U.S. Department of Transportation

Federal Highway Administration

Program Review

Office of Infrastructure

Program Management Improvement Team

National Review on Nonstructural Precast Concrete Elements

February 2012









FINAL REPORT

U.S. Department of Transportation
Federal Highway Administration

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Executive Summary

One of the purposes of the national review on nonstructural precast concrete elements was to review the acceptance processes for state highway agencies (SHA) to determine if they allow for enough oversight of precast concrete producers to minimize the risk of material not meeting the specifications for nonstructural precast concrete elements. The other purpose was to verify if producers placed steel reinforcement in the precast concrete elements in accordance with applicable shop drawings and specifications. After conducting field reviews on nine SHAs and 39 precast concrete producers from September through November 2011, the review team found only one out of the nine SHAs reviewed, had a comprehensive approach to manage the construction oversight and acceptance of nonstructural precast concrete elements. The eight SHAs not considered to have comprehensive approaches, did have varying degrees of oversight and acceptance processes as described in the Review Results of Acceptance Processes included in Appendix A. The one SHA with a comprehensive approach still had some areas in need of improvement. Most of the SHAs chosen for this review were selected based on deficiencies identified in their programs through a National Survey on the acceptance of nonstructural precast concrete elements conducted by the Office of Infrastructure. Due to this selection process, the percentage of states without comprehensive approaches is higher than what exists nationally. However, the National Survey showed there is still a high occurrence of SHAs without comprehensive approaches.

As part of the field reviews, electronic equipment capable of scanning the steel reinforcement in precast concrete elements was used to verify if the elements were fabricated with the required steel reinforcement. The results of the nondestructive testing conducted revealed all elements had steel reinforcement. For the most part, the steel reinforcement was found to be placed in accordance with applicable shop drawings and specifications. The few instances where the review team was unable to determine the cover and spacing were due to factors such as difficulties operating nondestructive testing equipment or the lack of availability of shop drawings, both addressed in the recommendations below. While these results provide some assurance to FHWA that precast concrete producers are using the required steel reinforcement in the precast concrete elements, it does not completely eliminate the need for SHAs to include verification testing as part of their ongoing acceptance activities. Therefore, the review team is encouraging SHAs to consider the use of some form of verification testing including nondestructive testing as part of their comprehensive approach to oversight and acceptance of nonstructural precast concrete.

The review resulted in six recommendations with the primary recommendation being to encourage SHAs to improve their comprehensive approach to oversight and acceptance of nonstructural precast concrete elements. The other five recommendations support improvements in a comprehensive approach. The following is a summary of the recommendations included in the Observations and Recommendations section of this report:

- The FHWA Office of Infrastructure will provide guidance on a comprehensive approach to oversight and acceptance of nonstructural precast concrete that encourage SHAs to strengthen their programs.

- The Office of Infrastructure will include within the guidance on a comprehensive approach to oversight and acceptance, discussion on the SHAs keeping their standard drawings and specifications current for nonstructural precast concrete and ensuring producer shop drawings are reviewed and approved when they vary from SHA standard drawings.

- The Contract Administration Group within the Office of Infrastructure will provide guidance to SHAs on the Buy America requirements for nonstructural precast concrete.

- The Office of Infrastructure will initiate contact with the appropriate organizations, not limited to National Transportation Products Evaluation Program to develop methods to improve the use of third party organizations as part of the comprehensive approach to the oversight and acceptance of precast concrete elements.

- The Office of Infrastructure Research and Development will issue a research project to develop recommended procedures for nondestructive testing (Recommendation 5) and visual inspection (Recommendation 6) of completed precast concrete elements.

Background

Precast concrete elements are those concrete elements produced at a precast fabrication plant instead of cast-in-place at a project site. The use of precast concrete offers many advantages for SHAs over cast-in-place construction at a project site such as precast concrete elements are delivered to projects ready to install reducing the construction time by eliminating the need to place the forms and reinforcement, pour the concrete, wait for the element to cure and strip the forms. Also, precast concrete elements are typically produced under a roof in a controlled environment while cast-in-place elements are exposed to environmental factors which can directly affect the product quality.

While precast concrete offers many advantages over cast-in-place, it does require the SHA to have some type of acceptance processes to address the oversight on the production of the precast concrete elements to ensure product quality and workmanship. Precast concrete elements are typically divided into structural and nonstructural elements. Structural precast concrete elements such as bridge items are treated as a high risk item requiring close oversight by the SHA. Whereas nonstructural precast concrete elements such inlets, manholes, end-walls, etc. are generally accepted with less oversight due to the elements having a lower risk of impact to the traveling public if there is a failure.

The quality assurance oversight of nonstructural precast concrete elements varies greatly between states. Some SHAs provide minimal plant inspections and verification testing while others inspect the precast concrete plants frequently and have strong specifications to govern the qualifications and quality management system practices for a precast concrete fabrication plant. The differences in SHA quality assurance oversight can be attributed to a number of factors including performance histories, SHA resources, overall maturity of the SHA Quality Assurance Program and interpretation and assignment of risk for the nonstructural precast concrete elements. In particular, many SHAs have in recent times reduced SHA personnel providing oversight without adjusting the acceptance processes to cover risks of nonconforming work.

On Federal-aid projects, the guidance on acceptance processes for manufactured items including precast concrete elements is governed through the non-regulatory supplement of 23 CFR 637 (see Appendix E). Paragraph 2(n) of the supplement encourages SHAs to perform a risk analysis when developing acceptance processes for manufactured items such as precast concrete elements. When performing a risk analysis, the SHA should consider the use of the product, safety, cost and the historical quality of the product. The acceptance processes should draw from a full range of activities such as an initial and yearly evaluation of the producer; review and approval of the producer's quality control plan; inspection of precast plants by the SHA; evaluation of producer material certifications; verification testing; and visual inspection of the completed elements at the plant and/or project site. The frequency of when these activities occur should be included as part of the acceptance processes based on the risks associated with the specific product.

In addition to FHWA acceptance guidance, there are national standard specifications and testing procedures covering precast concrete elements that are provided by the American Association of State Highway and Transportation Officials (AASHTO) and the American Society for Testing and Materials (ASTM). Please see Appendix E. These national specifications and procedures provide additional guidance on the quality of nonstructural precast concrete.

One of the reasons for the need of a review on nonstructural precast concrete elements was the recent investigations by the United States Department of Transportation Office of Inspector General (US DOT OIG) on precast concrete producers. In August 2005, a precast producer of drainage assemblies such as catch basins was found to have falsely certified the drainage assemblies conform to Connecticut Department of Transportation's specifications. Upon further evaluation, one shipment of several drainage assembly components accompanied with the producer's certification in 2001, did not meet Connecticut DOT's specifications because the components lacked the reinforcing steel.

In September 2011, the US Attorney General in Maryland announced an employee working for a precast producer pleaded guilty to falsely certifying precast concrete elements being delivered to federally-funded projects met the Maryland State Highway Administration requirements. US DOT OIG investigations during the summer of 2007 revealed the Maryland producer provided several precast concrete elements that contained the wrong number and/or type of steel rebar pieces in their frames. Other elements were fabricated with unapproved substitutions of wire mesh in place of steel rebar. Review of the producer's records also revealed several precast structures didn't meet the minimum strength requirements, yet were certified to be in compliance.

In November 2009, the Tennessee Department of Transportation (TDOT) discovered a precast pipe end-wall section did not contain the required reinforcing steel bars shown in a TDOT Standard Drawing. This triggered TDOT and the FHWA Tennessee Division Office to conduct further reviews. As of March 2011, numerous precast pipe end-wall sections and catch basins produced by Tennessee's three major precast producers were found out of compliance with TDOT's Standard Drawings. The US OIG is currently investigating these producers.

With what appeared to be a growing trend of precast producers providing nonstructural precast concrete elements in which the reinforcing steel was not in compliance with SHA specifications, the FHWA Office of Infrastructure sent out a National Survey to the FHWA Division Offices by Memorandum dated June 9, 2011. The intent of the National Survey was to determine what activities are included in the acceptance processes of SHAs for nonstructural precast concrete elements. The survey included questions on the initial approval of producers, review of the producer's quality control plans, SHA inspection frequency, material certifications, verification using destructive or nondestructive testing and visual inspection of the final products. The results showed that very few states provided full-time plant inspection for the production of nonstructural precast concrete elements, but rather had varying frequencies of inspection from

periodic to none. Also, over two-thirds of states didn't perform any kind of verification testing of completed nonstructural precast concrete elements. Additionally, only five out of 52 FHWA Division Offices had reviewed nonstructural precast concrete within the last five years.

With the limited plant inspections, lack of verification testing on completed elements and the recent incidents in three states in which nonstructural precast concrete elements were supplied that did not meet the contract requirements, the Office of Infrastructure was concerned there may be issues with the production of nonstructural precast concrete at a national level and determined a National Review on Nonstructural Precast Concrete Elements was needed. The Office of Infrastructure contacted the FHWA Program Management Improvement (PMI) Team regarding setting up the national review in August 2011. A review team was formed and the work plan and team charter were created (see Appendix C). On September 1, 2011, a webinar was hosted by the Office or Infrastructure for the materials representatives from the FHWA Division Offices and members of the review team to kick off the beginning of the National Review on Nonstructural Precast Concrete Elements.

Purpose and Objective

One of the purposes of this national review was as follows: 1) Determine if State highway Agencies (SHA) have acceptance processes in place to reduce the risk of non-specification material in nonstructural precast concrete elements; 2) Verify SHAs are following the acceptance processes; and 3) Evaluate what should be included as part of the acceptance processes. The acceptance processes are used by an SHA to determine if completed nonstructural precast concrete elements such as walls, inlets, manholes and pipes meet the SHA specifications. These acceptance processes for nonstructural precast concrete elements are typically made up of a full range of activities such as initial evaluation of the product; review and approval of the manufacturer's quality control plan, periodic plant visits; a material certification; verification testing; and visual inspection at the plants. The frequency of these activities should be included as part of the acceptance processes based on the risks associated with the specific product.

The other purpose of this review was to verify if producers are complying with the SHA requirements for the specified steel reinforcement in the precast concrete elements. The review team used nondestructive testing equipment to test completed precast concrete elements at each of the plants visited when available. The testing allowed the team to determine if steel reinforcement was placed in the elements in accordance to applicable shop drawings and specifications.

Scope

The team conducted field reviews in eight states from September through November 2011. States were largely selected based on the information from the National Survey. In particular, candidate where chosen from those state highway administrations with infrequent plant inspections and limited verification testing. Most of the states selected had infrequent to no periodic inspection of plants producing nonstructural precast concrete elements. All eight states selected had limited verification testing with none conducting destructive or nondestructive testing to determine if the required amount reinforcement steel was in the nonstructural precast concrete elements and only some states taking cores or cylinders to check concrete compressive strength.

There were other factors that went into the selection of states. One such factor was to provide a geographical representation of the entire country. Another was some FHWA Division Offices requested a review of their State while others declined due to schedule or resource conflicts. The following states were selected:

- North Carolina, September 12-16, 2011
- Maine, September 19-23, 2011
- New Jersey, October 17-21, 2011
- Wisconsin, October 17-21, 2011
- Kentucky, October 31-November 4, 2011
- Colorado/Wyoming, October 31-November 4, 2011
- Florida, November 14-18, 2011
- Missouri, November 14-18, 2011

The review of Colorado/Wyoming was conducted on five producers in Colorado, but included the Wyoming Department of Transportation (WYDOT) because four of the producers visited were approved to provide precast concrete for WYDOT. After being made aware of the comprehensive approach of the New York State Department of Transportation for managing the oversight and acceptance of precast concrete, the review team conducted an interview on their program as a way to benchmark their successful practices against the programs of the SHAs reviewed. Please refer to the Successful Practices section of this report.

