MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
QUALITY CONTROL AND ACCEPTANCE OF STRUCTURAL PRECAST CONCRETE

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a. Description. The Contractor must administer quality control (QC) and the Department will administer quality assurance (QA) procedures that will be used for acceptance of and payment for all Portland cement concrete (PCC) used to fabricate structural precast (prestressed and non-prestressed) concrete elements. This special provision applies to the following fabricated structural precast concrete elements:

- Bridge prestressed concrete beams;
- Culverts (span length equal to or greater than 10 feet measured from inside of exterior walls, parallel to the roadway centerline);
- Prefabricated bridge elements and systems;
- Mechanically stabilized earth walls;
- Spun concrete poles;
- Sound walls; and
- Other fabricated elements required to be accepted based on “Fabrication Inspection” per MDOT’s Materials Quality Assurance Procedures (MQAP) manual or as specified in the contract.

Except as explicitly modified by this special provision, all materials, test methods, and PCC mixture requirements of the standard specifications and the contract apply.

Provide the Engineer with 7 calendar days notification prior to the start of fabrication unless a longer notification period is specified in the contract. Additionally, provide the Engineer with adequate prior notification, as determined at the prefabrication meeting, prior to placement of PCC. Inadequate prior notification may result in rejection of the element due to lack of quality assurance verification inspection.

The following definitions apply when used herein:

Air Content of Fresh Portland Cement Concrete. The recorded air content of fresh PCC sampled and tested in accordance with this special provision.

Alkali-Silica Reactivity (ASR). A chemical reaction which occurs over time within PCC between highly alkaline cement paste and reactive forms of silica found in some aggregates. In the presence of moisture, an expansive ASR gel is formed which can exert pressure within the PCC, causing random cracking and premature deterioration of the PCC. See subsection c.5.A of this special provision.

Correction. Action to eliminate a detected nonconformity. This could include determining and executing a specific disposition (use as-is, rework, scrap, or repair) or restoring a process to within control limits.

Corrective Action. Action to eliminate the cause of a detected nonconformity or other undesirable situation such as a repetitive process control issue, a severe or repetitive procedural violation, or a severe customer complaint, or any internal or external audit finding. This "action" includes identifying the extent of the nonconformity (quantity of affected product or materials, number of affected machines or instruments, etc.), containing the extent (like segregating, process interruption, personnel stand-down, etc.), correcting the nonconformity (see "Correction" above), identifying the root cause, and implementing long-term verifiable action to prevent recurrence.

Job Mix Formula (JMF). The actual batch quantities (mixture proportions) of each constituent included in the PCC mixture, based on adjustments to the target weights attained from the mix design process necessary to optimize the PCC mixture properties.

Portland Cement Concrete Mix Design. The process, by which the PCC mixture performance characteristics are defined, based on selected materials, performance requirements, environmental exposure considerations, placement methods, and other factors that control the plastic and hardened properties of the PCC in efforts to produce an economical and durable product.

Preventive Action. Action to eliminate the cause of any potential nonconformity or other undesirable potential situation, as part of a regular continuous improvement program unrelated to a specific or repeating nonconformity (See Corrective Action).

Production Lot. A discrete quantity of PCC containing the same JMF and used for the same application as described in subsection c.5.F of this special provision.

Quality Assurance (QA). Activities administered by the Department dealing with acceptance of the product, including, but not limited to, materials selection, sampling, testing, fabrication inspection, and review of Contractor QC documentation. All PCC QA sampling and testing will be administered by the Engineer. Department administered QA is described in section d of this special provision.

Quality Control (QC). All activities administered by the Contractor to monitor, assess, and adjust production and fabrication processes to ensure the final product will meet the specified levels of quality, including, but not limited to, training, materials selection, sampling, testing, project oversight and documentation. Contractor administered QC is described in section c of this special provision.

QC Action Limits. A range of values established by the Contractor in the QC plan that if exceeded, requires correction be taken by the Contractor to restore the continuity and uniformity of the mixture and methods in conformance with specification requirements. The QC action limits must not exceed the QC suspension limits.

QC Plan. The plan developed by the Contractor describing, in detail, all aspects of production and fabrication for the project to ensure consistent control of quality to meet specification requirements and plant certification requirements. Suppliers of main member bridge prestressed concrete beams must also meet the *MDOT Supplier Qualification Standard for Prestressed Concrete Beams*.

QC Manager. An employee of the Contractor responsible for developing and overseeing all aspects of QC for the project. This includes, but is not limited to preparing the QC plan,

managing all QC personnel, communicating routinely with the production personnel to ensure quality, initiating correction, suspending operations when the process is found to be producing non-conforming materials, and preparing and submitting all necessary QC documentation to the Engineer within the specified time period.

