TechBrief

The Construction and Materials Quality Assurance Program is an integrated, national effort to improve the effectiveness of the State acceptance of materials both in the inspection, sampling and testing. The program is designed to provide tools and guidance in implementing Quality Assurance programs. The program is designed to provide tools and guidance in implementing Quality Assurance programs.

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ACCEPTANCE OF NON-STRUCTURAL PRECAST ELEMENTS

This Technical Brief provides information regarding processes used for acceptance of non-structural precast elements.

Introduction

The non-regulatory supplement of 23 CFR 637, which can be found at http://www.fhwa.dot.gov/pavement/0637bsup.cfm, indicates in paragraph 2(n) that a risk analysis should be performed when developing an acceptance plan for manufactured products.

A manufactured product acceptance plan should draw from a full range of activities including: initial evaluation of the product, submission of a quality control plan, plant inspections, manufacturer's certification, periodic verification testing and visual inspection at the project site. The frequency as to when these activities should occur should also be included in the acceptance plan based on the risks associated with the specific product. For precast items a typical acceptance plan could include, initial evaluation of the product, review and approval of the manufacturer's quality control plan, periodic plant visits, a material certificate, a combination of periodic breaking or coring of elements and nondestructive testing as well as visual inspection at the project.

Background

One of the reasons for the development of this guidance on nonstructural precast concrete elements were the investigations by the United States Department of Transportation Office of Inspector General (US DOT OIG) on precast concrete producers, in the States of Connecticut, Maryland and Tennessee. The investigations centered on whether non-structural precast elements contained proper amounts of reinforcing steel.

With what appeared to be a growing trend of precast producers not providing nonstructural precast concrete elements with the reinforcing steel in compliance with State specifications, the FHWA Headquarters surveyed the Division Offices. The intent was to determine what activities are included in the acceptance processes of States for nonstructural precast concrete elements. The results showed that very few States provided full-time plant inspection for the production of nonstructural precast concrete elements, but had varying frequencies of inspection from periodic to none. Also, over two-thirds of States did not perform any verification testing of completed nonstructural precast concrete elements.

As a result of the survey and concerns that there may be issues with the production of nonstructural precast concrete at a national level, the FHWA determined that a national field review on nonstructural precast concrete elements was needed.

One of the recommendations from the review resulted in FHWA developing this additional guidance on the acceptance plans for Nonstructural Precast Concrete Elements.

The final report on the review can be viewed at
http://www.fhwa.dot.gov/pavement/materials/program_review.pdf

Scope

The following activities are typically included in acceptance plans used by States for accepting precast items:

1. initial qualification of producer
2. routine inspection
3. a material certificate from the producer, including Buy America certifications
4. periodic verification testing
5. visual inspection of elements at the project site
6. requalification of producer

The exact frequency of periodic inspection, verification testing and visual inspection should be based on the risks involved, findings from the qualification process and the quality of the elements manufactured by the producer.

This Tech Brief will discuss best practices for each of the above activities.

Many State Transportation Agencies classify load bearing products under the umbrella classification of non-structural precast concrete elements. Items such as the tops for precast reinforced concrete manhole sections or inlet top sections, reinforced concrete pipe & elliptical culvert sections in excess of 5 feet and single cell precast reinforced concrete box sections for culverts, storm drains, and sewers that require special design or box culverts in excess of 10 feet should be considered by State Transportation Agencies to represent higher risk than other non-load bearing precast concrete elements, and quality assurance activities for these items should reflect the higher risk level.

1. Initial Qualification of Producer

As part of the initial qualification, producers should provide a quality control plan which covers the following items:

a. Qualification of personnel
b. Calibration of Production and Test Equipment
c. Industry Standards and Shop drawings
d. Materials
    i. Sources of raw materials
    ii. Mix designs
    iii. Sources of reinforcing steel
e. Pre-pour
    i. Condition of forms
    ii. Application of form release agent
    iii. Fabrication and Positioning of Reinforcing Steel
    iv. Positioning of embedded items (including location of block-outs)
f. Materials Quality Control
    i. Aggregate tests
    ii. Plastic concrete
    iii. Hardened concrete
        1) Strength tests
        2) absorption
g. Placement and consolidation of concrete
h. Post pour
    i. Curing of concrete
    ii. Product dimensions
    iii. Handling, storing and transporting products
i. Recordkeeping

An onsite plant inspection should be performed prior to initial qualification. The inspection should ensure that the plant is in compliance with the quality control plan.

a. Qualifications of Personnel

The producer's personnel conducting the sampling and testing should be qualified by the State's qualification program. In addition, the testing personnel should be evaluated during the annual plant evaluation process.