Once the states were selected and the dates of the review were established, the review team worked with the FHWA Division Office and SHA for the selected state to choose the producers to visit during a weeklong field review. For the field reviews, four to six producers were selected to be visited over a three day review period. The producers were selected based on following criteria:

- Producers actively fabricating precast concrete elements over the past year for the SHA;

- Logistics involved with traveling to the producers and SHA Materials' Office;
- Sampling of national, regional and local producers;
- Mixture of producers who are and aren't third party certified; and
- Variety in types (inlets, walls, manholes, etc.) of nonstructural precast elements that were not being inspected full-time by the SHA.

Once the precast concrete producers were selected, a schedule was developed based on a weeklong field review in each state. The schedule involved a kick off meeting, visits to precast producers and a closeout meeting. The kick-off meeting was typically with the SHA and the FHWA Division Office on the first day and involved a discussion on the purpose of the review and an overview of the acceptance program of the SHA for precast concrete elements. Over the next three days, the team visited the selected precast concrete producers to review their operations and the associated SHA oversight to determine if the acceptance procedures of the SHA were being followed. Finally, the team closed out with the SHA and the FHWA Division Office at the end of the week by providing a report on observations and suggestions for improvement to be considered by the SHA and FHWA Division Office.

Methodology

The review team developed and utilized three checklists (see Appendix D) to provide the framework for completing the field reviews. The Program Checklist was utilized at the kick-off meeting to better understand the acceptance processes currently being used by the SHA. Such acceptance processes include the qualification of precast producers, periodic inspection of precast plants, verification testing and acceptance at the projects. The Plant Checklist was used for reviewing the producer's operations and processes and the SHA inspection at the plant. The Project Checklist covered reviews of material certifications and visual inspections of completed products at the project site. The plant reviews were much more critical to obtaining the needed information for this national review than the project reviews. Therefore, the Project Checklist was used only once on a field review because of the limited number of plants to review in that state.

In addition to the checklists, the review team utilized nondestructive testing on completed precast concrete elements to determine if steel reinforcement was placed in the elements in accordance with the applicable SHA standard specifications and drawings. For two of the reviews (Maine and New Jersey), the team used a Mira Tomographer which operates on a form of ultrasonic pulse-echo method testing as way to conduct nondestructive testing on completed precast concrete. This piece of equipment required an experience technician to operate. The technician was provided by FHWA's Office of Infrastructure Research and Development at Turner-Fairbank Highway Research Center. Due to funding and availability constraints, the team used pachometers on the other six reviews. Recommendation 5 discusses the team's experiences

using the MIRA Tomographer and the pachometer and some of the differences between the two devices.

Following the completion of all field reviews in November 2011, the team began compiling the results of the field reviews. A checklist results matrix was developed based on the answers from the checklist questions. National trends in SHA acceptance programs were identified and analyzed. Based on the analysis, observations and recommendations were developed by the review team. The observations and recommendations have been reported back to the Office of Infrastructure for action.

Team Members

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Observations and Recommendations

1. **SHA Acceptance Processes:**

Observation: The review team found only one out of the nine SHAs reviewed, had a comprehensive approach to manage the construction oversight and acceptance of nonstructural precast concrete elements. The other eight SHAs did have varying degrees of oversight and acceptance processes as described in the Review Results of Acceptance Processes included in Appendix A. Even the one SHA with a comprehensive approach still had some areas in need of improvement. Most of the states had not completed full risk assessments of different classifications of precast concrete elements which is necessary for a comprehensive approach. This was evident by the inconsistencies in SHA inspection frequencies for specific types of precast concrete elements. As an example, three of eight states were inspecting box culverts (up to 20-foot spans) at a similar frequency as lower risk non-load bearing precast elements. In many instances, light and sign pole structure foundations, traffic barriers, MSE walls, etc. were being treated with the same risk as lower risk elements.

None of the FHWA Division Offices in the nine states reviewed has assessed the nonstructural precast concrete programs of their SHAs recently. In addition, the National Survey from the Office of Infrastructure found only five of the 52 FHWA Division Offices had conducted reviews on precast concrete elements in the last five years. Compounding the lack of reviews, most of the personnel in the FHWA Division Offices of the states reviewed were found to have limited experience and knowledge of nonstructural precast concrete.

Discussion: A comprehensive approach to managing the construction oversight and acceptance processes for nonstructural precast concrete is not required by Federal regulations. The comprehensive approach established for making acceptance decisions on nonstructural precast elements should be based on the risks associated with the specific product while complying with SHA and national requirements. A periodic risk assessment should be completed on specific classifications of nonstructural precast concrete elements to take into account failures of manufactured items and include assessments of safety, road user impacts and replacement costs. Typically a high, medium, low risk level is assigned to a manufactured item or class of manufactured items. Each risk level is associated with acceptance procedures, ranging from 100% quality assurance inspection for high risk items to Manufacturer's Certifications for low risk items. The acceptance procedures should also consider the frequency of plant inspections and other aspects of quality assurance such as periodic non-destructive and destructive testing (verification testing) of the producer's completed products.

Recommendation 1: The Office of Infrastructure should write a Technical Brief to encourage SHAs to develop a more comprehensive approach that will improve their construction oversight and acceptance processes for making acceptance decisions on

nonstructural precast concrete elements. The Brief should discuss developing a comprehensive approach based on a risk assessment of the different classifications of precast elements and should take into consideration the Review Results of Acceptance Processes in Appendix A. It should be written at a fundamental level that will ease the implementation.

Recommendation 1A: Once the technical brief has been completed, the Office of Infrastructure should provide training through a webinar or other means to assist the FHWA Division Offices in becoming familiar with this information.

Recommendation 1B: Following the training on the technical brief, the Office of Infrastructure should request the FHWA Division Offices meet with the SHA personnel responsible for Nonstructural Precast Concrete Programs in their states. The Division Office and SHA should evaluate their program based on the technical brief and determine if improvements are needed. Based on the results of the evaluation, the Division Office should decide if a field review is needed on the acceptance processes for nonstructural precast producers in their State.

Recommendation 1C: The Office of Infrastructure should consider assessing the status of the Division Office evaluations of their state's acceptance processes for non-structural precast concrete elements again in 2014.

2. **Standard Drawings and Specifications and Producer Shop Drawings:**
Observation: State highway agencies are often not ensuring standard drawings and associated approvals are kept up to date. At least seven out of nine states had not updated their standard drawings for nonstructural precast concrete elements in over five years. In at least two of the states, it was difficult to determine the required steel reinforcement in the drawing details which led to inconsistencies in shop drawings at the precast plants. In another state, the standard drawing showed only standard deformed bar type reinforcing steel, but the producers were using welded wire fabric in lieu of deformed bar as allowed by AASHTO, without the SHA's knowledge or approval. In another state, polypropylene fibers were allowed to be used in the concrete mix design as a substitute for the required steel reinforcement in structures with diameters of four-feet or less. This substitution was permitted without any kind of engineering analysis conducted to provide criteria of when fibers could be used in lieu of steel reinforcement and how fiber dosage amounts were determined and recorded. In discussion with one state, they were aware some of their elements may not have enough steel reinforcement for construction placement of depths greater than 10 feet.

In addition to SHAs ensuring standard drawings are kept up to date, they are, not reviewing and approving shop drawings that differ from standard drawings. Seven states were found to not be approving or keeping up with the approval of drawings submitted by the producers as changes to the SHA standard drawings occurred.

Discussion: The SHAs should keep their standard drawings current because it assists with the following: 1) Lessens the need for producers to submit shop drawings for variations to be approved; 2) Improves consistency with the latest AASHTO, ASTM and other industry standards; and 3) Improves product quality by reducing/eliminating ambiguous details which lead to subjective interpretation by producers. It is important that shop drawings are required to be reviewed periodically by the state for the following reasons: 1) Ensures the shop drawings match a Standard Drawing or if they deviate, then approved by the State; 2) Allows more consistency with the shop drawings of the different producers within a state; and 3) Enables the State and other groups to better audit producers to ensure quality control processes are being followed by the producer; and 4) Provides another means for states to keep up with industry changes. By SHAs updating their standard drawings on a regular basis and reviewing and approving any producer's shop drawings that don't match the standard drawings, it deters producers from not providing the required steel reinforcement in precast concrete elements as follows: 1) It lets the producer know there is an expectation that precast concrete elements are fabricated to requirements and 2) It provides industry an opportunity to provide input anytime they believe the design for a specific precast concrete element needs modified.

Recommendation: The Office of Infrastructure should include guidance in the Technical Brief (Recommendation 1) regarding SHAs keeping their standard drawings and specifications current for nonstructural precast concrete and encouraging SHAs to review and approve shop drawings periodically (at least annually) to ensure the producer's shop drawings match the SHA standard drawings.

3. **Buy America Requirements:**

Observation: While all producers appear to be utilizing steel products that were melted and manufactured in the United States, some of the producers were not providing the necessary certifications that they were meeting the Buy America requirements. Of the 39 producers examined during this review, only three producers appeared to have foreign steel at their plant and they were able to demonstrate this steel was not being used in SHA products. However, in six of the eight states, there were two to three producers per state that the team was unable to match a tag of a steel product currently being used by the precast producers to a mill certification on file. The team found that four of nine states did not require a certification of compliance for completed elements from producers and none of the states require this certification to include a statement that the producer has met the requirements of Buy America. Producers in many states are using tie guns to assist with the fabrication of precast concrete elements which require a compatible tie wire reel to operate the device that may not be manufactured by American companies.

Discussion: The Buy America Requirements listed in 23 CFR 635.410 apply to nonstructural precast concrete items. The producers need to demonstrate through their processes and procurement documentation that they are meeting these requirements. The team had the following concerns:

- On many occasions, the team was unable to match a tag of a steel product currently being used by the precast producers to a mill certification on file. While being able to match a tag with a mill certification is a minimum that would be expected from a producer, it is unclear if more should be required. Based on discussion with the SHAs and producers, the guidance provided by FHWA on the Buy America requirements is not clear what is required of producers to meet these requirements.

- The certification of compliance provides verification that the producer certifies the completed elements meet the material requirements of a contract. This includes compliance with the Buy America requirements. As part of the Technical Brief in Recommendation 1, SHAs will be encouraged to require producers to provide a certification of compliance for all precast elements fabricated for Federal-aid projects. A good practice for ensuring precast producers are aware of the Buy America Requirements is to encourage SHAs to require the producer's certification of compliance include a statement that the producer has met the requirements of Buy America.

- During one of our last field reviews, it was brought to the team's attention that there are no manufacturers of the steel tie wire used in tie guns that can meet the Buy America requirements. Therefore, producers in that state were not using tie guns on precast in that state for Federal-aid projects. The team did observe producers in most of the other states using tie guns. Although it has not been confirmed, there does not appear to be any American manufacturers of steel tie wire for tie guns. Therefore, if the steel tie wire used for tie guns doesn't meet the Buy America requirements then tie guns can't be used to tie steel reinforcement in precast concrete elements and other construction items incorporated into Federal-aid projects.

Recommendation 3A: The Contract Administration Group within the Office of Infrastructure should provide greater guidance on the Buy America Requirements for nonstructural precast concrete elements. SHAs should be encouraged to require the producer's certification of compliance to include a statement that the producer has met the requirements of Buy America.