QC Suspension Limits. A range of values that if exceeded on a single QC test, requires that the Contractor suspend operations and determine, correct, and document the deficiencies before resuming production. The QC suspension limit must not exceed specification limits.

Sample. A representative quantity of PCC taken during production which is used to measure the quality characteristics for the PCC.

Sampling Rate. The number of times the fresh PCC is sampled.

Specification Limits. The threshold values placed on a quality characteristic used to evaluate the quality of the material.

Strength Sample Test Result. The average of two or three companion strength sample test specimens (28-day compressive strength and work progress) for non-prestressed structural precast concrete and prestressed structural precast concrete, respectively, taken from the same sample of PCC is considered a strength sample test result.

Strength Test Specimen. A strength test specimen is an individual 6-inch by 12-inch strength test cylinder or 4-inch by 8-inch strength test cylinder molded and cured in accordance with *AASHTO T23/ASTM C31* and tested in accordance with *AASHTO T22/ASTM C39*. Ensure all QC strength test specimens are the same nominal size. Strength test specimen cylinder size of 4-inch by 8-inch is permitted only if the nominal maximum coarse aggregate particle size, as specified for the coarse aggregate in the PCC mixture, is 1-inch or less.

Sublot. A portion of a production lot represented by a complete set of QC tests, as described in subsection c.5.F of this special provision. The Engineer and Contractor may agree to reduce the typical sublot size based on other project conditions.

b. Materials. Ensure mixture requirements are in accordance with the contract. Ensure aggregate meets *MDOT Procedures for Aggregate Inspection*.

c. Contractor Administered Quality Control (QC).

1. Contractor Quality Control Plan (QC plan). Prepare, implement, and maintain a QC plan for PCC, in accordance with applicable plant certification requirements shown in the contract, which will provide quality oversight for production, testing, and control of fabrication processes. Ensure the QC plan is in conformance with the contract and identifies all procedures used to control production and placement including when to initiate correction necessary to maintain the quality and uniformity of the work. Suppliers of main member bridge prestressed concrete beams must also meet the *MDOT Supplier Qualification Standard for Prestressed Concrete Beams*.

Develop PCC mix designs and JMFs, as specified, and conduct QC sampling, testing, and inspection during all phases of the PCC work at the minimum frequency, or at an increased frequency sufficient to ensure that the work conforms to specification requirements.

2. QC Records. Maintain complete records of all QC tests and inspections. Include sufficient information to allow the test results to be correlated with the items of work represented. Document what action was taken to correct deficiencies.

Furnish one copy of all QC records, including test reports for the fresh PCC placement, to the Engineer within 24 hours after the date covered by the record in a format acceptable to the Engineer. The Engineer will withhold acceptance of the PCC for failure to provide properly documented and timely QC records and reports.

3. Personnel Requirements. The QC Manager must have full authority and responsibility to take all actions necessary for the successful implementation of the QC plan, including but not limited to, the following:

A. Monitoring and utilizing QC tests, control charts, and other QC practices to ensure that delivered materials and proportioning meets specification requirements.

B. Monitoring all materials prior to their use, to ensure their continued compatibility toward producing consistent quality.

C. Periodically inspecting all equipment utilized in transporting, proportioning, mixing, placing, consolidating, finishing, and curing to ensure proper operation.

D. Monitoring materials stockpile management, PCC batching, mixing, transporting, placement, consolidation, finishing, and curing to ensure conformance with specification requirements.

E. Maintaining and submitting all QC records and reports to the Engineer.

F. Directing the necessary correction to ensure continual conformance within specification limits.

G. Conducting or monitoring adjustments to the JMF.

H. Observing PCC placement during the entire casting operation.

Individuals performing QC tests must demonstrate that they are proficient and capable of sampling and testing PCC or aggregate, where applicable, in accordance with the associated test procedures and Department requirements prior to commencement of related work. Ensure concrete testing is performed by a certified concrete technician [Michigan Concrete Association (MCA) Level I Concrete Field Testing Technician or ACI Concrete Field Testing Technician - Grade I]. The period of effectiveness for the ACI certification is reduced from 5 years to 3 years. Ensure any adjustments to the JMF are made by a certified concrete technician [MCA Level II or Precast/Prestressed Concrete Institute (PCI) Level III].

Individuals performing concrete strength testing (performing, recording, and reporting) must possess an ACI Concrete Strength Testing Technician certification.

