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16. Abstract

State departments of transportation (DOTs) have seen significant funding increases throughout the past decade. The additional funding has also brought about an increase in the construction inspection and testing workload, but the DOTs have not seen a sufficient increase in personnel to manage the additional work. As a result, TxDOT was motivated to identify efficient strategies for reducing the construction testing and inspection workload without decreasing the quality of the end product. This study investigated current practices in other state DOTS and summarized workload reduction strategies that have the potential for efficiently reducing inspection workload within TxDOT.

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SYNTHESIS OF WORKLOAD REDUCTION STRATEGIES FOR CONSTRUCTION INSPECTION

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Chapter 1. Introduction

1.1 Background and Significance of Work

An increase in transportation budgets these past two decades and a consequent movement toward more outsourcing of DOT activities can be significantly attributed to two historic events. The 1998 authorization of the Transportation Equity Act of the 21st Century (TEA-21), which resulted in an average increase in state funding of more than 44% in transportation programs. The subsequent authorization of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) in 2005, which extended and expanded the TEA-21 (Warne 2003). As a result, DOTs were able to complete projects that would have not been feasible without the additional funding. While these additional projects will decrease congestion and increase transportation safety, the DOTs have not seen a sufficient increase in personnel to manage the additional work. Consequently, TxDOT and other state DOTs are addressing their workforce challenges by outsourcing key project responsibilities that were previously performed by in-house DOT forces and adapting their practices to perform construction administration more efficiently.

1.2 Problem Statement

TxDOT faces significant workforce challenges, particularly in the Districts, where the testing and inspection workload is increasing but the workforce is decreasing. As a result of these workforce challenges, TxDOT is looking for more effective ways to manage their testing, inspection, and measurement workload. To help alleviate problems of a shrinking workforce facing an increased workload, TxDOT has started outsourcing some of the materials testing activities. Specifically, TxDOT requires contractor personnel or consultants to perform testing on (1) hot mix asphalt (HMA) levels 1-A, 2, and 1-B; and, (2) concrete materials, pavements, and prefabricated products. Additional test methods, primarily intended for in-house use, are available to contractor personnel on TxDOT's website. One of TxDOT's primary considerations is the outsourcing of several additional testing procedures to contractor personnel.

TxDOT is looking to other DOTs from which they believe much can be learned. Other states are facing similar challenges and have taken actions to implement procedures to reduce their construction workload. Such procedures include increasing contractor testing and inspection responsibilities, outsourcing testing and inspection to third parties, creating extensive training and certification programs, and modifying their specifications to minimize time intensive testing and measurement. Accordingly, there is a need to summarize the best practices from those state DOTs that have already instituted successful programs to reduce the inspection workload that could potentially aid TxDOT in addressing their specific workload challenges.

1.3 Objectives, Research Scope, and Limitations

The primary goal of the research was to identify workload reduction strategies with the most potential to effectively reduce construction inspection workload. The objectives of this research project are to:

- Identify the quality assurance and quality control workload reduction strategies that have been implemented in other states, including construction inspection, materials testing, and certification of personnel

- To develop a document that summarizes these quality control/quality assurance (QC/QA) workload reduction strategies
- Highlight those workload reduction strategies that demonstrate the greatest potential for efficiently reducing the testing and inspection workload for TxDOT personnel.

This document should be used by TxDOT Construction Division and district personnel at all levels to encourage dialogue and consideration of potential methods for efficiently reducing the current testing and inspection workload without significantly impacting the level of quality of the work. These objectives were accomplished through the following research tasks:

1) Comprehensive review of other states' QC/QA programs
2) Characterization of TxDOT workforce challenges, QC/QA Requirements and comparison to other programs
3) Assessment of top QC/QA workload reduction strategies
4) Finalize recommendations and present the results

The scope and limitations of this research are presented here to properly use and apply the results of this project. The kickoff meeting held October 5, 2007 produced major revelations including "Project is not just about testing. Want to increase quality of the product and reduce personnel workload" and "Reduce inspection workload any way we can while maintaining quality". Many of these issues identified at the kickoff meeting shaped the direction of this research project. Site visits that were originally included in the proposal were replaced with an initial and follow up meeting with the IDP team. The IDP team remained involved throughout the duration of the project. The suggested workload reduction strategies came from both TxDOT and other state DOT construction divisions. However, the ranking process and implementation guide were created with the bias of implementation within TxDOT under the department's conditions at the time of the research. In addition, the strategies were only ranked by TxDOT employees. At the onset of the research, there was a heavy focus on outsourcing inspection activities. However, the environment within TxDOT changed during the course of the research because of budget constraints and outsourced activities received lesser priority than originally anticipated. Eight state DOTs with progressive QC/QA programs were interviewed to answer questions regarding their construction inspection policies and practices. A limitation that might have influenced the outcome of the research includes the size of this sample, where additional state DOT interviews might have permitted a larger degree of confidence. The researchers acknowledge that there might have been inherent differences between state DOTs that were willing to participate and those that were not willing to participate. Lastly, additional research is needed to develop a more comprehensive method for fully implementing some of the strategies presented in this report.

1.4 Organization of Report

This final report is divided into eight chapters. Chapter 1 presents the project's background, significance of work, problem statement, research objectives, scope and limitations and the organization of the report. Chapter 2 presents the study methodology including an overview of the process, data collection and study participants. Chapter 3 is the literature review on the impacts of the transportation workforce shortage and efforts by state DOTs to mitigate the workforce shortage. Chapter 4 characterizes TxDOT's QC/QA program, impact of workforce shortage on TxDOT and current inspection workforce challenges. Chapter 5 includes the preliminary workload reduction strategies developed. Chapter 6 discusses the procedure followed during the analysis and prioritization of the suggested workload reduction strategies. Chapter 7 presents the description of the recommended guidelines for successful implementation of the workload reduction strategies throughout TxDOT. The guidelines are location in Appendix A. Each guideline developed in Appendix A includes the following headings: Description, Potential Benefits or Intent, Implementation Strategy, Conditions for Successful Implementation and Cautions, Anticipated Cost for Implementation, Examples, References and Attachments if needed. Finally, Chapter 8 provides recommendations, next actions and conclusions.

Chapter 2. Study Methodology

2.1 Overview of Process

At the onset of this study, the researchers met with four high level inspectors that are part of a special program within TxDOT designed to train and mentor inspectors, identified as the Inspector Development Program (IDP). The IDP Team discussed testing, inspection, and measurement challenges faced by inspectors within TxDOT. An initial list of workload challenges was developed, and these challenges were used to structure subsequent interviews with personnel from TxDOT and other state DOTs. In-person and phone interviews were conducted with five TxDOT experts who had knowledge of concrete, hot mix asphalt, soils and bases, testing and materials, and striping. Directors of Construction from eight districts, both urban and rural, were also interviewed to identify challenges unique to various districts. The purpose of the interviews conducted with TxDOT officials was to investigate the impacts of the workload challenges identified by the IDP Team, identify additional workload challenges unique to various districts, and lastly gather suggestions for making changes within TxDOT to reduce the testing, inspection, and measurement workload.

Concurrently, telephone interviews were conducted with eight state DOTs who were selected from regions across the U.S. These states interviewed include: Arizona, California, Florida, Indiana, South Carolina, Virginia, Washington, and Wisconsin. The purpose of these interviews was to identify potential workload reduction strategies that other states had successfully implemented to reduce their workload challenges and could potentially be of benefit to TxDOT as well. These states were questioned about their own workload challenges and innovative solutions they had developed. In addition, they were questioned about whether they were also experiencing challenges similar to TxDOT and if they had developed effective solutions. Documents, such as specifications, manuals, policies, checklists, flow charts, etc., were requested to allow the researchers to examine specific language, diagrams, and products that might provide a model for implementing other states' innovative workload reduction strategies within TxDOT.

After the interviews were completed, the researchers compiled the data and identified over 100 workload reduction strategies that were recommended by TxDOT and other states. Several strategies were consolidated, and a list of 60 strategies was presented to members of TxDOT's Project Monitoring Committee. The Project Monitoring Committee reduced the 60 strategies to 31. These strategies were used to conduct a ranking workshop during which 14 TxDOT subject-matter experts and district personnel reviewed each strategy. A list of the workshop participants is included in Section 6.1. The ranking workshop was conducted on June 12, 2008. The research team prepared a package of materials for the workshop. From those materials, a list of the preliminary workload reduction strategies is included in Table 5.1 and the information sheets developed for each strategy is included in Appendix C.

Each of the workshop participants ranked it according to the following eight criteria:

1) In-house Control Over Quality
2) Quality of Project or Product
3) TxDOT Inspection Workload
4) TxDOT Non-Inspection Workload (Administration and Oversight)

5) Direct Project Cost
6) Indirect Cost (e.g. third-party contracts, training, certification)
7) Need for (or Development of) New Processes, Tools or Resources
8) Ease of Implementation

The research team realized that not all the criteria were equally as important. As a result, members of TxDOT's Project Monitoring Committee and IDP Team performed a weighting exercise to assign relative importance to the eight criteria. The weightings were averaged based on the responses and then normalized. The final results were analyzed to determine which workload reduction strategies will likely provide the greatest benefit to TxDOT. For each of the workload reduction strategies, the workshop rankings and weightings were combined to give a ranking raw score. Using the raw scores, each strategy was rank ordered from 1-31. This paper presents the rank ordered list of workload reduction strategies that are being considered for implementation in order to ease TxDOT's workforce challenges in Table 6.2. A guideline was developed by the research team that TxDOT can use to implement the top 10 ranked workload reduction strategies broadly throughout the districts, which has been included in Appendix A. The PMC group also identified two additional strategies that were not ranked in the top, but they wanted to be included in this implementation guide. They have been identified as specialty workload reduction strategies SP 1 and SP 2. The implementation guide is a summary for each strategy, including benefits, costs, and conditions for successful implementation.

2.2 Data Collection and Study Participants

The research team used the priorities established by the IDP team to create interview guides for TxDOT and other states. Examples of these interview guide agendas are included in Appendix B. During Task 1, the Directors of Construction from eight state DOTs were interviewed. These participants and the date of the phone interviews are listed in Table 2.1.

Table 2.1: List of Interview Participants from Other State DOTs

State DOT	Interviewee	Date
AZ	Julio Alvarado	4/1/2008
CA	Chuck Suszko	3/5/2008
FL	Brian Blanchard	3/20/2008
IN	Ron Heustis	3/7/2008
SC	Danny Shealy	3/7/2008
VA	Dan Liston	3/13/2008
WA	Linea Laird	3/25/2008
WI	Donald Greuel	3/10/2008

State DOTs were selected to give a representative distribution based on geographical location. A map of the state DOTs selected for interviews is shown in Figure 2.1.

Figure 2.1: Map of State DOTs that Participated in Interviews

During Task 2, in-person and phone interviews were conducted with TxDOT experts, districts, and consultants. The participants and the date of the interviews are listed in Table 2.2.

Table 2.2: List of Interview Participants from TxDOT

TxDOT Experts	Interviewee	Date
Soils & Bases	Caroline Herrera	2/7/2008
Concrete QC/QA & Certification	Lisa Lukefahr	2/7/2008
HMA	Dale Rand	2/15/2008
Materials & Pavements	Jeff Seiders & David Belser	11/30/2007
Striping	Johnnie Miller	2/15/2008
TxDOT District	**Interviewee**	**Date**
San Antonio	David Kopp	3/21/2008
Bryan	Pat Williams	3/7/2008
Dallas	Tracey Friggle	3/13/2008
Odessa	Stephen Smith	3/14/2008
El Paso	David Head	3/14/2008
Yoakum	Glen Dvorak	3/14/2008
Austin	James Klotz	3/27/2008
Childress	Darwin Lankford	3/21/2008
Consultant	**Interviewee**	**Date**
Terracon	David Pickett	3/5/2008
Raba Kistner	Gabe Ornelas	4/8/2008

Chapter 3. Literature Review

3.1 Transportation Workforce Shortage and Impacts

In the 1990s, the United States began to predict a potentially devastating workforce shortage that would result from an expanding economy combined with the mass retirement of our aging population. Experts forecasted that the U.S. could experience "the most significant talent and brain drain ever experienced by government," with more than 40% of state and local government employees eligible for retirement between the years 2000-2015 (Martin 2001). Subsequent studies developed statistical figures to predict the impact of the shortage on various industry sectors. Investigators identified several specific causes of the growing shortage of skilled workers, including decreases in productivity, an inadequate education system, an unprecedented number of retirements, difficult immigration processes, and a departure of workers from the workforce – temporarily or permanently – because of family responsibilities, early retirement, or disabilities (Grossman 2005, Atwater 2004).

During the late 1990s, a study on the factors necessary to develop and maintain the "workforce for the future" was commissioned by the transportation industry to combat the consequences of a potential scarcity of workers (CTC & Associates 2005). The New Mexico State Highway and Transportation Department conducted the study and documented the workforce development practices within all 50 state DOTs. The purpose of the study was to identify existing staffing procedures and also create a framework for organizing innovative workforce management practices. In addition, state DOTs began outsourcing to consultants to meet the demands of an increasing workload and also began streamlining practices in an effort to work more efficiently.

3.2 Efforts by State DOTs to Mitigate the Workforce Shortage

The increase in state DOT projects and inadequate staffing has greatly impacted the DOT Construction Divisions. Furthermore, a U.S. DOT study recently reported that two activities – construction engineering (inspection) and materials testing – were among the most commonly outsourced activities within DOTs (Warne 2003). The report stated that 63% of state DOTs were outsourcing some or all of these two functions. Table 3.1 identifies several states that responded to the Warne survey who reported that they use outside resources to accomplish testing and inspection activities. The most common reason stated by state DOTs for moving to outsourcing is an increased workload combined with staffing constraints (Warne 2003). This has been attributed to the fact that most DOTs have staffing restrictions and also because they have frequent turnover of their experienced in-house staff (Hancher, Brenneman, Meagher, & Goodrum 2006). Other factors that Warne stated contributed to the trend towards outsourcing include a need for specialized skills, considerations such as quality and a need for a third-party. There is political pressure to shift towards using outsourcing because legislators like outsourcing. In addition, there is significant demand from the driving public for better and quicker construction with minimal traffic delays (Hancher & Werkmeister 2001). In response to workforce shortages and increased workload, states have implemented other innovative practices to reduce the workload of their inspection personnel in addition to outsourcing. Such procedures include (1) delegating materials testing activities to contractors, (2) hiring consultants to perform construction inspections, and (3) requiring contractor personnel to be certified to perform specific operations, such as asphalt placement.

Table 3.1: States that Reported Outsourcing Construction Activities (Source: Warne 2003)

State	Construction Engineering	Materials Testing
Florida	Y	Y
Indiana	Y	Y
Iowa	Y	
Kansas	Y	
Kentucky	Y	Y
Louisiana		N
Maryland	Y	Y
Minnesota	Y	Y
Mississippi	Y	
Montana		Y
Nebraska	Y	
New Hampshire		Y
West Virginia	Y	
NOTES: Responses to the question: Does your state outsource this activity? Y =Yes; N = No		

There is a growing trend in state DOTs requiring contractors to perform quality control (CPCQ) (Mahboub, Hancher and Wang 2004). Even some states are using contractor testing for acceptance and payment. The concern is raised as to whether or not the state DOTs can trust what the contractor is reporting. As a result, Mahboub, Hancher and Wang researched contractor quality control programs in various states as well as examined projects in Kentucky (2004). Items that commonly are performed by contractor quality control across several states include: grading/earthwork, Portland cement concrete pavement, HMA, concrete bridge deck, bridge painting, pavement striping and traffic control system. Of these items, HMA is by far the most often required, showing up in 26 out of 29 of the states followed by concrete items. The DOT is still performing verification testing, but this is significantly lower than the amount of testing the contractor is performing. The result of their study showed that there was no significant difference between contractor's acceptance data and the DOT's verification data. In addition, Turochy, Willis and Parker performed an analysis on the Georgia Department of Transportation (GDOT) to compare the results of contractor quality control testing and in-house assurance testing for HMA concrete. The results showed that contractor's tests were more accurate and had less variance than the GDOT tests. The fact that the contractor testing is comparable to in-house testing allows for the level of trust to increase between the two parties.

There is a large concern over whether there is an impact on quality due to the increased amount of consultant services (Warne 2003). Warne states that studies completed by Wisconsin, Montana and TxDOT showed that consultant work was comparable to in-house work and there was no evidence of poor consultant quality on state DOT projects. South Carolina Department of Transportation (SCDOT) completed 200 highway construction projects in an accelerated program where 27 years worth of work was completed in 7 years (Hancher and Werkmeister 2001). SCDOT augmented their in-house staff by hiring two independent consulting firms to manage 93 of those projects. The progress on the jobs was cited as good with the main problem associated to the "learning curve" of the new consultant relationship. In addition, the work done by the consultants had satisfactory impact on quality and schedule.

Ernzen & Feeney discuss the success of an Arizona Department of Transportation (ADOT) project that was the first to integrate a design-build contract that required the design-builder to assume the responsibility for the quality control and quality assurance on the project. ADOT would only perform verification and independent assurance sampling and testing (2002). Additional constraints that influenced the project were that the design-builder implemented an aggressive schedule, where for 2 years they performed double-shift work. The project was located in the center of Phoenix along one of the most traversed highways in the nation. The contract was awarded based on technical-merit and price, which allowed ADOT to analyze the firms based on their record and commitment to quality. In the end, the project was actually finished ahead of what ADOT had originally anticipated. The analysis of the data shows, despite the constraints of the project, the quality of the work was not compromised. The quality exceeded what was required in the specifications and also had comparable results to in-house acceptance testing from traditional contracting projects. This shows how state DOTs can be successful at shifting quality assurance and quality control responsibility to contractors. In addition, the use of an alternative delivery method such as design-build ended up returning a project quality equal or greater than that obtained by traditional methods.

Florida has a comprehensive and well structured QC/QA program to aid in-house and external inspectors. The QC/QA procedures consist of a series of checklists, guidelines, and requirements. The QC/QA program has greatly assisted the Florida DOT at addressing their workload challenges and still maintaining quality while currently outsourcing 60%-75% of the inspections on their large projects and 20% on their small projects. They have also developed an extensive certification program for both their in-house, consultant, and contractor personnel to make sure that inspectors are properly trained. The California DOT (Caltrans) has increased the amount of quality control responsibilities on the contractor who performs the work so that Caltrans can focus on quality assurance (Caltrans 2002). Similar to FDOT, Caltrans has also significantly increased their certification requirements for in-house, consultant, and contractor personnel. While Caltrans still completes most of the construction inspection services using their in-house forces, some of the inspection work is being outsourced in response to workforce shortages. Likewise, SCDOT has augmented the in-house administration of their extensive certification program by collaborating with two state universities. The in-house, consultant and contractor personnel can be certified to perform a variety of inspection tests, including: earthwork, nuclear density gauge, foundations, Portland Cement Concrete, base coarse, asphalt, and welding.

Chapter 4. TxDOT's Quality Control/Quality Assurance Program

4.1 Characterization of TxDOT's QC/QA Program

Texas has experienced similar benefits from the TEA-21 and SAFETEA-LU legislation that other states have experienced. Specifically, TxDOT has seen a significant increase in the number of projects authorized, particularly in metropolitan areas, since the passage of these two acts. For example, Houston is currently performing significant construction on the I-10 corridor; Dallas recently completed the High Five interchange project, and Austin has seen tremendous highway project growth with the development of toll roads.

Like Caltrans, TxDOT has historically performed all quality control and quality assurance activities using their own in-house forces. In spite of reductions in their staffing resulting from an overall movement to reduce the size of government agencies in Texas, TxDOT has not yet embraced widespread outsourcing of QA or QC activities. However, the escalating workload has caused an increasing strain on construction personnel at all levels of the hierarchy. This strain is causing TxDOT to explore possible ways to augment their in-house construction staff.

Currently, TxDOT does not require certifications for their in-house personnel (Hunter 2007). Furthermore, very few certifications are required for construction consultants and contractor personnel, and there is little consistency in the certification requirements among the various districts. Current construction certifications that are required include: (1) roadway construction management and inspection; (2) major bridge construction management and inspection; (3) material testing; (4) asphaltic concrete; (5) Portland cement concrete; and (6) plant inspection and testing (TxDOT 2007). One noteworthy certification program is the Certification Program for Hot Mix Asphalt Specialists, a partnership between TxDOT and the Texas Asphalt Paving Association (TxAPA). The program—which certifies specialists to "design, test, and manage hot mixed asphalt pavements" (TxAPA 2007)—provides three levels of certifications (1-A, 2, and 1-B).

TxDOT does not currently outsource any of the inspection requirements, which has made quality control and quality assurance especially challenging for construction personnel in the districts and at the division level. In fact, TxDOT has historically assigned one project to each inspector, with the inspector remaining on-site all day to ensure that the quality of the work conformed to the appropriate specification. This "one-project-per-inspector" standard prevented projects from being held up by TxDOT inspectors, who currently must travel to the jobsite at prescribed times to inspect the work. Presently, one inspector may be assigned to multiple projects, causing the inspectors to divide their time among geographically dispersed locations that often require lengthy commutes between locations.

4.2 Impact of Workforce Shortage on TxDOT

TxDOT's Construction Division and the district construction departments have a shortage of skilled inspectors that is impacting TxDOT's ability to efficiently manage its QC/QA workload, as suggested by anecdotal evidence. Several large highway projects, especially in the urban areas, where contractors are working six or seven days each week, result in construction inspectors working overtime in order to inspect the work as it is completed. Long-term overtime is a known cause of fatigue (Hanna 2005), and labor laws typically limit the number of consecutive days that a person can work. As a result, the district personnel have had considerable difficulty meeting the inspection needs and requirements, especially because state DOTs have difficulty recruiting and retaining experienced and well qualified inspection personnel. The situation is further complicated with the increase in complexity of transportation construction projects.

4.3 TxDOT's Current Inspection Workforce Challenges

During an initial meeting with the IDP Team, the researchers questioned the team about current inspection workload challenges. The IDP Team consists of four senior inspectors charged with the task of traveling to each TxDOT district to launch a new training and mentoring program for junior and mid-career inspectors. These team members had a comprehensive view of the difficulties that both urban and rural inspectors faced, and as a result, they were especially well qualified to develop a list of TxDOT inspection challenges. Ultimately, the IDP Team identified 10 challenges that were used by the researchers to develop interview guides for TxDOT and other states interviews, including:

1) Need to outsource an entire project to a *single* testing technician that will be assigned to manage and perform all field testing on site; currently, multiple technicians may visit the same site each day, reducing the efficiency of operations
2) Need to completely outsource low risk projects, such as curb and gutter, landscaping, etc., so that TxDOT inspectors can focus on high risk projects
3) Need to develop a comprehensive concrete QC/QA program so that contractors, rather than TxDOT, performs most of the materials tests
4) Reduce the need for measuring certain pay items, such as treated bases, embankment, and rip rap, in order to reduce the time inspectors spend on measuring for payment
5) Reduce the number of specification items and consolidate when possible; currently, the extensive number of pay items creates confusion for inspectors who must spend time determining which exact item is applicable
6) TxDOT inspectors spend a significant amount of time checking compliance with the Storm Water Pollution Prevention Plan (SW3P); this activity could be outsourced to a third-party consultant who would check multiple projects daily or weekly
7) Contractor training of personnel to work on TxDOT projects is insufficient, requiring extensive TxDOT oversight; contractors should be tested on knowledge of the specifications and basic construction operations, and they should be required to have appropriate certifications
8) Contractors have rejected TxDOT's efforts to incorporate warranties into projects; however, TxDOT should continue to pursue this option as a possible method for reducing inspection requirements
9) Double data entry of testing and inspections results into the *SiteManager* software program occurs frequently as a result of inadequate field technology; computers should be provided to all inspectors so that data entry can occur in the field

10) To improve the inspection efficiency, provide inspection checklists so that inspectors can identify the most critical items and ensure no item is missed; currently, new inspectors are overwhelmed by the inspection tasks but could increase their knowledge and comfort level by using detailed checklists

Interview guides were developed by the researchers to identify the nature of each of the 10 challenges within various TxDOT urban and rural districts and to question TxDOT experts about potential changes to policies and procedures in order to reduce the inspection workload. Likewise, interview guides were prepared to question other state DOTs about similar or identical challenges and strategies they had developed to address their workload challenge. Examples of these interview guide agendas are included in Appendix B. During the interviews, both TxDOT and other state DOT personnel were invited to brainstorm creative strategies for resolving the 10 workload challenges and to identify successful strategies that had already been implemented in other states that could be adopted by TxDOT.

Chapter 5. Preliminary Workload Reduction Strategies

5.1 Introduction to Preliminary Workload Reduction Strategies

During the interviews with TxDOT and other state DOTs, over 100 workload reduction strategies were identified to address the 10 workforce challenges identified by the IDP Team. The researchers consolidated several strategies that were similar, reducing the number of viable techniques to 60. These 60 were reviewed by the TxDOT Project Management Committee and reduced to 31 strategies, which are identified in Table 5.1. Approaches that were similar were grouped under broad headings that described the common goal of the workload reduction strategy, such as increasing inspector efficiency. Table 5.1 is not arranged in any particular order; however, it is anticipated that certain approaches will be easy to implement and beneficial to TxDOT. Hence, TxDOT personnel will rank the strategies so that the top methods for reducing inspection workload can be identified.

5.2 List of Preliminary Workload Reduction Strategies

Table 5.1 is a list of the preliminary workload reduction strategies grouped by broad categories that described the common goal of the workload reduction strategy.

Table 5.1: Preliminary Workload Reduction Strategies Grouped by Broad Categories

WLRS	
Sub-Strategy Num.	**Workload Reduction Sub-Strategy**
A. Modify Inspector Training Methods	
1	Create checklists for selected pay items that help inspectors prioritize inspection elements and direct them to relevant inspection documents.
2	Create construction training matrices that document training required of, and received by, inspectors on TxDOT projects (e.g. inspection, lab technician) (see info sheet for more).
3	Have consultants administer all or a portion of inspector training.
4	Convert inspector training courses to Computer-Based Training Courses as much as possible to make training easier to obtain.
5	Increase or improve *SiteManager* system training to reduce double data entry and reduce time spent on paperwork.
B. Increase Inspector Effectiveness and Efficiency Through Certification	
6	Work with a third-party to develop and administer a more extensive QC/QA certification program.
7	Require compatible or equivalent certifications for in-house inspectors, consultants, and contractors for the area of work they will be inspecting.
8	Accept certain NICET and ASTM QC/QA certifications (to be selected by TxDOT experts).
9	Simplify TxDOT concrete certification process
9a	Require workers who will inspect concrete to have their ACI certification first before being eligible to complete the TxDOT concrete certification.

Table 5.1: Preliminary Workload Reduction Strategies Grouped by Broad Categories (cont.)

WLRS	
Sub-Strategy Num.	**Workload Reduction Sub-Strategy**
9b	Replace TxDOT concrete certification with ACI certification for as many pay items as feasible.
C. Outsource Testing and Inspection to a Third-Party	
10	Outsource inspection and measurement of low-risk pay items to third-party consultants.
10a	Landscaping
10b	Seeding
10c	Traffic Stripes and Markings
11	Outsource some specialty inspection items.
11a	Steel Painting
11b	Welding
11c	Involving Hazardous Materials
12	Use third-party consultant inspectors to perform inspection for SW3P.
13	Completely outsource entire projects to consultants to manage and inspect all aspects of the project.
D. Establish a More Extensive Contractor QC Program	
14	Replace some TxDOT QC testing with more extensive contractor QC testing.
15	Use contractor QC/QA results in lieu of TxDOT QC/QA results for measurement and as a basis for payment.
E. Shift Risk to the Contractor by Delegating Control	
16	Require the contractor to provide independent consultant QC/QA services.
16a	Seal Coat or Overlay
16b	Embankment
16c	Subgrade Compaction
17	Use Lump Sum or Plan Quantity approach to payment where the contractor certifies compliance so that TxDOT does not have to measure.
17a	Bridge Projects
17b	Fencing
17c	Guardrail
17d	Landscaping
17e	Lighting
17f	Seeding
17g	Sidewalks
17h	Signing
17j	Signals
17k	Traffic Stripes and Markings
18	Make the contractor responsible for collecting quantity tickets and delivering them to TxDOT on a daily basis.
19	Make the contractor responsible for on-site concrete testing (e.g. slump, air, temperature, making cylinders).

Table 5.1: Preliminary Workload Reduction Strategies Grouped by Broad Categories (cont.)

WLRS	
Sub-Strategy Num.	**Workload Reduction Sub-Strategy**
F. Streamline Specifications to Simplify the Inspection Process	
20	Convert some specifications to performance-based specifications.
20a	HMA
20b	Landscaping
20c	Seal Coats
20d	Seeding
20e	Traffic Stripes and Markings
21	Reduce the number of specifications and combine items and quantities for payment.
G. Use Alternative Delivery Methods	
22	Use more Design-Build project delivery systems, where the design-builder provides QC (and possibly QA).
H. Optimize the Use of Inspection Resources	
23	Reduce the amount of time inspectors spend testing at the HMA plant.
23a	Replace an employee who works full-time at the plant with an employee who works part-time at the plant and only pulls samples twice a day.
23b	Take HMA samples at the site in lieu of taking samples at the plant.
23c	Use a certified QC/QA bond and weigh program where non-DOT plant employees are certified in an effort to reduce TxDOT inspectors at the plant.
I. Implement the Usage of Technology to Decrease Inspection Requirements	
24	Use equipment technology for the measurement of temperature and segregation in HMA.
25	Modify specification to allow the replacement of density measurement with stiffness in order to encourage the use of high-tech "Intelligent Compactors".
26	Standardize information provided to contractors for input into GPS controlled construction machinery.
J. Reduce Paperwork and Data Entry	
27	Use an off-the-shelf shared-access software system for contractors to submit required inspection data and reports.
K. Implement Performance Warranties and Warranty Bonds	
28	Work with industry and contractors to establish contractor supplied long-term incentivized performance warranty (non-bond based) on specific pay items.
28a	Bridge Components
28b	Highway Lighting System
28c	HMA
28d	Portland Cement Concrete Pavement
28e	Signal Installation
29	Require surety-issued warranty bonds on specific pay items.
29a	HMA
29b	Landscaping
29c	Seal Coats
29d	Traffic Signals
29e	Traffic Stripes and Markings

Chapter 6. Analysis and Prioritization of Strategies

6.1 Workshop Participants

There were 14 TxDOT employees that participated in the ranking workshop June 12, 2008. There was a combination of employees from division and district offices and from the Inspector Development Program (IDP). The employees who participated in the workshop are listed below:

1) Karl Bednarz- San Angelo Director of Construction
2) David Belser- QA Program Manager
3) Thomas Bohuslav- Director of Construction Division
4) Glenn Eilert- Inspector Development Program (IDP)
5) Charles Gaskin- Houston Director of Construction
6) Darlene Goehl- Engineer
7) Caroline Herrera- Branch Manager Geotechnical, Soils and Aggregates
8) Paul Hoelscher- Abilene Director of Construction
9) Tom Hunter- Lufkin Director of Construction
10) Richard Izzo- Engineer
11) Lisa Lukefahr- Branch Manager Rigid Pavements and Concrete Materials
12) Johnnie Miller- Branch Manager Traffic Materials
13) Duane Schwarz- Waco Director of Construction
14) Steve Strmiska- Engineer

6.2 Analysis Procedure for Ranking and Weighting Workshop Results

During the workshop, the 14 TxDOT personnel ranked the 31 strategies based on eight criteria so the top methods for reducing inspection workload could be identified. The eight criteria are listed in Table 6.1. An example of the form used during the ranking exercise is shown in Figure 6.1. After the workshop, four members of TxDOT's Project Monitoring Committee and IDP Team performed a weighting exercise to assign relative importance to the eight criteria. An example of the form used during the weighting exercise is shown in Figure 6.2. For each of the workload reduction strategies, the workshop rankings and weightings were combined to yield a ranking raw score. The maximum raw score that a strategy could receive was 57.1 and the minimum was 11.2. Using the raw scores, the strategies were rank ordered from 1 to 31, which are identified in Table 6.2.

Table 6.1: Criteria for Evaluating Workload Reduction Strategies in Response to the Question: How does implementing the workload reduction strategy impact each criterion?

Criteria		Description
1	In-house Control Over Quality	The amount of TxDOT in-house control over quality.
2	Quality of Project or Product	The long-term performance of the highway component over its entire life cycle.
3	TxDOT Inspection Workload	The total current inspection work-hours.
4	TxDOT Non-Inspection Workload (Administration and Oversight)	The implementation of the strategy may impact TxDOT personnel oversight and efforts in some other areas (or department/division, such as human resources).
5	Direct Project Cost	The bid or contract cost.
6	Indirect Cost (e.g. consultant contracts, training, certification)	The overhead cost incurred by TxDOT for providing in-house inspectors (for example, training and certifications). In addition, the cost incurred by TxDOT for outsourcing QC/QA services to third-party consultants (for example, rent-a-techs and professional service contracts).
7	Need for (or Development of) New Processes, Tools or Resources	New processes, tools or resources that will have to be created in order for the strategy to be implemented.
8	Ease of Implementation	How easy it will be to implement the strategy when considering economical, political, and legal or any other constraints.
NOTE: Criteria 1-6 are ranked from *Decrease* to *Increase*; Criteria 7-8 are ranked from *Low* to *High*. Each ranking has a *No Change* option.		