Recommendation 3B: The Contract Administration Group should confirm there are no American manufacturers of steel tie wire for tie guns. If there are not any American manufacturers, then the FHWA Division Offices should be notified tie guns can't be used to tie steel reinforcement in precast concrete elements or any other item incorporated into Federal-aid projects. The team also recommends the FHWA's Buy America Questions and Answers for Federal-aid Program be updated to address that until tie wire for tie guns meets the Buy America requirements, tie guns can't be used on Federal-aid projects.

Recommendation 3C: As part of the Technical Brief on a comprehensive approach to managing construction oversight and acceptance processes on nonstructural precast concrete elements, the Office of Infrastructure should include a discussion on responsibilities of SHAs for ensuring the Buy America requirements are met.

4. **Use of Third Party Certification Organizations for Qualifying Producers**

Observation: Six of nine SHAs required third party certifications from National Industry certification organizations such as the National Precast Concrete Association (NPCA) and the American Concrete Pipe Association (ACPA) as part of their acceptance program. One state had implemented a local certification program being run by its industry organization using criteria approved by the state. The team observed third party certifications being used to replace or supplement state qualification of producers. Three states that required third party certifications used it to replace their annual SHA qualification inspection. While these Industry sponsored third party certification appear to have robust standards for evaluating precast concrete producers to help ensure quality to meet industry standards, with the exception of the local program they did not cover many SHA specific requirements. Such SHA requirements include the review of the following: concrete mix designs and source materials, shop drawings to ensure they match SHA standard drawings and/or were approved by the SHA, reinforcing steel to ensure they meet the Buy America requirements, and segregation protocols for domestic and foreign steel. The team also observed that the annual plant evaluations completed by third party organizations had some inconsistencies in the final scores or rating assigned to production facilities. The review team observed some producers with lesser quality control processes and standards were receiving higher annual audit scores than higher quality producers. Additionally, the locally-developed program of one state did not provide the level of quality of the national organizations.

Discussion: With the increasing pressure on SHA's to restrain personnel and operational costs, the team sees a trend indicating states are becoming more interested in incorporating the use of third party organizations into their acceptance processes. The programs we saw during this review are fee-based programs, fee borne by the producers, and are renewed annually with a plant inspection and documentation review. This model is common throughout the transportation sector with other products making use of a similar approach. While the model is common, there are no guidelines for states to follow when making the determination to include a third party organization into its acceptance process. SHAs have nothing to go by to determine if the existing organizations are adequate to meet the need or what criteria should be used to establish a new local or regional program.

The review team visited fabrication plants that were certified through programs sponsored by NPCA and ACPA and reviewed the documentation from the certification process of those individual precast plants. The team observed significant benefits to making use of third party certifications which can lead to reducing SHA risk when properly incorporated with other SHA oversight activities. The team does not feel that it should be used as a wholesale substitute for SHA oversight activities, such as initial, annual and periodic inspections at the

production facility. While the scope of the review did not include a detailed evaluation of third party certification programs, including qualification of assessors, we did observe enough inconsistency and, in the case of the state with the local program, weaknesses to conclude SHAs would benefit from guidance on how to effectively incorporate third party certifications into their acceptance processes. Significantly, when the review team pointed out the weaknesses in the local program, both SHA and Division Office agreed with each observation made and began to address them with the industry certification sponsor.

Recommendation: The FHWA Office of Infrastructure should initiate contact with the appropriate organizations, not limited to National Transportation Products Evaluation Program to develop methods to improve the use of third party certifications in the acceptance processes for precast concrete products.

5. **Nondestructive Testing:**

Observation: The team had difficulty determining the best equipment to use for conducting nondestructive testing on completed precast concrete elements at the precast fabrication plants. The biggest challenge was the lack of information available on the capabilities, operational knowledge required and the cost to purchase nondestructive equipment.

Discussion: One of the purposes of this review was to verify if producers are placing the steel reinforcement in the precast concrete elements as required. The review team used nondestructive equipment to test completed precast concrete elements at each of the plants visited. The tests determined if the steel reinforcement in the elements was placed in accordance with the applicable shop drawings or specifications. Prior to starting the review, review team members met with the FHWA's Nondestructive Evaluation Team located in Turner-Fairbank Highway Research Center to determine what equipment FHWA might have available that could be easily operated and provide the best results. Based on this meeting, the review team chose the pachometer and a MIRA Tomographer to conduct nondestructive testing on precast concrete elements found in the precast plant stockyards for all eight states reviewed.

Two pachometers were used on six of the state reviews. These devices used were found to be relatively easy to operate. The devices typically confirmed if there was steel reinforcement in the elements for depths less than three inches, the cover and roughly the spacing of the steel. The device did not provide the size or type of steel reinforcement.

A MIRA Tomographer was utilized by the review team in two states. This device is based on pulse echo ultrasonic method and was complex enough to require a technician to operate it. The team didn't get a true gauge of the device's capabilities because even the technician was inexperienced operating the device. It was possible to determine if steel was in the element and it did provide a rough idea of spacing and cover. It was difficult to tell the size or type of steel.

The nondestructive equipment did seem to have potential to scan precast concrete elements to determine if the steel reinforcement met requirements. The advantage of the devices is they can be easily utilized during plant inspections and on project sites and are less expensive overall than destructive testing. The concern is with the accuracy the devices. Also, the MIRA Tomographer required a trained technician to operate.

Recommendation 5: The Office of Infrastructure Research and Development should issue a research project to develop recommended procedures for nondestructive testing of completed precast concrete elements. The project should determine the accuracy, precision, ease of operation and cost of the nondestructive test equipment, as well as recommended procedures for using the equipment to evaluate precast concrete elements. This recommendation can be implemented in combination with the visual inspection research project discussed in Recommendation 6.

6. **Visual Inspection of Completed Nonstructural Precast Concrete Elements by the SHA:**
Observation: All of the states reviewed had limited to no acceptance criteria for completing a visual inspection on completed nonstructural concrete elements. They did not have strong guidelines for visual inspection and a listing of repairable and allowable defects of the completed nonstructural precast concrete elements. These visual inspection criteria are applicable at both the precast fabrication plant storage yard as well as inspection at the project site.

Discussion: Project staff should visually inspect all products delivered to a project to make sure the product is not damaged prior to installation and that the product matches with the material certification provided by the manufacturer for that product. Field inspection personnel at the project site should understand the visual inspection criteria to use for inspection of these products. The criteria should include discussion on the types of defects such as cracks, honeycombing, bug holes, spalling, scaling, delamination, exposed reinforcement, etc. It should also include the severity, patterns, location and orientation. Visual inspection criteria, with a clear definition of what quality characteristic(s) will be measured should be incorporated as a critical element of any specification. Guidance on visual inspection criteria would also be valuable for visual inspections completed by SHA inspectors and producers at the precast plant.

Recommendation 6: The Office of Infrastructure Research and Development should issue a research project to develop recommended procedures for visual inspection of completed precast concrete elements. The project should produce a visual inspection reference guide for use by inspectors to evaluate the acceptability of precast elements delivered to the jobsite or at the precast plant. The reference guide should clearly define the quality characteristics that will be used for inspection. This recommendation can be implemented in combination with the nondestructive research project discussed in Recommendation 5.

Successful Practices

Successful Practice 1:
The New York State Department of Transportation (NYSDOT) and the Florida Department of Transportation (FDOT) were observed to exhibit effective acceptance processes for nonstructural precast concrete elements. The review team conducted an interview on the comprehensive approach of NYSDOT for managing the construction oversight and acceptance processes for precast concrete elements as a way to benchmark their successful practices against the programs of the SHAs reviewed. The NYSDOT acceptance processes for their precast concrete program requires initial and annual qualifications of producers and has six stages of production status for their qualified producers list. NYSDOT typically conducts over 500 audits per year on their 23 approved precast producers. The audits occur annually with both their central office and regional staffs and periodically with regional personnel comprised of both state employees and consultants. NYSDOT obtains cores from randomly selected elements to test compressive strength and air content with the frequency based of production rate growth. Material Procedure No: 09-02 is a well organized manual establishing the requirements and procedures precast producers must follow to be qualified. Please refer to Appendix B for a more detailed discussion of the NYSDOT acceptance processes for nonstructural precast concrete.

The acceptance processes of FDOT were examined as part of this review and found to include many successful practices as follows:

- FDOT reviews the qualifications of producers initially and annually. The reviews include a yearly evaluation of the producer's quality control plan and an annual audit of the producer's plant by central and district office personnel.

- FDOT district offices conduct inspections of the producer's plants monthly for incidental precast concrete elements and quarterly for precast concrete drainage elements. During the quarterly inspections for the drainage elements, cores or cylinders are taken and compressive strength is checked.

- FDOT has an excellent system for assuring the qualifications of the producer's quality control personnel and requires producer personnel responsible for sampling and testing to be reviewed as part of the independent assurance program.

- FDOT keeps their standard drawings updated. In addition, the producers' shop drawings were found to rarely deviate from the standard drawings and when they did, were approved by FDOT.

- FDOT participates in quarterly meetings with industry. The FDOT Materials manual provides the expectations for quality assurance to producers and FDOT personnel and helps to ensure consistency throughout the state.

Please refer to Appendix B for a more detailed discussion of the FDOT acceptance processes for nonstructural precast concrete.

Successful Practice 2:
Colorado Department of Transportation (CDOT) Procedure 11 (CP 11) requires each production facility provide a Quality System Manual (QSM) on an annual basis. The QSM includes such items as the mix designs, shop drawings for the products produced, an inventory of major equipment used for sampling and testing, a list of quality control personnel along with their testing certifications. The mix design is reviewed so that CDOT can check to ensure that the constituent materials such as the reinforcing steel, concrete and admixtures are on the CDOT approved product lists.

Successful Practice 3:
Six of nine states require nonstructural precast concrete plants to be certified by third party organizations for at least some classes of precast concrete elements. The third party organizations include the National Precast Concrete Association, American Concrete Pipe Association and Precast Concrete Institute. The review team observed these organizations to complete thorough reviews on the plants that resulted in documented improvements to the plants' quality control processes. Industry sponsored third party certification appear to have robust standards for evaluating precast concrete producers to help ensure quality to meet industry standards. For example, these organizations require the plants to have very detailed quality control plans. While, the use of third party organizations to certify precast concrete organizations is a good practice, it does not relieve SHAs of their obligations. Therefore, third party certifications should be used to complement the oversight of precast concrete producers by SHAs. Through Recommendation 4 of this report, the team requested further development of methods to improve the use of third party organizations in the acceptance processes for precast concrete products.

Conclusion

The review team conducting the National Review on Nonstructural Precast Concrete Elements achieved the review purposes of evaluating the acceptance processes of State Highway Agencies (SHA) and verifying if producers are using the required steel reinforcement in the precast concrete elements. The review team found only one out of the nine SHAs reviewed, had a comprehensive approach to manage the construction oversight and acceptance processes of nonstructural precast concrete elements. The other eight SHAs did have varying degrees of oversight and acceptance processes as described in the Review Results of Acceptance Processes in Appendix A. The one SHA with a comprehensive approach still had some areas in need of improvement. Most of the SHAs chosen for this review were selected based on deficiencies identified in their programs by a National Survey on the acceptance of nonstructural precast concrete elements conducted by the Office of Infrastructure. Due to this selection process, the percentage of states found in this review to not have comprehensive approaches is higher than what exists nationally. However, the National Survey showed there is still a high occurrence of SHAs without comprehensive approaches.