4. QC Laboratory Requirements. Laboratories, including field laboratories and all associated testing equipment that prepare PCC mixes or perform QC testing, must demonstrate to the Engineer that they are equipped, staffed, calibrated, and managed so as to be capable of batching and testing PCC in accordance with the applicable test methods

and procedures. Mix designs and their accompanying JMFs must include a statement, signed by a certified concrete technician (MCA Michigan Level II or PCI Level III), that all applicable standard test methods have been followed in verifying the mix design and JMF.

QC aggregate testing is required for coarse aggregate from MDOT prequalified aggregate sources. Perform sieve analysis per *MTM 109* and loss by wash per *MTM 108* after material has been transported to the precast plant. Ensure aggregate sampling and testing is conducted by a Michigan Certified Aggregate Testing (MCAT) Level I technician.

5. Mix Design and Documentation. Design PCC mixtures meeting the requirements specified in the contract. Request variance in writing when proposing a mix design that exhibits temperature, slump, or air content other than those specified. Include the proposed mix design, JMF, and associated trial batch verification test data.

Non-prestressed structural precast concrete mixtures using Type III Portland cement must contain 25 to 40 percent replacement of the Portland cement in the concrete mixture with supplementary cementitious material.

Unless otherwise specified in the contract, do not exceed 40 percent replacement of the Portland cement in the concrete mixture with a supplementary cementitious material. Do not exceed 40 percent total replacement of the Portland cement if more than one supplementary cementitious material is used in the concrete mixture.

Blended cement meeting the requirements of *ASTM C595 Type IL* is permitted.

Ensure supplementary cementitious materials are from an MDOT Approved Manufacturer. Ensure slag cement and fly ash meet the requirements of section 901 of the Standard Specifications for Construction.

Ensure air content is 5.5 percent to 8.5 percent. Ensure that the concrete temperature is from 45 to 90 degrees Fahrenheit, inclusive.

A. Alkali-Silica Reactivity. Provide documentation to the Engineer that the PCC mixture does not present the potential for excessive expansion caused by alkali-silica reactivity (ASR). Provide current ASR test results (valid for 2 years from completion of testing) for in-state and out-of-state fine aggregate sources and for out-of-state coarse aggregate sources. Ensure testing is performed by an independent testing laboratory proficient in ASR testing. The independent testing laboratory must certify in writing, including a signed statement that all testing was conducted in accordance with the designated standard test procedures, described herein. Test results must conform to the specified criterion for one of the following standard test methods. Use the Rounding Method described in *ASTM E29* when determining significant digits for reporting expansion test results.

(1) Method 1. *ASTM C1293*. Concrete Prism Test. If the expansion of concrete prisms is not greater than 0.040 percent (rounded to the nearest 0.001 percent) after 1 year, the fine aggregate is considered non-deleterious to ASR and may be used in the JMF.

(2) Method 2. *ASTM C1567*. Mortar Bar Test. If no previous test data are available for the fine aggregate that shows it is resistant to ASR using Method 1,

above, replace 25 to 40 percent of the Portland cement in the concrete mixture with a supplementary cementitious material. A blended cement meeting the requirements of *ASTM C595* containing the above Portland cement and supplementary cementitious material proportions may also be used.

Demonstrate the ability of the supplementary cementitious material to control the deleterious expansion caused by ASR by molding and testing mortar bars in accordance with the standard test method described in *ASTM C1567* using the mix proportions and constituent sources for both the aggregates and the cementitious materials that will be used for the project. Make at least three test specimens for each cementitious materials-aggregate combination. If the average of three mortar bars for a given cementitious materials-aggregate combination produces an expansion less than 0.10 percent (rounded to the nearest 0.01 percent) at 14 days of immersion, the JMF associated with that combination will be considered non-deleterious to ASR. If the average expansion is 0.10 percent (rounded to the nearest 0.01 percent) or greater, the JMF associated with that combination will be considered not sufficient to control the deleterious expansion caused by ASR and the JMF will be rejected.

(3) Method 3. *ASTM C1260*. Mortar Bar Test. If the expansion of the mortar bars is less than 0.10 percent (rounded to the nearest 0.01 percent) at 14 days of immersion, the fine aggregate is considered non-deleterious to ASR and may be used in the concrete without the need for ASR mitigation.

The Engineer will not approve the use of the JMF if the expansion exceeds the respective threshold limits for the respective *ASTM* test method used.

B. Contractor Provided Mixes. Provide mix design and accompanying JMFs using the methods of verification included in this special provision. Include sufficient information on constituent materials, trial batch verified physical properties of the fresh PCC, mix proportions per cubic yard for all constituents and compressive strength test results necessary to allow the Engineer to fully evaluate the expected performance of the PCC mixture.

