimated project duration. Based on this information, the user can identify the recommended number of personnel for each project. For example, for a $1.5 million interstate project with an estimated duration of 9 months the recommended staffing level is two inspectors and half of a survey crew's time. The form only provides recommended staffing guidelines and does not perform any calculations for the user. To forecast staffing needs for an entire district or DOT the table shown in Figure 18 would be implemented to estimate staffing requirements for each type of project and then aggregate the personnel across the project portfolio.

CONSTRUCTION STAFF FORECASTING AT NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

The North Dakota Department of Transportation estimates construction staffing needs according to the *Construction Manpower Planning Staff Standards*, which was provided to the study team through the survey by the agency. The standard is provided in Appendix C.

MONTHLY RESOURCE REQUIREMENT TO ST

MICHIGAN DEPARTMENT OF TRANSPORTA

TSC

PROJECT DESCRIPTION

		Estimated Dates				
Route	Location	Start	Finish	Type	Fix	Estimated Cost
M-89	12th Street easterly to 8th	Apr-12	Jul-13		Total Reconstruct/Bridge replacement	$ 11,000,000
I-196	Glenn Rest Area	Mar-12	Jun-12		Landscaping	$ 75,000
US-131	144th, 146th, Rabbit River, 120th Ave Bridges	Apr-12	Jul-12		Bridge Rehab	$ 2,000,000
US-131	Martin to 120th Ave	Jul-12	Aug-12		Mill and resurface	$ 5,000,000
I-196	130th Ave to US-31 Split (68th Street)	May-12	Nov-12		Total reconstruct, Concrete pavement	$ 12,000,000
M-43	Railroad tracks at Kzoo and Michigan Ave	Sep-12	Oct-12		Remove and Replace Railrosd crossings	$ 200,000
M-331	At Axtell Creek	Mar-12	Jul-12		Remove and Replace Bridge over Creek	$ 1,300,000
I-94	12th Street westerly to Co line, Kalamazoo	Sep-12	Oct-12		Mill and resurface	$ 5,000,000
US-131/M-222	US-12 to north limits of Constantine, Kzoo river to weeks road	Aug-12	Oct-12		Mill and resurface and ADA ramps	$ 1,000,000
Various	TSC wide Pavement Marking Contract	May-10	Sep-10		Pavement Markings	$ 2,000,000
Various	TSC wide Traffic Signal Upgrades	12-Oct	Apr-13		TSC wide Traffic Signal Upgrades	$ 1,000,000
Various	Local Agency Program	Jan-12	Dec-12	LAP	All Local Agency Program for the TSC	$ 19,000,000
					Total Estimated Costs for 2010	**$ 59,575,000**

G | JAN '12 | **FEB '12** | MAR '12 | APR '12 | MAY '12 | JUN '12 | JUL '12 | AUG '12 | SEP '12 | OCT '12 | NOV '12 | DEC '12

FIGURE 15 Michigan DOT ongoing projects for a single month.

The stated purpose of the standard is:

- "To provide guidelines for determining the number of engineers and technicians required to adequately staff construction projects.
- To maximize personnel use.
- To provide a resource for evaluating staffing patterns.
- To provide estimates of numbers and classifications of employees required to meet future staffing needs.
- To provide personnel projections for budgeting purposes.
- To provide an estimate of numbers and types of vehicles needed for construction."

To use the system to estimate staffing requirements for a project the user must estimate the number and type of people needed for a particular type of project and the construction duration of the project. The system uses a set of 15 construction staffing standards that provide recommended staffing levels for different types of projects. Figure 19 shows the standard for a grading and aggregate surfacing project.

The standard also provides a tool for estimating the project duration based on the length of the project (Figure 20). For each type of improvement shown in Figure 20, a staffing standard (similar to the one shown in Figure 19) is provided in the manual.

' TO STAFF PROJECTS

ISPORTATION

			CONSTRUCTION MANAGEMENT DESCRIPTION AND OVERSIGHT					
			* MDOT				** MDOT, Consultant or Co-Op	
			Staff Position Type					
			**Constr. Engineer	**Asst. Constr. Eng.	**Staff Eng.	**Senior Tech.	**Technician	**Office Tech.
Estimated Cost	CE	Office	Man Hours (per Month)	Man Hours (per Month)	Man Hours (per Month)	Man Hours (per Month)	Man Hours (per Month)	Man Hours (per Month)
[redacted]	MDOT	Woods	16	20	0	16	160	16
[redacted]	MDOT	Woods	16	8	0	8	160	8
[redacted]	MDOT	Woods	16	8	0	0	80	8
[redacted]	MDOT	Woods	8	0	0	16	0	8
[redacted]	MDOT	Woods	8	8	0	0	0	8
[redacted]	MDOT	Woods	0	0	0	0	0	8
[redacted]	MDOT	Woods	8	8	0	32	0	0
[redacted]	MDOT	Woods	0	0	0	0	0	0
[redacted]	MDOT	Woods	0	0	0	0	0	0
[redacted]	MDOT	Woods	0	0	0	16	0	0
[redacted]	MDOT	Woods	0	0	0	0	0	0
[redacted]	MDOT	Woods	16	8	0	32	0	0

FIGURE 16 Michigan DOT estimated staffing requirements by type for a single month per project.

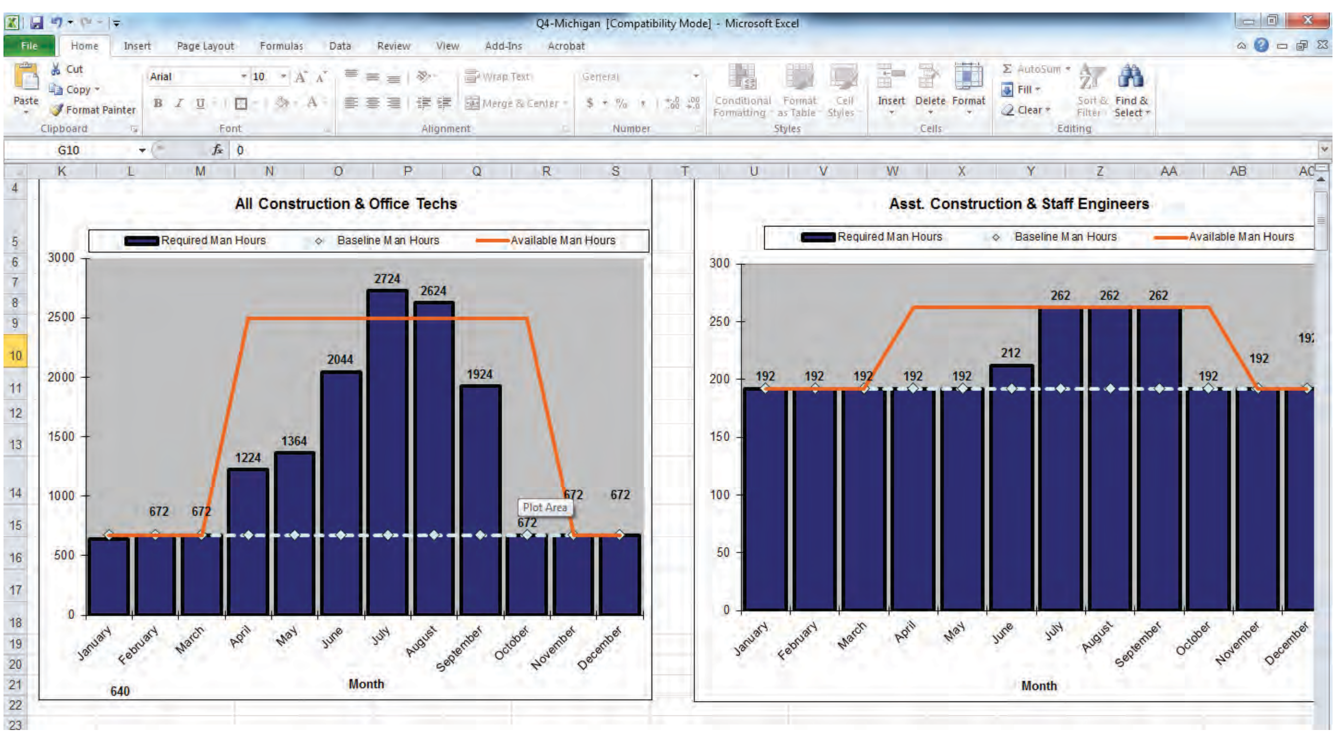

FIGURE 17 Output of Michigan DOT construction forecasting tool.

		PROJECT A	PROJECT B	PROJECT C	PROJECT D	PROJECT E	PROJECT F	PROJECT G
BRIDGE(B)	$ AMOUNT (MILLIONS)	<0.5	0.5-1	1-1.5	1.5-2	2-5	5-10	>10
	MONTHS	9	12	16	18	20	30	36+
	PROPOSED # OF INSPECTORS	1	1	1	1	2	2	3
	PROPOSED # OF SURVEY PARTIES	0.50	0.50	0.50	0.50	0.50	0.50	0.50
INTERSTATE (I)	$ AMOUNT (MILLIONS)	<1	1-2	2-5	5-10	10-25	25-50	>50
	MONTHS	6	9	12	18	24	36	36
	PROPOSED # OF INSPECTORS	2	2	3	4	6	8	10
	PROPOSED # OF SURVEY PARTIES	0.50	0.50	1.00	1.00	1.00	1.00	1.00
RURAL(R)	$ AMOUNT (MILLIONS)	<1	1-2	2-5	5-10	10-25	25-50	>50
	MONTHS	6	9	15	24	36	40	40
	PROPOSED # OF INSPECTORS	1	2	3	4	5	6	8
	PROPOSED # OF SURVEY PARTIES	0.50	0.50	0.50	1.00	1.00	1.00	1.00
URBAN(U)	$ AMOUNT (MILLIONS)	<1	1-2	2-5	5-10	10-25	25-50	>50
	MONTHS	6	10	18	24	30	36	36
	PROPOSED # OF INSPECTORS	2	2	3	4	5	6	8
	PROPOSED # OF SURVEY PARTIES	0.50	0.50	1.00	1.00	1.00	1.00	1.00
REST AREA (K)	$ AMOUNT (MILLIONS)	ALL						
	MONTHS	9						
	PROPOSED # OF INSPECTORS	1						
	PROPOSED # OF SURVEY PARTIES	0.50						
SAFETY (W)	$ AMOUNT (MILLIONS)	ALL						
	MONTHS	6						
	PROPOSED # OF INSPECTORS	1						
	PROPOSED # OF SURVEY PARTIES	0.50						

FIGURE 18 Construction staff forecasting data from North Carolina DOT.

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 10

TYPE OF IMPROVEMENT:

Grading & Aggregate Surfacing

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	1		1
General Inspector	2		2
Survey Crew	1	2½	1
Compaction & Culvert Inspector		1	1
Lab Person	1		1
Scale & Checker *		0	
Office Person		½	
Total	5	4	6

* Not Applicable if Contractor Supplied.

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor	1
Engr Technician IV	1
Engr Technician III	2
Engr Technician II	1

VEHICLE REQUIREMENTS

Utility	1
Survey Pickup	1
Pickup/Utility	4

FIGURE 19 Example staffing standard for North Dakota DOT project.

CONSTRUCTION STAFFING TIME BY TYPE OF PROJECT

CODE	TYPE OF IMPROVEMENT	CALENDAR DAYS PER CONSTRUCTION MILE
10	Grading & Aggregate Surface	20.0
11	Grade & Bituminous Base (Select Grade, Widen, & Base and Mine & Blend)	17.0
12	Bituminous Surfacing/Structural Overlay	3.0
13	Subgrade Repair, Milling, Base & Hot Bituminous Pavement	12.0
14	Contract Patching/Thin Lift Overlay	2.0
15	Surface Coat	1.0
16	Recycled PCC or PCC Surfacing	15.0
17	Concrete Pavement Repair	14.0
18	Box Culvert	30.0
19	Bridges & Deck Overlay	100.0
20	Municipal Items (Grade, Surfacing Sewer, Curb & Gutter)	(Variable)
21	Contract Striping	(Variable)
22	Signing and/or Guardrail	5.0
23	Landscaping	(Variable)

FIGURE 20 Table to estimate project duration from North Dakota DOT.

In addition to providing a description for the methodology, the standard also specifies when the forecast is to be performed and by whom [district engineer]:

> Before February 15 of each year, the districts will furnish the Construction Services Engineer with a district staffing plan. The plan will be reviewed, revised if necessary, and adopted by March 1. These plans will provide staffing guidelines for the construction season and will become part of the Construction Services Staffing Plan.

CONSTRUCTION STAFF FORECASTING AT UTAH DEPARTMENT OF TRANSPORTATION

The construction staff forecasting tool used by the Utah DOT (UDOT) differs considerably from the previously discussed tools. The system is contained within a macro enable Microsoft Excel® template. A screenshot of part of the template is shown as Figure 21.

The system aggregates the billable hours for both technicians and engineers by pay period based on estimated information imported into the system from UDOT's Electronic Program Management System (ePM). ePM is the system UDOT uses to track the planning, funding, scheduling, and staffing of their design projects. Information from this system contains the estimates of staffing needs for each project that is imported into the Excel template. The template is extremely detailed and includes the names of specific engineers and technicians, their billable rate, and their project assignments. The sheet also contains information about specific projects, including the current location of the project in the development process. Once staff is assigned the project the total billable hours for each person can be tabulated across the project and the project portfolio.

CONSTRUCTION STAFF FORECASTING AT VIRGINIA DEPARTMENT OF TRANSPORTATION

The Virginia DOT (VDOT) has developed construction staff forecasts periodically in the past for specific time periods. Each district calculates the number of construction personnel required based on the projects funded in each fiscal year by type, location, duration, and dollar value of the project.

CONSTRUCTION STAFF FORECASTING AT TEXAS DEPARTMENT OF TRANSPORTATION

Although a response to the online survey was not received from the Texas DOT (TxDOT), the study team was able to collect information on a construction staffing forecasting tool currently being developed by the agency with assistance from the Center for Transportation Research at the University of Texas–Austin. Information on the system was obtained from the workshop FHW12-012 Coming Out of the Recession: Changes in Transportation Infrastructure Construction in the New Economy held during the 91st Annual Meeting of the Transportation Research Board in 2012 (Lehman 2012).

Staffing needs for future projects are estimated using a regression model developed by means of a step-wise regression analysis of historic project staffing needs. The primary input variables for the model are project cost and project type. The model has a number of underlying assumptions listed here:

- One inspector can handle $250,000/month.
- Seal coat inspectors can handle $850,000/month and project will be completed the next season after letting (start—May, complete—end of August).
- One inspector can handle up to a $5 million bridge project; above this amount two inspectors are required.
- Overlay projects that produce up to $1,500,000 monthly estimates. One inspector can handle up to $1,500,000/month in overlay work.
- Sharing of work duties will take place. Number of inspectors is average required over life of project. Inspectors from other projects will assist during peak periods on individual projects.
- One manager is required for 14 employees. For this calculation, a manager is defined as AE, AAE, project engineer, project manager, etc.
- Support staff includes record keepers, AO lab staff, district lab staff, district construction, etc.
- One inspector can handle ten local-let projects.
- Inspector needs for Comprehensive Development Agreement and Pass-Through Financing projects will require district decision dependent on type of project and nature of the agreement/contract.
- Inflation will increase by 5% annually and will reduce effective inspector needs by that rate.
- FTE staffing needs increased by 10% as follows: 5% inefficiency for vacation, sick leave, etc.; 5% contingency for increased letting, project delays, added work, etc.