Based on these results, the review team made several recommendations focused on improving the oversight and acceptance processes for SHAs on nonstructural precast concrete elements. While there are no federal regulations requiring oversight and acceptance processes for nonstructural precast concrete, it is considered a good practice. The principal recommendation for this review is the writing of a technical brief to assist SHAs in the development of a comprehensive approach to manage the construction oversight and acceptance processes of nonstructural precast concrete elements. The comprehensive approach should be based on full risk assessments of different classifications of precast concrete elements.

The other purpose of this review was to verify if producers are using the required steel reinforcement in the precast concrete elements. The review team conducted nondestructive testing by using electronic equipment to scan completed precast concrete elements to determine if the steel reinforcement in the elements was placed in accordance with the applicable shop drawings or specifications. The review team found all 94 precast concrete elements tested had steel reinforcement. For most of the precast elements, the team was able to determine the steel reinforcement for the elements had the required cover and spacing in accordance with applicable shop drawings and specifications. The instances where the review team was unable determine the cover and spacing were due to factors such as difficulties operating nondestructive testing equipment or the lack of availability of shop drawings. These results should provide some assurance to FHWA that the incidents in the three states in which producers were investigated by the US DOT OIG for not providing the required steel reinforcement in the precast concrete elements were somewhat isolated. However, it does not completely eliminate the need for SHAs to include verification testing as part of their ongoing acceptance activities. The sample checked was small and none of the states reviewed were using any forms of verification testing to check if completed precast concrete elements had the required steel reinforcement. Therefore, the

review team is encouraging SHAs consider the use of some form of verification testing including nondestructive testing as part of their comprehensive approach to oversight and acceptance of nonstructural precast concrete.

Acknowledgements

This National Review of Nonstructural Precast Concrete Elements could not be completed without the contributions of numerous individuals, agencies and offices. The Team acknowledges the contributions of the Office of Infrastructure and the FHWA Division Offices, state highway agencies and selected precast concrete producers in the following states: North Carolina, Maine, New Jersey, Wisconsin, Kentucky, Colorado, Wyoming, Florida, Missouri and New York.

Appendices

Appendix A

Review Results of Acceptance Processes

Review Results of Acceptance Processes

One of the main intents of this review was to evaluate the programs of the state highway administrations (SHA) for making acceptance decisions on nonstructural precast concrete elements. The programs should involve a comprehensive approach to managing the construction oversight and acceptance processes of nonstructural precast concrete elements. The review team found only one out of the nine SHAs reviewed, had a comprehensive approach. The eight SHAs not considered to have a comprehensive approach, did have varying degrees of oversight and acceptance processes. This observation regarding lack of a comprehensive approach by many SHAs is based on the results of this review as discussed in this section. This section will first explain the need of SHAs to strengthen their requirements for nonstructural precast concrete and then follow with discussion of the acceptance processes that make up a comprehensive approach.

SHA Requirements

The requirements for producers' quality control processes varied greatly between states and from producers who are third party certified to those who are not. The national specifications and testing procedures provided by AASHTO and ASTM provide the requirements and guidance for these quality control processes. The industry standards of third party certification organizations such as the National Precast Concrete Association (NPCA) and the American Concrete Pipe Association (ACPA) build further on the guidance for producers to control their quality processes. The nonstructural precast concrete specifications for SHAs should consider meeting these requirements and guidelines as a minimum. The following are observations on the producer's quality control processes:

SHA Requirements for Producers Quality Control:

Review Result: The requirements for producers' quality control processes varied greatly among states and between producers who were and were not third party certified as follows:

- Five of nine states lacked sampling and testing frequencies for testing plastic properties such as slump, air content, concrete temperature, and unit weight on a daily and/or lot basis.
- Most of the SHAs reviewed deviated from AASHTO/ASTM Standards such as the following:
  - Most SHAs failed to require absorption tests. Some producers were conducting annual absorption tests to satisfy national third party certification requirements, not SHA Specifications.
  - Many SHAs failed to conduct ladder rung load testing annually as called for in AASHTO M 170 for precast concrete manholes.
  - Many SHAs failed to conduct annual pull test on welded splices of wire hoops as required by AASHTO M 170.

- Process controls for concrete batching varied significantly:
  - Five of nine states do not require daily moisture content of aggregate, to adjust water in the concrete mix design.
  - In some states, producers relied solely on the aggregate gradations from the supplier and never checked them at the plant. Many states lacked a sampling and testing frequency for aggregate gradation at the precast plant.
- At least six states don't require concrete cylinders to be broken to test compressive strength for stripping forms and four states don't require final design strength to be achieved prior to shipping.
- Seven of nine states don't require pre-pour and post-pour checklists.

Discussion: SHAs should ensure producers are in compliance with the national specifications and testing procedures and the industry standards for the above observations as follows:

- Testing plastic properties such as concrete temperatures, slump, air content, unit weight, etc. are industry recognized quality indicators to insure quality concrete.
- AASHTO/ASTM Standards have requirements SHAs should be enforcing such as conducting absorption tests to gauge the durability of the concrete used in the precast items.
- Checking daily moistures of aggregates ensures the water/cement ratio are kept within specification allowances and reduces process variability. Checking moistures daily and gradations periodically for aggregates are industry standards.
- Stripping and shipping strength tests requirements ensure elements are not prematurely stripped from their forms or shipped without meeting certain minimum compressive strength requirements.
- SHA minimum requirements for pre-pre and post-pour checklists ensure producers understand the SHA's areas of greatest concern and have incorporated these areas into the quality control processes.

Acceptance Processes

A comprehensive approach to managing the construction oversight and acceptance processes for nonstructural precast concrete entails selecting from the following group of activities: Qualification of Producers, Periodic Inspections, Verification Testing and Acceptance at the Projects. The activities and their frequencies should be based on a risk assessment for the type of precast concrete elements to take into account failures of manufactured items and includes assessments of safety, road user impacts and replacement costs.

SHA Qualification of Producers:

Review Result: Many SHAs were not conducting initial and annual reviews to qualify precast concrete producers. The SHAs in four out of the nine states did not conduct an initial review of producers to qualify them. Six of nine SHAs did not conduct annual reviews of producers with SHA personnel to determine if the producers have maintained qualification. The evaluations from the initial and subsequent annual reviews are typically used to place and maintain producers on a Qualified Producers List (QPL). Three of the nine SHAs did not have a QPL for nonstructural precast concrete producers. Two of these three states had not conducted initial reviews of the producers before placing these plants on the QPL. For the six states that had a QPL for nonstructural precast concrete producers, only three states conducted annual reevaluations of the qualified producers using state staff and two states rely solely on third party certification organizations such as the National Precast Concrete Association (NPCA) and the American Concrete Pipe Association (ACPA) for maintaining active status on lists.

Discussion: The review of producer qualifications should be completed initially and annually to evaluate if a producer has the personnel, equipment, facilities and procedures in place to produce quality precast elements for the SHA. The SHA should review the producer to make sure they are able to control the quality and workmanship of manufactured materials incorporated into projects to ensure they're in compliance with the SHA specifications. As a way to track qualified producers, SHAs should consider developing and maintaining a QPL for producers approved to fabricate precast concrete elements for a SHA. The QPL should be updated at least annually and whenever the status of a producer changes. The process can be used by the SHA to suspend or disqualify a producer when they're not performing up to SHA expectation and/or requirements.

With the current makeup of the third party certification programs, the review team recommends caution with using third party organizations as the sole source of information for the initial and annual qualification reviews of producers. Instead, third party organizations should only be used to complement the SHA's reviews, not replace them. These third party organizations complete industry plant certifications focused on ensuring that candidate precast concrete producers and their management, inspection staff and related business practices all lead to quality products that meet industry standards. These certification programs are a fee-based program, fee borne by the producers, and are renewed annually with a detailed plant inspection. What the team observed on a limited basis was third party certifications were being used to replace or supplement state qualification of producers. While the industry-sponsored third party organizations appear to have robust standards for evaluating precast concrete producers to ensure their products and fabrication processes meet industry standards, they did not cover SHA specific requirements. Such SHA requirements include the review of concrete mix designs and associated source materials, the approval of shop drawings to ensure the manufacturing methods and finished products match what is required by the SHA standard drawings, enforcement of Buy America requirements for reinforcing steel, and assurances segregation protocols are in place to control the use of domestic and foreign steel at a plant. There were other observations with the certification programs of third party organizations that are discussed further in Recommendation Number 4.

It should be noted the team visited precast concrete plants that were approved by the certifications programs of the NPCA and the ACPA and reviewed documentation from the certification process of those individual plants. However, the scope of the review did not include a detailed evaluation of third party certification programs including qualification of assessors, processes to assure consistency and statistical accuracy of reporting. As such, the team is not in a position to be able to identify all potential strengths and weaknesses of these programs. However, based on the reviews, third party organizations should only be used to complement the SHA's reviews, not replace them. Involvement of third party organizations beyond this would require a further evaluation beyond the scope of this review.

As part of the initial and annual reviews of producers' qualifications, the SHA should review shop drawings, producer quality control plans, concrete mix designs and source materials, and qualifications of producers' testing personnel. Among the nine states reviewed, SHA review of these activity components varied greatly as follows:

Shop Drawings:
Review Result: Only two of nine states were found to be approving or keeping up with the approval of drawings submitted by the producers as changes to the SHA standard drawings occurred.

Discussion: It is important that shop drawings are required to be reviewed periodically by the state for the following reasons: 1) Ensures the shop drawings match a Standard Detail or if they deviate, then approved by the State; 2) Allows more consistency with the shop drawings of the different producers within a state; and 3) Enables the State and other groups to better audit producers to ensure quality control processes are being followed by the producer; and 4) Provides another means for states and producers to keep up with industry changes in standards or production innovations. This concern is addressed in Recommendation Number 2.

Quality Control Plans:
Review Result: Five of nine states do not require precast producers to provide quality control plans (QCP) as an integral part of the qualification process for producers. For some of the states requiring a QCP, the requirements don't go beyond those found in the National Industry Certification Process (third-party organizations). While other states expand upon these requirements to address state specific quality concerns, such as review and approval of shop drawings, concrete mix designs and associated source materials and enforcement of Buy America requirements for Federal-aid funded projects. One of the states requiring a QCP did not have specifics quality control requirements.

Certifying third party organizations require producers to have quality control plans that outline their complete business and production processes as they relate to ensuring product quality. However, these organizations fall short on requiring and reviewing state specific concerns such as mix designs and Buy America procurement documentation for reinforcing steel on Federal-aid projects.

Discussion: A Producer's QCP is the blueprint or roadmap into how the precast producer will conduct business to ensure quality products. It addresses organizational structure related to product quality, inspection technician qualifications and production and laboratory equipment calibration protocols and annual certifications. It covers specifics on approved concrete mix designs; production capabilities; fabrication requirements such as the types of forms used; pre-pour checklists; post-pour check lists; sampling and testing frequencies; curing processes such as hot and cold weather pours and curing conditions; and procedures for marking, shipping and handling elements. The producer's quality control plan is created to define and control the operational techniques and activities performed or conducted to fulfill contract requirements.

Without state requirements and reviews of the producer's QCP, the SHAs lose an opportunity to ensure elements are fabricated in compliance with the SHA's requirements. The business processes defined in the QCP can provide an excellent framework for periodic and/or annual plant inspections by SHAs. SHAs should require producers to provide QCPs annually as part of the SHA's Producers Qualification Approval process. Also, the third party certification organization requirements for a quality control plans should complement and incorporate the SHA's requirements.