All testing personnel should be qualified through the State's qualification program or a nationally recognized technician certification programs, such as American Concrete Institute, Level I Certification. Qualification programs for inspection personnel are available from third parties.

b. Calibration of Production & Test Equipment

The producer should describe what production and test equipment is required to be calibrated, the means and methods of calibration, how calibration records are to be

maintained, and the current status of each piece of production and testing equipment. The following is a partial list of equipment to be covered; concrete batch plant scales, admixture dosing station calibration, curing temperature data logging equipment, and physical properties test equipment calibration

c. Industry Standards and Shop Drawings

It is important that shop drawings are periodically reviewed by the State for the following reasons:

- Ensures the shop drawings match a Standard Detail or if they deviate, they are approved by the State;
- Allows more consistency with the shop drawings of the different producers within a State; and
- Enables the State and other groups to better audit producers to ensure quality control processes are being followed by the producer; and
- Provides another means for States and producers to keep up with industry changes in standards or production innovations.

The appropriate industry standards for precast elements are listed below under Further Information.

d. Materials

i. Source of raw materials, aggregates, Portland cement, supplementary cementious materials and admixtures should be on the State's approved supplier's list.

~~ii.~~ Mix designs, at a minimum mix design proportions should be verified to ensure that they meet the State's specification requirements including cementious content and water cementious ratios.

iii. Source of reinforcing steel should be on the State's approved supplier list. The reinforcing steel need to meet Buy America requirements. Question and answers concerning Buy America may be viewed at: http://www.fhwa.dot.gov/construction/contracts/buyam_qa.cfm

If a foreign supply of reinforcing steel is used at the plant, processes need to be in place to segregate the foreign and domestic steel and also the resultant precast elements.

Miscellaneous steel such as tie wires, and lifting hooks are not subject to Buy America requirements. This was clarified by a December 2, 2012 memorandum signed by John Baxter, Subject: ACTION: Clarification of Manufactured items under Buy America. The memorandum can be viewed here: http://www.fhwa.dot.gov/construction/contracts/121221.pdf

e. Pre-pour

Pre-pour checklists should include the following items:

i. Forms should be inspected to ensure they are in good mortar tight condition and meet dimensional requirements of the piece that is being fabricated.

ii. Approved form release agent needs to be applied in a proper and uniform rate. Excessive release agent should not be ponded in the forms.
iii. The reinforcement steel should be of the proper size and spacing to meet the shop drawings. The steel should also be place within the forms to ensure proper cover and secured against movement.
iv. All appropriate embedded items (including block-out materials) need to be place in their proper location according to the standard drawings.

f. Materials Quality Control.

The following testing should be part of the quality control plan:

i. Performing aggregate moisture content testing and gradation testing in accordance with industry standards. Checking the moisture of aggregates on a daily basis is a good practice for ensuring the water/cement ratio are kept within specification requirements and reduce process variability.
ii. Plastic properties such as concrete temperature, slump, air content, unit weight, etc. are industry recognized quality indicators to insure quality concrete.
iii. Compressive strength testing ensures elements are not prematurely stripped from their forms or shipped without meeting minimum strength requirements.

When required by the specifications and standard plans, producers should run: absorption tests to gauge the durability of the concrete used in the precast items and/or perform destructive testing such as the 3 edge bearing tests to confirm product acceptance.