WLRS		Criteria							
Sub-Strategy Num.	Workload Reduction Sub-Strategy	In-house Control Over Quality	Quality of Project or Product	TxDOT Inspection Workload	TxDOT Non-Inspection Workload (Administration and Oversight)	Direct Project Cost	Indirect Cost (e.g. third party contracts, training, certification)	Need for (or Development of) New Processes, Tools or Resources	Ease of Implementation
A. Modify Inspector Training Methods									
1	Create checklists for selected pay items that help inspectors prioritize inspection elements and direct them to relevant inspection documents. *Intent: Increase inspector efficiency*	Increase Slight Increase No Change Slight Decrease Decrease	Increase Slight Increase No Change Slight Decrease Decrease	Increase Slight Increase No Change Slight Decrease Decrease	Increase Slight Increase No Change Slight Decrease Decrease	Increase Slight Increase No Change Slight Decrease Decrease	Increase Slight Increase No Change Slight Decrease Decrease	Very High High Moderate Low Very Low No Change	Very High High Moderate Low Very Low
COMMENTS Add additional comments here									

Figure 6.1: Example of Ranking Exercise Form

	Criteria							
	In-house Control Over Quality	Quality of Project or Product	TxDOT Inspection Workload	TxDOT Non-Inspection Workload (Administration and Oversight)	Direct Project Cost	Indirect Cost (e.g. third party contracts, training, certification)	Need for (or Development of) New Processes, Tools or Resources	Ease of Implementation
PMC Assigned Weight (Multiple of 1)								

Figure 6.2: Example of Weighting Exercise Form

6.3 Rank Ordered Workload Reduction Strategies

Table 6.2 is a list of the rank ordered workload reduction strategies from 1 to 31 based upon their ranking raw score.

Table 6.2: Rank Ordered Workload Reduction Strategies

Strategy Rank Order	Ranking Raw Score	Workload Reduction Strategy Description
1	38.52	Create checklists for selected pay items that help inspectors prioritize inspection elements and direct them to relevant inspection documents.
2	38.27	Use Lump Sum or Plan Quantity approach to payment where the contractor certifies compliance so that TxDOT does not have to measure: Bridge Projects, Fencing, Guardrail, Landscaping, Lighting, Seeding, Sidewalks, Signing, Signals, Traffic Stripes and Markings.
3	38.22	Make the contractor responsible for collecting quantity tickets and delivering them to TxDOT on a daily basis.
4	38.10	Reduce the number of specifications and combine items and quantities for payment: Landscaping, Signals, Traffic Stripes and Markings.
5	36.75	Use equipment technology for the measurement of temperature and segregation in HMA.
6	35.46	Increase or improve *SiteManager* system training to reduce double data entry and reduce time spent on paperwork.
7	35.14	Convert inspector training courses to Computer-Based Training Courses as much as possible to make training easier to obtain.
8	35.07	Standardize information provided to contractors for input into GPS controlled construction machinery.
9	35.05	Use an off-the-shelf shared-access software system for contractors to submit required inspection data and reports.
10	34.16	Modify specification to allow the replacement of density measurement with stiffness in order to encourage the use of high-tech "Intelligent Compactors".
11	33.85	Have consultants administer all or a portion of inspector training.
12	33.82	Outsource some specialty inspection items: Steel Painting and Welding.
13	33.43	Require compatible or equivalent certifications for in-house inspectors, consultants, and contractors for the area of work they will be inspecting.
14	33.33	Simplify TxDOT concrete certification process: Replace TxDOT concrete certification with ACI certification for as many pay items as feasible.
15	33.20	Use third-party consultant inspectors to perform inspection for SW3P.
16	33.17	Create construction training matrices that document training required of, and received by, inspectors on TxDOT projects (e.g. inspection, lab technician) (see info sheet for more).
17	32.87	Convert some specifications to performance-based or performance-related specifications: HMA, Landscaping, Seal Coats, Seeding, Traffic Stripes and Markings.
18	32.75	Replace some TxDOT QA testing and inspection with more extensive contractor QC testing and inspection.
19	32.72	Reduce the amount of time inspectors spend testing at the HMA plant: Replace an employee who works full-time at the plant with an employee who works part-time at the plant and only pulls samples twice a day.

Table 6.2: Rank Ordered Workload Reduction Strategies (cont.)

Strategy Rank Order	Ranking Raw Score	Workload Reduction Strategy Description
20	32.53	Reduce the amount of time inspectors spend testing at the HMA plant: Take HMA samples at the site in lieu of taking samples at the plant.
21	32.33	Work with a third-party to develop and administer a more extensive QC/QA certification program.
22	32.09	Accept certain NICET and ASTM QC/QA testing certifications (to be selected by TxDOT experts).
23	31.93	Make the contractor responsible for on-site concrete testing (e.g. slump, air, temperature, making cylinders).
24	31.85	Outsource inspection and measurement of low-risk pay items to third-party consultants: Landscaping, Seeding, Traffic Stripes and Markings.
25	31.56	Require surety-issued warranty bonds on specific pay items: HMA, Landscaping, Seal Coats, Traffic Signals, Traffic Stripes and Markings.
26	30.14	Work with industry and contractors to establish contractor supplied long-term incentivized performance warranty (non-bond based) on specific pay items: Bridge Components, Highway Lighting System, HMA, Portland Cement Concrete Pavement, Signal Installation.
27	29.76	Use contractor QC results in lieu of TxDOT QA results for measurement and as a basis for payment.
28	29.30	Reduce the amount of time inspectors spend testing at the HMA plant: Use a certified QC/QA bond and weigh program where non-DOT plant employees are certified in an effort to reduce TxDOT inspectors at the plant.
29	29.14	Use more Design-Build project delivery systems, where the design-builder provides QC (and possibly QA).
30	28.81	Require the contractor to provide independent consultant QA services: Seal Coat or Overlay, Embankment, Subgrade Compaction.
31	26.42	Completely outsource entire projects to consultants to manage and inspect all aspects of the project.

Chapter 7. Implementation Guide for Recommended Workload Reduction Strategies

7.1 Introduction to Recommended Workload Reduction Strategies

As a result of interviews with TxDOT and other state DOTs and the analysis from a TxDOT ranking workshop, the workload reduction strategies have been rank ordered from 1 to 31. The top 10 strategies and two additional specialty strategies requested by the PMC are listed in Table 7.1. The research team has prepared a guideline that TxDOT can use to implement these top ranked workload reduction strategies broadly throughout the districts in Appendix A.

7.2 List of Recommended Workload Reduction Strategies

Table 7.1 is a list of the recommended workload reduction strategies 1 to 10 and also includes specialty strategies SP 1 and SP 2.

Table 7.1: Recommended Workload Reduction Strategies

Strategy Rank Order	Ranking Raw Score	Workload Reduction Strategy Description
1	38.52	Create checklists for selected pay items that help inspectors prioritize inspection elements and direct them to relevant inspection documents.
2	38.27	Use Lump Sum or Plan Quantity approach to payment where the contractor certifies compliance so that TxDOT does not have to measure: Bridge Projects, Fencing, Guardrail, Landscaping, Lighting, Seeding, Sidewalks, Signing, Signals, Traffic Stripes and Markings.
3	38.22	Make the contractor responsible for collecting quantity tickets and delivering them to TxDOT on a daily basis.
4	38.10	Reduce the number of specifications and combine items and quantities for payment: Landscaping, Signals, Traffic Stripes and Markings.
5	36.75	Use equipment technology for the measurement of temperature and segregation in HMA.
6	35.46	Increase or improve *SiteManager* system training to reduce double data entry and reduce time spent on paperwork.
7	35.14	Convert inspector training courses to Computer-Based Training Courses as much as possible to make training easier to obtain.
8	35.07	Standardize information provided to contractors for input into GPS controlled construction machinery.
9	35.05	Use an off-the-shelf shared-access software system for contractors to submit required inspection data and reports.
10	34.16	Modify specification to allow the replacement of density measurement with stiffness in order to encourage the use of high-tech "Intelligent Compactors".
SP1	26.42	Completely outsource entire projects to consultants to manage and inspect all aspects of the project.
SP2	28.81	Require the contractor to provide independent consultant QA services: Seal Coat or Overlay, Embankment, Subgrade Compaction.

7.3 Implementation Guide for Recommended and Special Interest Workload Reduction Strategies

An implementation guide has been developed for the top 10 workload reduction strategies in addition to two specialty strategies per the PMC's request. It is important to note that additional research is needed to develop a more comprehensive method for fully implementing these strategies.

The implementation guide for the workload reduction strategies is included in Appendix A.

Chapter 8. Recommendations and Conclusions

8.1 Recommendations and Next Actions

Additional research is needed to develop a more comprehensive method for fully implementing these strategies. In particular, the PMC felt that strategies listed in Table 8.1 were especially promising and should become immediate topics of research. WLRS 1 could be the subject of a future research project that would develop and lay out a framework for implementing a TxDOT checklist system. WLRS 2 could be the subject of a future research project that would develop and lay out a framework for implementing a TxDOT Lump Sum bidding, payment, and measurement process. WLRS 4 strategy could be the subject of a future research project that would analyze the current specifications and identify specific pay items that show the greatest potential for reducing time spent measuring. The research would include incorporating a framework for implementing a TxDOT Lump Sum bidding, payment, and measurement process that combines numerous pay items into one lump sum item. WLRS 7 could be outsourced to a third-party that would develop the computer-based training courses.

The PMC group also identified two additional strategies that were not ranked in the top 10, but they wanted to be included in this implementation guide. They have been identified as specialty workload reduction strategies SP 1 and SP 2. It is also recommended that further research be completed for these specialty strategies as well. WLRS SP 1 strategy could be the subject of a future research project that would evaluate similar programs in other states and public agencies and would develop a best practice third party consultant project management process. WLRS SP 2 could be the subject of a future research project that would evaluate similar programs in other states and public agencies and would develop guidelines for implementing a successful independent consultant QC/QA program in TxDOT.

Table 8.1: Workload Reduction Strategies that Need Additional Research

Strategy Rank Order	Ranking Raw Score	Workload Reduction Strategy Description
1	38.52	Create checklists for selected pay items that help inspectors prioritize inspection elements and direct them to relevant inspection documents.
2	38.27	Use Lump Sum or Plan Quantity approach to payment where the contractor certifies compliance so that TxDOT does not have to measure: Bridge Projects, Fencing, Guardrail, Landscaping, Lighting, Seeding, Sidewalks, Signing, Signals, Traffic Stripes and Markings.
4	38.10	Reduce the number of specifications and combine items and quantities for payment: Landscaping, Signals, Traffic Stripes and Markings.
7	35.14	Convert inspector training courses to Computer-Based Training Courses as much as possible to make training easier to obtain.
SP1	26.42	Completely outsource entire projects to consultants to manage and inspect all aspects of the project.
SP2	28.81	Require the contractor to provide independent consultant QA services: Seal Coat or Overlay, Embankment, Subgrade Compaction.

8.2 Need to Expand the Contractor Quality Control Program

Throughout the course of the research, interviews with other state DOTs revealed that these states had implemented extensive contractor quality control (QC) programs, which were then supplemented by a DOT quality assurance (QA) program. For example, in South Carolina, Florida, Arizona and Virginia, the trend is to require contractors to be responsible for their own QC, with the state DOT providing QA services. These programs are documented in detail in their QC, QA, and IA procedures and manuals and are generally available on the DOT websites.

In fact, TxDOT is unique in that it has only implemented a contractor QC program for hot mix asphalt. Other efforts at implementing contractor QC programs (such as for concrete pavement and structures) have largely been resisted by the contractors. While "implementing a contractor QC program" did not make the top 10 list of Workload Reduction Strategies, ***the researchers believe this is an important strategy that should be investigated further and seriously considered for future implementation within TxDOT***.

Other states have successfully implemented contractor QC programs, and, in fact, TxDOT has demonstrated that implementation ***is*** possible because the HMA contractor QC program has been a tremendous success. Many states mentioned that they had achieved a significant time savings through their programs; consequently, TxDOT might, likewise, achieve a significant time savings with minimum or no additional costs. The researchers recommend that a research project or implementation project be initiated to develop an effective comprehensive contractor QC program in TxDOT.

8.3 Conclusions

TxDOT and other state DOTs are experiencing inspection workforce shortages that can be addressed by implementing creative workload reduction strategies. This project summarized TxDOT's current workload challenges, identified successful workload reduction strategies that have been implemented in other state DOTs, and compared TxDOT's challenges and practices to the other states' challenges and practices. Overall, 31 workload reduction strategies were identified by TxDOT and other state DOTs to address 10 key workload challenges within TxDOT. These strategies show promise at increasing inspection and testing efficiency and decreasing unproductive time spent on activities that involve low risk pay items or particularly time consuming tasks. A workshop with TxDOT personnel was conducted and the 31 workload reduction strategies were ranked on eight criteria, with an emphasis on highlighting strategies with the greatest potential of decreasing inspection time without increasing construction project costs or reducing the overall quality of the end product. As a result of the workshop analysis, the top workload reduction techniques with the potential to provide the most benefit to TxDOT have been identified. A guideline was developed for implementing the top 10 ranked and two specialty workload reduction strategies within TxDOT. The guideline should be implemented within TxDOT to more effectively manage their inspection workload while maintaining quality.

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Appendix A: Implementation Guide for Workload Reduction Strategies

Implementation Guide for Recommended Workload Reduction Strategy 1

Recommended Strategy	WLRS Implementation Strategy
1	**Create checklists for selected pay items that help inspectors prioritize inspection elements and direct them to relevant inspection documents.**

1. **Description**
   Checklists will be designed as an additional tool or resource to help inspectors more efficiently and effectively monitor the construction of TxDOT projects. The checklists will include a list of prioritized inspection elements so that inspectors can identify the most important items to inspect. The checklists will also reference the specifications and other relevant inspection documents. These checklists provide easily accessible documentation of quality requirements and allow inspectors to monitor construction processes to make sure that the project or product meets TxDOT's quality standards.

2. **Potential Benefits or Intent**

   - Checklists will increase in-house control over quality because they will serve as a tool that is easily accessible to inspectors and will record and track the inspection documentation throughout a project. This documentation will be especially useful if inspection services are outsourced to third parties or as evidence if a project goes to litigation.
   - An increase in quality of project or product because inspectors will be equipped with an additional tool to aid in the supervision of the quality of projects. Checklists will provide inspectors knowledge of what items are the most critical to inspect as well as the proper procedure for inspection.
   - Anticipate no change in TxDOT inspection workload because inspectors are already inspecting items, but the checklists will serve as a way to help organize the inspection with a focus on highlighting the inspection of critical items.

3. **Implementation Strategy**
   3.1 Form a committee to oversee the development of checklists
   3.2 Identify specific pay items that are strong candidates for checklist development
   3.3 Compile steps to be included in each checklist

   - TxDOT will have the discretion to require checklist usage for projects or designate the checklists as guidelines for construction inspection.
   - When possible, checklists should be compatible with *SiteManager*.
   - It is recommended that these pay item checklists be integrated with checklists already developed in the TxDOT IDP Manual.
   - NOTE: As an alternative, this workload reduction strategy could be the subject of a future research project that would develop and lay out a framework for implementing a TxDOT checklists system.

4. Conditions for Successful Implementation and Cautions

- A passionate team committed to developing an effective checklist system for TxDOT will be essential to the success of this strategy.
- Checklists should be created to be compatible with TxDOT specifications. They need to reference item article numbers to point inspectors to TxDOT specifications and other relevant inspection documents.
- Checklists should be used as a complement to current inspector training and certification. The checklist should be used as one of many tools to aid an inspector. Checklists do not serve as a replacement for proper training or certification, but refer the inspector to the appropriate specifications and test methods.
- Checklists should not become a substitute for knowledge of the specification and good construction practice, which could lead to poor long-term inspector abilities.
- A significant amount of time will be spent on the development of the checklists. However, for the checklists to be effective there will need to be updates and revisions to stay up to date with the current specifications.
- It is anticipated that there will be a slight increase in TxDOT administration and oversight. By implementing checklists, a new program is being created that will require management, training and routine updates.

5. Anticipated Cost for Implementation

- There will be a slight increase to indirect project cost associated with the overhead cost to develop the checklists. In addition, there will be administrative costs to manage the new program and update the checklists.
- Anticipate no immediate impact on direct project cost. Potential cost benefits will be experienced in the long term as the checklists will enable inspectors to focus on inspection of important items more effectively and efficiently.

6. Examples

- Florida and Arizona have already developed comprehensive checklists that TxDOT could use as a model for adapting to their needs.
- Florida has developed checklists or what they refer to as “guidelists” that provide guidance for all major tasks that need to be completed relevant to construction inspection. The guidelists also highlight critical requirements, which are items that if not properly performed, have a high probability of causing problems during the construction phase. Some of the types of inspector guidelists developed in Florida include: Environmental Compliance, Earthwork, Drainage, Base, Asphalt, Concrete, Bridge Structures, Signalization, Lighting, Grassing, Landscaping (FDOT 2008).
- Arizona has created massive checklists or what they refer to as “quantlists” that cover every aspect of their work. The quantlists are described as allowing for an objective evaluation of construction processes. Their quantlists must be completed along with their diary and other documentation requirements.
- The Western Federal Lands Highway Division of the Federal Highway Administration (FHWA) has created inspection checklists for various construction items which can be

accessed online (FHWA 2008). An example of a checklist they created for Structural Concrete is included in Attachment 1.

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8. Attachments for Recommended WLRS 1

- Attachment 1: FHWA Structural Concrete Inspection Checklist

US DEPARTMENT OF TRANSPORTATION – FEDERAL HIGHWAY ADMINISTRATION

Construction Inspection Checklist

Section 552 Structural Concrete

Project Name:	Project No.:
Date:	Weather:
Contractor:	Subcontractor:
Inspector:	Location/Station:
Description of work being inspected:	

Conformance			CHECKS (characteristics)
Yes	**No**	**N.A.**	
			Composition (Concrete Mix Design)
☐	☐	☐	1. Was a concrete mix design submitted in accordance with Subsection 552.03? (552.03)
☐	☐	☐	2. Does the submitted concrete mix design meet the requirements of Subsection 552.03? (552.03)
			Storage and Handling of Material
☐	☐	☐	3. Were all materials stored and handled in a manner that prevents segregation, contamination, or other harmful effects? (552.04)
☐	☐	☐	4. Was cement and fly ash containing evidence of moisture contamination used? (552.04)
☐	☐	☐	5. Was aggregate stored and handled in a manner that ensured uniform moisture content at the time of batching? (552.04)
			Measuring Material
☐	☐	☐	6. Was the concrete batched according to the approved mix design and the following tolerances: Cement ± 1 percent, Water ± 1 percent, Aggregate ± 2 percent, and Additive ± 3 percent? (552.05)
			Batching Plant, Mixers and Agitators
☐	☐	☐	7. If a batching plant, mixer and agitator was used did it conform to AASHTO M 157? (552.06)
☐	☐	☐	8. Did the continuous volumetric mixing equipment conform to AASHTO M 241? (552.06)
			Mixing
☐	☐	☐	9. Was all mixing equipment (mix plant or truck) operated within manufacturer's recommended capacity? (552.07)
☐	☐	☐	10. Was the concrete produced, of a uniform consistency? (552.07)
☐	☐	☐	11. If concrete was produced in a Central-mix plant was it according to Subsection 552.07(a)? (552.07a)
☐	☐	☐	12. If concrete was mixed in a truck were any sections of the blades worn 1 inch or more below the original manufactured height? (552.07b)

Conformance			CHECKS (characteristics)
Yes	No	N.A.	
☐	☐	☐	13. If concrete was mixed in a truck did the mixers and agitators in the mixing drum have accumulated hard concrete or mortar on them? (552.07b)
☐	☐	☐	14. If concrete was mixed in a truck, were admixtures added to the mix water before or during mixing? (552.07b)
☐	☐	☐	15. If concrete was mixed in a truck was the batch charged into the drum so a portion of the mixing water entered in advance of the cement? (552.07b)
☐	☐	☐	16. If concrete was mixed in a truck was each batch mixed according to AASHTO M 157? (552.07b)
			Delivery
☐	☐	☐	17. Was concrete delivered according to Subsection 552.08 and Table 552-4? (552.08)
			Quality Control of Mix
☐	☐	☐	18. Was the quality control of mix performed according to Subsection 552.09? (552.09)
			Temperature and Weather Conditions
☐	☐	☐	19. Was the temperature of the concrete mixture just before placement between 50 and 90°F, except for bridge decks the mixture should be between 50 and 80°F? (552.10)
☐	☐	☐	20. Was cold weather placement done according to Subsection 552.10(a) and for hot weather placement according to Subsection 552.10(b)? (552.10a,b)
☐	☐	☐	21. When placing concrete in bridge decks or other exposed slabs, was the expected evaporation rate less than 0.1 pound per square foot per hour as determined by figure 552-1? (552.10)
☐	☐	☐	22. If necessary was one or more of the following actions taken: (1) Construct windbreaks or enclosures to reduce wind velocity throughout the area of placement; (2) Use of fog sprayers upwind of placement to increase relative humidity; (3) Reduce the temperature of the concrete according to Subsection 552.10(b)? (552.10c)
☐	☐	☐	23. Was the concrete protected from rain at all times during and immediately after placement? (552.10d)
			Handling and Placing Concrete
☐	☐	☐	24. Was the handling and placing of the concrete done according Subsection 552.11? (552.11)
			Construction Joints
☐	☐	☐	25. Were construction joints provided at locations shown on the plans? (552.12)
☐	☐	☐	26. If additional construction joints were added was written approval provided? (552.12)

Conformance	CHECKS (characteristics)
Yes No N.A.	
☐ ☐ ☐	27. Was reinforcing steel extended uninterrupted through construction joints? (552.12)
☐ ☐ ☐	28. Were lap splices or mechanical splices embedded within the concrete and not in a construction joint? (552.12)
☐ ☐ ☐	29. Dowels were not used? (552.12)
☐ ☐ ☐	30. Were gauge strips placed at horizontal construction joints inside the forms along all exposed faces to produce straight joint lines? (552.12)
☐ ☐ ☐	31. If a joint was between two fresh concrete placements, was the first placement rough floated to thoroughly consolidate the surface and leave the joint surface in a roughened condition? (552.12)
☐ ☐ ☐	32. Was the joint surface kept saturated? (552.12)
☐ ☐ ☐	33. Immediately before placing new concrete, were the forms drawn tightly against previously placed concrete and, where accessible, was the joint surface thoroughly coated with a very thin coating of cement mortar? (552.12)
☐ ☐ ☐	34. If a joint was between existing concrete and a new placement, was the existing concrete cleaned by abrasive blasting or other approved method to remove all laitance and foreign material, to expose clean aggregate, and to roughen the joint surface? (552.12)
☐ ☐ ☐	35. Before concrete was placed, was an approved bonding product applied to the joint surface according to the manufacture's recommendation? (552.12)
	Expansion and Contraction Joints
☐ ☐ ☐	36. Were expansion and contraction joints formed according to Subsection 553.13? (552.13)
	Finishing Plastic Concrete
☐ ☐ ☐	37. Was the finishing of plastic concrete performed according to Subsection 552.14? (552.14)
	Curing Concrete
☐ ☐ ☐	38. Was curing begun immediately after the free surface water was evaporated and the finishing was completed? (552.15)
☐ ☐ ☐	39. If the surface of the concrete began to dry before the selected cure method was implemented was the concrete surface kept moist using fog spray, without damaging the surface? (552.15)
☐ ☐ ☐	40. Were surfaces to be rubbed kept moist after forms were removed and was the surface cured immediately following the first rub? (552.15)
Conformance	**CHECKS (characteristics)**

Yes	No	N.A.	
☐	☐	☐	41. Were the top surfaces of bridge decks cured using the liquid membrane curing compound method combined with the water method and if so was the liquid membrane curing compound applied immediately after finishing and the water cure applied within 4 hours after finishing? (552.15)
☐	☐	☐	42. Was all concrete cured uninterrupted for at least 7 days, unless pozzolans were used in excess of 10 percent by mass of the hydraulic cement and then cured uninterrupted for at least 10 days? (552.15)
☐	☐	☐	43. If the following methods of curing were used were they used according to Subsection 552.15 (a) forms in place, (b) water method or (c) liquid membrane curing compound? (552.15)
☐	☐	☐	44. If the steam-curing method was used, was it used according to Subsection 552.15(d)? (552.15)
			Finishing Formed Concrete Surfaces
☐	☐	☐	45. Were all rock pockets or honeycombed concrete removed and replaced or repaired? (552.16)
☐	☐	☐	46. Were all sound, formed concrete surfaces finished according to Subsections 552.16 (a), (b), (c), (d), (e), (f) or (g) depending of the finish required? (552.16)
			Concrete Anchorage Devices
☐	☐	☐	47. Were concrete anchorage devices tested and installed according to Subsection 522.17? (552.17)
			Loads on New Concrete Structures
☐	☐	☐	48. Was traffic kept off of concrete bridge decks until all deck concrete had attained the design compressive strength and had been in place for at least 14 days or longer? (552.18)
☐	☐	☐	49. Construction loads of 4000 pounds or more were not placed on the deck until after the concrete had cured at least 7 days and the concrete in the entire span had attained a compressive strength of at least 70 percent of the specified design strength? (552.18)
☐	☐	☐	50. For precast concrete multi-beam sections, vehicles were not allowed on any span before the grout attained strength of 3000 pounds per square inch and tie rods had been tightened? (552.18)
☐	☐	☐	51. For post-tensioned concrete structures, vehicles were not allowed over 4500 pounds on any span before the prestressing steel for that span was tensioned, grouted, and cured, the grout obtained a strength of 3000 pounds per square inch, and the tie rods tightened? (552.18)
☐	☐	☐	52. Were vehicles' weighing less than 4500 pounds permitted on a span provided the mass of the vehicle was included in the falsework design? (552.18)

Percent Conformance Calculations	$\frac{\text{Yes}}{\text{Yes + No}}(100) = \underline{\qquad\qquad}(100) = \underline{\qquad\qquad}$ % Conformance

Comments:

____

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Implementation Guide for Recommended Workload Reduction Strategy 2

Recommended Strategy	WLRS Implementation Strategy
2	**Use Lump Sum or Plans Quantity approach to payment where the contractor certifies compliance so that TxDOT does not have to measure.**

<u>Lump Sum</u>

1. Description

- DOT inspection staffs are spending a large amount of time measuring and verifying pay items. Inspector efficiency would be increased if certain measurement-intensive pay items were changed to Lump Sum (LS).
- Lump Sum Contracting Technique as defined by FDOT requires the Contractor to submit a lump sum price to complete a project as opposed to bidding on individual pay items with quantities provided. The Contractor will be provided a set of bid documents (plans, specifications, etc.) and will develop a Lump Sum bid for all work specified in the contract drawings (2000).

2. Potential Benefits or Intent

- Using Lump Sum will reduce the time inspection staff spends on quantity verification and measurement in order to free-up inspector time for other duties.
- Lump Sum contracts streamline the payment process for the DOT because the contractor is responsible for estimating progress and invoicing (Scott and Mitchell 2007).
- Lump Sum reduces the administrative responsibility because several pay items are lumped together in one unit item (Scott and Mitchell 2007).

3. Implementation Strategy

3.1. Implementation is envisioned to require a considerable effort and commitment from a dedicated TxDOT team, but the potential benefits are significant. This method is fundamentally different than TxDOT's current unit price bidding and payment method.

3.2. Work with the Construction Division and TxDOT Specification Committee to form a sub-committee to oversee the development and administration of Lump Sum Contracting

3.3. Use a method to identify the most promising pay items to change measurement method to Lump Sum

3.4. Modify specifications for new Lump Sum pay items. It is recommended that this strategy be implemented with enough time to have the modifications incorporated into the next specification revision in 2014.

3.5. Use new Lump Sum guidelines on pilot projects and incorporate any necessary adjustments to guidelines

3.6. NOTE: As an alternative, this workload reduction strategy could be the subject of a future research project that would develop and lay out a framework for implementing a TxDOT Lump Sum bidding, payment, and measurement process.

4. Conditions for Successful Implementation and Cautions

- According to FDOT's Lump Sum Guidelines (2000), LS should be used on projects:
  - with a well-defined scope for all parties (Design and Construction)
  - with low risk of unforeseen conditions (i.e., projects that do not involve such things as significant underground utilities, earthwork variations, underground drainage pipes, bricks under pavement in urban areas, etc.)
  - with low possibility for change during all phases of work – Design and Construction (i.e., limited possibilities for added driveways, median modifications due to developments, changes due to political involvement, etc.)
- For Lump Sum items, require the contractor to provide a schedule of values to break out the quantities so TxDOT is able to quantify the cost of the changes, overruns and underruns.
- Lump Sum contracting places more risk on the contractor for quantity overruns. The increased risk could lead to the contractor adding additional contingency costs to their bid prices. Also, the DOT runs the risk that they will pay more than necessary when the quantities underrun the estimate, because they agreed to the lump sum price (Scott and Mitchell 2007).

5. Anticipated Cost for Implementation

- Lump Sum projects are anticipated to reduce the costs of design and inspection associated with quantity calculation, verification and measurement (FDOT 2000).
- There will be a slight increase to indirect project cost associated with the overhead cost to establish lump sum guidelines and modify the specifications for select pay items. In addition, there will be administrative costs associated with monitoring the effectiveness of lump sum items.

6. Examples

- From our interviews with TxDOT employees, it became overwhelmingly apparent that there was too much time being spent on measuring traffic stripes and markings. Therefore, it is highly recommended that the measurement of these pay items be changed to Lump Sum method.
- Florida recommends the following items as good Lump Sum candidates (Warne 2003): Bridge Projects, Fencing, Guardrail, Landscaping, Lighting, Seeding, Sidewalks, Signing, Signals, Traffic Stripes and Markings.
- Florida gives examples of projects that may not be good Lump Sum candidates (FDOT 2000): Urban Construction/Reconstruction, Rehabilitation of Movable Bridges, Projects with Subsoil Earthwork, Concrete Pavement Rehabilitation Projects, and Major Bridge Rehabilitation/Repair Projects Where There Are Many Unknown Quantities.

7. References

- Blanchard, Brian. (2008). Director of Construction, Florida Department of Transportation. Phone: 850-414-4140. Email: brian.blanchard@dot.state.fl.us. Telephone conversation on March 20, 2008.
- Florida Department of Transportation (FDOT). (January 2000). *Plans Preparation Manual: Chapter 22 Lump Sum Project Guidelines*. Available at http://www.dot.state.fl.us/rddesign/PPMManual/2008/Volume1/zChap22.pdf.
- Scott, Sidney and Mitchell, Kathryn. (2007). *Alternative Payment and Progress Reporting Methods Task #2*. Trauner Consulting Services, Inc. Available at http://www.fhwa.dot.gov/programadmin/contracts/etgpayment.cfm.

Plans Quantity

1. Description

- DOT inspection staffs are spending a large amount of time measuring and verifying pay items. Inspector efficiency would be increased if certain measurement-intensive pay items were changed to Lump Sum (LS) or Plan quantity (PQ).
- According to TxDOT's 2004 Specifications, plans quantities may or may not represent the exact quantity of work performed or material moved, handled, or placed during the execution of the Contract. The estimated bid quantities are designated as final payment quantities, unless revised by the governing specifications.

2. Potential Benefits or Intent

- The Wisconsin Department of Transportation (WisDOT) lists the benefits of plan quantity items (2004), including:
    - Reduces time need for taking measurements
    - Eliminates resolving minor quantity variations
    - Provides for quicker payment to the contractor

3. Implementation Strategy

3.1. Work with the Construction Division and TxDOT Specifications Committee and assign a sub-committee to oversee the modification of Plan Quantity Guidelines and Pay Items
3.2. Identify additional specific pay items that can be changed to a Plans Quantity measurement method
3.3. Modify specifications for new Plans Quantity pay items
3.4. Monitor application of new Plans Quantity pay items and modify as necessary

4. Conditions for Successful Implementation and Cautions

- TxDOT will not measure items that are designated as plans quantity items and will pay the quantity shown on the schedule of items, unless exceptions occur (WisDOT 2004).
- During interviews with TxDOT employees, there seemed to be variation in the frequency of measuring of plans quantity items amongst the districts. In order for plans quantity

items to be used as a successful workload reduction strategy, inspectors need to limit the amount of measuring they perform unless exceptions occur.

  - According to TxDOT Specifications (2004), exceptions occur if the quantity measured as outlined under "Measurement' varies by more than 5% (or as stipulated under "Measurement" for specific Items) from the total estimated quantity for an individual Item originally shown in the Contract, an adjustment may be made to the quantity of authorized work done for payment purposes. The party to the Contract requesting the adjustment will provide field measurements and calculations showing the revised quantity.

- General guidance for selecting plans quantity pay items is summarized by WisDOT (2004). Select Pay items that:
  - Can be estimated accurately
  - Are not expected to vary beyond specification thresholds during construction
  - Are measured linearly or by area
  - Can be measured after the fact and can be measured later if needed
- Do not select pay items that are (WisDOT 2004):
  - Measured by volume or weight, especially large quantities
  - Shown on plans as undistributed quantities
  - Traditionally have varied beyond the spec thresholds
  - For repair or rehab work
  - Pay items with small quantities
- The contractor should be required to certify the quantities to TxDOT for compliance to the Plans and Specifications.

5. Anticipated Cost for Implementation

- There will be a slight increase to indirect project cost associated with the overhead cost to establish plans quantity guidelines and modify the specifications for select pay items. In addition, there will be administrative costs associated with monitoring the effectiveness of plans quantity items.
- Anticipate no immediate impact on direct project cost. Inspectors should be able to spend less time measuring, but this likely will be offset with an increase time being now spent monitoring quality.

6. Examples

- WisDOT has prepared a list of guidance for selecting plan quantity items for various work types, including: concrete, asphalt, structural, traffic control, electrical and grading, landscaping and sewer. This presentation is included in Attachment 1 (WisDOT 2004).