The system also includes allowance for seasonal variability by geographic location of work and therefore staffing needs.

The system is still under development and is currently being tested on a limited basis by TxDOT personnel. An example of the output of the system showing the estimated construction staff required for all TxDOT projects is shown in Figure 22. The final Center for Transportation Research report on the system is expected to be published at the completion of the project, currently scheduled for Fall 2013.

CONSTRUCTION STAFF FORECASTING AT CALIFORNIA DEPARTMENT OF TRANSPORTATION

Information was received on construction staff forecasting practices at Caltrans. The system used at Caltrans was described in an e-mail communication with the Central

Report Year	Construction or CE	Resident Engineer	Period	Project Manager	PIN Status	Local Gov.	Proj. Deliv. Method
2013	C.E. Estimate	JACE MECHAM	Calendar YR	·	·	·	·

PIN	Project Number	Project Location	Project Concept	PIN Status	Submit Adv. Date	Construction Estimate	C.E. Estimate	Project Delivery Method	Project Manager	Resident Engineer	LG	ePM Const. Begin Date	ePM Const. End Date	Override Const. Begin Date	Override Const. Duration (days)	Override Const. End Date (calc'd)
6457	S-0252(6)0	SR-252; 1000 WEST, LOGAN, CACHE COUNTY	Bituminous Pavement, Minor Widening	Under Construction	10-Nov-10	21,553,318	1,675,000	Design, Bid, Build	ROD TERRY	NICK PETERSON	N	8-Feb-11	31-Oct-12			
7580	S-0091(34)22	SR-91 IN NIBLEY - MP 22.3	CLOSE SIDE STREET ACCESS	Active	30-Apr-12	128,000	10,000	Design, Bid, Build	NATHAN PETERSON	NICK PETERSON	N	8-Jun-12	3-Oct-12			
8289	S-0165(6)10	SR-165 & 300 SOUTH, PROVIDENCE	CONSTRUCT NEW TRAFFIC SIGNAL	Under Construction	30-Nov-11	412,188	40,000	Design, Bid, Build	ROD TERRY	NICK PETERSON	N	31-Jan-12	31-May-12			
9375	F-0091(42)10	SR-91; MP 10.30 to MP 11.86	Barrier / Guardrail / Fence	Under Construction	14-Sep-11	319,777	30,000	Design, Bid, Build	DARYL BALLANTYNE	NICK PETERSON	N	12-Dec-11	29-Jun-12	4-Apr-12	150	1-Sep-12
9382	S-0091(43)32	State Route: SR-91 from: 32.13 to: 32.33 for: .20	Intersection Modification	Active		50,000	6,000	Design, Bid, Build	ROD TERRY	NICK PETERSON	N	31-Dec-11	7-Jun-12			
9413	S-0252(7)0	State Route: SR-252 from: .00 to: 6.77 for: 6.77	Reconstruction - Added Capacity	Active	21-Mar-12	11,100,000	750,000	Design, Bid, Build	ROD TERRY	NICK PETERSON	N	1-Mar-12	31-Dec-12			
9552	S-0165(7)10	State Route: SR-165 from: 9.70 to: 10.72 for: 1.03	Maintenance Resurfacing	Under Construction	7-Dec-11	155,868	7,000	Design, Bid, Build	DARYL BALLANTYNE	NICK PETERSON	N	2-Apr-12	3-Sep-12			
9553	F-0165(8)5	State Route: SR-165 from: 4.92 to: 9.70 for: 4.78	Maintenance Resurfacing	Active	2-Feb-12	596,198	40,000	Design, Bid, Build	DARYL BALLANTYNE	NICK PETERSON	N	15-Jul-12	15-Sep-12			
9556	S-0030(52)102	State Route: SR-30 from: 102.32 to: 108.66 for: 6.34	Maintenance Resurfacing	Under Construction	21-Jul-11	339,900	32,000	Design, Bid, Build	ROD TERRY	NICK PETERSON	N	2-Aug-11	2-Jul-12			
9564	F-0091(44)3	State Route: SR-91 from: 3.34 to: 10.11 for: 6.78	Maintenance Restoration & Rehabilitation	Under Construction	6-Sep-11	4,855,117	400,000	Design, Bid, Build	ROD TERRY	NICK PETERSON	N	31-Oct-11	2-Jul-12			
9567	F-I15-8(140)385	State Route: I-15 from: 384.88 to: 400.59 for: 15.71	Maintenance Restoration & Rehabilitation	Active	31-Aug-12	5,750,000	265,625	Design, Bid, Build	NATHAN PETERSON	NICK PETERSON	N	######	######			
10293	F-0091(47)19	SR-91; MP 19.54 to MP 25.50	Bituminous Pavement, Chip Seal	Advertised	15-Dec-11	376,905	18,000	Design, Bid, Build	DARYL BALLANTYNE	NICK PETERSON	N	1-Jul-12	1-Aug-12			
10301	F-0089(29 5)487	SR-89; MP 486.92 to MP 492.10	Bituminous Pavement, Chip Seal	Active	15-Feb-12	317,000	20,930	Design, Bid, Build	DARYL BALLANTYNE	NICK PETERSON	N	15-Jun-12	15-Aug-12			

Print | Create Current Report Tab

PIN	1 12/22/12	2 1/5/13	3 1/19/13	4 2/2/13	5 2/16/13	6 3/2/13	7 3/16/13	8 3/30/13	9 4/13/13	10 4/27/13	11 5/11/13	12 5/25/13	13 6/8/13	14 6/22/13
6457														
7580														
8289														
9375														
9382														
9413	32,609													
9552														
9553														
9556														
9564														
9567	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838
10293														
10301														
Payperiod Total	12,447	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838	9,838

Report | TransTechs | REs | Maintenance Sheds

Filter Mode

FIGURE 21 Control panel for Utah DOT construction staffing forecasting tool.

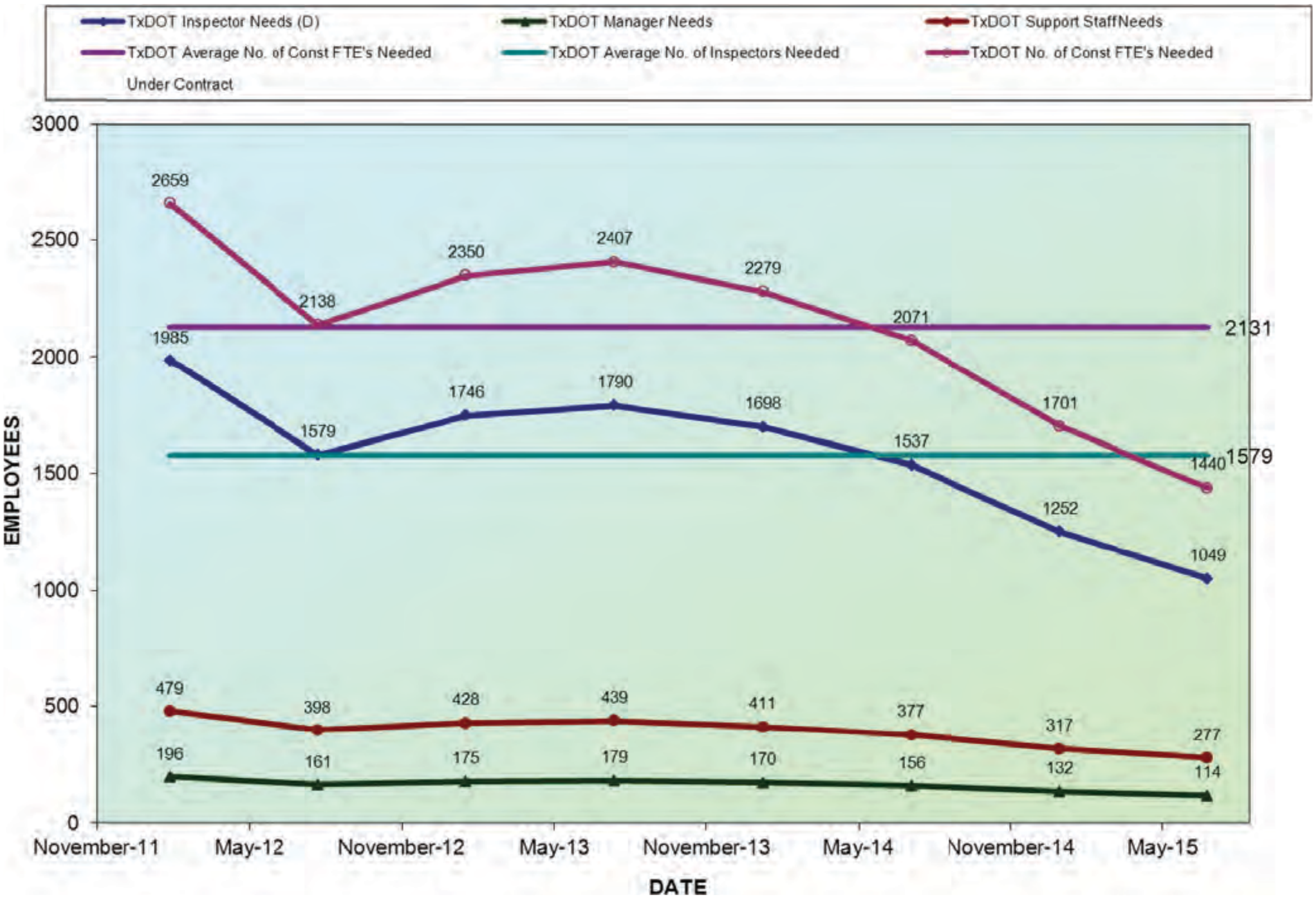

FIGURE 22 Texas DOT construction staffing analysis (horizontal lines represent average number of staff needed) (Draft).

Region Construction Chief (M. Der Matoian, personal communication, July 6, 2012) as follows:

> The California Department of Transportation uses a bottoms-up method for estimating support needs for most of its capital improvement projects. Preventative maintenance projects like chip seals and small signal projects do not, nor do general small projects under $1,000,000.
>
> It should be noted that as these smaller projects many times require a high support budget as a percentage of the capital cost, which is difficult to explain without a detailed breakdown, expanding the workplan method to these smaller projects could have significant benefits.
>
> For all major projects and some significant small projects, a workplan is developed early in the life of the project. The workplan contains a series of linked activities, with man hour resource needs and duration estimates for each. When developing the cost, scope and schedule, and writing the programming document, each division generates its estimated support needs. There is no one proscribed method for doing so. The Construction Division in the Central Region of California (a Cooperative of capital functions for Districts 5, 6, 9 and 10) uses a method that is similar to the other districts and regions in the state.
>
> A centralized support squad starts the process by taking the basic job information, location, length, description of work to be performed, and capital cost estimate, and then generates a straw man type estimate. It estimates the type of personnel needed, Resident Engineer, Construction Manager, Inspector, etc., and gives an estimated number that will be needed over the life of the project for each, sometimes using fractions of a person for smaller jobs. Factors for weather day disruptions are also applied, as well as any anticipated logistic factors for remote location projects. These initial estimates are made with our historical usages in mind, but are not solely based on our historical project spending data.
>
> This base workplan is then sent to the Resident Engineer (RE) and Construction Manager that will most likely be assigned to the project when it goes to construction. They review the estimate and suggest changes based on their experience with similar projects, the anticipated breakdown and experience level of their staff, any area specific conditions, as well as potential economies of scale due to their overall workload from other projects.
>
> When completed, this workplan is sent to the project manager (PM). They review and if necessary meet with the Construction team to negotiate the final workplan details for the Construction Division. When the workplan is agreed to, the PM enters the details into a proprietary program known as XPM. XPM lists all scheduled projects and can generate estimated resource needs for a project, series of projects or program in a specified geographic area, or for an individual RE or PM.
>
> Each district has its series of projects at all stages of development entered into XPM, and can use the system to analyze and break down resource needs now and in the future for all divisions. As with any system, the projections are only as good as the assumptions they are based on. As each project is developed, after its initial scoping, more information about the details of the project is generated, and therefore a more refined estimate of the resources needed in Construction can be made. At least once a year, and at important programmatic milestones during the year, the Construction Division reviews its upcoming projects, and requests any updates to the estimates it feels are necessary

based on the new and more detailed descriptions of the projects and their various construction features. As each new fiscal year approaches, a new allocation is made by combining the resource needs generated by the XPM system, and the estimates of non-workplanned projects and other non-project direct needs (training, safety programs etc.).

One important omission in the system is the estimation of the number of vehicles and types of equipment needed, and other cost information necessary to properly anticipate support spending on the project. As a result, there are times when the equipment needed is not available or is in the wrong locations, resulting in inefficient use of the personnel resources.

At any point in time, you can get a project direct workload estimate for Construction for the next several years. Using average percentages for the non-project direct resource needs, you can estimate your total Personnel Equivalents for any given future year. It must be noted that the group of projects shown in XPM to be worked on in any given year are subject to change as funding levels for future years become more accurate, and as the development of the projects proceeds, and the final delivery date to construction becomes more predictable.

CONSTRUCTION STAFF FORECASTING AT NON-STATE TRANSPORTATION AGENCIES

Although the response to the survey by non-STA transportation entities was low, the study team was able to collect information on construction staff forecasting practices at some of these agencies through site visits by some members of the study team to the organizations in January 2012. The organizations visited included the San Diego Association of Governments (SANDAG), the Los Angeles Country Metropolitan Transportation Authority, the San Francisco Municipal Transportation Agency, and the San Francisco Bay Area Rapid Transit District.

San Diego Association of Governments

Members of the study team met with the Principal Transportation Engineer and Principal Construction Engineer for SANDAG. The agency does not utilize a model or formula to determine project staffing. A resident engineer is appointed to a project. This individual, based on an analysis of the project characteristics and anticipated construction methods, estimates the project's staffing requirements. This analysis includes an assessment of issues such as: Does the project have unique storm water impacts or implications? Is there a potential for archeological issues? Will the project have significant noise impacts that must be addressed and monitored? Is the project in a politically sensitive area? The resident engineer then determines the nature and number of staff required for the project.