Types of repairs that can be made as well repair procedures should be approved by the State and be made part of the quality control plans.

g. Placement, consolidation, and curing of concrete

The following items need to be documented during the fabrication of the precast elements using a checklist or inspection report:

- Concrete needs to be transported in a manner to avoid segregation.
- Concrete needs to be placed in the forms as close as possible to the final location.
- Concrete should be properly consolidated.
- Proper hot weather and cold weather concrete procedures need to be used under appropriate conditions.
- The concrete shall be proper cured to maintain moisture so that cement hydration occurs.

h. Post-pour

The post-pour checklists should include the following item:

i. Forms shall not be released until proper strength is obtained.
ii. Elements shall be visually inspected for acceptable surface conditions and conformity to plans.
iii. Approved repairs are made and documented.

iv. Conforming elements and non-conforming elements are marked as required by the State's procedures

h. Recordkeeping.

Records on the following items need to be maintained:

- Personnel qualification and training records.
- Raw materials, aggregate, Portland cement, supplementary cementious materials, admixtures, reinforcing steel, mix water potability, etc. including test results.
- Quality control testing results for the aggregate and concrete.
- Pre-pour and post-pour inspection reports.
- Concrete batching records
- Records of disposition of failing products
- Records of element specific test results; example, AASHTO M199-Manhole Step Load Test, or Welded Steel Hoop splice pull test results (annual test results)
- Shipping records

2. Routine Plant Inspection

Routine inspections of the producers during fabrication of precast elements are one way to ensure the producers are following the State's requirements. Inspectors should not only verify component specific fabrication details, but they should also verify that the producers are complying with their Quality Control Plan for items such as pre-pour and post-pour checklists, current status of qualified quality control plant technicians, proper concrete batching procedures (aggregate gradation, moistures, State approved source materials), mill certifications for reinforcing steel, proper curing methods employed, product marking, handling and storage. 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.

As part of their risk assessment of nonstructural precast concrete elements, States should consider balancing periodic inspections with other activities such as verification testing. Another option is to use consultants to supplement the State's periodic inspections of precast concrete elements. Also, as a way to support periodic State inspections, the reviews by third party organizations can be used to complement the SHA's reviews. SHA's should ask for copies of third party organization annual inspection results and subsequent producer feedback to third party organizations as a potential indicator of the producers' strengths and weaknesses.

3. Manufacturer's Certification

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

In addition, the certification of compliance should include a certification that the elements are in compliance with the Buy America requirements.

State should ensure only legally responsible personnel from the producer are signing the Certifications for Compliance. The responsible personnel should be named in the Producer's Quality Control Plan.

4. Verification Testing

The State should perform verification testing. Verification testing validates that the products meet certain State requirements. In the case of nonstructural precast concrete elements, verification testing by destructive or nondestructive testing should validate if the reinforcing steel placed in the element meets requirements such as size, type, spacing and cover; strength and if appropriate absorption. Nondestructive testing involves the use of a piece of test 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 for determining if the element meets steel reinforcement requirements varies from completely breaking an element to doing something less damaging such as coring that can then be repaired. 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 that can be 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 State for a specific nonstructural precast concrete element. In deciding the type and frequency of verification testing, the State needs to take into consideration that nondestructive testing can be performed at a much greater frequency and lesser cost than destructive testing, but is typically less accurate. For nondestructive testing, the States with electronic systems that track elements can base the frequency of testing on the number of elements produced. Nondestructive testing can also be included as part of routine periodic plant inspections or onsite project reviews. The combined frequency of verification testing, both non-destructive and destructive testing should be sufficient to effectively deter producers from fabricating products that are not in compliance with State requirements.

Ultimately, the amount of verification testing must also be balanced with the amount of oversight at the plant. When a State allows the production of nonstructural precast concrete elements without State oversight, verification testing at the plant with some testing at the project reduces the owner's risk of incorporating noncompliant precast concrete elements into Federal-aid projects. that don't comply with State specifications.

Research is being conducted to provide additional guidance for the use of non-destructive testing devices for verification testing.

5. Visual Inspection of Elements at the Project Site

Precast pieces shipped to the project site should be subject to evaluation by project personnel. The project engineer should be responsible for acceptance of materials delivered to the project site and has the authority to reject pieces that are damaged or mis-fabricated to the extent that they cannot be satisfactorily repaired or incorporated into the work.