Mix Designs and Associated Source Materials:
Review Result: Four of nine states do not review and approve concrete mix designs for nonstructural precast concrete elements. One of the states did not have a qualified list of approved aggregates. Most states did have approved product lists for cement, aggregates, admixtures, etc. However, since some are not approving concrete mix designs, it was unclear if approved materials from acceptable sources were being checked. Third party organizations were not consistently checking the mix designs.

Discussion: Review and approval of concrete mix designs and their composite ingredients are a critical element to producing quality nonstructural precast concrete elements and require minimum effort if the ingredients are already included on qualified/approved product lists. Review of the mix designs by the SHA or an organization representing the concerns of the SHA should be part of periodic reviews of producers. While SHAs may decide not to require the approval of a mix design, as a minimum, the mix design review should ensure the ingredient materials are from approved sources and the review is documented.

Qualifications of Producers Testing Personnel:
Review Result: Most states required an American Concrete Institute certification for the producer's personnel conducting the sampling and testing. Only two of nine states had their own SHA certification for sampling and testing. One of the nine states required the producer's personnel to be independently evaluated through that state's independent assurance program which provides added assurance that the producer's personnel are qualified and is considered a best practice.

Discussion: All Inspection Personnel should be qualified through SHA, local/regional technician certification programs, or nationally recognized construction technician certification programs, such as American Concrete Institute, Level I Certification.

SHA Periodic Inspection:

Review Result: Six of nine states did not conduct any periodic inspections of nonstructural precast concrete producers. None of the states were conducting full-time inspection on nonstructural precast concrete. For the states providing periodic inspections, the inspection frequency varied from weekly to quarterly.

Discussion: Periodic inspections involving spot checks on the producers during fabrication of SHA Precast elements is one way to ensure the producers are following the SHA's requirements. Inspectors should not only verify specific fabrication details, but they should also validate that the producers are complying with their Quality Control Plan. Such reviews include examining items such as pre-pour and post-pour checklists, current status of certified quality control plant technicians, proper concrete batching procedures (aggregate gradation, moistures, SHA approved source materials), mill certifications for reinforcing steel on the shop floor, proper curing methods employed, product marking, handling and storage. These are the same components covered under the Qualifications of Producers. The frequency of the periodic inspections should be based on a risk analysis of the specific nonstructural precast concrete elements being reviewed as well as the other acceptance activities being utilized. Other factors should also be taken into consideration such as production rates and performance histories.

Many states mentioned a shortage of resources as a problem for providing an adequate number of periodic inspections. As part of their risk assessment of nonstructural precast concrete elements, SHAs should consider balancing periodic inspections with other activities such as verification testing. Another option is to use consultants to supplement the SHA's periodic inspections of precast concrete plants similar to one state discussed in the Successful Practices Section. Also, as a way to support periodic SHA inspections, the reviews completed by third party organizations can be used to complement the SHA's reviews as previously discussed in the section called the SHA Qualification of Producers.

As part of their periodic inspections, SHAs should ensure precast concrete producers are meeting the Buy America Requirements. The review team found significant number of precast producers were not meeting these requirements as discussed below and addressed in Recommendation Number 3.

Buy America Requirements:

Review Result**:** While all producers appear to be utilizing steel products that were melted and manufactured in the United States, some of the producers were not providing the necessary certifications that they were meeting the Buy America requirements. Of the 39 producers examined during this review, only three producers appeared to have foreign steel at their plant and they were able to demonstrate this steel was not being used in SHA products. However, in

six of the eight states, there were two to three producers per state that the team was unable to match a tag of a steel product currently being used by the precast producers to a mill certification on file. The team found that four of nine states did not require a certification of compliance for completed elements from producers and none of the states require this certification to include a statement that the producer has met the requirements of Buy America. Producers in many states are using tie guns which may be using foreign tie wire to assist with the fabrication of precast concrete elements.

Discussion: The Buy America Requirements listed in 23 CFR 635.410 apply to nonstructural precast concrete items. The producers need to demonstrate through their processes and procurement documentation that they are meeting these requirements. SHA inspectors should check to see if the tag of a steel product currently being used by the precast producers matches a mill certification on file. Also, inspectors should ensure tie wire for tie guns meets the Buy America requirements. These Buy America concerns were carried forward in Recommendation Number 3.

Verification Testing:

Review Result: The review team found limited verification testing on completed nonstructural precast concrete elements. None of the nine states reviewed were conducting any forms of destructive or nondestructive testing on completed nonstructural precast concrete elements to verify the required amount of reinforcement steel was being used in the elements. Checks on concrete compressive strength of the elements was limited with only one state taking cores (twice a year) and another state obtaining and breaking cylinders for some precast elements on a quarter-yearly basis. Four of the seven states were witnessing three-edge bearing tests on concrete pipe, but the frequency varied greatly from weekly to yearly.

The limited verification testing observed during this review is consistent with the results of the National Survey discussed earlier in this report. The survey showed that over two-thirds of the states do not perform random verification testing on completed elements to determine if the concrete has the required compressive strength and the reinforcing steel has been placed in compliance with the SHA standard drawings and specifications or the SHA approved shop drawings. Of the one-third states conducting verification testing, most are only checking compressive strength.

Discussion: Verification testing validates that the products meet certain State and/or ASTM/AASHTO requirements. In the case of nonstructural precast concrete elements, verification testing by destructive or nondestructive testing validates if the reinforcing steel placed in the element meets requirements such as size, type, spacing and cover. Nondestructive testing involves the use of equipment that has the capability of scanning the element to gather information on the steel reinforcement in an element without damaging the element. Destructive testing used for determining if the element meets steel reinforcement requirements entails methods varying from completely breaking an element to doing something less damaging that can be repaired such as coring. Coring can also be used for taking concrete samples (in lieu of cylinder samples) that can be tested to confirm the completed elements are meeting the minimum

compressive strength requirements. The three-edge bearing test on reinforced concrete pipe is a destructive method used to verify both design and ultimate strength as sampling of the production lot.

The frequency of verification testing will depend on the types of testing used and the level of inspection provided by the SHA for a specific nonstructural precast concrete element. In deciding the type and frequency of verification testing, the SHA should consider nondestructive testing can be performed at a much greater frequency and lesser cost than destructive testing, but is typically less accurate. Please see Recommendation Number 5 for the discussion on nondestructive testing accuracy. For nondestructive testing, the states with electronic systems that track elements can base the frequency of testing off of the elements produced. Nondestructive testing can also be included as part of routine periodic plant inspections or onsite project reviews. The frequency of destructive testing should be a sufficient number of tests to effectively deter producers from fabricating products that are not in compliance with SHA requirements. This number of destructive tests should be statistically based. A combination of nondestructive and destructive testing may work best.

Ultimately, the amount of verification testing must also be balanced with the amount oversight at the plant. In situations where the SHA is unable to conduct production oversight to ensure precast elements are built to the state's requirements, verification testing of end products provides a means for ensuring the elements are in compliance. When allowing the production of nonstructural precast concrete elements without SHA oversight, verification testing reduces the owner's risk of precast concrete elements being incorporated into Federal-aid projects that don't comply with SHA specifications.

Acceptance at Projects:

Acceptance of nonstructural precast concrete elements at the projects should be based on the shipped precast concrete elements being accompanied with a Certification of Compliance and the elements being visually inspected by the project personnel.

Certification of Compliance:

Review Result: Four of nine states did not require a certification of compliance for completed elements from producers. In addition, two of these states did not conduct periodic plant or annual inspections.

Discussion: A producer certification of compliance that the completed product meets the material requirements of a contract is a good practice for the precast concrete elements which receive limited inspection at the producer's plant if other acceptance process activities are in place. It shifts the liability from the SHA to the producer to take corrective action for nonstructural precast concrete elements not meeting the SHA specifications.

SHAs should ensure only qualified and responsible personnel from the Producer are signing the Certifications for Compliance. The qualifications of the personnel should be outlined in the Producer's Quality Control Plan and meet the SHA's minimum requirements.

Visual Inspection of Completed Nonstructural Precast Concrete Elements by the SHA:
Review Result: All of the states reviewed had limited to no acceptance criteria for completing a visual inspection on completed nonstructural concrete elements. They did not have strong guidelines for visual inspection and a listing of repairable and allowable defects of the completed nonstructural precast concrete elements. These visual inspection criteria are applicable at both the Precast Fabrication Plant storage yard as well as inspection at the project site.

Discussion: Project staff should visually inspect all products delivered to a project to make sure the product is not damaged prior to installation and that the product matches with the material certification provided by the manufacturer for that product. Field inspection personnel at the project site should understand the visual inspection criteria to examine these products. The criteria should include discussion on the types of defects such as cracks, honeycombing, bug holes, spalling, scaling, delamination, exposed reinforcement, etc. It should also include the severity, patterns, location and orientation. Visual inspection criteria, with a clear definition of what quality characteristic(s) will be measured should be incorporated as a critical element of any specification. Guidance on visual inspection criteria would also be valuable for visual inspections completed by SHA plant inspectors and producers at the precast plant. Recommendation Number 6 in the next section of this report advocates a research project to provide guidance on how to conduct a visual inspection on completed nonstructural precast concrete elements.

Appendix B

Successful Practices Supplements

Successful Practices - The New York State Department of Transportation

In addition to the eight states visited, the team reached out to New York State Department of Transportation (NYSDOT) to learn about their Precast Concrete Quality Control/Quality Assurance (QC/QA) Program, considered by many to have one of the highest levels of oversight for these products. Details of NYSDOT Precast Concrete QC/QA Program can be found in Material Procedure (MP) 09-02 at the following link: https://www.dot.ny.gov/divisions/engineering/technical-services/materials-bureau/forms-manuals

This program establishes the requirements and procedures precast manufacturers must follow in order to be placed, and remain on the NYSDOT's Approved List of Precast Concrete Manufacturers Approved for QC/QA Production. The QC/QA program provides industry the ability to independently control their production process and provide timely delivery of product while at the same time providing the Department with assurances that product of acceptable quality is produced on a consistent basis. The procedure applies to precast products manufactured under a conventional 'wet cast' process. It is not intended to cover precast products manufactured under a "dry cast" or "zero slump" process.

Each precast manufacturer must be certified by either National Precast Concrete Association (NPCA) or Precast Concrete Institute (PCI); however, NYSDOT goes well beyond the Industry Certification Program Quality Control Plan requirements and has outlined its own Quality Control Plan (QCP) requirements that cover topics such as Facility Certification and Approval, Personnel Certifications, QC Policies and Procedures, Production Policies and Procedures, Training, and Internal Quality Assurance. Annually, each manufacture must submit their QCP to NYSDOT for approval.

NYSDOT has six stages of production status, beginning with how to obtain Approval List Status, to Initial Production, Routine Production, Probationary Production, to Inactive Status and finally Approved List Removal.