7. References

- Scott, Sidney and Mitchell, Kathryn. (2007). *Alternative Payment and Progress Reporting Methods Task #2*. Trauner Consulting Services, Inc. Available at http://www.fhwa.dot.gov/programadmin/contracts/etgpayment.cfm.
- Texas Department of Transportation (TxDOT). (March 2005). *Plans Quantity Items.* Available at ftp://ftp.dot.state.tx.us/pub/txdot-info/des/specs/planquan.pdf.

- Texas Department of Transportation (TxDOT). (June 2004). *Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges.* Available at ftp://ftp.dot.state.tx.us/pub/txdot-info/des/specs/specbook.pdf.
- Wisconsin Department of Transportation (WisDOT). (September 2004). *Pay Plan Quantity*. Available at https://trust.dot.state.wi.us/static/standards/fdm/19/PayPlanQuantityALL.pdf.
- Wisconsin Department of Transportation (WisDOT). (April 2008). *Construction and Materials Manual.* Available at http://roadwaystandards.dot.wi.gov/standards/cmm/index.htm.

8. Attachments for Recommended WLRS 2

- Attachment 1: WisDOT Pay Plan Quantity Presentation (September 2004)

Pay Plan Quantity

Design Training - NetMeeting
Bureau of Highway Construction
September 2004

Pay Plan Quantity

Training Topics

- Objective
- Specification
- Selecting Bid Items
- Estimator & Trns•port Instructions
- Rollout - Implementation

Pay Plan Quantity

What is our objective?

- Pay Plan Quantity is one of several WisDOT initiatives to streamline contract administration.
- For selected bid items, Pay Plan Quantity will:
  - Eliminate field measuring
  - Eliminate time spent resolving minor quantity variations

Pay Plan Quantity

Standard Specifications

Section 109 - Measurement and Payment, establishes the general contractual requirement that WisDOT pays for all work acceptably completed, based on actual measured quantities.

Pay Plan Quantity

Standard Specifications

- 109.1 was revised in the 2004 Annual Supplement to add mechanism for Pay Plan Quantity
  (before letting decision to pay for work without measuring)
- 109.1 still includes mechanism for supplemental agreements
  (after construction decision to pay for work without measuring)

Pay Plan Quantity

Key specification elements:

- Pay Plan Quantity items are designated in the schedule of items with **P**
- Dept will not measure these designated items
- Dept will pay the quantity shown on the schedule of items, unless specified exceptions occur
- If specified exceptions do occur, Dept will make adjustments to the affected quantities

109.1.1.2 Bid Items Designated as Pay Plan Quantity

109.1.1.2.1 General

(1) If the schedule of items designates a bid item with a **P** in the item description, the department will not measure that bid item. The department will use the plan quantity, the approximate quantity shown on the schedule of items, for payment unless one or more of the following occurs:

1. A contract revision partially eliminates, completely eliminates, or affects the quantity for a designated bid item.
2. The quantity for a designated bid item varies by more than 5 percent from the plan quantity.
3. A quantity variation causes the value of the work under a designated bid item to vary by more than $5000 from the bid amount.

109.1.1.2.2 Adjustments for Contract Revisions

(1) The department will adjust the quantity for a designated bid item if the engineer revises the contract under 104.2 either with or without a change order. The engineer will either increase or decrease the affected quantity regardless of the magnitude of the revised work. The department will measure revised work as specified in 109.1.1.1. This adjustment has no impact on potential quantity changes the engineer might make under 109.1.1.2.3.

(2) If the department partially eliminates or completely eliminates a designated item, the department will pay for the designated item as specified in 109.5.

109.1.1.2.3 Adjustments for Quantity Variations

(1) If the actual work performed, excluding contract revisions, exceeds either the quantity threshold of item 2 of 109.1.1.2.1(1) or the value threshold of item 3 of 109.1.1.2.1(1), the engineer will adjust the affected quantity. Either the engineer or the contractor may identify an item for potential adjustment. If the contractor believes a quantity adjustment is necessary, notify the engineer as required under 104.3. Provide sufficient detail on the bid item in question to justify the engineer's review of that quantity.

(2) The engineer may adjust the quantity by re-computing or measuring all or only those portions of a bid item that vary from the plan quantity. The department will adjust the quantity to account for the entire variation from the plan quantity. If the engineer re-computes or measures only a portion of a bid item, the engineer will determine the quantity for the balance of that bid item based on the unaffected plan quantity.

Pay Plan Quantity

Selecting Bid Items

- General Guidance
- Guidance for Various Work Types
- Example Bid Items for Various Work Types

Pay Plan Quantity

General Guidance for Selecting Bid Items

Select Bid Items that:

- Can be estimated accurately
- Are not expected to vary beyond spec thresholds during construction
- Are measured linearly or by area
- Can be measured after the fact, i.e., have ability to measure later if needed

Pay Plan Quantity

General Guidance for Selecting Bid Items

Do not select Bid Items that are:

- Measured by volume or weight
  - Especially large quantities
  - Items with expansion factors

  (Note exception for structures, where volume and weight items are recommended)
- Shown on plans as undistributed quantities

Pay Plan Quantity

General Guidance for Selecting Bid Items

Do not select Bid Items that:

- Traditionally have varied beyond the spec thresholds
- Are for repair or rehab work

Pay Plan Quantity

General Guidance for Selecting Bid Items

There is not much value in selecting:

- Lump sum items
- Each items with small quantities

Pay Plan Quantity

Guidance for Various Work Types

- Concrete
- Asphalt
- Grading, Landscaping, and Sewer
- Structural
- Traffic Control
- Electrical

Pay Plan Quantity

Guidance for Concrete:

(See General Guidance)

Do not select:

- Concrete driveways
- Concrete pavement repair
- Spot replacements for curb & gutter and sidewalk

Pay Plan Quantity
Example Bid Item List

Work Type: Concrete Bid Items

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
204.0100	Removing Pavement	SY
204.0130	Removing Curb	LF
204.0140	Removing Gutter	LF
204.0150	Removing Curb & Gutter	LF
204.0155	Removing Concrete Sidewalk	SY
211.0400	Prepare Fundation for Asphaltic Shoulders	STA
211.0500	Prepare Foundation for Base Aggregate	STA
320.0105	Concrete Base 4 Inch	SY
320.0110	Concrete Base 4 1/2- Inch	SY
320.0115	Concrete Base 5 Inch	SY
320.0120	Concrete Base 5 1/2-Inch	SY
320.0125	Concrete Base 6 Inch	SY
320.0130	Concrete Base 6 1/2-Inch	SY
320.0135	Concrete Base 7 Inch	SY
320.0140	Concrete Base 7 1/2-Inch	SY
320.0145	Concrete Base 8 Inch	SY
320.0150	Concrete Base 8 1/2-Inch	SY
320.0155	Concrete Base 9 Inch	SY
320.0160	Concrete Base 9 1/2-Inch	SY
320.0165	Concrete Base 10 Inch	SY
320.0170	Concrete Base 10 1/2-Inch	SY
320.0305	Concrete Base HES 4 Inch	SY
320.0310	Concrete Base HES 4 1/2-Inch	SY
320.0315	Concrete Base HES 5 Inch	SY
320.0320	Concrete Base HES 5 1/2-Inch	SY
320.0325	Concrete Base HES 6 Inch	SY
320.0330	Concrete Base HES 6 1/2-Inch	SY
320.0335	Concrete Base HES 7 Inch	SY
320.0340	Concrete Base HES 7 1/2-Inch	SY
320.0345	Concrete Base HES 8 Inch	SY
320.0350	Concrete Base HES 8 1/2-Inch	SY
320.0355	Concrete Base HES 9 Inch	SY
320.0360	Concrete Base HES 9 1/2-Inch	SY
320.0365	Concrete Base HES 10 Inch	SY
320.0370	Concrete Base HES 10 1/2-Inch	SY
320.0500	Concrete Base Widening	SY
415.0060	Concrete Pavement 6 Inch	SY

Pay Plan Quantity
Example Bid Item List

Work Type: Concrete Bid Items

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
415.0065	Concrete Pavement 6 1/2-Inch	SY
415.0070	Concrete Pavement 7 Inch	SY
415.0075	Concrete Pavement 7 1/2-Inch	SY
415.0080	Concrete Pavement 8 Inch	SY
415.0085	Concrete Pavement 8 1/2-Inch	SY
415.0090	Concrete Pavement 9 Inch	SY
415.0095	Concrete Pavement 9 1/2-Inch	SY
415.0100	Concrete Pavement 10 Inch	SY
415.0105	Concrete Pavement 10 1/2-Inch	SY
415.0110	Concrete Pavement 11 Inch	SY
415.0115	Concrete Pavement 11 1/2-Inch	SY
415.0120	Concrete Pavement 12 Inch	SY
415.1080	Concrete Pavement HES 8 Inch	SY
415.1085	Concrete Pavement HES 8 1/2 Inch	SY
415.1090	Concrete Pavement HES 9 Inch	SY
415.1095	Concrete Pavement HES 9 1/2 Inch	SY
415.1100	Concrete Pavement HES 10 Inch	SY
415.1105	Concrete Pavement HES 10 1/2 Inch	SY
415.1110	Concrete Pavement HES 11 Inch	SY
415.1115	Concrete Pavement HES 11 1/2 Inch	SY
415.1120	Concrete Pavement HES 12 Inch	SY
416.0050	Concrete Pavement Approach Slab	SY
416.0055	Concrete Pavement Approach Slab HES	SY
416.0060	Concrete Pavement Widening	SY
416.0065	Concrete Pavement Widening HES	SY
416.0410	Concrete Pavement Header	SY
416.0415	Concrete Pavement Header HES	SY
416.0905	Concrete Pavement Continuous Diamond Grinding	SY
601.0105	Concrete Curb Type A	LF
601.0110	Concrete Curb Type D	LF
601.0115	Concrete Curb Type G	LF
601.0120	Concrete Curb Type J	LF
601.0150	Concrete Curb Integral Type D	LF
601.0155	Concrete Curb Integral Type J	LF
601.0205	Concrete Gutter 24 Inch	LF
601.0318	Concrete Curb & Gutter 18 Inch	LF
601.0322	Concrete Curb & Gutter 22 Inch	LF

Pay Plan Quantity
Example Bid Item List

Work Type: **Concrete Bid Items**

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
601.0331	Concrete Curb & Gutter 31 Inch	LF
601.0342	Concrete Curb & Gutter Integral 18 Inch	LF
601.0344	Concrete Curb & Gutter Integral 36 Inch	LF
601.0405	Concrete Curb & Gutter 18 Inch Type A	LF
601.0407	Concrete Curb & Gutter 18 Inch Type D	LF
601.0409	Concrete Curb & Gutter 30 Inch Type A	LF
601.0411	Concrete Curb & Gutter 30 Inch Type D	LF
601.0413	Concrete Curb & Gutter 30 Inch Type G	LF
601.0415	Concrete Curb & Gutter 30 Inch Type J	LF
601.0417	Concrete Curb & Gutter 30 Inch Type K	LF
601.0419	Concrete Curb & Gutter 30 Inch Type L	LF
601.0421	Concrete Curb & Gutter 36 Inch Type A	LF
601.0423	Concrete Curb & Gutter 36 Inch Type D	LF
601.0452	Concrete Curb & Gutter Integral 30 Inch Type D	LF
601.0454	Concrete Curb & Gutter Integral 30 Inch Type J	LF
601.0456	Concrete Curb & Gutter Integral 30 Inch Type L	LF
601.0502	Concrete Curb & Gutter Integral 4 Inch Mountable 36 Inch	LF
601.0512	Concrete Curb & Gutter Integral 6 Inch Mountable 36 Inch	LF
601.0552	Concrete Curb & Gutter 4 Inch Mountable 36 Inch Type A	LF
601.0554	Concrete Curb & Gutter 4 Inch Mountable 36 Inch TypeD	LF
601.0556	Concrete Curb & Gutter 6 Inch Mountable 36 Inch Type A	LF
601.0558	Concrete Curb & Gutter 6 Inch Mountable 36 Inch Type D	LF
602.0405	Concrete Sidewalk 4 Inch	SF
602.0410	Concrete Sidewalk 5 Inch	SF
602.0415	Concrete Sidewalk 6 Inch	SF
602.0420	Concrete Sidewalk 7 Inch	SF
603.0105	Concrete Barrier Single-Faced 32 Inch	LF
603.0110	Concrete Barrier Single-Faced 42 Inch	LF
603.0115	Concrete Barrier Single-Faced 51 Inch	LF
603.0205	Concrete Barrier Double-Faced 32 inch	LF
603.0210	Concrete Barrier Double-Faced 42 Inch	LF
603.0215	Concrete Barrier Double-Faced 51 Inch	LF
603.0405	Concrete Barrier Transition Section 32 Inch	LF
603.0410	Concrete Barrier Transition Section 42 Inch	LF
603.0415	Concrete Barrier Transition Section 51 Inch	LF
603.0500	Concrete Barrier Temporary Precast Contractor Furnished & Delivered	LF
603.0600	Concrete Barrier Temporary Precast State Owned Contractor Delivered	LF

Page 3 of 4

Pay Plan Quantity
Example Bid Item List

Work Type: **Concrete Bid Items**

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
603.0800	Concrete Barrier Temporary Precast Cntractor Furnished & Installed	LF
603.0900	Concrete Barrier Temporary Precast State Owned Contractor Installed	LF
620.0100	Concrete Corrugated Median	SF
650.5000	Construction Staking Base	LF
650.5500	Construction Staking Curb Gutter and Curb & Gutter	LF
650.7000	Construction Staking Concrete Pavement	LF
650.7500	Construction staking Concrete Barrier	LF
690.0100	Sawing Existing Pavement	LF
690.0200	Sawing Concrete Pavement Full Depth	LF

Page 4 of 4

Pay Plan Quantity

Guidance for Asphalt:

(See General Guidance)

Do not select:

- Patching items

Pay Plan Quantity
Example Bid Item List

Work Type: **Asphalt Bid Items**

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
211.0400	Prepare Foundation for Asphaltic Shoulders	STA
325.0100	Pulverize and Relay	SY
330.0100	Mill and Relay	SY
335.0100	Rubblizing	SY
340.0100	Cracking and Seating	SY
455.0600	Tack Coat	TON
455.0605	Tack Coat	GAL
465.0310	Asphaltic Curb	LF
465.0400	Asphaltic Shoulder Rumble Strip	LF
490.0100	Salvaged Asphaltic Pavement	SY
490.0200	Salvaged Asphaltic Pavement Milling	SY

Page 1 of 1

Pay Plan Quantity

Guidance for Grading:

(See General Guidance)

Select:

- Common Exc.-rural, if quantity < 20,000 c.y.
- Common Exc.-urban, if typical section is relatively constant

NOTE:

- Plans must still include yardage information
- Can include EBS that is known
- Do not include EBS that is undistributed

Pay Plan Quantity

Guidance for Landscaping & Sewer:

(See General Guidance)

Select:

- Seed, sod, and mulch items on small projects only (i.e., small bridge projects)
- Storm sewer items

Pay Plan Quantity

Guidance for Landscaping & Sewer:

(See General Guidance)

Do not select:

- Rural drainage items

  (encourage use of supplemental agreement based on pipe list)
- Erosion Control Items

Pay Plan Quantity
Example Bid Item List

Work Type: **Grading & Landscaping Bid Items**

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit	Small Quantity
201.0105	Clearing	STA	
201.0110	Clearing	SY	
201.0205	Grubbing	STA	
201.0210	Grubbing	SY	
202.0105	Roadside Clearing (station)	STA	
202.0110	Roadside Clearing	SY	
204.0100	Removing Pavement	SY	
204.0105	Removing Pavement Butt Joints	SY	
204.0109.S	Removing Concrete Surface Partial Depth	SF	
204.0110	Removing Asphaltic Surface	SY	
204.0115	Removing Asphaltic Surface Butt Joints	SY	
204.0120	Removing Asphaltic Surface Milling	SY	
204.0130	Removing Curb	LF	
204.0140	Removing Gutter	LF	
204.0150	Removing Curb & Gutter	LF	
204.0155	Removing Concrete Sidewalk	SY	
204.0160	Removing Lip Curb	LF	
204.0165	Removing Guardrail	LF	
204.0170	Removing Fence	LF	
204.0175	Removing Concrete Slope Paving	SY	
204.0200	Removing Railroad Track	LF	
204.0245	Removing Storm Sewer (size)	LF	
205.0100	Excavation Common	CY	x
208.0100	Borrow	CY	x
208.1100	Select Borrow	CY	x
209.0100	Backfill Granular	CY	x
210.0100	Backfill Structure	CY	x
211.0400	Prepare Foundation for Asphaltic Shoulders	STA	
211.0500	Prepare Foundation for Base Aggregate	STA	
214.0100	Obliterating Old Road	STA	
313.0115	Pit Run	CY	x
612.0104	Pipe Underdrain 4-Inch	LF	
612.0106	Pipe Underdrain 6-Inch	LF	
612.0108	Pipe Underdrain 8-Inch	LF	
612.0110	Pipe Underdrain 10-Inch	LF	
612.0112	Pipe Underdrain 12-Inch	LF	
612.0115	Pipe Underdrain 15-Inch	LF	

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Pay Plan Quantity
Example Bid Item List

Work Type: Grading & Landscaping Bid Items

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit	Small Quantity
612.0118	Pipe Underdrain 18-Inch	LF	
612.0121	Pipe Underdrain 21-Inch	LF	
612.0204	Pipe Underdrain Unperforated 4-Inch	LF	
612.0206	Pipe Underdrain Unperforated 6-Inch	LF	
612.0208	Pipe Underdrain Unperforated 8-Inch	LF	
612.0210	Pipe Underdrain Unperforated 10-Inch	LF	
612.0212	Pipe Underdrain Unperforated 12-Inch	LF	
612.0215	Pipe Underdrain Unperforated 15-Inch	LF	
612.0218	Pipe Underdrain Unperforated 18-Inch	LF	
612.0221	Pipe Underdrain Unperforated 21-Inch	LF	
612.0404	Pipe Underdrain Wrapped 4-Inch	LF	
612.0406	Pipe Underdrain Wrapped 6-Inch	LF	
612.0408	Pipe Underdrain Wrapped 8-Inch	LF	
612.0410	Pipe Underdrain Wrapped 10-Inch	LF	
612.0412	Pipe Underdrain Wrapped 12-Inch	LF	
612.0415	Pipe Underdrain Wrapped 15-Inch	LF	
612.0504	Pipe Underdrain Wrapped and Plowed 4-Inch	LF	
612.0506	Pipe Underdrain Wrapped and Plowed 6-Inch	LF	
614.0100	Cable Guard Fence	LF	
614.0200	Steel Thrie Beam Structure Approach	LF	
614.0250	Steel Thrie Beam Structure Approach Temporary	LF	
614.0305	Steel Plate Beam Guard Class A	LF	
614.0310	Steel Plate Beam Guard Class B	LF	
614.0340	Steel Plate Beam Guard Over Low-Fill Culverts Class A	LF	
614.0355	Steel Plate Beam Median Guard	LF	
614.0360	Steel Plate Beam Guard Temporary	LF	
614.0400	Adjusting Steel Plate Beam Guard	LF	
614.0500	Salvaged Guard Fence Cable	LF	
614.0555	Salvaged Guard Fence Steel Beam	LF	
615.0100	Guard Fence Timber Rail	LF	
625.0100	Topsoil	SY	x
625.0500	Salvaged Topsoil	SY	x
627.0200	Mulching	SY	x
629.0205	Fertilizer Type A	CWT	x
629.0210	Fertilizer Type B	CWT	x
630.0110	Seeding Mixture No. 10	LB	x
630.0120	Seeding Mixture No. 20	LB	x

Pay Plan Quantity
Example Bid Item List

Work Type: Grading & Landscaping Bid Items

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit	Small Quantity
630.0130	Seeding Mixture No. 30	LB	x
630.0140	Seeding Mixture No. 40	LB	x
630.0160	Seeding Mixture No. 60	LB	x
631.1000	Sod Lawn	SY	x
645.0105	Geotextile Fabric Type C	SY	
645.0110	Geotextile Fabric Type DF	SY	
650.4500	Construction Staking Subgrade	LF	
650.5000	Construction Staking Base	LF	
650.5500	Construction Staking Curb Gutter and Curb & Gutter	LF	
650.7000	Construction Staking Concrete Pavement	LF	
650.7500	Construction Staking Concrete Barrier	LF	
650.8000	Construction Staking Resurfacing Reference	LF	
650.9900	Construction Staking Initial Layout	LF	

Pay Plan Quantity

Guidance for Structures:

(See General Guidance)

Select:

- Concrete masonry items measured by volume
- Bar steel reinforcement items measured by weight

Do not select:

- Piling Items
- Maintenance or repair items

Pay Plan Quantity
Example Bid Item List

Work Type: Structural Bid Items

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
502.0100	Concrete Masonry Bridges	CY
502.1100	Concrete Masonry Seal	CY
502.2000	Compression Joint Sealer Preformed Elastomeric (width)	LF
502.5002	Masonry Anchors Type L No. 4 Bars	Each
502.5005	Masonry Anchors Type L No. 5 Bars	Each
502.5010	Masonry Anchors Type L No. 6 Bars	Each
502.5015	Masonry Anchors Type L No. 7 Bars	Each
502.5020	Masonry Anchors Type L No. 8 Bars	Each
502.5025	Masonry Anchors Type L No. 9 Bars	Each
502.6102	Masonry Anchors Type S 1/2 Inch	Each
502.6105	Masonry Anchors Type S 5/8 Inch	Each
502.6110	Masonry Anchors Type S 3/4 Inch	Each
502.6115	Masonry Anchors Type S 7/8 Inch	Each
502.6120	Masonry Anchors Type S 1 Inch	Each
502.3200	Protective Surface Treatment	SY
503.0128	Prestressed Girder Type I 28-Inch	LF
503.0136	Prestressed Girder Type I 36-Inch	LF
503.0145	Prestressed Girder Type I 45-Inch	LF
503.0154	Prestressed Girder Type I 54-Inch	LF
503.0155	Prestressed Girder Type I 54W-Inch	LF
503.0170	Prestressed Girder Type I 70-Inch	LF
503.0172	Prestressed Girder Type I 72W-Inch	LF
504.0100	Concrete Masonry Culverts	CY
505.0405	Bar Steel Reinforcement HS Bridges	LB
505.0410	Bar Steel Reinforcement HS Culverts	LB
505.0605	Bar Steel Reinforcement HS Coated Bridges	LB
505.0610	Bar Steel Reinforcement HS Coated Culverts	LB
506.0105	Structural Steel Carbon	LB
506.0605	Structural Steel HS	LB
506.2605	Bearing Pads Elastomeric Non-Laminated	Each
506.2610	Bearing Pads Elastomeric Laminated	Each
506.3005	Welded Stud Shear Connectors 7/8 x 4 Inch	Each
506.3010	Welded Stud Shear Connectors 7/8 x 5 Inch	Each
506.3015	Welded Stud Shear Connectors 7/8 x 6 Inch	Each
506.3020	Welded Stud Shear Connectors 7/8 x 7 Inch	Each
506.3025	Welded Stud Shear Connectors 7/8 x 8 Inch	Each
506.4000	Steel Diaphragms (structure)	Each

Pay Plan Quantity
Example Bid Item List

Work Type: Structural Bid Items

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
506.5000	Bearing Assemblies Fixed (structure)	Each
506.6000	Bearing Assemblies Expansion (structure)	Each
511.3000	Pile Points	Each
514.0440	Floor Drains Type G	Each
514.0445	Floor Drains Type GC	Each
514.0460	Floor Drains Type H	Each
516.0100	Dampproofing	SY
516.0500	Rubberized Membrane Waterproofing	SY
604.0400	Slope Paving Concrete	SY
604.0500	Slope Paving Crushed Aggregate	SY
612.0106	Pipe Underdrain 6-Inch	LF
612.0206	Pipe Underdrain Unperforated 6-Inch	LF
612.0406	Pipe Underdrain Wrapped 6-Inch	LF
614.0150	Anchor Assemblies for Steel Plate Beam Guard	Each
616.0204	Fence Chain Link 4-Ft.	LF
616.0205	Fence Chain Link 5-Ft.	LF
616.0206	Fence Chain Link 6-Ft.	LF
616.0207	Fence Chain Link 7-Ft.	LF
616.0208	Fence Chain Link 8-Ft.	LF
645.0110	Geotextile Fabric Type DF	SY
645.0130	Geotextile Fabric Type R	SY
645.0120	Geotextile Fabric Type HR	SY
645.0105	Geotextile Fabric Type C	SY
502.0300.S	QMP Concrete Structures 5-Cylinder	SF
SPV.0060	Bar Couplers, 1/2 Inch	Each
SPV.0060	Bar Couplers, 5/8 Inch	Each
SPV.0060	Bar Couplers, 3/4 Inch	Each
SPV.0060	Bar Couplers, 7/8 Inch	Each
SPV.0060	Bar Couplers, 1 Inch	Each
SPV.0060	Bar Couplers, 1 1/8 Inch	Each

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Pay Plan Quantity

Specific Guidance for Traffic Control:

(See General Guidance)

Select:

- Temporary pavement markings measured linearly

Do not select:

- Each items
- Day items

Pay Plan Quantity
Example Bid Item List

Work Type: Traffic Control Bid Items

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
643.1000	Traffic Control Signs Fixed Message	SF
646.0103	Pavement Marking Paint 4-Inch	LF
646.0106	Pavement Marking Epoxy 4-Inch	LF
646.0109	Pavement Marking Preformed Plastic 4-Inch	LF
646.0113	Pavement Marking Paint 6-Inch	LF
646.0116	Pavement Marking Epoxy 6-Inch	LF
646.0119	Pavement Marking Preformed Plastic 6-Inch	LF
646.0223	Pavement Marking Channelizing Paint 8-Inch	LF
646.0226	Pavement Marking Channelizing Epoxy 8-Inch	LF
646.0229	Pavement Marking Channelizing Preformed Plastic 8-Inch	LF
646.0403	Pavement Marking Same Day Paint 4-Inch	LF
646.0406	Pavement Marking Same Day Epoxy 4-Inch	LF
646.0413	Pavement Marking Same Day Paint 6-Inch	LF
646.0416	Pavement Marking Same Day Epoxy 6-Inch	LF
646.0600	Removing Pavement Markings	LF
647.0453	Pavement Marking Curb Paint	LF
647.0456	Pavement Marking Curb Epoxy	LF
647.0503	Pavement Marking Curb Ramp Paint	LF
647.0506	Pavement Marking Curb Ramp Epoxy	LF
647.0509	Pavement Marking Curb Ramp Preformed Plastic	LF
647.0553	Pavement Marking Stop Line Paint 12-Inch	LF
647.0556	Pavement Marking Stop Line Epoxy 12-Inch	LF
647.0559	Pavement Marking Stop Line Preformed Plastic 12-Inch	LF
647.0563	Pavement Marking Stop Line Paint 18-Inch	LF
647.0566	Pavement Marking Stop Line Epoxy 18-Inch	LF
647.0569	Pavement Marking Stop Line Preformed Plastic 18-Inch	LF
647.0573	Pavement Marking Stop Line Paint 24-Inch	LF
647.0576	Pavement Marking Stop Line Epoxy 24-Inch	LF
647.0579	Pavement Marking Stop Line Preformed Plastic 24-Inch	LF
647.0653	Pavement Marking Parking Stall Paint	LF
647.0656	Pavement Marking Parking Stall Epoxy	LF
647.0659	Pavement Marking Parking Stall Preformed Plastic	LF
647.0706	Pavement Marking Diagonal Epoxy 6-Inch	LF
647.0713	Pavement Marking Diagonal Paint 8-Inch	LF
647.0716	Pavement Marking Diagonal Epoxy 8-Inch	LF
647.0719	Pavement Marking Diagonal Preformed Plastic 8-Inch	LF
647.0723	Pavement Marking Diagonal Paint 12-Inch	LF

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Pay Plan Quantity
Example Bid Item List

Work Type: Traffic Control Bid Items

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
647.0726	Pavement Marking Diagonal Epoxy 12-Inch	LF
647.0729	Pavement Marking Diagonal Preformed Plastic 12-Inch	LF
647.0736	Pavement Marking Diagonal Epoxy 18-Inch	LF
647.0743	Pavement Marking Diagonal Paint 24-Inch	LF
647.0746	Pavement Marking Diagonal Epoxy 24-Inch	LF
647.0749	Pavement Marking Diagonal Preformed Plastic 24-Inch	LF
647.0763	Pavement Marking Crosswalk Paint 6-Inch	LF
647.0766	Pavement Marking Crosswalk Epoxy 6-Inch	LF
647.0769	Pavement Marking Crosswalk Preformed Plastic 6-Inch	LF
647.0773	Pavement Marking Crosswalk Paint 12-Inch	LF
647.0776	Pavement Marking Crosswalk Epoxy 12-Inch	LF
647.0779	Pavement Marking Crosswalk Preformed Plastic 12-Inch	LF
647.0783	Pavement Marking Crosswalk Paint 18-Inch	LF
647.0786	Pavement Marking Crosswalk Epoxy 18-Inch	LF
647.0789	Pavement Marking Crosswalk Preformed Plastic 18-Inch	LF
647.0803	Pavement Marking Aerial Enforcement Bars Epoxy 24-Inch	LF
647.0806	Pavement Marking Aerial Enforcement Bars Preformed Plastic 24-Inch	LF
647.0830.S	Pavement Marking Raised Pattered Tape 4-Inch	LF
647.0850.S	Pavement Marking High Performance Contrast Tape	LF
647.0853	Pavement Marking Concrete Corrugated Median Paint	SF
647.0856	Pavement Marking Concrete Corrugated Median Epoxy	SF
648.0100	Locating No-Passing Zones	MI
649.0100	Temporary Pavement Marking 4-Inch	LF
649.0200	Temporary Pavement Marking Reflective Paint 4-Inch	LF
649.0300	Temporary Pavement Marking Reflective Tape 4-Inch	LF
649.0400	Temporary Pavement Marking Removable Tape 4-Inch	LF
649.0700	Temporary Pavement Marking Channelizing 8-Inch	LF
649.0800	Temporary Pavement Marking Channelizing Removable Tape 8-Inch	LF
649.0900	Temporary Pavement Marking Stop Line 12-Inch	LF
649.1000	Temporary Pavement Marking Stop Line Removable Tape 12-Inch	LF
649.1100	Temporary Pavement Marking Stop Line 18-Inch	LF
649.1200	Temporary Pavement Marking Stop Line Removable Tape 18-Inch	LF
649.1300	Temporary Pavement Marking Stop Line 24-Inch	LF
649.1400	Temporary Pavement Marking Stop Line Removable Tape 24-Inch	LF
649.1500	Temporary Pavement Marking Diagonal 12-Inch	LF
649.1600	Temporary Pavement Marking Diagonal Removable Tape 12-Inch	LF

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Pay Plan Quantity

Specific Guidance for Electrical:

(See General Guidance)

Select:

- Linear items – wiring, conduit, etc

Do not select:

- Lump sum traffic signals or lighting
- Each items

Pay Plan Quantity
Example Bid Item List

Work Type: Electrical Bid Items

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
652.0105	Conduit Rigid Metallic 3/4-Inch	LF
652.0110	Conduit Rigid Metallic 1-Inch	LF
652.0115	Conduit Rigid Metallic 1 1/4-Inch	LF
652.0120	Conduit Rigid Metallic 1 1/2-Inch	LF
652.0125	Conduit Rigid Metallic 2-Inch	LF
652.0130	Conduit Rigid Metallic 2 1/2-Inch	LF
652.0135	Conduit Rigid Metallic 3-Inch	LF
652.0140	Conduit Rigid Metallic 3 1/2-Inch	LF
652.0145	Conduit Rigid Metallic 4-Inch	LF
652.0205	Conduit Rigid Nonmetallic Schedule 40 3/4-Inch	LF
652.0210	Conduit Rigid Nonmetallic Schedule 40 1-Inch	LF
652.0215	Conduit Rigid Nonmetallic Schedule 40 1 1/4-Inch	LF
652.0220	Conduit Rigid Nonmetallic Schedule 40 1 1/2-Inch	LF
652.0225	Conduit Rigid Nonmetallic Schedule 40 2-Inch	LF
652.0230	Conduit Rigid Nonmetallic Schedule 40 2 1/2-Inch	LF
652.0235	Conduit Rigid Nonmetallic Schedule 40 3-Inch	LF
652.0240	Conduit Rigid Nonmetallic Schedule 40 4-Inch	LF
652.0305	Conduit Rigid Nonmetallic Schedule 80 3/4-Inch	LF
652.0310	Conduit Rigid Nonmetallic Schedule 80 1-Inch	LF
652.0315	Conduit Rigid Nonmetallic Schedule 80 1 1/4-Inch	LF
652.0320	Conduit Rigid Nonmetallic Schedule 80 1 1/2-Inch	LF
652.0325	Conduit Rigid Nonmetallic Schedule 80 2-Inch	LF
652.0330	Conduit Rigid Nonmetallic Schedule 80 2 1/2-Inch	LF
652.0335	Conduit Rigid Nonmetallic Schedule 80 3-Inch	LF
652.0340	Conduit Rigid Nonmetallic Schedule 80 4-Inch	LF
652.0405	Conduit Reinforced Thermosetting Resin 2-Inch	LF
652.0410	Conduit Reinforced Thermosetting Resin 3-Inch	LF
652.0415	Conduit Reinforced Thermosetting Resin 4-Inch	LF
652.0605	Conduit Special 2-Inch	LF
652.0610	Conduit Special 2 1/2-Inch	LF
652.0615	Conduit Special 3-Inch	LF
652.0620	Conduit Special 3 1/2-Inch	LF
652.0625	Conduit Special 4-Inch	LF
652.0690	Conduit Special (inch)	LF
652.0705	Drain Duct 2-Inch	LF
652.0800	Conduit Loop Detector	LF
652.0900	Loop Detector Slots	LF