(1) Mix Documentation. Prepare mix designs for each grade of PCC required on the project. Submit JMF for each mix design, including all required documentation, to the Engineer for review at least 10 working days before fabrication of structural precast concrete elements. The Engineer will notify the Contractor of any objections within 5 working days of receipt of the mix documentation. Identify each individual JMF and reference all accompanying documentation to this identification. Reference each JMF to the appropriate method of verification. Mix design and JMF submittals that do not include all required mix documentation will be considered incomplete and the Engineer will return them without review. Fabrication must not begin until the Engineer has received all required mix documentation.

Mix documentation is valid for 2 years provided the material characteristics have not deviated beyond the requirements specified in the contract.

Ensure all mix designs and accompanying JMFs are traceable to a laboratory meeting the requirements of this special provision.

Submit mix design and JMF on the MDOT Job Mix Formula (JMF) Concrete Field

Communication form (MDOT Form Number 1976) or fabricator's standard JMF form; include accompanying documentation. List the source of materials, bulk density (unit weight) of coarse aggregate (rodding procedure or shoveling procedure), absorption of aggregates, relative density (specific gravity) of aggregates, aggregate correction factors, batch weights, and project specific or historical laboratory test data. Include the recorded air content of fresh PCC using the same admixture and cementitious material sources to be used in the production of the PCC for the project.

Four methods of verification of proposed JMF are acceptable.

(a) Method 1. Trial Batches. Verification of JMF is based on trial batches with the same materials and proportions proposed for use on the project. Prepare at least one trial batch for each mix design in sufficient time before starting PCC placement to allow for review in accordance with subsection c.5.B.(1) of this special provision. Provide the results of temperature, slump, density (unit weight), air content of fresh PCC, 28-day compressive strength, and age of PCC at the time of strength testing, for a minimum of three independent samples. All samples may be taken from a single trial batch for a mix design provided the trial batch is at least four cubic yards in volume. For JMF trial batch verification purposes only, 7-day compressive strength test results which report at least 70 percent of the specified 28-day lower specification limit (LSL) will be sufficient documentation in lieu of 28-day compressive strengths. The average of at least two strength test specimens represents one compressive strength sample test result for each independent sample. Provide the necessary ASR documentation as described in subsection c.5.A of this special provision.

(b) Method 2. Same Mix. Verification of JMF is based on experience with the same mix design, JMF, and the same materials. Provide the results of temperature, slump, density (unit weight), air content of fresh PCC, 28-day compressive strength, and age of PCC at the time of strength testing, for a minimum of three independent samples. The average of at least two strength test specimens represents one compressive strength sample test result for each independent sample. Do not substitute material types or sources, including admixtures or cementitious materials, nor change mix proportions in the JMF. Provide the necessary ASR documentation as described in subsection c.5.A of this special provision.

(c) Method 3. Similar Mix. Verification of JMF is based on requirements described in method 2, above. Substitution of coarse and intermediate aggregate sources is permitted if the new source is of the same geologic type as the original aggregate, and conforms to the specification requirements for the application. Substitution of fine aggregate is permitted only if the new source has been tested for ASR. Provide the necessary ASR documentation as described in subsection c.5.A of this special provision.

Provide the supporting laboratory trial batch documentation and accompanying calculations showing how the mix proportions in the JMF were adjusted, based on the documented differences in relative density (specific gravity), bulk density (unit weight) and absorption of the substituted aggregate sources, to produce a theoretical yield of 100 percent and the required fresh PCC properties.

(d) Method 4. Annual Verification. At the Engineer's option, verification may be accepted annually for a PCC plant rather than on a project basis provided the sources and proportions of the constituent materials, including cementitious materials and source and types admixtures, do not change. If the project is the continuation of work in progress during the previous construction season and written certification is submitted to the Engineer that materials from the same source and with the same mixture properties are to be used, the Engineer may waive the requirement for annual renewal verification of the JMF for the project. Provide the necessary ASR documentation as described in subsection c.5.A of this special provision.

C. Changes in Materials and Proportions. Prior to batching, verify that the proposed JMF changes will not affect the properties of the fresh PCC [slump, temperature, air content, density (unit weight), and workability], nor result in excessive mortar bar expansion as a result of deleterious reactivity between the aggregates and cementitious materials as described in subsection c.5.A of this special provision.

Record all changes to JMF in the QC records along with the rationale for the change.

D. QC Sampling and Testing. Conduct startup sampling and testing for temperature, slump, density (unit weight), and air content on the first load. Do not place PCC until testing verifies that the fresh PCC properties meet project specifications. If a concrete load is tested and found to be out of specification, then ensure the next concrete load is tested until concrete meets specifications without adjustment. Continue testing concrete as described in the QC plan for each JMF and ensure the testing correlation requirements of subsection d.2 of this special provision have been met. Ensure QC sampling and testing are independent from the Department’s QA sampling and testing.

