MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
QUALITY CONTROL AND ACCEPTANCE OF STRUCTURAL PRECAST CONCRETE FOR LOCAL AGENCY PROJECTS ONLY

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a. Description. The Contractor must administer QC and the Engineer may administer QA procedures that will be used for acceptance and payment for the fabricated structural precast (prestressed and non-prestressed) concrete elements. QA is only required if the basis of acceptance is "Fabrication Inspection" per the MDOT *MQAP Manual* or project special provision. This special provision applies to the following 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 the *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.

Furnish the Engineer with a minimum of 7 calendar days notification prior to the start of fabrication unless a longer notification period is specified in the contract. Additionally, furnish 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 QA verification inspection.

The following definitions apply when used herein:

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

Alkali-Silica Reactivity (ASR). A chemical reaction that 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 that 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, 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.

Engineer. The Engineer representing the local agency (City, County, or Village) for non-trunkline projects.

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 (PCC) 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 Engineer 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. Engineer 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, the key control 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. Contractors supplying prestressed concrete bridge beams must, at a minimum, double the number of remaining sublots for a production lot if a sublot (except the first sublot) QC test exceeds QC Suspension Limits.

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

Sampling Rate. The minimum number of times the fresh PCC is required to be 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 tests (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 or 4-inch by 8-inch strength test cylinder molded and cured in accordance with *ASTM C31/C31M* and tested in accordance with *ASTM C39/C39M*. 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. Contractor must increase the sublot size for prestressed concrete bridge beams each time QC Suspension Limits are activated.

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

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. The QC Plan must establish the required procedures for 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 required frequency, or at an increased frequency sufficient to ensure that the work conforms to specification requirements.

Contractors' supplying prestressed concrete bridge beams must include detailed QC Action Limits and QC Suspension Limits in their QC Plan.

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 actions 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 furnish 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 corrections 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 Engineer requirements prior to commencement of related work. Ensure concrete testing is performed by a certified concrete technician (MCA Level I Concrete Field Testing Technician or ACI Concrete Field Testing Technician - Grade I). Ensure any

adjustments to the JMF are made by a certified concrete technician (MCA Level II, NPCA PQS Level II – QA/QC, or 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, NPCA PQS Level II – QA/QC, 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, which must come from MDOT registered aggregate sources having documented suitable physical properties. 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 Technician (MCAT) Level I or ACI Aggregate Testing Technician - Level I.

5. Mix Design and Documentation. Design PCC mixtures that meet the requirements specified in the contract. Request variance in writing when proposing a concrete mixture that exhibits temperature, slump, or air content other than those specified.

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 (slag cement or fly ash).

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/C595M 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 between 5.5 percent and 8.5 percent. Ensure that the concrete temperature is from 45 to 90 °F, inclusive.

A. Alkali-Silica Reactivity. Furnish documentation to the Engineer that the PCC mixture does not present the potential for excessive expansion caused by alkali-silica reactivity (ASR). Furnish 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/C1293M*. 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/C595M* 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. Engineer Approval. Use JMFs representing concrete mixtures that are approved by the Engineer based on the methods of qualification defined in this special provision. Once approved, the duration of JMF approval is 2 years unless the qualification conditions change or approval is rescinded by the Engineer.

(1) Submittal Requirements. Prepare separate JMFs for each concrete mixture. Submit JMFs, including all required supporting documentation, to the Engineer for approval 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 mixture documentation. Identify each individual JMF and reference all accompanying documentation to this identification. Reference each JMF to the appropriate method of qualification as described below. Furnish 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. Submittals that do not include all required mixture documentation will be considered incomplete, and the Engineer will return them without review.

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

Summarize the concrete mixture on the *MDOT Job Mix Formula (JMF) Concrete Field Communication* (Form 1976) or fabricator's standard JMF form and include accompanying documentation. List the sources for 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.

(2) Required Average Compressive Strength, f'_{cr}. The concrete mixture must demonstrate a 28-day compressive strength equal to or exceeding the required average compressive strength, f'_{cr}. Incorrect application of equations, calculation errors, batch record deficiencies, and incomplete traceability in the data will be cause for invalidation and denial of approval.