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Pay Plan Quantity
Example Bid Item List

Work Type: Electrical Bid Items

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
655.0102	Cable In Duct 2-2 AWG	LF
655.0104	Cable In Duct 2-4 AWG	LF
655.0106	Cable In Duct 2-6 AWG	LF
655.0108	Cable In Duct 2-8 AWG	LF
655.0110	Cable In Duct 2-10 AWG	LF
655.0122	Cable In Duct 3-2 AWG	LF
655.0124	Cable In Duct 3-4 AWG	LF
655.0126	Cable In Duct 3-6 AWG	LF
655.0128	Cable In Duct 3-8 AWG	LF
655.0130	Cable In Duct 3-10 AWG	LF
655.0144	Cable In Duct 4-4 AWG	LF
655.0146	Cable In Duct 4-6 AWG	LF
655.0148	Cable In Duct 4-8 AWG	LF
655.0150	Cable In Duct 4-10 AWG	LF
655.0205	Cable Traffic Signal 3-12 AWG	LF
655.0210	Cable Traffic Signal 3-14 AWG	LF
655.0215	Cable Traffic Signal 4-12 AWG	LF
655.0220	Cable Traffic Signal 4-14 AWG	LF
655.0223	Cable Traffic Signal 5-10 AWG	LF
655.0225	Cable Traffic Signal 5-12 AWG	LF
655.0230	Cable Traffic Signal 5-14 AWG	LF
655.0233	Cable Traffic Signal 7-10 AWG	LF
655.0235	Cable Traffic Signal 7-12 AWG	LF
655.0240	Cable Traffic Signal 7-14 AWG	LF
655.0243	Cable Traffic Signal 9-10 AWG	LF
655.0245	Cable Traffic Signal 9-12 AWG	LF
655.0250	Cable Traffic Signal 9-14 AWG	LF
655.0253	Cable Traffic Signal 12-10 AWG	LF
655.0255	Cable Traffic Signal 12-12 AWG	LF
655.0260	Cable Traffic Signal 12-14 AWG	LF
655.0263	Cable Traffic Signal 15-10 AWG	LF
655.0265	Cable Traffic Signal 15-12 AWG	LF
655.0270	Cable Traffic Signal 15-14 AWG	LF
655.0273	Cable Traffic Signal 19-10 AWG	LF
655.0275	Cable Traffic Signal 19-12 AWG	LF
655.0280	Cable Traffic Signal 19-14 AWG	LF
655.0285	Cable Traffic Signal 21-12 AWG	LF

Page 2 of 4

Pay Plan Quantity
Example Bid Item List

Work Type: Electrical Bid Items

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
655.0290	Cable Traffic Signal 21-14 AWG	LF
655.0305	Cable Type UF 2-12 AWG Grounded	LF
655.0310	Cable Type UF 2-12 AWG	LF
655.0315	Cable Type UF 2-10 AWG	LF
655.0400	Communication Cable Plowed	LF
655.0405	Communication Cable Trenched	LF
655.0410	Communication Cable Installed in Conduit	LF
655.0505	Electrical Wire Traffic Signals 14 AWG	LF
655.0510	Electrical Wire Traffic Signals 12 AWG	LF
655.0515	Electrical Wire Traffic Signals 10 AWG	LF
655.0520	Electrical Wire Traffic Signals 8 AWG	LF
655.0525	Electrical Wire Traffic Signals 6 AWG	LF
655.0530	Electrical Wire Traffic Signals 4 AWG	LF
655.0535	Electrical Wire Traffic Signals 2 AWG	LF
655.0610	Electrical Wire Lighting 12 AWG	LF
655.0615	Electrical Wire Lighting 10 AWG	LF
655.0620	Electrical Wire Lighting 8 AWG	LF
655.0625	Electrical Wire Lighting 6 AWG	LF
655.0630	Electrical Wire Lighting 4 AWG	LF
655.0635	Electrical Wire Lighting 2 AWG	LF
655.0640	Electrical Wire Lighting 1 AWG	LF
655.0645	Electrical Wire Lighting 1/0 AWG	LF
655.0700	Loop Detector Lead In Cable	LF
655.0800	Loop Detector Wire	LF
671.0100	Conduit HDPE 4 Duct 1 1/4 Inch	LF
671.0200	Conduit HDPE Directional Bore 4-Duct 1 1/4-Inch	LF
674.0106	Cable ITS Communication 6 Pair	LF
674.0112	Cable ITS Communication 12 Pair	LF
674.0125	Cable ITS Communication 25 Pair	LF
674.0200	Cable Microwave Detector	LF
674.0300	Remove Cable	LF
674.0400	Reinstall Cable	LF
678.0006	Install Fiber Optic Cable Outdoor Plant 6-CT	LF
678.0024	Install Fiber Optic Cable Outdoor Plant 24-CT	LF
678.0036	Install Fiber Optic Cable Outdoor Plant 36-CT	LF
678.0048	Install Fiber Optic Cable Outdoor Plant 48-CT	LF
678.0072	Install Fiber Optic Cable Outdoor Plant 72-CT	LF

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Pay Plan Quantity
Example Bid Item List

Work Type: **Electrical Bid Items**

NOTE: Example Bid Item list provided for clarification of guidance only. Designers are not restricted to the bid items shown.

Item Number	Description	Unit
678.0096	Install Fiber Optic Cable Outdoor Plant 96-CT	LF
678.0144	Install Fiber Optic Cable Outdoor Plant 144-CT	LF

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Pay Plan Quantity

Example Bid Items for Various Work Types

- Lists of example Bid Items are provided for clarification of guidance only
- Designers aren't restricted to the Bid Items on the example lists
- Plan Examiners will not compare Bid Items selected by designers to the example lists

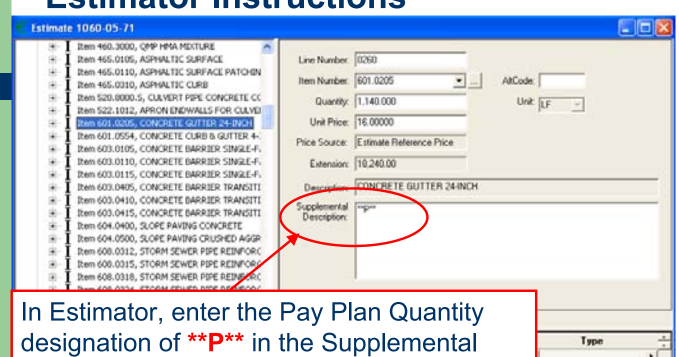
Pay Plan Quantity

Instructions for adding **P to Schedule of Items for both:**

- Estimator
- Trns•port

Pay Plan Quantity

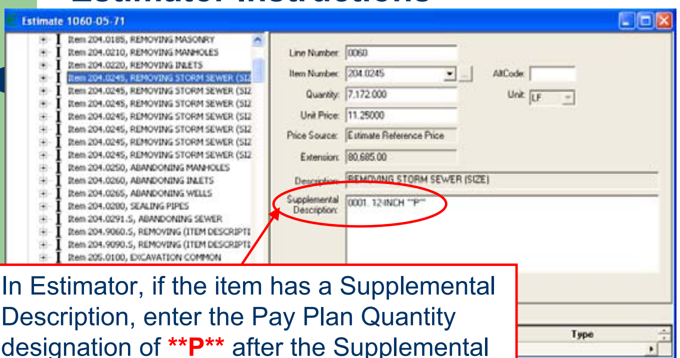
Estimator Instructions



In Estimator, enter the Pay Plan Quantity designation of ****P**** in the Supplemental Description field for the item

Pay Plan Quantity

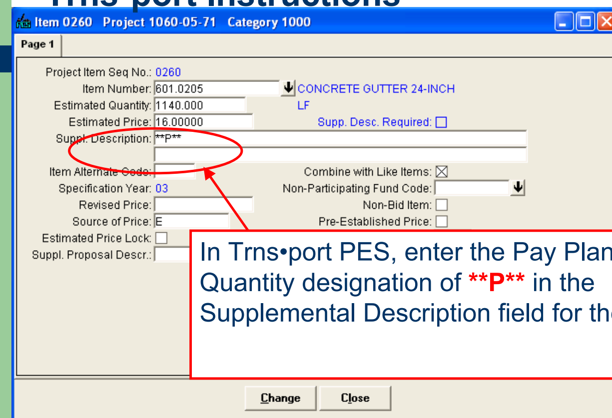
Estimator Instructions



In Estimator, if the item has a Supplemental Description, enter the Pay Plan Quantity designation of ****P**** after the Supplemental Description for the item

Pay Plan Quantity

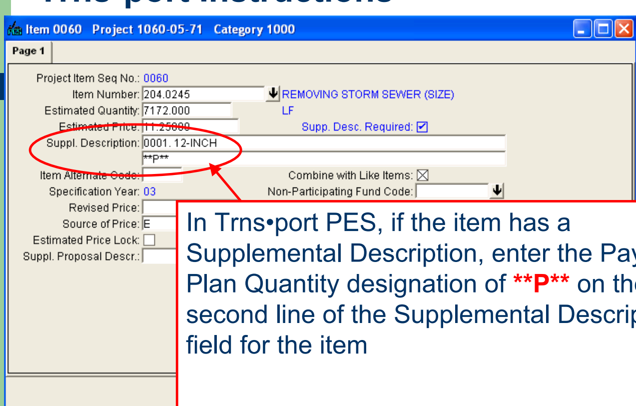
Trns•port Instructions



In Trns•port PES, enter the Pay Plan Quantity designation of ****P**** in the Supplemental Description field for the item

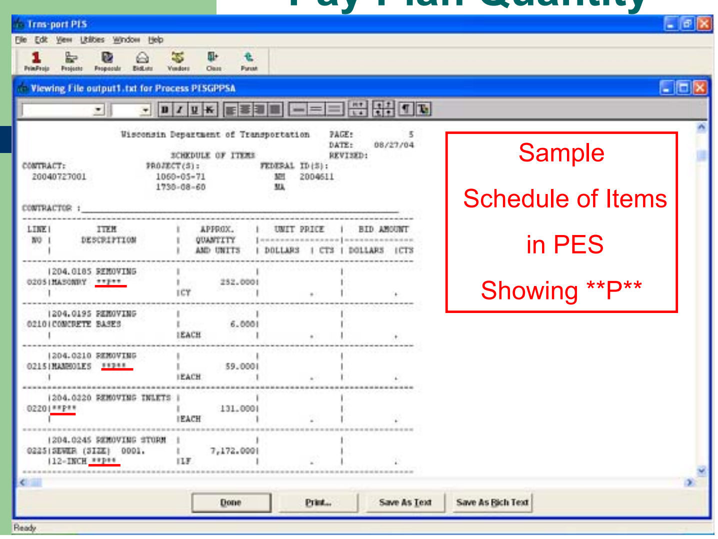
Pay Plan Quantity

Trns•port Instructions



In Trns•port PES, if the item has a Supplemental Description, enter the Pay Plan Quantity designation of ****P**** on the second line of the Supplemental Description field for the item

Pay Plan Quantity



Sample

Schedule of Items

in PES

Showing **P**

Pay Plan Quantity

Implementation

- District's <u>discretion</u> as to when it can be worked into PSE's
- Everything is available for immediate implementation
- District's encouraged to implement as soon as they can

Pay Plan Quantity

Implementation

- Districts should <u>stop</u> using the previous Bridge special provision that includes a list of pay plan quantity items and <u>start</u> using **P** mechanism
- Will look to expand Pay Plan Quantity to more items and possibly revise thresholds in the future

Implementation Guide for Recommended Workload Reduction Strategy 3

Recommended Strategy	WLRS Implementation Strategy
3	**Make the contractor responsible for collecting quantity tickets and delivering them to TxDOT on a daily basis.**

1. Description

- In several districts within TxDOT, inspectors are collecting tickets from trucks as they become available. Other districts are collecting tickets once or twice a day, while yet another district allows the contractors to collect tickets and drop them off with a TxDOT official. Collecting tickets is viewed as a very time consuming activity; consequently, a more efficient method for collecting tickets is to allow the contractors to collect their own tickets and give then to TxDOT at the end of the day.
- Currently, tickets are collected for two main reasons, to verify quantity for payment and to check the yield as construction is ongoing.

2. Potential Benefits or Intent

- By shifting responsibility to contractors for collecting tickets as they are delivered on-site and delivering them to TxDOT on a daily basis, this will free-up inspector time for other inspection obligations.
- This will allow the inspector to focus more on traffic control and on the lay down operations.

3. Implementation Strategy

3.1. In an effort to use in-house inspector time more efficiently, the contractor should be responsible for collecting the quantity tickets from trucks coming on-site instead of having TxDOT inspectors collecting them. The contractor should turn in these quantity tickets to TxDOT once a day.

3.2. The inspector should be present at the lay down operations and observe the collection of tickets

4. Conditions for Successful Implementation and Cautions

- This strategy is recommended for projects that:
    - Have seasoned inspectors that have a good working relationship with the contractor
    - On a uniform lay-down job
    - Have very small quantities or intermittent deliveries under conditions where the project engineer or inspector can visually determine the approximate quantity delivered (Iowa 2008).

- Even though the collection of the tickets will be the responsibility of the contractor, the inspector should be present at the lay down operations and observe the collection of tickets (Iowa 2008).
- There is a risk that the contractor will send in faulty tickets, but precautions should be taken to prevent such actions.

5. Anticipated Cost for Implementation

- Anticipate no impact on indirect or direct project cost.

6. Examples

- Tickets need to be collected from truck deliveries including:
  - HMA
  - Lime and Cement Treated Bases
  - Flexible Base

7. References

- Iowa Department of Transportation (Iowa DOT). (April 2008). *Iowa DOT Construction Manual*. Available at http://www.erl.dot.state.ia.us/APR_2008/CM/frames.htm.

Implementation Guide for Recommended Workload Reduction Strategy 4

Recommended Strategy	WLRS Implementation Strategy
4	**Reduce the number of specification items and combine items and quantities for payment.**

1. Description

- Several TxDOT officials highlighted the problem that many pay items have numerous sub-items that create confusion and make inspection, testing, and measurement very difficult and time consuming. One example is striping, which anecdotally is reported as having "hundreds" of separate but similar bid items. The overwhelming feeling is that similar bid items should be combined into a single item.
- This workload reduction strategy is closely related to strategy 2, "Use Lump Sum or Plans Quantity Approach to Payment." Specification items should be reviewed to determine which items could be combined into a single lump sum bid/pay item that will reduce the amount of measuring and tracking required.

2. Potential Benefits or Intent

- Reducing the number of bid items will decrease complexity and confusion.
- In addition, reducing the number of bid items will simplify the testing, measurement, and payment process.
- Because of the extensive number of bid items (i.e., 20,000+ according to TxDOT officials), this workload reduction strategy, along with strategy 2, has the potential to *significantly* reduce the amount of time spent on measuring and tracking pay items for payment. The PMC felt this strategy should be initiated immediately since it will likely take time to implement but the results would be tremendously beneficial and long-lasting.

3. Implementation Strategy

3.1. Work with the Construction Division and TxDOT Specification Committee to form a sub-committee to oversee the consolidation of the current specification items.
3.2. Identify time-consuming bid items that need to be reduced and can provide for the most time savings.
3.3. TxDOT's bid item structure needs to be modified and revised. Most other states have significantly fewer bid items than TxDOT.
3.4. Assign responsibility to experts to modify the current specifications by combining as many items as possible.
3.5. It is recommended that this strategy be implemented with enough time to have the modifications incorporated into the next specification revision in 2014.
3.6. NOTE: As an alternative, this workload reduction strategy could be the subject of a future research project that would analyze the current specifications and identify specific pay items that show the greatest potential for reducing time spent measuring. The research would include incorporating a framework for implementing a TxDOT Lump

Sum bidding, payment, and measurement process the combines numerous pay items into one lump sum item.

4. Conditions for Successful Implementation and Cautions

- Reduce the number of pay items and sub-items in order to reduce confusion and inefficiency.
- Combine and reduce pay items in so far as it does not compromise quality.
- During the interviews with TxDOT employees, it was brought up that the time spent measuring these multiple bid items was usually disproportional to the cost of the items. It is recommended that items with multiple bid items that are low risk and low cost items be combined.

5. Anticipated Cost for Implementation

- Implementation will require a significant amount of time and money to go through and reduce the current specification items. However, this upfront cost will be offset by the future savings for measurement and inspection.

6. Examples

- Pay items that are strong candidates for consolidation include: Landscaping, Signals, Traffic Stripes and Markers
  - It was recommended in our interviews with TxDOT experts that traffic striping has hundreds of similar items that could be reduced down to prevent confusion.
- Currently TxDOT has approximately 21,000 pay items. The following state DOTs and the number of total bid items they have are significantly less than TxDOT.
  - Washington DOT approximately has 1,600 bid items in total
  - California DOT approximately has 4,600 bid items in total
  - Kansas DOT approximately has 3,400 bid items in total
- TxDOT has approximately 700 traffic stripes and marking pay items. Other states comparatively have significantly fewer bid items associated with traffic stripes and markings.
  - Washington DOT has approximately 57 traffic stripes and markings bid items
  - California DOT has approximately 71 traffic stripes and markings bid items
  - South Carolina DOT has approximately 116 traffic stripes and markings bid items
  - Kansas DOT has approximately 159 traffic stripes and markings bid items
- California is currently in the process of streamlining their specifications in order to make it easier for bookkeeping and to reduce complexity.

7. References

- Suszko, Chuck. Chief of the Office of Construction Engineering, California Department of Transportation. Telephone 916-227-7314. Email Chuck.Suszko@dot.ca.gov. Telephone conversation on March 5, 2008.

8. Attachments for Recommended WLRS 1

- Attachment 1: List of Washington DOT's traffic stripes and markings bid items

Washington DOT Traffic Stripes and Markings Standard Items (Quantity 57)

Standard Item Number	Unit of Measure	Includes Obsolete (no longer used) Ibid Items Standard Item description	Section
6806	L.F.	PAINT LINE	TRAFFIC
6807	L.F.	PLASTIC LINE	TRAFFIC
6808	L.F.	EMBOSSED PLASTIC LINE	TRAFFIC
6809	L.F.	PROFILED PLASTIC LINE	TRAFFIC
6810	L.F.	PROFILED EMBOSSED PLASTIC LINE	TRAFFIC
6813	L.F.	GROOVED PLASTIC LINE	TRAFFIC
6817	L.F.	PAINTED WIDE LINE	TRAFFIC
6818	L.F.	PLASTIC WIDE LINE	TRAFFIC
6827	L.F.	PAINTED WIDE LANE LINE	TRAFFIC
6828	L.F.	PLASTIC WIDE LANE LINE	TRAFFIC
6833	EACH	PLASTIC TRAFFIC ARROW	TRAFFIC
6845	L.F.	PROFILED PLASTIC WIDE LANE LINE	TRAFFIC
6854	L.F.	PAINTED BARRIER CENTER LINE	TRAFFIC
6855	L.F.	PLASTIC BARRIER CENTER LINE	TRAFFIC
6856	S.F.	PAINTED CROSSWALK LINE	TRAFFIC
6857	S.F.	PLASTIC CROSSWALK LINE	TRAFFIC
6858	L.F.	PAINTED STOP LINE	TRAFFIC
6859	L.F.	PLASTIC STOP LINE	TRAFFIC
6860	EACH	PAINTED TRAFFIC ARROW	TRAFFIC
6862	EACH	PAINTED ACCESS PARKING SPACE SYMBOL	TRAFFIC
6863	EACH	PLASTIC ACCESS PARKING SPACE SYMBOL	TRAFFIC
6864	EACH	PAINTED HOV LANE SYMBOL	TRAFFIC
6865	EACH	PLASTIC HOV LANE SYMBOL	TRAFFIC
6866	EACH	PAINTED BICYCLE LANE SYMBOL	TRAFFIC
6867	EACH	PLASTIC BICYCLE LANE SYMBOL	TRAFFIC
6870	EACH	PAINTED TRAFFIC LETTER	TRAFFIC
6871	EACH	PLASTIC TRAFFIC LETTER	TRAFFIC
6878	EACH	PAINTED RAILROAD CROSSING SYMBOL	TRAFFIC
6879	EACH	PLASTIC RAILROAD CROSSING SYMBOL	TRAFFIC
6880	EACH	PAINTED DRAINAGE MARKING	TRAFFIC
6881	EACH	PLASTIC DRAINAGE MARKING	TRAFFIC
6882	HUND	RAISED PAVEMENT MARKER TYPE 1	TRAFFIC
6884	HUND	RAISED PAVEMENT MARKER TYPE 2	TRAFFIC
6886	HUND	RAISED PAVEMENT MARKER TYPE 3	TRAFFIC
6887	EACH	WHITE PLASTIC RUMBLE BAR	TRAFFIC
6888	L.F.	TEMPORARY PAVEMENT MARKING	TRAFFIC
6889	HUND	RECESSED PAVEMENT MARKER	TRAFFIC
6892	MI.	SHOULDER RUMBLE STRIP TYPE	TRAFFIC
6893	MI.	CENTERLINE RUMBLE STRIP	TRAFFIC
9237	EACH	PAINTED YIELD LINE SYMBOL	TRAFFIC
9238	EACH	PLASTIC YIELD LINE SYMBOL	TRAFFIC
9239	EACH	PAINTED YIELD AHEAD SYMBOL	TRAFFIC
9240	EACH	PLASTIC YIELD AHEAD SYMBOL	TRAFFIC

Standard Item Number	Unit of Measure	Includes Obsolete (no longer used) Ibid Items Standard Item description	Section
9241	EACH	PAINTED SPEED BUMP SYMBOL	TRAFFIC
9242	EACH	PLASTIC SPEED BUMP SYMBOL	TRAFFIC
9243	EACH	PAINTED AERIAL SURVEILLANCE FULL MARKER	TRAFFIC
9244	EACH	PLASTIC AERIAL SURVEILLANCE FULL MARKER	TRAFFIC
9245	EACH	PAINTED AERIAL SURVEILLANCE 1/2 MARKER	TRAFFIC
9246	EACH	PLASTIC AERIAL SURVEILLANCE 1/2 MARKER	TRAFFIC
9247	EACH	PAINTED ACCESS PARKING SPACE SYMBOL WITH BACKGROUND	TRAFFIC
9248	EACH	PLASTIC ACCESS PARKING SPACE SYMBOL WITH BACKGROUND	TRAFFIC
9362	EACH	PAINTED ACCESS PARKING SPACE SYMBOL	TRAFFIC
9363	EACH	PLASTIC ACCESS PARKING SPACE SYMBOL	TRAFFIC
9364	EACH	PAINTED HOV LANE SYMBOL	TRAFFIC
9365	EACH	PLASTIC HOV LANE SYMBOL	TRAFFIC
9370	EACH	PAINTED DRAINAGE MARKING	TRAFFIC
9371	EACH	PLASTIC DRAINAGE MARKING	TRAFFIC

http://www.wsdot.wa.gov/Design/ProjectDev/EngineeringApplications/StandardItems.htm

Implementation Guide for Recommended Workload Reduction Strategy 5

Recommended Strategy	WLRS Implementation Strategy
5	**Use equipment technology for the measurement of temperature and segregation in HMA.**

1. **Description**

- Advances in technology have proven to increase productivity and efficiency among workers in all industries. Within DOTs around the country, machines such as Intelligent Compactors and pavers with thermal imaging bars are performing tasks that inspectors used to perform manually. This use of equipment technology can be very time-efficient and can provide computer printouts of stiffness, temperature, etc., that are recorded automatically rather than taken manually. Hence, there are a few technologies that are currently available (or will be soon) that can be used to reduce the inspection workload and increase inspection efficiency.
- TxDOT is currently using a system called Pave-IR, which uses thermal imaging to provide real-time measurements of material surface temperature. The Pave-IR test system continuously performs these profiles, providing more coverage and better documentation of thermal uniformity as compared to the existing test method (Sebesta 2007).

2. **Potential Benefits or Intent**

- By incorporating technology into projects, inspectors could spend time on other activities while the machines could be used to augment the inspector's activities. As new technologies become available, TxDOT should endeavor to be on the cutting edge – their road network is large, and consequently, the time-savings might be substantial.
- The thermal imaging system allows for the sample of all the material as it is being laid down, not just a random sample as in current practice. This helps both TxDOT and contractors ensure a good quality pavement (Sebesta 2007).

3. **Implementation Strategy**

3.1. Continue evaluation projects with TTI and contractors to encourage the use of thermal imaging technology.
3.2. Modify the specification to allow for the acceptance of thermal imaging data reports.
3.3. Provide an incentive structure for contractors who implement this new technology. For example, encourage bidders to submit two bids: one with and one without the use of thermal imaging.
3.4. In the future, it would be beneficial for TxDOT to work with contractors and paver manufacturers to make the thermal imaging technology part of their paver or as an option to retrofit existing equipment.

4. Conditions for Successful Implementation and Cautions

- The thermal imaging technology is not readily available yet for commercial use. However, TxDOT can work to expand the availability of Pave-IR to contractors on their projects.
- In addition, TxDOT can work with contractors and paver manufacturers to integrate the thermal imaging technology to make the technology readily available.

5. Anticipated Cost for Implementation

- There is the initial cost for contractors to upgrade their paving equipment and this cost will likely get passed along to TxDOT in their project cost. However, the slight increase in cost will be offset with the greater control over pavement quality.
- With the real time data that is produced, contractors can detect any problems in the pavement quickly. There is a significant cost savings here because it can prevent having to replace an entire Section of pavement.

6. Examples

- Currently, TxDOT has partnered with Texas Transportation Institute and several paving contractors around the state to field test the Pave-IR system. TTI has used the new system on about 15 construction projects throughout its development and implementation. Currently, TTI is assisting with two TxDOT projects in the Odessa District and one in the Houston District. Currently, the Pave-IR system has to be attached to the back of the paver (Sebesta 2007).

7. References

- Sebesta, Stephen. (2007). "Partnership Tests Quality-Control Device for Asphalt Pavement". Texas Transportation Researcher, Volume 43, Number 2. Available at http://tti.tamu.edu/publications/researcher/newsletter.htm?vol=43&issue=2&article=10&year=2007.

Implementation Guide for Recommended Workload Reduction Strategy 6

Recommended Strategy	WLRS Implementation Strategy
6	**Increase or improve *SiteManager* system training to reduce double data entry and reduce time spent on paperwork.**

1. **Description**
   TxDOT inspectors need more training to efficiently navigate through *SiteManager,* especially the seasoned inspectors who are accustomed to standard paper documentation followed by data entry. Providing inspectors training on *SiteManager* to improve their skills will save time by reducing double-entry and the amount of paperwork.

2. **Potential Benefits or Intent**

   - Training for *SiteManager* has the potential to improve the navigation skills of inspectors and save time by reducing double-entry and paperwork. The inspectors may utilize this time for other inspection duties.

3. **Implementation Strategy**
   3.1 Identify specific training modules that need to be developed. It is recommended to interview inspectors to recognize areas that need the most improvement.
   3.2 Develop an in-house training program to help inspectors keep up with the most recent changes in the *SiteManager* software
   3.3 Develop a certification process for *SiteManager* that has multiple proficiency levels

4. **Conditions for Successful Implementation and Cautions**

   - It is recommended that the training come from within TxDOT because *SiteManager* has been customized to meet TxDOT's needs.
   - This *SiteManager* training should complement not duplicate training already provided through the Inspector Development Program (IDP).

5. **Anticipated Cost for Implementation**

   - By improving TxDOT employee training on *SiteManager*, inspectors will spend less time on paperwork and data entry. As a result, this will lower costs.

6. **Examples**

   - During the course of the TxDOT interviews, it was brought up that there were several inefficiencies with the use of *SiteManager*. It was recommended that inspector training be developed to help inspectors use *SiteManager* more efficiently. This would include a basic training for inspectors who needed it, as well as training for inspectors on the recent changes and updates to the program.

- In addition, it was recommended during our interviews that laptops are made available to the inspectors so that they are able to enter data into *SiteManager* while working in the field. During our interviews with other DOTs, laptops were being provided to their inspectors in the field in order to increase the efficiency of data entry, including South Carolina, Virginia and Arizona.

Implementation Guide for Recommended Workload Reduction Strategy 7

Recommended Strategy	WLRS Implementation Strategy
7	**Convert inspector training courses to Computer-Based Training Courses as much as possible to make training easier to obtain.**

1. **Description**
The Florida Department of Transportation (FDOT) is currently converting their inspector training courses to Computer Based Training (CBT) as much as possible. This allows Florida to train inspectors virtually anywhere at any time. Florida has experienced a significant increase in their ability to train large numbers of inspectors. This has resulted in Florida increasing the skills of their new inspectors more rapidly while decreasing the overall cost of training.

2. **Potential Benefits or Intent**

- By converting training to CBT, it will increase the accessibility of the training to inspectors. Typically inspectors would have to wait for training until the course was being offered at a location and date they were available to attend. CBT makes training more readily available because inspectors can complete the training at their own convenience.
- TxDOT will be able to train inspectors from their personal computers instead of having to pay to send inspectors to in-class training sessions. This will reduce the distance and costs associated with traveling to training courses.

3. **Implementation Strategy**
3.1 A large effort will be necessary to coordinate the conversion of training courses to computer-based training courses. The researchers strongly recommended this workload reduction strategy be outsourced to a third-party that would develop the computer-based training courses.
3.2 Form a committee to assist an independent third-party with the identification of training courses that should be converted to CBT.
3.3 The third-party will need to establish a common format for the training modules including tutorials, animation and quiz questions.
3.4 The third-party will need to create CBT modules and make them available to TxDOT inspectors
3.5 Monitor the effectiveness of the CBT and modify as necessary
3.6 Keep the CBT modules updated when processes and specifications are modified

4. **Conditions for Successful Implementation and Cautions**

- The CBT should be provided in a format that is easy to navigate for the user. Additionally, it would be useful to incorporate a feature to let the inspector resume training at a location in the module in case the user needs to pause the training or would like to complete the training at a different time.

- It is recommended to include pictures, video demonstrations, figures and specification references in order to provide the inspector comprehensive training materials.

5. Anticipated Cost for Implementation

- There will be an initial cost for TxDOT to develop the computer based training modules. However, it is anticipated that this initial cost will be offset with the savings based on the convenience the CBT will offer. Potential savings include travel, lodging, facility and instructor costs associated with in-person training sessions.
- There will also be a time-savings to inspectors. Inspectors will not have to take time away from projects to travel for training. Instead, training can be completed at the inspector's convenience from their personal computer.

6. Examples

- The Florida DOT established their training program in order to train their employees and contractors to meet their required certifications. Florida has converted some of their study guides into Computer Based training that uses Flash-based animation and a variety of quiz methods to provide training at the user's convenience. Written exams are administered in-person currently in order to obtain certification (CTT 2008).
- The types of interactive CBT inspector training courses that FDOT's Center for Transportation Training program is offering currently include (CTT 2008):
    - Asphalt Paving Level 1
    - Drilled Shaft Tutorial
    - Earthwork Inspection
    - FDOT Concrete Field Inspector Course
    - FDOT Concrete Laboratory Inspector Course
    - Final Estimates Level 1
    - Hot Mix Asphalt Plant Inspection
    - Hot Mix Asphalt Testing
    - Pile Driving Inspector's Tutorial

7. References

- Center for Transportation Training (CTT). (2008). "Computer Based Training". Available at http://ctt.ce.ufl.edu/courseMaterials.aspx.

Implementation Guide for Recommended Workload Reduction Strategy 8

Recommended Strategy	WLRS Implementation Strategy
8	**Standardize information provided to contractors for input into GPS controlled construction machinery.**

1. **Description**
   GPS controlled construction machinery combines design software with construction equipment to guide the operation of the machinery with a high level of accuracy. Currently GPS controlled construction machinery is being used by many construction companies across the country. TxDOT needs to standardize information provided to contractors so that this technology can be implemented on TxDOT projects.

2. **Potential Benefits or Intent**

   - Using GPS controlled construction machinery has the potential to save time and money on TxDOT projects. This will significantly reduce the time inspectors spend verifying survey and could increase quality on projects because of the accuracy the technology provides.
   - In-house inspectors will not have to spend time verifying survey and instead can check that the GPS units are calibrated properly. This will reduce inspection time as a result.
   - The GPS controlled construction machinery provides consistency and quality on the project with the use of automated construction.
   - The Contractor will be able to return paper and electronic "as-built" files when projects are completed.

3. **Implementation Strategy**
   3.1 Revise TxDOT Specifications to allow for GPS controlled construction machinery
   3.2 Create and implement quality control guidelines for GPS controlled construction machinery
   3.3 Establish a standard format to provide the contractor with 3-D electronic data and 2-D plans during the bid process and at contract award

4. **Conditions for Successful Implementation and Cautions**

   - It is imperative that the Contractors be provided the electronic files of the 3-D design along with 2-D plans from the DOT necessary for input into the GPS controlled machinery.
   - Provide proper training for DOT staff regarding the use of GPS technology.
   - Establish guidelines for monitoring contractor use of 3-D files.

5. **Anticipated Cost for Implementation**

   - Reduces TxDOT inspection costs because inspection can be simplified and reduced.

- There will be comparable costs associated with training TxDOT staff to learn how to inspect projects that use machine controlled construction versus traditional methods.
- Contractors will be required to purchase GPS controlled machinery. However, investment costs are offset with increased production, reduced labor costs, and increased accuracy.