Ensure PCC exceeding the maximum specification limits for slump or temperature are rejected regardless of the total mixing time at the time of arrival to the forms.

The Engineer may require the Contractor to administer additional QC sampling and testing if the Engineer determines the Contractor’s current QC sampling and testing methodology is shown to be insufficient to ensure continual control of the quality of the PCC.

Resume production only after making all necessary adjustments to bring the mixture into conformance with all applicable specifications.

E. Work Progress Test Specimens. Determine the strength of concrete for de-tensioning prestressed elements, if the contract requires verification of stripping or handling strength, or for acceptance if the element is shipped prior to testing 28-day standard cured test specimens. Cure work progress test specimens in the same manner as the in-situ PCC. Allow the Engineer to witness testing of work progress test specimens.

Lot Size and Make Up. A production lot will not include more than one grade of PCC, PCC of the same grade having different specified slump or air content, or PCC of the same grade having different mix designs, or JMFs. See Table 1 for production lot size requirements for typical structural precast concrete elements.

F. Sampling. Describe QC sampling in the Contractor QC plan in accordance with subsection c.1 of this special provision.

Table 1: Sublot Size Based on Casting Operation and Production Lot Size

Casting Operation	Production Lot Size	Sublot Size
Prestressed Element Bed Length (foot)	0 < X ≤ 400	3
Culvert Segment Span Length (foot) (a)	0 < X ≤ 40	1
Culvert Segment Span Length (foot) (a)	40 < X ≤ 60	2
Non-prestressed Wall Area (square feet)	0 < X ≤ 1500	2
Non-prestressed Wall Area (square feet)	1500 < X ≤ 2500	3
Prefabricated Bridge/Culvert Systems (cubic yard) (b)	0 < X ≤ 15	1
a. Span length is measured parallel to the roadway centerline. b. Applies to bridge substructure and culvert wing walls and headwalls.		

d. Department Administered Quality Assurance (Acceptance).

1. Department Quality Assurance Plan (QA plan). The Engineer will be responsible for administering the quality-based acceptance and will institute any actions necessary toward its successful implementation. The Engineer will follow the contract for acceptance of the structural precast concrete elements.

2. Testing Correlation. Ensure the testing equipment and associated testing personnel for both the Engineer's QA testing and Contractor's QC testing are used to conduct side by side correlation testing of the same PCC from the first load to verify correlation of both the Department's and the Contractor's test results for temperature and air content of fresh PCC. Conduct side by side testing correlation whenever there is a change in QC or QA equipment and/or personnel for the project, or as directed by the Engineer. Ensure the temperature measuring devices used for QC and QA correlate relative to each other within 2 degrees Fahrenheit. If the air content results of two tests conducted between the Engineer's and the Contractor's testers differ by more than 0.8 percent air by volume of PCC, conduct an air content test of fresh PCC by QC using a third air meter, designated by the Engineer, but independent of the project, prior to commencement of PCC placement in an effort to resolve issues relative to non-correlation.

3. QA Sampling and Testing. The Engineer will verify the Contractor's daily QC startup sampling and testing of temperature, slump, and air content of fresh PCC on the first load; conduct QA sampling and testing; monitor Contractor adherence to the QC plan; and inspect placed materials in such a manner as to ensure that all PCC for the project is represented. Ensure the testing correlation requirements of subsection d.2 of this special provision are met prior to concrete placement.

4. QA Stop Production Criteria. The Engineer will issue a Notice of Non-Compliance with Contract Requirements (Form 1165) and PCC production must stop when one or more of the following are observed.

A. The QC plan is not being followed.

B. Segregation or other notable changes in the fresh PCC properties is observed that

may prevent proper placement, consolidation and finishing, or compromise the performance or long-term durability of the finished product.

C. The required curing system is not being applied in a timely manner, as specified by the contract.

The Engineer will issue a Notice to Resume Work (Form 1165) only after all necessary adjustments are made to restore conformance with all applicable specifications, and the appropriate documentation is made in the QC records.

5. Acceptance. The Engineer will maintain a complete record of all QA tests and inspections. Acceptance will be based on the contract.

e. Measurement and Payment. Separate payment will not be made for providing, implementing, and maintaining an effective QC program. All costs associated with this work will be included in the applicable unit prices for the structural precast concrete elements. Failure by the Contractor to maintain the proper curing environment for strength test specimens during initial and final cure will not be basis for claim against the Department.