Los Angeles County Metropolitan Transportation Authority

Team members met with the project manager for a large construction project, the director for program management, and the Principal Technical Estimator for Program Management Oversight. Los Angeles County Metropolitan Transportation Authority (LA Metro) uses a budgeting process for staffing that is based on experience acquired on similar types of projects. The team was provided with the following budget information for the Metro Orange Line Bus Rapid Transit Project:

Percentage of Total Bid Cost (including indirects and profit):

- Construction Management Support (consultants) = 2.3%
- Project Management Assistance (consultant) = 1.0%
- Specialty consultants = 1.0%
- *Legal services = 1.3%
- Total Agency Cost = 14.5% inclusive of Construction Management Staff
- *3rd party = 7.7%
- *Contractor controlled insurance = 3.6%
- Contractor controlled QA/QC = 3.2%

*Services that may be classified elsewhere, but could fall under Construction Management Services guidelines. On light rail transit projects completed in the 1990s, the cost of Construction Management Services was as high as 20% of construction costs.

This budget information is converted to personnel requirements based on the specific needs of the project. The number of personnel and hours worked by each is adjusted during the project to reflect needs and budget requirements.

San Francisco Municipal Transportation Agency

Members of the team visited with the Construction Manager for Transportation Planning and Development for the Central Subway Project in San Francisco. The agency's approach is similar to that employed by LA Metro. Budgets are established for agency construction staffing requirements and the specific personnel requirements are determined by project needs and budgetary guidelines.

San Francisco Bay Area Rapid Transit District

Meetings were held with the Group Manager for Civil Engineering and Construction, Principal Engineer for the Automatic Fare Collection Capital Program, Project Manager for the Warm Springs Extension, and Project Director for the Silicon Valley Bay Area Rapid Transit (BART) expansion. During this visit the team reviewed several projects with BART representatives. These projects ranged in value from $300 million to $2.5 billion. Because of the size of the projects, extensive use is made of outside consultants for construction staffing. For example, on the Oakland Airport Connector project, there are 17 full-time construction management services personnel, but only two of these are BART employees. Staffing plans are developed individually for each project based on the project schedule, budget, and characteristics.

STAFFING AT MAJOR U.S. COMMERCIAL AIRLINES

One STA survey respondent suggested that the highway construction industry could learn lessons on construction forecasting from staff forecasting programs used by U.S. commercial airlines. Major U.S. airlines face complex scheduling problems on a daily basis. United Airlines operates over 5,000 daily departures to nearly 800 destination cities around the world. Poorly constructed crew schedules result in high crew cost for airline companies. In the 1980s, large U.S. airlines each paid several million dollars each month for hotel rooms (Gershkoff 1989).

The initial settings of a flight crew scheduling problem include a set of flight segments to be covered exactly once; a set of destinations, each having its assigned manpower; and restraints such as crew's maximum monthly work time. The problem involves pairing up flight segments into round-trip itineraries over several days and assigning these pairings to available crews. Optimization means finding a set of pairings that covers all of the flight segments with minimum cost (Graves et al. 1993).

The flight crew scheduling problem is to some extent similar to the problem of staffing highway construction projects, with flight segments representing projects and crews representing teams of engineers. Therefore, studying the method of how airlines solve their scheduling problems could provide insight into solving construction project staffing problems. In the 1970s, IBM developed a program called Trip Pairing Airline Crew Scheduling System (TPACS) (Graves et al. 1993). It divides flight segments into disjoint sets of pairings where no two pairings have the same flight segment. The program takes two to three pairings at a time and rearranges the flight segments in the pairing to find the one arrangement with minimum cost. The iterative process goes on when all combinations have been tried and a satisfying solution is found. This was the method that United Airlines used until the 1990s.

American Airlines and the former Continental Airlines use a system called Trip Reevaluation and Improvement Program (TRIP) (Graves et al. 1993). Schedulers build an initial feasible solution manually or using an interactive computer system. TRIP then randomly selects a set of pairings from the current best solution and optimizes the pairings as illustrated in Figure 23. The two methods use a local optimal strategy that breaks the large scheduling problem into smaller sub-problems.

Although it may be helpful for STAs to study how airlines schedule their crews, we must notice that there are big differences between scheduling flight crews and assigning construction personnel to transportation projects. For example, a flight crew cannot be working on flights that overlap in time; however, a project inspector can work on multiple concurrent projects. The flight crews are assembled teams, each being competent of performing any flight segments in the scheduling problem so that the prime concern of flight crew scheduling is to minimize overlay time to reduce cost, while construction personnel are not always teamed and staff members' competency may vary. Nonetheless, the methods being

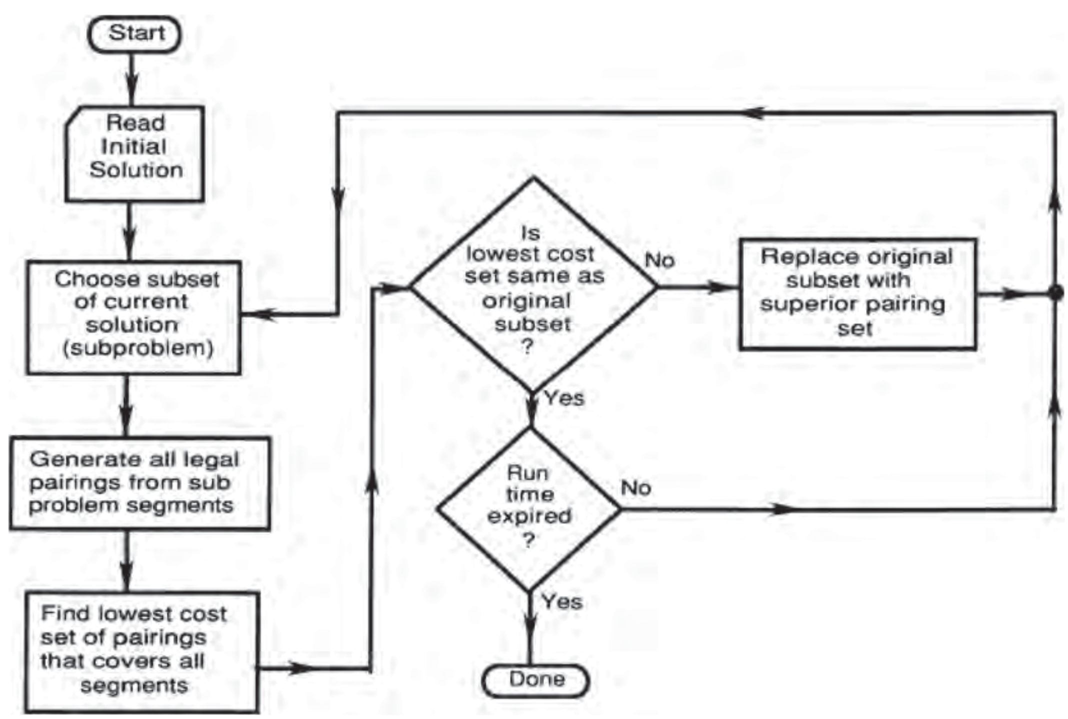

FIGURE 23 The block diagram of the optimization process used by TRIP (Gershkoff 1989).

used by major airlines for scheduling flight crews provide valuable insights into our problem of interest.

CHAPTER SUMMARY

Relatively few STAs reported having a formal system for estimating construction staffing requirements for future projects. The formal construction staff forecasting systems in use at the responding STAs represent a diverse set of approaches. Systems in North Dakota and North Carolina are relatively simple systems that rely on using recommended staffing levels for different generic project types. Systems in use in Michigan, Utah, and Texas are more complex and make extensive use of project data available through the STAs' electronic project databases. The approaches also varied in terms of how staff needs were estimated; some used recommended staffing levels based on a project type (North Dakota and North Carolina), some used historical data to develop regression analyses to estimate staffing needs (Texas), whereas others used a historic percentage estimate of staffing costs based on total project costs that could then be converted into staffing estimates.

Of the non-STA agencies visited, SANDAG (San Diego Association of Governments) is most like many transportation agencies in that an ad hoc approach is used to determine construction staffing requirements. Los Angeles Metro, San Francisco MTA, and BART are very similar. Limited in-house staff is utilized and the great majority of construction management oversight services are provided by external consultants. This allows the agencies to maintain minimal employment levels that are supplemented by consultants as needed.

CHAPTER FIVE

CONCLUSIONS

This study examined construction staffing practices at state transportation agencies (STAs) and selected non-STA transportation organizations using an online survey tool, site visits, and a review of STA literature on construction staffing. This project developed several findings and recommendations for future work in response to the work summarized here.

GENERAL FINDINGS

The data analyzed in this project offer a number of significant general findings related to STA construction staffing for highway construction projects:

- *Few STAs reported having formal systems to estimate construction staffing needs for highway construction projects.* Of the 40 STAs contacted regarding formal construction staff forecasting methodologies, seven states indicated that they use some type of formal system to estimate construction staffing needs for future projects.
- *STAs are managing larger roadway systems with fewer in-house staff than they were 10 years ago.* For the 40 STAs that responded to the survey, between 2000 and 2010 state-managed lane-miles increased by an average of 4.10%, whereas the number of full-time equivalents (FTEs) decreased by 9.68%. When FTEs are normalized across the managed road system, the responding transportation agency's FTEs per $ millions of disbursement on capital outlay decreased by an average of 37.26%.
- *The types of construction staff forecasting methods employed by STAs are diverse and widespread in their methodology.* The forecasting methods range from simple staffing heuristics based on generic project types to multi-variate regression models developed from historical project data. These methods also varied in the processes used to estimate staffing numbers with some using work type and others using total project cost to estimate staff requirements.
- *The two most cited factors by responding STAs for increasing construction staffing requirements for a project were poor quality plans, specifications, and cost estimates, and an accelerated construction schedule.* Other factors that increased staffing requirements for construction administration and construction engineering personnel differed from those for construction inspection. Construction engineering and construction administration staffing requirements were supplemented by increased third-party coordination efforts. Construction inspection personnel requirements were increased by expanded environmental mitigation requirements.
- *Few factors were identified that tended to decrease construction staffing requirements for highway construction projects.* The lone exception was that increased experience for construction inspectors and contractors reduced the number of construction inspection personnel required. However, it is important to note that the survey did not specifically collect data on factors that could decrease construction staffing requirements.
- *Outsourcing of construction personnel is more common now than reported in previous studies.* Ninety-six percent of survey respondents noted using consultant personnel to meet staffing needs in construction administration, engineering, and inspection. The most common reason cited for the use of consultant labor was inadequate in-house construction staff.
- *The adoption of mobile information technology* (*IT*) *within STA construction organizations appears to be limited.* Less than 30% of responding agencies reported smart phone use and less than 15% reported using tablet computers among their field personnel. Of those using mobile IT, 60% reported no increase in user productivity from the mobile devices. Limited data were available to identify why adoption has been slow; however, the data collected indicated a lack of system support from STA central IT departments and the limited availability of mobile applications specific to highway construction.

COMMON CHARACTERISTICS OF CONSTRUCTION STAFF FORECASTING SYSTEMS

For STAs that are interested in developing a construction staff forecasting network for their own agency, the systems examined in the current work share a number of common characteristics to be considered when developing a new system.

- *A timeline for the construction staffing forecast.* Although the timelines for the systems differ, all the systems examined in the current work base their staffing estimates on a specified analysis period. The systems in use at the North Carolina Department of Transportation (DOT) and North Dakota DOT forecast staffing needs for a single project. The system in use at the Michigan DOT focuses on projections for a single calendar year. Those systems in use by the Utah DOT, Texas DOT, and California DOT (Caltrans) forecast at a more strategic level over several years. It can also be noted that of the systems examined only the Utah DOT and Caltrans systems began formally tracking construction projects during the design phase. It can be noted from the systems examined that the longer the analysis timeline, the more complex the system, and likely the more resources required for development and maintenance.

- *Some form of project schedule is needed to estimate staffing needs.* None of the examined forecasting systems reported developing a critical path schedule as part of their methodology. However, each system used some formal or informal method to estimate project duration, with some systems including some generic type of activity. The North Dakota DOT system estimated project duration based on activity type and construction-miles of the work zone presumably developed from the analysis of historical data. The Michigan and Texas DOT systems included an estimated start and end date for the projects. The Utah DOT system uses project milestones throughout the design and construction phases and Caltrans uses assumptions about the durations of basic activities.
- *Some type of connection between staff requirements and the work performed is needed.* The Kentucky Transportation Cabinet, West Virginia DOT, and North Dakota DOT publish recommended staffing standards for different types of work. The Texas DOT uses a regression analysis of historical data to estimate staff requirements for a given volume of work as well as some assumptions as to the staff requirements based on certain project characteristics. Caltrans uses assumptions about the volume and type of work that can be managed by a single individual. The Michigan DOT system does not explicitly describe how staff requirements are linked to work type; however, its user must make this connection when entering man-hours into the system. Although most of these systems use some type of historical data or published standard for staffing levels, these data are not to be used without taking into account the current project or project portfolio. Relying on historical data can lead to a self-fulfilling prophesy, where since a project provided a certain level of staff that staff is used regardless of whether more or fewer people are needed on the project.

FUTURE WORK

This current work highlights the lack of widespread use of formal construction staffing methodologies across STAs. This does not imply that STAs are not performing some type of construction staffing analysis at either an informal level or as a discrete, periodic planning exercise. However, as these agencies continue to be tasked to manage larger infrastructure systems with fewer employees the need for an accurate estimate of construction staffing personnel will be critical. A tool that accurately forecasts construction staff over both the short and long term would improve personnel management decisions, budgeting decisions, and project selection. Such a tool could be used to estimate the number of FTEs needed to execute a project portfolio and management could then adjust resources accordingly (hire new employees, bring in consultant labor, employ interns, etc.). However, the tool could be used as a decision aid in more areas than simply adjusting human resources. If a forecast shows that a program plan results in unsustainable variations in FTEs, the individual project schedules could be adjusted to distribute the projects more evenly and allow for a more sustainable staffing plan. In addition, if a spike in human resources is identified, STA management could review the assigned duties and responsibilities of construction personnel and temporarily (or permanently) adjust duties and responsibilities to allow the existing workforce to cover a larger project volume.

The forecasting methodologies used in the current work implement two general approaches: (1) construction staff needs based on staffing metrics or (2) construction staff projections based on historic project staffing data. It is not possible to identify which method is superior; therefore, future research could assist in the development of forecasting tools for construction staff. Given the variation in the resources, organizational structure, project delivery methods, project volume, project type, and human resources across STAs it is unlikely that a single forecasting tool could be applied to all STAs. However, future research could address some common issues related to forecasting construction staff for highway construction, including:

- *What is the most accurate method to forecast construction staffing for future projects?* Recent work in examining the accuracy of contract time determination at STAs demonstrated the lack of accuracy in at least some these tools for estimating contract time. Part of the reason for this inaccuracy was the lack of validation of the tools. Of the construction staffing forecasting tools examined in the current work, none reported any validation efforts to date. For the tools that use staffing metrics, do these metrics reflect the adequate staff requirements for a given project? Do they overestimate or underestimate the staff needed? For the tools that rely on regression analysis has the accuracy of these systems been tested against actual projects?
- *What factors have the greatest impact on the staffing requirements for highway construction projects?* Any forecasting tool in current use is based in some way on an average or typical project; however, there are many variations in highway construction projects. Identifying the factors that cause the largest fluctuations in construction staffing requirements would allow staffing for a project to be adjusted based on the unique project characteristics. This work should also consider how project performance metrics (e.g., achievement of schedule milestones, accelerated construction requirements, contractor evaluations) and construction personnel experience factor into the construction staffing

requirements for a specific project. The survey results indicated that a more experienced contractor lowers STA construction staffing requirements; therefore, it would appear that the average experience of the contracting fleet for specific STA regions would need to be included in the staff forecasting system.