6. Examples

- The following is a list of automated excavation and earthmoving technologies currently available for use (Purdue 2008):
    - Automated Dump Trucks
    - Earthmoving Guidance System
    - Pile Positioning and Recording System
    - Blade Pro Grading System
    - Computerized Intelligent Excavator
    - Roboback Demolition Machines
    - Robotic Drilling and Cutting System
    - Soil Compaction
    - Startrak-Excavator
    - Unmanned Deep Shaft Construction System
    - Unmanned Earthmoving and Materials Handling
    - Unmanned Ground Vehicles
    - Virtual Reality Excavator, Tower Crane, and Truck

7. References

- Townes, Douglas. (2008). "GPS in Construction". AASHTO Subcommittee on Construction 2008 Annual Meeting, August 3-7, 2008. Available at http://www.transportation.org/sites/construction/docs/Townes%20-%20GPS%20in%20Construction.pdf.
- Townes, Douglas. (2008). "GPS in Construction 2008". EPA Region 4 Environmental Workshop, June 30-July 2, 2008. Available at http://region4dod.com/proceedings/0%20_GPS%20In%20Construction2008_Townes.pdf.
- Purdue University. (2008). "Design Practices to Facilitate Construction Automation: Excavating and Earthmoving". Available at http://rebar.ecn.purdue.edu/ECT/PT183/excavation.aspx.

8. Attachments for Recommended WLRS 8

- Attachment 1: "Design Practices to Facilitate Construction Automation: Excavating and Earthmoving" from Purdue University.
- Attachment 2: Douglas Townes from FHWA "GPS in Construction" at the Subcommittee on Construction Annual Meeting Aug 3-7, 2008.
- Attachment 3: Douglas Townes from FHWA "GPS in Construction 2008" at the EPA Region 4 Environmental Workshop June 30-July 2, 2008.

Design Practices
to Facilitate Construction Automation

Project Features

- Excavating and Earthmoving
- Concrete and Masonry
- Structural Steel
- Piping
- Painting and Coating
- Finishes
- Site Inspection and Surveying
- Material and Asset Management

Project Development Process

- Project Level Practices
- Industry-wide Practices

Related Links

- Design Practices Mainpage
  - Research Study
  - Lessons from Other Industries
  - Related Research & Other Resources
- CII Homepage
- ECT Homepage

Excavating and Earthmoving

Excavation and earthmoving operations provide many opportunities for automation. The work area is often exposed and spread out, and the nature of the work is such that it can be readily undertaken by remotely operated, mechanical means. Automation is especially effective in the excavation and compaction of soils. Moving materials over a project site can be conducted with the implementation of on-board computer technologies that free the operator from many tasks. Much of the automated construction equipment available makes use of GPS technologies.

Example Automated Technologies:

The following are examples of automated excavation and earthmoving technologies that are currently available for use:

Technology	Description
Automated Dump Trucks	Truck operation controlled offsite via computers or joystick
Earthmoving Guidance System	Vehicles guided by GPS sensors
Pile Positioning and Recording System	Automated pile placement using programmed coordinates
Blade Pro Grading System	Grade performed by GPS-guided blade
Computerized Intelligent Excavator	Excavator outfitted with automated controls
Roboback Construction System	Miniaturized backhoes for digging
Robotic Demolition Machines	Remotely controlled demolition machine
Robotic Drilling and Cutting System	Control-guided drilling and cutting system
Soil Compaction	Remote controlled compacting of soil
Startrak-Excavator	Excavator equipped with GPS controls
Unmanned Deep Shaft Construction System	Remote guided deep shaft construction
Unmanned Earthmoving and Materials Handling	Remote controlled dump trucks and other equipment
Unmanned Ground Vehicles	Remote controlled vehicles
Virtual Reality Excavator, Tower Crane, and Truck	Set site in virtual reality prior to commencement of work

Common Limiting Design Features

The following are examples of design features that often limit the use of automated excavation and earthmoving technologies during construction:

- Inadequate clearance for access and operation of the equipment, especially when working in trenches and other confined excavations.
- The presence of obstructions, such as underground and aboveground utilities.
- Irregularly sloped sites and steep grades.
- Excavations with benches or other abrupt features.
- A lack of electronically available site data.
- Incompatibility of electronic site data provided with that required of automated technologies.

Recommended Design Practices

The following are examples of suggested design practices that facilitate the use of automated excavation and earthmoving technologies during construction:

Excavation/Earthmoving:

- Provide a digital copy of existing surface profiles with the construction documents.
- Locate stations within laser range for grading areas.
- Design uniformly sloped grading plans with well-defined break lines.
- Eliminate diagonal grade breaks and warped crown within five feet of the edge of the roadway.
- Minimize obstacles in the pathway of the receiver and transmitter; maintain an open grading area.
- Specify more precise standards for installing underground utilities effectively. This is more so important with automated technologies because the operator does not get to see as much of the excavation.
- Design excavation depths to be conducive to the use of automated equipment. Stronger pipe does not need to be buried as deep, so automation implementation may balance or lower costs through increased productivity.
- Maximize visibility between the operator and the equipment for remote-controlled equipment.

Soil Compaction:

- Allow for adequate space for the size of the equipment.
- Specify backfill material conducive to the use of automated equipment.
- Adjust trench slopes to slope within the range of the equipment.
- Adjust lift specifications to allow clearance for perpendicular objects (pipes, shoring supports, etc.).
- Use slopes in place of vertical inclines.
- Design placement and extraction points for the equipment.
- Maximize visibility between the operator and the equipment for remote-controlled equipment.
- Eliminate obstructions. If obstructions cannot be eliminated, locate the obstructions away from compacted areas, and vice versa.

Expected Benefits

The following are examples of benefits that have been realized from the use of automated excavation and earthmoving technologies during construction:

- Increased production for excavating and moving soil.
- Reduced labor force associated with centrally-controlled, driverless haul trucks and other heavy equipment.
- Improved ability to meet grade specifications.
- Shorter time required to compact soil and greater consistency in compacted soil properties.
- Decreased worker exposure to safety and health hazards such as cave-ins and struck by heavy equipment.

Example productivity improvements that have been realized:

Automated Technology	When automated technology is used		Productivity when technology not used
	Set-up and breakdown	Productivity	
Agtek Graphic Grade 3D	1.5 hrs.	300 cy/hr	200 cy/hr
	25 min.	80 tons/hr	60 tons/hr
Topcon Depth Master	1.5 hrs.	300 cy/hr	200 cy/hr
Laser Grade (EDM)	--	1 man less	1 man more
Blade Pro Grading System	1 day	3/4 mile x 60 ft.	1/2 mile x 60 ft.

Division of Construction Engineering and Management
550 Stadium Mall Drive, Purdue University
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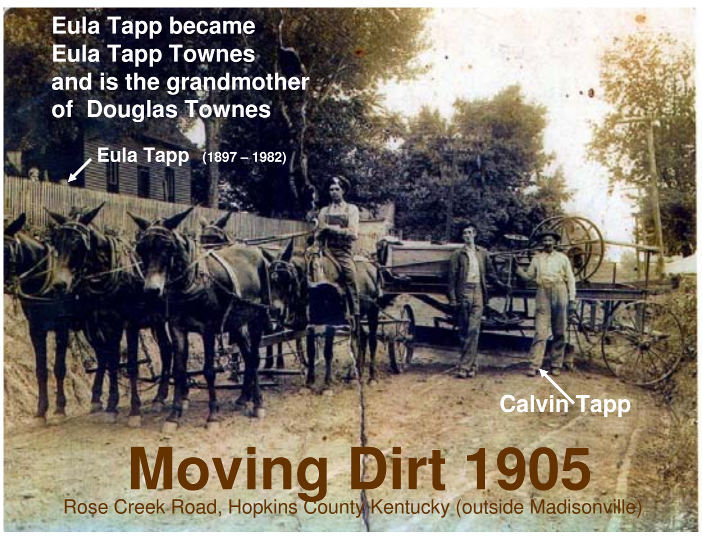
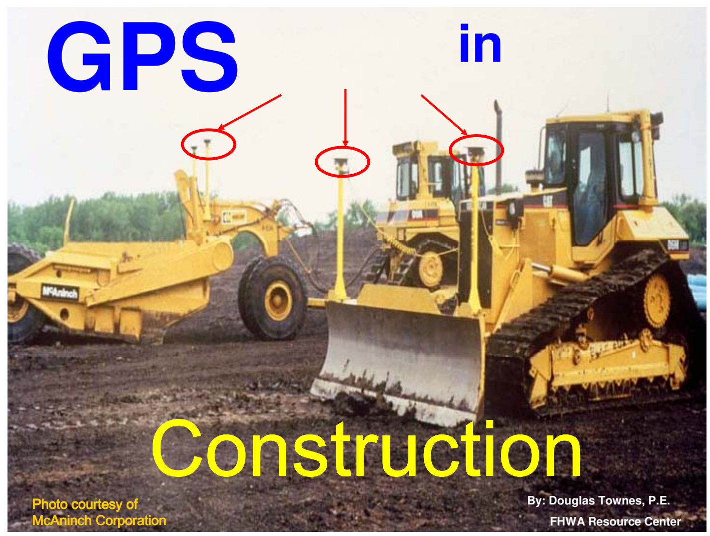




During this session

- You will:
  - Hear about the history of GPS in Construction
  - Hear from the Construction Industry about the advantages of GPS
  - Hear about the impediments that block implementation of GPS technology
  - Here how members of AASHTO SOC can become a part of the solution

History of GPS in Construction

- 1982 Trimble bought technology and began incorporating into surveying instruments
- 1988 first GPS survey instruments sold
- 1993 first strip mining machines began using GPS for "location"
- 1998 first product to have GPS and cellular on a single board for fleet management

History of GPS in Construction
(Continued)

- 1999 first GPS grade control system for the construction market
- 2000 Contractors begin using "Stakeless" grading
- 2002 GPS machine controls are installed on Caterpillar excavators and motor graders

Show Caterpillar Video
(1 minutes, 30 seconds)

Introduction of 3D Technology & Machine Control Systems

JONES BROS INC.

Bret Alsobrooks

Jones Bros., Inc. GPS Project List

PROJECT	D.O.T.	COUNTY	CITY
INTERSTATE 840 7 miles 4-lane rock subgrade / I-65 Interchange	Tennessee	Williamson	Franklin
I-4 MEMORIAL BLVD. 6 miles new construction (6 lane)	Florida	Polk	Lakeland
HIGHWAY 153 A. 4-Lane, 5 miles 1. Lack of radio signal 2. Poor plans elevation 3. Poor JBI training	Tennessee	Hamilton	Chattanooga
JOE B. JACKSON PARKWAY 4 mile subgrade / I-24 Interchange	Tennessee	Rutherford	Murfreesboro
US HWY 79 3.5 mile new construction (4 lane)	Tennessee	Stewart	Dover
PRIMARY 29 A. 14 miles 1. Soil cement subgrade 2. Base cement in rock cuts	Virginia	Amherst	Amherst
FM 1187 4-lane, 7 miles subgrade; lime treated subgrade	Texas		Fort Worth
US 71 / 59 INTERCHANGE 6 miles subgrade, select fills	Texas		Texarkana
INTERSTATE 4 / MEMORIAL BLVD.	Florida		Lakeland
CORRIDOR H (Two Projects) 10 miles; 200 ft cuts and fills; boxed cuts; select fills	West Virginia	Hardy	

Introduction

- Good Practice Survey
- De-mystify 3D Machine Control
- How to analyze which tool will help you meet or exceed project specifications
- A look at some new, high tech grade control tools that are changing the way grading is being done.

Introduction

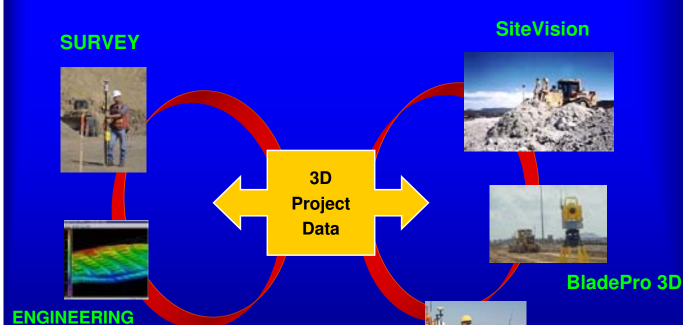
- 3D Systems require a set "Process" to be followed
- 3D Machine Control Systems are not "Plug and Play" products

"Stakeless" Grade Control

BladePro 3D-ATS

What is "Stakeless" Grade Control ? How does the 'process' work?

TOTAL SOLUTION



Projects are being surveyed and designed in 3-D for the DOT's but the Contractors are not allowed to get a copy of those same electronic files when the project is awarded.

Quality Control

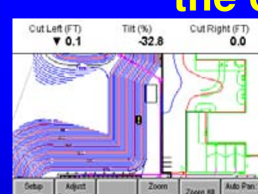
Applications of 3D Machine Control and GPS Survey Systems

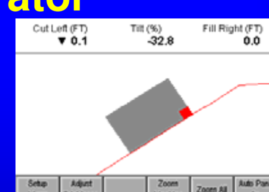
- BladePro 3D (BP3D)- Total Station Based
  - Finishing Subgrade
  - Knockdown and placing of materials in various zones
  - Finish Grading
  - Phased Construction
  - Erosion Control
  - Bridge Structures
  - Drainage
  - Signs, Guardrail
  - Location of test results

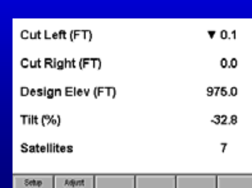
The Global Positioning System (GPS) is used to...

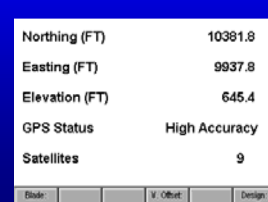
- Accurately position the grading machine BLADE , on the 3D digital model of the project
  - Within 1cm in X and Y
  - Within 1-3 cm in Z = 1.18 of an inch
  - Old school one tenth = 1.2 of an inch
- This puts the blade on the design, precisely located in 3D

Four screens available to the operator









Dozers D3-D11 manual and automatic

Two Antennas

Gives You:

TWO ANTENNA'S

- Most Accurate Solution!
- Cuts/Fills calculated along the entire blade cutting edge, from the right tip all the way to the left tip (no matter how the blade is tilted or rotated)
- Always know which way the machine is facing and moving. (operator must tell the system which direction with single antenna)
- No need for rotation or tilt sensors that are affected by vibration (especially on dozers)
- No daily/weekly/monthly calibration of sensors

Scaleable Lightbars

Blades-manual and automatic

Considerations when using GPS Technology

Advantages

- Places the design in front of the operator.
- Unlimited machines possible on one base
- Line of sight not required
- Dramatically increases production
- Dramatically reduces labor costs-layout,stakes
- Not effected by fog, dust etc.
- Operators love to use it!

Disadvantages

- **You need a clear view of the sky**
  - Tree canopy
  - Tall buildings
  - Blocking terrain
- **Requires a local "champion" to manage-**
  - Data and site Cal
  - Radio coverage
  - Proper application requiring attention
  - PDOP issues

I-4 Lakeland Florida

SiteVision GPS

GPS Technology

GPS technology	Compared with	Estimated savings
Grade Checking	Manual method	Up to 66%
Reduction or Elimination of Stakes	Using stakes	Up to 85%
Improved material yields/select fills/undercutting	Overruns using manual methods	3% to 6% in volume
Un-interrupted earth moving production under any weather conditions (24/7)	Daytime / fine weather operation only/night work	30% to 50%
RTK, robotics stakeout	Traditional survey stakeout	More than 100% in speed and 66% in staffing

- **Other savings from:**
  - **Improved utilization of equipment/30%**
  - **Lower skill level required realize over 100%**
  - **Erosion control as you go**
  - **Accurate location of testing for QAQC**

How to get up and running faster

- **Fully committed to the process**
- **Draw upon experienced resources**
- **Stay the course and be willing to follow through the learning curve**
- **Job planning**
- **Do not panic!**

Help Needed With GPS Machine Control

- Provide 3-D electronic data along with 2-D paper plans during bid process and at contract award
- Revise standard specifications tolerances to allow stakeless machine grading
- Quality control guidelines for stakeless construction need to be implemented by DOT's
- DOT's need to add Machine control as an option in their Bid packages
- Provide training of the entire Team involved with the project (certification by Level of Training)
- Have Contractor return paper and electronic "asbuilt" files when Project is complete

JONES BROS QUESTIONS ?

Email: bret@jonesbrosinc.com

The use of GPS Technology in Construction provides:

- **More accuracy in setting grades and control points**
- **Reduces construction time for the Contractor**
- **Provides higher quality grading with GPS controlled machinery**

What is happening in DOT Construction Today?

- According to this subcommittee's Technology Implementation Group's (TIG) 2002 survey:
  - Only 9 of 36 States reported contractors were using GPS controlled machinery
- 6 of 17 reported GPS use in Construction in the SOC "Technologies Used in Construction" 2004 survey

So why isn't GPS Technology being used in more State transportation construction projects?

- State DOTs are reluctant to give electronic survey data with contract documents
  - Fear of misuse or misapplication
  - Procedure for QC does not exist for stakeless grading
  - Current plans are 2 dimensional and leave a paper trail
  - Due to the initial high cost of the equipment, smaller contractors will be at a disadvantage

We are surveying a DOT project in 3 dimensions and Contractors are building projects in 3 dimensions. Designers produce plans for construction in 2 dimensions (on paper) because this has been the standard since roads were first designed.

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We need to find a way to embrace latest technology and begin producing 3-D electronic plans along with paper plans that facilitate the production of transportation construction projects of highest quality by the most economical means.

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We need to find a way to embrace latest technology and begin producing 3-D electronic plans along with paper plans that facilitate the production of transportation construction projects of highest quality by the most economical means.

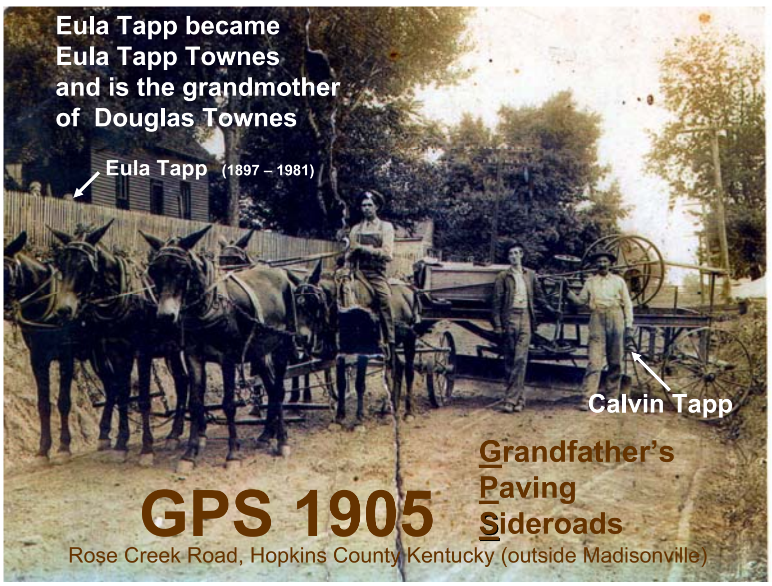
Where do we go from here?

- Appoint a joint committee to come up with a standard format to give electronic plans to a contractor
  - This committee should be multidisciplinary with representation from Survey, Design, CAD and Construction

Many thanks go to the following:

- Bret Alsobrooks for traveling and making his presentation to the group
- McAninch Corporation for preparing the white paper for distribution
- Caterpillar for providing the video and the brochures in the back of the room

Questions?



Users of GPS technology need different accuracies

- Recreational (10 – 30 meters)
- Mapping (1 – 3 meters)
- Surveying (± 0.2 centimeters)

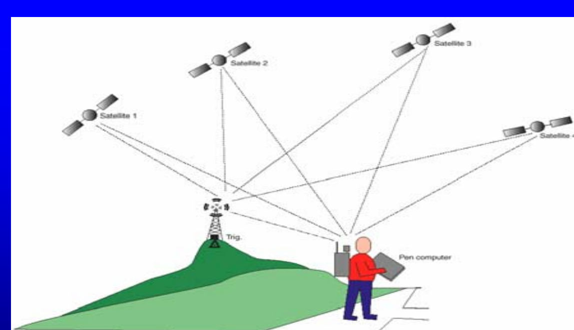
In the Transportation Construction Industry, we need "survey" level accuracy

Lets focus on

Survey GPS

- How does it work?
- How is it used in the Transportation Construction Industry?
- What are the benefits?
- How much does it cost?
- How much training is involved?

How Survey GPS Works



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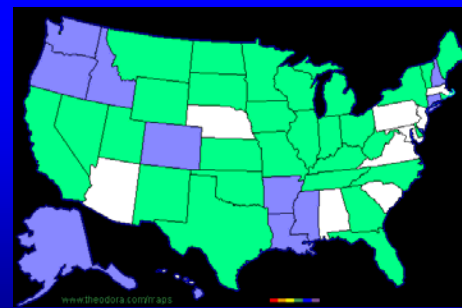
2006 States use of GPS Technology in Construction



Using GPS in Construction | Not using GPS in Construction | No Response

Revised November, 2006

Contractor's are using GPS

- Many contractors are using GPS data for placing survey stakes (unless a State DOT specification prevents this).
- Many contractors are using GPS data to guide their grading machines

WHY ?

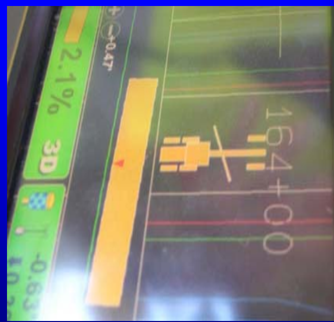
Advantages to the Contractor

- Places the design in front of the operator.
- Unlimited machines possible on one base
- Line of sight not required
- Dramatically increases production
- Dramatically reduces labor costs- layout,stakes
- Not effected by fog, dust etc.
- Operators love to use it!

"Stakeless" Grade Control on TN DOT Project

GPS controlled finish grader on a Georgia DOT project

What the operator is seeing in the cab



How much does equipment cost?

- **Contractor:** To equip one grader, one total station relay and one portable relay ($ 100,000 - $160,000)
- **State:** DOT can choose to purchase one "rover" (to be used with total station) approximately $25,000

Equipment should be reusable for at least 3 years (depending on technology advances and use)

What are training costs?

- Contractor states an operator can be trained in less that ½ day
- If Construction chooses to purchase survey equipment, training time would be the same as any State survey course

(State could elect to hire survey work)

Contractor file conversion

- Contractor receives 2 dimensional plans from DOT
- Contractor converts 2-D, DOT paper plans into electronic files that his equipment can process

GPS Technology

GPS technology	Compared with	Estimated savings
Grade Checking	Manual method	Up to 66%
Reduction or Elimination of Stakes	Using stakes	Up to 85%
Improved material yields/select fills/undercutting	Overruns using manual methods	3% to 6% in volume
Un-interrupted earth moving production under any weather conditions (24/7)	Daytime / fine weather operation only/night work	30% to 50%
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- Other savings from:
  - Improved utilization of equipment/30%
  - Lower skill level required realize over 100%
  - Erosion control as you go
  - Accurate location of testing for QAQC

How Project Costs are saved

- Greater accuracy (less rework)
- Contractor can eliminate (at least minimize) survey stakes
- State Inspection can be simplified and reduced
- Finish grading can be done with a production grader instead of a trimmer

The use of GPS Technology in Construction may also provide:

- **Training challenges for DOT Staff**
- **GPS survey equipment challenges**
  - **STD can choose to purchase one "rover" (to be used with total station) approximately $17,000**
- **Greater coordination between various offices within the STD**

So why isn't GPS Technology being used in more State transportation construction projects?

- **State DOTs are reluctant to give electronic survey data with contract documents**
  - **Fear of misuse or misapplication**
  - **Procedure for QC does not exist for stakeless grading**
  - **Current plans are 2 dimensional and leave a paper trail**

How does FHWA assist?

- **Continues to facilitate all State Transportation Department's (STD)'s use of GPS Technology from initial survey through plans development to construction and back to the STDs**
- **Continues to explore new and innovative uses of this technology that will benefit the transportation construction industry.**

Questions?

Implementation Guide for Recommended Workload Reduction Strategy 9

Recommended Strategy	WLRS Implementation Strategy
9	**Use an off-the-shelf shared-access software system for contractors to submit required inspection data and reports.**

1. **Description**
   Project-specific websites (PSWS) are web-based applications that take advantage of the Internet to provide a collaboration platform to perform typical project-management tasks, such as storing and managing project information. They allow all necessary groups (contractors, engineers, architects, etc.) to have controlled access and automated distribution of information (Cox 2007). Inspectors spend a great deal of time on administrative duties. By using a shared-access software system, such as PSWS, they will be able to better manage and track in-house and contractor inspection data and reports. In addition, there could be additional project documentation that could be controlled by this system.

2. **Potential Benefits or Intent**

   - Provide a convenient way for contractors to upload their QC results. In addition, it will be easier for TxDOT to track these documents.
   - TxDOT inspectors could save a substantial amount of time by improved efficiency of data entry and management. In addition, using a software system like Constructware ® will allow for documents to easily be created, tracked and stored in the system.
   - Benefits listed by Villeneuve and Fayek (2003) of project-specific website applications include:
     - Reduced project costs and time savings by allowing the large volumes of information associated with any project to be instantly accessed by members of the project team
     - Improved productivity and partnerships since all project communications can take place in one location, the project website, without requiring the participants to be present at one place at the same time
     - Immediate and easy access to meeting notes, specifications, shop drawing submittal logs, requests for information (RFIs) and site photos.
     - A forum for real time collaborative work, with participants in remote locations sharing and modifying images and other data.
     - More effective communications and collaborations among team members, who are also better informed.

3. **Implementation Strategy**
   3.1 Establish guidelines and responsibilities for all parties who will use the software system
   3.2 Choose an off-the-shelf software system to use
   3.3 Provide proper training to all parties who will be using the software
   3.4 Include the use of the software in the contract documents and define the legality of the electronic data.

3.5 Implement the software on projects and make adjustments as necessary

4. Conditions for Successful Implementation and Cautions

- A construction project will benefit most from this software if all parties collaborate and share information.
- Incorporate a tool for contractors to upload their QC/QA testing and inspection reports for review by TxDOT.

5. Anticipated Cost for Implementation

- There will be a slight increase in the costs for implementing this software system. The software will have to be purchased and there will be training costs associated with teaching the DOT employees how to use the software.

6. Examples

- Use a web-based fully automated system so that contractors can upload electronic paperwork and efficiently communicate with TxDOT for items such as:
  - RFIs
  - Transmittals
  - Submittals
  - Meeting Minutes
  - Change orders
  - Reports
- Examples of currently available PSWS applications include:
  - Autodesk Constructware®
  - Primavera PrimeContract℠
  - Meridian ProjectTalk®
  - eBuilder™
  - Citadon
- NOTE: We are not endorsing any particular software, but we do think the concept of a web-based software system like one of the PSWS applications listed can be used efficiently within TxDOT.

7. References

- Cox, Robert F. (2007). "Using Project-Specific Websites to Manage Construction Project Delivery". Available at http://www.buildings.com/articles/detail.aspx?contentID=3652.
- Villeneuve, Claudia E. and Aminah Robinson Fayek. (2003). "Construction Project Websites: Design and Implementation". Cost Engineering, Volume 45, Number 1.

8. Attachments for Recommended WLRS 9

- Attachment 1: Villeneuve and Fayek's article "Construction Project Websites: Design and Implementation"

Construction Project Websites: Design and Implementation

Claudia E. Villeneuve and Aminah Robinson Fayek

Technical Articles - Each month, **Cost Engineering** journal publishes one or more technical articles. These articles go through a blind peer review evaluation prior to publication. Experts in the subject area judge the technical accuracy of the articles. They advise the authors on the strengths and weaknesses of their submissions and what changes can be made to improve the article.

ABSTRACT: A construction project team can consist of many contractors, subcontractors, suppliers, manufacturers, clients and consultants. The management of information for such a project team can be difficult, requiring the rapid transfer of a great deal of project information on a timely basis. The arrival of the Internet began improving the exchange of project data among team members. Now, the latest Internet advance in construction project data dissemination is the project website (PWS). The PWS works as an interactive repository on the Internet of all project-specific data and messages, with variable levels of access by members of the project team and the public. This article describes the functionality of a project website and provides a guide for its design and implementation for the construction industry.

KEY WORDS: Construction, Internet, project extranets, project websites

As construction projects become more complex, so do construction project teams. A construction project team can have numerous contractors, subcontractors, suppliers, manufacturers, clients and consultants, all of whom have different information needs. Effective communication among team members requires the rapid transfer of a large amount of project information on a timely basis. The management of information and communications for the project team can be very challenging because of the number and diversity of people involved and because of geographical constraints that make the regular transfer of data difficult.

One of the most common complaints from construction managers is the difficulty in requesting information (like an approval for action), or relaying information (like changes to the original design) to every member of the construction team. The traditional practice has been to print on paper all the documents that have changed, and then proceed to mail them to everyone. This practice accounts for much of the overhead expenses and much of the time consumed by the construction manager. The arrival of computers and of electronic information exchange (like ftp, or file transfer protocol) improved the speed and capacity for dissemination of project data. The arrival of the Internet, the World Wide Web and electronic mail (e-mail) helped to further improve the dissemination of project data among team members.

The latest advancement in construction project data dissemination is the project website (PWS). The PWS acts as an interactive repository on the Internet of all project-specific data and messages. Unlike other websites, a project website can only be accessed by a pre-authorized number of users—members of the project team. The team therefore needs to have access to a computer or laptop. The data for the project website include typewritten documents, spreadsheets, drawings, schedules, and various audiovisual (AV) data. These AV data are collected using digital cameras and digital video cameras. The general public may also be allowed to view selected information related to the project through the PWS.

In developing a PWS, there are two aspects an organization must consider. One is whether to build the project website in-house or to outsource its development. In-house development has the advantages of greater control over content and formatting, while outsourcing can speed up the development process and provide for software and hardware support in cases where the company lacks such technical expertise. Whether an organization creates a project website from scratch or adopts an existing service is an important aspect to consider. The existence of ready-made project websites, sometimes called project portal sites, like buzzsaw.com, offer an alternative to building a project website from scratch. Ready-made websites limit the flexibility in tailoring specific features of the website but offer time and cost savings.

This article illustrates the functionality of a project website and provides a guide to construction companies for website design and implementation. For those wishing to acquire a ready-made website, this article provides a guide to the features that can be expected and therefore requested in the process of tailoring a ready-made website for specific users. A prototype model of a PWS is presented to illustrate its potential uses. Finally, implementation issues related to project websites are discussed.

DEFINITION AND BENEFITS OF A PROJECT website

Internet technology has revolutionized the delivery of information [5]. The corporate website, which provides a means of external communication, allows businesses to have a presence in the global marketplace. Corporate Intranets dramatically improve interoffice communication by providing instant access to corporate data [1]. The extranets extend the communication benefits of an Intranet to selected outside parties. A project website is an extranet that holds information specific to a project. Project websites "contain a repository of drawings and other information such as parts lists, schedules, and requests for information; they automatically keep track of all messages exchanged and modifications made in a design throughout the process" [3]. In its most basic form, "a project website is a modern-proxy to the filing cabinet, the traditional repository for project documents" [2]. The objective of the project website is "to provide all project team members with project information in a reliable and simple retrievable manner, in theory improving project communication and leading to better projects" [7].

The potential benefits of implementing a PWS are numerous. These benefits include:

- Reduced project costs and time savings by allowing the large volumes of information associated with any project to be instantly accessed by members of the project team [1].

- Improved productivity and partnerships since all project communications can take place in one location, the project website, without requiring the participants to be present at one place at the same time.
- Immediate and easy access to meeting notes, specifications, shop drawing submittal logs, requests for information (RFIs), and site photos.
- A forum for real time collaborative work, with participants in remote locations sharing and modifying images and other data [4].
- More effective communications and collaborations among team members, who are also better informed.

A significant aspect of the website implementation is the server setup for handling the information on the company's network. The large amount of data being transferred and the multiple, simultaneous users of the website can overload the system, if it is not properly designed and maintained. The website must be designed to reduce the duplication of information and to ensure that only current project information is displayed. Proper archiving of historical data can help ensure that the server capacity is not exceeded.

The multiple group nature of the architecture, engineering, and construction (A/E/C) industry creates a challenging environment for successful project implementation. Project success relies heavily on timely transfer of information among project members [8]. The project website enhances such communications and can help in achieving project success.

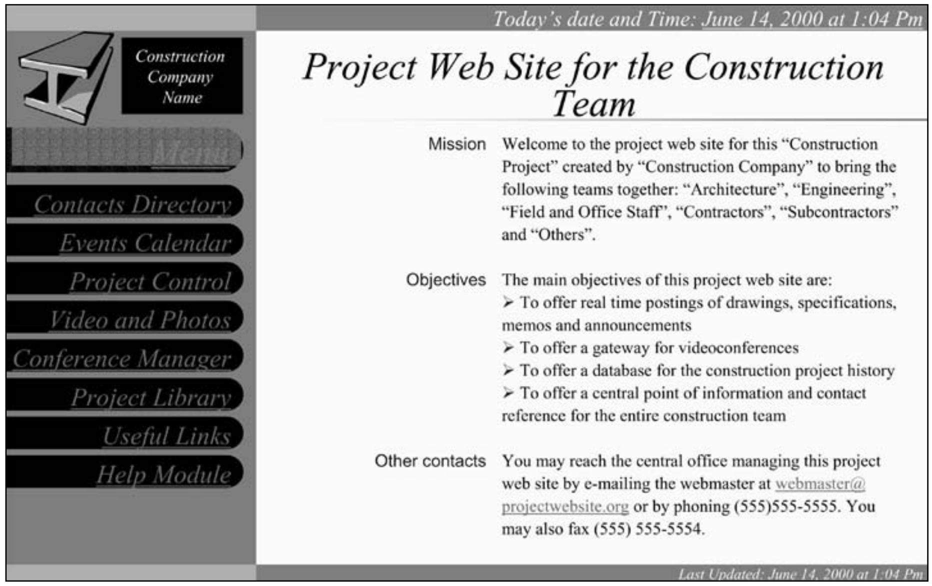

Figure 1—Main Page of PWS Prototype

Figure 2—Contacts Directory Page

PROTOTYPE OF A PROJECT WEBSITE

A prototype of a project website is presented to illustrate its potential functionality. Companies looking to develop a PWS can use this prototype as a guide to design and development.