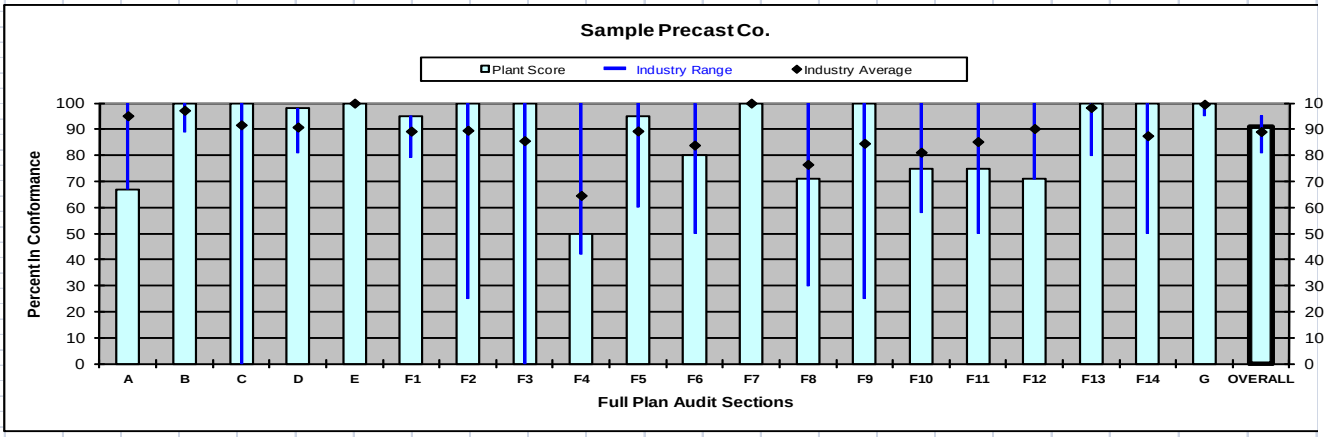
The heart of the program is the Department Audits conducted on the 23 Precast Plants who provide material to SHA projects. A handful of these plants are located in adjacent states and require out-of-state travel for auditors to monitor the quality program in these plants. The audit process is used to measure and document a manufacturer's compliance with their QCP and Department Specifications. The Department's auditors are granted full access to all production, storage and record keeping areas of the plant. It is the auditor's role to observe, document and report their findings. It is the manufacturer's responsibility to review the findings and take corrective action as necessary. Although manufacturers are expected to react to non-conformances identified on audit reports, they are strongly encouraged to be proactive in identifying and correcting problems before they are identified on an audit. A manufacturer's status on NYSDOT's QC/QA program of supply is determined, in part, by the results of audit findings. Repeat failure to correct non-compliant findings may result in removal from the Approved List.

There are three types of Audits conducted by NYSDOT Staff or by their Consultant Services Inspection staff. Routine audits are conducted once every two weeks by Regional based staff closest to the precast manufacturer's plant. These audits focus on one segment of the QCP. The next is an Annual Audit conducted by both Regional staff and Main Office Material Bureau staff. The Annual Audit is a detailed comprehensive look at the entire QCP, which typically can last 2 days or more. An exit interview is conducted with the precast manufacturer's staff to discuss the audit findings and required action items identified for formal follow-up. Lastly, is a Project Site Audit where Regional staff and/or Main Office staff will conduct a audit on manufacturer's shipped items to the project where the auditor will evaluate the quality and condition of the delivered precast elements, review supporting manufacturer's documentation and report on the findings. Included in these audits are evaluations of overall quality of the finished product, is it properly marked and a review for any repaired areas and were they approved repairs, and lastly the properly prepared manufacturer's certification received with the unit.

The program also incorporates the use of Monitoring Cores. The department will monitor the manufacturer's production of SHA precast items by obtaining cores from randomly selected precast products and test the cores to assure compressive strength and air contents meet specification requirements. Manufacturer's must have at least 70% of their annual monitor cores achieve the specified compressive strengths and have a hardened air content within specification limits of 5.0% - 9.0%. Additionally, a minimum of 90% of the annual monitor cores must achieve at least 85% of the specified compressive strength and have air contents in the range of 4.0% - 10.0%. Coring frequencies are high during initial production and grow progressively less frequent as production rates grow through routine production.

During a typical production year, well over 500 audits are performed on the 23 plants providing non-structural precast concrete elements to NYSDOT. The program was developed jointly with the precast industry and has been in existence since late 2000.

Below is a graphical example of NYSDOT's Conformance Report back to a Precast Manufacturer outlining the results of their Annual Audit.



A - Quality Control Plan	F1 - Component Materials Acceptance	F6 - Curing	F11 - Final Inspection
B - Individual Qualifications	F2 - Mix Designs	F7 - Cold Weather Manufacturing	F12 - Shipping and Certification
C - Training	F3 - Shop Drawings	F8 - Stripping / Post-Pour Inspection	F13 - Monitor Cores
D - Facility Components	F4 - Pre-Pour Inspections	F9 - Handling and Storage	F14 - Internal Review
E - Manufacturing Products	F5 - Pour Inspections	F10 - Repairs	G - Documentation

Successful Practices - The Florida Department of Transportation

Successful Practice 1:
FDOT exhibited a presence at the precast plants as demonstrated by the following:

- An annual inspection is performed by an FDOT review team which includes a representative from the State Materials Office. The review team conducts a thorough review of the producer on an annual basis and uses a checklist based on the required standards or contract documents. The checklist includes checks on producer compliance with FDOT specifications and record-keeping requirements.
- In addition to the annual reviews, the FDOT district plant inspectors conduct monthly reviews of incidental precast concrete elements and quarterly reviews of precast concrete drainage elements. It was clear to us that the inspectors are knowledgeable of their job requirements and we were impressed with the documentation provided by their completed checklists.
- FDOT inspectors take core or cylinder tests during quarterly inspections of precast concrete drainage. For concrete pipe, the FDOT inspector witnesses the three-edge bearing test. This type of verification testing is ensures producers provide concrete that meets the minimum compressive strength requirements. It should be noted that FDOT does not take cores or cylinders for incidental precast concrete.
- FDOT inspectors check Buy America requirements by ensuring the producer has the mill certifications that match the tags on steel products currently being used in production.

Successful Practice 2:
FDOT has an excellent system for assuring the competence of the producer's quality control personnel. FDOT's Materials Manual requires specific certifications for the producer's quality control personnel for inspection and sampling and testing, design and verification of concrete mixes, and operation of the batch plant. The producer's personnel qualifications must be included in the producer's quality control plans. Additionally, FDOT's Construction Training Qualification Program allows for electronic tracking of the personnel qualifications.

Successful Practice 3:
The producer's sampling and testing personnel are required to be reviewed through an independent assurance review conducted by FDOT's District personnel. The procedures for independent assurance are described in Section 5.5 of FDOT's Materials Manual and include a three strike system in which the Supervisor, District Construction Engineer and Resident Engineer are notified of personnel failing the tests three times.

Successful Practice 4:
Producers are required to submit quality control plans for each of the following nonstructural precast concrete elements: pipe, incidental and drainage. Producers cannot begin production on State products until the FDOT has accepted the plans. The quality control plans must be updated as changes occur to the producer's processes, personnel, mix designs, etc. The quality control plans are reviewed during FDOT's annual inspections.

Successful Practice 5:
The Materials Manual defines the expectations for quality assurance to producers and FDOT personnel and helps to ensure consistency throughout the State. Section 5.6 establishes quality control and process control standards for production and construction operations such as the requirement for the producers to have a quality control plan. Sections 6.2, 6.3 and 8.2 cover the Quality Assurance of precast concrete pipe, precast concrete drainage elements and precast concrete incidental items respectively. These three sections are broken into two volumes, Volume I covering the FDOT personnel's responsibilities and Volume II providing guidance to producers on the manufacture, storage and transportation of precast concrete elements for FDOT projects. Section 9.2 provides guidelines to standardize the activities associated with the concrete production facilities used for FDOT projects.

Successful Practice 6:
FDOT uses a large selection of standard drawings of precast concrete elements that are updated frequently. The producers typically follow the standard drawings rather than submit shop drawings for approval that deviate from the standards.

Successful Practice 7:
FDOT has comprehensive procedures for the acceptance of precast elements:

- Producers are required to provide pre-pour and post-pour checklists along with a shop drawing for each unique precast element (in the rare case where they choose to deviate from the standards). The pre-pour checklist is required to be signed by the producer's quality control personnel prior to pouring. The post-pour checklist is then required to be signed by the producer's quality control personnel upon completion of the element. The standard drawings/shop drawing with the approved completed checklists must then be kept with the corresponding lot package.
- Testing and documentation requirements on incidental and pipe precast concrete elements help to ensure the producer has good quality control procedures in place and only products meeting the specifications are provided to FDOT projects.
- Patching and repair work must be completed, and documented, prior to stamping of products.
- The Quality Control Manager or their designated technician must stamp the structure.
- A notarized certification of compliance must be provided by the producer for the elements produced for each project.
- The list of structures must be included with each shipment of the products to the project site.

Successful Practice 8:
FDOT has good procedures in place for tracking source materials being used in concrete mixes. All mix designs are reviewed and approved for incidental and pipe precast concrete elements. All source materials are required to be on the qualified product list. The aggregate stockpiles are required to be labeled in the field including the supplier and the mine numbers.

Successful Practice 9:
The Florida Department of Transportation has quarterly meetings with precast concrete producers whom are part of the Precast Concrete Structures Association of Florida (PCSAF). These meetings allow FDOT to proactively engage with industry.

Appendix C

Work Plan

Team Charter

Work Plan
Review of Nonstructural Precast Concrete Elements

Purpose of Review

The purpose of this national review is as follows: 1) Determine if State highway administrations (SHA) have acceptance plans in place to reduce the risk of non-specification material in nonstructural precast concrete elements; 2) Verify SHAs are following the acceptance plans; 3) Evaluate what should be included in an acceptance plan.

The need for this review was identified by the Office of Infrastructure based on recent investigations of nonstructural precast concrete element producers and a National Survey conducted by the Office of Infrastructure. Producers in Tennessee, Maryland and Connecticut were found to have provided nonstructural precast concrete elements such as walls, inlets, manholes and pipes where the steel reinforcement didn't meet the requirements as shown in the contract drawings. Two producers, one each in Maryland and Connecticut, were investigated by the Office of the Inspector General (OIG). The investigations found the producers were not providing elements that met the State's requirements. The OIG is currently investigating several producers in Tennessee.

The Office of Infrastructure sent out a National Survey to the FHWA Division Offices by Memorandum dated June 9, 2011 with the intent to determine what activities are included the acceptance plans of SHAs for nonstructural precast concrete elements. The results showed that while most states require quality control plans and material certifications and do some type of inspection, about two-thirds of the states do not perform random verification testing on completed elements including the amount of reinforcing steel. With the lack of acceptance testing on completed elements and the recent incidents in three states in which nonstructural precast concrete elements were supplied that did not meet the contract requirements, it is unclear to FHWA if issues exist with the quality of nonstructural precast concrete elements on a national level. Thus, a national review is being conducted to determine if there are quality concerns.

Scope

The review will be conducted by FHWA's Program Management Improvement Team (PMIT) at the request of the Office of Infrastructure. If the review budget allows, the team hopes to conduct six field reviews between September and December 2011. The field reviews will each be one week long and involve visiting six to 10 different states. The weeklong visit will involve the team meeting with the SHA and the Division Office to kick-off the review and discuss the program, reviewing three to five precast concrete producer plants, reviewing some projects if time is allowable and closing out with the FHWA Division Office.

For the field reviews, the team will be comprised of two PMIT members and two technical specialists. The first two field reviews will involve all members reviewing the same state, plants, and projects. For the remaining field reviews, the team will split into two sub-teams, composed of one PMIT member and one technical specialist. Each sub-team may either review separate states or different geographical areas within a state.

For this review, the states will be selected as follows: 1) Based on information provided in the National Survey; 2) Represent each region in the country; and 3) Take into consideration the FHWA Division Offices desire for their state to be reviewed.