Research is being conducted to provide recommendations for criteria to be used for accepting elements based on visual inspection.

6. Requalification of Producer

The same process that is used for the initial producer qualification should be used to reevaluate the producer on an annual basis

Use of National Third Party Plant Certification Programs (National Precast Concrete Association (NPCA), American Concrete Pipe Association (ACPA) and Precast/Prestressed Concrete Institute (PCI))

As indicated earlier the States should qualify producers initially and annually. Many States are currently requiring the producers to participate in third party plant certification programs. These programs may be used with the following limitations.

At this point there has been no comprehensive evaluation of the third party programs to ensure that the personnel are properly qualified and that the evaluations as well as the decisions are consistent. In addition, the programs assess the plants against the criteria that the third party organizations developed and may not cover such State specification issues such as use of approved sources of materials, reviews of mix designs, particular quality control requirements, and Buy America requirements. As such these programs should only supplement State qualification programs and not replace the State programs. States should request a copy from the precast producer of the most recent report and certification from a third party program for each plant as part of the annual plant approval process.

Further Information:

- National Review on Nonstructural Precast Concrete Elements
- "23 CFR Part 637," Subpart B - Quality Assurance Procedures for Construction, Federal Highway Administration, *Federal Register*, Washington, DC published on June 29, 1995, and amended on December 10, 2002, and September 24, 2007, http://www.gpo.gov/fdsys/pkg/CFR-2003-title23-vol1/pdf/CFR-2003-title23-vol1-part637.pdf
- Non-regulatory supplement for 23 CFR Part 637, Subpart B - Quality Assurance Procedures for Construction, Federal Highway Administration. The non-regulatory supplement was updated on July 19, 2006. http://www.fhwa.dot.gov/pavement/0637bsup.cfm

- Frequently asked questions (FAQ) on the Quality Assurance Regulation. The FAQs were updated on November 26, 2006. http://www.fhwa.dot.gov/pavement/materials/qanda637.cfm

- Memorandum, Subject: ACTION: Clarification of Manufactured items under Buy America, dated December 2, 2012. The memorandum can be viewed here: http://www.fhwa.dot.gov/construction/contracts/121221.pdf

- The websites of the three national third party certification programs may be viewed at:

    - ACPA - http://www.concrete-pipe.org/pages/qcast.html
    - NPCA - http://precast.org/npcaservices/certify/
    - PCI - http://www.pci.org/about/certification/index.html

- AASHTO/ASTM Specifications Related to Nonstructural Precast Concrete Elements

    - AASHTO M 199/ASTM C478 Precast Reinforced Concrete Manhole Sections.
    - AASHTO M 170/ASTM C76 Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
    - ASTM C76 Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
    - ASTM C443 Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
    - AASHTO M 242/ASTM C655 Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe.
    - AASHTO M 206/ASTM C506 Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe
    - AASHTO M 207/ASTM C507 Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
    - AASHTO T 280/ASTM C497 Standard Method of Test for Concrete Pipe, Manhole Sections, or Tile
    - AASHTO M 157/ASTM C94 Standard Specification for Ready Mixed Concrete
    - AASHTO M 85/ASTM C150 Portland Cement
    - AASHTO M 240/C595 Blended Hydraulic Cement
    - AASHTO M 295/ASTM C618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
    - AASHTO M 302/ASTM C989 Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
    - AASHTO M 6 Fine Aggregate for Portland Cement Concrete
    - AASHTO M 80 Coarse Aggregate for Portland Cement Concrete
    - ASTM C33 Standard Specification for Concrete Aggregates
    - AASHTO T 26/ASTM C1602 Quality of Water to be Used in Concrete
    - AASHTO M 154/ASTM C260 Air-Entraining Admixtures for Concrete
    - AASHTO M 194/ASTM C494 Chemical Admixtures for Concrete

- AASHTO M 241/ASTM C685 Concrete Made by Volumetric Batching and Continuous Mixing AASHTO R 38: Standard Practice for Quality Assurance of Standard Manufactured Materials
- AASHTO HS20: Design Live Load Requirements

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