Team members access the PWS through its Internet address. An individual user name and password allows them variable access to project data. Access can be in the form of read-only or with the added ability to modify data. Variable access ensures that confidential data is restricted to appropriate members of the team. The following modules are possible in a PWS:

Main Page—The first page presents an introduction to the construction project and to all services the project website provides. It includes the project plan, scope, description, and project sponsor. The main page presents the project information under separate modules, which are described below. Figure 1 shows the main page of the PWS prototype.

Contacts Directory—This module contains contact information for each of the project team members, such as: title, company, address, telephone, cell, beeper, fax, e-mail address, website address, project functions and times of availability (please see Figure 2).

Events Calendar—This module serves as a community posting for the construction team. The events calendar module links the user to a schedule of project-related events such as meetings, videoconferences, site visits, and project milestone dates (please see Figure 3).

Project Control—The project control module provides data related to the daily status of the project, including labor, material and equipment tracking. The project control module is subdivided into a number of reports. The reports presented in Figure 4 are a sample of what the module can contain; the design of each report is, of course, company specific. The sub-modules included within the project control module are RFIs (requests for information), construction documents, current progress reports, accounting department reports, and cumulative progress reports (please see Figure 4).

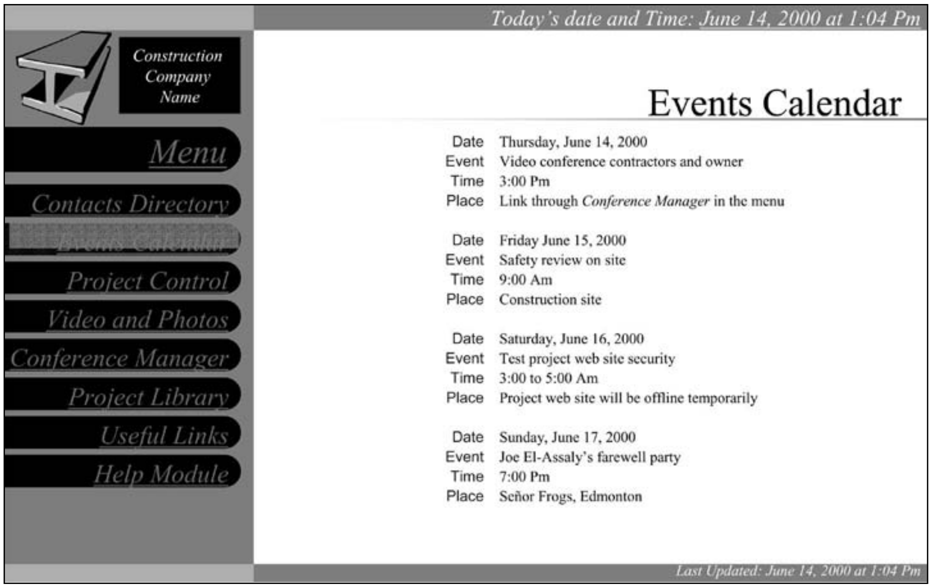

Figure 3—Events Calendar Page

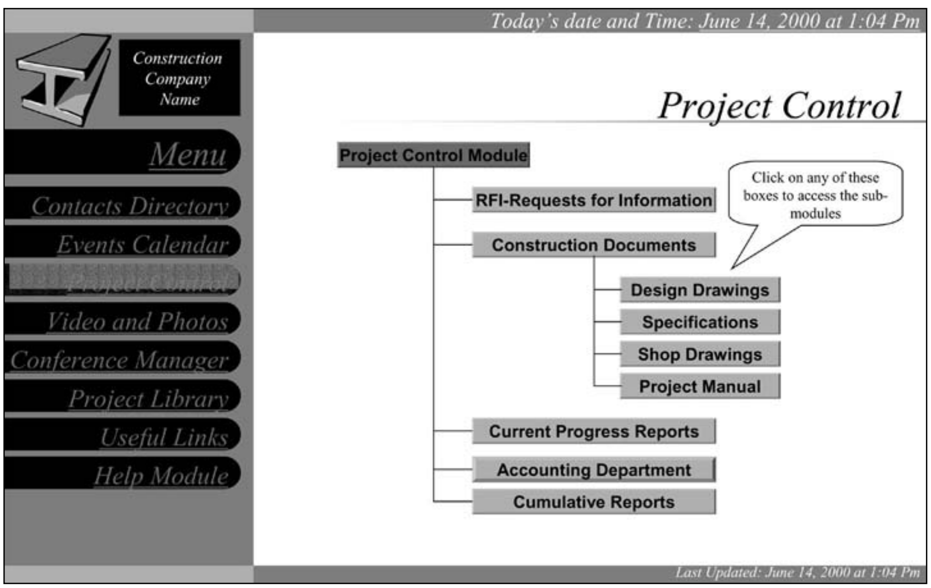

Figure 4—Project Control Module Page

Video and Photos—Project status, in picture and motion picture form, can be displayed using video and photographs of the construction site and its activities (please see Figure 5).

Conference Manager—This module allows the project team to coordinate Internet meetings when face-to-face meetings are not possible or necessary. The submodules included in the conference manager module are the computer up-link to conference, and the minutes of past meetings (please see Figure 6).

Project Library—This module represents the accumulation of other project data, separate from the progress data that is included in the project control module. The project library contains documents from any of the previous project phases such as design and procurement, and from the other modules in the project website such as the video module. A sample of the documents in the project library includes bid documents, the construction contract and past video and photos. During the project closeout phase, all the files in this module become part of the closeout package in electronic form (please see Figure 7).

8. **Useful Links**—This module contains a list of potentially useful websites that the project may use and links to each site (please see Figure 8).

Help Module—The help module contains a list of contents and an index that allows keyword searches on the project website (please see Figure 9).

The modules described here cover most of the data that is required for the management of a construction project, and when placed on the Internet it allows the construction team to have continuous information access. The project website can be organized so that certain files are deemed restricted, and team members have variable access to files. A project website can be tailored or personalized to offer different users a different interface in which only files that they have authorization to see are included.

THE LIFECYCLE PHASES OF A PROJECT WEBSITE

A project website initiative requires the investment of time and money, and the main deliverable, the Internet site itself, needs to be of good quality. A project website also involves the use of resources such as personnel, equipment, and materials. The development of a project website, therefore, needs to be managed like a construction project in itself. Without proper management, the PWS as a project will run late, over budget, and result in a low quality product. A project website has development phases similar to the development phases of a construction project. To better understand this similarity, the lifecycle management of the project website has been paralleled to the development phases of a design-build-operate-transfer/decommission project. These phases are: concept, design, procurement, construction, operation, and decommissioning. They are described as follows:

Concept Phase—For a project website, the concept phase begins with an analysis of the information needs of the stakeholders. Next, a simple cost-benefit analysis is performed to compare the costs of Internet communications to the cost of traditional communications, before a decision is made to proceed with the development of the PWS. The cost-benefit analysis is based on whether the project website will be built in-house or the service will be outsourced. Basically, the in-house project website will allow the company total control over its design and content, whereas the outsourced project website will require the client to adapt to the conditions of the service. In terms of financial advantages, the in-house website may be more expensive initially because the system needs to be built piece by piece but may yield savings in future developments and upgrades.

Design Phase—For a project website, this includes the selection of a leader and a team to champion the PWS initiative. Next, the formal assessment of information needs is performed, including the need to connect everyone to the Internet and the need to agree on a file standard.

Procurement Phase—Procurement involves the selection and purchase of either a project website service, or the selection of an in-house system. Other purchases include software and bandwidth to satisfy the project website's connection requirements.

Construction Phase—Initially, a working prototype of the PWS should be built. Training of users on the use of the PWS is required. Through the operation of the prototype, its design and functionality may be modified based on user feedback and functionality issues. The 'final' version of the PWS may result only after several iterations.

Operation Phase—The operation phase consists of the use of the project website, and the continued application of user feedback to satisfy new information requirements.

Decommission Phase—For a project website, this phase consists of the disconnection of the project website from the live server. The project website then serves as a repository of data used to construct the closeout package (in the form of a project archive) and to build the next generation of project websites.

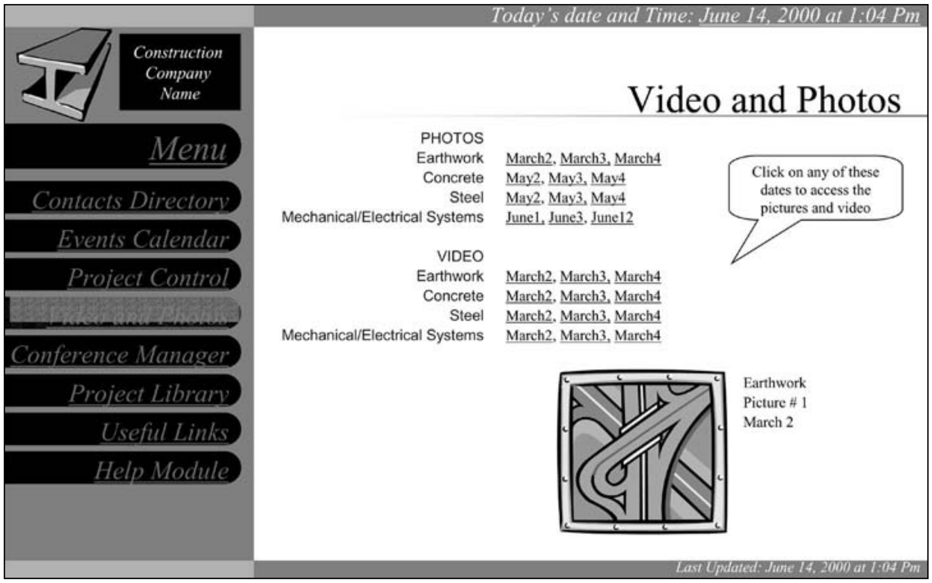

Figure 5—Video and Photos Page

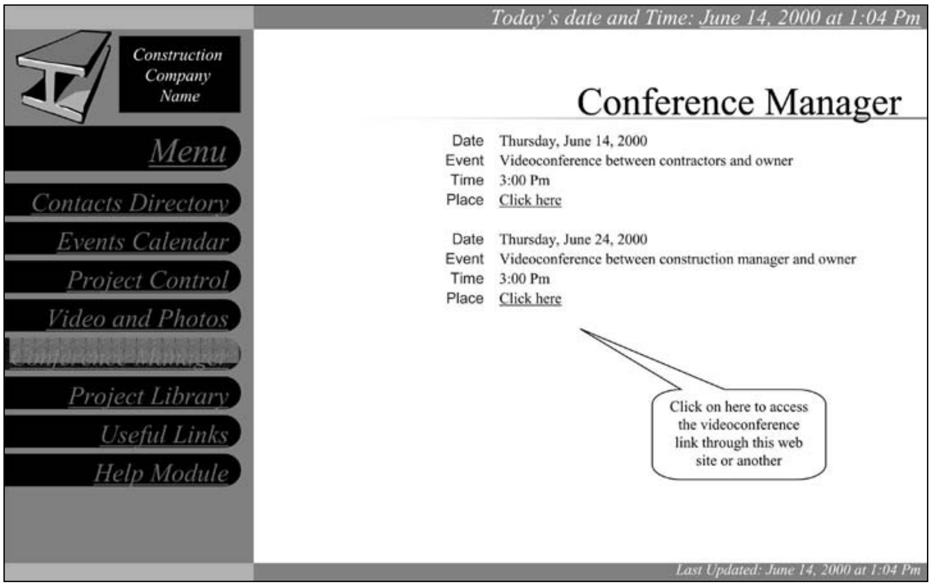

Figure 6—Conference Manager Page

Numerous sources of information are available on the subject of project websites and use of the Internet in construction to create a PWS plan [9]. These resources may be useful to companies interested in developing their own PWS.

IMPLEMENTATION ISSUES

Project websites are a new technology. A construction team consists of many individuals with differing needs. This combination of immature technology and a large number of people creates a number of issues that need to be addressed, such as the natural resistance to change, the existence of too many communication channels, and the demands of real teamwork.

The acceptance of, or resistance to, change is part of human nature. Some people, the 'innovators' accept new technologies like project websites readily, while others, the 'pragmatists', need to be shown how the technology can benefit them before they will adopt it. In a normal market situation, the former group uses the technology first until the latter is ready to adopt it. In a project website situation, every person is required to use the project website when it is ready (during the project), and not when he or she is ready. To improve this situation, the project's communication strategy regarding the PWS can be modified, allowing the innovators almost total participation in the PWS and the pragmatists minimal participation. To ease the transition, it may be necessary to define the individual's job in relation to the project website [7].

The arrival of a project website as the central repository of project data and information exchange increases the communication channels that project team members have at their disposal [7]. By default, they may use the channels they are more familiar with and the ones that offer no restrictions (e.g. restriction by the use of passwords). This leaves the project website as possibly the last natural choice. To improve this situation, electronic communication channels (e.g. e-mail, PWS, etc.) can be augmented and others (e.g. fax, post mail, etc.) can be scaled back or replaced so that the usefulness of the PWS can be maximized.

A construction project benefits more greatly from a project website if the construction team is willing to work together

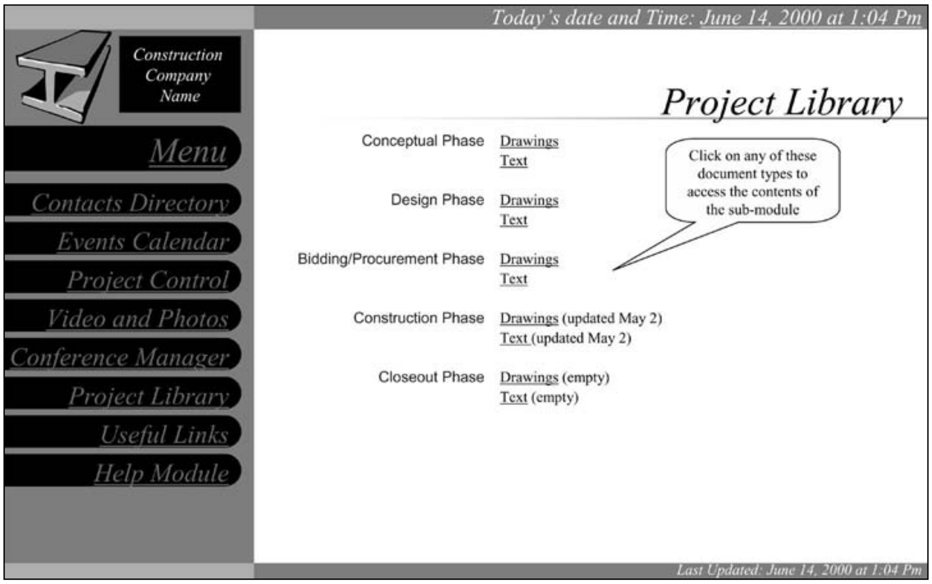

Figure 7—Project Library Page

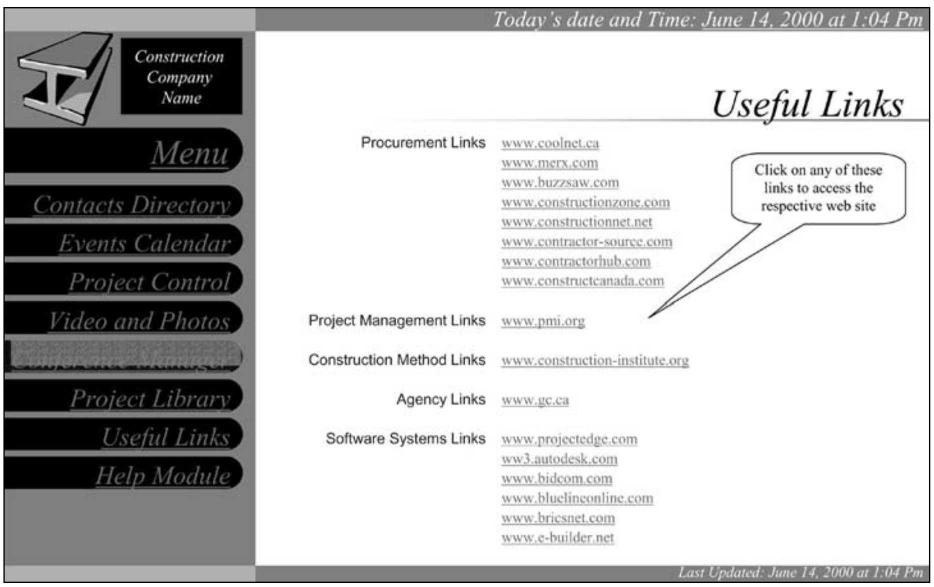

Figure 8—Useful Links Page

and share information and experiences to make the project succeed [7]. The construction industry experiences different levels of collaboration. These levels vary from the highly litigious and non-cooperative project teams to the partnering ventures that rely heavily on collaboration. Even in the most collaborative teams, people are uncomfortable giving up control, and they may see project websites as a potential threat. A possible strategy to deal with this issue is to perform a careful mapping of PWS use to job tasks, making more explicit the type of communication that it is to occur and how it is to be accomplished.

Another significant issue is the concern over the security and legality of data in electronic form. The project data contain memos, change orders, bills of sale, and other documents that include contract conditions. The data on the project website are exposed to the project team and sometimes to unauthorized extraneous people (e.g. computer hackers). Unfortunately, the law does not provide clear answers to questions such as: is my message going to arrive safely; who is really sending me this message; and, is an electronic file a legal document. Fortunately, there are security and legal options available for electronic data exchange through the Internet. Such options include: data exchange networks providing audit trail and document backup services; options for auto-acknowledging the receipt of messages; data verification checks built into messages; message encryption options; digital signatures; and, digital certificates to confirm message status [6].

Project websites are useful in enhancing the communication capabilities of a construction project team by increasing the speed of communication among team members in remote areas. Having all project documents on a project website on the Internet guarantees that everyone on the team with a computer, a modem and a password entry has the same information, regularly updated, available 24-hours a day for 7-days a week, and accessible from anywhere in the world. The project website prototype presented in this article can help a company develop the basic specifications for its own project website, or provide a reference regarding expectations and features to request in the process of tailoring a ready-made website for specific users. The existence of ready-made project websites, sometimes called project portal sites, like buzzsaw.com, offer an alternative to building a project website from scratch. By ensuring that the major communication needs of a project team are satisfied, the prototype can enhance the quality of information management on a project. A lifecycle plan for a project website is described to help view the development of a PWS in terms of a project in itself. This lifecycle plan provides the framework by which to organize the creation and development of a project website plan.

Project websites are changing traditional construction communication practices and delivering good results. For a highly competitive industry such as construction, having a project website can make the difference between obtaining a contract or not. PWS technology is still in its early stages, providing those who adopt it with the opportunity to gain a competitive advantage. ◆

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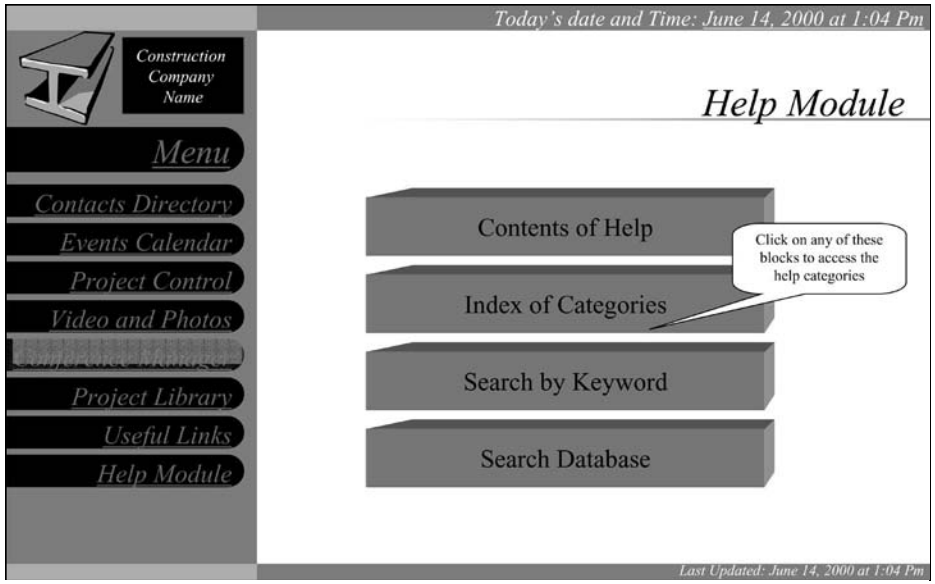

Figure 9—Help Module Page

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Press Release

Charles Farley, Farley Communication

Orlando Hires Boyken for Construction Cost Estimating

ORLANDO, FL—The City of Orlando has awarded a two-year contract to Boyken International for construction cost estimating and other consulting services covering a variety of public works projects.

Under the agreement, Boyken's Orlando office will provide a construction estimate for each project to help the city compare bids to what a project should cost based on specifications, local market conditions, and other factors.

"We are pleased to help to city control costs and participate in the maintenance, enhancement, and growth of Orlando," said John L. Ott, vice president and manager of Boyken's Orlando office. AACE International member Donald R. Boyken CCC, is CEO/President of Boyken International and works out of the Atlanta, GA office.

The construction-consulting firm's experience includes the State of Florida, Greater Orlando Airport Authority, Orange County School District, Orlando Utilities Commission and city governments in Atlanta; Spartanburg, S.C. and Knoxville, Tenn.

Boyken International is an international consulting firm that provides program management and consulting services - from concept through completion - to building owners, developers and other construction industry clients. Based in Atlanta with offices in Orlando and Kingston.

News items and press releases published in ***Cost Engineering*** *journal do not represent an official position of AACE International, but are printed for informational purposes only. AACE International is endorsing or sponsoring release suppliers.*

Implementation Guide for Recommended Workload Reduction Strategy 10

Recommended Strategy	WLRS Implementation Strategy
10	**Modify specification to allow the replacement of density measurement with stiffness in order to encourage the use of high-tech "Intelligent Compactors".**

1. **Description**
   Intelligent Compaction (IC) is an evolving technology in the US but in Europe it has been widely used for several years. IC refers to vibratory rollers that are equipped with units that measure stiffness and temperature during compaction. This will control compaction to prevent under-compaction and over-compaction of materials. This technology can be applied with common highway materials, including soils, aggregate and HMA.

2. **Potential Benefits or Intent**

   - There are several benefits associated with integrating IC technology in TxDOT specifications:
     - The inspector workload would be reduced significantly because of the reduction in density measurements.
     - IC automatically adjusts compaction, which will allow for more consistent compaction and increased quality on projects.
     - The IC documentation results could be used for several purposes including QC documentation, determination of bonus and penalty pay, performance-based specifications and warranties.

3. **Implementation Strategy**
   3.1 The high-tech “Intelligent Compactors” measure stiffness. New compaction specifications and procedures must be developed to incorporate the use of Intelligent Compactors. The current specification would have to be modified to allow for the replacement of density measurement with stiffness.
   3.2 The DOT will need to establish a policy regarding IC and the QC/QA testing policies
   3.3 Training will have to be developed for DOT employees about IC technology, the new specifications and procedures

4. **Conditions for Successful Implementation and Cautions**

   - DOTs need to develop procedures to utilize the output data collected from Intelligent Compactors.
   - There is still difficulty in relating the measurements from IC (e.g. modulus and stiffness) to existing field measurements (e.g. density).

5. Anticipated Cost for Implementation

- Anticipate a slight increase in cost for implementing the use of Intelligent Compaction associated with modifying specifications, providing proper training and the cost of purchasing the equipment.
- IC provides precise and consistent compaction results and also provides detailed documentation of compaction quality and temperature. This could reduce costs by lessening the time that in-house staff spends taking density and temperature measurements. Instead they would simply have to review the documented results that the IC provides.

6. Examples

- The documentation results that the IC provides could also be used as contractor's proof of performance. This may be used as a basis for pay of bonus and penalties, as well as for performance related to warranties.
- In the future, the data and material properties collected from IC could be used to develop performance-based specifications that correlate long-term performance and properties produced during construction.
- FHWA is working on pilot projects, including a project with TxDOT in Fort Worth. It is recommended that TxDOT follow the IC research being conducted by the US FHWA research project DTFH61-07-C-R0032 "Accelerated Implementation of Intelligent Compaction Technology for Embankment Subgrade Soils, Aggregate Base, and Asphalt Pavement Materials". The research of FHWA is further discussed in the presentation slides in Attachment 1.
- Manufactures who currently have IC models include in the United States (FHWA 2007):
  - Caterpillar (single drum)
  - Bomag America (both single and tandem drum)
  - Sakai America (tandem drum)
  - Ammann America (single drum)

7. References

- Arasteh, Michael M. (2007). "Innovations in Compaction Control and Testing" presented at the 2007 FHWA Construction Conference, March 20, 2007. Available at http://www.dot.nd.gov/conferences/construction/presentations/2007/Intelligent%20Compaction%20M%20Arasteh%20FHWA.ppt.
- Intelligent Compaction. Website documenting US FHWA research project DTFH61-07-C-R0032. Available at http://www.intelligentcompaction.com/.

8. Attachments for Recommended WLRS 10

- Attachment 1: Arasteh's FHWA presentation "Innovations in Compaction Control and Testing"

Intelligent Compaction
2007 Construction Conference
March 20, 2007
Bismarck, North Dakota

Innovations in Compaction Control and Testing

Michael M. Arasteh
Federal Highway Administration
www.fhwa.dot.gov/pavements/

[redacted]

Intelligent Compaction, IC

What is "Intelligent?"
- Oxford Dictionary: *"…able to vary behavior in response to varying situations and requirements"*
- Ability to:
  - Collect information
  - Analyze information
  - Make an appropriate decision
  - Execute the decision

Intelligent Compaction 2

Key Question?

"Can we make the compaction process work smarter not harder?"

Intelligent Compaction 3

FHWA IC Team

- 12 State Pooled Fund Partners…
- Roller & Test Equipment Manufacturers
- V. Lee Gallivan, HQ/RC
- Michael Arasteh, RC
- Fred Faridazar, RD
- Tom Harman, RC
- John D'Angelo, HQ
- Bob Horan, SaLUT *(Support Staff)*

Intelligent Compaction 4

Intelligent Compaction 5

Our Visit

- Goal of Roadway Compaction
- Conventional Limitations *"Challenges"*
- Goal of Intelligent Compaction, IC
- Roadway Compaction 101 *"Basics"*
- NCHRP IC Project
- Pooled Fund IC Project
- Shared Vision

Roadway Compaction

- Proper in-place density is vital for good performance
- Conventional compaction procedures have some limitations…
- Intelligent compaction technology appears to offer *"a better way"*

Conventional Compaction

- Provides little or no "on the fly" feedback
- Density-related properties (coring) are not measured until after the compaction is complete…

Conventional Compaction

- Density measurements may not be representative of entire section
- Overcompaction can occur and can actually reduce the density already obtained on the previous passes

Conventional Limitations

- The Compaction Process…

Limited "On Fly" Feedback

Over or Under-Compaction Can Occur

Intelligent Compaction 11

Conventional Limitations

- Density Acceptance…

Limited Number of Locations

After Compaction is Complete

Intelligent Compaction 12

Conventional Limitations

- The Compaction Process…

Limited "On Fly" Feedback

Over or Under-Compaction Can Occur

Intelligent Compaction

Can we make the process…smarter?


Improved Roller Technology

Sophisticated / Clear Documentation Systems

ACE

Advanced Hardware & Software

IC – Goals / Benefits

- **Short Term**
  - Improve density… better performance
  - Improve efficiency… cost saving$
  - Increase information… better QC/QA
- **Long Term**
  - Comprehensive Compaction Control (CCC)
  - Estimate pavement moduli?
  - Tie to M-E Design Guide (verify design)?
  - Performance specifications?

Roadway Materials Compaction 101

What are the basics of compaction?

Importance of Compaction

We've known it for a long time…

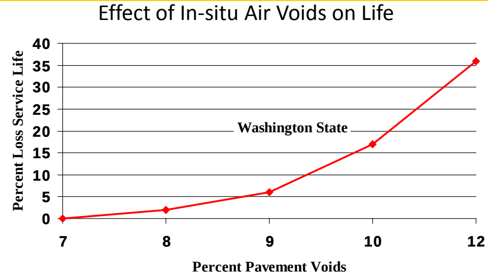
THE IMPORTANCE OF COMPACTION in highway construction has long been recognized. Recent laboratory and field investigation have repeatedly emphasized the value of thorough consolidation in both the base and surfacing courses. Thorough compaction in known to produce the following desirable results:

1. It increases interlocking of the aggregate particles, which is the primary factor in developing a high degree of stability.
2. It retards the entrance of moisture, thus preventing excessive loss of stability under adverse service conditions.
3. It reduces the flow of air and water through bituminous mixtures and is therefore an effective means of lessening damage from weathering and film stripping."