Expected Results

The following are the expected results of this review:

- Determine if there is a national issue with the quality of nonstructural precast concrete elements;
- Provide recommendations to the Office of Infrastructure for additional policy and procedures as needed on the acceptance plans for nonstructural precast concrete elements;
- Present suggestions for improvement as needed to FHWA Division Offices and State Highway Administrations during field reviews;
- Support FHWA Division Office reviews on nonstructural precast concrete elements; and
- Provide assurance to the Office of Inspector General that FHWA is providing appropriate oversight of this area of the Federal-aid Program on national basis and determining if there are national issues with the SHA oversight of nonstructural precast concrete elements.

Team members

Fulltime Team Members:
Tom Goldstein, Program Management Improvement Team, Review Leader
George Jones, Program Management Improvement Team Leader
*Mike Rafalowski, Pavement Materials Engineer, Office of Pavement Technology
Dennis Dvorak, Pavement and Materials Engineer, Resource Center
John Steele, Pavement and Materials Engineer, Tennessee Division
Mike Praul, Team Leader, Maine Division
* Note: Mike Rafalowski will not be conducting field reviews

Support Team (potential members available for field reviews):
Tim LaCoss, Pavement and Materials Engineer, New York Division
Bob Conway, Pavement and Materials Program Engineer, Michigan Division

Rick Bradbury, Research Civil Engineer, Office of Infrastructure

Methodology

The review team has developed and will utilize a review guide to provide the framework for completing the field reviews. The review guide is divided into the following areas: 1) Program level discussions with the SHAs to understand their policies and procedures for the acceptance of nonstructural precast concrete elements; 2) Plant visits to review the precast concrete producers quality control procedures and SHA's inspection operation; and 3) Project visits (if time warrants) to review the acceptance of the precast concrete elements at the project site. The guide covers the following activities included in an acceptance plan for nonstructural precast concrete elements: initial evaluation of the product, review and approval of the producer's quality control plan, periodic plant visits, material certifications, acceptance testing of completed product and visual inspection at the project.

This review will utilize nondestructive testing on completed precast concrete elements to determine if steel reinforcement was placed in the elements in accordance with the applicable SHA standard details. The testing will involve a state-of-the-art piece of equipment called a Mira Tomographer that utilizes a form of ultrasonic pulse-echo method testing as way to conduct nondestructive testing on completed precast concrete. This piece of equipment is complicated and will require a technician. The equipment and the technician will be provided by FHWA's Office of Infrastructure Research and Development. Due to time constraints and the splitting of the team into two subteams that will conduct reviews in different locations, it will only be possible to utilize the ultrasound equipment in five of ten states being reviewed.

Once all field reviews have been completed, the resulting data will be compiled. Program trends will be identified and analyzed. Observations and recommendations will be developed. The results will be reported back to the Office of Infrastructure in a formal report.

Review Schedules

Schedule I- Field Reviews

Begin Date	End Date	Activity
9/12/2011	9/16/2011	Field Review in State 1
9/19/2011	9/23/2011	Field Review in State 2
10/17/2011	10/21/2011	*Field Review in State 3 and State 4
10/31/2011	11/4/2011	*Field Review in State 5 and State 6
11/14/2011	11/18/2011	*Field Review in State 7 and State 8
12/5/2011	12/9/2011	*Field Review in State 9 and State 10

* Note schedule assumes review team will split into two teams with each reviewing separate states

Schedule II - Overall Review Schedule

Begin Date	End Date	Activity
8/15/2011	8/22/2011	Draft Work Plan and Team Charter
8/15/2011	8/29/2011	Draft Field Review Checklist
8/22/2011	8/29/2011	Finalize Work Plan and Team Charter
8/29/2011	9/8/2011	Finalize Field Review Checklist
9/1/2011	9/1/2011	Webinar with Headquarters, Resource Center FHWA Division offices
9/12/2011	12/9/2011	Field Reviews (see above) and reports on field reviews
12/9/2011	12/23/2011	Draft Observations and Recommendations
12/23/2011	1/6/2012	Finalize Observations and Recommendations
1/6/2012	1/20/2012	Draft Report and submit to PMI Team Leader Review
1/20/2012	2/3/2012	PMI Team leader, Office of Infrastructure (sponsor), and DFS-North review and comment on Draft Report
2/3/2012	2/10/2012	Review Team addresses comments and provides revised draft Final Report to PMI Team Leader
2/10/2012	3/9/2012	PMI Team Leader formally submits the draft Final Report to FHWA Senior Leadership for concurrence
3/9/2012	3/16/2012	All Senior Leadership comments and concerns are addressed and DFS the North and PMI Team Leader jointly issue the Final Report
3/16/2012	3/16/2012	PMI Team enters Final Report into the “Review Tracker”.

Team Charter

Process or Problem Studied:

Review of Nonstructural Precast Concrete Elements

Process Description or Problem Statement:

The purpose of this national review is as follows: 1) Determine if State highway administrations (SHA) have acceptance plans in place to reduce the risk of non-specification material in nonstructural precast concrete elements; 2) Verify SHAs are following the acceptance plans; 3) Evaluate what should be included in an acceptance plan.

Goals or Objectives:

1	Determine if there is a national issue with the quality of nonstructural precast concrete elements.
2	Provide recommendations to the Office of Infrastructure for additional policy and procedures as needed on the acceptance plans for nonstructural precast concrete elements;
3	Present suggestions for improvement as needed to FHWA Division Offices and State Highway Administrations during field reviews;
4	Support FHWA Division Office reviews on nonstructural precast concrete elements; and
5	Provide assurance to the Office of Inspector General that FHWA is providing appropriate oversight of this area of the Federal-aid Program on national basis and determining if there are national issues with the SHA oversight of nonstructural precast concrete elements.

Parameters or Limits of Review:

- Budget Limits:
  - Team will only be able to complete six field reviews based on PMI Team funding constraints.
  - Team has enough funding to cover two field reviews in FY 2011, but it still must be determined if the team will receive funding for the other four field reviews in FY 2012.
- Acceptance testing of final products: Team may not be able to use nondestructive or destructive methods to test completed concrete elements to determine if they meet states requirements.
- Team may be limited to visiting fabricating plants and may not have time to visit projects.
- Members may not be able to participate in all field reviews and will need to have replacements available.
- Schedule for review completion may be affected by delays in funding for FY 2012.

Team Leader:

Tom Goldstein

Team Members:

George Jones	Dennis Dvorak	Mike Praul
Mike Rafalowski	John Steele	Tim LaCoss

Team Sponsor:

Office of Infrastructure

Budget:					
Expertise available:					
The team is composed of members from Headquarters, Resource Center and Division Offices with expertise on quality assurance of construction materials.					
Time Frame:	8 months	**Starting Date:**	8/15/2011	**Completion Date:**	3/16/2012
Authority or responsibility of the team:					
Team is responsible for completing goals and objectives to meet request of the sponsor (Office of Infrastructure).					
Potential restraining forces:					
23 CF 637 and the non-regulatory supplements to this regulation. State Highway Administrations' policies, procedures and guidance.					
Timing of Progress Reports:					
Schedules for the field reviews and the overall review have been completed and are included with the work plan. Periodic updates of the review status will be provided to the PMI Team Leader (Mike Graf) and the Sponsor (Office of Infrastructure).					
Follow-Up Responsibility:					
A Work Plan and Guide Lists will be completed prior to starting the field reviews. Additionally, the states being reviewed will be selected and the field reviews set up accordingly.					

Review of Nonstructural Precast Concrete Elements

Appendix D

Review Checklists

Review of Nonstructural Precast Concrete Elements
Program Review Checklist

State: _____
Date: _____
Review Type: _____Program Review
Location: _____

PROGRAM LEVEL

1. Design Requirements

What are the standards and/or details of the State Highway Administration (SHA) for specific concrete elements that provide information such as the element dimensions, the steel reinforcement specifications (size and type of steel and spacing and cover for steel) and concrete mix requirements (an approved state mix)?

2. SHA Acceptance Plan Requirements

What is the SHA's Acceptance Plan for nonstructural precast concrete elements and has FHWA approved the Acceptance Plan?

3. Initial Evaluation of Precast Suppliers

a) Does the SHA evaluate precast concrete suppliers and their precast elements for inclusion in a State Qualified Products List (QPL)?
    a. How does the SHA's prequalification process work?
    b. Once a supplier is added to a State QPL, do they have to be periodically reevaluated (explain)?
b) If precast suppliers are not handled through a QPL, how are they evaluated?
c) How many precast plants are approved to fabricate nonstructural precast concrete elements for the state?

4. Plant Review and Quality Control Plan (QC Plan)

a) Does the SHA do any review of the supplier's plant and if so, what are the specific items reviewed and is there a standard checklist?
b) Does the SHA use a third party certification organization to review a supplier's plant?
c) Does the SHA review a QC Plan?
    a. Does the SHA specify what needs to be included in the QC Plan?
    b. Is the QC Plan formally approved or reviewed by the SHA?
    c. How frequent is a QC Plan reviewed for particular plant (i.e. every three years)?
d) What requirements are included in the QC Plans?
    a. Are technicians required to be qualified and if so, what are the requirements?
        i. Does the state have of its own technician certification program and what national certification programs does it rely on?
        ii. Who is required to be certified (SHA and producer personnel)?
        iii. Are there different levels of certifications (i.e. sampling and testing, mix design and batching)?
    b. Is testing equipment required to be calibrated and if so, what are the requirements and frequency?
    c. What are the requirements for curing facilities?

5. Inspection for Nonstructural Precast Concrete Elements at Plant

a) Is an inspector required to be present at the plant on a full time or part time basis?
b) Are there any differences between the inspections required for structural precast concrete items versus nonstructural precast concrete elements?
c) Do the inspectors complete daily reports/checklists or other documentation for their inspections?
d) What is he/she required to inspect (is there a checklist)?
    a. Does the inspector check Buy America Certifications for the steel?
    b. Does the inspector check the element dimensions, the steel reinforcement (steel certifications size and type of steel and spacing and cover for steel) and concrete mix (an approved state mix)?
    c. Is the inspector involved with any forms of acceptance testing of completed product such as compression strength tests for concrete and nondestructive or destructive tests

to determine if the concrete element meets requirements (in particular, the correct amount of steel)?

d. Are invoices checked for the reinforcement steel to insure they correspond to the manufactured items?

6. Material Certificate and Shipping

a) Does the acceptance plan include material certifications provided by the supplier for specific concrete elements as a way for project staff to identify that specific precast elements were shipped?

b) Does the supplier keep steel certifications showing their product meets Buy America requirements?

7. Random Verification Testing on Completed Elements

a) Is the final product cored for compression strength tests?

b) Is there any nondestructive or destructive testing on the final product to determine if steel is being incorporated into the element as required?

Review of Nonstructural Precast Concrete Elements
Plant Review Checklist

State: _____
Date: _____
Plant Name and Number: _____
Location: _____
Plant Type: _____

General Information:
What types of precast concrete elements are produced at the plant for the SHA?
What is the typical production rate for the precast plant? CUYD/Day
What rough percentage of that production is for the SHA?
What types of concrete mixes are being used at the plant for SHA work (Wet, Dry, Self consolidating)?
Discuss nondestructive testing completed and the results:

PLANT VISIT

1. Initial Evaluation of Precast supplier

Has the supplier's plant producing precast concrete elements been evaluated using the SHA's procedures?