- *What is the ideal construction staffing level for a given type of project?* With reductions in the number of STA in-house personnel across the country (and additional reductions possible in the near future) a balance must be struck between the duties and responsibilities of construction staff, the volume of work being managed by a single person, and the budget constraints of the STA. Too many staff assigned to a single project wastes resources and can lead to inefficiencies. Too few staff could lead to cost overruns, project delays, and final construction products that do not meet desired quality standards. Part of this investigation would need to examine methods to increase the productivity of existing staff whether through adoption of technology or modifications to the current job responsibilities of each position.
- *How can plans, specifications, and project administration processes be modified to improve construction staff efficiency?* The survey results identified poor quality plans, specifications, and estimates as the most commonly cited contributors to increased construction staffing requirements for highway construction. Future research in this area could identify specific plans, specifications, and project administration deficiencies that lead to the greatest increase in project staffing requirements. For example, recent work on analyzing the causes of change orders at the Kentucky Transportation Cabinet identified guardrails as a high change order risk work item. Research into design elements that lead to increased construction staffing requirements could identify design areas that might receive increased attention during the design process to minimize staffing requirements during the construction phase.
- *How can currently available mobile IT be used to improve FTE productivity at state transportation agencies?* Mobile IT devices such as smart phones and tablet computers are being used by private business to improve staff productivity. However, the results of this synthesis show that improvements offered by mobile IT devices to STA personnel have been minimal. As previously noted there are several potential hindrances to the impact of new IT on staff productivity. There may also be limited availability of IT infrastructure at the project site. Discussions with several STAs indicated reluctance by their central office IT groups to allow the use of wireless technology owing to concerns with data security. The limited availability of mobile applications specific to the transportation construction industry may also contribute to the low acceptance of IT. Finally, there are different levels of compatibility between current tablet operating systems and existing STA IT systems that may prohibit the use of certain tablets. Additional work in this area could identify barriers to the usefulness of mobile IT platforms in STA construction divisions and develop recommendations for how mobile IT can be used to improve STA construction personnel productivity.

Addressing these issues could aid in the development of a construction staff forecasting system that is accurate, easy to use, and straightforward to maintain. A draft NCHRP research needs statement to address these issues is included in Appendix D.

REFERENCES

Abt. Associates, Inc., *Engineers in the United States: An Overview of the Profession,* National Science Foundation, Arlington, Va., 2004.

Gershkoff, L., “Optimazing Flight Crew Schedules,” *Interfaces,* Vol. 19, No. 4, 1989, pp. 29–43.

Goodrum, P., T. Taylor, W. Lester, A. McCoy, M. Uddin, and Y. Shan, “Change Orders and Lessons Learned,” Kentucky Transportation Center, Lexington, 2010.

Graves, G.W., R.D. McBride, I. Gershkoff, D. Anderson, and D. Mahidhara, “Flight Crew Scheduling,” *Management Science,* Vol. 39, No. 6, 1993, pp. 736–745.

Hancher, D. and R. Werkmeister, *Kentucky Contract Time Determination System*, KYSPR-99-195, Kentucky Transportation Center, Lexington, 2000.

Kentucky Transportation Cabinet (KTC), *Construction Guidance Manual*, KTC, Frankfort, 2009.

Lehman, M., “State Department of Transportation Staffing Levels to Support Construction,” *Transportation Research Board Workshop: Coming Out of the Recession: Changes in Transportation Infrastructure Construction in the New Economy,* 91st Annual Meeting of the Transportation Research Board, Washington, D.C., Jan. 22, 2012.

Lopez, R. and P. Love, “Design Error Costs in Construction Projects,” *Journal of Construction Engineering and Management,* ASCE, Vol. 138, No. 5, 2012, pp. 585–593.

Newman, R., *NCHRP Synthesis 146: Use of Consultants for Construction Engineering Inspection,* Transportation Research Board, National Research Council, Washington, D.C., 1989, 70 pp.

Taylor, T., M. Uddin, P. Goodrum, A. McCoy, and Y. Shan, “Change Orders and Lessons Learned: Knowledge from Statistical Analyses of Engineering Change Orders on Kentucky Highway Projects,” *Journal of Construction Engineering and Management,* ASCE, Vol. 138, No. 12, 2012, pp. 1360–1369.

United Airlines, “United—The World’s Leading Airline” [Online]. Available: http://www.unitedcontinentalholdings.com/documents/FactSheet.pdf?file=united_factshfac.pdf&type=pdf [accessed Aug., 15, 2012].

U.S. Census Bureau, *Intercensal Estimates of the Resident Population of the United States* [Online]. Available: http://www.cdc.gov/nchs/nvss/bridged_race.htm [Accessed May 1, 2012].

U.S. Department of Transportation, *Disbursements by States for State-administered Highways* [Online]. Available: http://www.fhwa.dot.gov/policyinformation/statistics/2010/sf4.cfm [accessed May 1, 2012].

United States Code of Federal Regulations (USCFR) [Online]. Available: http://cfr.regstoday.com/23cfr635.aspx#23_CFR_635p105 [accessed Aug. 18, 2012].

Witheford, D.K., *NCHRP Synthesis 246: Outsourcing of State Highway Facilities and Services*, Transportation Research Board, National Research Council, Washington, D.C., 1997, 75 pp.

BIBLIOGRAPHY

Bell, L. and S. Brandenburg, "Forecasting Construction Staffing for Transportation Agencies," *Journal of Management in Engineering,* ASCE, Vol. 19, No. 3, 2003, pp. 116–120.

Code, U.S.F. [Online]. Available: http://cfr.regstoday.com/23cfr635.aspx#23_CFR_635p105 [accessed Aug. 18, 2012].

Taylor, T.U., "Change Orders and Lessons Learned: Knowledge from Statistical Analyses of Engineering Change Orders on Kentucky Highway Projects," *Journal of Construction Engineering and Management,* ASCE, Vol. 138, No. 12, 2012, pp. 1360–1369.

United Airlines, *United—The World's Leading Airline,* n.d. [Online]. Available: http://www.unitedcontinentalholdings.com/documents/FactSheet.pdf?file=united_factsheet.pdf&type=pdf [accessed Aug. 15, 2012].

U.S. Department of Transportation, *Federal Highway Administration Highway Statistics* [Online]. Available: http://www.fhwa.dot.gov/policy/ohim/hs05/xls/ps1.xls [accessed May 1, 2012].

U.S. Department of Transportation, *Federal Highway Administration Deficient Bridges by State and Highway System* [Online]. Available: http://www.fhwa.dot.gov/bridge/deficient.cfm [accessed May 1, 2012].

U.S. Department of Transportation, *National Highway Construction Cost Index* (*NHCCI*) [Online]. Available: http://www.fhwa.dot.gov/policyinformation/nhcci/pt1.cfm. [accessed Aug. 1, 2012].

APPENDIX A

Survey Tool

NCHRP SYNTHESIS 43-13
FORECASTING CONSTRUCTION STAFFING REQUIREMENTS FOR FUTURE PROJECTS

INTRODUCTION

Dear Transportation Professional:

The Transportation Research Board (TRB) is preparing a synthesis on forecasting construction staffing requirements for future projects. This is being done for NCHRP, under the sponsorship of the American Association of State Highway and Transportation Officials, in cooperation with the Federal Highway Administration.

Transportation agencies are facing dynamic local, state and national revenue streams. The expected fluctuation in available funding will impact both project development and delivery. Many transportation agencies will be faced with streamlining these operations and will create new business models to address current practices and innovations in construction management. Construction workforce (project administration, engineering, and inspection) loading challenges appear to be inevitable. These will involve the assignment/location of in-house staff as well as determining future staffing levels. Construction staffing is a chief component of project delivery cost for owners, and a strategy to staff the construction function is essential in establishing future programs and to effectively determine total project costs. No known standardized approach is available to adequately determine resource levels for construction staffing. The purpose of this study is to identify the current state-of-practice in forecasting construction staffing in transportation organizations and to identify factors that affect construction staffing for highway construction.

This questionnaire is being sent to U.S. state departments of transportation. Your cooperation in completing the questionnaire will ensure the success of this effort. If you are not the appropriate person at your agency to complete this questionnaire, please forward it to the correct person. Please complete and submit this survey by Friday, April 13, 2012. *We estimate that it should take approximately 60 minutes to complete. If you have any questions, please contact our principal investigator Timothy R. B. Taylor, Ph.D., P.E. at taylor@engr.uky.edu or (859)-323-3680. Any supporting materials can be sent directly to Timothy R. B. Taylor by email or at the postal address shown at the end of the survey.*

QUESTIONNAIRE INSTRUCTIONS

1. *To view and print the entire questionnaire, Click on the following link and print using "control p" http://surveygizmolibrary.s3.amazonaws.com/library/64484/survey_7881561.pdf*
2. *To save your partial answers and complete the questionnaire later, click on the "Save and Continue Later" link in the upper right hand corner of your screen. A link to the incomplete questionnaire will be emailed to you from* SurveyGizmo**.** *To return to the questionnaire later, open the email from* SurveyGizmo *and click on the link. We suggest using the "Save and Continue Later" feature if there will be more than 15 minutes of inactivity while the survey is opened, as some firewalls may terminate due to inactivity.*
3. *To pass a partially completed questionnaire to a colleague, click on the on the "Save and Continue Later" link in the upper right hand corner of your screen. A link to the incomplete questionnaire will be emailed to you from SurveyGizmo." Open the email from* SurveyGizmo *and forward it to a colleague.*
4. *To view and print your answers before submitting the survey, click forward to the page following question 50. Print using "control p."*
5. *To submit the survey, click on "Submit" on the last page.*

Thank you very much for your time and expertise.

The following definitions are used in the current work are provided to ensure consistency across survey respondents.

- *Construction: those activities performed by construction personnel related to the physical construction of highway infrastructure (e.g., construction supervision, construction inspection), contract administration (e.g., payment approval, change order management), construction planning (e.g., constructability reviews, pre-bid meetings), and project closeout (e.g., organizing final inspections, final documentation). Activities that support highway construction but are not typically performed by construction personnel and are therefore not considered within the scope of this project include highway infrastructure design, payment processing, specialized final inspections (e.g., traffic signals, trees and seeding, etc.), and off-site material testing. Some maintenance activities that include a bidding process may also be included in this definition such as milling and filling activities.*
- *Construction Personnel: those persons in both field, regional, and central offices assigned to the administration and inspection of construction of highway infrastructure. This definition would include positions such as project engineer, project inspector, and construction technician but would not include positions such as design engineer, materials testing technician, and maintenance inspector. Construction personnel is further divided into the following categories for this project.*
- *Warranty: a guarantee of the integrity of a product and its performance and the maker's (i.e., contractor's or manufacturer's) responsibility to repair or replace defective items.*

Please enter the date (MM/DD/YYYY).*

____

Please identify your contact information.

Agency/Organization*: ____
Address*: ____
City*: ____
State*: ____
Zip Code*: ____
Questionnaire Contact*: ____
Position/Title*: ____
Tel*: ____
E-mail*: ____

General Information about Your State and Transportation Organization

1) General Information about Your State and Transportation Organization

	2000	**2005**	**2010**
What was the population of your state?	___	___	___
How many lane-miles are in your managed road system?	___	___	___
How many bridges?	___	___	___
How many full-time equivalent positions?	___	___	___
What is your annual budget, including state, federal, and private funds, for all purposes?	___	___	___
What is the Annual Vehicle-miles Traveled (AVMT) statistic for your road system?	___	___	___
How many Administrative or Highway Engineering Districts does your agency operate?	___	___	___

2) Which of the following ranges best describes the average age of your construction staff?*

( ) 30–40

( ) 40–50

( ) 50–60

( ) 60–70

3) Which of the following ranges best describes the average experience level of your construction staff?*

( ) 1–5 years

( ) 5–10 years

( ) 10–15 years

( ) 15–20 years

( ) 20–25 years

( ) 25–30 years

( ) 30+ years

4) Does your agency have a method for forecasting construction staffing requirements?*

( ) Yes

( ) No

6) Are employees of your agency represented by a union?*

( ) Yes

( ) No

7) Does the union contract specify minimum staffing levels for a project?*

( ) Yes

( ) No

Survey Questions

9) Does your agency utilize public-private partnerships (PPP) for highway construction projects?*

( ) Yes

( ) No

10) If "Yes," what is the impact on your construction staffing requirements for a PPP project?*

( ) Less construction staff is required

( ) There is no difference in construction staffing requirements

( ) More construction staff is required

11) Over the next 10 years, do you predict that the volume of PPP projects in your agency will:*

( ) Increase

( ) Remain constant at current level

( ) Decrease

12) Does your agency utilize design-build delivery systems for highway construction projects?*

( ) Yes

( ) No

13) If “Yes,” what is the impact on your construction staffing requirements for a design-build project?*

( ) Less construction staff is required

( ) There is no difference in construction staffing requirements

( ) More construction staff is required

14) Over the next 10 years, do you predict that the volume of design-build projects in your agency will:*

( ) Increase

( ) Remain constant at current level

( ) Decrease

15) Does your agency undertake projects involving warranties?*

( ) Yes

( ) No

16) What is the impact on your construction staffing requirements for a warranty project?*

( ) Less construction staff is required

( ) There is no difference in construction staffing requirements

( ) More construction staff is required

17) During the warranty period, what agency resources are deployed to monitor the enforcement of the warranty:

Function*

	Yes	No
Construction Administration	( )	( )
Construction Engineering	( )	( )
Construction Inspection	( )	( )

Others resources: Please identify:

____

____

____

____

18) In the past five years, as a part of the FHWA independent oversight agreement inspection, have FHWA inspectors stated that projects were understaffed in construction resources?*

( ) No FHWA communications/notices

( ) FHWA communications/notices on fewer than 5 projects

( ) FHWA communications/notices on 5–10 projects

( ) FHWA communications/notices on more than 10 projects

19) Does your agency have staffing metrics for Construction Administration? A staffing metric can be stated as “Placement of asphalt mixtures and aggregate: At least one inspector should be on the project to collect weigh tickets and inspect placement of these materials at all times.”*

( ) Yes

( ) No

21) Does your agency have staffing metrics for Construction Engineering?

( ) Yes

( ) No

23) Does your agency have staffing metrics for Construction Inspection?

( ) Yes

( ) No

25) Does your agency have staffing metrics for other functional groups?