Reference -- "Public Roads, **May 1939**, authors J.T. Pauls and J.F. Goode"

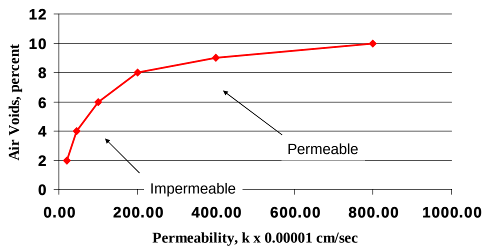
Basics of HMA Compaction

Effect of In-situ Air Voids on Life



Basics of HMA Compaction

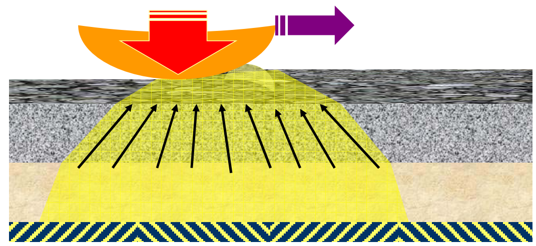
Typical Permeability vs. In-situ Air Voids



Intelligent Compaction 19

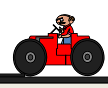
Basics of Compaction

- Effort (Roller) versus Resistance…



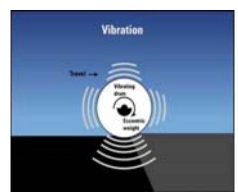
Basics of Compaction using Vibratory Rollers

- Constant Mass
- Variables of Vibration
  - Frequency, f (Hz)
  - Amplitude, A
  - Roller speed, v (fps)



Vibratory Effort

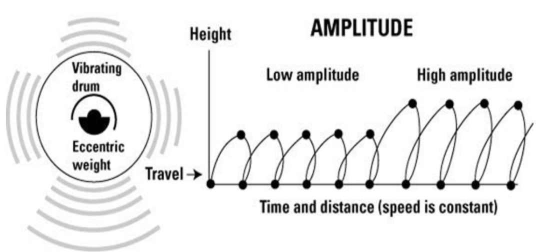
- Vibration sets aggregates in motion
- Helps aggregates re-orient for better contact



Intelligent Compaction

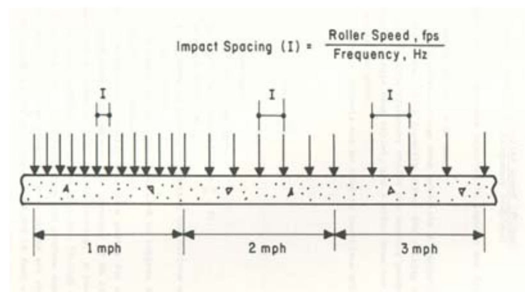
Amplitude

- Amplitude determines impact force



Intelligent Compaction 23

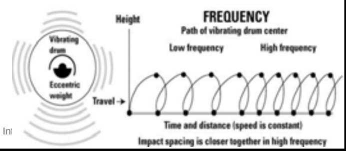
Impact Spacing, I = f (v , Hz)



Intelligent Compaction 24

Optimization…

- Amplitude controls force & depth
- Frequency and Speed control Impacts
- Ex. "Best" results when impact spacing is 10 - 14 impacts / foot for HMA



Basics of Compaction

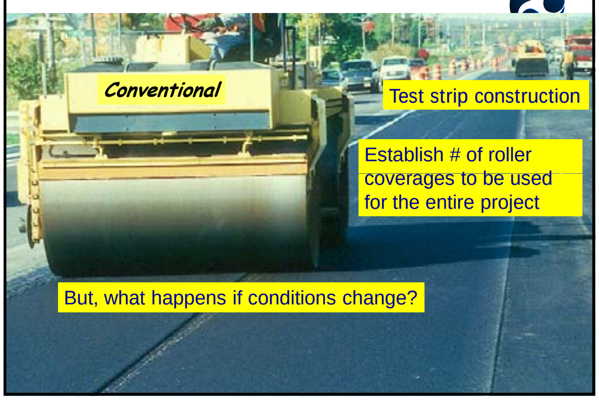
Compaction is a function of:

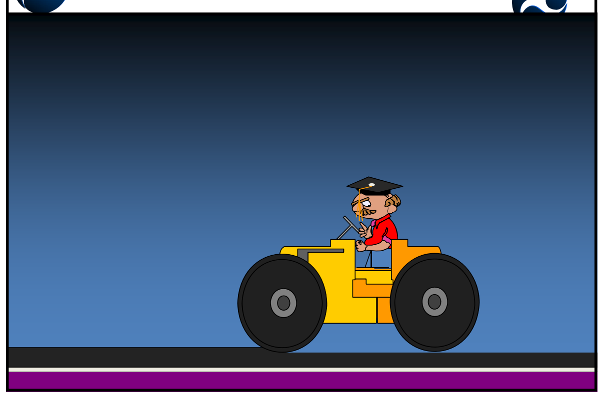
1. Materials type
2. Moisture content
3. Support from underlying materials
4. Type, size, number of Rollers
5. Roller speed and operation
6. Number of roller coverage's


Courtesy of Mn/DOT

Intelligent Compaction 26

Basics of HMA Compaction





IC TPF / FHWA Definition

1. Vibratory rollers with measurement / control system
   - Measurement system, ex. material stiffness
   - Control system automatically changes parameters (amplitude and possibly frequency) based on measurement…

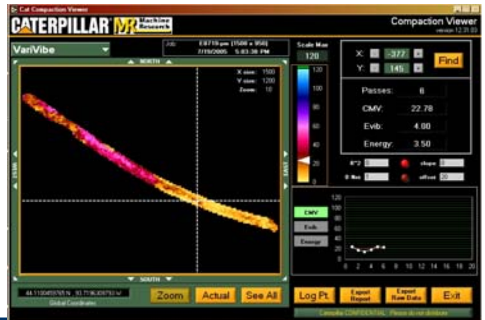
IC TPF / FHWA Definition

2. GPS-based documentation systems
   - Continuous recordation of materials stiffness
   - Continuous recordation of corresponding roller location
   - Color-coded mapping of stiffness

Advantages to GPS system

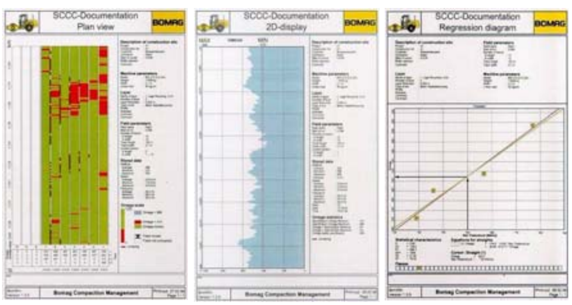
- Continuous recordation
  - density related outputs
  - corresponding roller location
- Color-coded mapping
- Project mapping
- Easy identification of poor density

Ex. Caterpillar



Courtesy of Caterpillar

Ex. Bomag

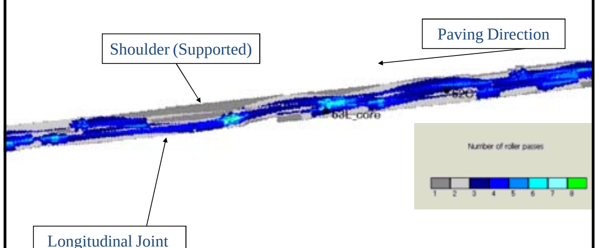


Courtesy of Bomag America

Ex. Sakai…

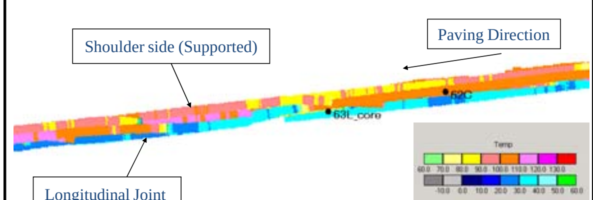
Sakai IC Roller Project

- Roller Passes



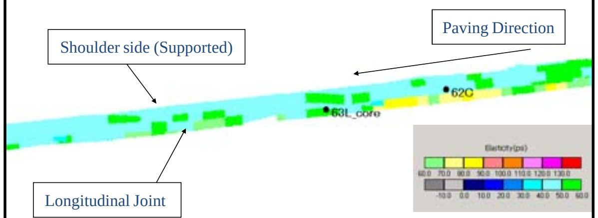
Sakai IC Roller Project

- Temperature



Sakai IC Roller Project

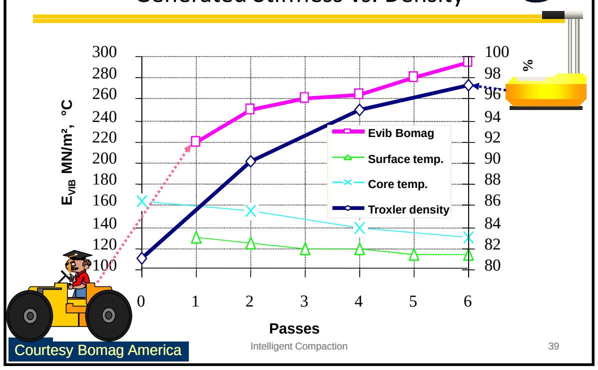
- Stiffness



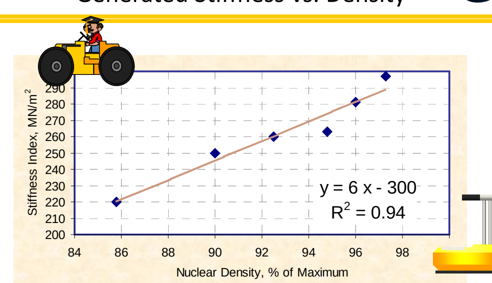
Benefits of IC

- **Maximum productivity** of the compaction process
- **Improved density** of pavement materials
- Measurement and recordation of **materials stiffness values**
- **Identification** of non-compactable areas
- **Improved depth** of compaction
- Reduction in highway repair **costs**

Bomag America Generated Stiffness vs. Density



Bomag America Generated Stiffness vs. Density



- Construction specs on 4 different material types
  - Granular subgrade soil
  - Cohesive subgrade soil
  - Aggregate base and subbase
  - Asphalt pavement material
- Comparison of IC and conventional– Is IC really better?

- Correlation of roller-generated stiffness and in-place density?
- Correlation of roller-generated stiffness and in-situ test methods? (FWD, LWD, DCP, GeoGauge, etc.)

- Needed accuracy of GPS
- Best methods of using roller-generated data in agency's QA and acceptance testing
- Assessment of roller operators ability to understand and utilize more complex equipment

National Research Efforts

- NCHRP 21-09 "Examining the Benefits and Adoptability of Intelligent Soil Compaction"
- Transportation Pooled Fund #954 – "Accelerated Implementation of Intelligent Compaction Technology for Embankment Subgrade Soils, Aggregate Base and Asphalt Pavement Material"

- Study of IC of subgrade soils (limited aggregate base/subbase)
- Objectives: Based on data / information obtained from field studies:
  - Develop generic IC construction specifications for subgrade soils
  - Evaluate the reliability of IC system components

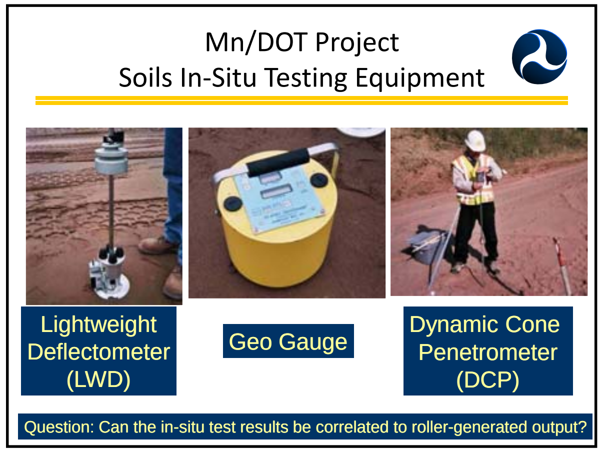
Two year project in two phases

- Phase 1: One project
- Phase 2: Four projects
  - June, 2006 - June, 2008
  - Allocated Funding: $600,000
  - Awarded 12/05
    - Dr. Michael Mooney, Colorado School of Mines, Principal Investigator
    - Dr. David White, Iowa State University, Co-Principal Investigator

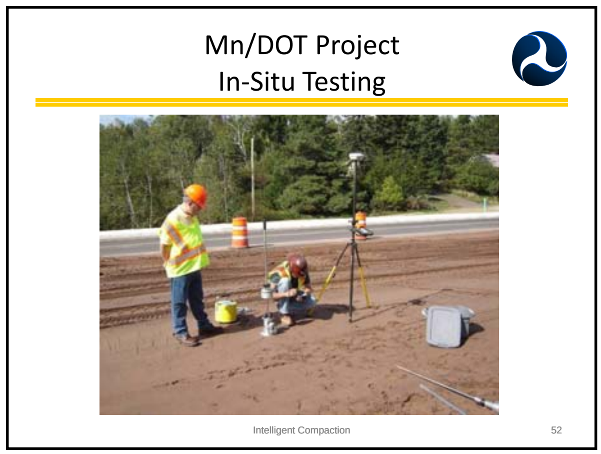
July 2006; MnROAD Research Center

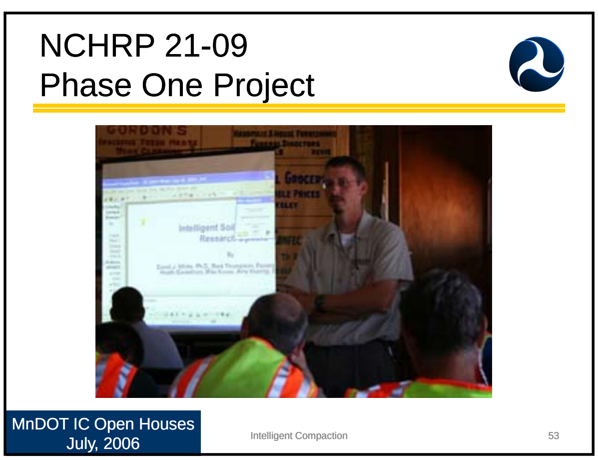
NCHRP 21-09 Phase One Project

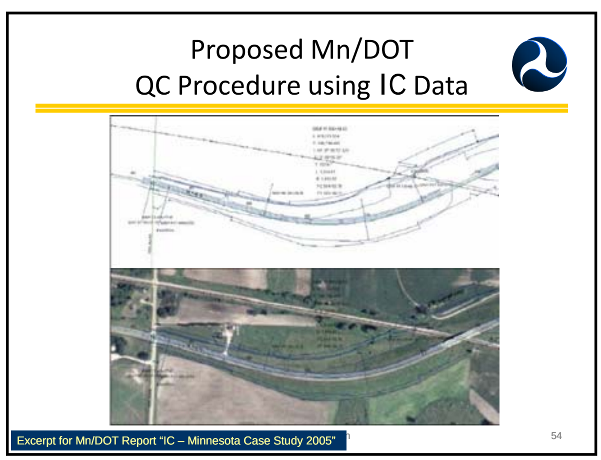

NCHRP 21-09 Phase One Project
LAB SPONSORS
IOWA STATE UNIVERSITY
GEOTECHNICAL MOBILE
Advancing Intelligent Construction
Iowa State University Geotechnical Mobile Lab
“Advancing Intelligent Construction”
Compaction
49


Mn/DOT Project
Soils In-Situ Testing Equipment
Lightweight Deflectometer (LWD)
Geo Gauge
Dynamic Cone Penetrometer (DCP)
Question: Can the in-situ test results be correlated to roller-generated output?

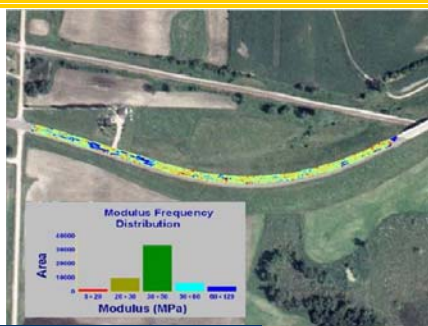

NCHRP 21-09
Phase One Project


Mn/DOT Project
In-Situ Testing
Intelligent Compaction
52


NCHRP 21-09
Phase One Project
MnDOT IC Open Houses
July, 2006
Intelligent Compaction
53

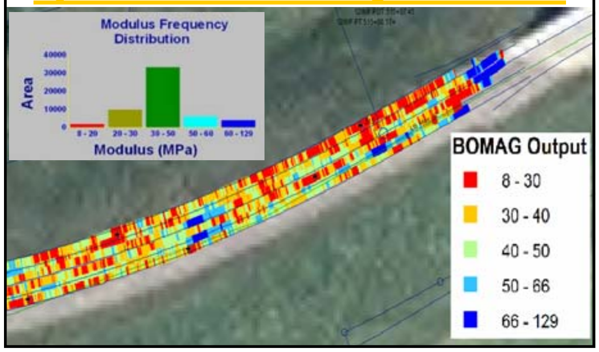

Proposed Mn/DOT
QC Procedure using IC Data
Excerpt for Mn/DOT Report "IC – Minnesota Case Study 2005"
54

Proposed Mn/DOT QC Procedure using IC Data



Excerpt for Mn/DOT Report "IC – Minnesota Case Study 2005"

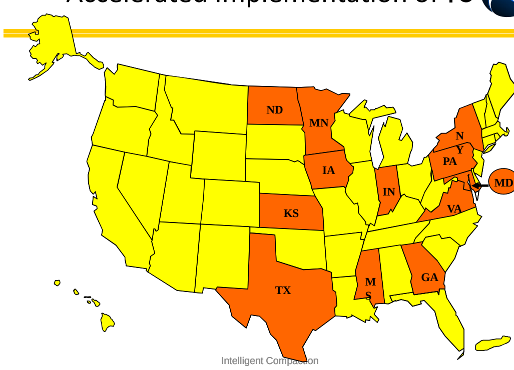
Proposed Mn/DOT QC Procedure using IC Data



Pooled Fund (Soils / HMA)

- 3 year study of IC for all materials
- Solicitation period ended on Dec 2005
- 12 participating states
- Estimate 1 project / State / year ~ 30?
- Close coordination with NCHRP project
- Stated goal to work closely with roller suppliers to increase the number of IC rollers and manufacturers

Accelerated Implementation of IC



Pooled Fund, Objectives

- Objectives: Based on data obtained from field studies:
  - Accelerated development of QC/QA specifications for granular and cohesive subgrade soils, aggregate base and asphalt pavement materials…

Pooled Fund, Objectives

- Develop an experienced and knowledgeable IC expertise base within Pool Fund participating state DOT personnel
- Identify and prioritize needed improvements to and/or research of IC equipment and field QC/QA testing equipment (DCP, FWD, GeoGauge, etc)

Comparison on Pooled Fund and NCHRP Projects

- Pooled Fund #954
  - Specification develop.
  - Identify and prioritize needed improvements
  - More projects
  - All pavement materials and entire pavement structure
  - Active participation of state DOT personnel
  - Emphasis on inform./ technology transfer
- NCHRP 21-09
  - Specification develop.
  - Evaluate existing IC components
  - Detailed research on fewer projects
  - Primarily subgrade soils; some agg. base
  - Research team / NCHRP panel

State DOT IC Research

- Limited number of projects by several State DOTs (MN, NC, MD)
- Mn/DOT has conducted an ongoing research effort over last several years
  - 5 projects complete
  - Subgrade soils only
  - 3 different roller manufacturers
  - Compare roller-generated output to in-situ test methods (DCP, LWD and GeoGauge)
  - Required GPS-based, color coded mapping of roller output and locations

Intelligent Compaction 62

- 5 Roller Manufacturers have announced their intentions to supply IC rollers in US
  - 4 have announced plans to have both single drum soils rollers and tandem drum asphalt rollers
  - 1 has only single drum soils rollers, at this time
- 4 Manufacturers that currently have IC rollers for public display, at this time:
  - Bomag America (both single and tandem drum)
  - Ammann America (single drum)
  - Caterpillar (single drum)
  - Sakai America (tandem drum)

Intelligent Compaction 63

Tandem drum asphalt rollers

Single drum soils / base rollers

Intelligent Compaction 64

Special Issues for Asphalt IC

- Thin lift construction
- Allowable temperature ranges
- Surface vs. internal temperature measurement
- Non-destructive, in-situ stiffness / modulus companion tests

Intelligent Compaction 65

What have we learned so far?

- IC technology appears to have great potential to improve the compaction process
- Improved and more uniform density should increase pavement service life
- There is a great deal of interest among federal and state DOTs to learn more about it

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What have we learned so far?

- Roller manufacturers are responding to this interest by performing R&D, providing rollers and by coordinate efforts with state and national research efforts.
- Preliminary findings from studies in US are encouraging

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What is next?

- FHWA is committed to working with others to accelerate the study and implementation of the technology.
- Two major national studies of IC technology are being performed along with state projects.
- A large number of projects are planned for the 2007 construction season.

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What is next?

- Short term goals are:
  - To increase the number of IC rollers in the US,
  - To learn how to use the technology effectively and to develop construction specifications for all material types.

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Intelligent Compaction

The Vision

FHWA Strategic Plan

- Proper compaction is vital to optimum service life.
- IC is an emerging technology that will allow greater control of the compaction process, resulting in better density.
- IC provides a new tool for in-situ measurement.

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Intelligent Compaction

The Objectives

FHWA Strategic Plan

- Accelerate the development of IC
- Increase awareness and encourage acceptance
- Conduct needed research to clarify the advantages and appropriate uses of the technology
- Provide organizational support for the process of developing intelligent compaction technologies

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Intelligent Compaction

The Rationale

FHWA Strategic Plan

- FHWA Strategic Outcomes
  - Reduction of Congestion
    - Maintenance and repair activities delayed / eliminated.
    - Less traffic disruption due to construction activity.

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Intelligent Compaction

The Rationale — *FHWA Strategic Plan*

- FHWA Strategic Outcomes
  - –Improved Roads
    - Higher density and better uniformity,
    - Pavement service life increased, and
    - Reduced pavement distress.

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Intelligent Compaction

The Rationale — *FHWA Strategic Plan*

- FHWA Strategic Outcomes
  - –Increased Safety
    - Pavements are smoother and safer
    - Less construction activity eliminates dangerous road hazards

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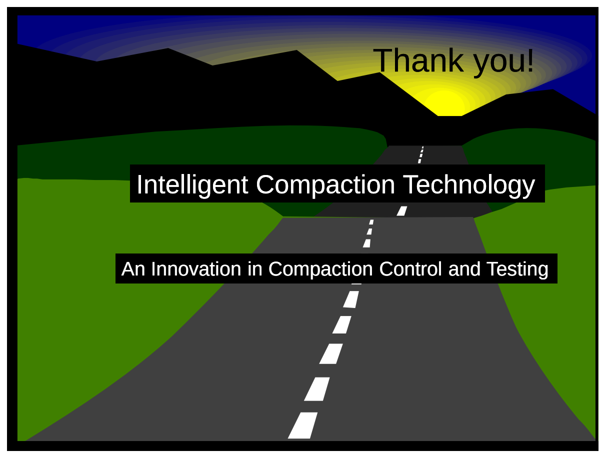
IC – Goals / Benefits

- **Short Term**
  - – Improve density… better performance
  - – Improve efficiency… cost saving$
  - – Increase information… better QC/QA



Intelligent Compaction 75



Implementation Guide for Recommended Workload Reduction Strategy SP 1

Recommended Strategy	WLRS Implementation Strategy
SP 1	**Completely outsource entire projects to consultants to manage and inspect all aspects of the project.**

1. **Description**
   In order to address the high number of projects but comparatively small in-house inspection force, state DOTs have begun to completely outsource entire projects to consultants to manage and inspect.

2. **Potential Benefits or Intent**

   - Outsourcing part or all of infrastructure projects helps to (Moore, Segal, McCormally 2000):
     - Achieve improved quality
     - Accommodate peak demand
     - Speed project delivery and meet deadlines
     - Gain access to expertise
     - Improve efficiency
     - Cut or contain costs.
   - By outsourcing entire projects, TxDOT would be able to better manage a high number of projects and make sure they are properly staffed with qualified inspectors without increasing the number of in-house inspectors. As a result, this will free-up in-house inspector time for other duties.

3. **Implementation Strategy**
   3.1. Develop a Consultant Administration Manual that defines consultant contract and field administration procedure throughout TxDOT. Possible topics to be covered include: when to use consultant contracts, what monitoring is required by TxDOT, and define the role and responsibilities of each party.
   3.2. NOTE: As an alternative, this workload reduction strategy could be the subject of a future research project that would evaluate similar programs in other states and public agencies and would develop a best practice third part consultant project management process.

4. **Conditions for Successful Implementation and Cautions**

   - In Florida, the process is administered using a professional services contract. This is recommended so that FDOT can choose firms based on qualifications for the management of projects.
   - It is important to get guidelines and procedures set up now for consultant administration so that TxDOT can be ready to implement this strategy when the construction budget rebounds.

- The third-party inspectors are expected to have the same qualifications as those required of DOT inspectors and will have the same responsibilities for verifying that the contractor is working in accordance with the project plans and specifications. The DOT will have full access to all of the third-party's inspection reports and testing results.
- The third-party consultant will be required to have a supervising engineer that will be responsible for reviewing all documents and test results before they are submitted to the DOT.

5. Anticipated Cost for Implementation

- There will be an increase in the indirect project cost associated with administering the third-party contracts.
- There will be an increase in direct project cost because third-party services are typically more expensive than in-house costs.

6. Examples

- In South Carolina, they completed an accelerated bonding program where they completed 27 years worth of work in 7 years, which was approximately 4 times their normal construction budget. During those seven years, they actually hired two experienced consulting firms to manage 100 projects. In the management of projects, it was anywhere from the complete development of the plan from proposals and field inspection to just doing the field inspection if they already had the plans developed. The accelerated bonding program in South Carolina went very well.
- In Florida and Virginia, they give entire projects to the consultant and only have one DOT employee who oversees them.

7. References

- Alvarado, Julio. State Engineer for Construction, Arizona Department of Transportation. Phone 602-712-7323. Email jalvarado@azdot.gov. Telephone conversation on April 1, 2008.
- Arizona Department of Transportation (ADOT). (January 2007). *Consultant Construction Administration Manual.* Available at http://www.azdot.gov/Highways/constgrp/PDF/CCAManual.pdf.
- Blanchard, Brian. (2008). Director of Construction, Florida Department of Transportation. Phone: 850-414-4140. Email: brian.blanchard@dot.state.fl.us. Telephone conversation on March 20, 2008.
- Adrian T. Moore, Geoffrey F. Segal, and John McCormally. (September 2000). "Infrastructure Outsourcing: Leveraging Concrete, Steel, and Asphalt with Public-Private Partnership". Policy Study No. 272. Available at http://www.reason.org/ps272.pdf.
- Shealy, Danny. Director of Construction, South Carolina Department of Transportation. Phone 803-737-1308. Email shealydr@dot.state.sc.us. Telephone conversation on March 7, 2008.

Implementation Guide for Recommended Workload Reduction Strategy SP 2

Recommended Strategy	WLRS Implementation Strategy
SP 2	**Require the contractor to provide independent consultant QC/QA services.**

1. **Description**
   In order to augment limited in-house personnel, state DOTs have begun to use independent third parties that are retained by the contractor. The DOT is able to specify the required qualifications and responsibilities of the third-party inspectors, but the contractor will be responsible for administering the contract.

2. **Potential Benefits or Intent**

   - Instead of TxDOT directly outsourcing inspection services to a third-party and alternatively requiring the contractor to be responsible, TxDOT would reduce the administrative burden of managing the consultant contract. This would reduce in-house inspection efforts, while ensuring unbiased results.

3. **Implementation Strategy**
   3.1. Establish guidelines for the responsibilities of each party involved in the independent consultant QC/QA contract.
   3.2. Establish a prequalification process for the contractor and TxDOT to both approve the consultant.
   3.3. Test the strategy on a few pilot projects to measure the effectiveness.
   3.4. NOTE: As an alternative, this workload reduction strategy could be the subject of a future research project that would evaluate similar programs in other states and public agencies and would develop guidelines for implementing a successful independent consultant QC/QA program in TxDOT.

4. **Conditions for Successful Implementation and Cautions**

   - TxDOT would need to establish a prequalification process, where the consultant is approved by both the contractor and TxDOT.
   - The third-party inspectors are expected to have the same qualifications as required of TxDOT inspectors and will have the same responsibilities for verifying that the contractor is working in accordance with the project plans and specifications. TxDOT will have full access to all of the third-party's inspection reports and testing results.
   - The third-party consultant will be required to have a supervising engineer that will be responsible for reviewing all documents and test results before they are submitted to TxDOT. The engineer will be licensed and will sign all of the documents.
   - By having the contractor responsible for administering the consultant contract, it will reduce the administrative burden for the DOT. If entrusting the contractor with this

responsibility is viewed as too high a conflict of interest, the alternative would be having TxDOT administer the consultant contract directly.

5. Anticipated Cost for Implementation

- This strategy would reduce the indirect project cost because TxDOT would not have to administer the consultant contract. However, it would increase the direct project cost because the contractor's bid would increase as a result of the new responsibility.

6. Examples

- Pay items that could be included in contractor provided independent consultant QC/QA services include: Seal Coat or Overlay, Embankment, Subgrade Compaction.
- In Virginia, they had a few pilot projects with contractor QC/QA. The contractor hired an independent inspection firm and provided that service through the contract, where VDOT did some limited oversight and sampling. In these cases, the contractor had to hire an inspection firm that reported to VDOT. There was a potential conflict of interest because the consultant was hired and paid by the contractor but technically working for the state. However, it was successful but some projects required more oversight than others. Virginia has not fully embraced this as a way of doing business yet.

7. References

- Liston, Dan. Director of Construction, Virginia Department of Transportation. Telephone 804-786-2847. Email daniel.liston@vdot.virginia.gov. Telephone conversation on March 13, 2008.

Appendix B: Example Interview Agendas

Example Expert Interview Agendas

3. **Important questions we would like to get answered in today's meeting:**

CONCRETE

1. Concrete QC/QA program: which pay items get QC and/or QA?
2. Who performs QC, QA, and Acceptance testing?
3. Concrete testing certifications
   a. TxDOT's certification process
   b. ACI Certifications: is it feasible or planned to accept more ACI certs?
   c. NICET certifications: future directions?
   d. Western Area Quality Control: ASTM adoption – status? What will this do for TxDOT?
4. Are there concrete pay items that you would classify as "inspection-intensive" ?
5. Can we brainstorm whether there are ways to modify the spec items so that they are less inspection-intensive?

Example District and Other State DOTs Interview Agendas

3. Important questions we would like to get answered in today's meeting:

1. How are you using Construction Materials Testing Techs (professional service contracts) versus how are you using Rent-a-Techs?
    a. Are Construction Materials Testing Techs and rent-a-techs readily available?
    b. Have you hired a single consultant technician to do all testing and inspection on any of your projects?
2. Are you using concrete QC (contractor QC) practices on any of your projects?
    a. If yes, we would like to learn more about your practices.
3. Describe the certifications that are commonly obtained by, or required of,:
    a. Your inspectors
    b. Rent-a-techs
    c. Other third party consultants
4. How are you accomplishing testing and inspection for the following "time-intensive" pay items:
    a. Striping (are your specs standard or performance specs?)
    b. Seeding
    c. Landscaping
    d. Treated Bases (How are tickets collected? How do you measure lime, density, etc.)
    e. Embankment (Same)
    f. HMA (How are you collecting tickets? How are you sampling and testing? Do you collect samples in the field, as material is installed?)
    g. Concrete (How are you testing? Which pay items require contractor QC? What certifications do your inspectors have?)
    h. Rip Rap
5. Can we brainstorm whether there are ways to modify the pay/spec items so that they are less inspection-intensive?
6. How are you using Site Manager, and are you experiencing duplication of effort (first hand-record, then enter into computer)?
7. Would you feel comfortable allowing the contractor to hire an independent third party for testing and inspection services? (i.e. shif the risk)
8. What additional workload challenges do you have?
9. Have you developed any innovative methods for managing/reducing inspection workload?
10. How well is the IDP Program working for you, and do you have suggestions for improvements?

Appendix C: Workshop WLRS Information Sheets

Workload Reduction Strategy Information Sheet 1

1. Workload Reduction Strategy (WLRS):
   A. Modify Inspector Training Methods

2. WLRS Implementation Strategy:

No.	Description
1	**Create checklists for selected pay items that help inspectors prioritize inspection elements and direct them to relevant inspection documents.**

3. Background and Context:
   Florida has developed checklists or what they refer to as "guidelists" that provide guidance for all major tasks that need to be completed relevant to construction inspection. The guidelists also highlight critical requirements, which are items that if not properly performed, have a high probability of causing problems during the construction phase. In addition, Arizona has created massive checklists or what they refer to as "quantlists" that cover every aspect of their work. The quantlists are described as allowing for an objective evaluation of construction processes. The motivation behind the development of these checklists is for inspectors to know what the most important items to inspect are and reference where to find additional relevant inspection documents. These checklists document expected quality requirements and monitor construction processes to make sure that the end product meets established quality standards.

4. Specific Example or Application:
   Some of the types of inspector guidelists developed in Florida include:
   1. Environmental Compliance
   2. Earthwork
   3. Drainage
   4. Base
   5. Asphalt
   6. Concrete
   7. Bridge Structures
   8. Signalization
   9. Lighting
   10. Grassing
   11. Landscaping

   http://www.dot.state.fl.us/construction/CONSTADM/guidelist/guideindex.htm

5. Reported or Expected Benefit:
   The reality is that departments of transportation are facing a shortage of inspection personnel. It is important that inspection is performed in the most efficient manner. Checklists will provide inspectors knowledge of what items are the most critical to inspect as well as the proper procedure for inspection. In addition, inspection checklists provide for good documentation of what has been inspected on projects. This documentation will be especially useful if inspection services are outsourced to third parties or as evidence if a project goes to litigation. Florida and Arizona have already developed comprehensive checklists that TxDOT could use as a model for adapting to their needs.

Workload Reduction Strategy Information Sheet 2

1. Workload Reduction Strategy (WLRS):
   A. Modify Inspector Training Methods

2. WLRS Implementation Strategy:

No.	Description
2	**Create construction training matrices that document training required of, and received by, inspectors on TxDOT projects (e.g. inspection, lab technician).**

3. Background and Context:
   Arizona has created training matrices to show what certifications are required for employees in their Construction Group. This was originally created for engineers-in-training to show what certifications they have currently completed and what additionally is needed in the future for permanent status or promotion.

4. Specific Example or Application:
   The types of inspector matrices developed in Arizona include:
   1. Construction Inspection Certification Matrix
   2. Construction Lab Technician Certification Matrix
   3. Landscape Inspection Certification Matrix
   4. Survey Technician Certification Matrix
   5. Traffic Signal and Lighting Certification Matrix
   6. Construction Office Certification Matrix
   7. Transportation Engineering Associate (TEA) Certification Matrix

   http://www.dot.state.az.us/Highways/ConstGrp/Training.asp

5. Reported or Expected Benefit:
   It would be useful to incorporate training matrices into the IDP program already developed in TxDOT. The matrices would categorize the various levels of construction inspectors depending upon training certifications and level of experience. Matrices will be beneficial for TxDOT to be able to easily identify how qualified their in-house staff is and identify what areas have a need for further training or certifications. An additional benefit would be that third parties would be able to easily identify what levels of inspectors they had on-staff according to TxDOT's classifications.

Workload Reduction Strategy Information Sheet 3

1. Workload Reduction Strategy (WLRS):
   A. Modify Inspector Training Methods

2. WLRS Implementation Strategy:

No.	Description
3	**Have consultants administer all or a portion of inspector training.**

3. Background and Context:
   Florida and Arizona augment their training by in-house personnel with consultants. The reason behind this is there are not enough in-house personnel to handle all of their training.

4. Specific Example or Application:
   1. In Arizona and Florida, they have training classes that are prepared and/or administered by consultants.
   2. In Arizona, consultants are hired for training courses based on an individual basis depending on the particular skill set required for the training.

5. Reported or Expected Benefit:
   TxDOT could provide additional training to their in-house staff by using consultants to augment their training program. This would allow TxDOT to increase the skills of their personnel without an additional strain on their internal resources.

Workload Reduction Strategy Information Sheet 4

1. Workload Reduction Strategy (WLRS):
   A. Modify Inspector Training Methods

2. WLRS Implementation Strategy:

No.	Description
4	**Convert inspector training courses to Computer-Based Training Courses as much as possible to make training easier to obtain.**

3. Background and Context:
   Florida is trying to convert their inspector training courses to Computer Based Training (CBT). This will allow Florida to train inspectors virtually anywhere at any time.

4. Specific Example or Application:
   The types of interactive inspector training courses that Florida is offering currently through CBT include:
   1. Asphalt Paving Level 1
   2. Drilled Shaft Tutorial
   3. Earthwork Inspection
   4. FDOT Concrete Field Inspector Course
   5. FDOT Concrete Laboratory Inspector Course
   6. Final Estimates Level 1
   7. Hot Mix Asphalt Plant Inspection
   8. Hot Mix Asphalt Testing
   9. Pile Driving Inspector's Tutorial

   http://ctt.ce.ufl.edu/courseMaterials.aspx

5. Reported or Expected Benefit:
   Florida has experienced a significant increase in the ability to train large numbers of inspectors. This has resulted in Florida increasing the skills of their new inspectors more rapidly while decreasing the overall cost of training.

Workload Reduction Strategy Information Sheet 5

1. Workload Reduction Strategy (WLRS):
   A. Modify Inspector Training Methods

2. WLRS Implementation Strategy:

No.	Description
5	**Increase or improve *Site Manager* system training to reduce double data entry and reduce time spent on paperwork.**

3. Background and Context:
   TxDOT inspectors need more training to efficiently navigate through *Site Manager,* especially the seasoned inspectors who are accustomed to standard paper documentation followed by data entry. Providing inspectors training on *Site Manager* to improve their skills will save time by reducing double-entry and the amount of paperwork.

4. Specific Example or Application:
   The type of inspector training courses that TxDOT can implement to improve inspector skills include:
   1. Develop an in-house training program that will help inspectors keep up with the most recent changes in the software and develop a certification process for *Site Manager* that has multiple levels.

5. Reported or Expected Benefit:
   Training for *Site Manager* will improve the navigation skills of inspectors and save time by reducing double-entry and paperwork. The inspectors may utilize this time for other inspection duties.

Workload Reduction Strategy Information Sheet 6

1. Workload Reduction Strategy (WLRS):
   B. Increase Inspector Effectiveness and Efficiency Through Certification

2. WLRS Implementation Strategy:

No.	Description
6	**Work with a third-party to develop and administer a more extensive QC/QA certification program.**

3. Background and Context:
   Several DOTs have begun to move towards certification programs to ensure that inspectors on their projects are properly trained. This has been beneficial to maintain consistency of inspection and testing in lieu of the growing trend toward increased contractor QC/QA and outsourcing to consultants. The certification programs allow for the DOTs to ensure that whoever is working on their projects has been certified for the area of work they are responsible for.

4. Specific Example or Application:
   1. South Carolina and Wisconsin have universities administer their certification programs and they are responsible for certifying and decertifying workers.
   2. Florida has a consultant administer their certification program.
   3. Florida is converting their certification exams and training to computer based as much as possible.
   4. Wisconsin negotiates a cost per person per course to be the same for in-house personnel, consultants or contractors.

5. Reported or Expected Benefit:
   The certification programs allow for the DOTs to ensure that whoever is working on their projects has been certified for the area of work they are responsible for. By having a third-party responsible for administering the certification program, it reduces the stress on in-house resources. In addition, the third-party can maintain a database documenting the certification records. This enables TxDOT to increase inspector skill level and qualifications, while decreasing the burden of administering an extensive certification program.

Workload Reduction Strategy Information Sheet 7

1. Workload Reduction Strategy (WLRS):
   B. Increase Inspector Effectiveness and Efficiency Through Certification

2. WLRS Implementation Strategy:

No.	Description
7	**Require compatible or equivalent certifications for in-house inspectors, consultants, and contractors for the area of work they will be inspecting.**

3. Background and Context:
   There is a growing trend toward increased contractor QC/QA and outsourcing to consultants. Several DOTs have begun to move towards certification programs to ensure that inspectors on their projects are properly trained. As a result, state DOTs require compatible or equivalent certifications for in-house inspectors, consultants and contractors for the area of work they will be inspecting. This has been beneficial to maintain consistency of inspection on DOT projects regardless of who is the responsible party.

4. Specific Example or Application:
   1. South Carolina requires that anyone doing inspections on their projects has to be certified in the area that they are doing inspection. This includes in-house, consultants and contractors.
   2. Florida does not require inspectors to sit through the certification training course and allows them to just take the certifying exam. This is a way for workers with years of experience to get certified while reducing the time and money spent on certification.
   3. Wisconsin requires all workers to sit through the certification training. They will not allow workers to “test-out” of certification training because they want everyone to be familiar with their state’s specifications.

5. Reported or Expected Benefit:
   Requiring compatible or equivalent certifications for all parties working on TxDOT projects will improve consistency of inspection skills and qualifications. There are several options for how TxDOT will administer their particular certification program, but there needs to be emphasis put on consistency in an effort to maintain quality on their projects.

Workload Reduction Strategy Information Sheet 8

1. Workload Reduction Strategy (WLRS):
   B. Increase Inspector Effectiveness and Efficiency Through Certification

2. WLRS Implementation Strategy:

No.	Description
8	**Accept certain NICET and ASTM QC/QA certifications (to be selected by TxDOT experts).**

3. Background and Context:
   Accepting NICET & ASTM certifications will allow more consultants to work for TxDOT because many third-party consultants have these certifications already. Also allowing TxDOT inspectors to replace or augment TxDOT concrete certifications with NICET and ASTM might simplify TxDOT's concrete certification process. ASTM and NICET certifications are available for Asphalt, Soils, Concrete and Geotechnical.

4. Specific Example or Application:
   NICET & ASTM certifications are accepted by other public departments and many consultants are ACI & NICET certified, including Terracon (consulting firm), who is certified for NICET & ASTM and they are capable of doing more material testing.

5. Reported or Expected Benefit:
   TxDOT will be able to reduce their in-house certification programs that overlap with NICET and ASTM certifications. An increased number of consultants would be qualified to work for TxDOT because many consultants already have these certifications.

Workload Reduction Strategy Information Sheet 9

1. Workload Reduction Strategy (WLRS):
   B. Increase Inspector Effectiveness and Efficiency Through Certification

2. WLRS Implementation Strategy:

No.	Description
9	**Simplify TxDOT concrete certification process.**

3. Background and Context:
   TxDOT has its own concrete certification program. In some districts, ACI is also accepted for concrete but this is not standard throughout TxDOT and cannot replace TxDOT's certification. Many consultants are ACI certified for concrete because their other clients require such certification, especially clients that are private businesses.

4. Specific Example or Application:
   1. Require workers who will inspect concrete to have their ACI certification first before being eligible to complete the TxDOT concrete certification (including in-house personnel, third parties and contractors). The ACI certification will serve as a minimum base of knowledge for concrete inspection. As a result, the TxDOT concrete certification will be able to be modified to reduce duplication of training and focus on concrete inspection requirements specific to TxDOT.
   2. Replace TxDOT concrete certification with ACI certification for as many pay items as feasible.

5. Reported or Expected Benefit:
   Adapting the ACI concrete certification will allow more consultants and contractors to be qualified to work for TxDOT that are already ACI certified. Likewise, being able to reduce the TxDOT in-house certification for concrete will reduce in-house administration efforts.

Workload Reduction Strategy Information Sheet 10

1. Workload Reduction Strategy (WLRS):
   C. Outsource Testing and Inspection to a Third-Party

2. WLRS Implementation Strategy:

No.	Description
10	**Outsource inspection and measurement of low-risk pay items to third-party consultants.**

3. Background and Context:
   Low-risk pay items can consume a significant amount of inspector time because inspectors must test and measure these items to ensure compliance with specifications. Many districts reported that these items tend to receive less attention, which they feel is risky but necessary when the inspectors are busy and must carefully allocate their time. A preferred method for dealing with a lot of time-intensive, low risk pay items is to outsource the testing and inspection to a third-party consultant. This would free up TxDOT inspectors' time for monitoring high risk pay items.

4. Specific Example or Application:
   1. Outsource inspection and measurement of low-risk pay items including:
      a. Landscaping
      b. Seeding
      c. Traffic Stripes and Markers

5. Reported or Expected Benefit:
   Outsourcing low-risk items will free-up inspector time which can be better utilized on high-risk items. The low risk items would not be completely set aside, but would instead be inspected by a third-party, who may be inspecting numerous low risk items, resulting in a significant time-savings for TxDOT inspectors.

Workload Reduction Strategy Information Sheet 11

1. Workload Reduction Strategy (WLRS):
   C. Outsource Testing and Inspection to a Third-Party

2. WLRS Implementation Strategy:

No.	Description
11	**Outsource some specialty inspection items.**

3. Background and Context:
   Items that require specialty inspection training (such as welding) can be outsourced to third-party consultants, who are better able to maintain the skills and certifications necessary to perform the inspections. Currently, TxDOT has their own specialty inspectors who drive around various districts to perform inspections. Perhaps a more efficient method for completing these inspections is to hire highly-qualified third-party inspectors who are likely to be very responsive while also providing a skill that TxDOT needs.

4. Specific Example or Application:
   Inspection specialty items that could be outsourced include:
   1. Steel Painting
   2. Involving Hazardous Materials

5. Reported or Expected Benefit:
   It may not be very cost effective to keep in-house personnel qualified to perform specialty inspections, whereas using a third-party who performs these types of inspections for many clients might be very efficient. Third-party consultants can readily fill the demand for inspection of these items when needed, reducing TxDOT's need to have in-house inspectors trained to perform specialty inspections.

Workload Reduction Strategy Information Sheet 12

1. Workload Reduction Strategy (WLRS):
   C. Outsource Testing and Inspection to a Third-Party

2. WLRS Implementation Strategy:

No.	Description
12	**Use third-party consultant inspectors to perform inspection for SW3P.**

3. Background and Context:
   Currently, TxDOT performs inspections to ensure compliance with the SW3P (Storm Water Pollution Prevention Plan). These inspections are time consuming, and ensuring compliance requires multiple inspections throughout the project. Consequently, this activity might be outsourced to qualified third-party consultant inspectors using a professional service contract. These consultants would report the results (and potential violations) back to TxDOT so that TxDOT can ensure the contractor corrects any defects in the SW3P measures.

4. Specific Example or Application:
   One type of SW3P measure is silt fencing, which is used to prevent silt and debris from polluting nearby drainage culverts and ponds. A third-party consultant could be hired to check the silt fencing on a project weekly to ensure it is intact. Likewise, numerous other mitigation measures could be checked by the consultant on a routine basis. The consultant could verbally notify the contractor of the problem but inform TxDOT of the problem so TxDOT can officially notify the contractor to make a correction. An alternative option would be to put more liability on the Contractor by making them at least a co-permitee.

5. Reported or Expected Benefit:
   Because SW3P compliance inspections are so time consuming, outsourcing of SW3P can increase the amount of time available to TxDOT inspectors, which can be utilized for other duties. Likewise, the consultant can develop special expertise in these compliance inspections, which might result in noticing defects that might otherwise be missed by TxDOT inspectors (who must divide their time among many activities).

Workload Reduction Strategy Information Sheet 13

1. Workload Reduction Strategy (WLRS):
   C. Outsource Testing and Inspection to a Third-Party

2. WLRS Implementation Strategy:

No.	Description
13	**Completely outsource entire projects to consultants to manage and inspect all aspects of the project.**

3. Background and Context:
   In order to address the high number of projects but comparatively small in-house inspection force, state DOTs have begun to completely outsource entire projects to consultants to manage and inspect.

4. Specific Example or Application:
   1. The third-party inspectors are expected to have the same qualifications as required of DOT inspectors and will have the same responsibilities for verifying that the contractor is working in accordance with the project plans and specifications. The DOT will have full access to all of the third-party's inspection reports and testing results.
   2. The third-party consultant will be required to have a supervising engineer that will be responsible for reviewing all documents and test results before they are submitted to the DOT.
   3. In Florida and Virginia, they give entire projects to the consultant and only have one DOT employee who oversees them.
   4. In South Carolina, they completed an accelerated bonding program where they completed 27 years worth of work in 7 years, which was approximately 4 times their normal construction budget. During those seven years, they actually hired two experienced consulting firms to manage 100 projects. In the management of projects, it was anywhere from the complete development of the plan from proposals and field inspection to just doing the field inspection if they already had the plans developed.

5. Reported or Expected Benefit:
   The program in South Carolina went very well. Using third parties can assist in-house inspection forces if they lack the time, experience and/or training to effectively enforce quality control on their projects. By outsourcing entire projects, TxDOT would be able to better manage a high number of projects and make sure they are properly staffed with qualified inspectors without increasing the number of in-house inspectors. As a result, this will free-up in-house inspector time for other duties.

Workload Reduction Strategy Information Sheet 14

1. Workload Reduction Strategy (WLRS):
   D. Establish a More Extensive Contractor QC Program

2. WLRS Implementation Strategy:

No.	Description
14	Replace some TxDOT QC testing with more extensive contractor QC testing.

3. Background and Context:
   In order to reduce the in-house inspection workload, DOTs are shifting testing and inspection responsibilities over to contractors by requiring contractor QC. States DOTs interviewed that are currently requiring contractor QC include South Carolina, Florida, Arizona and Virginia.

4. Specific Example or Application:
   1. Require the contractor to have a separate, designated QC manager.
   2. In Virginia, the contractor is responsible for all the QC of the project, which covers several items, not just HMA. The contractor is responsible to build to a certain standard and the DOT oversees to verify if they met that standard.
   3. The DOT needs to review contractor QC results and their focus will be on verifying that the contractor's tests are accurate.

5. Reported or Expected Benefit:
   Overall, contractor QC programs shift some of the responsibility for sampling and testing over to the contractor. This has been successful at reducing the in-house inspection workload in DOTs that have implemented contractor QC. This will allow TxDOT to focus more on QA testing and acceptance.

Workload Reduction Strategy Information Sheet 15

1. Workload Reduction Strategy (WLRS):
   D. Establish a More Extensive Contractor QC Program

2. WLRS Implementation Strategy:

No.	Description
15	**Use contractor QC/QA results in lieu of TxDOT QC/QA results for measurement and as a basis for payment.**

3. Background and Context:
   There has been a general trend toward shifting the responsibility for QC/QA to contractors. In order to reduce the amount of time that in-house inspectors spend testing and measuring, Florida and Wisconsin have begun accepting contractor testing for payment and acceptance.

4. Specific Example or Application:
   1. Florida uses contractor testing for payment and acceptance. FDOT does not view this as a conflict of interest because they are verifying the tests and then paying the contractor based on their tests. If there is a difference in the testing, they have a resolution testing process. They have not had a problem with this.
   2. In Wisconsin, contractors do the majority of all the testing, which is QC. Quality Verification (QV) testing is done in-house or by consultants. QV is usually one for every 10 QC tests. The contractor QC testing is used for payment.

5. Reported or Expected Benefit:
   TxDOT inspectors spend a significant amount of time measuring for payment. Using the contractor's QC and measurements will free-up in-house inspector time for other duties. If the contractor is already testing and measuring items, it will decrease the duplication of effort if TxDOT does not go out and test and measure also. In-house inspectors will still verify the contractor's testing and measurements, but overall this will significantly reduce the amount of time they spend measuring.

Workload Reduction Strategy Information Sheet 16

1. Workload Reduction Strategy (WLRS):
   E. Shift Risk to the Contractor by Delegating Control

2. WLRS Implementation Strategy:

No.	Description
16	**Require the contractor to provide independent consultant QC/QA services.**

3. Background and Context:
   In order to augment limited in-house personnel, state DOTs have begun to use independent third parties that are retained by the contractor. The DOT is able to specify the required qualifications and responsibilities of the third-party inspectors, but the contractor will be responsible for administering the contract.

4. Specific Example or Application:
   1. Pay items that could be included in contractor provided independent consultant QC/QA services include:
      a. Seal Coat or Overlay
      b. Embankment
      c. Subgrade Compaction
   2. The third-party inspectors are expected to have the same qualifications as required of DOT inspectors and will have the same responsibilities for verifying that the contractor is working in accordance with the project plans and specifications. The DOT will have full access to all of the third-party's inspection reports and testing results.
   3. The third-party consultant will be required to have a supervising engineer that will be responsible for reviewing all documents and test results before they are submitted to the DOT.
   4. In Virginia, they had a few pilot projects with contractor QC/QA. The contractor hired an independent inspection firm and provided that service through the contract, where VDOT did some limited oversight and sampling. In these cases, the contractor had to hire an inspection firm that reported to VDOT. There was a potential conflict of interest because the consultant was hired and paid by the contractor but technically working for the state. However, it was successful but some projects required more oversight than others. Virginia has not fully embraced this as a way of doing business yet.

5. Reported or Expected Benefit:
   Using third parties can assist in-house inspection forces because they lack the time, experience and/or training to effectively enforce quality control on their projects. Instead of TxDOT directly outsourcing inspection services to a third-party and instead requiring the contractor to be responsible, they would reduce the administrative burden of managing the consultant contract. This would reduce in-house inspection efforts, while ensuring unbiased results.

Workload Reduction Strategy Information Sheet 17

1. Workload Reduction Strategy (WLRS):
   E. Shift Risk to the Contractor by Delegating Control

2. WLRS Implementation Strategy:

No.	Description
17	**Use Lump Sum or Plan Quantity approach to payment where the contractor certifies compliance so that TxDOT does not have to measure.**

3. Background and Context:
   DOT inspection staffs are spending a large amount of time measuring and verifying pay items. Inspector efficiency would be increased if certain measurement-intensive pay items were changed to Lump Sum or Plan Quantity.

4. Specific Example or Application:
   1. Florida recommends the following items as good Lump Sum candidates:
      a. Bridge Projects
      b. Fencing
      c. Guardrail
      d. Landscaping
      e. Lighting
      f. Seeding
      g. Sidewalks
      h. Signing
      i. Signals
      j. Traffic Stripes and Markings

      http://www.dot.state.fl.us/rddesign/PPMManual/2008/Volume1/zChap22.pdf
   2. Items listed in 4.1 above would also be beneficial as Plan Quantity to reduce the time spent measuring. The contractor would be required to certify the quantities to TxDOT for compliance to the Plans and Specifications.
   3. For Lump Sum items, require the contractor to provide a schedule of values to break out the quantities so TxDOT is able to quantify the cost of the changes, overruns and underruns.

5. Reported or Expected Benefit:
   Using Lump Sum and Plan Quantity will reduce the time inspection staff spends measuring in order to free-up inspector time for other duties.

Workload Reduction Strategy Information Sheet 18

1. Workload Reduction Strategy (WLRS):
   E. Shift Risk to the Contractor by Delegating Control

2. WLRS Implementation Strategy:

No.	Description
18	**Make the contractor responsible for collecting quantity tickets and delivering them to TxDOT on a daily basis.**

3. Background and Context:
   In several districts within TxDOT, inspectors are collecting tickets from trucks as they become available. Other districts are collecting tickets once or twice a day, while yet another district allows the contractors to collect tickets and drop them off with a TxDOT official. Collecting tickets is viewed as a very time consuming activity; consequently, a more efficient method for collecting tickets is to allow the contractors to collect their own tickets and give them to TxDOT at the end of the day.

4. Specific Example or Application:
   In an effort to use in-house inspector time more efficiently, the contractor should be responsible for collecting the quantity tickets from trucks coming on-site instead of having TxDOT inspectors collecting them. The contractor should turn-in these quantity tickets to TxDOT once a day. Tickets collected from trucks deliveries include:
   1. Treated Bases
   2. HMA

5. Reported or Expected Benefit:
   By shifting responsibility for collecting tickets from in-house inspectors to contractors, this will free-up inspector time for other inspection obligations.

Workload Reduction Strategy Information Sheet 19

1. Workload Reduction Strategy (WLRS):
   E. Shift Risk to the Contractor by Delegating Control

2. WLRS Implementation Strategy:

No.	Description
19	**Make the contractor responsible for on-site concrete testing (e.g. slump, air, temperature, making cylinders).**

3. Background and Context:
   TxDOT inspectors spend substantial time performing on-site concrete testing. It was suggested during our interviews that this responsibility could be shifted to the contractors in order to free up time for other inspection obligations. The contractor would perform the concrete tests, and TxDOT would implement a QA process whereby they check the contractors' results to ensure they are achieving the quality required and perform fewer of their own tests to verify the contractors' results.

4. Specific Example or Application:
   1. TxDOT may share testing risks with the contractor by requiring them to perform the following concrete testing and responsibilities:
      a. Slump
      b. Air Entrainment
      c. Temperature
      d. Making Cylinders
   2. TxDOT personnel may witness contractor testing. TxDOT may use the contractor's test results for acceptance.

5. Reported or Expected Benefit:
   Require the contractor to be responsible for on-site concrete testing in order to free-up TxDOT inspector time, which can be utilized for other duties. The contractor will also be involved in a more central role for controlling quality.

Workload Reduction Strategy Information Sheet 20

1. Workload Reduction Strategy (WLRS):
   F. Streamline Specifications to Simplify the Inspection Process

2. WLRS Implementation Strategy:

No.	Description
20	**Convert some specifications to performance-based specifications.**

3. Background and Context:
   There is a general trend within state DOTs to modify their specifications from prescriptive specifications to performance-based specifications. This change is slowly being developed as the responsibilities of state DOTs and contractors are being modified and redefined. TxDOT has, likewise, modified some specifications from prescriptive to performance. However, there are many other opportunities to convert various specifications within TxDOT to performance specifications.

4. Specific Example or Application:
   1. Potential pay items that could be converted to performance-based specifications include:
      a. HMA
      b. Landscaping
      c. Seal Coats
      d. Seeding
      e. Traffic Stripes and Markings
   2. Florida is moving towards more extensive performance-based specifications. FDOT is trying to get away from telling the contractor what to use. They are concerned about the end result.

5. Reported or Expected Benefit:
   Prescriptive specifications are used currently used most prevalently within state DOTs. The shift towards incorporating more performance-based specifications will simplify the measurement process to free-up inspector time for other duties. Likewise, performance specifications can be paired with warranties to allow the contractor to have more control over the quality of the product they provide while also providing some assurance to TxDOT that the product accepted will perform as expected. The best contractors will like this shift, but marginal contractors (or smaller contractors who are risk-averse) will resist implementation.

Workload Reduction Strategy Information Sheet 21

1. Workload Reduction Strategy (WLRS):
   F. Streamline Specifications to Simplify the Inspection Process

2. WLRS Implementation Strategy:

No.	Description
21	**Reduce the number of specifications and combine items and quantities for payment.**

3. Background and Context:
   It was brought to our attention that many pay items have numerous sub-items that create confusion and make inspection, testing, and measurement very difficult and time consuming. One example is striping, which anecdotally is reported as having "hundreds" of separate but similar items. The overwhelming feeling is that similar pay items should be combined into a single item.

4. Specific Example or Application:
   1. Pay items that need to be reduced include:
      a. Landscaping
      b. Signals
      c. Traffic Stripes and Markers
   2. California is currently in the process of streamlining their specifications in order to make it easier for bookkeeping and to reduce complexity.

5. Reported or Expected Benefit:
   Reducing the number of pay items will decrease complexity and confusion. In addition, it will simplify the testing, measurement, and payment process.

Workload Reduction Strategy Information Sheet 22

1. Workload Reduction Strategy (WLRS):
   G. Use Alternative Delivery Methods

2. WLRS Implementation Strategy:

No.	Description
22	**Use more Design-Build project delivery systems, where the design-builder provides QC (and possibly QA).**

3. Background and Context:
   Design-Build is emerging as an alternative delivery method for DOTs in contrast to traditional Design-Bid-Build. Design-Build combines design, construction and inspection into a single contract. Design-Build projects allow the contractor to participate early in the design process and as a result have been found to reduce costs and accelerate construction. While there are many benefits to this delivery method, perhaps one of the most important is the ability to make the D-B contractor responsible for their own testing and inspection. TxDOT can define their role as simply QA or Independent Assurance (IA).

4. Specific Example or Application:
   1. Design-Build alternative delivery contracts include:
      a. Design-Build
      b. Design-Build-Maintain
      c. Design-Build-Warranty
   2. Florida uses many design-build projects, which saves on inspection costs. It is a single point of responsibility where the Design-Build firm is responsible for design, construction and inspection services. Florida has created detailed Design-Build Guidelines.
      http://www.dot.state.fl.us/construction/DesignBuild/DB%20Rules/DesignBuildGuidelines.doc
   3. In Arizona, QC is the responsibility of the Design-Builder but QA sampling and testing is an option to be required by the Design-Builder. ADOT is always responsible for Quality Verification, Independent Assurance and final acceptance. Arizona has created a detailed Design-Build Manual. http://www.azdot.gov/Highways/ConstGrp/PDF/DesignBuildGuide.pdf

5. Reported or Expected Benefit:
   Design-Build projects have proven to reduce costs and accelerate the construction process. In addition, there is a significant reduction in inspection time required by the DOT because the design-builder assumes quality responsibilities and documentation. Incorporating a maintenance or warranty period into a design-build contract will also increase the contractor's focus on quality. In Arizona, the payment method is lump sum with an agreement as to monthly payments according to the contractor's schedule. This also reduces inspector time usually spent measuring.

Workload Reduction Strategy Information Sheet 23

1. Workload Reduction Strategy (WLRS):
   H. Optimize the Use of Inspection Resources

2. WLRS Implementation Strategy:

No.	Description
23	**Reduce the amount of time inspectors spend testing at the HMA plant.**

3. Background and Context:
   Inspectors are spending a significant amount of time testing at the HMA plant. In Virginia, inspectors have been removed from the HMA plant and have instead focused on field sampling. The responsibility of plant testing has been shifted to plant employees through a certified HMA QC/QA bond and weigh program.

4. Specific Example or Application:
   1. Replace an employee who works full-time at the HMA plant with an employee who works part-time at the plant and only pulls samples twice a day. This will allow the inspector to spend more time inspecting and testing at the site.
   2. Take HMA samples at the site in lieu of taking samples at the plant. Taking samples at the site instead of at the plant would reduce the need for TxDOT inspectors to be present at the plant all the time. The results from the on-site testing can be used and substituted for plant samplings.
   3. Virginia uses a certified HMA QC/QA bond and weigh program where non-DOT plant employees are certified in an effort to reduce TxDOT inspectors at the plant. They took their people out of the HMA plants several years ago and do QC/QA at the site now. The field inspectors will take the temperature, density testing, visual inspection (lay down, straight edging, roller patterns, etc.) to inspect and accept the product. The plant materials inspectors are asphalt plant employees who go through the VDOT certification program and then are bonded. The batch operator, the bond and weigh person, will send VDOT a form once a day that specifies how many tons of asphalt were sent to that project that day. If the tickets do not add up to that total, then they will deduct the difference from the tickets delivered on-site.

5. Reported or Expected Benefit:
   By reducing or eliminating the time inspectors spend at the plant, this will allow inspectors to work more efficiently by spending their time on other duties on-site.

Workload Reduction Strategy Information Sheet 24

1. Workload Reduction Strategy (WLRS):
   I. Implement the Usage of Technology to Decrease Inspection Requirements

2. WLRS Implementation Strategy:

No.	Description
24	**Use equipment technology for the measurement of temperature and segregation in HMA.**

3. Background and Context:
   Advances in technology have proven to increase productivity and efficiency among workers in all industries. Within DOTs around the country, machines such as Intelligent Compactors and pavers with thermal imaging bars are performing tasks that inspectors used to perform manually. This use of equipment technology can be very time-efficient, by providing computer printouts of stiffness, temperature, etc., that are recorded automatically rather than taken manually. Hence, there are a few technologies that are currently available (or will be soon) that can be used to reduce the inspection workload and increase inspection efficiency.

4. Specific Example or Application:
   A few applications include:
   1. Infrared bars for the temperature measurement and thermal segregation of HMA
   2. Intelligent compactors that record density/stiffness of compacted base

5. Reported or Expected Benefit:
   By incorporating technology into projects, inspectors could spend time on other activities while the machines could be used to augment the inspectors' activities. As new technologies become available, TxDOT should endeavor to be on the cutting edge – their road network is large, and consequently, the time-savings might be substantial.

Workload Reduction Strategy Information Sheet 25

1. Workload Reduction Strategy (WLRS):
   I. Implement the Usage of Technology to Decrease Inspection Requirements

2. WLRS Implementation Strategy:

No.	Description
25	**Modify specification to allow the replacement of density measurement with stiffness in order to encourage the use of high-tech "Intelligent Compactors".**

3. Background and Context:
   Intelligent Compaction (IC) is an evolving technology in the US but in Europe it has been widely used for several years. IC refers to vibratory rollers that are equipped with units that measure stiffness and temperature during compaction. This will control compaction to prevent under-compaction and over-compaction of materials. This technology can be applied with common highway materials, including soils, aggregate and HMA.

4. Specific Example or Application:
   1. The high-tech "Intelligent Compactors" measure stiffness. The current specification would have to be modified to allow for the replacement of density measurement with stiffness.
   2. IC provides precise and consistent compaction results and also provides detailed documentation of compaction quality and temperature. This could reduce the time that in-house staff spends taking density and temperature measurements. Instead they would simply have to review the documented results that the IC provides.
   3. The documentation results that the IC provides could also be used as contractor's proof of performance. This may be used as a basis for pay of bonus and penalties, as well as for performance related to warranties.
   4. In the future, the data and material properties collected from IC could be used to develop performance-based specifications that correlate long-term performance and properties produced during construction.

5. Reported or Expected Benefit:
   There are several benefits associated with integrating IC technology in TxDOT specifications. The inspector workload would be reduced significantly because of the reduction in density measurements. IC automatically adjusts compaction, which will allow for more consistent compaction and increased quality on projects. The IC documentation results could be used for several purposes including QC documentation, determination of bonus and penalty pay, performance-based specifications and warranties.

Workload Reduction Strategy Information Sheet 26

1. Workload Reduction Strategy (WLRS):
   I. Implement the Usage of Technology to Decrease Inspection Requirements

2. WLRS Implementation Strategy:

No.	Description
26	**Standardize information provided to contractors for input into GPS controlled construction machinery.**

3. Background and Context:
   Currently GPS controlled construction machinery is being used by many construction companies across the country. TxDOT needs to standardize information provided to contractors so that this technology can be implemented on TxDOT projects.

4. Specific Example or Application:
   1. Contractors should be encouraged to use GPS controlled construction machinery. As a result, TxDOT needs to provide digital files to the contractor for input into the GPS controlled construction machinery.
   2. In-house inspectors will not have to spend time verifying survey and instead can check that the GPS units are calibrated properly. This will reduce inspection time as a result.
   3. The GPS controlled construction machinery potentially could increase consistency and quality on the project with the use of automated construction.

5. Reported or Expected Benefit:
   Using GPS controlled construction machinery has the potential to save time and money on TxDOT projects. This will significantly reduce the time inspectors spend verifying survey and could increase quality on projects because of the accuracy the technology provides.

Workload Reduction Strategy Information Sheet 27

1. Workload Reduction Strategy (WLRS):
   J. Reduce Paperwork and Data Entry

2. WLRS Implementation Strategy:

No.	Description
27	**Use off-the-shelf shared-access software system for contractors to submit required inspection data and reports.**

3. Background and Context:
   Inspectors spend a great deal of time on administrative duties. By using a shared-access software system, they will be able to better manage and track in-house and contractor inspection data and reports. In addition, there could be additional project documentation that could be controlled by this system.

4. Specific Example or Application:
   1. Use a web-based fully automated system like Constructware® so that contractors can upload electronic paperwork and efficiently communicate with TxDOT for items such as:
      a. RFIs
      b. Transmittals
      c. Submittals
      d. Meeting Minutes
      e. Change orders
      f. Reports
   2. Create a way for contractors to upload their QC/QA testing and inspection reports for review by TxDOT.

5. Reported or Expected Benefit:
   TxDOT inspectors could save a substantial amount of time by improved efficiency of data entry and management. In addition, using a software system like Constructware ® will allow for documents to easily be created, tracked and stored in the system.

   NOTE: We are not endorsing Constructware®, but we do think the concept of a web-based software system like Constructware® can be used efficiently within TxDOT.

Workload Reduction Strategy Information Sheet 28

1. Workload Reduction Strategy (WLRS):
   K. Implement Performance Warranties and Warranty Bonds

2. WLRS Implementation Strategy:

No.	Description
28	**Work with industry and contractors to establish contractor supplied long-term incentivized performance warranty (non-bond based) on specific pay items.**

3. Background and Context:
   Florida requires contractors to provide a "Value-Added" warranty on select pay items, which are negotiated with industry that requires the contractor to meet certain criteria or threshold at the end of a specified number of years. There is no surety bond associated with this type of warranty. Instead, if the contractor fails to replace the pay items during the warranty period, FDOT will revoke the contractor's prequalification status or right to do work for FDOT for a minimum of 6 months. There is a general trend within state DOTs to modify their specifications from prescriptive specifications to warranties. This change is slowly being developed as the responsibilities of state DOTs and contractors are being modified and redefined.

4. Specific Example or Application:
   Pay items that are covered under Florida's "Value-Added" warranties include:
   1. Bridge Components: Performance Period of 5 years
   2. Highway Lighting System: Performance Period of 3 years
   3. HMA : Performance Period of 3 years
   4. Portland Cement Concrete Pavement: Performance Period of 5 years
   5. Signal Installation: Performance Period of 3 years

5. Reported or Expected Benefit:
   One main benefit of this type of warranty is that the risk is shifted to the contractor without requiring the contractor to take out a surety bond, which can sometimes prove to be difficult. In Florida, "Value-Added" warranties have been successful at reducing FDOT's inspection obligation. In addition, these performance warranties will reduce the amount of post-construction maintenance requirements for TxDOT.

Workload Reduction Strategy Information Sheet 29

1. Workload Reduction Strategy (WLRS):
   K. Implement Performance Warranties and Warranty Bonds

2. WLRS Implementation Strategy:

No.	Description
29	**Require surety-issued warranty bonds on specific pay items.**

3. Background and Context:
   Florida requires surety-issued warranty bonds on select pay items in order to reduce the amount of in-house inspection that has to take place during construction. There is a general trend within state DOTs to modify their specifications from prescriptive specifications to warranties, which specify performance after a predetermined time in service. This change is slowly being developed as the responsibilities of state DOTs and contractors are being modified and redefined.

4. Specific Example or Application:
   1. Pay items that are covered under Florida's warranty bond requirement include:
      a. Landscaping: 1 year warranty bond for maintenance, survival and condition of all landscape items
      b. Traffic Signals: 90-day warranty bond for repair or replacement
      c. Traffic Stripes and Markings: 5 yr warranty bond for the total sum bid
   2. Additional pay items suggested to be covered under a warranty bond include:
      a. HMA
      b. Seal Coats (because they often experience failures)

5. Reported or Expected Benefit:
   In Florida, landscaping is not a problem anymore since they have required the warranty bond. If the contractor is responsible for maintenance and repair of select pay items, this will relax selected inspection obligations because the risk is now shifted over to the contractor.