2. Plant Review and Quality Control Plan (QC Plan)

a) Has the supplier's plant been reviewed by the SHA and if so, what specific items were reviewed?
b) Does the plant have a third party certification (provide date and 3rd party organization)?
    a. Are there third party and/or internal audit reports (if there are then review)?
c) Is the Plant's QC Plan approved by the SHA?
    a. Does the QC Plan include all of the SHA's requirements?
    b. Is the QC Plan being reviewed and approved by the SHA at the required frequency?
    c. Is the supplier following the processes as shown on their QC Plan?
        a) Are technicians qualified as required (types of certifications)?
        b) Is testing equipment calibrated as required?
        c) Do curing facilities meet requirements?
d) Quality Control processes:

a. Does the plant have pre-pour and post-pour checklists and are they following them?
b. Is the plant taking concrete cylinders to check their processes?
    a) How frequent is the sampling and testing occurring?
    b) Are the strengths meeting the requirements of the SHA?
c. Is the precast plant checking air content, concrete temperature and slump (if applicable)?
    a) What is the frequency these characteristics are being recorded?
    b) Are their test results meeting the requirements of the SHA?

3. SHA Inspection for Nonstructural Precast Concrete Elements at Plant

a) How often has the SHA inspector been present at the plant?
b) Has the inspector done anything different for the inspection of structural precast concrete items versus nonstructural precast concrete elements at the plant?
c) What type of documentation has the inspector completed (daily reports, checklist, etc.)?
d) What have they inspected?
    a. Has the inspector checked Buy America Certifications for the steel?
    b. Has the inspector checked the element dimensions, the steel reinforcement (steel certifications size and type of steel and spacing and cover for steel) and concrete mix (an approved state mix)?
    c. Has the inspector completed any forms of acceptance testing on finished products such as compression strength tests for concrete and nondestructive or destructive tests to determine if the concrete element meets requirements?

4. Steel Certifications

a) Have the steel certifications been checked to ensure that they meet Buy America requirements?
b) Are steel certifications kept at the plant and do they tie to the steel being used for the precast concrete elements?
c) Has the supplier marked or identified pieces that do not meet specifications?

5. Review of Processes at Plant

a) Are the precast elements being built to meet the requirements of a particular SHA detail?
    a. Is the plant using the SHA Standard Details or using their own shop drawings?
        i. If they're using their own shop drawings to set the steel and formwork prior to the pour, is it approved by the SHA?
    b. Are the dimensions of the element correct?
    c. Is the correct size and type of steel used?
    d. Is the steel at the correct spacing and have the required cover?
b) Is the approved concrete mix being used?
    a. Are the aggregates approved in the mix design being used?
    b. Is the approved brand and amount of cement and admixtures being used?
    c. Is the moisture in the aggregate stockpiles checked accounted for prior to production of concrete?

6. Review of Final product

a) Are the dimensions correct for the precast concrete element?
b) Is coring or cylinders showing the concrete meets strength requirements?
c) Is nondestructive testing showing the concrete element has the proper amount of steel?
d) Is verification testing done on completed elements at the plant (such as compression strength tests for concrete and nondestructive or destructive tests to determine if the concrete element meets requirements)?

Review of Nonstructural Precast Concrete Elements
Project Review Checklist

State: _____
Date: _____
Project Name: _____
Project Number: _____

PROJECT Review

1. Material Certifications

a) Have material certifications been submitted for all installed and paid concrete structures?
b) Do the material certifications tie to the precast concrete elements incorporated into the project?
c) Have the Buy America Certifications been submitted for precast concrete elements containing steel and do the certifications tie to the elements on the project?

2. Review of Final product

a) Are the dimensions correct for the precast concrete element?
b) Was the precast concrete element visually inspected for damage prior to installation?
c) Has coring shown the concrete to meet strength requirements?
d) Has nondestructive testing shown the concrete element meets the steel requirements?

Appendix E

Federal Guidelines

Applicable AASHTO Specifications

Design and Analysis

Materials and Construction Technology

Management and Preservation

Surface Characteristics

Construction and Materials Quality Assurance

Environmental Stewardship

Quality Assurance

Formerly Federal-aid Policy Guide Non-Regulatory Supplement
NS 23 CFR, Part 637B,
July 19, 2006, Transmittal 36
See Order 1321.1C FHWA Directives Management

1. **POLICY (23 CFR 637.205).** The Division Administrator shall provide appropriate oversight to ensure that the State's quality assurance program is being implemented as approved. At a minimum the oversight should cover:

   a. Materials sampling and testing issues,

   b. Construction inspection issues covering the specific attributes which reflect the quality of the finished product, and

   c. State capabilities - maintaining an adequate, qualified staff to administer the quality assurance program and qualified laboratories.

2. **QUALITY ASSURANCE PROGRAM (23 CFR 637.207)**

   a. The State's acceptance program should provide a reasonable level of inspection to adequately assess the specific attributes which reflect the quality of the finished product. Acceptance inspection should include inspection of the component materials at the time of placement or installation, as well as the workmanship and quality of the finished product.

   b. Samples used in the acceptance decision should be taken as close as possible to where the material is incorporated into the project.

   c. The State should retain control of the verification sampling locations and timing until immediately prior to sampling.

   d. Sampling and testing frequencies may vary from State to State as the quality and uniformity of the material varies. The State may reduce its testing frequency for materials with a history of accurate, uniform test results that consistently meet specification requirements. The rate of testing should be higher on newly developed material sources, sources with questionable quality, sources with a

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wide range of test results, and sources with failing test results.

e. When contractor's tests are used in the acceptance decision and the State and contractor test results do not compare, the frequency of verification testing should be increased.

f. The State should obtain the contractor's test data as soon as it is available, no later than 24 hours after sampling is completed. The State's test results should not be given to the contractor until after the contractor results are received.

g. The State should review the contractor's source documentation as part of the State's quality assurance program.

h. Test results should not be discarded unless it is known that the sampling or testing was flawed. It may be appropriate to perform additional testing when the quality of the material is in question. However, in cases where additional tests are performed, the acceptance and pay criteria need to be adjusted to account for the additional test results.

i. If project materials are used in the Independent Assurance (IA) program, the IA samples should be split samples when possible, or in close proximity to the same location as the samples used in the acceptance decision.

j. Observation of sampling and testing procedures should be included as part of an IA system to evaluate sampling and testing personnel and ensure that test procedures are performed correctly.

k. When using the project approach for IA, the frequency should be approximately 10 percent of the frequency of the tests used in the acceptance decision.

l. When using the system approach for IA, each inspector should be covered once or twice a year.

m. The State is encouraged to develop a Qualified Products List for manufactured materials.

n. The State is encouraged to perform a risk analysis when developing an acceptance program for manufactured items. When performing a risk analysis, the State should consider the use of the product, safety, cost, and historical quality of the product.

o. The State should consider the data from the National Transportation Product Evaluation Program (NTPEP) when developing qualified product lists. See http://www.ntpep.org/.

p. The State is encouraged to report the evaluation of new products to the American Association of State

Highway and Transportation Officials Product Evaluation List (APEL). See http://apel.transportation.org/.

q. The State should consider visual inspection and/or the manufacturer's certification as a basis for accepting small quantities of non-critical material.

3. **LABORATORY AND SAMPLING AND TESTING PERSONNEL QUALIFICATION (23 CFR 637.209)**

a. All test procedures used in the acceptance decision should be in the scope of accreditation for the States central laboratory.

b. The National Cooperation for Laboratory Accreditation (NACLA) "Recognition Procedure" and the National Institute of Standards and Technology (NIST) Interagency Report 7012 (NISTIR 7012), "Technical Requirements for Construction Materials Testing", is the criteria required for the approval of comparable laboratory accreditation programs as indicated in a Notice in the Federal Register on September 22, 2004. The accreditation bodies will be evaluated against the NACLA Recognition Procedure and the Technical Requirements for Construction Materials Testing, and they must be recognized by NACLA with the Technical Requirements for Construction Materials Testing listed within its scope before the accreditation bodies will be approved by the Federal Highway Administration (FHWA). To meet the quality assurance requirements in 23 CFR 637.209(a)(2), (3), and (4), the laboratories' scope of accreditation must indicate that the laboratory was assessed according to the requirements in NISTIR 7012. The NACLA Recognition Procedure is available at http://www.nacla.net/Pdf/Evaluation%20Procedure%20RevA.pdf. The Technical Requirements for Construction Materials Testing is available at http://ts.nist.gov/ts/htdocs/210/gsig/pubs/ir7012.pdf.

c. The following should be used as guidance for reviewing and revising laboratory qualification programs for non-accredited laboratories that provide test results and information used in the acceptance decision:

1. **Personnel**
   a. **Supervisors**. Supervisors of testing personnel should have a minimum of 3 years experience in testing of highway construction materials.
   b. **Technicians**. Guidance for technician qualification programs is listed in paragraph 3d.
2. **Documentation**. State DOT's should develop test procedures and/or test manuals referencing standard testing procedures. These procedures should also cover handling, identification, conditioning, storage, retention and disposal of test samples.

3. **Proficiency In Testing**. Testing personnel should be routinely evaluated by observations and split samples or proficiency samples.
4. **Frequency of Assessments**
    a. Laboratory assessments should be made on a 3- to 5-year cycle.
    b. Data from the IA program along with observations during IA tests should be used as part of the ongoing evaluation of the laboratory.

d. The following should be used as guidance for reviewing and revising a technician qualification program:

1. Formal training of personnel including all sampling and testing procedures with instructions on the importance of proper procedures and the significance of test results.
2. Hands-on training to demonstrate proficiency of all sampling and testing to be performed.
3. A period of on-the-job training with a qualified individual to assure familiarity with State DOT procedures.
4. A written examination and demonstrated proficiency of the various sampling and testing methods.
5. Requalification at 3- to 5-year intervals (data from the IA program can be used as one element of requalification).
6. A documented process for retraining or removing personnel that perform the sampling and testing procedures incorrectly.
7. The following are not appropriate criteria for achieving or maintaining qualification status: Grandfathering, the acceptance of a Professional Engineer or Engineer-in-Training certificate, or lifetime qualification.

4. **MATERIALS CERTIFICATE (23 CFR 637 APPENDIX A).** The intent of the material certification is to ensure that the quality of all materials incorporated into the project is in conformance with the plans and specifications, thus ensuring a service life equivalent to the design life. Any material represented by an acceptance test that does not meet the criteria contained in the plans and specifications is considered an exception. Exceptions should be investigated to determine if in fact the material is in reasonably close conformity with the plans and specifications.

Updated: 04/07/2011

AASHTO/ASTM Specifications Related to Nonstructural Precast Concrete Elements

1. **AASHTO Designation: M 199M/M 199-10 (ASTM Designation: C 478M-09 and C 478-09):** Precast Reinforced Concrete Manhole Sections.

2. **AASHTO Designation: M 170-101 (ASTM Designation: C 76-08a):** Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

3. **ASTM C-76:** Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

4. **ASTM C443:** Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets

5. **AASHTO M 242 (ASTM-C655)**: Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe.

6. **AASHTO M 206 (ASTM C506):** Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe

7. **AASHTO M 207 (ASTM C507):** Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe

8. **AASHTO HS20:** Design Live Load Requirements

9. **AASHTO T 280 (ASTM C497):** Standard Method of Test for Concrete Pipe, Manhole Sections, or Tile.

AASHTO Standard Related to Quality Assurance of Manufactured Materials

AASHTO R-38: Standard Practice for Quality Assurance of Standard Manufactured Materials

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