( ) Yes

( ) No

26) Please identify the other groups:

____

28) For each of the project types defined below, indicate the size (in $) of the average size project and the number of Full Time Equivalent construction staff positions that would be assigned in each function on that project:

Project Type	Description
Reconstruction Limited Access	This is a project that utilized the existing alignment but may revise the profile, number of lanes, or drainage issues on a restricted access roadway (e.g., interstate system).
Reconstruction Open Access	This is a project that utilized the existing alignment but may revise the profile, number of lanes, or drainage issues on an open access roadway (e.g., a road with signaled intersections and numerous access points).
New Route	This is a project that builds a new road system be constructed on a new alignment (e.g., “greenfield” construction).
Relocation	This is a project that relocates a portion of an existing road onto a new alignment and grade.
Bridge Rehabilitation	This is a project that involves repairing an existing bridge (e.g., lane resurfacing, bridge widening).
Bridge Replacement	This is a project that involves the construction of a new bridge.

	Size	**Administration**	**Engineering**	**Inspection**	**Other**	**If Other, please explain**
Reconstruction Limited Access	___	___	___	___	___	___
Reconstruction Open Access	___	___	___	___	___	___
New Route	___	___	___	___	___	___
Relocation	___	___	___	___	___	___
Bridge Rehabilitation	___	___	___	___	___	___
Bridge Replacement	___	___	___	___	___	___

29) For a typical project for your agency: if the factors shown in each row differ materially from that encountered in the average project, please indicate whether the level of staff in each function (columns) will decrease (–), increase, (+), or remain unchanged (0) by checking the corresponding button.

	Administra-tion			**Engineering**			**Inspection**			**Other**			**If Other, please explain.**
	–	**0**	**+**	**–**	**0**	**+**	**–**	**0**	**+**	**–**	**0**	**+**	
Increased Environmental Mitigation	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___
Project located in a large metropolitan area	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___

Project located in a rural area	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___
Increased ADT count	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___
Increased coordination with other agencies	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___
Inclement weather	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___
Increased funding	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___
Accelerated schedules	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___
Increased Utility Relocation/Coordination Requirements	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___
Increased construction staff experience	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___
Limited material availability	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___
Expected poor Plan, Specifications and Estimate quality	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___
Increased contractor experience	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___
Expected increase in contractor quality	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	___

30) If there are factors not listed that significantly impact construction staffing needs please list and briefly explain here:

____

31) How does a decision to expedite a project (i.e., a project that receives more attention due to its negative impact on the surrounding) impact construction staffing requirements?*

( ) Less construction staff is required

( ) There is no difference in construction staffing requirements

( ) More construction staff is required

32) Does your agency have separate divisions for construction and maintenance activities or are they handled as part of a single, integrated department?*

( ) Separate divisions

( ) Integrated divisions

( ) Other (Please specify): _________________

33) In times of limited construction staff availability, which of the following strategies has your agency used in the recent past to address staff shortfall (please check all that apply):*

[ ] Reduce inspection requirements

[ ] Outsource consulting duties

[ ] Reduce work volume

[ ] Place existing staff on overtime

[ ] Assign non-construction personnel to construction duties

[ ] Hire additional staff

[ ] Transfer staff among districts

[ ] Other (Please identify):

34) In each of the project phases listed below, please indicate in which functions your construction staff participates by checking the appropriate box?

	Function				If Other, please explain
	Administration	Engineering	Inspection	Other	
Design Phase	[ ]	[ ]	[ ]	[ ]	___
Bid Phase	[ ]	[ ]	[ ]	[ ]	___
Contract Award Phase	[ ]	[ ]	[ ]	[ ]	___
Construction Phase	[ ]	[ ]	[ ]	[ ]	___
Project Close out Phase	[ ]	[ ]	[ ]	[ ]	___

35) Does your agency perform construction with its own workforce?*

( ) Yes

( ) No

36) If "Yes," What differences are there in your staffing, if any, in the positions and manning levels between projects constructed with your own workforce and those constructed with outside contractors?

Function

	Own workforce uses fewer positions/lower manning levels	Own workforce uses more positions/higher manning levels
Construction Administration	( )	( )
Construction Engineering	( )	( )
Construction Inspection	( )	( )

Other: Please identify: ____

37) Do you do anything differently on projects built with your own forces (e.g., reduced inspection requirements, reduced construction supervision)?*

( ) Yes

( ) No

38) If "Yes," what?* ____

39) In meeting your construction staffing requirements, do you use contract personnel (e.g., outsourced construction inspectors)?*

( ) Yes

( ) No

40) For which functions do you use contract construction personnel? Please check all that apply.*

[ ] Construction Administration

[ ] Construction Engineering

[ ] Construction Inspection

[ ] Other: Please identify:

41) Which factors do you consider in making the outsourcing decision? Please check all that apply.*

[ ] Lack of availability of in-house personnel

[ ] Cost

[ ] Qualifications lacking in-house

[ ] Other: Please identify:

42) How are these factors considered?* ____

43) Are construction personnel using any of the following information technologies?

			Other
	Smart Phone	**Tablet Computer**	
Construction Administration	[ ]	[ ]	___
Construction Engineering	[ ]	[ ]	___
Construction Inspection	[ ]	[ ]	___
Other Functions: Please specify	[ ]	[ ]	___

44) If these technologies are being used, please check the tasks for which they are being used:

			Other: Please specify
	Smart Phone	**Tablet Computer**	
Communication	[ ]	[ ]	___
Inspection	[ ]	[ ]	___
Plan & Specs	[ ]	[ ]	___
Daily Work Report	[ ]	[ ]	___
Change Orders	[ ]	[ ]	___
Other: Please specify	[ ]	[ ]	___

45) The productivity of the individuals using this technology has:*

( ) Increased

( ) Stayed unchanged

( ) Decreased

46) If increased, by approximately how much (percentage)?*

____

47) If decreased, by approximately how much (percentage)?*

____

48) Has the increased productivity allowed you to reduce the number of people in these positions?*

( ) Yes

( ) No

49) Are you doing more with the same number of people as you were 10 years ago?*

( ) Yes

( ) No

50) Are you doing more with fewer people than you were 10 years ago?*

( ) Yes

( ) No

Thank You!

The survey is complete. Thank you for your participation! Your response is very important to us. If you have any questions or comments, please feel free to contact Timothy R. B. Taylor at:

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APPENDIX B

Survey Data

1. General Information

Response ID	State	Population				
		2000	2005	2010	2000–2010 Net Increase	% Increase
5	Louisiana	4,471,885	4,576,628	4,544,228	72,343	1.62%
9	Idaho	1,299,430	1,428,241	1,571,450	272,020	20.93%
11	Maine	1,277,072	1,318,787	1,327,567	50,495	3.95%
12	Virginia	7,105,817	7,577,105	8,024,617	918,800	12.93%
13	Wyoming	494,300	514,157	564,460	70,160	14.19%
15	Rhode Island	1,050,268	1,067,916	1,052,886	2,618	0.25%
18	New Jersey	8,430,621	8,651,974	8,801,624	371,003	4.40%
19	Pennsylvania	12,284,173	12,449,990	12,709,630	425,457	3.46%
21	Iowa	2,929,067	2,964,454	3,049,883	120,816	4.12%
26	Colorado	4,326,921	4,631,888	5,049,071	722,150	16.69%
27	Oklahoma	3,454,365	3,548,597	3,761,702	307,337	8.90%
30	Tennessee	5,703,719	5,991,057	6,356,897	653,178	11.45%
31	Delaware	786,373	845,150	899,769	113,396	14.42%
32	Illinois	12,434,161	12,609,903	12,843,166	409,005	3.29%
33	North Dakota	642,023	646,089	674,499	32,476	5.06%
35	Kansas	2,693,681	2,745,299	2,859,169	165,488	6.14%
36	Michigan	9,952,450	10,051,137	9,877,574	(74,876)	-0.75%
37	North Carolina	8,081,614	8,705,407	9,561,558	1,479,944	18.31%
39	Vermont	609,618	621,215	625,960	16,342	2.68%
40	Oregon	3,429,708	3,613,202	3,838,957	409,249	11.93%
41	Nebraska	1,713,820	1,761,497	1,830,429	116,609	6.80%
43	Kentucky	4,049,021	4,182,742	4,346,266	297,245	7.34%
45	Georgia	8,227,303	8,925,922	9,712,587	1,485,284	18.05%
48	New Hampshire	1,239,882	1,298,492	1,316,759	76,877	6.20%
49	Minnesota	4,933,692	5,119,598	5,310,584	376,892	7.64%
52	Connecticut	3,411,777	3,506,956	3,577,073	165,296	4.84%
56	Montana	903,773	940,102	990,898	87,125	9.64%
57	West Virginia	1,807,021	1,820,492	1,853,973	46,952	2.60%
58	Missouri	5,607,285	5,790,300	5,996,231	388,946	6.94%
59	Washington	5,910,512	6,257,305	6,744,496	833,984	14.11%
65	Hawaii	1,213,519	1,292,729	1,363,621	150,102	12.37%

66	Utah	2,244,502	2,457,719	2,776,469	531,967	23.70%
67	Nevada	2,018,741	2,432,143	2,704,642	685,901	33.98%
69	California	33,987,977	35,827,943	37,349,363	3,361,386	9.89%
71	New York	19,001,780	19,132,610	19,392,283	390,503	2.06%
73	Florida	16,047,515	17,842,038	18,843,326	2,795,811	17.42%
75	Wisconsin	5,373,999	5,546,166	5,691,047	317,048	5.90%
78	Massachusetts	6,361,104	6,403,290	6,557,254	196,150	3.08%
80	New Mexico	1,821,204	1,932,274	2,065,932	244,728	13.44%
81	Maryland	5,311,034	5,592,379	5,785,982	474,948	8.94%
	Average	**5,566,068**	**5,815,522**	**6,055,097**	**489,029**	**9.47%**

Data source: U.S. Census Bureau, *Intercensal Estimates* . . . .

Total Lane-miles						
Response ID	State	2000	2005	2010	2000–2010 Net Increase	% Increase
5	Louisiana	127,883	128,194	129,003	1,120	0.88%
9	Idaho	95,180	96,703	99,860	4,680	4.92%
11	Maine	46,345	46,652	47,102	757	1.63%
12	Virginia	152,329	156,034	161,305	8,976	5.89%
13	Wyoming	56,781	57,525	58,387	1,606	2.83%
15	Rhode Island	12,813	13,682	13,702	889	6.93%
18	New Jersey	78,164	83,876	85,279	7,115	9.10%
19	Pennsylvania	249,170	251,431	249,815	645	0.26%
21	Iowa	232,921	234,726	234,497	1,576	0.68%
26	Colorado	176,995	181,982	183,740	6,745	3.81%
27	Oklahoma	232,712	233,816	234,296	1,584	0.68%
30	Tennessee	183,642	190,758	199,059	15,417	8.39%
31	Delaware	12,559	13,222	13,717	1,158	9.22%
32	Illinois	288,878	290,519	293,049	4,171	1.44%
33	North Dakota	175,348	175,716	175,974	626	0.36%
35	Kansas	274,015	276,115	286,820	12,805	4.67%
36	Michigan	256,156	255,354	256,503	347	0.14%
37	North Carolina	209,335	216,937	263,471	54,136	25.86%
39	Vermont	29,358	29,596	29,552	194	0.66%
40	Oregon	136,866	132,949	122,246	(14,620)	–10.68%
41	Nebraska	188,273	189,645	190,462	2,189	1.16%
43	Kentucky	164,232	162,056	165,008	776	0.47%
45	Georgia	241,086	248,137	259,875	18,789	7.79%
48	New Hampshire	31,364	32,112	33,093	1,729	5.51%
49	Minnesota	271,177	271,244	283,813	12,636	4.66%
52	Connecticut	44,474	45,206	45,590	1,116	2.51%

56	Montana	141,977	141,554	152,572	10,595	7.46%
57	West Virginia	76,672	76,220	79,561	2,889	3.77%
58	Missouri	251,209	259,597	270,902	19,693	7.84%
59	Washington	167,210	173,965	173,658	6,448	3.86%
65	Hawaii	9,255	9,411	9,604	349	3.78%
66	Utah	87,434	91,010	94,843	7,409	8.47%
67	Nevada	79,050	72,617	75,164	(3,886)	–4.92%
69	California	371,689	379,357	383,645	11,956	3.22%
71	New York	239,033	240,167	242,660	3,627	1.52%
73	Florida	253,348	264,087	269,295	15,947	6.29%
75	Wisconsin	231,340	235,477	237,484	6,144	2.66%
78	Massachusetts	74,506	75,815	76,576	2,070	2.78%
80	New Mexico	124,839	133,634	142,612	17,773	14.24%
81	Maryland	67,019	67,990	69,222	2,203	3.29%
	Average	**153,566**	**155,877**	**159,825**	**6,260**	**4.10%**

Data source: U.S.DOT, *FHWA Highway Statistics*.
Note: Decreases in lane-miles may be due to differences in reporting requirements among states.