Determine the required average compressive strength, f'_{cr}, according to the provisions contained in *ACI 211.1, 214R, 301*, and *318*, or according to plant certification requirements, using the higher of the results. Include a complete statistical analysis showing values and dates of each test result, all related batch records, standard deviation, and the results of each required average compressive strength equation.

When using standard deviation of field strength tests to establish f'_{cr}, a minimum of 15 consecutive tests over at least 45 days is required. Ensure tests are from a mixture with the same type of cementitious materials, aggregates, and admixtures having a specified compressive strength within 1000 psi, and no test may be older than 24 months at the time of approval.

For the proposed JMF, determine and document the average compressive strength of the concrete mixture based on the 10 most recent tests taken from the data used to establish the required average compressive strength, f'_{cr}. The initial average compressive strength of the concrete mix is based on 28-day compressive strength tests taken from at least 10 independent samples from mixture qualification.

(3) Mixture Qualification Process. Qualification of JMF is based on trial batches with the same materials and proportions proposed for use on the project. Conduct trial batching for each mixture design in sufficient time before starting PCC placement to allow for review in accordance with subsection c.5.B.(1) of this special provision. Furnish 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 10 independent samples from batches encompassing a period of not less than 45 days. Up to three samples may be taken from a single trial batch for a mixture design provided the trial batch is at least four cubic yards in volume. The average of at least two strength test specimens represents one compressive strength

sample test result for each independent sample. Furnish the necessary ASR documentation as described in subsection c.5.A of this special provision.

Substitution of coarse and intermediate aggregate sources is permitted if the new source is of the same geologic type (e.g. crushed limestone, natural aggregate) 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. Furnish the necessary ASR documentation as described in subsection c.5.A of this special provision.

Furnish the supporting laboratory trial batch documentation and accompanying calculations showing how the mixture 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.

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 ASR 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 the JMFs in the QC records along with the rationale for the changes.

Calculate and track the average compressive strength, standard deviation, and required average compressive strength, f'_{cr}. If average compressive strength is less than the new required average compressive strength, f'_{cr}, take immediate steps to increase average compressive strength of the concrete. If average compressive strength exceeds the new required average compressive strength, $f'_{cr,}$ mixture proportions may be adjusted to achieve an average compressive strength above the revised required average compressive strength for the duration of the project.

D. QC Sampling and Testing. Conduct startup sampling and testing for temperature, slump, density (unit weight), and air content on the first batch. Do not place PCC until testing verifies that the fresh PCC properties meet project specifications. If a concrete batch is tested and found to be out of specification, then ensure the next concrete batch 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 Engineer'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.

F. Lot Size and Make Up. A production lot must 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.

G. Sampling. Describe QC sampling in the Contractor QC Plan in accordance with subsection c.1 of this special provision. Ensure the last sublot is taken from the last or second from last concrete batch. Ensure the remaining sublots are evenly distributed amongst the remaining concrete batches when selected by QC. However, QA has the authority to randomly select the remaining sublots.

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

Casting Operation	Production Lot Size	Minimum Sublot Size
Prestressed Bridge Beam (bed length) (a)	0 < X ≤ 400 foot	3
Prestressed Non-Bridge Beam (bed length)	0 < X ≤ 300 foot	3
Culvert Segment (span length) (b)	0 < X ≤ 40 foot	1
Culvert Segment (span length) (b)	40 < X ≤ 60 foot	2
Non-Prestressed Wall (area)	0 < X ≤ 1500 square foot	2
Non-Prestressed Wall (area)	1500 < X ≤ 2500 square foot	3
Prefabricated Bridge/Culvert System (c)	0 < X ≤ 15 cubic yard	1

a. Ensure at least one-half of the concrete batches produced for the production lot are sampled and tested (e.g. 7 batches of concrete requires 4 sublots).
b. Span length is measured parallel to the roadway centerline.
c. Applies to bridge substructure and culvert wing walls and headwalls.

d. Engineer Administered Quality Assurance (Acceptance).

1. Engineer 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 if the fabricated element is required per the *MQAP Manual* to be accepted based on “Fabrication Inspection”. In this case, the MDOT’s *Structural Fabrication Quality Manual (SFQM)* will be followed in addition to this section of the special provision for acceptance of the structural precast concrete products.

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 batch to verify correlation of both the Engineer’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 °F. 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 and air content of fresh PCC on the first batch; 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 element.

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 a claim against the Department.