Highway Bridge Count						
Response ID	State	2000	2005	2010	2000–2010 Net Increase	% Increase
5	Louisiana	13,399	13,334	13,361	(38)	–0.28%
9	Idaho	4,032	4,060	4,132	100	2.48%
11	Maine	2,360	2,370	2,393	33	1.40%
12	Virginia	12,710	13,249	13,522	812	6.39%
13	Wyoming	3,110	3,027	3,059	(51)	–1.64%
15	Rhode Island	747	749	757	10	1.34%
18	New Jersey	6,350	6,445	6,520	170	2.68%
19	Pennsylvania	22,052	22,291	22,357	305	1.38%
21	Iowa	24,632	24,846	24,731	99	0.40%
26	Colorado	7,977	8,260	8,506	529	6.63%
27	Oklahoma	22,799	23,387	23,692	893	3.92%
30	Tennessee	19,404	19,763	19,875	471	2.43%
31	Delaware	824	849	861	37	4.49%
32	Illinois	25,457	25,777	26,309	852	3.35%
33	North Dakota	4,517	4,477	4,418	(99)	–2.19%
35	Kansas	25,720	25,513	25,329	(391)	–1.52%
36	Michigan	10,567	10,879	10,928	361	3.42%
37	North Carolina	16,814	17,509	18,096	1,282	7.62%
39	Vermont	2,703	2,701	2,712	9	0.33%
40	Oregon	7,255	7,238	7,255	0	0.00%
41	Nebraska	15,507	15,457	15,376	(131)	–0.84%

43	Kentucky	13,374	13,519	13,842	468	3.50%
45	Georgia	14,382	14,490	14,670	288	2.00%
48	New Hampshire	2,344	2,359	2,409	65	2.77%
49	Minnesota	12,811	13,014	13,108	297	2.32%
52	Connecticut	4,178	4,168	4,191	13	0.31%
56	Montana	4,980	4,923	5,119	139	2.79%
57	West Virginia	6,730	6,919	7,069	339	5.04%
58	Missouri	23,388	23,883	24,245	857	3.66%
59	Washington	7,867	7,634	7,755	(112)	–1.42%
65	Hawaii	1,066	1,106	1,137	71	6.66%
66	Utah	2,741	2,815	2,911	170	6.20%
67	Nevada	1,423	1,632	1,753	330	23.19%
69	California	23,665	24,007	24,556	891	3.77%
71	New York	17,387	17,338	17,365	(22)	–0.13%
73	Florida	11,187	11,536	11,912	725	6.48%
75	Wisconsin	13,418	13,687	13,982	564	4.20%
78	Massachusetts	4,953	4,920	5,113	160	3.23%
80	New Mexico	3,694	3,835	3,902	208	5.63%
81	Maryland	4,964	5,071	5,195	231	4.65%
	Average	**10,587**	**10,726**	**10,861**	**273**	**3.17%**

Data source: U.S.DOT, *Deficient Bridges by State and Highway Systems.*

Annual Vehicle-miles Traveled (Million)						
Response ID	State	2000	2005	2010	2000–2010 Net Increase	% Increase
5	Louisiana	40,849	44,979	45,439	4,590	11.24%
9	Idaho	13,534	14,866	15,801	2,267	16.75%
11	Maine	14,190	14,925	14,549	359	2.53%
12	Virginia	74,801	80,337	82,171	7,370	9.85%
13	Wyoming	8,090	9,058	9,568	1,478	18.27%
15	Rhode Island	8,359	8,300	8,280	(79)	–0.94%
18	New Jersey	67,446	73,819	73,028	5,582	8.28%
19	Pennsylvania	102,337	108,042	100,329	(2,008)	–1.96%
21	Iowa	29,433	31,060	31,389	1,956	6.64%
26	Colorado	41,771	47,962	46,940	5,169	12.37%
27	Oklahoma	43,355	47,019	47,746	4,391	10.13%
30	Tennessee	65,732	70,814	70,439	4,707	7.16%
31	Delaware	8,240	9,508	8,948	708	8.59%
32	Illinois	102,866	107,706	105,788	2,922	2.84%
33	North Dakota	7,217	7,570	8,263	1,046	14.49%
35	Kansas	28,130	29,621	29,900	1,770	6.29%

36	Michigan	97,792	104,052	97,567	(225)	–0.23%
37	North Carolina	89,504	101,268	102,385	12,881	14.39%
39	Vermont	6,811	7,713	7,248	437	6.41%
40	Oregon	35,010	35,282	33,774	(1,236)	–3.53%
41	Nebraska	18,081	19,291	19,438	1,357	7.50%
43	Kentucky	46,803	47,466	48,007	1,204	2.57%
45	Georgia	105,010	113,509	111,722	6,712	6.39%
48	New Hampshire	12,021	13,429	13,065	1,044	8.69%
49	Minnesota	52,601	56,904	56,632	4,031	7.66%
52	Connecticut	30,756	31,675	31,294	538	1.75%
56	Montana	9,882	11,126	11,190	1,308	13.23%
57	West Virginia	19,242	20,523	19,203	(39)	–0.20%
58	Missouri	67,083	68,754	70,864	3,781	5.64%
59	Washington	53,330	55,476	57,190	3,860	7.24%
65	Hawaii	8,543	10,083	9,995	1,452	16.99%
66	Utah	22,597	25,158	26,585	3,988	17.65%
67	Nevada	17,639	20,776	21,119	3,480	19.73%
69	California	306,649	329,267	322,849	16,200	5.28%
71	New York	129057	137521	131252	2,195	1.70%
73	Florida	152136	201531	195755	43,619	28.67%
75	Wisconsin	57266	60017	59420	2,154	3.76%
78	Massachusetts	52796	55458	54362	1,566	2.97%
80	New Mexico	22760	23966	25325	2,565	11.27%
81	Maryland	50174	56319	56126	5,952	11.86%
	Average	**52997.325**	**57803.75**	**57023.625**	**4026.3**	**8.25%**

Data source: U.S.DOT, *FHWA Highway Statistics*.

Disbursement on Capital Outlay (Thousand Dollars)						
Response ID	State	2000	2005	2010	2000–2010 Net Increase	% Increase
5	Louisiana	767,993	962,512	1,773,985	1,005,992	130.99%
9	Idaho	236,204	321,519	515,630	279,426	118.30%
11	Maine	215,597	256,544	351,451	135,854	63.01%
12	Virginia	1,270,665	1,117,012	1,024,147	(246,518)	–19.40%
13	Wyoming	236,615	267,525	413,103	176,488	74.59%
15	Rhode Island	109,947	184,844	258,958	149,011	135.53%
18	New Jersey	1,857,191	1,743,540	2,499,863	642,672	34.60%
19	Pennsylvania	2,323,646	2,122,168	4,383,427	2,059,781	88.64%
21	Iowa	696,081	528,933	763,931	67,850	9.75%
26	Colorado	702,660	603,948	626,143	(76,517)	–10.89%
27	Oklahoma	779,750	478,244	1,303,943	524,193	67.23%
30	Tennessee	803,504	897,193	1,212,747	409,243	50.93%

31	Delaware	297,648	357,736	452,803	155,155	52.13%
32	Illinois	1,613,768	1,943,765	2,852,653	1,238,885	76.77%
33	North Dakota	157,014	284,581	353,808	196,794	125.34%
35	Kansas	589,171	707,018	639,070	49,899	8.47%
36	Michigan	1,142,434	1,316,860	1,446,347	303,913	26.60%
37	North Carolina	1,464,209	2,075,266	2,111,677	647,468	44.22%
39	Vermont	116,640	124,562	217,828	101,188	86.75%
40	Oregon	357,751	723,430	799,910	442,159	123.59%
41	Nebraska	382,069	386,604	408,559	26,490	6.93%
43	Kentucky	911,249	847,748	1,338,098	426,849	46.84%
45	Georgia	982,582	1,159,180	1,673,095	690,513	70.28%
48	New Hampshire	163,572	85,484	319,550	155,978	95.36%
49	Minnesota	600,841	856,449	973,934	373,093	62.10%
52	Connecticut	552,254	555,676	817,795	265,541	48.08%
56	Montana	300,018	360,763	513,614	213,596	71.19%
57	West Virginia	673,882	673,472	793,051	119,169	17.68%
58	Missouri	959,378	940,764	1,409,407	450,029	46.91%
59	Washington	691,572	1,118,922	1,792,834	1,101,262	159.24%
65	Hawaii	148,304	209,440	249,537	101,233	68.26%
66	Utah	689,455	478,668	1,250,471	561,016	81.37%
67	Nevada	424,280	519,456	565,371	141,091	33.25%
69	California	2,576,376	2,865,105	5,924,164	3,347,788	129.94%
71	New York	2,247,825	2,309,108	2,953,432	705,607	31.39%
73	Florida	2,420,787	4,063,856	4,603,339	2,182,552	90.16%
75	Wisconsin	716,077	946,906	1,315,867	599,790	83.76%
78	Massachusetts	2,089,620	1,151,518	1,064,039	(1,025,581)	–49.08%
80	New Mexico	439,998	293,521	486,543	46,545	10.58%
81	Maryland	568,270	983,356	1,005,289	437,019	76.90%
	Average	**856,922**	**945,580**	**1,336,485**	**479,563**	**61.71%**

Data source: U.S.DOT, *Disbursements by States* . . . .

Disbursement on Capital Outlay—Adjusted for Inflation (Thousand Dollars, Base Year 2000)						
Response ID	State	2000	2005	2010	2000–2010 Net Increase	% Increase
5	Louisiana	767,993	816,518	1,670,891	902,898	117.57%
9	Idaho	236,204	272,751	485,665	249,461	105.61%
11	Maine	215,597	217,631	331,027	115,430	53.54%
12	Virginia	1,270,665	947,584	964,629	(306,036)	–24.08%
13	Wyoming	236,615	226,947	389,096	152,481	64.44%
15	Rhode Island	109,947	156,807	243,909	133,962	121.84%
18	New Jersey	1,857,191	1,479,080	2,354,585	497,394	26.78%
19	Pennsylvania	2,323,646	1,800,278	4,128,687	1,805,041	77.68%

21	Iowa	696,081	448,705	719,536	23,455	3.37%
26	Colorado	702,660	512,341	589,755	(112,905)	–16.07%
27	Oklahoma	779,750	405,704	1,228,165	448,415	57.51%
30	Tennessee	803,504	761,107	1,142,269	338,765	42.16%
31	Delaware	297,648	303,475	426,489	128,841	43.29%
32	Illinois	1,613,768	1,648,935	2,686,873	1,073,105	66.50%
33	North Dakota	157,014	241,416	333,247	176,233	112.24%
35	Kansas	589,171	599,778	601,931	12,760	2.17%
36	Michigan	1,142,434	1,117,119	1,362,293	219,859	19.24%
37	North Carolina	1,464,209	1,760,490	1,988,958	524,749	35.84%
39	Vermont	116,640	105,668	205,169	88,529	75.90%
40	Oregon	357,751	613,700	753,424	395,673	110.60%
41	Nebraska	382,069	327,964	384,816	2,747	0.72%
43	Kentucky	911,249	719,162	1,260,335	349,086	38.31%
45	Georgia	982,582	983,356	1,575,864	593,282	60.38%
48	New Hampshire	163,572	72,518	300,980	137,408	84.00%
49	Minnesota	600,841	726,543	917,334	316,493	52.68%
52	Connecticut	552,254	471,391	770,269	218,015	39.48%
56	Montana	300,018	306,043	483,766	183,748	61.25%
57	West Virginia	673,882	571,320	746,963	73,081	10.84%
58	Missouri	959,378	798,069	1,327,500	368,122	38.37%
59	Washington	691,572	949,204	1,688,645	997,073	144.17%
65	Hawaii	148,304	177,672	235,035	86,731	58.48%
66	Utah	689,455	406,064	1,177,801	488,346	70.83%
67	Nevada	424,280	440,665	532,515	108,235	25.51%
69	California	2,576,376	2,430,527	5,579,885	3,003,509	116.58%
71	New York	2,247,825	1,958,863	2,781,795	533,970	23.75%
73	Florida	2,420,787	3,447,452	4,335,819	1,915,032	79.11%
75	Wisconsin	716,077	803,280	1,239,396	523,319	73.08%
78	Massachusetts	2,089,620	976,856	1,002,203	(1,087,417)	–52.04%
80	New Mexico	439,998	249,000	458,268	18,270	4.15%
81	Maryland	568,270	834,201	946,867	378,597	66.62%
	Average	**856,922**	**802,155**	**1,258,816**	**401,894**	**52.31%**

Note: FHWA's *National Highway Construction Cost Index (NHCCI)* (U.S.DOT) is used to adjust disbursements for inflation. For complete table of NHCCI, go to http://www.fhwa.dot.gov/policyinformation/nhcci/pt1.cfm.

Full-Time Equivalent Positions										
Response ID	State	2000	2005	2010	2010–2000 Increase	% Increase	2000 FTE/Million Dollars of Capital Outlay	2005 FTE/Million Dollars of Capital Outlay	2010 FTE/Million Dollars of Capital Outlay	% change
5	Louisiana									
9	Idaho									
11	Maine	2,396	2,390	2,260	–136	–5.68	11.11	10.98	6.83	–38.52
12	Virginia			7,000					7.26	
13	Wyoming	2,000	2,000	2,000	0	0.00	8.45	8.81	5.14	–39.17
15	Rhode Island		200	230				1.28	0.94	
18	New Jersey		3,973					2.69		
19	Pennsylvania			11,000					2.66	
21	Iowa									
26	Colorado									
27	Oklahoma	2,350	2,350	2,350	0	0.00	3.01	5.79	1.91	–36.54
30	Tennessee			4,800					4.20	
31	Delaware									
32	Illinois	8,000	5,750	5,270	–2,730	–34.13	4.96	3.49	1.96	–60.48
33	North Dakota	1,040	1,044	1,055	15	1.44	6.62	4.32	3.17	–52.11
35	Kansas	3,304	3,247	2,916	–388	–11.74	5.61	5.41	4.84	–13.73
36	Michigan	3,244	2,872	2,863	–381	–11.74	2.84	2.57	2.10	–26.06
37	North Carolina	14,457	14,544	13,957	–500	–3.46	9.87	8.26	7.02	–28.88
39	Vermont			1,200					5.85	
40	Oregon	4,727	4,559	4,550	–177	–3.74	13.21	7.43	6.04	–54.28
41	Nebraska	2,200	2,200	2,200	0	0.00	5.76	6.71	5.72	–0.70
43	Kentucky	5,972	5,108	4,814	–1,158	–19.39	6.55	7.10	3.82	–41.68
45	Georgia	5,895	5,807	4,950	–945	–16.03	6.00	5.91	3.14	–47.67
48	New Hampshire									
49	Minnesota									
52	Connecticut									
56	Montana			1,377					2.85	
57	West Virginia	5,100	5,000	4,900	–200	–3.92	7.57	8.75	6.56	–13.34
58	Missouri			6,000					4.52	
59	Washington			7,000					4.15	
65	Hawaii									
66	Utah	1,920	1,820	1,753	–167	–8.70	2.78	4.48	1.49	–46.40
67	Nevada									
62	California	23,444	21,035	20,796			9.10	8.65	3.73	
71	New York			9,000					3.24	
73	Florida	10,354	7,579	7,443	–2911	–28.11	4.28	2.20	1.72	–59.81
75	Wisconsin									
78	Massachusetts									

80	New Mexico									
81	Maryland			3,181					3.36	
	Average						**6.73**	**5.82**	**4.01**	**–37.26**

2. Which of the following ranges best describes the average age of your construction staff?

Value	Count	Percent
30–40	15	39.5
40–50	23	60.5
50–60	0	0
60–70	0	0

3. Which of the following ranges best describes the average experience level of your construction staff?

Value	Count	Percent
1–5 years	0	0
5–10 years	10	27
10–15 years	16	43.2
15–20 years	8	21.6
20–25 years	3	8.1
25–30 years	0	0
30+ years	0	0

4. Does your agency have a method for forecasting construction staffing requirements?

Value	Count	Percent
Yes	9	23.7
No	29	76.3

6. Are employees of your agency represented by a union?

Value	Count	Percent
Yes	24	63.2
No	14	36.8

7. Does the union contract specify minimum staffing levels for a project?

Value	Count	Percent
Yes	0	0
No	24	100

9. Does your agency utilize public–private partnerships (PPP) for highway construction projects?

Value	Count	Percent
Yes	7	19.4
No	29	80.6

10. If “Yes,” what is the impact on your construction staffing requirements for a PPP project?

Value	Count	Percent
Less construction staff is required	5	71.4
There is no difference in construction staffing requirements	2	28.6
More construction staff is required	0	0

11. Over the next 10 years, do you predict that the volume of PPP projects in your agency will:

Value	Count	Percent
Increase	5	71.4
Remain constant at current level	2	28.6
Decrease	0	0

12. Does your agency utilize design-build delivery systems for highway construction projects?

Value	Count	Percent
Yes	27	75
No	9	25

13. If "Yes," what is the impact on your construction staffing requirements for a design-build project?

Value	Count	Percent
Less construction staff is required	12	44.4
There is no difference in construction staffing requirements	14	51.9
More construction staff is required	1	3.7

14. Over the next 10 years, do you predict that the volume of design-build projects in your agency will:

Value	Count	Percent
Increase	16	59.3
Remain constant at current level	10	37
Decrease	1	3.7

15. Does your agency undertake projects involving warranties?

Value	Count	Percent
Yes	14	38.9
No	22	61.1

16. What is the impact on your construction staffing requirements for a warranty project?

Value	Count	Percent
Less construction staff is required	1	7.1
There is no difference in construction staffing requirements	12	85.7
More construction staff is required	1	7.1

17. Function

	Yes		No		Avg.	Responses
	%	#	%	#	#	
Construction Administration	71.4	10	28.6	4	0.0	14
Construction Engineering	57.1	8	42.9	6	0.0	14
Construction Inspection	71.4	10	28.6	4	0.0	14
Average	66.7		33.3		0.0	42

Others resources: Please identify:

Count	Response
1	Maintenance
1	Maintenance personnel

1	Maintenance and operations staff
1	We use maintenance forces in some cases to manage the warranty.
1	FDOT established performance measures for its warranty work (Value Added Features) that utilized existing evaluation systems.

18. In the past five years, as a part of the FHWA independent oversight agreement inspection, have FHWA inspectors stated that projects were understaffed in construction resources?

Value	Count	Percent
No FHWA communications/notices	26	72.2
FHWA communications/notices on fewer than 5 projects	8	22.2
FHWA communications/notices on 5–10 projects	1	2.8
FHWA communications/notices on more than 10 projects	1	2.8

19. Does your agency have staffing metrics for Construction Administration? A staffing metric can be stated as "Placement of asphalt mixtures and aggregate: At least one inspector should be on the project to collect weigh tickets and inspect placement of these materials at all times."

Value	Count	Percent
Yes	7	19.4
No	29	80.6

21. Does your agency have staffing metrics for Construction Engineering?

Value	Count	Percent
Yes	5	13.9
No	31	86.1

23. Does your agency have staffing metrics for Construction Inspection?

Value	Count	Percent
Yes	8	22.9
No	27	77.1

25. Does your agency have staffing metrics for other functional groups?

Value	Count	Percent
Yes	1	6.7
No	14	93.3

28. For each of the project types defined below, indicate the size (in $) of the average size project and the number of Full-Time Equivalent construction staff positions that would be assigned in each function on that project:

	Size (Million $)	Administration	Engineering	Inspection	Other	Specify "other"
Reconstruction Limited Access	17.53 (50,3)	1.8 (7,0.3)	2.01 (8,1)	4.43 (12,1)	8 (20,0)	This would be support from other areas of the department such as Structures, Materials, etc. There also may be contract employees to help in the areas of testing and inspection.
Reconstruction Open Access	15.28 (40,0.5)	1.16 (3,0.2)	1.01 (2,0)	3.7 (6,1)	7 (20,0)	
New Route	20.88 (50,3)	2.07 (6,0.4)	2.01 (6,1)	9.74 (40,1)	11.33 (30,0)	This would be support from

Relocation	10.85 (39.4,0.4)	1.36 (3,0.5)	1.17 (2,1)	3.71 (12,1)	3.67 (10,0)	other areas of the department such as Structures, Materials, etc. Also on larger projects, this may involve a dedicated financial employee and PI employees.
Bridge Rehabilitation	2.95 (10, 0.25)	0.79 (3,0)	0.69 (1,0)	1.94 (4.5,1)	2.67 (7,0)	
Bridge Replacement	8.16 (34.9,1)	1.06 (3,0)	1.01 (1,0.5)	2.8 (6,1)	2.67 (7,0)	
*Numbers in each cell are: average (maximum, minimum)						

If other, please explain:

County	Response
1	This would be support from other areas of the department such as Structures, Materials, etc. Also on larger projects, this may involve a dedicated financial employee and PI employees.
1	Numbers are typical, but not average (we combine Admin., Engineering, and Inspection into one category).
1	This would be support from other areas of the department such as Structures, Materials, etc. There also may be contract employees to help in the areas of testing and inspection. All of these projects would be DB, so there would be and IQF to do the inspection, thus fewer inspectors needed from Staff.

29. For a typical project for your agency: if the factors shown in each row differ materially from that encountered in the average project, please indicate whether the level of staff in each function (columns) will decrease (–), increase, (+), or remain unchanged (0).

Factor	No.	Administration			Engineering			Inspection			Other			Specify "Other"
		–	0	+	–	0	+	–	0	+	–	0	+	
Accelerated schedules	1	0%	46.7%	53.3%	0%	50%	50%	6.3%	18.8%	75%	0%	100%	0%	
Expected increase in contractor quality	2	12.5%	87.5%	0%	18.8%	75%	6.3%	33.3%	60%	6.7%	0%	100%	0%	
Expected poor Plan, Specifications and Estimate quality	3	0%	50%	50%	0%	37.5%	62.5%	0%	50%	50%	0%	50%	50%	
Inclement weather	4	0%	87.5%	12.5%	0%	87.5%	12.5%	6.3%	62.5%	31.3%	0%	66.7%	33.3%	
Increased ADT count	5	0%	82.4%	17.6%	0%	87.5%	12.5%	0%	50%	50%	0%	33.3%	66.7%	Traffic Control
Increased Environmental Mitigation	6	0%	70.6%	29.4%	0%	56.3%	43.8%	0%	31.3%	68.8%	0%	25%	75%	
Increased Utility Relocation/Coordination Requirements	7	0%	43.8%	56.3%	0%	43.8%	56.3%	0%	53.3%	46.7%	0%	33.3%	66.7%	
Increased construction staff experience	8	13.3%	86.7%	0%	33.3%	66.7%	0%	62.5%	37.5%	0%	33.3 %	66.7%	0%	
Increased contractor experience	9	12.5%	81.3%	6.3%	12.5%	81.3%	6.3%	37.5%	56.3%	6.3%	0%	100%	0%	
Increased coordination with other agencies	10	0%	41.2%	58.8%	0%	62.5%	37.5%	0%	87.5%	12.5%	0%	50%	50%	
Increased funding	11	0%	68.8%	31.3%	0%	75%	25%	0%	56.3%	43.8%	0%	100%	0%	
Limited material availability	12	0%	87.5%	12.5%	0%	87.5%	12.5%	6.3%	93.8%	0%	0%	66.7%	33.3%	
Project located in a large metropolitan area	13	0%	58.8%	41.2%	0%	50%	50%	0%	37.5%	62.5%	0%	33.3%	66.7%	Traffic Management
Project located in a rural area	14	11.8%	82.4%	5.9%	12.5%	87.5%	0%	12.5%	81.3%	6.3%	50%	50%	0%	

If other, please explain:

Count	Response
1	Not the need for as much of the support functions.
1	Public Information Officer
1	Support from Traffic Engineering, Utility Engineering, Public Involvement, ROW, etc.
1	Traffic Control

30. If there are factors not listed that significantly impact construction staffing needs please list and briefly explain here:

Count	Response
1	3rd party agreements—utility, railroad, right of way, env
1	Basic state funded maintenance projects are managed with fewer staff
1	Increase complexity
1	Late 20th Century Birth Rates.
1	Night work, Contract Restrictions on Work Times
1	In the table above, there may be instances where we would have liked to increase inspection levels but we do not have the personnel to do so. We would like to have more inspection staff when more operations are concurrent.
1	Small contracts of similar scope; for instance having 5 sign projects each of $150,000 creates more administrative work.

31. How does a decision to expedite a project (i.e. a project that receives more attention due to its negative impact on the surrounding) impact construction staffing requirements?

Value	Count	Percent
Less construction staff is required	0	0
There is no difference in construction staffing requirements	11	30.6
More construction staff is required	25	69.4

32. Does your agency have separate divisions for construction and maintenance activities or are they handled as part of a single, integrated department?

Value	Count	Percent
Separate Divisions	26	72.2
Integrated Divisions	6	16.7
Other (Please specify):	4	11.1

33. In times of limited construction staff availability, which of the following strategies has your agency used in the recent past to address staff shortfall (please check all that apply):

Value	Count	Percent
Reduce inspection requirements	7	20.6
Outsource consulting duties	30	88.2
Reduce work volume	1	2.9
Place existing staff on overtime	26	76.5
Assign non-construction personnel to construction duties	12	35.3
Hire additional staff	7	20.6
Transfer staff among districts	9	26.5
Other (Please identify):	3	8.8

34. In each of the project phases listed below, please indicate in which functions your construction staff participates by checking the appropriate box?

	Design Phase	Bid Phase	Contract Award Phase	Construction Phase	Project Close-Out Phase
Administration	37.00%	73.30%	81.30%	82.40%	93.30%
Engineering	63.00%	33.30%	25.00%	94.10%	73.30%

Inspection	7.40%	0%	0%	58.80%	53.30%
Other	3.70%	0%	0%	2.90%	0%

If other, please explain.

Count	Response
1	Review plans

35. Does your agency perform construction with its own workforce?

Value	Count	Percent
Yes	11	30.6
No	25	69.4

36. Function

	Own workforce uses fewer positions/lower manning levels		Own workforce uses more positions/higher manning levels		Avg.	Responses
	%	#	%	#	#	
Construction Administration	87.5	7	12.5	1	0.0	8
Construction Engineering	87.5	7	12.5	1	0.0	8
Construction Inspection	87.5	7	12.5	1	0.0	8
Average	87.5		12.5		0.0	24

Other: Please identify:

Count	Response
1	We integrate consultants into our staff—i.e., staff augmentation
1	Some paving work; lot of bridge maintenance work
1	No difference in “manning” levels (complement)

37. Do you do anything differently on projects built with your own forces (e.g., reduced inspection requirements, reduced construction supervision)?

Value	Count	Percent
Yes	6	54.5
No	5	45.5

38. If “Yes,” what?

Count	Response
1	No inspection activity
1	Self-inspection
1	Generally the work done with our own forces are very small projects. We have less testing overall, but the workers doing the work are all certified testers/inspectors and have done some of the testing.
1	Reduced construction supervision/inspection; there is not the same need as our own work force polices themselves.
1	I don’t believe we test all the materials placed by our maintenance folks as we do for contract work.

39. In meeting your construction staffing requirements, do you use contract personnel (e.g., outsourced construction inspectors)?

Value	Count	Percent
Yes	32	97
No	1	3

40. For which functions do you use contract construction personnel? Please check all that apply.

Value	Count	Percent
Construction Administration	18	56.3
Construction Engineering	26	81.3
Construction Inspection	30	93.8
Other: Please identify:	3	9.4

41. Which factors do you consider in making the outsourcing decision? Please check all that apply.

Value	Count	Percent
Lack of availability of in-house personnel	31	96.9
Cost	12	37.5
Qualifications lacking in-house	22	68.8
Other: Please identify:	2	6.3

42. How are these factors considered?

Count	Response
1	Do not understand the question.
1	I don't understand this question.
1	Man power projections
1	By doing annual workplans and selecting engineering firms based on qualifications
1	On a project basis
1	A review of the construction work program is done, in-house staffing levels & qualifications considered, then jobs not able to be managed by in-house staff is outsourced.
1	Regional Engineer staff the projects based on the scope of work, experience of staff available and decides what skills are needed to cover the work. Mostly experientially based decisions.
1	Use of consultant inspectors is generally considered if the need for additional inspectors is deemed to be a temporary need.
1	Not sure what you are asking. We hire consultants if we are short staffed or are lacking specialized qualifications
1	When our manpower projections exceed available resources we consider using consultant inspectors. We do consider cost in hiring a consultant versus bringing back a former DOT employee as a temporary employee.
1	As inspector availability is reduced. WSDOT is looking to technology to help offset inspectors. By looking to after-the-face nondestructive testing (MIT on concrete pavement, MOBA on paving), WSDOT is working to reduce the required number of inspectors in the field while ensuring the Finished quality meets or exceeds our contractual requirements.

43. Are construction personnel using any of the following information technologies?

	Construction Administration	Construction Engineering	Construction Inspection
Smart Phone	25.0%	27.5%	17.5%
Tablet Computer	15.0%	10.0%	15.0%

Other

Count	Response
1	Some trials of iPads and iPhones are underway.
1	Notebooks
1	We don't use them.

44. If these technologies are being used, please check the tasks for which they are being used:

	Communication	Inspection	Plans & Specs	Daily Work Report	Change Orders	Other
Smart Phone	32.5%	10.0%	7.5%	5.0%	5.0%	2.5%
Tablet Computer	12.5%	12.5%	15.0%	15.0%	12.5%	0%

Other: Please identify:

Count	Response
1	Road Condition survey inspections
1	laptops by inspectors used for some functions

45. The productivity of the individuals using this technology has:

Value	Count	Percent
Increased	14	38.9
Stayed unchanged	22	61.1
Decreased	0	0

46. If increased, by approximately how much (percentage)?

Count	Response
1	±10%
1	1%
2	10
2	10%
1	15
1	25
1	5
1	Increased efficiencies gained by technology but not measured
1	Not evaluated
1	Not measured
1	don't know
2	unknown

48. Has the increased productivity allowed you to reduce the number of people in these positions?

Value	Count	Percent
Yes	4	28.6
No	10	71.4

49. Are you doing more with the same number of people as you were 10 years ago?

Value	Count	Percent
Yes	14	38.9
No	22	61.1

50. Are you doing more with fewer people than you were 10 years ago?

Value	Count	Percent
Yes	31	86.1
No	5	13.9

APPENDIX C

North Dakota Staffing Standards

CONSTRUCTION MANPOWER PLANNING STAFFING STANDARDS

PURPOSE

The Department has adopted 15 construction staffing standards. The purpose of these standards is:

+ To provide guidelines for determining the number of engineers and technicians required to adequately staff construction projects.
+ To maximize personnel use.
+ To provide a resource for evaluating staffing patterns.
+ To provide estimates of numbers and classifications of employees required to meet future staffing needs.
+ To provide personnel projections for budgeting purposes.
+ To provide an estimate of numbers and types of vehicles needed for construction.

BASIS OF PLANNING AND CONTROL

Planning and controlling construction staffing activities needs two basic elements:

+ Estimates of the length of time employees will be needed on a project.
+ The number of employees required on each project.

(These staffing standards will aid in fulfilling the requirements of the elements.)

PLANNING RESPONSIBILITY

Before February 15 of each year, the districts will furnish the Construction Services Engineer with a district staffing plan. The plan will be reviewed, revised if necessary, and adopted by March 1. These plans will provide staffing guidelines for the construction season and will become part of the Construction Services Staffing Plan.

STAFFING RESPONSIBILITY

The District Engineer is responsible for effective and efficient staffing and for maintaining adequate project control, inspection, and documentation.

Changing workloads and conditions may result in some districts needing additional staff for short-term assignments. Districts with unassigned personnel will notify the Construction Services Engineer so employees can be assigned to districts needing additional staff. The Construction Services Engineer will be responsible for coordinating short-term assignments.

CONSTRUCTION STAFFING STANDARDS

The staffing standards define the number of employees normally required on each type of project. In addition, standards describe the number of employees required for each project by personnel classification.

Some standards show one-half employee. In these instances, the standard means that the employee will not be needed full-time for the work described. When possible, project supervisors will fill one-half employee needs by transferring employees between projects in the general area.

The standards do not anticipate all contingencies. The number of personnel assigned to a project should exceed the number shown in the standards only in extreme cases. At times, and under certain conditions, a project may not need all the personnel listed in the standard. It is the responsibility of each project supervisor to adjust staff to the minimum level consistent with good construction engineering practices.

TABLE OF CONTENTS

CONSTRUCTION STAFFING TIME BY TYPE OF PROJECT

CODE	TYPE OF IMPROVEMENT	CALENDAR DAYS PER CONSTRUCTION MILE
10	Grading & Aggregate Surface	20.0
11	Grade & Bituminous Base (Select Grade, Widen, & Base and Mine & Blend)	17.0
12	Bituminous Surfacing/Structural Overlay	3.0
13	Subgrade Repair, Milling, Base & Hot Bituminous Pavement	12.0
14	Contract Patching/Thin Lift Overlay	2.0
15	Surface Coat	1.0
16	Recycled PCC or PCC Surfacing	15.0
17	Concrete Pavement Repair	14.0
18	Box Culverts	30.0
19	Bridges & Deck Overlay	100.0
20	Municipal Items (Grade, Surfacing Sewer, Curb & Gutter)	(Variable)
21	Contract Striping	(Variable)
22	Signing and/or Guardrail	5.0
23	Landscaping	(Variable)

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 10

TYPE OF IMPROVEMENT:

Grading & Aggregate Surfacing

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	1		1
General Inspector	2		2
Survey Crew	1	2½	1
Compaction & Culvert Inspector		1	1
Lab Person	1		1
Scale & Checker *		0	
Office Person		½	
Total	5	4	6

*Not applicable if contractor supplied.

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor	1
Engr. Technician IV	1
Engr. Technician III	2
Engr. Technician II	1

VEHICLE REQUIREMENTS

Utility	1	
Survey Pickup	1	
Pickup/Utility		4

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 11

TYPE OF IMPROVEMENT:

Grade & Bituminous Base (Selective Widen & Base and Mine & Blend)

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	1		1
General Inspector	2		2
Survey Crew	1	2½	1
Lab & Plant Inspector	1		1
Compaction & Culvert Inspector		1	1
*Scale & Checker		0	
Office Person		½	
Total	5	4	6

*Not applicable if contractor supplied.

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor 1

Engr. Technician IV 1

Engr. Technician III 2

Engr. Technician II 1

VEHICLE REQUIREMENTS

Utility 1

Pickup/Utility 4

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 12

TYPE OF IMPROVEMENT:

Bituminous Surfacing/Structural Overlay

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	1		1
General Inspector & Survey	2	1	2
Lab & Plant Inspector	1		1
Checker		1	1
Office Person		1	
Total	4	3	5

<u>REGULAR PERSONNEL BY CLASSIFICATON</u>

Project Supervisor 1

Engr. Technician IV 1

Engr. Technician III 1

Engr. Technician II 1

VEHICLE REQUIREMENTS

Utility 1

Pickup/Utility 3

CONSTRUCTION MANPOWER
STAFFING STANDARDS

CODE 13

TYPE OF IMPROVEMENT:

Subgrade Repair, Milling, Base & Hot Bituminous Pavement

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	1		1
General Inspector	2		2
Survey Crew	1	2	1
Lab/Plant Inspector	1		1
*Scale & Checker		2	1
Office Person		1	
Total	5	5	6

*Not applicable if contractor supplied.

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor 1

Engr. Technician IV 1

Engr. Technician III 2

Engr. Technician II 1

VEHICLE REQUIREMENTS

Utility 1

Pickup/Utility 4

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 14

TYPE OF IMPROVEMENT:

Contract Patching/Thin Lift Overlay

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	1		1
General Inspector	1		1
Lab & Plant	1		1
Scale & Checker		1	1
Total	3	1	4

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor 1

Engr. Technician III 1

Engr. Technician II 1

VEHICLE REQUIREMENTS

Utility 1

Pickup/Utility 3

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 15

TYPE OF IMPROVEMENT:

Surface Coat

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	1		1
General Inspector	1	1	2
Scale & Checker		2	
Total	2	3	3

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor 1

Engr. Technician II 1

VEHICLE REQUIREMENTS

Utility 1

Pickup/Utility 2

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 16

TYPE OF IMPROVEMENT:

Recycled PCC or PCC Surfacing

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	1		1
Project Engineer	1		1
Plant Inspector	½		½
Subgrade & Trimmer Inspection	½		½
Paving Train Inspector	1	0	1
Survey Crew	1	2	1
Compaction & Subbase		1	1
Lab	1	1	1
Concrete Testing		2	1
Profilograph	As needed from the rest of the crew		
Scale & Checker		2	1
Office Person		1	
Total	6	9	9

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor	2
Engr. Technician IV	2
Engr. Technician III	1
Engr. Technician II	1

VEHICLE REQUIREMENTS

Utility	2	
Survey Pickup	1	
Pickup/Utility		6

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 17

TYPE OF IMPROVEMENT:

Concrete Pavement Repair

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	1		1
General Inspector & Testing	1	1	2
Sawing & Crack Sealing	½		½
Lab & Plant Inspector	½	½	½
Office Person		½	
Total	3	2	4

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor 1

Engr. Technician IV 1

Engr. Technician III 1

VEHICLE REQUIREMENTS

Utility 1

Pickup/Utility 1

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 18

TYPE OF IMPROVEMENT:

Box Culverts

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	1		1
General Inspector, Survey & Lab	1		1
Utility Person		1	
Total	2	1	2

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor 1

Engr. Technician III 1

VEHICLE REQUIREMENTS

Utility 1

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 19

TYPE OF IMPROVEMENT:

Bridge

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	1		1
General Inspector	1		1
Survey Crew	1	1	1
Lab & Plant Inspector		½	1
Office Person		½	
Total	3	2	4

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor 1

Engr. Technician IV 1

Engr. Technician II 1

VEHICLE REQUIREMENTS

Utility 1

Pickup/Utility 2

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 20

TYPE OF IMPROVEMENT:

Municipal Items (Grading, Base, Drains, Curb & Gutter, & Surfacing)

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	1		1
General Inspector	2	1	2
Survey Crew	1	2	1
Lab & Plant Inspector	1	1	1
Scale & Checker		1	
Office Person		1	
Total	5	6	5

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor 1

Engr. Technician IV 1

Engr. Technician III 2

Engr. Technician II 1

VEHICLE REQUIREMENTS

Utility 1

Pickup/Utility 3

CONSTRUCTION MANPOWER
STAFFING STANDARDS

CODE 21

TYPE OF IMPROVEMENT:

Contract Striping

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	½		½
General Inspector	2		2
Total	2½	0	2½

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor ½

Engr. Technician II 2

VEHICLE REQUIREMENTS

Utility ½

Pickup/Utility 2

CONSTRUCTION MANPOWER
STAFFING STANDARDS

CODE 22

TYPE OF IMPROVEMENT:

Signing and/or Guard Rail

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	½		½
General Inspector	1	1	1
Total	1½	1	1½

REGULAR PERSONNEL BY CLASSIFICATON

Project Supervisor ½

Engr. Technician III 1

VEHICLE REQUIREMENTS

Utility ½

Pickup/Utility 1

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 23

TYPE OF IMPROVEMENT:

Landscaping

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Supervisor	½		½
General Inspector	1		1
Total	1½	0	1½

<u>REGULAR PERSONNEL BY CLASSIFICATON</u>

Project Supervisor ½

Engr. Technician III 1

<u>VEHICLE REQUIREMENTS</u>

Automobile ½

Pickup/Utility 1

CONSTRUCTION MANPOWER STAFFING STANDARDS

CODE 24

Staffing for District Lab

MAJOR ACTIVITY	Regular	Temporary	Vehicle
Highway Materials Coordinator	1		1
Lab Person	1		1
Total	2		2

<u>REGULAR PERSONNEL BY CLASSIFICATON</u>

Materials Coordinator 1

Engr. Technicians III & IV 1

<u>VEHICLE REQUIREMENTS</u>

Utility 1

Pickup 1

APPENDIX D

Research Needs Statement Draft

AASHTO STANDING COMMITTEE ON RESEARCH

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

I. PROBLEM NUMBER

To be assigned by NCHRP staff.

II. PROBLEM TITLE

State Transportation Agency Construction Staff Forecasting Methodology for Highway Construction Oversight

III. RESEARCH PROBLEM STATEMENT

In recent years, State Transportation Agencies (STA) have experienced evolutions in their traditional business models for the development of highway construction projects. These evolutions have been driven by several influences including fluctuations in funding levels (e.g., lean periods of state funding followed by the influx of federal stimulus funding), dynamic sources of funding (e.g., local vs. state vs. national, public-private partnerships), alternative contracting methods (e.g., design-build, QA/QC practices, warrantee contracts), changes in traditional job responsibilities (e.g., integration of construction and maintenance departments), increased use of consultant services to augment in-house personnel (e.g., design outsourcing, construction inspection outsourcing), changes in project requirements (e.g., increased environmental mitigation requirements for planning and construction), and advances in design and construction technology (e.g., GPS machine control, 3D design) among others. This evolution also comes at a time when STAs are experiencing staff turnover. Experienced personnel are leaving STAs through retirement and are being replaced by less experienced personnel who are encountering more rapid increases in responsibility earlier in their careers than their predecessors. These changes have impacted all divisions of STA personnel, particularly those tasked with the construction of highway infrastructure.

STA oversight of highway construction is important because it helps ensure that public money is efficiently utilized to improve the nation's highway infrastructure. This oversight requires construction oversight staff of the appropriate quality and quantity to ensure projects are constructed in accordance with the plans and specifications. In adequate staffing levels can delay project completion, lead to project cost overruns, and reduce project quality. Conversely overstaffing can also negatively impact project performance as well as waste scarce human resources.

In most STAs, construction personnel are concentrated in field offices throughout the state with construction support staff located in central or regional offices. STAs are tasked not only with ensuring that construction staffing levels are adequate to meet the state's current construction needs but also forecasting future construction personnel staffing levels. Forecasting construction personnel needs is challenging due to many factors mostly related to the dynamic nature of highway infrastructure construction. Total state construction volume can vary from year-to-year which adds uncertainty to personnel requirements at the central and field office level. However, construction volume within state districts can also fluctuate year-to-year which can require adjustments to field personnel. Construction staff forecasting is further complicated by variations in personnel experience levels in identical positions across the state, variations in construction staff productivity, variations in contractor quality, variation in project type and complexity, variations in local government requirements, changes in construction technology, and changes in construction staff responsibilities.

NCHRP Synthesis 43-13 *Forecasting Construction Staffing Requirements for Future Projects* highlighted the lack of widespread use of formal construction staffing methodologies across STAs. This likely does not mean that STAs are not performing some type of construction staffing analysis at either an informal level or as a discrete, periodic planning exercise. However, as these agencies continue to be tasked to manage larger infrastructure systems with fewer employees the need for an accurate estimate of construction staffing personnel will be critical. A tool that accurately forecasts construction staff over both the short and long term would improve personnel management decisions, budgeting decisions, and project selection. Obviously, such a tool could be used to estimate the number of Full Time Equivalent (FTE) positions needed to execute a project portfolio and then management could adjust resources accordingly (hire new employees, bring in consultant labor, employ interns, etc.). However, the tool could be used as a decision aid in more areas than simply adjusting human resources. If a forecast shows that a program plan results in unsustainable variations in FTEs, the individual project schedules could be adjusted to distribute the projects more evenly and allow a more sustainable staffing plan. In addition, if a spike in human resources is identified, STA management could review the assigned duties and responsibilities of construction personnel and temporarily (or permanently) adjust duties and responsibilities to allow the existing workforce to cover a larger project volume.

The proposed research should address the following questions:

- What project characteristics have the greatest impact on STA staffing requirements?
- What types of information are needed to accurately predict construction staffing requirements?
- What tools can be developed to assist STAs in estimating construction staffing needs?

IV. LITERATURE SEARCH SUMMARY

Based on the review of the TRB Transportation Research Information System (TRIS) online, the TRB Research in Progress database, construction management and infrastructure academic journals, and the authors' own knowledge on this topic, prior research on highway related construction staff forecasting is limited. NCHRP Synthesis 43-13 *Forecasting Construction Staffing Requirements for Future Projects* identified some type of formal construction staff forecasting systems in place at seven STAs (California, Michigan, North Carolina, North Dakota, Texas Utah, and Virginia). These systems varied in their forecast horizon, forecast methodology, and their complexity. Additionally, Bell and Brandenburg [15] developed a regression model to estimating staffing requirements on South Carolina highway construction projects. Insights into the developments of commercial airline staff scheduling methods developed over the past 30 years may offer useful insights into approaches to forecasting construction staffing requirements.

V. RESEARCH OBJECTIVE

The main objective is to develop a process and tools to accurately estimate STA construction staffing requirements for highway construction projects. Proposed tasks to accomplish the main objective include:

Task 1 – A literature review of existing forecasting methods among the transportation agencies and other industries.
Task 2 – Identify the "best practice" forecasting process which include key steps and practices to accurately estimate construction staffing requirements among state Departments of Transportation.
Task 3 – Finalize the estimation process and develop tool(s) that states can use to forecast construction staffing needs.
Task 4 – Obtain industry input on the final forecasting process and validate tool(s) on actual projects to validate its accuracy and robustness.
Task 5 – Develop the guideline to help states successfully implement the forecasting process and related tool(s).

VI. ESTIMATE OF PROBLEM FUNDING AND RESEARCH PERIOD

Recommended Funding: Recommended funding for the project is $400,000

Research Period: It is estimated that 24 months will be required to perform the research.

VII. URGENCY, PAYOFF POTENTIAL, AND IMPLEMENTATION

NCHRP Synthesis 43-13 *Forecasting Construction Staffing Requirements for Future Projects* found that between 2000 and 2010 state managed lane-miles increased by an average of 4.10% while the number of FTEs decreased by 9.68%. When FTEs are normalized across the managed road system the responding STAs FTEs per million dollars of disbursement on capital outlay decreased by an average of 37.26%. This indicates that STAs are increasingly being asked to execute larger volumes of work construction work with fewer oversight personnel. Accurately forecasting personnel requirements will help ensure that the scare human resources that are availability are efficiently utilized and augmented with additional resources when necessary to ensure project success. By developing and validating the process and tools through the practitioner focused NCHRP research process will help ensure the research is useful to STAs.

VIII. PERSON(S) DEVELOPING THE PROBLEM

Tim Taylor, University of Kentucky [others to be added as appropriate]

IX. PROBLEM MONITOR

TBD

X. DATE AND SUBMITTED BY

TBD.

Abbreviations used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation