MISSISSIPPI DEPARTMENT OF TRANSPORTATION

CONCRETE FIELD MANUAL

MATERIALS DIVISION
Rev. June 28, 2016

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1 General

1.1 Purpose

The purpose of this manual is to establish uniform procedures and practices for Portland Cement Concrete (or "concrete") with respect to:

- mixture design,
- mixture design review and approval,
- mixture production and transportation,
- mixture sampling and testing, and
- handling and testing of hardened concrete as applied to concrete in bridges, structures, and other items.

There are two methods of materials acceptance employed by the Department to ensure the requirements of Department specifications are satisfied.

For the first method of acceptance the Department primarily performs all the sampling and testing tasks associated with ensuring the requirements for concrete in the Department specifications are satisfied. A specific example of this method is the sampling and testing of plastic concrete by Department personnel to ensure the concrete meets the acceptance criterion for slump prior to incorporating the concrete into a Department project. Whereas Department personnel perform the tasks associated with testing the concrete mixture, this method does not completely absolve the Contractor from some responsibilities associated with concrete. One example of this is the Contractor's responsibility to design the proportions of a concrete mixture which meets all the requirements for plastic concrete, like the slump, and compressive strength.

The sampling frequencies and tests are outlined in Department SOP's TMD-20-04-00-000 and TMD-20-05-00-000.

For the second method of acceptance the Department shares much of the responsibility for ensuring the materials meet the requirements for concrete in the Department specifications with the Contractor. The Department is still responsible for ensuring the requirements for concrete in the Department specifications are satisfied; however, the Contractor is responsible for quality control (QC) of most of the materials. This manual outlines the requirements of the Department's verification activities as well as requirements for the Contractor's QC activities.

The sampling frequencies and tests and other related activities are found in Section 804 of the Department specifications.

For ready reference sample forms are provided in Appendix B. Materials Division SOP's and other guidance can be found in the current Materials Division *Inspection, Testing, and Certification Manual* which can be found on the Department's website at www.gomdot.com.

1.2 Terminology

AAP – AASHTO Accreditation Program
AASHTO – American Association of State Highway and Transportation Officials
ACI – American Concrete Institute
APL – the list of the Department's Approved Sources of Materials
ASTM – American Society of Testing Materials
DME – District Materials Engineer - the engineer in a specific MDOT District responsible for the activities at the applicable District Laboratory. The DME may be represented by other engineers, engineers-in-training, or technicians under his supervisory authority assigned to the applicable District Laboratory.
FHWA – Federal Highway Administration
JC – Job Control
LQ – Large Quantity – a project on which the concrete which is evaluated under the QC/QA Sampling and Testing materials inspection program exceeds a quantity of 1000 cubic yards or more. Concrete for this project is evaluated by statistical methods.
MCIA – Mississippi Concrete Industries Association
MDOT – Mississippi Department of Transportation
MDOT Class I technician – Contractor or Department Personnel who have successfully completed the ACI Concrete Field Technician Grade I Program for sampling and testing concrete in the field. This certification level is required for all performance of sampling and testing of concrete mixtures. In addition to having an ACI Grade I certification, the Personnel must maintain a good standing with the Department with respect to performing sampling and testing of concrete in accordance with the Department specifications.
MDOT Class II technician – Contractor or Department Personnel who have successfully completed the ACI Aggregate Testing Technician Level 1 Program for sampling and testing of aggregates. This certification level is required for performance of sampling and testing of aggregates used in concrete mixtures. In addition to having an ACI Aggregate Testing Technician Level 1 certification, the Personnel must maintain a good standing with the Department with respect to performing sampling and testing of concrete in accordance with the Department specifications.
MDOT Class III technician – Contractor or Department Personnel who have successfully completed the MDOT QC/QA Concrete Technician Certification Program for the design of concrete mixtures. This certification level is required for designing or approving the design of concrete mixtures. All personnel at this level must have first completed requirements and obtained MDOT Class I, MDOT Class II, and MDOT Strength Testing certification levels. MDOT Class I and Class II and Strength Testing are equivalent to ACI Concrete Field Testing Technician and ACI Aggregate Testing Technician and ACI Strength Testing Technician certification classes. A MDOT Class III technician has to have successfully completed and passes passed MDOT Class I, MDOT Class II, and MDOT Strength Testing Technician Classes at least one time to obtain MDOT Class III certification. MDOT only requires recertification of MDOT Class III to obtain certification as a concrete mixture designer . A MDOT Class III technician is must be knowledgeable concerning concrete and aggregate properties. A concrete mix designer that does not exhibit knowledge of concrete and aggregate properties must recertify for MDOT Class I, Class II and Strength Testing Technician every 5 years.
MDOT Strength Testing technician – Contractor or Department Personnel who have successfully complete the ACI Strength Testing Technician Program for strength testing of concrete test specimens. This certification level is required for performance of testing of concrete test specimens. In addition to have an ACI Strength Testing Technician certification, the Personnel must maintain a good standing with the Department with respect to performing testing of concrete test specimens in accordance with Department specifications.
MDITCM – Materials Division Inspection, Testing, and Certification Manual

MQ – Medium Quantity - a project on which the concrete which is evaluated under the QC/QA Sampling and Testing materials inspection program exceeds a quantity of 200 cubic yards, but is less than 1000 cubic yards. Concrete for this project is evaluated by comparison of individual sets of cylinders.
NIST – National Institute for Standards and Technology
NRMCA – National Ready Mixed Concrete Association
PCC – Portland Cement Concrete
PCI – Precast / Prestressed Concrete Institute
QA – Quality Assurance
QC – Quality Control
QCP – Quality Control Plan
QSM – Quality System Manual (a QCP for manufacturers of precast-prestressed concrete bridge members)
SOP – Standard Operating Procedure
SQ – Small Quantity - a project on which the concrete which is evaluated under either the Department Sampling and Testing or the QC/QA Sampling and Testing materials inspection programs less than 200 cubic yards. For additional information, refer to TMD-20-05-00-000, "Sampling and Testing of Small Quantity of Miscellaneous Materials."
STTAC – Slump, Temperature, and Total Air Content

1.3 Definitions

Batch – a quantity of concrete mixture mixed together at a specific, unique time, typically transported in its entirety in a single ready-mix truck or a dump truck, and documented on a single, unique batch ticket
Batch Ticket – the documentation containing specific information concerning an individual batch of concrete mixture. See Subsection 804.02.12.3 for the information required on a batch ticket for each batch of concrete mixture.
Concrete – concrete mixture which has completed or nearly completed the hydration process by which some of the mixture's ingredients chemically react resulting in a usually hard and durable stone-like construction material; also called PCC
Concrete Mixture – an unhardened (i.e., "plastic") mixture of Portland cement and possibly other cementitious materials, water, fine aggregate(s), coarse aggregate(s), and possibly admixture(s)
Concrete Mixture Design – see *Mixture Design*
Concrete Batch Plant – the facility or location where the ingredients of a concrete mixture are initially combined
Concrete Producer – a company that produces concrete mixtures; the concrete producer may be the Contractor or a sub-Contractor
Department – Mississippi Department of Transportation (MDOT)
Discharge for Placement – removal of the concrete mixture from the method of conveyance (i.e., ready-mix truck, …) for incorporation into the project
Large Quantity Project – a project where the total volume of concrete used in Pay Items under Section 804 is 1000 cubic yards or more, as described in Subsection 804.02.1.
Maximum Allowable Slump – the slump specified by the Department which may not be exceeded
Maximum Permitted Slump – the slump specified by the Contractor for a specific mixture design to meet the workability requirements for an application, which may not be exceeded. This may be less than the Maximum Allowable Slump, but may not exceed it.
Medium Quantity Project – a project where the total volume of concrete used in Pay Items under Section 804 is more than 200 cubic yards, but less than 1000 cubic yards, as described in Subsection 804.02.1.
Mixture Design - a unique combination of specific materials in specific quantities (i.e., the proportions) meeting the requirements of the specifications

Placement – incorporation of the concrete mixture into the project
Plastic Properties – the slump, temperature, and total air content of concrete mixture
Sample – the concrete mixture discharged into the receptacle for the purposes of creating test samples (i.e., the concrete mixture in the wheelbarrow, from which concrete mixture is taken and placed in a slump cone or air meter)
Small Quantity Project – a project where the total volume of concrete used in Pay Items under Section 804 is 200 cubic yards or less, as described in Subsection 804.02.1. Sampling and testing of concrete mixture under SQ projects is outlined in TMD-20-05-00-000.
Test Sample – the concrete mixture actually used during determination of its plastic or hardened properties (i.e., the concrete mixture in the slump cone or air meter)
Verification – the activities performed by the Department to ensure the materials incorporated into a project meet the contract requirements

For additional definitions not defined here, refer to Section 101 of the Department's *Mississippi Standard Specifications for Road and Bridge Construction*.

1.4 Referenced AASHTO and ASTM Standards

AASHTO Standards

AASHTO R 18	Establishing and Implementing a Quality System for Construction Materials Testing Laboratories
AASHTO R 39	Making and Curing Concrete Test Specimens in the Laboratory
AASHTO R 60	Sampling Freshly Mixed Concrete
AASHTO T 2	Sampling Aggregates
AASHTO T 19	Bulk Density ("Unit Weight") and Voids in Aggregates
AASHTO T 22	Compressive Strength of Cylindrical Concrete Specimens
AASHTO T 23	Making and Curing Concrete Test Specimens in the Field
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 84	Specific Gravity and Absorption of Fine Aggregate
AASHTO T 85	Specific Gravity and Absorption of Coarse Aggregate
AASHTO T 119	Slump of Hydraulic Cement Concrete
AASHTO T 121	Mass per Cubic Meter (Cubic Foot), Yield, and Air Content (Gravimetric) of Concrete
AASHTO T 152	Air Content of Freshly Mixed Concrete by Pressure Method
AASHTO M 157	Ready-Mixed Concrete
AASHTO T 196	Air Content of Freshly Mixed Concrete by the Volumetric Method
AASHTO T 231	Capping Cylindrical Concrete Specimens
AASHTO T 248	Reducing Field Samples of Aggregate to Testing Size
AASHTO T 255	Total Evaporable Moisture Content of Aggregate by Drying
ASTM C 1064	Temperature of Freshly Mixed Portland Cement Concrete

2 Personnel Requirements

2.1 General

The Department requires trained and knowledgeable personnel to perform all manner of duties associated with concrete materials, concrete mixture, and compressive strength testing of concrete cylinders. This includes Department personnel as well as Contractor personnel. Department personnel directly involved with the

Department's materials inspection activities and Contractor personnel directly involved with the Contractor's materials inspection activities shall have successfully complete the Department's Concrete Technician Certification program as outlined in the Materials Division *Inspection, Testing, and Certification Manual*, Subsection 1.3.4, to obtain certification at the level commensurate with their duties. Recertification is required at the frequency listed in Materials Division *Inspection, Testing, and Certification Manual*, Subsection 1.3.4.

2.2 MDOT's Personnel

2.2.1 MDOT Class I Technician

All sampling or testing of concrete mixture by the Department must be conducted by a technician representing the Department and having a current MDOT Class I certification. The Department must provide at least one technician with this level of certification the job site during acceptance of the concrete mixture as part of the Department's materials inspection activities. It is *not* necessary that the Department provide a technician with this level of certification at *all* times during the Contractor's materials inspection activities, but only as required to verify and ensure the quality of the Contractor's materials inspection data.

It is the responsibility of the technician representing the Department and having a current MDOT Class I certification to determine if concrete mixture arriving at the job site meets all the applicable specification requirements. Concrete mixture which does not meet the applicable requirements shall be rejected by the Contractor's testing personnel in accordance with the applicable specifications. If it is not, the Department technician must report this non-conformance to the Project Engineer for his disposition.

2.2.2 MDOT Class II Technician

All sampling by the Department of aggregates used in concrete must be conducted by either a technician representing the Department and having a current MDOT Class II certification or by technicians under the direct supervision of the Department's technician having a current MDOT Class II certification. All testing of aggregates used in concrete must be conducted by a Department's technician having a current MDOT Class II certification. The Department must provide at least one technician having a current MDOT Class II certification during the testing of concrete aggregates as part of the Department's materials inspection activities.

2.2.3 MDOT Class III Technician

Department technicians having a current MDOT Class III certification may review mixture designs and field verification.

2.2.4 MDOT Concrete Strength Testing Technicians

The Department must provide at least one technician having a current MDOT Concrete Strength Testing certification to perform strength testing of concrete test specimens.

2.3 Contractor's Personnel

If required by the specifications, the Contractor shall perform QC testing of concrete mixture, compressive strength of concrete cylinders, and aggregates used on Department projects with technicians meeting the following requirements.

2.3.1 MDOT Class I Technician

All sampling or testing of concrete mixture by the Contractor must be conducted by the technician representing the Contractor and having a current MDOT Class I certification. The Contractor must provide at least one technician having a current MDOT Class I certification full time at the job site to perform sampling and testing

for QC purposes. The technician will perform all the tests listed in Table 2 of Section 804 associated with the certification level.

It is the responsibility of the Contractor's technician to determine if concrete arriving at the job site meets all the applicable specification requirements and reject concrete which does not meet these requirements.

2.3.2 MDOT Class II Technician

All sampling of aggregates by the Contractor used in concrete must be conducted either by an MDOT technician representing the Contractor and having a current MDOT Class II certification or by technicians under the direct supervision of the Contractor's technician having a current MDOT Class II certification. All testing of concrete aggregates used by the Contractor must be conducted by the Contractor's technician having a current MDOT Class II certification. The Contractor must provide at least one technician having a current MDOT Class II certification full time during testing of concrete aggregates used by the Contractor.

The Contractor's technician having a current MDOT Class II certification will perform all the tests listed in Table 2 of Section 804 associated with the certification level.

2.3.3 MDOT Class III Technician

All concrete mixtures submitted by the Contractor for review must be developed by the technician representing the Contractor and having a current MDOT Class III certification. All revisions to concrete mixtures submitted by the Contractor for review must be developed by the technician representing the Contractor and having a current MDOT Class III certification. The Contractor shall have a technician having a current MDOT Class III certification available for mixture adjustments and revisions during each field verification of the mixture.

2.3.4 MDOT Concrete Strength Testing Technicians

The Contractor must provide at least one technician having a current MDOT Concrete Strength Testing certification to perform strength testing of concrete specimens.

2.3.5 Maturity Training

If the Contractor elects to use maturity to estimate the in-place strength of concrete, the technician representing the Contractor interpreting or applying the maturity data shall have previously received a minimum of two hours training in the development and application of maturity curve data correlated to strength. Contractor technicians holding a current MDOT Class III certification, obtained prior to May 1, 2015 also fulfill this requirement. After May 1, 2015, MDOT Class III certification will not include Maturity Training Certification. A separate training must be attended.

3 Concrete Mixture Design

3.1 General

The Contractor is responsible for the proportioning of materials of each concrete mixture used on the project, the field verification of each mixture design, and for any necessary adjustments of each mixture design during production to ensure that the concrete meets the specifications.

3.2 Definition

A concrete mixture design (or "mixture design") is defined as the "recipe" for a specific concrete mixture composed of a unique combination of specific materials in specific quantities (i.e., the proportions) meeting the requirements of the specifications. Each mixture design is specific to the individual company.

3.3 Concrete Mixture Design Review

3.3.1 General Mixture Submittal Process

At least 10 days prior to production of concrete, the Contractor shall submit the proposed mixture design(s) to the Project Engineer. The mixture design shall be designed by a technician representing the Contractor having a current MDOT Class III certification. Production of concrete mixture shall not begin until the Engineer has in hand either an approved mixture design or a tentatively approved mixture design from the Materials Division.

The *Concrete Mix Design* form on www.gomdot.com shall be used for submitting mixture designs for Department projects and for Office of State Aid and Road Construction projects. See paragraph 3.3.1.1 for additional information.

Not all Pay Items have their mixture design requirements programmed into the *Concrete Mix Design* form. Mixture designs for Pay Items which have not yet been programmed into the *Concrete Mix Design* form, the following process for communication between the Contractor and the Materials Division, Concrete Section, applies. This communication process may be either by letter or e-mail.

The Project Engineer will review the Contractor's request to ensure conformance with the Pay Items in the contract. If the request does not conform to the mixture class set out in the Pay Items, the Project Engineer shall reject the request and return to the Contractor by cover letter explaining the reason for rejection. If the Contractor's request is in conformance with the Pay Items, the Project Engineer will forward the request to the District Materials Engineer.

The District Materials Engineer will review the mixture design for conformity with the contract requirements (for example, ensure the mixture meets the applicable requirements for sulfate exposure) and verify that each source of materials is from an MDOT approved source. If it is found to be acceptable, the District Materials Engineer shall forward a copy of the mixture design to the Materials Division along with his written concurrence or recommendation for modification. If it is found not acceptable, the District Materials Engineer shall return the mixture design to the Contractor, through the Project Engineer, along with his written cause for rejection.

The Materials Division will complete the mixture design review and provided electronic approval to the District Materials Engineer stating the acceptance, modification, or rejection of the Contractor's mixture design.

For all mixture design reviews, including field verifications, mixture revisions and field verifications, and mixture design transfers, concrete eform will be send notification to the DME, PE, District Engineer, Contractor, Concrete Producer, and other applicable parties from the Materials Division. For field verifications, mixture revisions and field verifications, and mixture design transfers, both the current mixture design and the current field verification data shall be attached to the correspondence detailing the results of the review in the communication from the Materials Division.

3.3.1.1 *Concrete Mix Design Form*

The Department's *Concrete Mix Design* form for submitting mixture designs is located at www.gomdot.com. The *Concrete Mix Design* form consists of an area for inputting mixture design information, with programming to verify that the input data conforms to the applicable requirements. Communication generated by the *Concrete Mix Design* form is by email to the PE, DME, Materials Division, and Concrete Producer, with fields for adding an e-mail address for the Contractor and Mixture Designer. Due to complex nature of the *Concrete Mix Design* form and the Department's continuing efforts to improve its capabilities and usability, only this basic information is given here. For all additional questions about the *Concrete Mix Design* form, please contact the Materials Division, Laboratory Operations at 601-359-1666.

3.3.2 Design Submittal Requirements – New Mixtures

The mixture design shall either be based on previous field experience as stated in Subsection 804.02.10.1.1, or laboratory trial mixture as stated in Subsection 804.02.10.1.2. The mixture design aggregate weights shall be reported in the oven-dried state with oven-dried specific gravities. The water reported for the mixture shall only be the water used to calculate the water/cementitious materials (w/cm) ratio (i.e., the "free water"). The absolute volume of each material, except the non-air-entraining admixtures (i.e., water reducing admixtures), shall be calculated. The mixture design shall be proportioned to yield a total theoretical absolute volume of 27.0 ft^3.

For mixture designs based on previous field experience with a theoretical absolute volume that does not equal 27.0 ft^3 it is allowable to adjust the fine and coarse aggregate proportions such that the theoretical absolute volume does equal 27.0 ft^3. The w/cm ratio shall not be changed.

In addition to reporting the proportions in the oven-dried state, the mixture design proportions may also be reported in the saturated-surface dry condition. However, this saturated-surface dry proportioning information will not be used by the Department as mixture review information.

In addition to the mixture design proportions for each material, the following information shall also be included:

Cementitious Material information:

- Sources of and certified test reports for cement, pozzolans, and/or other cementitious materials, indicating conformance with the requirements for the material in accordance with the Standard Specification.
- The test report shall show test results no older than 6 months prior to the submittal of the mixture design for review or reflect any recent changes by the manufacturer if less than 6 months

Chemical Admixture information:

- A notarized certificate from the Admixture Producer indicating conformance with the requirements of Subsection 713.02 of the Standard Specification.
- The notarized certificate shall be no more than 6 months old, with respect to the submittal of the mixture design for review or reflect any recent changes by the manufacturer if less than 6 months.
- The mixture design shall list the admixture type and the dosage range which will be used during all times of production of the mixture.
- The dosage range listed shall conform to the manufacturer's recommended dosage range for the admixture.

Coarse Aggregate information:

- MDOT Source Number

- Size Number
- Gradation – The aggregate gradation for the coarse aggregate shall have been performed within 30 days of the mixture design submittal.
- Bulk Specific Gravity (i.e., the oven-dried specific gravity)
- Absorption
- Dry Rodded Unit Weight

Fine Aggregate information:

- MDOT Source Number
- Gradation – The aggregate gradation for the fine aggregate shall have been performed within 30 days of the mixture design submittal.
- Bulk Specific Gravity (i.e., the oven-dried specific gravity)
- Absorption
- Fineness Modulus

Basis of Proportioning information:

For mixture designs based on Previous Field Experience:

- Compressive strength data for the individual cylinders in each compressive strength test. The compressive strength data shall verify that the requirements of Subsection 804.02.10.1.1 are met.
- Plastic test data for each compressive strength test, including the date sampled, slump, total air content, and temperature recorded for the plastic concrete for each strength test. For each of these tests on the plastic concrete the test data shall meet the acceptance criteria of Subsection 804.02.13.1.

For mixture designs based on Laboratory Trial Batches:

- Compressive strength data for the individual cylinders in each compressive strength test. The compressive strength data shall indicate that the requirements of Subsection 804.02.10.1.2 are met.
- Plastic test data for each compressive strength test, including the date sampled, slump, total air content, temperature, and yield recorded for the plastic concrete for the strength test. For each of these tests on the plastic concrete the test data shall meet the acceptance criteria of Subsection 804.02.10.1.2.

Mixture designs which meet all the applicable contract requirements and the requirements listed in this manual shall receive approval according to this manual and listed as follows: design tentatively approved pending field verification, design rejected, field verification approved, field verification rejected, transfer approved, or transfer rejected.

3.3.3 Design Submittal Requirements – Transferred Mixtures

A field verified mixture design may be transferred from one project to another. The mixture design information concerning the specific material sources and proportions shall be submitted along with a copy of the approved field verification from the Materials Division.

If the mixture design is currently being placed on a Department project, the mixture design materials and proportions submitted for transfer shall not have been changed from the previously acceptably field verified mixture design materials and proportions. If changes in the mixture design have been made, the revised mixture design must be field verified on the project where the mixture design is currently being placed prior to being accepted for transfer to another project. Once the field verification of the revised mixture is approved by the Materials Division, the Contractor may request that the approved mixture be transferred.

If the mixture design is not currently being placed on a Department project, but has changed in materials and/or proportions in accordance with the allowable revisions listed in paragraph 3.5, the mixture design may be tentatively approved for use, pending acceptable field verification on the project to which the mixture is being transferred. The revised mixture shall be field verified prior to receiving final approval. Changes of materials and/or proportions may require a new mixture be submitted (see paragraph 3.5).

3.3.4 Requirements for Concrete Mixtures used in Drilled Shafts

In accordance with Subsection 803.03.2.7.1 prior to placement of the mixture the requirements for the slump loss test and set time test shall be performed.

3.3.5 Considerations for Concrete Mixtures using Lightweight Aggregates for Internal Curing

Lightweight Aggregates (LWA) may be used for internal curing of concrete. A method for determining a required quantity of LWA may be found in Appendix XI of ASTM C 1761, Paragraph X1.3.

If a specific quantity of water available for internal curing is desired, in lieu of using *CS* as the chemical shrinkage of the cementitious materials, this desired quantity of water may be substituted for *CS*. For example, if the desired quantity of water available for internal curing is 8.0 lbs / 100 lbs total cementitious materials, the value to substitute in Equation X1.1 for *CS* is 0.08.

For the purposes of verifying the water available for internal curing for a submitted mixture design against specification requirements, Equation X1.1 in ASTM C 1761 will be used by the Materials Division.

3.4 Concrete Mixture Design Field Verification

3.4.1 General

In general, concrete mixture designs require field verification in accordance with Subsection 804.02.10.3, to obtain final approval. Concrete mixture designs are tentatively approved by the Department based on the review of submitted performance data. The field verification of each concrete mixture proves the Contractor's ability to produce the concrete mixture meeting the requirements of Subsection 804.02.10.3. Because all batching equipment is required to conform to the criteria of AASHTO M 157, the field verifications are not batching equipment specific (i.e., batch plants or transit mixers), but only mixture design specific.

3.4.2 Intent of Field Verification

The goal of field verification is twofold: 1) verify the field performance of new and revised mixture designs using the concrete batch plant and 2) fine tune the operations at the concrete batch plant to ensure batch-to-batch consistency of delivered concrete mixture.

This is accomplished by requiring the Contractor to achieve all the specific plastic properties within the narrow range specified for field verification at least one time for each mixture design placed on the project. No materials may be added to the batched concrete mixture, except those batched by the plant or water added as ice at the plant to control the temperature.

3.4.3 Plastic Property Requirements

Once the concrete mixture arrives at the job site the Contractor's QC technician samples and tests the concrete mixture under the observation of the Department's QA technician to determine the mixture's plastic properties. In order to pass field verification, all the plastic properties of one batching of the concrete mixture must fall within the criteria for field verification. If any of the plastic properties falls outside the criteria for field verification, the concrete mixture fails the entire field verification.

A failed field verification does not mean the concrete mixture must be rejected from placement. If all plastic properties of the concrete mixture do meet the applicable acceptance criteria, the concrete mixture may still be placed. Additionally, after it is determined that the concrete mixture does not pass all criteria for field verification, water may be added, as allowed by the specification, to adjust the slump of the concrete mixture in order to meet the requirement for acceptance of the slump. However, if water is added after the initial testing of the plastic properties, the tests to determine the plastic properties shall be performed again.

For the classes of concrete which do not have a specified requirement for one or more of the plastic properties (i.e., the lack of required entrained air in Classes F and FX except in the presence of seawater), the plastic property in question shall be determined. In this case, only the required plastic properties will be used to determine whether the mixture passes field verification.

The plastic properties information shall be reported on form TMD-892 shown in Figure 1.

3.4.4 Aggregate Requirements

Prior to the field verification of the mixture design, but no more than one week before, the Contractor shall determine the specific gravity and gradation of each of the aggregates used in the concrete mixture using the testing facility or testing laboratory listed in the Contractor's QCP as responsible for performing these tests.

This information shall be reported on the form TMD-892 shown in Figure 1.

3.4.5 Batching Requirements

As required in Subsection 804.02.12, all concrete batching shall conform with the requirements in AASHTO M157. Included are requirements on the measuring of materials of the concrete mixture. During the review of the field verification information, the Materials Division shall verify that the proportions of materials batched correspond to the tentatively approved mixture design within the tolerances specified in AASHTO M 157, Section 8.

To accomplish this verification, the weights of the materials on the field verification batch ticket are reduced to the oven-dry state for a one cubic-yard batch. The reason for mathematically converting the batch ticket target weights and actual weights to oven-dry and one cubic-yard is to establish a base system for comparison. This is done for both the target weights (i.e., the weights which the batch plant computer was supposed to batch according to the mixture listed in the computer) and the actual weights (i.e., the listed weights of each materials which was added to the truck or mixing drum). This process of reviewing the batch weights ensures the Contractor can hit the target weights with his actual weights and ensures the Contractor is batching the right mixture design.
The "converted" oven-dry, one cubic-yard, target weights are compared to the tentatively approved mixture design. The converted targets must be within the following tolerances of the tentatively approved mixture design for the materials listed:

MDOT Batch Tolerances: Comparing Target Weights to Tentatively Approved Weights	
Cementitious Materials	
Cement Fly Ash Slag Other Cementitious Materials	± 1 lbs
Aggregates	
Coarse(s) Fine(s)	± 20 lbs
Water	± 8.33 lbs

The purpose of comparing the target weights to the tentatively approved proportions is to verify the Contractor has the tentatively approved mixture design proportions as the target weights he is attempting to batch. The purpose of the tolerances on these target weights is to accommodate the actual weighing precision of the batching equipment.

The "converted" oven-dry, one cubic-yard, actual weights are compared to the converted oven-dry, one cubic-yard target weights to verify the batching requirements of AASTHO M 157 have not been exceeded.

3.4.6 Field Verification Submittal Requirements

The field verification data will be summarized on form TMD-892 with the following information.

At the top of the form, complete the following:

- **Date** – the date the field verification was performed
- **Project No**. – the project number for which the mixture was field verified
- **County** – the county in which the project is located
- **Contractor** – the name of the Prime Contractor
- **PCC Producer** – the name of the Concrete Producer
- **PCC Producer's Mixture No.** – the Concrete Producer's mixture identification number
- **Plant Location** – the city of the Concrete Producer's plant

In the section under MIX QUANTITIES, complete the following:

- **Source** – the source of each material used. If the Department has assigned specific source identification number to a source (i.e., aggregate plants), the Contractor shall use this information to identify the source.
- **Description** – the type, class, grade, size, or other applicable designation for distinguishing materials.
- **Bulk Specific Gravity** – the oven-dry bulk specific gravity for each material.
- **Unit Weight** – the unit weight of each aggregate used.
- **Fineness Module** – the fineness module for each aggregate used. This shall confirm the fineness module calculated from the aggregate gradation information determined for field verification.
- **Quantities Oven-Dry** – the quantity of each material used, in the oven-dry state.
- **Absolute Volume** – the theoretical absolute volume of each constituent material.
- **Total** – the sum of all the absolute volumes for each constituent material. The total theoretical absolute volume shall equal 27.0 ft^3.

NOTE: Instead of weights for admixtures, the dosages shall be listed in fluid ounces in the Quantities column. Additionally, with the exception of the total air content in the mixture, the absolute volumes of admixtures shall not be calculated.

In the section under BATCH QUANTITIES, complete the following:

- **Batch Volume** – the theoretical volume of the batched materials
- **Target Batch Weight** – the target batch weight of each material used to be loaded into the mixer.
- **Actual Batch Weight** – the actual batched weight of each material used as loaded into the mixer. These are listed in the total moisture state.
- **Actual Weight per yd^3** – the actual batch weight of each material on a one cubic-yard basis. This is the actual batched weight of each material described above divided by the **Batch Volume** listed above. These are listed in the total moisture state.

- **Total Moisture** – the total moisture on each aggregate.
- **Absorption** – the absorption of each aggregate.
- **Surface Moisture (%)** – the surface moisture on each aggregate, as a percentage of the oven-dry weight the aggregate.
- **Surface Moisture (lbs)** – the weight surface moisture on each aggregate.
- **Target Dry Weight** – the target weight of each material on a one cubic-yard basis. This is the target weight of each material described above (in **Target Batch Weight**) divided by the **Batch Volume** listed above. Additionally, based on the absorption, and the total and surface moistures listed, these target weights are mathematically converted to the oven-dry state.
- **Actual Dry Weight** – the actual weight of each material on a one cubic-yard basis from the information from **Actual Weight per yd^3**. Based on the absorption, and the total and surface moistures listed, these actual cubic-yard weights are mathematically converted to the oven-dry state.

Below the section under BATCH QUANTITIES, complete the following:

- **Water Content** – the total surface moisture content on all the aggregates and the batched water.
- **Slump** – the measured slump of the field verified concrete mixture.
- **Air Content** – the measured total air content of the field verified concrete mixture.
- **Temperature** – the measured temperature of the field verified concrete mixture.
- **Unit Weight** – the determined unit weight of the field verified concrete mixture.
- **Yield** – the yield, based on the Unit Weight and total actual weights of each material on a one cubic-yard basis.

Please see the TMD-892 form shown in Figure 1.

3.4.7 Requirements for Field Verification of Concrete Mixture Designs used in Drilled Shafts

Field verification of mixture designs used in drilled shaft will be performed during the performance of the slump loss test and the set time test prior to the first placement of the mixture, per Subsection 803.03.2.7.1.

3.4.8 Review of Field Verification Information

It is the responsibility of the Department's Project Office QA technician or District Laboratory QA technician to summarize the field verification data on the electronic version of the form TMD-892 and review the plastic properties for conformance with the applicable field verification requirements. Based on this review, if the Department's QA technician determines the plastic properties pass all the applicable field verification requirements for the concrete mixture, the Department's QA technician will tentatively approve the field verification. Final *review* of the field verification information will be performed by the Materials Division. The review performed by the Materials Division will include review of the plastic properties information if applicable, the aggregate gradation information, the batching information, and other submitted information required.

The Materials Division will submit the reviewed field verification information to the DME for historical purposes. The Materials Division will send the results of the field verification review by either written correspondence or correspondence by e-mail to the DME, the PE, the Contractor, the Concrete Producer, and other applicable parties.

The correspondence by the Materials Division concerning the acceptable field verification information is the final approval of the mixture design.

3.4.9 Typical Field Verification Failures

Failure to meet the field verification requirements typically fall into the following three categories:

1. **Incorrect Target Weights** - the target weights in the batch computer do not correspond with the tentatively approved mixture weights within the allowable differences listed in Section 3.4.5, either with or without the plastic properties meeting the requirements for field verification;
2. **Misbatched Actual Weights** - the actual weights batched are not within the allowable tolerances of the target weights (see AASHTO M157, Section 8 for the required tolerances for batching); and/or
3. **Plastic Properties** - the plastic properties are not within the required range for field verification.

Following are suggested methods to correct these.

3.4.9.1 Incorrect Target Weights

If the target weights in the batching computer do not correspond with the tentatively approved mixture weights and the plastic properties of slump, temperature, total air content, and yield are all within the requirements for field verification, the MDOT Class III technician representing the Contractor may:

- revise the mixture design to conform to the target mixture weights in the batching computer and submit the mixture revision; OR
- have the target mixture weights in the batching computer revised to conform to the tentatively approved mixture weights and re-perform the field verification on another batch.

If the target weights in the batching computer do not correspond with the tentatively approved mixture weights and the plastic properties of slump, total air content, and yield are not within the requirements for field verification, the Contractor may make similar adjustments as listed above together with adjustments listed Redbook Section 804.02.12 and the Contractor's approved quality control plan.

3.4.9.2 Misbatched Actual Weights

If the actual weights batched do not conform to the target weights in the batching computer, the following is a suggested list of things to check. This list is not all-inclusive.

- Water and Aggregates
    - accurate determination of aggregate total moisture, aggregate surface moisture, and/or aggregate absorption,
    - the batching computer to ensure the proper aggregate moisture values are being used
    - moisture meters for proper calibration,
    - the loader operation in moving aggregates from the stock piles into the storage bins,
    - properly working batching equipment
- Cementitious Materials
    - properly working batching equipment

The field verification must be re-performed on another batch.

3.4.9.3 Plastic Properties

If the plastic properties do not conform to the requirements for field verification, the Contractor shall make the necessary batching adjustments. The following is a suggested list of things to check. This list is not all-inclusive.

- Slump

    - adjust the water content of the mixture design;
    - vary the dosage of water reducing admixtures within the manufacturer's recommended dosage range to adjust the slump considering how the adjustment of water reducing admixtures will affect the set time of the concrete;
    - ensure proper mixing speeds and times are being used
- Total Air Content
    - vary the dosage of air-entraining admixtures within the manufacturer's recommended dosage range to adjust the total air content;
    - check the Loss On Ignition of the fly ash on the mill certificate;
    - ensure proper mixing speeds and times are being used
- Yield
    - adjust and revise the mixture

The field verification must be re-performed on another batch.

MISSISSIPPI DEPARTMENT OF TRANSPORTATION
Materials Division

Form for Approving Field Verification Testing of Portland Cement Concrete Mixtures

Confirmation Number: 1
Mixture Design Number:

Version Number:

Project Type:
Date Submitted for Review:
Mixture Designer's Email Address:
Primary County:
Project Number:
FMS Number:
Project Engineer:
Project District:
District Materials Engineer:
Project Office:
Contractor:
Contractor Email:
Designer:
Sulfate Exposure Results:
Associated Mix ID:

Project Units:
Project Specification:
Mixture Class:
Design Slump:

Concrete Producer:
Concrete Producer's Mixture ID:
Specified Min. Strength:
Basis of Proportioning:
Application:
Project Specified Air Content:

Remarks

Mix Design Quantities

Material	Source	Description	Bulk Specific Gravity (OD)	Unit Weight (lb/yd³)	Fineness Modulus	Quantity (OD) (lb/yd³)	Absolute Volume (yd³)
Cement:							
Fly Ash:							
GGBFS:							
Other CM:							
Water			1				
Fine #1:							
Fine #2:							
Coarse #1:							
Coarse #2:							
Coarse #3:							
AEA*							
Admixture* (A)							
Admixture*F							
Admixture*							
Admixture*							
					Total:	3900	26.93

Batch Volume: yd³ **Tolerance Type:** Cumulative **Field Verification:** Date Performed

Batch Quantities

Material	Target Batch Weight (SSD) (lb)	Actual Batch Weight (SSD) (lb)	Actual Quantity (SSD) (lb/yd³)	Total Moisture (%)	Absorption (%)	Surface Moisture (%)	(lb)	Target Quantity (OD) (lb/yd³)	Actual Quantity (OD) (lb/yd³)	Status
Cement:										
Fly Ash:										
GGBFS:										
Other CM:										
Water										
Fine #1:										
Fine #2:										
Coarse #1:										
Coarse #2:										
Coarse #3:										
AirEntraining										
Admixture*										
Admixture*										
Admixture*										
Admixture*										
Total:						Total:				

Note: * = Admixtures expressed in fluid ounces

			Status
Water Content		lb	
Slump		within minus (-) 2-1/2 in. of design	
Air Content		within minus (-) 1-1/2 percent of maximum	
Temperature		°F	
Unit Weight		lb/yd³	
Yield		within ± 2%	

Aggregate Analysis

Fine Aggregate			Coarse Aggregate		
Test Date Performed		Bulk Specific Gravity (OD) =	Test Date Performed		Bulk Specific Gravity (OD) =
Test Date Performed		Bulk Specific Gravity (OD) =	Test Date Performed		Bulk Specific Gravity (OD) =
			Test Date Performed		Bulk Specific Gravity (OD) =
Test Date Performed		Sieve Analysis	Test Date Performed		Sieve Analysis
Test Date Performed		Sieve Analysis	Test Date Performed		Sieve Analysis
			Test Date Performed		Sieve Analysis

Aggregate Analysis

	Fine Aggregate		Coarse Aggregate		
	Fine #1	Fine #2	Coarse #1	Coarse #2	Coarse #3
Init Wt(g)					
Blend(%)					

Sieve	Accum. Wt. Retained	Total Passing %	Gradation Rqmt %	Accum. Wt. Retained	Total Passing %	Gradation Rqmt %
1/2			100			100
3/8			97-100			97-100
No. 4			92-100			92-100
No. 8			75-100			75-100
No. 16			45-90			45-90
No. 30			25-70			25-70
No. 50			3-35			3-35
No. 100			0-10			0-10
Pan						

Sieve	Accum. Wt. Retained	Total Passing %	Gradation Rqmt %	Accum. Wt. Retained	Total Passing %	Gradation Rqmt %	Accum. Wt. Retained	Total Passing %	Gradation Rqmt %
2			100						
1-1/2			100						
1			100						
3/4			80-100						
1/2									
3/8			20-55						
No. 4			0-10						
No. 8			0-5						
Pan									

Save Submit Evaluate

Combined Sieve Analysis Data

Sieve	Design Passing	Design Individual Retained	FV Passing	FV Individual Retained
2	100	0	0	100
1-1/2	100	0	0	0
1	100	0	0	0
3/4	94.89	5.11	0	0
1/2	71.87	23.02	0	0
3/8	55.47	16.40	0	0
No. 4	38.69	16.78	0	0
No. 8	32.30	6.39	0	0
No. 16	27.02	5.28	0	0
No. 30	20.96	6.06	0	0
No. 50	2.77	18.19	0	0
No. 100	0.52	2.25	0	0

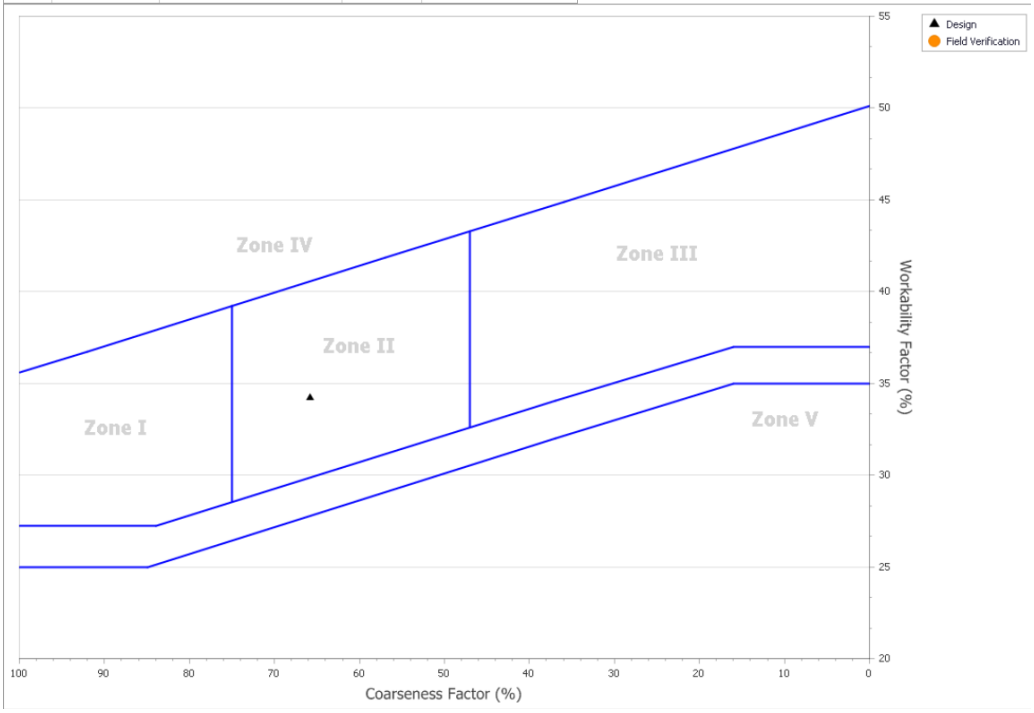
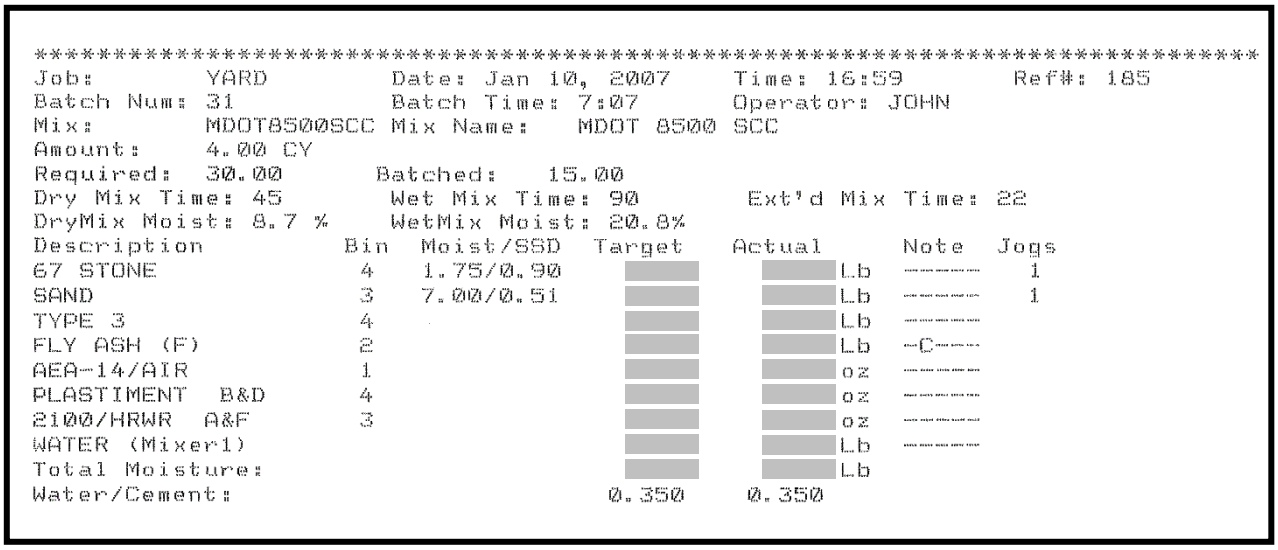


Figure 1 - Sample TMD-892 – Form for Approving Field Verification Testing of Portland Cement Concrete Mixtures



Job: YARD Date: Jan 10, 2007 Time: 16:59 Ref#: 185
Batch Num: 31 Batch Time: 7:07 Operator: JOHN
Mix: MDOT8500SCC Mix Name: MDOT 8500 SCC
Amount: 4.00 CY
Required: 30.00 Batched: 15.00
Dry Mix Time: 45 Wet Mix Time: 90 Ext'd Mix Time: 22
DryMix Moist: 8.7 % WetMix Moist: 20.8%

Description	Bin	Moist/SSD	Target	Actual		Note	Jogs
67 STONE	4	1.75/0.90	[redacted]	[redacted]	Lb	------	1
SAND	3	7.00/0.51	[redacted]	[redacted]	Lb	------	1
TYPE 3	4		[redacted]	[redacted]	Lb	------	
FLY ASH (F)	2		[redacted]	[redacted]	Lb	-C----	
AEA-14/AIR	1		[redacted]	[redacted]	oz	------	
PLASTIMENT B&D	4		[redacted]	[redacted]	oz	------	
2100/HRWR A&F	3		[redacted]	[redacted]	oz	------	
WATER (Mixer1)			[redacted]	[redacted]	Lb	------	
Total Moisture:			[redacted]	[redacted]	Lb		
Water/Cement:			0.350	0.350			

Figure 2 - Example Batch Ticket submitted for Field Verification Analysis
(with the actual weights and target weights edited out)

3.5 Concrete Mixture Design Revisions

Because a mixture design is defined as a "unique combination of specific materials, from specific sources, in specific proportions of each material" the Department uses a mixture design series number to track revisions in the material sources and/or proportions for mixture designs. Actions requiring a mixture design revision are as follows:

Material and Revision	Example	Allowed	Not Allowed	Required Action(s)
Cement *				
Source change	Holcim Type I to Cemex Type I	X		Field verify revised mixture design
Proportion change				
Increase	Increasing from 451 lbs to 460 lbs	X		Field verify revised mixture design
Decrease	Decreasing from 460 lbs to 451 lbs	X		Verify $\overline{X}$ complies with the inequality of Subsection 804.02.10.1.1 prior to mixture revision. See Subsection 804.02.10.4. After revision, field verify revised mixture design.
Type change	Holcim Type I to Holcim Type II		X	New mixture design required
Water*				
Proportion change	Increasing or decreasing water content	X		Field verify revised mixture design
Chemical Admixture(s)				
Source change	Sika Type WR to BASF Type WR	X		Field verify revised mixture design
Proportion change	Increasing or decreasing admixture dosage	X		Nothing
Brand change	W.R. Grace WRDA 79 (Type WR) to W.R. Grace WRDA 20 (Type WR)	X		Field verify revised mixture design
Type change	Sika Type WR to Sika Type WR/RET		X	New mixture design required
Pozzolanic Material*				
Source change	Boral Class C to Headwaters Class C	X		Field verify revised mixture design
Proportion change				
Increase	Increase from 113 lbs to 120 lbs	X		Field verify revised mixture design
Decrease	Decrease from 120 lbs to 113 lbs	X		Verify $\overline{X}$ complies with the inequality of Subsection 804.02.10.1.1 prior to mixture revision. See Subsection 804.02.10.4. After revision, field verify revised mixture design.
Type change	Boral Class C to ProAsh Class F		X	New mixture design required
Aggregates				
Source change	Vulcan (A-2(L)) to TXI (6-L-20)		X	New mixture design required
Proportion change	Increasing or decreasing either fine or coarse aggregate contents	X		Field verify revised mixture design
Size change	#57 to #67		X	New mixture design required

* Changes in proportions of cementitious materials or water may not exceed the maximum w/cm ratio.

For the materials for which there are specific requirements on the percentage required (i.e., fly ash or GGBFS for sulfate exposure or the 95°F acceptance temperature limit), any change in proportions must meet the requirements specified for those applications.

3.5.1 Mixture Design Revision

The Contractor is responsible for notifying the Project Engineer in writing a minimum of 7 days prior to revising a mixture design. The Contractor shall list the specifics of the revision, including source change(s) and/or proportioning change(s) information, and the reason for the revision.

The revised mixture must be field verified in accordance with paragraph 0 prior to final approval.

3.6 Concrete Mixture Design Identification

Mixture designs are tracked by the Department by the mixture ID. The MDOT Mixture ID number is assigned during the mixture design review by the Materials Division. The Department assigned mixture ID is independent of any Contractor assigned mixture ID. Once a mixture ID is assigned by the Materials Division, the Contractor shall include the Department's mixture ID on mixture documentation, including batch tickets and test reports.

3.6.1 Identification Format

Department mixture ID's are assigned using the following format:

CCAAA.YYSSSRR

where

CC = the class of concrete
AAA = the coarse aggregate size
. = a number separator
YY = the last two numbers of the year the initial mixture was submitted for review under the current ID format
SSS = the mixture sequence number
RR = the mixture suffix number

In practice, CC may vary in length from 1 to 2 characters and AAA may vary in length from 1 to 3 numbers.

The following are the classes of concrete symbolized by CC with additional information, as shown:

Section 804 Designations

a. AA Varied Applications
b. AA Bridge Deck
c. BB (allowed only in Office of State Aid and Road Construction specification, Section S-804)
d. B
e. C
f. D
g. DS
h. F
i. FX
j. S

Designations from Other Sections

k. L (**L**ightweight, not allowed in the 2004 Standard Specification)
l. P (**P**aving, not allowed in the 2004 Standard Specification)
m. PA (**P**aving with entrained **a**ir, from Section 501)
n. PO (**P**unch-**O**ut for full or partial depth repair of concrete pavement, from Section 503)
o. WT (**W**hite-**T**opping for thin or ultra-thin pavement, from Section 504)

The following are the sizes of coarse aggregate symbolized by AAA:

a. 67
b. 57
c. 467
d. 7
e. 8
f. 78
g. 89

Other coarse aggregates sizes do exist but are not listed here as they are not typically allowed in concrete used on Department projects. For those coarse aggregate sizes or ones for which a gradation is not specified by the Department, use the size number and gradations listed in AASHTO M 43, Sizes of Aggregate for Road and Bridge Construction. The following is a summary of MDOT's master proportion table and specifications. Review contract documents to determine if the information provided in this table is applicable to your specific project.

Class	Application	Coarse Aggregate Size No.	Minimum-Maximum w/cm Ratio	Specified Compressive Strength (f'c) psi	Maximum Permitted Slump, or Slump Flow inches	Nominal Total Air Content (%)	Maximum Static Segregation (%)
AA	Varied	57,67, 7, 8, 78, 89	0.45	4000	3 [-1.5]	4.5±1.5	N/A
AA	Bridge Deck*	57,67 ,7, 8, 78, 89	0.43-0.45	4000	3 [-1.5]	4.5±1.5	N/A
AA	Bridge Deck*	57,67, 7, 8, 78, 89	0.43-0.45	4000	3 [-1.5]	6.5±1.5	N/A
B	General use, heavily reinforced sections	57,67,7, 8, 78, 89	0.5	3500	4 [-2.5]	4.5±1.5	N/A
C	Massive sections	57,67, 7, 8, 78, 89	0.55	3000	4 [-2.5]	4.5±1.5	N/A
D	Massive unreinforced sections	57,67, 7, 8, 78, 89	0.7	2000	4 [-2.5]	4.5±1.5	N/A
F	Prestressed members	67, 7, 8, 78, 89	0.4	5000	3 [-1.5]	**	NA
F	Prestressed members SCC	67, 7, 8, 78, 89	0.4	5000	28 [-4]	**	15
FX	Extra strength for prestressed members	67, 7, 8, 78, 89	(As per mixture design)	(As shown on plans)	3 [-1.5]	**	NA
FX	Extra strength for prestressed members	67, 7, 8, 78, 89	(As per mixture design)	(As shown on plans)	28 [-4]	**	15
S	Seal concrete deposited under water	67, 7, 8, 78, 89	0.45	3000	8 [-2.5]	4.5±1.5	N/A
DS	Drilled shaft	67 ,7, 8, 78, 89	0.45	4000	8±1	**	N/A
DS	Drilled shaft SCC	67, 7, 8, 78, 89	0.45	4000	24 [-6]	**	15

*For Class AA concrete for bridge decks, the water/cementitious material ratio range shall be 0.43-0.45 and the maximum cementitious material content shall be 550 pounds per cubic yard. Also, an approved synthetic structural fiber meeting the requirements of Special Provision 907-711, Synthetic Structural Fiber Reinforcement, shall be incorporated into the mixture at 1.25 times the approved dosage rate. For each additional pound of fibers per cubic yard added in excess of the requirement stated above, an additional inch of slump will be allowed up to a maximum permitted slump of eight (8) inches.

**Entrained air is not required for Class F, FX, and DS concrete unless exposed to seawater. For concrete not exposed to seawater, the total air content shall not exceed 6.0%. For concrete exposed to seawater, the nominal total air content shall be 4.5%.

Lightweight aggregate (LWA) meeting the requirements of Subsection 907-703.19.2 may also be used as a partial replacement for fine aggregate.

The replacement limits of Portland cement by weight by other cementitious materials (such as fly ash, GGBFS, silica fume, or others) shall be in accordance with the values in Subsection 907-701.02. Other hydraulic cements may be used in accordance with the specifications listed in Section 701

Note: Brackets [#] indicate minus slump tolerances. According to AASHTO M 157, a design slump of 3 or less is -1.5 inches and greater than 3 inches is -2.5 inches.

3.7 Mixture Designs Formulas

W_{OD} = weight of material in the oven-dry (OD) state
W_{TM} = weight of material in total moisture (or "wet") state
W_{SSD} = weight of material in the saturated-surface dry (SSD) state
W_{SM} = weight of surface moisture on "wet" material
SG_{OD} = the bulk specific gravity of the material in the OD state
SG_{SSD} = the bulk specific gravity of the material in the SSD state
$\%M_T$ = the percentage of total evaporable moisture
$\%M_S$ = the percentage of surface moisture
$\%M_{ABS}$ = the percentage of absorbed moisture

$W_{OD,CA}$ = minimum W_{OD} of coarse aggregate required for mixture designs in Section 501
$DRUW_{CA}$ = average dry-rodded unit weight of coarse aggregate
$\%VOL_{CA,Req}$ = the minimum percentage of coarse aggregate volume per cubic yard of concrete

$W_{TM} = W_{OD} * [1 + (\%M_T / 100)]$
$W_{SM} = W_{OD} * [(W_{OD} * \%M_S) / 100]$
$W_{SSD} = W_{OD} + [(W_{OD} * \%M_{ABS}) / 100]$

$\%M_T = [(W_{TM} – W_{OD})/W_{OD}] * 100$
$\%M_T = \%M_{ABS} + \%M_S$

$\%M_{ABS} = [(W_{SSD} – W_{OD})/W_{OD}] * 100$
$\%M_{ABS} = (SG_{SSD} / SG_{OD}) – 1$

$SG_{SSD} = SG_{OD} * [1 + (\%M_{ABS} / 100)]$

$W_{OD,\,CA} = DRUW_{CA} * 27 * \%VOL_{CA,Req}$

4 Sampling and Testing

Sampling and testing are performed to ensure that materials incorporated into Department projects meet the requirements of the specifications. Sampling and testing are performed in accordance with the specified test methods and at the frequency required in the specifications. Please refer to paragraph 1.4 for a list of required test methods.

Depending on the method of acceptance, either the Department or both the Department and the Contractor perform sampling and testing. Please refer to paragraph 5 for specifics concerning the two methods of acceptance.

Below are specific details which should be followed by Department personnel or Contractor personal when either is performing sampling and testing.

4.1 Specifics for Sampling, Testing, and Job Site Acceptance of Freshly Mixed Concrete Mixture

4.1.1 Sampling

4.1.1.1 Random Sampling for QC Testing

At the beginning of each day, the Contractor shall specify the anticipated cubic yards to be produced for each separate mixture. The frequency of sampling is then determined from Table 4, of Section 804. The anticipated cubic yardage for each separate mixture shall be split into appropriate testing lots and a sample obtained randomly from each lot. The Contractor shall complete MDOT Form TMD-999 for each production day and submit it to the Engineer no later than 1 hour prior to the day's production.

EXAMPLE - QC Testing per Table 4

Anticipated Cubic Yardage For The Day	115 CY
Sampling Frequency	1 Sample per 50 CY
Number of Samples Required (115 CY ÷ 1 Sample per each 50 CY)	3 Samples
Lot Size (115 CY ÷ 3 Samples)	38.3 CY per Sample
Lot 1	From 1 to 38 CY
Lot 2	From 39 to 76 CY
Lot 3	From 77 to 115 CY

4.1.1.2 Determining Sample Location

The approximate location of each sample within the lot shall be determined by selecting random numbers according to S.O.P. CSD-50-70-54-000, or from Table 1 of ASTM D 3665 according to the procedures in Sections 5.2 through 5.6. At the start of the first day, the Contractor shall select random numbers from a randomly selected starting point on one of the charts. The number of random number selected shall exceed the number of lot required by one. Therefore, from the example above, four lots of 38 CY shall have random numbers selected, one for each lot.

For subsequent days, the Contractor shall select new random numbers by continuing from the ending number of the previous day in the same direction established when the initial numbers were chosen. The Contractor shall keep a copy of each day's TMD-999 in the project files. The calculations of sampling cubic yardages shall be completed for all random numbers even if the Contractor anticipates that fewer tests would be required. This is done just in case the Contractor's production exceeds the original anticipated placement quantity. The random numbers selected shall be multiplied by the lot size selected for the day. This number shall then be added to the total cubic yardage of all previous increments to yield the approximate cubic yardage when the sample is to be taken.

EXAMPLE - Sample Cubic Yardage Random Selection

Lot	Cubic Yard Range	Lot Size	Random Number	Lot Size x Random No.	+ Total Cubic Yards Previous Increment	Sample Cubic Yardage
1	1 - 38	38	0.907	35	+ 0	35
2	39 - 76	38	0.643	24	+ 38	62
3	77 - 115	38	0.089	3	+ 76	79
4	116 - 153	38	0.950	36	+115	151

Sampling shall be performed from concrete mixture in the truck which contains the randomly selected cubic yard. It is not necessary to attempt to select the specific cubic yard selected by the random process for testing as the truck is discharging the mixture for placement. Only taking the sample from the truck which contains the randomly sampled cubic yard is required.

For example, for the anticipated 115 CY above, if each truck carries 8 cubic yards, then based on the randomly selected cubic yardages for sampling in the previous example would be in trucks 5, 8, and 10.

This procedure is to be used for any number of samples per day.

The plant operator shall not be advised ahead of time when any of the samples are to be taken.

4.1.1.3 QC Test on First Truck

In addition to taking samples at the randomly selected cubic yardages, the Contractor shall also test the first truck of each production day for STTAC in accordance with the requirements and paragraph 4.1.2. If the randomly selected cubic yardage occurs during the first truck, no additional sampling of the first truck is required.

4.1.1.4 Compressive Strength Cylinders

Compressive strength cylinders shall be made by the Contractor from the truck from which the first randomly sampled cubic yardage is taken in accordance with the requirements of Section 804, Table 4 and paragraph 4.1.3. Compressive strength cylinders shall be made from the first truck only if the randomly selected cubic yardage occurs during the first truck.

For example, for the anticipated 115 CY above which each truck carrying 8 cubic yards, compressive strength cylinders would be taken from trucks 5 and 10. Compressive strength cylinders would be taken from truck 5 because that is the truck which contains the first randomly sampled cubic yardage. The concrete for this first set of compressive strength cylinders covers the first 100 CY. Compressive strength cylinders would be taken from truck 10 because that is the truck which contains the randomly sampled cubic yardage which covers the second 100 CY (i.e., the "or fraction thereof" concrete).

4.1.1.5 Sampling for QA Testing

Department sampling will be taken from a truck on which no QC sampling is required in accordance with paragraph 4.1.1.2.

In the cases where no QC sampling is required, Department sampling for STTAC will be performed in accordance with the requirements of paragraphs 4.1.1.1 through 4.1.1.3.

4.1.2 Procedure for Sampling to Determine Slump, Temperature, and Total Air Content

When sampling concrete mixture for slump, temperature, and/or total air content (STTAC), follow the procedure for sampling in AASHTO R 60 with the following exception:

- discharge at least 1/4 cubic yard before obtaining a sample.

For comparison's sake 1/4 cubic yard is equivalent to 6-3/4 cubic feet. Most industrial grade wheelbarrows will hold 6 cubic feet.

Following the requirements of Table 4 in Section 804, sample the first load following the above listed procedure.

If the slump of the batch is below the allowable limit, the Contractor may opt to field-adjust the batch by adding the allowable additional water in accordance with Subsection 804.02.12. See paragraph 4.1.4 for additional information.

If the total air content of the batch is below the allowable limit, *and* if the Contractor included a specific plan in the QCP to address below-minimum total air contents through the job site addition of air-entraining admixtures

to increase the total air content, the Contractor may opt to field-adjust the mixture by adding additional air-entraining admixture in accordance with his plan. If after the addition of air-entraining admixture the total air content exceeds the maximum allowable limit, the batch shall be rejected.

Obtain a completely new sample of the field-adjusted batch after the addition of either water or air-entraining admixture, completion of the required number of revolutions at mixing speed, and another discharge at least 1/4 cubic yards of concrete mixture. Retest this new sample for STTAC.

Whenever field adjustments to a batch of concrete mixture are made at the job site for slump and/or total air content, the Contractor shall:

- make batching procedure adjustments such that next batching-procedure-adjusted batch arrives at the job site and does not need field adjustments, and
- test this batch for STTAC.

The Contractor shall repeat this process of "fine tuning" the batching by sampling, testing for STTAC, field-adjusting the batch, and adjusting the batching procedure until field adjustments at the job site are not required in order to achieve the desired job site slump and/or total air content,

Whenever visual inspection or changes in the workability of the concrete mixture are noticed, repeat the sampling procedure for STTAC. Based on the results of the tests for STTAC, the process listed above for making adjustments at the Concrete Batch Plant shall be repeated.

4.1.3 Procedure for Sampling for Casting Concrete Test Specimens

When sampling concrete mixture for casting concrete test specimens, follow the procedure for sampling in AASHTO R 60 and discharge enough concrete mixture to get to approximately the middle of the batch before obtaining the sample.

Once discharge for placement of the batch begins no field adjustments for slump and/or total air content shall be made.

For comparison's sake, the middle 80% of an 8 cubic yard batch is reached after discharging about 22 cubic feet or enough to a completely fill 4 wheelbarrows.

During the casting of concrete test specimens, determine the STTAC of the same sample of concrete mixture.

If during the tests for STTAC performed for casting concrete test specimens it is determined that the concrete mixture does not meet all the requirements for plastic properties, discard all concrete mixture which has not yet been placed. If any concrete mixture has been placed, do not discard the concrete test specimens. These must be retained as they represent the concrete mixture placed on the project. If no concrete mixture has been placed, reject the batch of concrete. After making the required batching procedure adjustments per paragraph 4.1.1, test the next truck for STTAC and cast concrete test specimens from the middle portion of the batch.

4.1.4 Addition of Water

The exception listed in Subsection 804.02.12 to AASHTO M 157, Section 11.7 allows the Contractor to add the listed amount water to the batch at the job site per AASHTO M 157, Section 6. This may only be utilized during the acceptance of the batch based on the plastic properties and prior to discharge for placement of the batch. If the result of this addition of water increases the slump greater than the maximum permitted slump, the

batch shall be rejected by the Contractor and not incorporated into the project. Once the batch is accepted by the Contractor, additional water shall not be added to the batch. The requirement of AASHTO M 157, Section 11.7 shall be followed except, on arrival to the job site, a maximum of 1½ gallons per cubic yard shall be allowed to be added. Water shall not be added at a later time. Job site adjustment of a batch using chemical admixtures or the mechanical adjustment of a batch may be performed by the Contractor if the requirements of Subsection 907-804.02.12.1.1 have been satisfactorily addressed in the Quality Control Plan. If either the maximum permitted slump is exceeded or the total air content is not within the required range after all adjustments are made at the job site, the concrete shall be rejected.

4.1.5 The "Check Test" Performed Prior to Rejection of a Batch

If the tests for STTAC indicates the batch does not meet the required plastic properties, as required in Subsections 804.02.13.1.1 through 804.02.13.1.4, perform one additional re-test (i.e., the "check test" described in these Subsections) for the plastic properties on the same sample prior to rejecting the concrete mixture from being placed on the project. For the purposes of verifying the initial STTAC results, no other or additional sample of concrete mixture shall be obtained.

4.1.6 Rejection of Freshly Mixed Concrete Mixture

If a batch does not meet the applicable STTAC acceptance criteria as required in Subsections 804.02.13.1.1 through 804.02.13.1.4, after adjustments for slump, total air content, or both, the concrete mixture shall be rejected by the Contractor and not incorporated into the project. If the Contractor does not reject the concrete mixture, the Department inspector must reject it.

4.1.7 Time/Revolution Limits on Freshly Mixed Concrete Mixture

Requirements in AASHTO M 157, Section 11.7 limit the amount of time between concrete mixture batching and complete discharge to 1-1/2 hours. Similarly, it limits the number of batch truck drum revolutions to 300. After 1-1/2 hours or 300 revolutions, the Contractor should reject any remaining concrete mixture contained in a batch truck which is not still satisfactorily workable and placeable without adding water to the batch truck. Additionally, after 1-1/2 hours or 300 revolutions, the Department has the right to reject any remaining concrete mixture contained in a batch truck which is not still satisfactorily workable and placeable without adding water to the batch truck.

However, these requirements may be waived at the Department's discretion if the concrete mixture is still satisfactorily workable and placeable without adding water to the batch truck. This extension of placement time is particularly applicable to Class DS concrete mixtures which typically contain set retarding chemical admixtures and are designed to maintain slump and workability for a minimum of 4 hours.

4.2 Specifics for Curing and Transporting Compressive Strength Cylinders

4.2.1 Standard Curing of Compressive Strength Cylinders

Compressive strength cylinders used for acceptance of concrete shall be Standard Cured per AASHTO T 23, Section 10.1.

Compressive strength cylinders used for form removal or opening to traffic shall be Field Cured per AASHTO T 23, Section 10.2. For specifics concerning field curing of compressive strength cylinders, please refer to paragraph 7.1.

4.2.1.1 Initial Curing of Compressive Strength Cylinders

Compressive strength cylinders used for acceptance of concrete shall be given an initial cure per AASHTO T 23, Section 10.1.2.

Store cylinders during initial curing for up to 48 hours, with the exception that concrete mixtures used in drilled shafts may take longer than 48 hours to set and shall not be transported until the concrete in the cylinders is set and hard. After the time of initial curing transport the cylinders to the place of final curing per paragraph 4.2.1.3.

Record the minimum and maximum temperatures experienced by the cylinders during the period of initial curing. The required temperature range for the area surrounding the cylinders is 60 to 80°F. The required ambient temperature range for the area surrounding the cylinders of concrete with a specified strength of 6000 psi or greater is 68 to 78°F.

AASHTO T 23, Section 10.1.2 lists several methods for ensuring the proper temperature is experienced by the cylinders during initial curing. The most practical and economic method the Department has found is the combined use of ice, water, and commercially available "coolers" with an advertised capacity of 120 quarts or larger.

The type of coolers found to give the best results are the "5-day cooler" variety, or better, which are advertised as keeping ice inside the cooler for 5 days when the outside temperature is 90°F. Most of the Igloo brand MaxCold™, Quick & Cool™, and "Marine" lines of coolers are the "5-day" type. Also, most of the Coleman brand Xtreme®, Ultimate® Xtreme®, and "Marine" lines of coolers are the "5-day" type.

Depending on the time of the year, different combinations of ice, water, and coolers are required. During spring or fall, ice will not likely be required. Depending on the weather, water may or may not be required.

During summer, cylinders should *never* be initially cured in a cooler without ice and water. Without ice and water to keep the cylinders cool, the cooler will end up acting like an oven as it traps the heat inside, which will affect the 28-day strength of the cylinders.

A couple of methods for keeping cylinders in the required temperature range have been found by the Department to work well during summer weather. The simplest method uses only ice, water, and a cooler with an advertised capacity of 120 quarts or larger, and is described below.

1. Put the water in the cooler followed by enough ice to cool the water down to 60°F. This is the minimum temperature in the required initial curing temperature range.
2. Place a thermometer or other temperature recording device in the water capable of recording the minimum and maximum temperatures of the water during initial curing.
3. Stir the ice around in the water until it all melts and allow the water temperature to stabilize. If the water temperature drops below the 60°F, slowly add more water while stirring the water, until the temperature reaches 60°F or greater.
4. After the water temperature has stabilized in the required range, with the plastic caps on the molds, carefully submerge the freshly made cylinders entirely in the water.
5. Store the cylinders in the water for up to 48 hours until they are taken to the place for final curing.
6. Record the minimum and maximum temperatures of the water during initial curing.
7. Do not remove the cylinders from the molds until they are ready to be final cured.

For testing this method, the Department placed a 120 quart cooler in a room with an ambient temperature of 100°F. The room temperature was maintained approximately at 100°F for the full 48 hours. With this size cooler and temperature conditions, the most number of cylinders which could be placed in the cooler was six, 6"x12" cylinders, which were also approximately at 100°F from exposure to the room temperature. With this configuration, after 48 hours the water temperature in the cooler rose from 60°F to just below the maximum temperature of 80°F, meeting the required temperature range.

These ambient room temperature and temperature duration conditions are an extreme case and unlikely to be experienced on a job site, but it proved the method and configuration to meet the requirements.

The number of cylinders which can be placed in the cooler depends on several things:

- the size of the cooler,
- the size of the cylinders,
- the temperature and class of concrete, and
- the weather conditions.

These all affect how much water is needed to keep the cylinders in the required temperature range. The size of the cooler and size of the cylinders affects how much water can be used to absorb heat from the outside. With either a larger cooler or smaller cylinders (like 4"x8"s), there is more room for water to absorb heat from the outside. With more water, more cylinders should be able to be stored in one cooler. As the temperature of the concrete mixture goes up, more water is required to absorb heat from the cylinders, and therefore, fewer cylinders can fit in the cooler. As the class of concrete increases (with an increase in the amount of cement), the amount of heat created by the cylinders as they age increases. Therefore more water is required, and fewer cylinders can fit in the cooler. As the outside temperature increases, or if the cooler is in direct sunlight, the cooler is exposed to more heat from the outside, which requires more water to absorb the heat. Therefore more water is required, and fewer cylinders can fit in the cooler.

During winter, the method for initially curing the cylinders is similar to the one for summer.

1. Put the water in the cooler with a water temperature of 80°F. This is the maximum temperature in the required initial curing temperature range.
2. Place a thermometer or other temperature recording device in the water capable of recording the minimum and maximum temperatures of the water during initial curing.
3. With the plastic caps on the molds, carefully submerge the freshly made cylinders entirely in the water.
4. Store the cylinders in the water for up to 48 hours until they are taken to the place for final curing.
5. Record the minimum and maximum temperatures of the water during initial curing.
6. Do not remove the cylinders from the molds until they are ready to be final cured.

Do not remove the cylinders from the molds until they are ready to be final cured per paragraph 4.2.1.3.

4.2.1.2 Transportation of Compressive Strength Cylinders

After initial curing is complete, transport the cylinders to where they will be stored and final cured. Typically this is the District Laboratory. Prior to transporting the cylinders, remove the cover from each cylinder and verify the concrete has set and is hard enough to transport. Concrete mixtures used in drilled shafts may take longer than 48 hours to set and must be initially cured until concrete is set and hard. Keep the cylinders from being jarred during transportation by laying them on foam or other cushioning material. Placing them on the bare bed or cab floorboard of a pickup truck can damage the cylinders.

Do not exceed 4 hours after removing the cylinders from initial curing to get them to the location for final curing and into either the moisture room or lime-water bath.

Do not remove the cylinders from the molds.

4.2.1.3 Final Curing of Compressive Strength Cylinders

Compressive strength cylinders used for acceptance of concrete shall be final cured per AASHTO T 23, Section 10.1.3.

After completing initial curing of no more than 48 hours after making the cylinders, take the cylinders to the place of final curing. Remove the cylinder from the mold. Within 30 minutes of removing the cylinders from the mold, place the cylinders in either a moisture room or a lime-water bath ("lime" meaning calcium hydroxide) meeting the requirements of AASHTO M 201. The lime-water in the bath must have enough lime so that not all the lime dissolves, but collects on the bottom of the bath. The temperature of the moisture room or lime-water bath must be kept between 70° and 77°F. The moisture room or lime-water bath must have a recording thermometer to record the temperature of the moisture room or lime-water. Recording the temperature of the air of the room where the lime-water bath resides is insufficient. The temperature of the lime-water must be recorded. The recording thermometer must record the temperature at least every 15 minutes.

4.3 Specifics for Testing Compressive Strength Cylinders

Compressive strength cylinders used for acceptance of concrete shall be tested for compressive strength per AASHTO T 22.

Following the requirements of the test procedure, test the compressive strength cylinders until failure as noted by a well-defined fracture or, for testing machines with a specimen failure detector, until the load has dropped to less than 95% of the peak load.

5 The Department's Concrete Acceptance Programs

The Department is responsible for ensuring that all materials incorporated into a Department project meet the requirements of the specification. To accomplish this, the Department uses one of the following materials inspection programs:

1) acceptance by Department Sampling and Testing; and
2) acceptance by Quality Control / Quality Assurance (QC/QA) Sampling and Testing

Concrete mixture and concrete compressive strength shall meet the acceptance requirements in Subsection 804.02.13 for the sampling and testing programs in paragraph 5.1 for Department Sampling and Testing and paragraph 5.2 for QC/QA Sampling and Testing. Discussion concerning the validation of the Contractor's test results by comparison with the Department's test results is in paragraph 5.2.2 and its subsequent paragraphs.

5.1 Department Sampling and Testing

For this materials inspection program, the Department performs all the sampling and testing on materials associated with concrete incorporated into a project to ensure the contract requirements are met. Only the Department's test results are considered with respect to accepting materials. The Department's sampling and

testing activities are outlined in TMD-20-04-00-000. This SOP lists the required sampling frequencies and tests for aggregates and plastic concrete mixture, tests for concrete, and sampling frequencies for other materials associated with concrete

The *acceptance requirements* for these tests are found in Subsection 804.02.13.1.

The Contractor is still responsible for ensuring that the materials meet the contract requirements are incorporated into the project.

5.2 QC/QA Sampling and Testing

For this materials inspection program, the Department's sampling and testing activities are outlined in Table 5 in Section 804. This table lists the required sampling frequencies and tests for aggregates and plastic concrete mixture, and tests for concrete.

The *acceptance requirements* for these tests are found in Subsection 804.02.13.1.

Additionally, the Contractor is required to maintain a sampling and testing program which includes the activities and frequencies listed in Table 4 in Section 804. The sampling and testing activities by the Contractor is referred to as *quality control* (QC). The performance and material characteristic requirements for aggregates and plastic concrete mixture, and tests for concrete are the same as for the Department's for the Contractor's QC activities.

In accordance with Subsection 804.02.13, if the Contractor's test results are validated as comparing with the Department's test results, the Contractor's test results will be used for acceptance of the materials. The validation requirements for comparison are found in Subsection 804.02.13.

5.2.1 Specifics Concerning the Sampling Frequency for the Department for Concrete Mixture for Casting Compressive Strength Cylinders

The sampling frequency for concrete mixture depends on the requirements of the applicable materials inspection program.

Regardless of the sampling frequency, for each set of compressive strength cylinders cast, determine the slump, the temperature, and the total air content.

For the Department Sampling and Testing materials inspection program, the Department will cast one set of compressive strength cylinders at the frequency listed in TMD-20-04-00-000.

For the QC/QA Sampling and Testing materials inspection program requirements of Section 804, the Department will cast at least three sets of compressive strength cylinders for each of the Contractor's 10 sets of compressive strength cylinders as the minimum sampling frequency when a Comparison is required. For more information on Comparisons, see paragraph 5.2.2 and its subsequent paragraphs. For this materials inspection program, it is likely that in order the meet the minimum Comparison Ratio of 10:3, the amount of concrete represented by each set of compressive strength cylinders cast by the Department will be less 100 cubic yards. When it is determined Comparison has been established, the Department may cease following the requirement to cast compressive strength cylinders based on the amount of concrete mixture placed (i.e., the requirement for one set per each 100 cubic yard) provided the minimum 3 sets of compressive strength cylinders are cast by the Department for each of the Contractor's 10 compressive strength cylinder sets cast.

It is recommended that the Department cast compressive strength cylinder from different batches of concrete mixture (i.e., samples of concrete mixture for casting compressive strength samples for the Department and Contractor coming from *different trucks*).

5.2.2 Comparisons

5.2.2.1 Use of Comparison Allowed

Subsection 804.02.13 gives provision for the Department to use the concept of comparison in order that the Department may use the Contractor's QC test results "as a part of the acceptance procedures instead of the results of QA tests, provided:

a) The Department's inspection and monitoring activities indicate that the Contractor is following the approved Quality Control program and, respectively,
b) For aggregates, the results from the Contractor's QC and the Department's QA testing of aggregate gradations compare by both meeting the aggregate type's gradation requirements;
c) For concrete, the Contractor's QC and Department's QA testing of concrete compressive strengths compare when using the data comparison computer program with an alpha value of 0.01 for projects with 1000 cubic yards and more; or, strength comparisons are within 990 psi for projects of more than 200 but less than 1000 cubic yards."

At a minimum during periods of construction comparisons for aggregates and concrete will be made monthly.

Additionally, when "it is determined that the Contractor's QC test results of [aggregate gradations or concrete compressive strengths] are comparative to that of the Department's QA test results, then the Department will use the Contractor's QC results as a basis for acceptance of the [aggregates or concrete] and the Department's QA testing frequency of [aggregates or concrete compressive strengths] may be reduced to a frequency of no less than three QA tests to every 10 QC tests."

The following paragraphs discuss the application of the Department's policies with respect to comparison between Department data and Contractor data.

Because the main emphasis of comparison by the Department deals primarily with comparing two sets compressive strength data of concrete cylinders, these paragraphs address the concept of comparison from a compressive strength point of view. Comparison of aggregate gradations follows the Individual Comparison concept.

5.2.2.2 The Basic Principle of Comparison

The basic principle of comparison is that two sets of data from a single source should have similar characteristics. For example, suppose there is an enormous jar of marbles of many different colors. If 10 marbles are pulled out of the jar for one set and compared with another set containing 20 marbles out of the jar, there should be approximately the same proportion of red marbles in the set of 10 as there is in the set of 20. So if there are 4 red marbles in the set of 10, giving a percentage of 40% red marbles, and the 4 red marbles in 10 is an accurate representation of the marbles in the jar, there should be approximately 8 red marbles in the set of 20. In the case of concrete for structural applications, the concerning measurable factor is not the number of red marbles, but the compressive strength of the concrete test cylinders.

5.2.2.3 Consideration for Different Sample Set Sizes

Following the idea of the marbles, if one organization (the Contractor) is sampling and testing cylinders from the same concrete another organization (the Department) is also sampling and testing, the two sets of compressive strength data should be comparative, provided both organizations are following the same sampling and testing procedures. And, like there being 10 marbles in one set and 20 in another, provided there are enough samples in each set to adequately represent the concrete being used, a difference in the relative number of samples in one set of compressive strength data with respect to another, larger number of samples in the other set, does not prevent there from being an accurate comparison of the two sets of compressive strength data. In other words, like the marbles it is OK to have a different number of marbles in one set than the other.

Also, if the set of 20 is the Contractor side and the set of 10 is the Department side, then the Comparison Ratio is 20:10. In the case of structural concrete the maximum Comparison Ratio is 10:3, per the above quoted specification. This means two things: 1) the number of consecutive Contractor samples considered for a comparison is *always* 10, and 2) for any 10 consecutive Contractor samples obtained in a period of time there should be *at least* three Department samples obtained during the same period of time. There may be as many as 10 Department samples taken in the period of time, but no less than three. See paragraph 5.2.2.10 and paragraph 5.2.2.11 for additional information on comparing sample sets with different numbers of sample in each set.

5.2.2.4 Individual Comparison vs. Collective Comparison

For comparison purposes, one of the important considerations is how to make the comparison between the Contractor side and Department side. For this consideration, there are two ways to "look" at two sets of data for comparison purposes. (There are other ways to "look" at two sets of data, but only two are considered here.) The first is looking at samples individually for comparison between the two sides. Looking at samples individually means comparing the compressive strength of just one test on the Contractor side with the compressive strength of just one test on the Department side. Per Subsection 804.02.13.c, the criteria for determining if the two individual samples compare is if the compressive strength of the two tests are within 990 psi of each other.

The second is looking at samples collectively for comparison between the two sides. Looking at samples collectively means making separate summarizations of the Contractor data and the Department data, then making the comparison of the summarizations. Per Subsection 804.02.13.1.6, the method of collective summarization is made through calculating 1) the running average and 2) the standard deviation of the compressive strength tests for each side (see paragraph 5.2.2.6 for information concerning the use of running averages for quality control of concrete mixtures), then using statistical analysis to perform the comparison.

The decision made by the Department is to use the *Individual Comparison method* for projects falling in the Medium Quantity category and the *Collective Comparison method* for projects falling in the Large Quantity category. See Subsection 804.02.1 and paragraph 1.3 for additional information concerning the definitions for the different project sizes, Small Quantity, Medium Quantity, and Large Quantity.

5.2.2.5 Individual Comparison: an Example with a 10:10 Comparison Ratio

The following is an example of the *Individual Comparison method* for projects falling under the Medium Quantity requirements. This table summarizes a number of dates on which cylinders were taken by the Contractor and the Department.

Date	Contractor	Department
11-15	4900	4800
11-16	4800	4950
11-18	4970	4910
11-19	4600	4800
11-20	4950	4950
11-21	4840	3720
11-25	4910	4870
11-26	4820	4800
11-27	4950	4960
11-28	4860	4810

In this example every set of Contractor cylinders has a corresponding set of Department cylinders for each date. Whereas the Comparison Ratio is 10:10 in this example, this may not always be the case. Additional information concerning Individual Comparison with different Comparison Ratios are in paragraph 5.2.2.10.

To perform a comparison calculate the difference between the Contractor and Department sample for any one date. If the difference between the two sides is less than or equal to 990 psi then the two samples compare.

Date	Contractor	Department	Difference	Comparative Samples
11-15	4900	4800	100	Yes
11-16	4800	4950	150	Yes
11-18	4970	4910	60	Yes
11-19	4600	4800	200	Yes
11-20	4950	4950	0	Yes
11-21	4840	3720	1120	No
11-25	4910	4870	40	Yes
11-26	4820	4800	20	Yes
11-27	4950	4960	10	Yes
11-28	4860	4810	50	Yes

Looking at the samples taken on 11-18, 4970 psi for the Contractor and 4910 psi for the Department, the difference between these two is 60 psi. Because the difference is less than 990 psi, these samples compare. Additionally, because of the comparison, the Contrator's data is used for acceptance of the concrete represented by this sample.

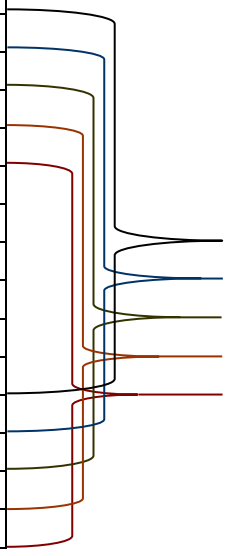
Looking at the samples taken on 11-21, 4840 psi for the Contractor and 3720 psi for the Department, the difference between these two is 1120 psi. Because the difference is more than 990 psi, these samples do not compare. Additionally, because of the non-comparison, the Department's data is used for acceptance of the concrete represented by this sample.

In both of these cases only the individual samples in the Contractor side and the Department side for a specific date are being compared.

5.2.2.6 Collective Comparison: Considerations for Concrete Production though Time

Unlike the enormous jar whose entire quantity of marbles was established at one time prior to sampling, the production of concrete on a project is stretched over a period of time. In order to take the production of concrete over time into consideration for determining the compressive strength of the concrete, the running averages and standard deviations of compressive strengths with respect to time are typically used as a method of QC. The following is a set of data for the individual compressive strength test samples which were taken on the following dates on which concrete was produced for a project. The groups of cylinders for each running average are listed to the side. Each group is called a Test Lot. The maximum number of set of cylinders in any Test Lot is 10 sets. For the Contractor, there are always 10 sets of cylinders in a QC Test Lot. For the Department, there may be many as 10 sets of cylinders in Department Test Lot, but may be as few as three, for any given QC Test Lot.

Date	Individual Test
11-08	4880
11-12	4710
11-13	4820
11-14	4650
11-15	4560
11-16	4870
11-18	4730
11-19	4660
11-20	4600
11-21	4760
11-25	4830
11-26	4660
11-27	4650
11-28	4580



Collective Summary Groups			
Test Lot No.	Test Lot Date Range	Running Average	Standard Deviation
1	11-08 to 11-21	4720	109.7
2	11-12 to 11-25	4720	102.7
3	11-13 to 11-26	4710	104.4
4	11-14 to 11-27	4700	98.9
5	11-15 to 11-28	4690	104.9

This method of collectively summarizing the compressive strength data as time progresses using running averages and standard deviations is applied to both the Contractor side and the Department side. For comparison purposes, it is these collective summarizations of Test Lots on each side which are compared using the statistical evaluation from the above quoted specification.

5.2.2.7 Collective Comparison: an Example

The following is an example of the *Collective Comparison method*. This table summarizes a number of dates on which cylinders were taken by the Contractor and the Department. Following the requirement that the running average and standard deviation for a Test Lot is calculated based on 10 samples, the first nine of any new project can not have running averages or standard deviations calculated for them; hence, the "Not Applicable" for the Date Range, the Running Average, and the Standard Deviation for the first nine samples.

Date	Date Range for Test Lot Running Average and Standard Deviation	Contractor			Department		
		Individual Test	Test Lot Running Average	Test Lot Standard Deviation	Individual Test	Test Lot Running Average	Test Lot Standard Deviation
11-08	Not Applicable (N/A)	4880	N/A	N/A	4650	N/A	N/A
11-12	Not Applicable (N/A)	4710	N/A	N/A	4690	N/A	N/A
11-13	Not Applicable (N/A)	4820	N/A	N/A	4660	N/A	N/A
11-14	Not Applicable (N/A)	4650	N/A	N/A	4890	N/A	N/A
11-15	Not Applicable (N/A)	4560	N/A	N/A	4770	N/A	N/A
11-16	Not Applicable (N/A)	4870	N/A	N/A	4660	N/A	N/A
11-18	Not Applicable (N/A)	4730	N/A	N/A	4560	N/A	N/A
11-19	Not Applicable (N/A)	4660	N/A	N/A	4640	N/A	N/A
11-20	Not Applicable (N/A)	4600	N/A	N/A	4510	N/A	N/A
11-21	11-08 to 11-21	4760	4720	109.7	4860	4690	120.4
11-25	11-12 to 11-25	4830	4720	102.7	4870	4710	132.0
11-26	11-13 to 11-26	4660	4710	104.4	4890	4730	143.2
11-27	11-14 to 11-27	4650	4700	98.9	4800	4750	142.3
11-28	11-15 to 11-28	4580	4690	104.9	4880	4740	141.2

In this example every set of Contractor cylinders has a corresponding set of Department cylinders for each date. Whereas the Comparison Ratio is 10:10 in this example, this may not always be the case. Additional information concerning different Comparison Ratios are in paragraph 5.2.2.11

To perform a comparison, using the prescribed α value of 0.01, calculate:

- the f-test distribution on the standard deviations between the two sides and
- the t-test distribution on the averages of the two sides.

If the results of both tests show that the Contractor side is statistically the same as the Department side, then the two sides compare. These f-test and t-test calculations and the subsequent comparison are performed by the Department's COMPARE Excel workbook, using a Visual Basic for Applications macro derived from the FHWA's COMPARE FORTRAN program. For more information on the Department's COMPARE Excel workbook, see Appendix A.

5.2.2.8 On Comparing "Apples to Apples" or Addressing Non-10:10 Comparison Ratios

Following the idea that the number of samples on one side *does not* need to be the same as the number of samples on the other side, like the example of marbles with 10 on one side and 20 on the other, the number of samples on the Contractor side *does not* necessarily need to be the same as the number of samples on the

Department side for there to be a comparison. In other words, because the Comparison Ratio may not always be 10:10 there may not necessarily be a test on the Department side for every specific date on which there is a test on the Contractor side. Per the Subsection 804.02.13 the maximum ratio permitted is 10:3. In previous examples there has always been either a specific, individual test or a collective test on one side corresponding by date to another either a specific, individual test or a collective test on the other side with which to perform the comparison between the two sides.

In the first individual comparison example from above, for each date listed there is a sample on the Contractor side and a corresponding sample on the Department side. Likewise, in the collective comparison for each date starting on 11-21 there was a collective running average and standard deviation on the Contractor side and a corresponding running average and standard deviation on the Department side. This was because the Comparison Ratio for these examples is 10:10.

If the Comparison Ratio is something less than 10:10, there is a necessity for another important consideration: knowing what to compare on the Contractor side with what on the Department side. Knowing this ensures that "apples are compared with apples."

5.2.2.9 The Forward Comparison

There are at least three methods to approach a difference on each side in the number of samples for a Comparison Ratio of not 10:10 (but only three are mentioned here). The terms give here to these three methods are 1) forward comparison, 2) backwards comparison, and 3) comparison both ways. The decision made by the Department is to use forward comparison. Forward comparison means that a Department sample is considered to correspond to all the Contractor samples from the date both the Contractor and Department samples were taken, until the date before the next Department sample is taken. The term given to a Department sample which corresponds to several Contractor samples is a *QA Group*. The term "forward comparison" is derived from the application of the individual Department sample in a QA Group "forward" in time such that it is considered to correspond with the other Contractor samples for which there is not directly corresponding Department sample. Additionally, any results, whether they are results from a compressive strength test or results from making a comparison between the Contractor side and the Department side, are applied to all the dates represented by the QA Group.

The following table shows four QA Groups in a Department Test Lot corresponding to 10 Contractor samples in a Contractor Test Lot.

Date	Contractor	Department
11-15	4900	4820
11-16	4800	
11-18	4970	
11-19	4600	4800
11-20	4950	
11-21	4840	3720
11-25	4910	
11-26	4820	
11-27	4950	
11-28	4860	4810

The Department sample in each QA Group above each represent the concrete placed over one or more days. Additionally, note that this example conforms to the requirement that there be a minimum of three Department samples in a Department Test Lot for every 10 Contractor samples in the Contractor Test Lot. Specifically, there a set of four QA Groups in the Department Test Lot corresponding to the set of 10 Contractor samples in the Contractor Test Lot.

Another way to look at the Department Test Lot is shown below.

Date	Department
11-15	4820
11-16	
11-18	
11-19	4800
11-20	
11-21	3720
11-25	
11-26	
11-27	
11-28	4810

Date	Department
11-15	4820
11-16	4820
11-18	4820
11-19	4800
11-20	4800
11-21	3720
11-25	3720
11-26	3720
11-27	3720
11-28	4810

These two Department Test Lots are equivalent. By applying the forward comparison to the Department Test Lot on the left, this is identical to the Department Test Lot on the right.

5.2.2.10 Individual Comparisons and a Non-10:10 Comparison Ratio

For projects falling under the requirements for Medium Quantity projects the *Individual Comparison method* is still used even if the Comparison Ratio is not 10:10. The following table is an example applying the *Individual Comparison method* to samples where the Comparison Ratio is not 10:10.

Date	Contractor	Department	Difference
11-15	4900	4800	100
11-16	4800		
11-18	4970		
11-19	4600	4800	200
11-20	4950		
11-21	4840	3720	1120
11-25	4910		
11-26	4820		
11-27	4950		
11-28	4860	4810	50

The results of the comparison on the Department side are applied as applicable.

5.2.2.11 Collective Comparisons and a Non-10:10 Comparison Ratio

For projects falling under the requirements for Large Quantity projects the *Collective Comparison method* is still used even if the Comparison Ratio is not 10:10. The following table is an example applying the *Collective Comparison method* to samples where the Comparison Ratio is not 10:10.

Date	Date Range for Running Average and Std. Dev.	Contractor			Department		
		Individual Test	Running Average	Std. Dev.	Individual Test	Running Average	Std. Dev.
11-08	Not Applicable	4880	N/A	N/A	4650	N/A	N/A
11-12	Not Applicable	4710	N/A	N/A		N/A	N/A
11-13	Not Applicable	4820	N/A	N/A	4770	N/A	N/A
11-14	Not Applicable	4650	N/A	N/A		N/A	N/A
11-15	Not Applicable	4560	N/A	N/A		N/A	N/A
11-16	Not Applicable	4870	N/A	N/A		N/A	N/A
11-18	Not Applicable	4730	N/A	N/A	4700	N/A	N/A
11-19	Not Applicable	4660	N/A	N/A		N/A	N/A
11-20	Not Applicable	4600	N/A	N/A		N/A	N/A
11-21	11-08 to 11-21	4760	4720	109.7	4860	4750	91.1
11-25	11-12 to 11-25	4830	4720	102.7		4780	80.2
11-26	11-13 to 11-26	4660	4710	104.4		4780	80.2
11-27	11-14 to 11-27	4650	4700	98.9	4880	4810	98.7
11-28	11-15 to 11-28	4580	4690	104.9		4810	98.7

The results of the comparison on the Department side are applied as applicable.

The tools used to accomplish these calculations and comparisons are two Excel workbooks. There is a workbook for each comparison method using Individual Comparison for MQ projects and Collective Comparison for LQ projects in both English units and and Metric units.

5.3 Dispute Resolution

In accordance with Subsection 804.02.14, "[d]isputes over variations between Contractor's QC test results and the Department's QA test results shall be resolved at the lowest possible level. When there are significant

discrepancies between the QC test results and the QA test results, the Contractor's Quality Control Manager, the Project Engineer, and/or the District Materials Engineer shall look for differences in the procedures, and correct the inappropriate procedure before requesting a third party resolution.

If the dispute cannot be resolved at the project or District level, the Department's Central Laboratory will serve as a third party to resolve the dispute. The Central Laboratory's decision shall be binding.

The Contractor shall be responsible for the cost associated with the third party resolution if the final decision is such that the Department's QA test results were correct. Likewise, the Department will be responsible for the cost when the final decision is such that the Contractor's QC test results were correct."

Use the applicable Pay Reduction Multiplier Determination Flowcharts in Figure 3 and Figure 4 to determine the applicable M (pay reduction multiplier).

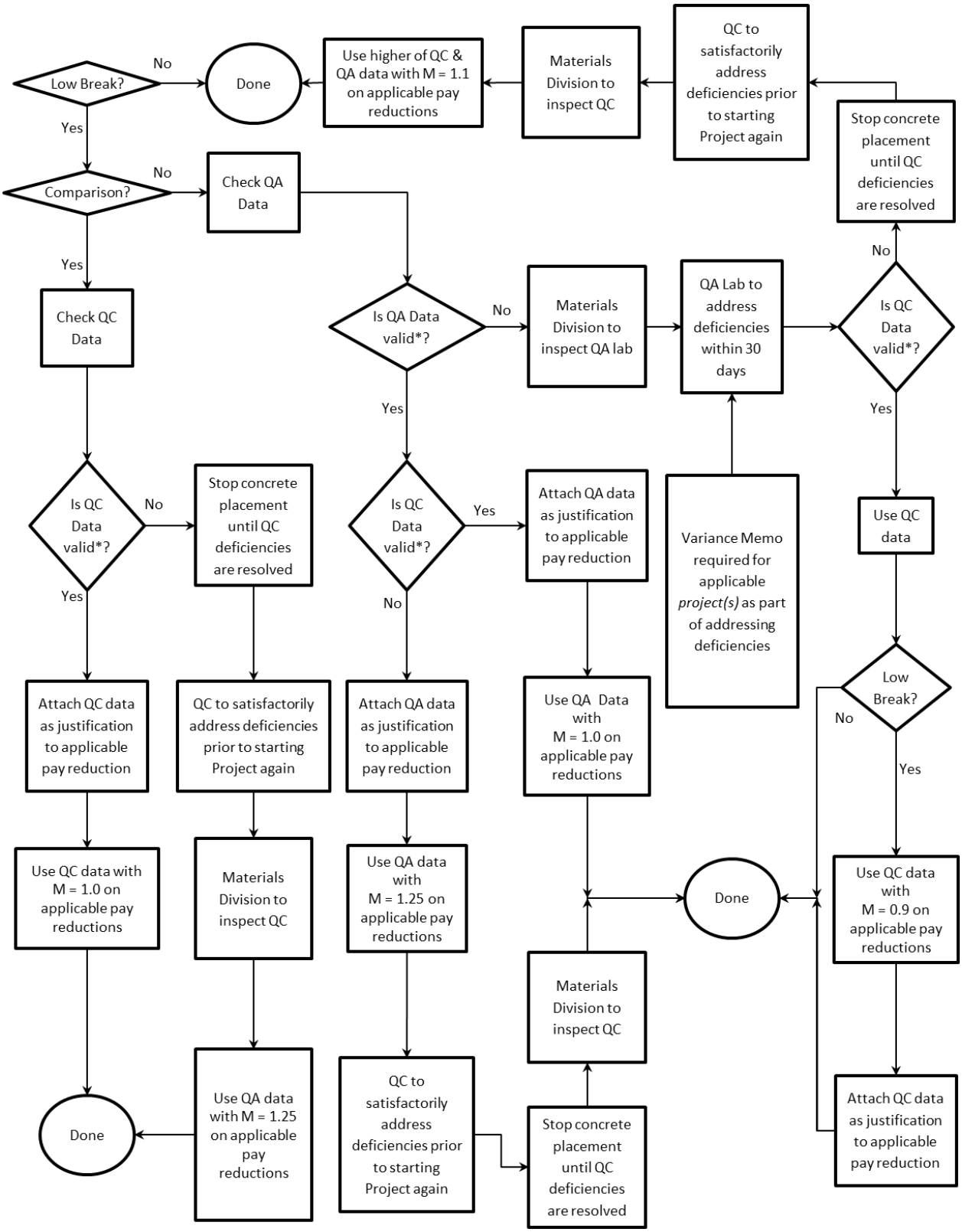


Figure 3 - Pay Reduction Multiplier Determination Flowchart for QC/QA Concrete

*See **Items to Investigate to Validate Strength Data**

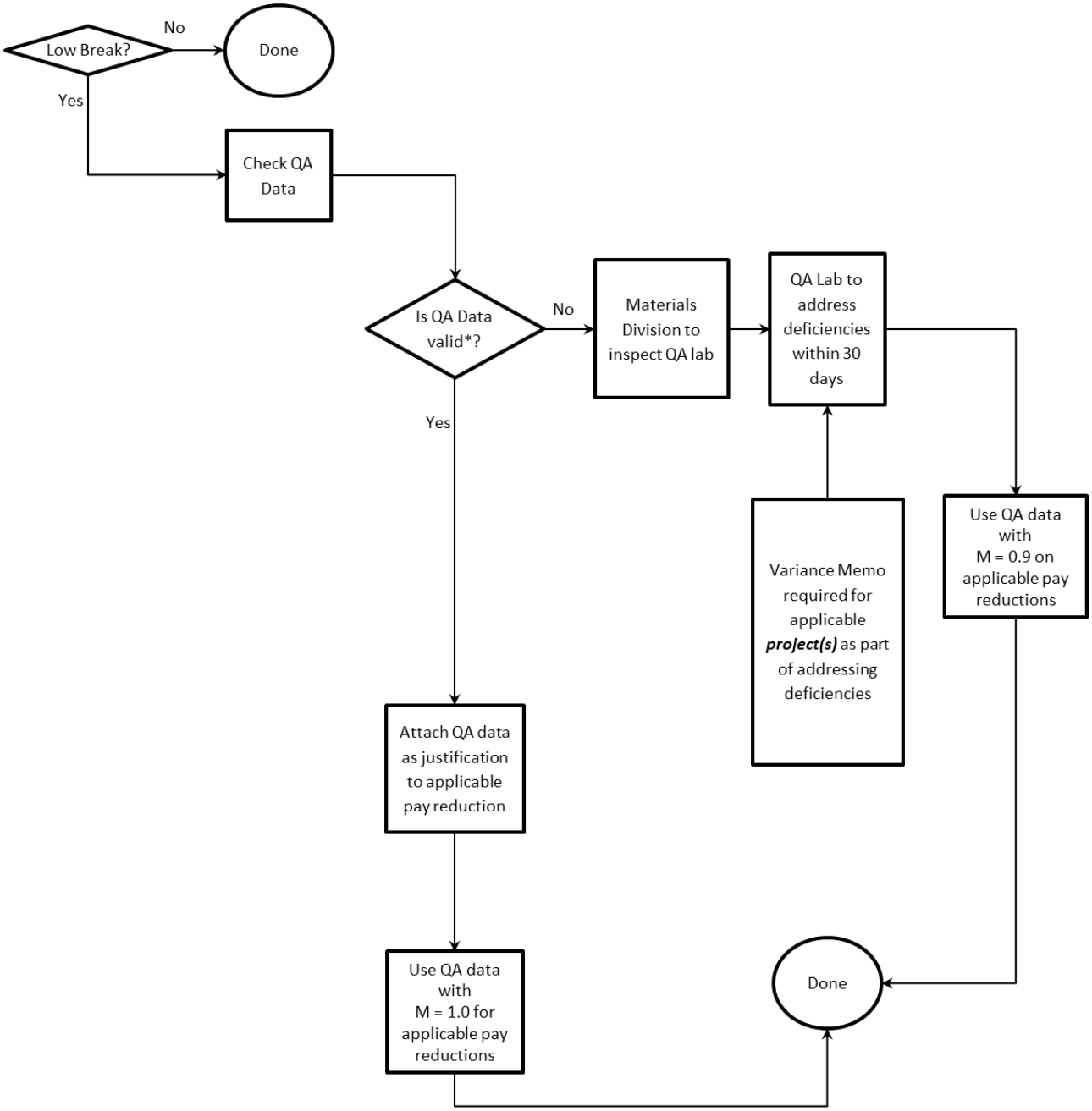


Figure 4 - Pay Reduction Multiplier Determination Flowchart for Non-QC/QA Concrete

*See **Items to Investigate to Validate Strength Data**

Items to Investigate to Validate Strength Data:

1. Cylinder curing

- Verify minimum and maximum temperature experienced by the cylinders during initial curing in the field. The required temperature range is 60.0 – 80.0°F.
- Verify that cylinders were transported to the lab for final curing not sooner than at least 8 hours after final set of the concrete. Typically this is between 24-48 hours after making the cylinder, but depends on the concrete mixture. Concrete for drilled shafts is designed to have a long time before reaching final set, so the cylinders made from concrete for use in drilled shafts may not be transportable even after 48 hours.
- Verify that transportation from the field to the lab curing bath/room did not exceed 4 hours.
- Verify minimum and maximum temperature experienced by the cylinders during final curing in the lab. The required temperature range is 70.0 – 77.0°F.

2. Lab testing

- Verify pads were not overused
- Verify the cylinders met the requirements for perpendicularity and end condition
- Verify calibration of compression machine
- Verify load rate was applied to the cylinders between 28 – 42 psi/sec.

3. Field testing

- Verify tests and samples were performed/created by MDOT Level 1 certified technicians.

4. Batch ticket

- Verify batching was completed within the allowable tolerances for the target batch weights to the mixture design and the actual batched weights compared to the target batch weights.
- Document this on the Field Verification form.

6 Contractor's QC Program

6.1 General

For Pay Items where the Contractor is required to implement and maintain a QC program, in addition to the previously referenced applicable requirements, the requirements in Subsection 804.02.12 must be met or exceeded.

6.2 Quality Control Plan

The Contractor must develop a Quality Control Plan (QCP). The QCP is a written tool for communication between the Contractor and the Department to address what the Contractor will do to ensure consistent quality concrete is delivered to the project. The Department has a form which may be used by the Contractor to complete the required information. For copies of this form, please contact the applicable DME.

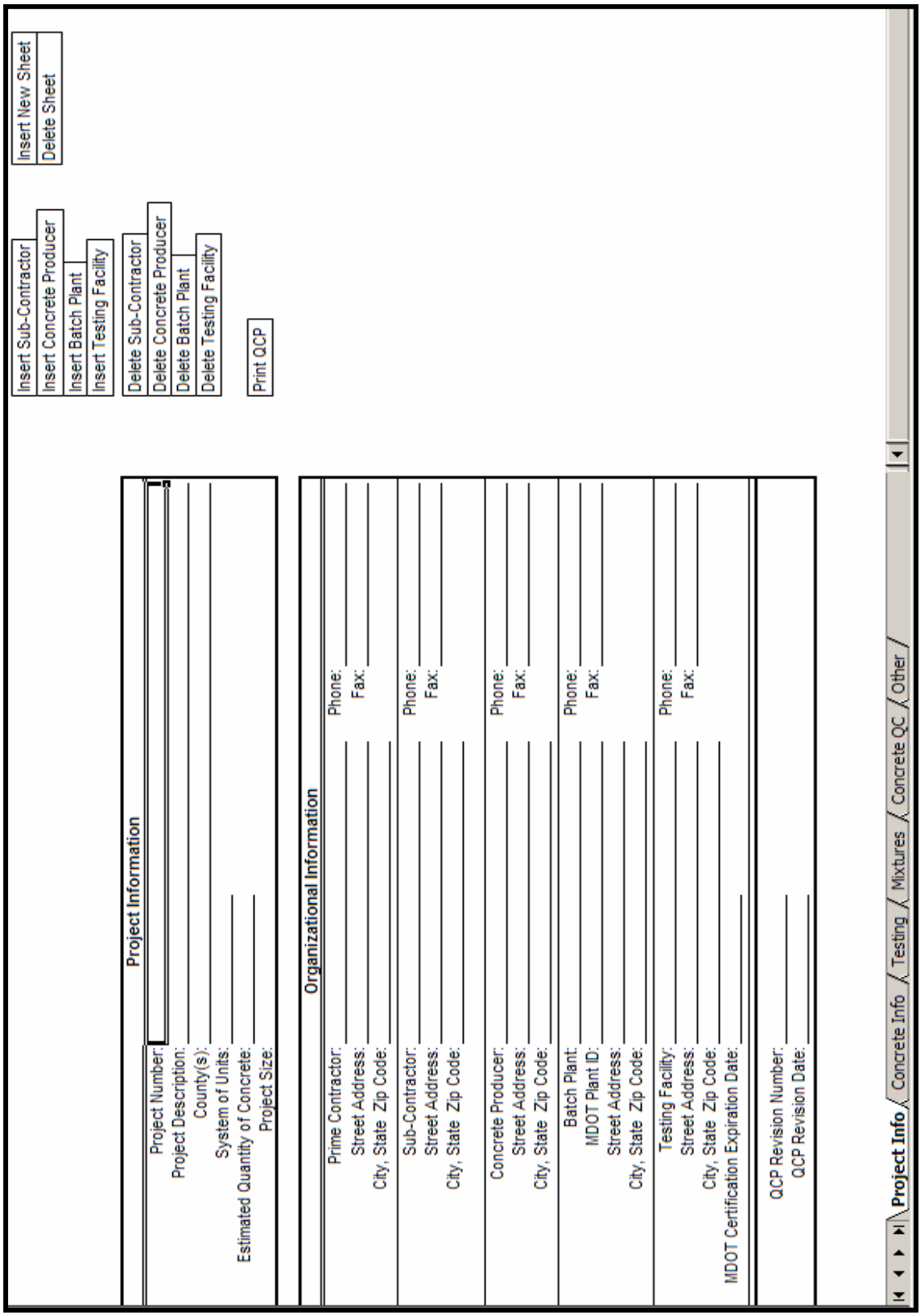


Figure 5 - QCP - Project Info Tab

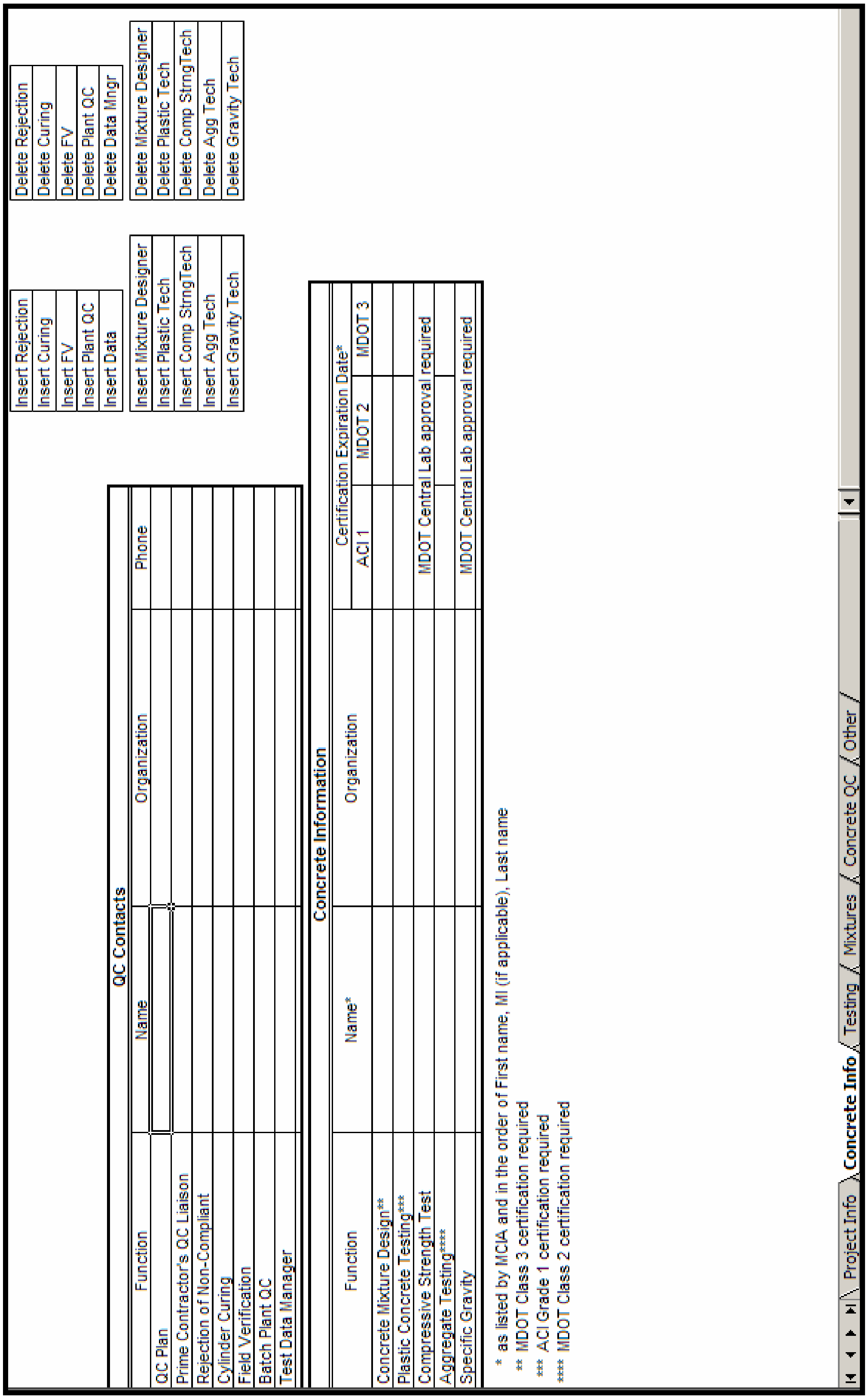
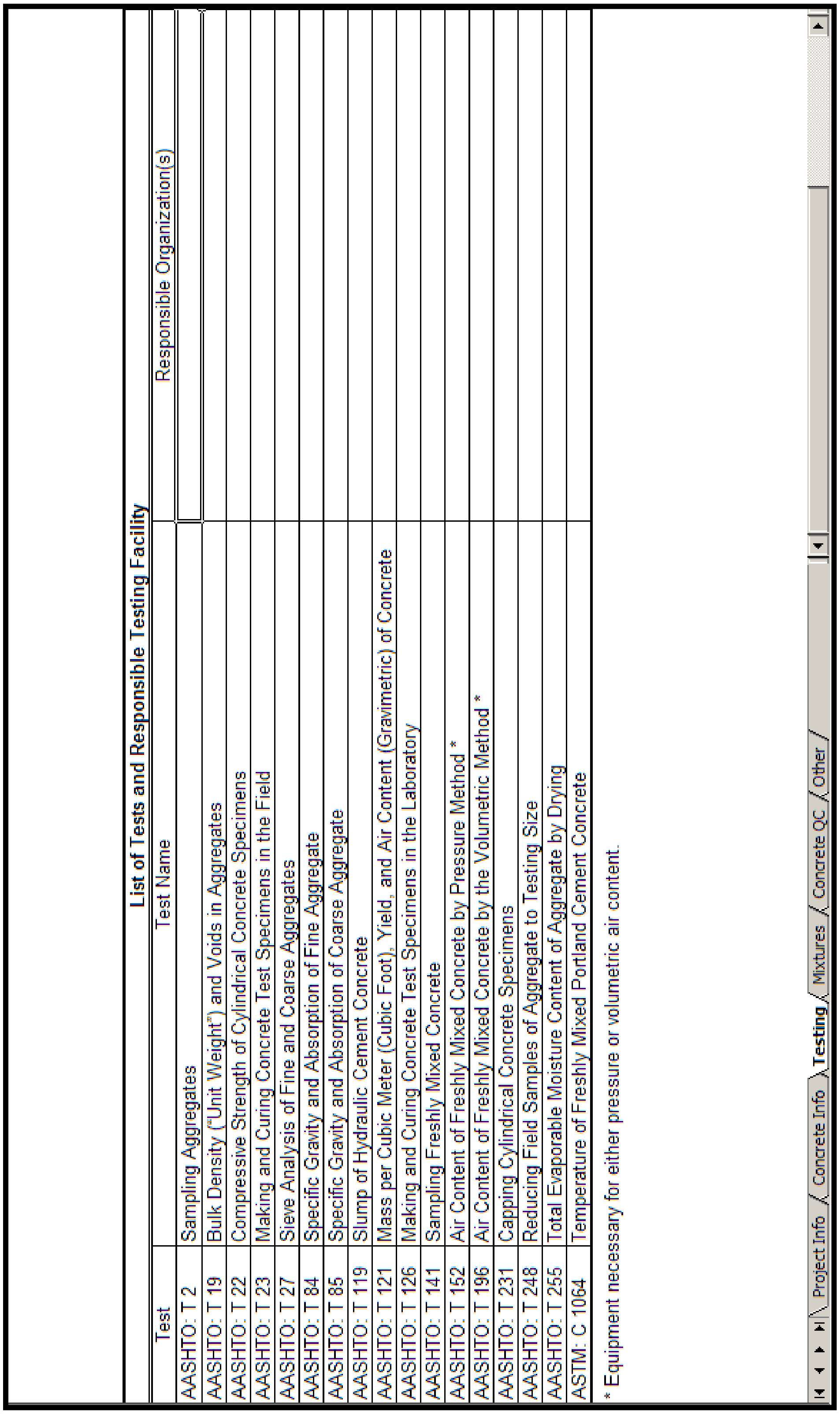


Figure 6 - QCP - Concrete Info Tab

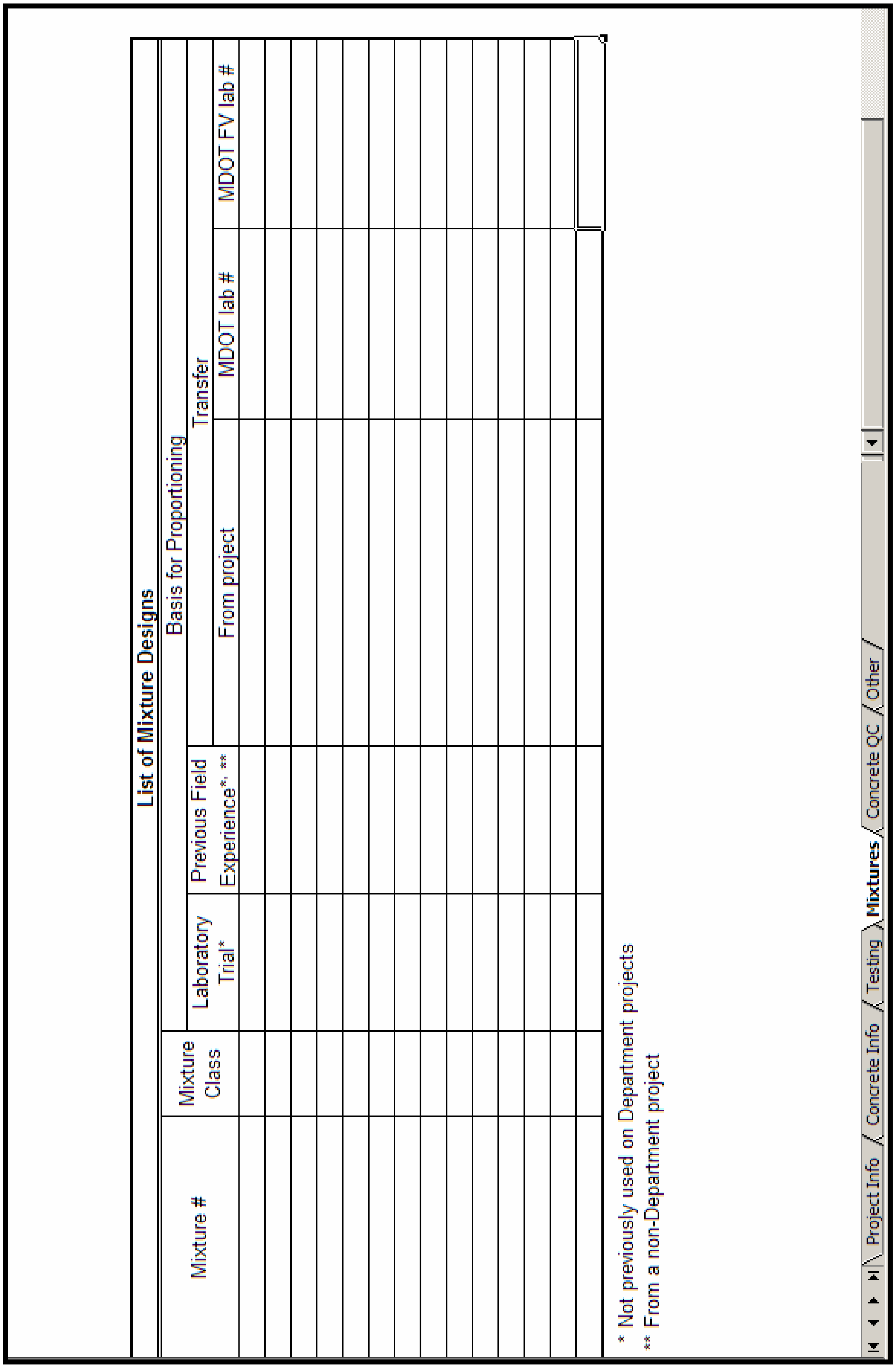


List of Tests and Responsible Testing Facility

Test	Test Name	Responsible Organization(s)
AASHTO: T 2	Sampling Aggregates	
AASHTO: T 19	Bulk Density ("Unit Weight") and Voids in Aggregates	
AASHTO: T 22	Compressive Strength of Cylindrical Concrete Specimens	
AASHTO: T 23	Making and Curing Concrete Test Specimens in the Field	
AASHTO: T 27	Sieve Analysis of Fine and Coarse Aggregates	
AASHTO: T 84	Specific Gravity and Absorption of Fine Aggregate	
AASHTO: T 85	Specific Gravity and Absorption of Coarse Aggregate	
AASHTO: T 119	Slump of Hydraulic Cement Concrete	
AASHTO: T 121	Mass per Cubic Meter (Cubic Foot), Yield, and Air Content (Gravimetric) of Concrete	
AASHTO: T 126	Making and Curing Concrete Test Specimens in the Laboratory	
AASHTO: T 141	Sampling Freshly Mixed Concrete	
AASHTO: T 152	Air Content of Freshly Mixed Concrete by Pressure Method *	
AASHTO: T 196	Air Content of Freshly Mixed Concrete by the Volumetric Method *	
AASHTO: T 231	Capping Cylindrical Concrete Specimens	
AASHTO: T 248	Reducing Field Samples of Aggregate to Testing Size	
AASHTO: T 255	Total Evaporable Moisture Content of Aggregate by Drying	
ASTM: C 1064	Temperature of Freshly Mixed Portland Cement Concrete	

* Equipment necessary for either pressure or volumetric air content.

Figure 7 - QCP - Testing Tab



List of Mixture Designs

Mixture #	Mixture Class	Basis for Proportioning				
		Laboratory Trial*	Previous Field Experience*, **	Transfer		
				From project	MDOT lab #	MDOT FV lab #

* Not previously used on Department projects
** From a non-Department project

Figure 8 - QCP - Mixtures Tab

Procedure for Controlling Concrete Temperatures

Cold Weather Concreting

Cold weather concrete will meet the requirements of Table 6 of the specifications.

Hot Weather Concreting

In order to control concrete temperatures one or more of the following indicated methods will be used:

___ Chilled Water
___ Shading Stockpiles
___ Sprinkling Stockpiles
___ Placement Optimization
___ Ice
___ Liquid Nitrogen
___ Pre-Placement Job Briefings
___ Other: _____

Stockpile Management

To ensure that aggregates will not be segregated or contaminated they will be stored by the method(s) checked

___ Aggregate sizes stored on separate platforms.
___ Aggregate sizes separated by barriers to prevent segregation.
___ Other: _____

Procedures for Corrective Actions for Non-Compliance of Specifications

Aggregate Gradations

Batching of Concrete

Compressive Strengths

Figure 9 - QCP - Concrete QC Tab

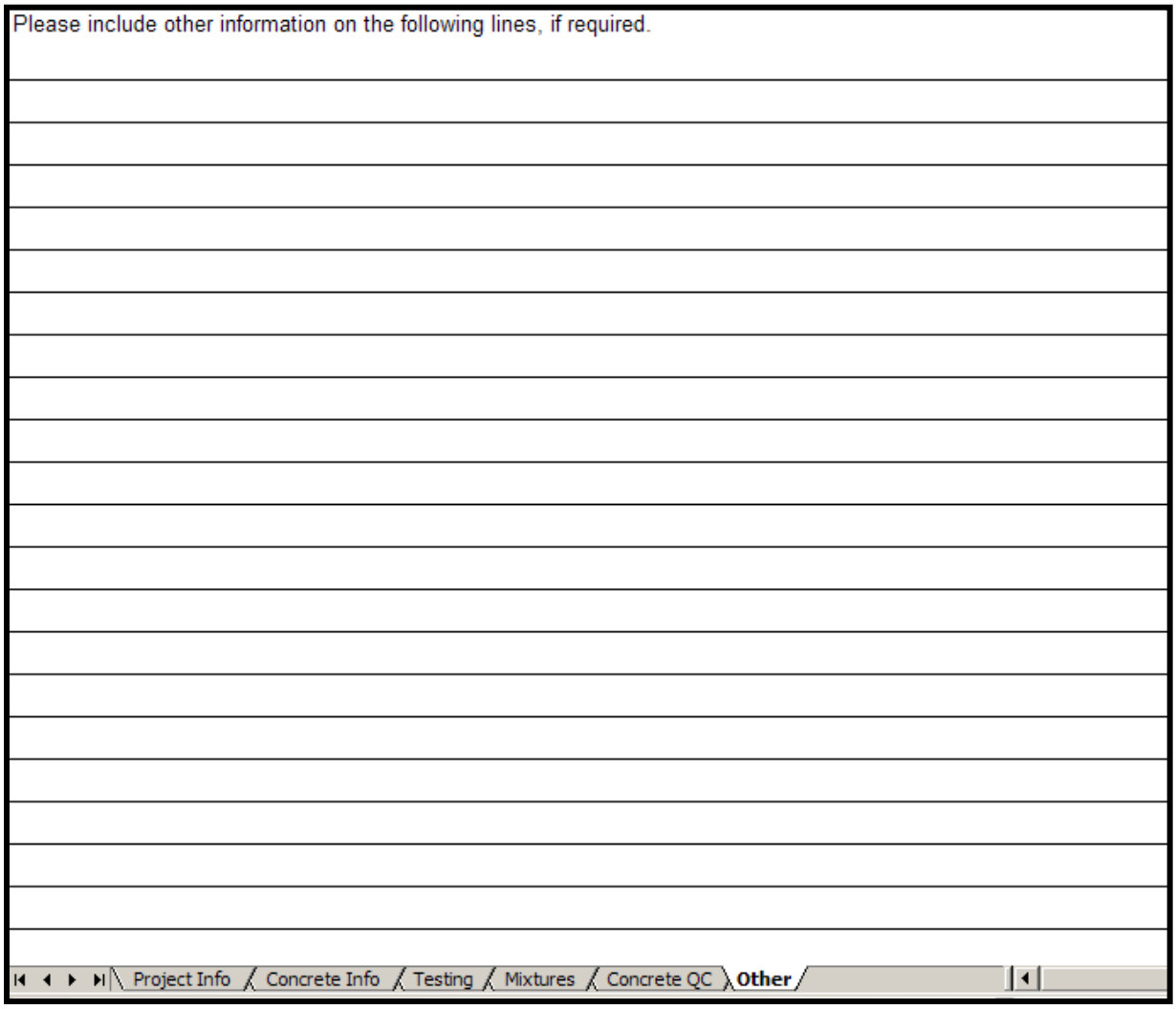


Figure 10 - QCP - Other Tab

7 Form Removal and Opening to Traffic

The Department allows the use of field cured cylinders to estimate the in-place compressive strength of concrete for the purposes of form removal from structural items and opening to traffic of concrete pavements and concrete pavement repairs. Additionally, where allowed by the specification, the maturity method may be used in lieu of field cured cylinders.

7.1 Field Curing of Compressive Strength Cylinders

Field cured cylinders **shall not** be used for the purpose of acceptance. Follow the requirements of AASHTO T 23, summarized here.

Store cylinders in or on the structure as near to the point of deposit of the concrete represented as possible. Protect the cylinders from the elements in as near as possible the way as the formed work. For example, if the formed work is in direct sunlight, place the cylinders in direct sunlight. Provide the cylinders with the same temperature and moisture environment as the structural work. For example, if the formed work has a curing blanket on it, place the cylinders also under a curing blanket. Test the specimens in the moisture condition resulting from the specified curing treatment. Protect the cylinders from excessive vibration from nearby traffic and/or other construction activities until they are sufficiently hardened, This may require removing the cylinders to some distance away from sources of vibration. If it is necessary to remove the cylinders from near the work due to vibration or other reasons, attempt to maintain a curing environment for the cylinders similar to the in-place concrete. In cool weather when the in-place concrete is under a curing blanket, it may be necessary to place the cylinders in an empty ice chest like on used for standard curing of cylinders in paragraph 4.2.1. For the purpose of determining when a structure is capable of being put into service (i.e., form removal) remove specimens from their molds just prior to testing the specimens to determine the estimated in-place strength of the concrete in the work.

7.2 Estimating Compressive Strength using the Maturity Method

The maturity method may be used in lieu of field-cured cylinders. See the applicable specification for additional information. Figure 11 shows an example of a maturity verses compressive strength curve used to estimate the in-place compressive strength.

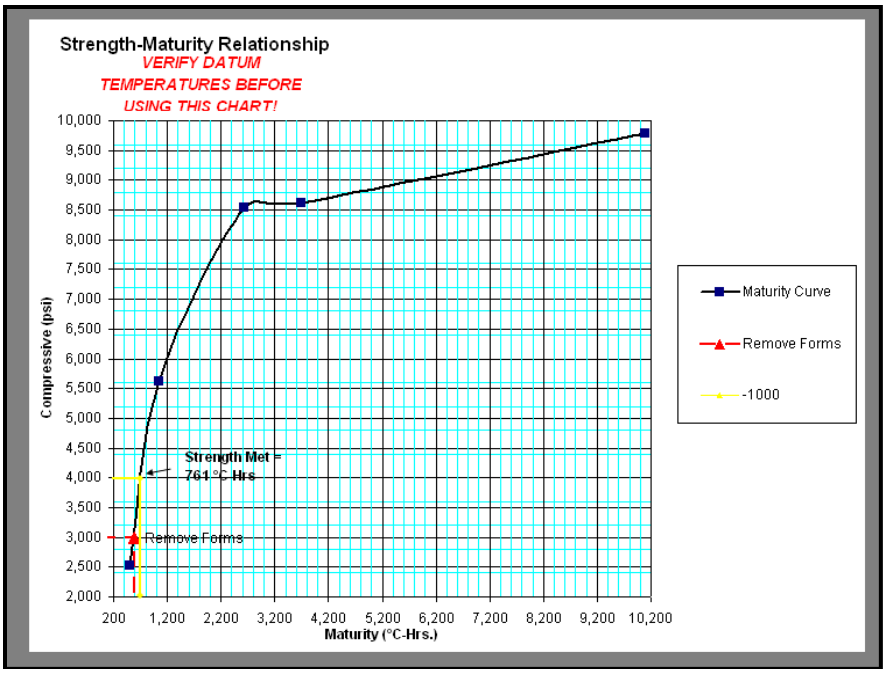


Figure 11 - Example Strength vs. Maturity Curve

7.2.1 Verification of the Compressive Strength-Maturity Relationship

For each concrete mixture design on which the maturity method is used, a verification of the compressive strength-maturity relationship (i.e., the "calibration curve") shall be made at least every 500 cubic yards by the Contractor. The purpose of the verification is to ensure the mixture has not changed substantially from when the compressive strength-maturity relationship was established.

The verification shall be accomplished by the following method:

- One set of compressive strength cylinders shall be cast following the requirements of AASHTO T 23 for the exclusive purpose of the verification. This set shall not be used as a part of the Contractor's regular QC testing.
- A third cylinder shall be similarly cast with a maturity meter placed into approximately the center of the cylinder during casting.
- Procedures for using the maturity meter shall follow the requirements of AASHTO T 325 and ASTM C 1074.
- The set of compressive strength cylinders and the cylinder with the active maturity meter shall be kept together during curing and shall experience the same curing conditions.
- When the maturity meter indicates the maturity index (M) is within the correlation range identified during the development of the compressive strength-maturity relationship, the compressive strength of the set shall be determined and M for the additional cylinder shall be determined.

The compressive strength of the set shall be within ±10% of the estimated compressive strength at M using the compressive strength-maturity relationship information developed for the mixture design.

If the compressive strength of the set is not within ±10% of the estimated compressive strength for M determined from the third cylinder, the verification shall be repeated by the Contractor during the next production day. If the compressive determined in the second verification is also not within ±10% of the estimated compressive strength, use of the maturity method shall be discontinued until a new compressive strength-maturity relationship is developed for the mixture design by the Contractor and accepted for use by the Department.

The Contractor shall report the results of the verification to the Project Engineer and DME within 24 hours of completing the verification.

8 Concrete Batch Plants

The Department requires regular inspection of all concrete batch plants and trucks to ensure proper batching (including proper scale calibration), mixing, and transportation of concrete mixture incorporated into Department projects. Please refer to paragraph 8.2 and paragraph **Error! Reference source not found.** for additional information. Additionally, the Department is required to verify proper calibration of scales with a capacity of 10,000 pounds or more of concrete batch plants producing concrete mixture not incorporated into Department projects. Please refer to paragraph 8.3 for additional information.

8.1 Department Policy

As required by Section 75-27-19 of the Mississippi Code of 1972 as amended by House Bill 935, passed during the 1997 regular session of the Mississippi Legislature the Department is responsible for the verification of the tolerance requirement of all "weighing devices with a capacity of ten thousand (10,000) pounds or more used to weigh of road construction materials." For reference, the required tolerance is "one-half of one percent (1/2 of 1%)" with concrete included in the classification of a road construction material. To the end of complying with this law, this section describes the Department's policy and the methods of implementation of this policy. To view this amended section of the Mississippi Code of 1972, please see http://billstatus.ls.state.ms.us/documents/1997/HB/0900-0999/HB0935SG.htm.

As shown in Figure 12 through Figure 14, the following letter describes the policy adopted by the Department to comply with the law in each District through the inspection activities of the District Material Engineer.

Mississippi Department of Transportation / P.O. Box 1850 / Jackson, Mississippi 39215-1850 / Telephone (601) 359-7001 FAX (601) 359-7110

February 10, 1998

MEMORANDUM

TO: Chief Engineer
State Materials Engineer
District Engineers

FROM: State Construction Engineer

RE: Revised Interim Policy for Implementation of H.B. No. 935 Relative to MDOT Regulation of Scales

House Bill No. 935 was passed during the 1997 regular session of the Mississippi Legislature and was approved by Governor Fordice. In addition to changing the tolerance required for the calibration of scales used to weigh "road construction material", the bill also requires that MDOT regulate these scales beginning July 1, 1997. Regulation is to include the installation of truck scales.

The Department will use the National Institute for Standards and Technology (NIST) Handbook 44 for the regulation of these scales, with the exception that the tolerance for the scales shall be one-half of one percent (1/2 of 1%) instead of the tolerance noted in Handbook 44. All other specifications, tolerances and regulations required by Handbook 44 shall be applicable.

The Materials Division shall be responsible for the implementation and day to day administration of this policy.

The District Engineer, through the District Materials Engineer, will be responsible for the application of the policy and shall serve as the contact person for the Department to coordinate the calibration of the scales in the various districts.

Figure 12 - HB 935 Policy Letter, page 1

The scale repairman shall be licensed by the Department of Agriculture and Commerce(see attached list). These repairmen shall be furnished with a State map showing the Districts and the name, address and phone number of the District contact person(see attached).

Also attached is a list of scales used to weigh road construction material which have been certified by the Department of Agriculture.

Finally, included is Subsection 907-401.03.2.1.11-Truck Scales, which contains the specification requirements for truck scales used on MDOT projects.

The attached Vehicle Scale Test Report form shall be used to record the test results and indicate the action taken. The scale repairman will fill out the form and sign his/her name and record his/her license number in the space provided under Remarks and/or Instructions at the bottom of the form.

Scales used in conjunction with MDOT highway construction projects shall be checked and certified every six(6) months during the life of the project. All other scales regulated by MDOT shall be checked and certified on a yearly basis.

The MDOT will have representatives present during the calibration of scales used to weigh road construction material to be incorporated into MDOT highway construction projects. All other scales used to weigh road construction material will be, first, calibrated, tested, serviced and repaired by a scale repairman licensed by the Department of Agriculture. The District Materials Engineer shall monitor the completed report and shall initiate the appropriate action, through the District Engineer, when a report indicates unsatisfactory results. Therefore, the licensed scale repairman shall furnish a copy of the Vehicle Scale Test Report to the applicable District Materials Engineer within three 3) days after he/she repairs or services the scale. Should the scale repairman not be able to certify that the scales meet the tolerances and specifications of Handbook 44, with the exception that the tolerance be one-half of one percent(1/2 of 1%) in lieu of the tolerance specified in Handbook 44, the owner of the scale shall be given written notice by MDOT sent registered mail that he/she must stop using this scale for commercial purposes not later than five(5) calendar days after receipt of the written notice.

Figure 13 - HB 935 Policy Letter, page 2

Page 3
HBN 935
February 10, 1998

The written notice will be from the District Engineer responsible for the county in which the scales are located and will be addressed to the scale owner's local representative.

The scale can only be placed back into service in accordance with the following. The scale owner must contact the District Engineer and arrange for a licensed scale repairman, in the presence of the an MDOT representative, to make the necessary adjustments, repairs and service in order for the scale repairman to certify the scale meets the requirements of Handbook 44 with the above mentioned revised tolerance.

The Department of Agriculture and Commerce has agreed to demonstrate the proper procedure for calibrating truck scales in each District. The Districts should contact this office to arrange a time for the demonstration. The District must make the arrangements, preferably with an asphalt plant, for the Department of Agriculture to demonstrate the proper procedure to calibrate the truck scales.

Should you have any questions concerning this policy, please contact this office.

SLY/TCR:cm

Attachments

Figure 14 - HB 935 Policy Letter, page 3

8.2 Concrete Batch Plants Producing for Department Projects

For Concrete Batch Plants that currently produce or plan to produce concrete mixture for Department projects, the following are required of the Concrete Producer for approval.

8.2.1 Calibration Frequency and Requirements

Each Concrete Batch Plant shall have its scales, gages, water meters, and other measuring devices calibrated at least every 6 months.

For the calibration of the scales, it is the responsibility of the Concrete Producer to schedule a time for calibration by the licensed scale repairman at a time convenient to the DME such that the DME may be present during the calibration. The requirements and responsibilities of the licensed scale repairman are outlined in Figure 12 through Figure 14. The licensed scale repairman shall complete form TMD-736 and submit it to the DME within 3 days of the calibration.

8.2.2 Inspection Frequency and Requirements

Concrete Batch Plants shall be inspected by an National Ready Mix Concrete Association (NRMCA) approved inspector utilizing the NRMCA QC-3 Checklist as required in paragraph **Error! Reference source not found.** at least every 2 years. It is the responsibility of the Concrete Producer to schedule a time for inspection by the professional engineer convenient to the DME such that the DME may be present during the inspection.

Within 7 days of the inspection by the professional engineer the Concrete Producer shall submit to the DME documentation proving the satisfactory inspection of the Concrete Batch Plant in accordance with the requirements of paragraph **Error! Reference source not found.**.

8.2.3 Concrete Batch Plant Approval

If all the requirements in paragraph 8.2.1 and paragraph 8.2.2 are met, the DME will approve the Concrete Batch Plant for producing concrete mixture for Department projects.

8.2.4 Concrete Batch Plant Deficiencies

If deficiencies of the Concrete Batch Plant are noted at any time, the DME or Engineer should notify in writing the plant outlining the deficiencies. If deficiencies are not corrected within a two-week period, the batch plant will be placed on probation. If after an additional two-week period the deficiencies have not been corrected, certification of the batch plant can be revoked.

8.2.5 Non-Satisfactory Concrete Batch Plants

Concrete Batch Plants which do not meet the requirements in paragraph 8.2.1 and paragraph 8.2.2 shall not be approved and shall not produce concrete for Department projects.

The DME should notify the Concrete Batch Plant in writing of any deficiencies which have prevented its approval.

8.2.6 Trucks

Only trucks meeting all the requirements of paragraph **Error! Reference source not found.** shall be used to transport concrete mixture. Trucks meeting these requirements shall be identified by a having the following Department-provided sticker on the driver-side door. The expiration date shall be 14 months after the date of inspection of the individual truck.

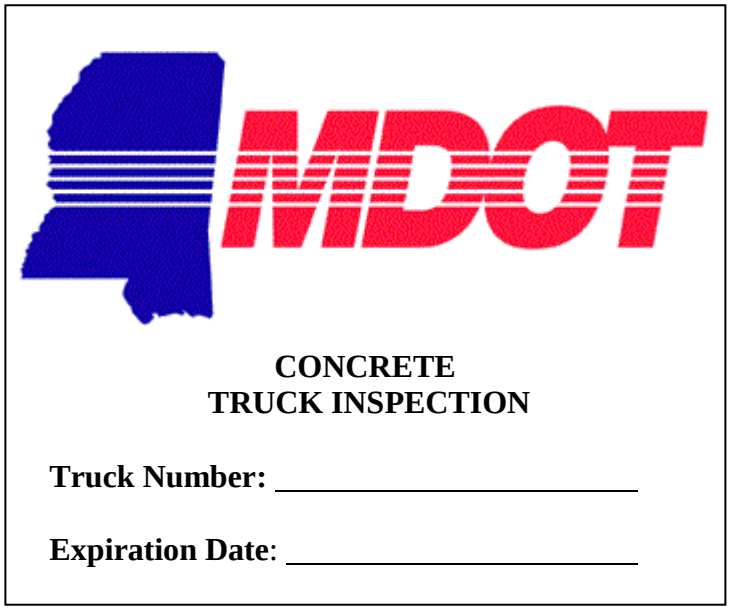


Figure 15 - Concrete Truck Inspection Sticker

8.2.7 Concrete Producer Responsibilities

The Concrete Producer shall comply with the following:

1 Make all parts of the Concrete Batch Plant and material storage accessible to authorized Department personnel.
2 Provide adequate and acceptable working facilities for Department personnel.
3 Supply such materials as necessary for testing purposes.
4 Purchase all cementitious materials from MDOT approved sources.
4.1 Obtain a copy of the accompanying Mill Test Report and Certificate "A" or "B" for cement and certificates of compliance for pozzolans (as applicable) for each shipment of cementitious materials and make these available to Department personnel upon request.
4.2 Not use different brands or types of cementitious materials or cementitious materials of the same brand from different sources without written permission from the Project Engineer.
5 Obtain copies of certification on each shipment of admixture, when used.
6 Assume, in conjunction with the Contractor, responsibility for the quality of concrete mixture produced.
7 Obtain the services of a licensed scale repairman as required by the specifications at the frequency required in paragraph 8.2.1.
8 Notify Project or District personnel as far in advance as possible of the beginning of production of concrete mixture for Department work.
9 Obtain all aggregates for Department work from sources approved by the Department. The plant shall conform to the requirements of Section 1.1.4 of this manual. A change of aggregate will require a new mix design.
10 Employ certified technicians and competent personnel to operate the plant and provide adequate quality control.

8.2.8 Department Responsibilities

The following are the responsibilities of the DME:

1 Be present during the calibration by the licensed scale repairman in paragraph 8.2.1.
2 Attach the Department's Concrete Truck Inspection sticker to the driverside door after the truck has been inspected in accordance with the requirements of paragraph **Error! Reference source not found.**.
3 Obtain and submit to the Materials Division a sample of water at the initial inspection and then one sample every 12 months.
4 Complete and submit to the Materials Division a copy of the form TMD-324 Inspection Report of Concrete Batch Plants for inclusion of the Concrete Batch Plant into the APL.
5 Keep a copy of each form TMD-324 and form TMD-736 on file.
6 Keep a copy of the current valid National Ready Mix Concrete Association (NRMCA) QC-3 Checklist.

The following are the responsibilities of the Materials Division:

1 Enter the Concrete Batch Plant inspection and calibration dates into SiteManager in order to update the APL with the currently approved Concrete Batch Plants.

8.3 Concrete Batch Plants NOT Producing for Department Projects

8.3.1 Calibration Frequency

Each Concrete Batch Plant shall have its scales, gages, water meters, and other measuring devices calibrated at least every 12 months.

For the calibration of the scales, it is the responsibility of the Concrete Producer to schedule a time for calibration by a licensed scale repairman at a time convenient to the DME such that the DME may be present during the calibration. The requirements and responsibilities of a licensed scale repairman are outlined in Figure 12 through Figure 14. The licensed scale repairman shall complete form TMD-736 and submit it to the DME within 3 days of the calibration.

8.3.2 Department Inspection Requirements

There are no inspection requirements for Concrete Batch Plants NOT producing concrete mixture for Department projects.

8.3.3 Concrete Batch Plant Approval

If all the requirements in paragraph 8.3.1 are met, the DME will approve the Batch Plant.

8.3.4 Trucks

There are no requirements for trucks used to transport concrete mixture NOT used for Department projects.

8.4 The NRMCA Checklist

Prior to production of concrete mixture for Department projects, a completed National Ready Mix Concrete Association (NRMCA) QC-3 Checklist (or "Checklist") meeting the acceptance criteria of paragraph **Error! Reference source not found.** shall be submitted by the Concrete Producer for each Concrete Batch Plant to be used to produce concrete mixture on Department projects. The Concrete Producer shall submit the Checklist to the DME during the initial inspection of the scales. The DME will review the checklist and ensure that requirements of the specifications are met.

Certification of the Concrete Batch Plant and delivery vehicles by NRMCA is not required by the Department. Specifically, a Concrete Producer is not required by the Department to submit the completed Checklist to NRMCA for certification of the Concrete Batch Plant and delivery vehicles by NRMCA; only the completion of the Checklist is required for approval by the Department. If there are differences between the requirements of the Checklist and the requirements of *Concrete Field Manual*, the requirements of *Concrete Field Manual* supersede the requirements of the Checklist.

Copies of the Checklist may be obtained from NRMCA's website at the following address: http://nrmca.org/products/certification/plantandtruck.asp.

8.4.1 Requirements for the Batch Plant Inspector

The Batch Plant Inspector shall be approved by NRMCA to inspect Concrete Batch Plants. The inspector shall be either a professional engineer (or "engineer"[1]) who is approved by NRMCA or an assistant approved by

[1] For the sake of completing the Checklist, the professional engineer performing the inspection shall be referred to as the "engineer" beginning with lower case "*e*." This is not be confused with the "Engineer," beginning with upper case "*E*," and being employed by the Department with the responsibility of acting as the Department's agent. Other direct references to specific language quoted from

NRMCA and employed by the NRMCA approved engineer. For additional qualifications and requirements for the engineer and the assistant to the engineer, please refer to Section 10 of the Checklist.

8.4.2 Acceptance Requirements for the NRMCA QC-3 Checklist

The DME will review the Checklist and Inspection and Certification of Delivery Vehicles checklist, if used, to ensure the following requirements are met:

1 The front cover of the Checklist shall be complete in the box titled "**ENGINEER – PLEASE COMPLETE (PRINT)**." On the line titled "(Plant Name, Example: "Plant No. 2")", the Department's concrete batch plant designation shall be listed, unless a designation has not yet been assigned, as in the case of a new concrete batch plant. Any additional plant identification information may also be listed on this line. The additional information required in the box shall be listed. If any information required in this box is blank or incomplete, the Checklist shall not be acceptable.

2 Each page shall be initialed with the engineer's initials. If the Checklist has any pages without the engineer's initials, the Checklist shall not be acceptable.

3 If any box is either incomplete or marked with "F," the Checklist shall not be acceptable.

4 In Section 1, "Material Storage and Handling," all boxes shall be marked with a check mark. The only exception to this requirement is for concrete batch plants **not** seeking certification to supply concrete mixture during subfreezing weather. For these concrete batch plants, "N" is acceptable.

5 In Section 2, "Batching Equipment" the following is required:

5.1 In Subsection "Scales," the applicable boxes for the concrete batch plant shall be marked with a check mark, with boxes for alternate options marked with "N." For projects where the total concrete volume on the project is 1,000 cubic yards or more, the following are required for approval for producing concrete mixture:

- all boxes under "Digital-Indicating Scales" shall be marked with a check mark
- all boxes for "Beam-Indicating Scales" and "Dial-Indicating Scales" shall be marked with "N".

5.2 In Subsection "Weigh Batchers," all boxes shall be marked with a check mark.

5.3 In Subsection "Volumetric Batching Devices for Water," all boxes shall be marked with a check mark under "Water Meters." All boxes under "Volumetric Tank Water Batchers" shall be marked with "N."

5.4 In Subsection "Dispensers for Liquid Admixtures," all boxes shall be marked with a check mark.

5.5 In Subsection "Accuracy of Plant Batching," all boxes shall be marked with a check mark.

5.6 In Subsection "Batching Systems," the applicable box under *System Requirements* for the concrete batch plant shall be marked with a check mark, with boxes for other type of systems marked with "N." For projects where the total concrete volume on the project is 1,000 cubic yards or more, only concrete batch plants with either "Semi-Automatic System" or "Automatic System" marked with a check mark shall be approved for producing concrete mixture.

5.7 In Subsection "Recorders" all boxes shall be marked with a check mark except those boxes for Graphical Recorders. The boxes for Graphical Recorders shall be marked with "N."

6 In Section 3, "Central Mixer" for concrete batch plants operating as a Central Mixing type, all boxes shall be marked with a check mark. If the concrete batch plant is not of the Central Mixing type, all boxes shall be marked with "N."

7 In Section 4, "Ticketing System", all boxes shall be marked with a check mark. Additionally, the requirements for information on a delivery ticket (or, "batch ticket") shall comply with the requirements of Subsection 804.02.12.3.

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the Checklist referring the "Engineer" (as on the front page of the Checklist) shall also be understood to mean the professional engineer performing the inspection and not the Department's Engineer.

8 In Section 5, “Delivery Fleet Inspection,” shall be completed by the either engineer or the assistant.

All boxes of either “Option A – Delivery Fleet Inspection by the Company” or “Option B – Delivery Fleet Inspection by the Inspecting Engineer” shall be marked with a check mark. For the non-exercised option, all boxes shall be marked with “N.”

If Option A is exercised, a record of Subsection “Inspection Record of Delivery Fleet (for Option A in Section 5)” shall be completed for every truck. All blanks under only one of the following truck types shall be marked with a check: “Truck Mixer,” “Agitators,” or “Non-agitating Units.” For the two other non-applicable truck types, each blank shall be marked with “N.” Each record shall be signed and dated as required by the assistant and a company official representing the concrete producer.

Additionally, Subsection “Summary of Fleet Condition,” shall be completed for all trucks associated with the Batch Plant. Each truck listed on the summary page shall have all the information required in each box including a check mark in the appropriate box. Neither “N” nor “F” is acceptable.

Any truck not meeting these requirements shall be rejected and may not be used in any phase of the production or transportation of concrete used on Department projects.

The information in Subsections “Inspection Record of Delivery Fleet (for Option A in Section 5)” and “Summary of Fleet Condition” may be summarized differently, provided the all the required information is included and the modified summary meets the satisfaction of the DME.

9 In Section 6, “Verification of Inspection and Application for Certificate” shall be completed by the engineer.

The applicable box under “General” shall be marked with a check box indicating the concrete batch plant’s type of operation. The other boxes under “General” shall be marked with “N.”

The applicable box under “Batching System” shall be marked with a check box indicating the concrete batch plant’s type of batching. For projects where the total concrete volume on the project is 1,000 cubic yards or more, only concrete batch plants with all boxes under either, “Semi-Automatic” or “Automatic” batching systems, with the other boxes marked with “N” shall be approved to produce concrete mixture.

The applicable box under “Recording” shall be marked with a check mark. For projects where the total concrete volume on the project is 1,000 cubic yards or more, only concrete batch plants with all boxes marked with a check mark shall be approved to produce concrete mixture.

10 In Section 7, “Agreement to Regularly Verify Accuracy of Scales, Volumetric Batching Devices and Dispensers, and if used, Devices for Automated Aggregate Moisture Measurement” shall be completed and signed by a company official representing the concrete producer.

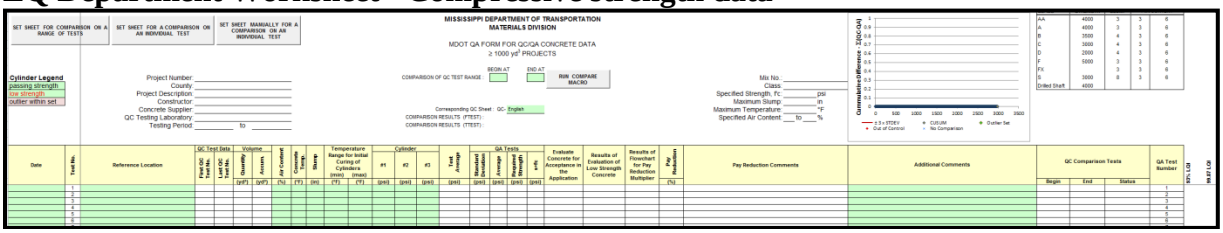
11 If the inspection of the Concrete Batch Plant and Checklist have been completed within the last two years, approved the Concrete Batch Plant Checklist will be acceptable for the remainder of the two years for producing concrete mixture for Department projects, and shall be completed every two years thereafter to maintain approval for producing concrete mixture for Department projects.

Appendix A COMPARE Excel Workbooks User Guide

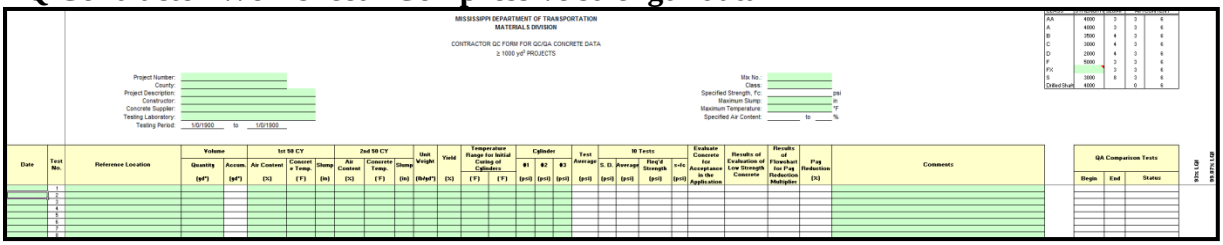
A.1 The Department's COMPARE Excel workbooks - LQ Projects

Below are screen shots of the Contractor and Department worksheets in the English CONCRETE COMPARE workbook for LQ projects. These show the entire working width portions of each worksheet. The workbooks and worksheets for the Metric version are nearly identical.

LQ Department Worksheet - Compressive strength data



LQ Contractor Worksheet - Compressive strength data



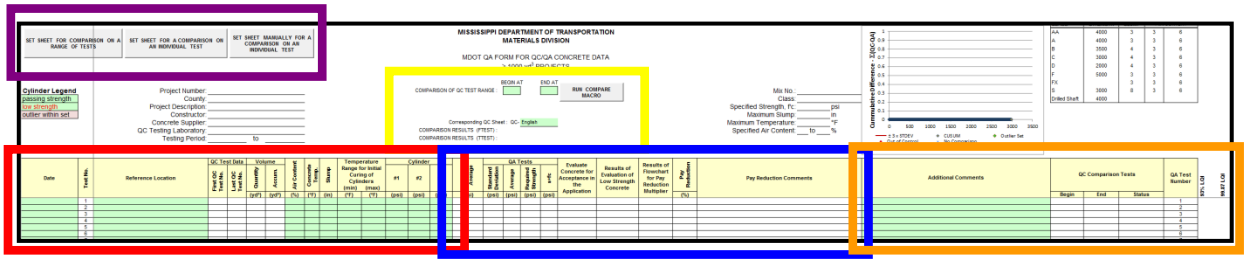
A.1.1 Cells in Light Green vs. Cells in White

For the LQ worksheets, cells in light green are places for user input. Cells in white are used by the worksheets and no user input is required for these fields.

A.1.2 BLANK

A.1.3 LQ QA Worksheet

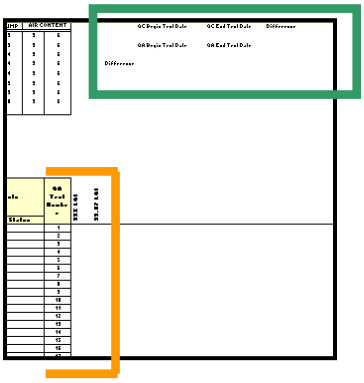
The LQ Department Worksheet has three data entry/analysis areas. In the red box is the main Data Entry area; in the blue is the Data Analysis and summary area; in the orange is the Additional Information area.



The other three areas are for performing the statistical comparison between Contractor data and Department data or to perform trouble-shooting. In the purple box are three buttons used to set the sheet for one of three levels of automation for performing the comparison between Contractor data and Department data; in the yellow box are fields used to set the ranges of

sample Test Numbers for comparison between Contractor data and Department data, the results of a comparison, and two fields for error messages; in the green box is an area used for trouble-shooting.

For information for cells not covered in one of the boxes above (like the Project Number cell) see paragraph A.1.14.



A.1.4 LQ Department Worksheet - Data Entry area

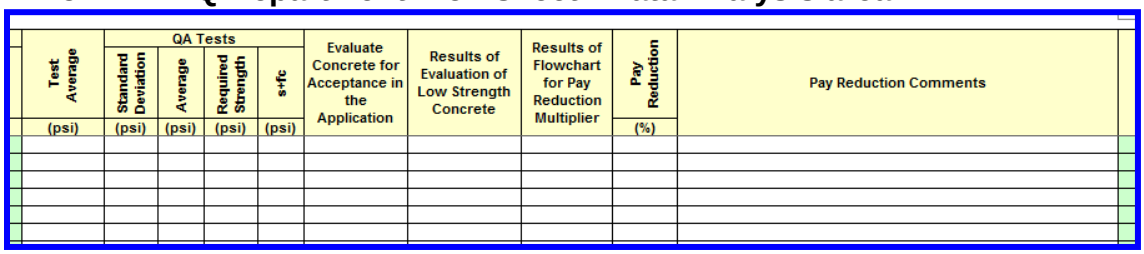
Date	Test No.	Reference Location	QC Test Data		Volume		Air Content	Concrete Temp.	Slump	Temperature Range for Initial Curing of Cylinders		Cylinder		
			First QC Test No.	Last QC Test No.	Quantity	Accum.				(min)	(max)	#1	#2	#3
					(yd^3)	(yd^3)	(%)	(°F)	(in)	(°F)	(°F)	(psi)	(psi)	(psi)
	1													
	2													
	3													
	4													
	5													
	6													

The Data Entry area is where all the data for each set of compressive strength cylinders (i.e., each sample) is input using the following as either a description of the column or a guide for the information required in each column:

- *Date* – entry field. In chronological order, enter the date the cylinders for the Department sample were cast.
- *Test No.* – not an entry field. This is a number by which the cylinders in the Department sample are referenced in the comparison analysis.
- *Reference Location* – entry field. Enter information required to identify the location of the concrete placed from which the cylinders for the Department sample were cast.
- *QC Test Data* – This is the range of tests on the Contractor worksheet represented by the specific Department test. Please refer to paragraph 5.2.2.9 for additional information.
    - *First QC Test No.* – not an entry field. This is the *Test No.* of a Contractor sample on the Contractor worksheet. The criterion for what determines which Contractor sample corresponds with the current Department sample is that the dates are equal. This *Test No.* for the Contractor sample is automatically determined by Excel using the date field of a specific Department sample on the Department worksheet to "find" the sample on the Contractor worksheet made on the same day as the Contractor sample.
    - *Last QC Test No.* – not an entry field. This is the *Test No.* of a Contractor sample on the Contractor worksheet. This number is automatically determined by Excel using the date field on the Department worksheet to "find" the last applicable sample on the Contractor worksheet which is represented by the Department sample.
- *Volume*
    - *Quantity* – not an entry field. This the quantity of concrete represented by the Department sample. This number is automatically determined by Excel as the sum of the concrete quantities represented by the range of corresponding Contractor Test No. determined by the *First QC Test No.* and the *Last QC Test No.*
    - *Accum.* – not an entry field. This is the accumulated volume of concrete placed to date.
- *Air Content* – entry field. Enter the total percent air content measured in the sample of concrete used to cast the cylinders.
- *Concrete Temp.* – entry field. Enter the temperature measured from the sample of concrete used to cast the cylinders for the Department sample.
- *Slump* – entry field. Enter the slump measure from the sample of concrete used to cast the cylinders.

- *Temperature Range for Initial Curing of Cylinders* – entry fields. Enter the minimum and maximum temperatures experienced by the cylinders for the Department sample during the period of initial curing in the field.
- *Cylinder* – entry field. Enter the compressive strength of each cylinder in the Department sample.

A.1.5 LQ Department Worksheet - Data Analysis area



Test Average	QA Tests				Evaluate Concrete for Acceptance in the Application	Results of Evaluation of Low Strength Concrete	Results of Flowchart for Pay Reduction Multiplier	Pay Reduction	Pay Reduction Comments
	Standard Deviation	Average	Required Strength	s+fc					
(psi)	(psi)	(psi)	(psi)	(psi)				(%)	

The Data Analysis area is where calculations are performed by Excel to summarize the information from the Data Entry area and evaluate the data for compliance with the specification requirements. The following is a description of the information for each column:

- *Test Average* – not an entry field. This is the average compressive strength for the cylinders in a Department sample. This average is automatically calculated by Excel and takes into account the consideration required if the strength result of one cylinder is greater than acceptable range of the cylinders tested. The test results of the cylinder that is greater than the acceptable range is considered to be an "outlier" and not used to calculate the average compressive strength and subsequently related calculations. The acceptable range is based on AASHTO T 22 precision and bias statements. Additionally, it takes into account the requirements for rounding test results to the nearest 10 psi. In Subsection 804.02.10.1.1, the test average of a Department sample is symbolized by X_i.

  For the COMPARE macro to properly work there can be no blank cells in this column in a Test Lot on which a comparison is performed.

A blank cell in this column indicates that for the Test No. in question either the compressive strength data has not yet been input in the Cylinder column or only plastic tests were performed for the Test No. If the compressive strength data has not yet been input, do not perform a comparison on this Test No. or any Test Lot which would include it.

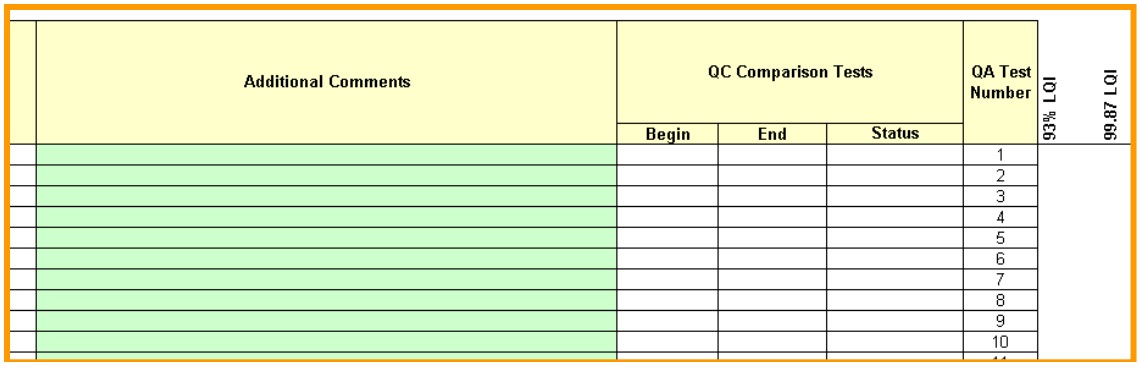
- *QA Tests*
    - *Standard Deviation* – not an entry field. This is the standard deviation of the compressive strengths of all the Department samples in the Department Test Lot for which the current Department sample is the first sample. This is calculated by the COMPARE macro which performs the comparison between the Contractor and Department data. In Subsection 804.02.10.1.1, the standard deviation of a Department Test Lot is symbolized by *s*.
      Average – not an entry field. This is the running average compressive strength for all the Department samples in the Department Test Lot for which the current Department sample is the first sample. This is calculated by the COMPARE macro which performs the comparison between the Contractor and Department data. In Subsection 804.02.10.1.1, the average compressive strength of a Department Test Lot is symbolized by $\overline{X}$.
    - *Required Strength* – not an entry field. This is the minimum average compressive strength required for the Department Test Lot for which the Department sample is the first sample. It is designated the *Required Average Strength*. This is automatically calculated by Excel after the COMPARE macro calculates the standard deviation of the Department Test Lot. In Subsection 804.02.10.1.1, the required average compressive strength of a Department Test Lot is symbolized by f'_{cr}.
    - *s+fc* – not an entry field. This is the sum of the standard deviation (*s*) and the allowable design stress (f_c). This is automatically calculated by Excel after the COMPARE macro calculates the standard deviation of the Department Test Lot. Allowable design stress is 40% of the Specified Compressive Strength (f'_c).
- *Evaluate Concrete for Acceptance in the Application* – not an entry field. This is a guide for assisting in the two step analysis of 1) the comparison between the Contractor test data and the Department test data and 2) the result of comparing the Test Average for the current Department sample to the Specified Compressive Strength. This is automatically calculated by Excel after the COMPARE macro calculates the standard deviation of the Department Test Lot.

  Step 1: In accordance with Subsection 804.02.13, if the results of the Contractor test results are comparative to the results of the Department test results, the Contractor test results are used as the basis for acceptance of the concrete. This field is then left blank showing no additional action required on the Department sheet. However, if the results of the QC test results are not comparative to the results of the Department test results then the Department test results are used as the basis for acceptance of the concrete. This leads to Step 2.

Step 2: If the Test Average of the current Department sample is above the Specified Compressive Strength, then no additional action is required. This field is then left blank showing no additional action required. However, if the Test Average of the current Department sample is below the Specified Compressive Strength then, in accordance with Subsection 804.0213.1.5, the Contractor may elect to remove and replace the concrete. If the Contractor elects to not remove the concrete, an evaluation by the Department as to the adequacy for the use intended is required. If the Test Average of the current Department sample is below the Specified Compressive Strength, this field gives a recommendation to give additional analysis of the test results. It works in conjunction with the results in the field under *Results of Evaluation of Low Strength Concrete* to recommend a percentage of pay reduction, if required.

- *Results of Evaluation of Low Strength Concrete* – entry field. This is the field to record the disposition of concrete represented by the current Department sample with a compressive strength below the Specified Compressive Strength. For concrete with a compressive strength below the Specified Compressive Strength, if the statistical analysis determines there is not a comparison between QC and QA the color of this field turns green to indicate than an entry is required. If the evaluation of the low-strength concrete by the Department shows that the concrete is not adequate for the intended use such that it is removed and replaced, choose "Remove/Replace." No pay reduction is applied as the concrete represented by this sample will be replaced to the satisfaction of the Department and no further action is required with respect to this test. If the evaluation of the low-strength concrete by the Department shows that the concrete is adequate for the intended use such that it may remain in place, choose "Stay in place." Based on the selection of "Stay in place," the results for the current Department sample are analyzed for the criteria in Subsection 804.02.13.1.5 and a pay reduction is applied as required.
- *Results of Flowchart for Pay Reduction Multiplier* – entry field. This is the field to record the results of an investigation into a sample with a compressive strength below the Specified Compressive Strength following the *Pay Reduction Multiplier Determination Flowchart* in Figure 3 and Figure 4. For concrete with a compressive strength below the Specified Compressive Strength, if the statistical analysis determines there is not a comparison between QC and QA the color of this field turns green to indicate than an entry is required.
- *Pay Reduction* – not an entry field. This is a guide for a pay reduction for the current Department sample for concrete with a compressive strength below the Specified Compressive Strength.
- *Pay Reduction Comments* – not an entry field. This is a guide for the application of a pay reduction for the current Department sample. If there is a pay reduction for concrete in a Contractor sample represented by the current Department sample, this field gives direction to review the Contractor worksheet. Additionally, if there is a discrepancy between the date the Department sample was cast and the Contractor sample, this field gives a note to correct the discrepancy.

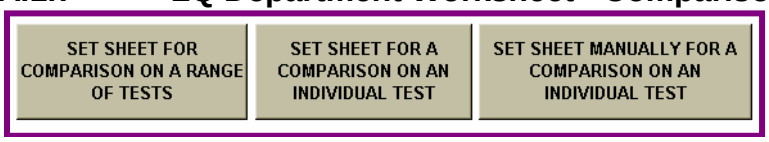
A.1.6 LQ Department Worksheet - Additional Information area



	Additional Comments	QC Comparison Tests			QA Test Number	93% LQI	99.87 LQI
		Begin	End	Status			
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					10		

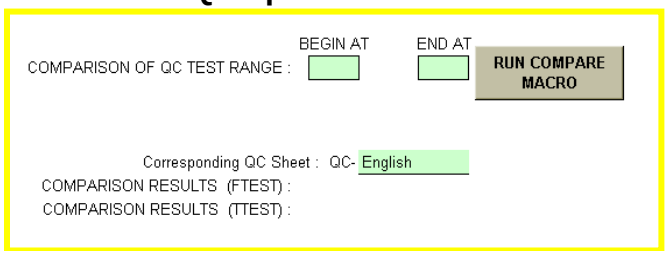
The Additional Information area is where Additional Comments may be made by the user concerning a sample. Also, this area has several fields which indicate the corresponding range of Contractor Test data used during the statistical evaluation and the values for each of the Lower Quality Indexes (LQI) used to ensure 93% of the compressive strengths are above f'_c and 99.87% of the compressive strengths are above f_c.

A.1.7 LQ Department Worksheet - Comparison Automation Setup area



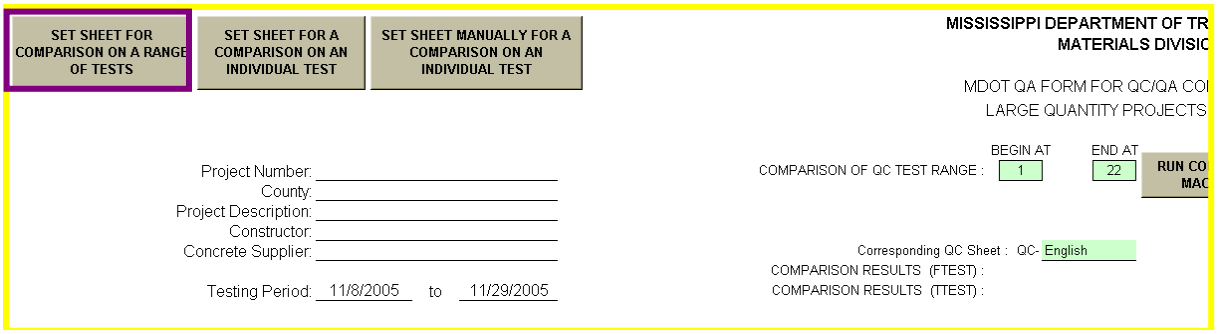
and

A.1.8 LQ Department Worksheet - Comparison Range Setup



The Comparison Automation Setup area contains three buttons used to set the worksheet for one of three levels of automation for performing the comparison between Contractor data and Department data. Depending on the level of automation chosen, the fields in the yellow Comparison Range Setup area change between light green and white indicating different inputs are required in order to perform a comparison between Contractor data and Department data. These different levels of automation give the user three options for how much he desires to control the comparison process. Typically the highest level of automation should be chosen using the *Set Sheet for Comparison on a Range of Tests* button, unless it is determined during the comparison process that additional user input or evaluation is required. Examples of additional required user input or evaluation are described in paragraph A.1.9.

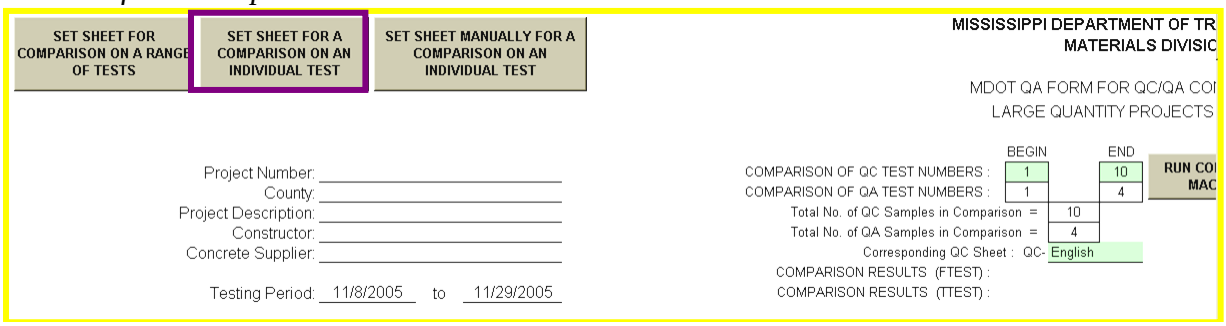
Set Sheet for Comparison on a Range of Tests



The button on the left is used to set the worksheet for the highest level of automation for performing the comparison between Contractor data and Department data for a range of tests. Selecting this option allows the user to select a beginning QC Test No. and ending QC Test No. for any range of Contractor Tests on which it is desired to perform a comparison with the corresponding Department Tests. Only the beginning QC Test No. and the ending QC Test No. are required as inputs. Based on the range selected for the beginning and ending QC Test Nos., the range of corresponding Department Tests is automatically selected as the COMPARE macro cycles through the Contractor Test Lots. The Comparison Range Setup area changes the inputs to those shown above in the LQ QA Comparison Range Setup area.

For example, in the screenshot above the range of Contractor Tests selected for comparison is QC Test 1 to QC Test 22. This range of Contractor Tests contains 13 Contractor Test Lots (1-10, 2-11, 3-12,…11-20, 12-21, and 13-22). Clicking the *Run Compare Macro* button will start the comparison process which automatically cycles through all the comparison ranges for the range of QC Tests selected. The COMPARE macro will stop when it has completed the comparisons on the selected range or if an error occurs which requires additional user input. See the Trouble-Shooting area below and the comparison examples in paragraph A.1.9.

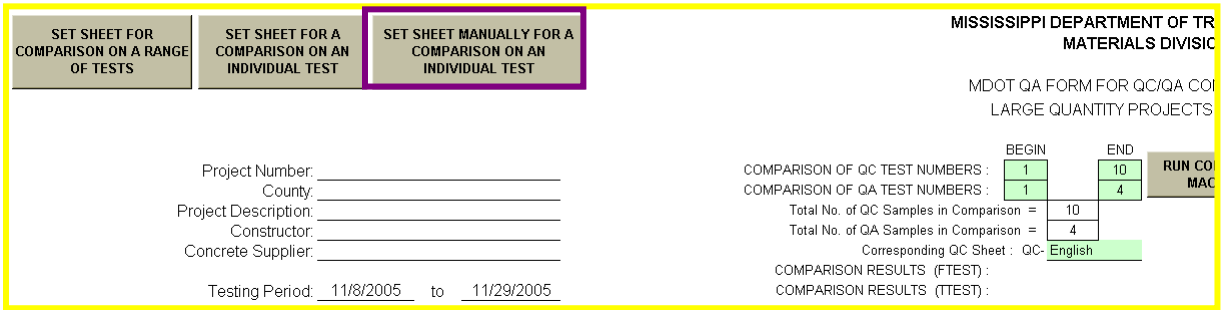
Set Sheet for a Comparison on an Individual Test



The button in the middle is used to set the worksheet for performing the comparison between Contractor data and Department data for a single, specific Contractor Test Lot. Selecting this option allows the user to select a specific Contractor Test Lot on which it is desired to perform a comparison with the corresponding Department Test Lot. This is accomplished by selecting the first QC Test No. in the desired Contractor Test Lot. Only the beginning QC Test No. of the specific Contractor Test Lot is required as an input. Based on the QC Test No. selected as the beginning of the Contractor Test Lot, the ending QC Test No. and the range of corresponding QA Tests Nos. are automatically selected.

For example, in the screenshot above the range of Contractor Tests selected for comparison is QC Test 1 to QC Test 10. By selecting QC Test No. 1 as the beginning, the ending QC Test No. is automatically selected (as being nine more than the beginning QC Test No. such that there is a Contractor Test Lot with 10 samples). Additionally, the corresponding QA beginning (1) and ending (4) Test Nos. are also automatically selected to correspond with the dates for the QC Test Lot. Clicking the *Run Compare Macro* button will start the comparison process for the single, specific Test Lot. To run a comparison on another Contractor Test Lot, enter a different QC Test No. in the beginning field for *Comparison of QC Test Numbers*. A new range of QC and QA Test Nos. is automatically selected. Click the *Run Compare Macro* button to start the comparison process for the single, specific Test Lot.

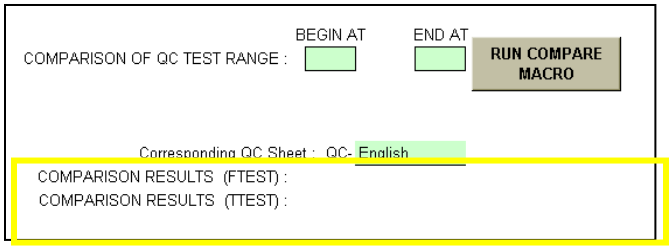
Set Sheet Manually for a Comparison on an Individual Test



The button on the right is used to manually set the worksheet for performing the comparison between Contractor data and Department data. This button should be used least of the three options as it is primarily used for trouble shooting when use of the other two buttons generates one of the errors listed in paragraph A.1.9. There is no automation for setting an ending QC Test No. or corresponding Department Test Lot. The user must select all four Test Nos. on which to run a comparison. The selected tests on which to perform a comparison are completely up to the user's discretion and must be carefully selected. Through the use of this button it is possible to perform a comparison between illegitimate ranges for the comparison of Contractor and Department data.

For example, in the screenshot above the range of Contractor Tests selected for comparison is QC Test 1 to QC Test 10. Additionally, the range of Department Tests corresponding to the selected Contractor Tests by date (as discussed in paragraph 5.2.2.9 and paragraph 5.2.2.11) were selected for the comparison. Clicking the *Run Compare Macro* button will start the comparison process for the single, specific Test Lot. To run a comparison on another Test Lot, enter a different range QC Test Nos. in the beginning and ending fields for *Comparison of QC Test Numbers* and a different range QA Test Nos. in the beginning and ending fields for *Comparison of QA Test Numbers*. Click the *Run Compare Macro* button to start the comparison process for the single, specific Test Lot.

A.1.9 LQ Department Worksheet - Results Messages and Error Messages area

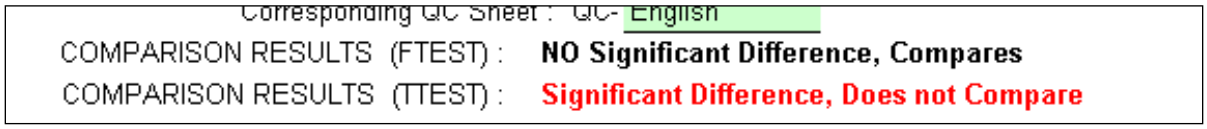


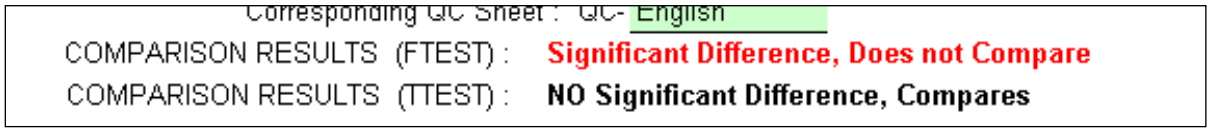
The QA Results Message area is where the results from performing the current comparison are shown (next to *Comparison Results*) along with any Error Messages (as applicable).

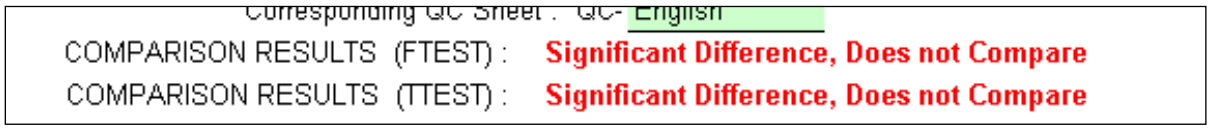
There are two possible results from performing a comparison:

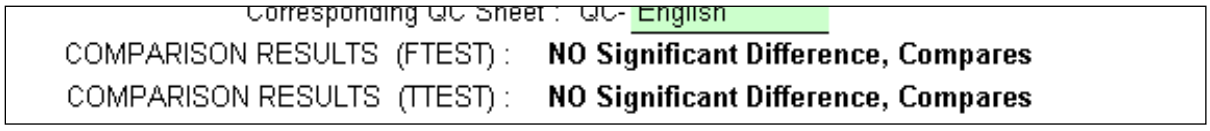
- *NO Significant Difference, Compares*
- *Significant Difference, Does not Compare*

Based on the data being compared, either of these results can be returned for the f-test and/or the t-test as shown in the following screenshots.









*Only when the results from the comparison with **both** the f-test and the t-test showing that the Contractor and Department Test Lots compare are the Contractor's test results used for acceptance or if required, reductions in pay.*

For the two automated methods of selecting the range of tests on which to perform a comparison (i.e., using the *left button* and the *middle button*), if an error is detected prior to running the COMPARE macro or during the comparison, the applicable error message is shown and the comparison process stops. This allows the user to determine the cause of the error and make adjustments to the data or selected range for comparison, if necessary, or select the manual method for comparison (i.e., the *right button*).

If the sheet is set manually to perform a comparison on an individual test, the comparison process does not stop.

The possible error messages are:

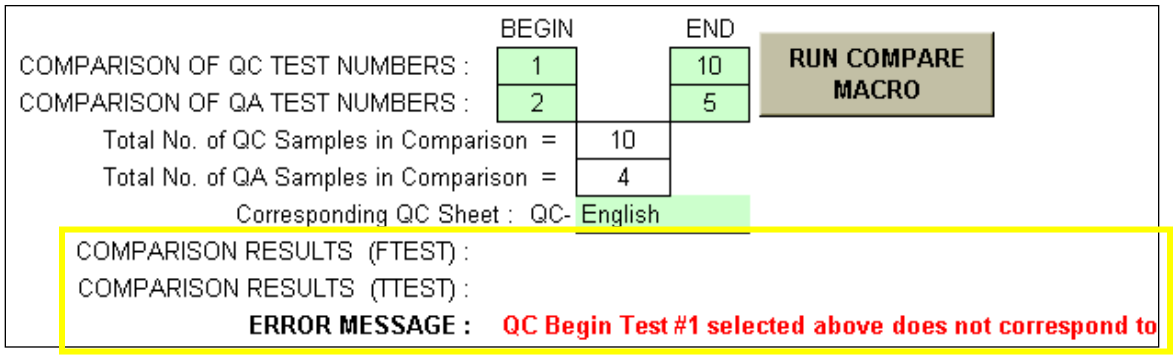
Prior to running the COMPARE macro

1. QC Begin Test #*X* selected above does not correspond to the QA Begin Test #*Y*. The range of QC Tests corresponding to QA Test #*Y* is QC Test #*A* to # *C*. The QA Begin Test or the QC Begin Test MAY need to be revised.
2. QC End Test #*X* selected above does not correspond to the QA End Test #*Y*. The range of QC Tests corresponding to QA Test #*Y* is QC Test #*A* to #*B*. The QA Begin Test or the QC Begin Test MAY need to be revised.
3. QC Data MAY be too spread for accurate comparison.
4. QA Data MAY be too spread for accurate comparison.
5. QC and QA BEGIN and END test dates MAY be too spread for accurate comparison.
6. QC and QA BEGIN test dates MAY be too spread for accurate comparison.
7. QC and QA END test dates MAY be too spread for accurate comparison.

During running the COMPARE macro

8. No QC start specified.
9. No QA start specified.
10. No QC end specified.
11. No QA end specified.
12. Warning: standard deviation for data B is 0

An example of one of these is shown below:



Explanations of each of these error messages listed below:

1. QC Begin Test #1 selected above does not correspond to the QA Begin Test #2. The range of QC Tests corresponding to QA Test #2 is QC Test #4 to # 9. The QA Begin Test or the QC Begin Test MAY need to be revised.

   Message 1 indicates that the QC Test No. selected for the beginning test does not fall within the corresponding range of QA Tests for the beginning QA Test No.

   In this example of an error message, the QC Test Lot selected is QC Test No. 1 to QC Test No. 10; the QA Test Lot selected is QA Test No. 2 to QC Test No. 5. But in looking at the figure below we see that the Contractor Tests corresponding to QA Test No. 2 is QC Tests 4 to 9, not QC Test No. 1, as listed. The reason for this is QC Test No. 4 was taken on the same day as QA Test No. 2. Unless there is a specific reason for not having

the Contractor Test Lot and Department Test Lot corresponding to each other, this should be changed.

Date	Test No.	Reference Location	QC Test Data		
			First QC Test No.	Last QC Test No.	
11/8/2005	1		1	3	
11/11/2005	2		4	9	
11/17/2005	3		10	11	
11/19/2005	4		12	12	
11/20/2005	5		13	15	
11/23/2005	6		16	18	
11/26/2005	7		19	21	
11/29/2005	8		22	22	
	9				

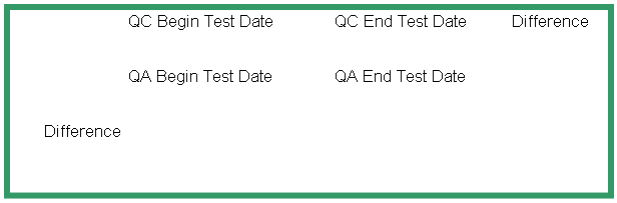
2. QC End Test #*X* selected above does not correspond to the QA End Test #*Y*. The range of QC Tests corresponding to QA Test #*Y* is QC Test #*A* to #*B*. The QA Begin Test or the QC Begin Test MAY need to be revised.

   Similar to Message 1 above, Message 2 indicates that the QC Test No. selected for the ending test does not fall within the corresponding range of Department Tests for the ending QA Test No.

3. QC Data MAY be too spread for accurate comparison.
4. QA Data MAY be too spread for accurate comparison.
5. QC and QA BEGIN and END test dates MAY be too spread for accurate comparison.
6. QC and QA BEGIN test dates MAY be too spread for accurate comparison.
7. QC and QA END test dates MAY be too spread for accurate comparison.

   Messages 3-7 are all similar in that they warn the user if the date ranges for the selected Contractor and Department Test Lots exceed 90 days. The thinking is that evaluating a Test Lot with cylinders in it that were made more than 90 days apart may not be the best evaluation. In order to batch concrete with consistent plastic properties throughout seasonal variations (resulting in varying water demand of the plastic concrete), slight and allowable changes in certain proportions are typically made to a mixture which may affect the compressive strength.

   The calculations for determining if the Contractor and Department Test Lot date ranges exceed 90 days is shown below in the green box.



8. No QC start specified.
9. No QA start specified.
10. No QC end specified.
11. No QA end specified.

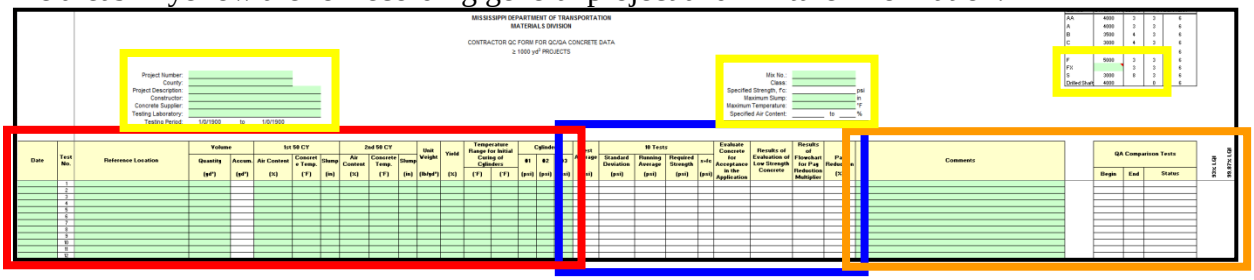
    Messages 8-11 are all similar in that they warn the user of missing information required to establish the Contractor or Department Test Lots.

12. Warning: standard deviation for data B is 0

    Message 12 only occurs if the standard deviation for a Test Lot is 0, which should be never.

A.1.10 LQ Contractor Worksheet - Compressive strength data

The LQ Contractor Worksheet for compressive strength data is similar to the LQ Department Worksheet, but less complex. Like the LQ Department Worksheet for compressive strength data, it also has three data entry/analysis areas. In the red box is the main Data Entry area; in the blue is the Data Analysis and summary area, in the orange is the Additional Information area. The areas in yellow are for recording general project and mixture information.



A.1.11 LQ Contractor Worksheet - Data Entry area

Date	Test No.	Reference Location	Volume		1st 50 CY			2nd 50 CY			Unit Weight	Yield	Temperature Range for Initial Curing of Cylinders		Cylinder		
			Quantity (yd^3)	Accum. (yd^3)	Air Content (%)	Concrete Temp. (°F)	Slump (in)	Air Content (%)	Concrete Temp. (°F)	Slump (in)	(lb/yd^3)	(%)	(min) (°F)	(max) (°F)	#1 (psi)	#2 (psi)	#3 (psi)
	1																
	2																
	3																
	4																
	5																
	6																
	7																
	8																
	9																
	10																

The Data Entry area is where all the data for each set of compressive strength cylinders (i.e., each sample) is input using the following as either a description of the column or a guide for the information required in each column.

- *Date* – entry field. In chronological order, enter the date the cylinders for the Contractor sample were cast.
- *Test No.* – not an entry field. This is a number by which the cylinders in the Contractor sample are referenced in the comparison analysis.
- *Reference Location* – entry field. Enter information required to identify the location of the concrete placed from which the cylinders for the Department sample were cast.
- *Volume*
    - *Quantity* – an entry field. This the quantity of concrete represented by the Contractor sample.
    - *Accum.* – not an entry field. This is the accumulated volume of concrete placed to date.
- *1st 50 CY* – Because tests on plastic concrete are performed each 50 CY, but compressive strength cylinders are made each 100 CY, there are two places for recording the plastic properties of concrete. Use these fields under **1st 50 CY** to record the plastic properties of the concrete associated with the compressive strength cylinder.
    - *Air Content* – entry field. Enter the total percent air content measured in the sample of concrete used to cast the cylinders.
    - *Concrete Temp.* – entry field. Enter the temperature measured from the sample of concrete used to cast the cylinders for the Contractor sample.
    - *Slump* – entry field. Enter the slump measure from the sample of concrete used to cast the cylinders.
- *2nd 50 CY* – Use these fields under **2nd 50 CY** to record the plastic properties of the second set of plastic properties each set of cylinders if the placement exceeds 50 CY. These plastic properties should be the ones determined during the casting of concrete test specimens.
    - *Air Content* – entry field. Enter the total percent air content measured in the sample of concrete used to cast the cylinders.
    - *Concrete Temp.* – entry field. Enter the temperature measured from the sample of concrete used to cast the cylinders for the Contractor sample.
    - *Slump* – entry field. Enter the slump measure from the sample of concrete used to cast the cylinders.
- *Temperature Range for Initial Curing of Cylinders* – entry fields. Enter the minimum and maximum temperatures experienced by the cylinders for the Contractor sample during the period of initial curing in the field.
- *Cylinder* – entry field. Enter the compressive strength of each cylinder in the Contractor sample.

A.1.12 LQ Contractor Worksheet - Data Analysis area

Test Average (psi)	10 Tests				Evaluate Concrete for Acceptance in the Application	Results of Evaluation of Low Strength Concrete	Results of Flowchart for Pay Reduction Multiplier	Pay Reduction (%)
	Standard Deviation (psi)	Running Average (psi)	Required Strength (psi)	s+fc (psi)				

The Data Analysis area is where calculations are performed by Excel to summarize the information from the Data Entry area and evaluate the data for compliance with the specification requirements. The following is a description of the information for each column.

- *Test Average* – not an entry field. This is the average compressive strength for the cylinders in a Contractor sample. This average is automatically calculated by Excel and takes into account the consideration required if the strength result of one cylinder is greater than acceptable range of the cylinders tested. The test results of the cylinder that is greater than the acceptable range is considered to be an "outlier" and not used to calculate the average compressive strength and subsequently related calculations. Additionally, it takes into account the requirements for rounding test results to the nearest 10 psi. In Subsection 804.02.10.1.1 section, the test average of a Contractor sample is symbolized by X_i.

  For the COMPARE macro to properly work there can be no blank cells in this column in a Test Lot on which a comparison is performed.

  A blank cell in this column indicates that for the Test No. in question either the compressive strength data has not yet been input in the Cylinder column or only plastic tests were performed for the Test No. If the compressive strength data has not yet been input, do not perform a comparison on this Test No. or any Test Lot which would include it.

- *10 Tests*
  - *S.D.* – not an entry field. This is the standard deviation of the compressive strengths of all the Contractor samples in the Contractor Test Lot for which the current Contractor sample is the first sample. This is calculated by the COMPARE macro which performs the comparison between the Contractor and Department data. In Subsection 804.02.10.1.1, the standard deviation of a Contractor Test Lot is symbolized by *s*.

- *Average* – not an entry field. This is the running average compressive strength for all the Contractor samples in the Contractor Test Lot for which the current Contractor sample is the first sample. This is calculated by the COMPARE macro which performs the comparison between the Contractor and Department data. In Subsection 804.02.10.1.1, the average compressive strength of a Department Test Lot is symbolized by $\overline{X}$.
- *Required Strength* – not an entry field. This is the minimum average compressive strength required for the Contractor Test Lot for which the Contractor sample is the first sample. It is designated the *Required Average Strength*. This is automatically calculated by Excel after the COMPARE macro calculates the standard deviation of the Contractor Test Lot. In Subsection 804.02.10.1.1, the required average compressive strength of a Contractor Test Lot is symbolized by f'_{cr}.
- *s+fc* – not an entry field. This is the sum of the standard deviation (*s*) and the allowable design stress (f_c). This is automatically calculated by Excel after the COMPARE macro calculates the standard deviation of the Department Test Lot. Allowable design stress is 40% of the Specified Compressive Strength (f'_c).

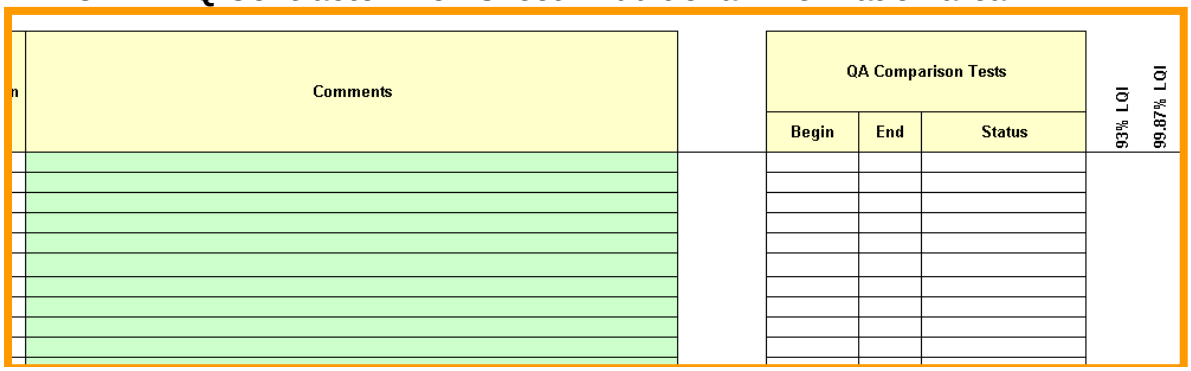
- *Evaluate Concrete for Acceptance in the Application* – not an entry field. This is a guide for assisting in the two step analysis of 1) the comparison between the Contractor test data and the Contractor test data and 2) the result of comparing the Test Average for the current Contractor sample to the Specified Compressive Strength. This is automatically calculated by Excel after the COMPARE macro calculates the standard deviation of the Contractor Test Lot.

  Step 1: In accordance with Subsection 804.02.13, if the results of the Contractor test results are comparative to the results of the Department test results, the Contractor test results are used as the basis for acceptance of the concrete. This leads to Step 2. If the results of the QC test results are not comparative to the results of the Department test results then the Department test results are used as the basis for acceptance of the concrete and no further action is required on the Contractor sheet.

  Step 2: If the Test Average of the current Contractor sample is above the Specified Compressive Strength, then no additional action is required. This field is then left blank showing no additional action required. However, if the Test Average of the current Contractor sample is below the Specified Compressive Strength then, in accordance with Subsection 804.0213.1.5, the Contractor may elect to remove and replace the concrete. If the Contractor elects to not remove the concrete, an evaluation by the Department as to the adequacy for the use intended is required. If the Test Average of the current Contractor sample is below the Specified Compressive Strength, this field gives a recommendation to give additional analysis of the test results. It works in conjunction with the results in the field under *Results of Evaluation of Low Strength Concrete* to recommend a percentage of pay reduction, if required.

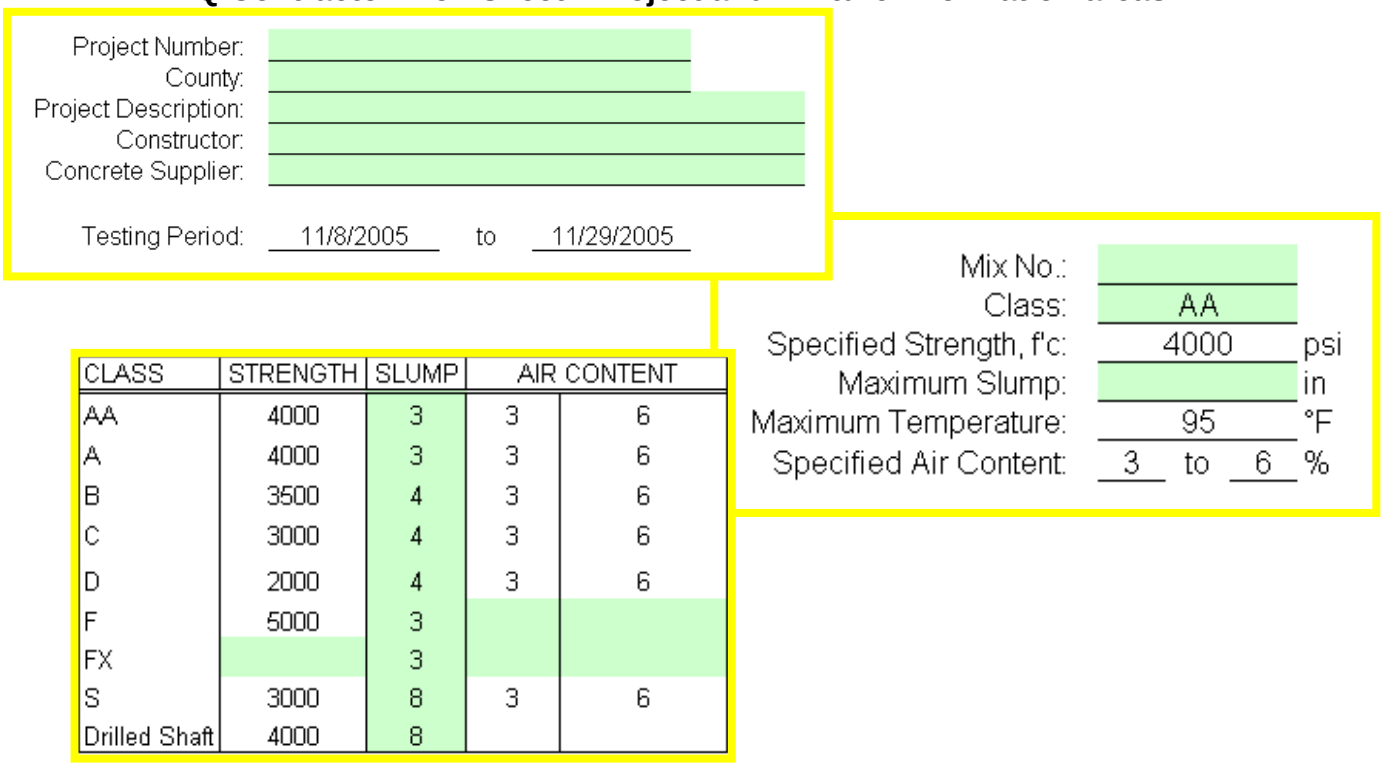
- *Results of Evaluation of Low Strength Concrete* – entry field. This is the field to record the disposition of concrete represented by the current QC sample with a compressive strength below the Specified Compressive Strength. For concrete with a compressive strength below the Specified Compressive Strength, the color of this field turns green to indicate than an entry is required. If the evaluation of the low-strength concrete by the Department shows that the concrete is not adequate for the intended use such that it is removed and replaced, choose "Remove/Replace." No pay reduction is applied as the concrete represented by this sample will be replaced to the satisfaction of the Department and no further action is required with respect to this test. If the evaluation of the low-strength concrete by the Department shows that the concrete is adequate for the intended use such that it may remain in place, choose "Stay in place." Based on the selection of "Stay in place," the results for the current Contractor sample are analyzed for the criteria in Subsection 804.02.13.1.5 and a pay reduction is applied as required.
- *Results of Flowchart for Pay Reduction Multiplier* – entry field. This is the field to record the results of an investigation into a sample with a compressive strength below the Specified Compressive Strength following the *Pay Reduction Multiplier Determination Flowchart* in Figure 3 and Figure 4. For concrete with a compressive strength below the Specified Compressive Strength, if the statistical analysis determines there is not a comparison between QC and QA the color of this field turns green to indicate than an entry is required.
- *Pay Reduction* – not an entry field. This is a guide for a pay reduction for the current Contractor sample for concrete with a compressive strength below the Specified Compressive Strength.
- *Pay Reduction Comments* – not an entry field. This is a guide for the application of a pay reduction for the current Contractor sample.

A.1.13 LQ Contractor Worksheet - Additional Information area



The Additional Information area is where Additional Comments may be made by the user concerning a sample. Also, this area has several fields which indicate the corresponding range of Contractor Test data used during the statistical evaluation and the values for each of the Lower Quality Indexes (LQI) used to ensure 93% of the compressive strengths are above f'_c and 99.87% of the compressive strengths are above f_c.

A.1.14 LQ Contractor Worksheet - Project and Mixture Information areas



CLASS	STRENGTH	SLUMP	AIR CONTENT	
AA	4000	3	3	6
A	4000	3	3	6
B	3500	4	3	6
C	3000	4	3	6
D	2000	4	3	6
F	5000	3		
FX		3		
S	3000	8	3	6
Drilled Shaft	4000	8		

These three areas are for recording general project and mixture information.

- Project Number – an entry field. Enter the project number.
- County – an entry field. Enter the county name in which the project is.
- Project Description – an entry field. Enter a description of the project, like a route number.
- Constructor – an entry field. Enter the name of the Prime Contractor for the project.
- Concrete Supplier – an entry field. Enter the name of the Concrete Supplier supplying the mixture.
- Mix No. – an entry field. Enter the Concrete Supplier's unique mixture identification number.

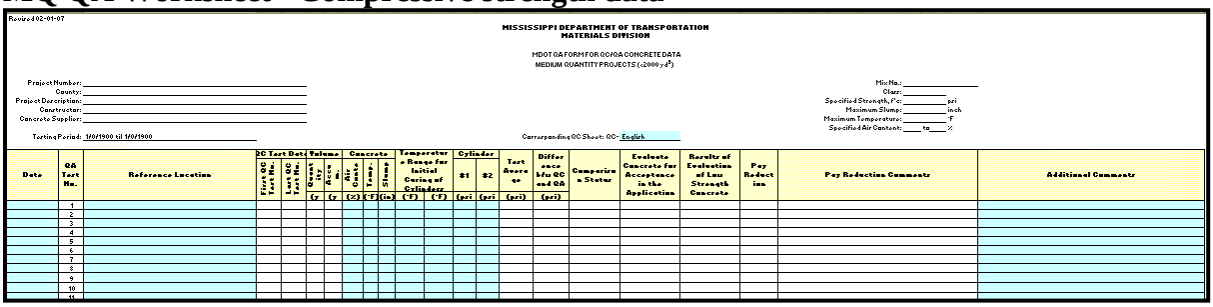
- Class – a drop-down. Select the class of concrete for the mixture.
    - Class FX concrete can have one of several different specified compressive strengths. For FX concrete, enter the specified compressive strength in the green cell to the right of "FX" under the Class heading.
    - The slumps listed are the maximum allowable slumps for each class of concrete having no Mid-Range or High Range water reducers in them. For mixture with these admixtures, the slump for the applicable class of concrete should be changed to correspond to the design slump listed on the mixture design review report from the Materials Division.
    - The air contents listed are the required total air contents required for each class of concrete. Classes DS, F, and FX do not require air-entraining admixtures unless they are exposed to seawater, in which case the required total air content would be 3-6%. For seawater exposure, the air content should be changed to 3 in the left column and 6 in the right column for the applicable class of concrete.

The information entered in these general project and mixture information areas will also be reflected on the LQ Department Worksheet and both the LQ Department and Contractor Worksheets for plastic concrete data.

A.2 The Department's COMPARE Excel workbooks - MQ Projects

Below are screen shots of the Contractor and Department worksheets in the English CONCRETE COMPARE workbook for MQ projects. These show the entire working portions of each worksheet. The workbooks and worksheets for the Metric version are nearly identical.

MQ QA Worksheet - Compressive strength data


Revised 02-01-07

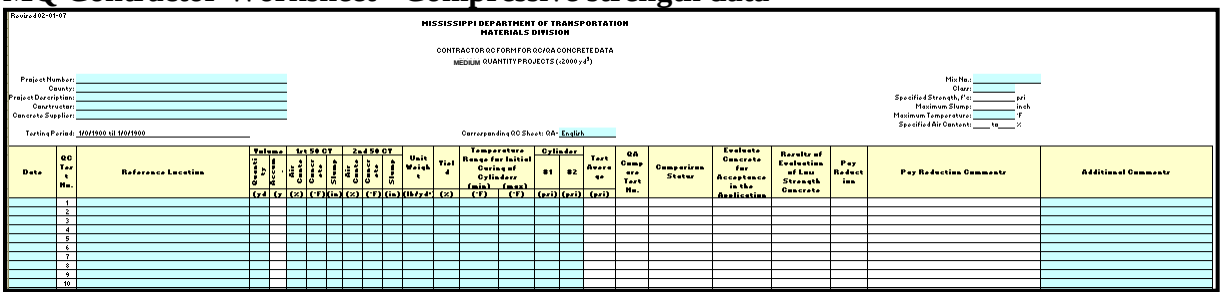
MISSISSIPPI DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION

MDOT QA FORM FOR QC/QA CONCRETE DATA
MEDIUM QUANTITY PROJECTS (<2000 yd³)

Project Number: _____ Mix No.: _____
County: _____ Class: _____
Project Description: _____ Specified Strength, f'c: _____ psi
Constructor: _____ Maximum Slump: _____ inch
Concrete Supplier: _____ Maximum Temperature: _____ °F
Specified Air Content: ____ to ____ %
Testing Period: 1/01/1900 till 1/01/1900 Corresponding QC Sheet: QC- English

Date	QA Test No.	Reference Location	QC Test Data: First QC Test No.	QC Test Data: Last QC Test No.	Volume: Quantity	Volume: Accum.	Concrete: Air Content	Concrete: Temp	Concrete: Slump	Temperature Range for Initial Curing of Cylinders	Cylinder: #1	Cylinder: #2	Test Average	Difference b/w QC and QA	Comparison Status	Evaluate Concrete for Acceptance in the Application	Results of Evaluation of Lot Strength Concrete	Pay Reductions	Pay Reduction Comments	Additional Comments
					(y	(y	(z)	(°F)	(in)	(°F)	(psi	psi	(psi)	(psi)						
	1																			
	2																			
	3																			
	4																			
	5																			
	6																			
	7																			
	8																			
	9																			
	10																			
	11																			

MQ Contractor Worksheet - Compressive strength data


Revised 02-01-07

MISSISSIPPI DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION

CONTRACTOR QC FORM FOR QC/QA CONCRETE DATA
MEDIUM QUANTITY PROJECTS (<2000 yd³)

Project Number: _____ Mix No.: _____
County: _____ Class: _____
Project Description: _____ Specified Strength, f'c: _____ psi
Constructor: _____ Maximum Slump: _____ inch
Concrete Supplier: _____ Maximum Temperature: _____ °F
Specified Air Content: ____ to ____ %
Testing Period: 1/01/1900 till 1/01/1900 Corresponding QC Sheet: QA- English

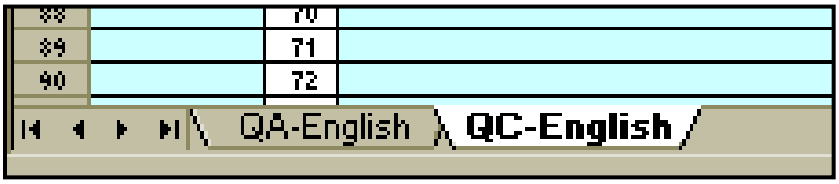
Date	QC Test No.	Reference Location	Volume: Quantity	Volume: Accum.	1st 50 CY: Air Content	1st 50 CY: Concrete	1st 50 CY: Slump	2nd 50 CY: Air Content	2nd 50 CY: Concrete	2nd 50 CY: Slump	Unit Weight	Yield	Temperature Range for Initial Curing of Cylinders (min)	Temperature Range for Initial Curing of Cylinders (max)	Cylinder: #1	Cylinder: #2	Test Average	QA Compare Test No.	Comparison Status	Evaluate Concrete for Acceptance in the Application	Results of Evaluation of Lot Strength Concrete	Pay Reductions	Pay Reduction Comments	Additional Comments
			(yd	(y	(z)	(°F)	(in)	(z)	(°F)	(in)	(lb/y d³	(z)	(°F)		(psi)	(psi)	(psi)							
	1																							
	2																							
	3																							
	4																							
	5																							
	6																							
	7																							
	8																							
	9																							
	10																							

A.2.1 Cells in Light Blue vs. Cells in White

For the MQ worksheets, cells in light blue are places for user input. Cells in white are used by the worksheets and no user input is required for these fields.

A.2.2 On the Importance of Tab Names

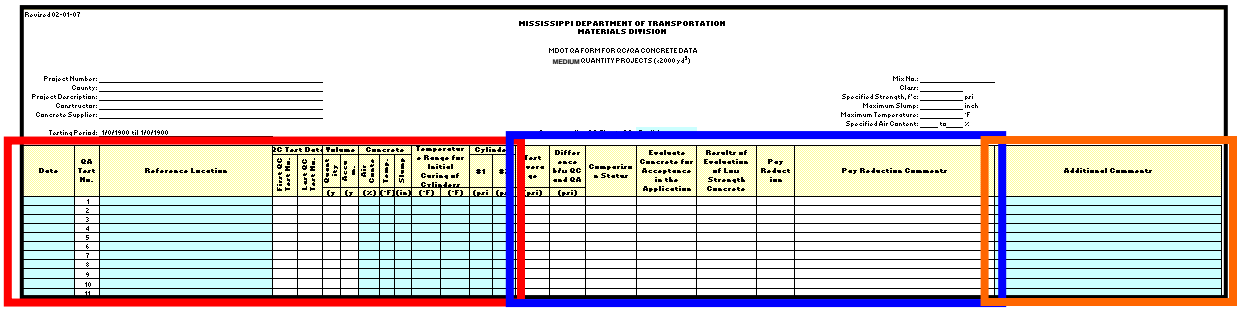
Each of the worksheets has a worksheet tab at the bottom of the Excel application screen. On each individual tab is the name of the individual worksheet. An example of these tabs is shown in the screenshot below. In the screenshot shown below the active worksheet is **QC-English**, as indicated by the highlighted tab on the far left.



The name of each worksheet is important in the comparison process as the worksheets are linked together by the worksheet name. In order for the comparison process to work properly, all worksheets must end with the same suffix. Additionally, the suffix must be listed on the Department worksheet for compressive strength data in the field shown below.

A.2.3 MQ QA Worksheet

The MQ Department worksheet has three data entry/analysis areas. In the red box is the main Data Entry area; in the blue is the Data Analysis and summary area; in the orange is the Additional Information area.



For information for cells not covered in one of the boxes above (like the Project Number cell) see paragraph A.2.11.

A.2.4 MQ QA Worksheet - Data Entry area

Date	QA Test No.	Reference Location	QC Test Data		Volume		Concrete			Temperature Range for Initial Curing of Cylinders		Cylinder	
			First QC Test No.	Last QC Test No.	Quantity	Accum.	Air Content	Temp.	Slump	(min)	(max)	#1	#2
					(yd^3)	(yd^3)	(%)	(°F)	(in)	(°F)	(°F)	(psi)	(psi)
	1												
	2												
	3												
	4												
	5												
	6												
	7												
	8												
	9												
	10												

The Data Entry area is where all the data for each set of compressive strength cylinders (i.e., each sample) is input using the following as either a description of the column or a guide for the information required in each column.

- *Date* – entry field. In chronological order, enter the date the cylinders for the Department sample were cast.
- *Test No.* – not an entry field. This is a number by which the cylinders in the Department sample are referenced in the comparison analysis.
- *Reference Location* – entry field. Enter information required to identify the location of the concrete placed from which the cylinders for the Department sample were cast.
- *QC Test Data* – This is the range of tests on the Contractor worksheet represented by the specific Department test. Please refer to paragraph 5.2.2.9 for additional information.
    - *First QC Test No.* – not an entry field. This is the *Test No.* of a Contractor sample on the QC worksheet. The criterion for what determines which Contractor sample corresponds with the current Department sample is that the dates are equal. This *Test No.* for the QC sample is automatically determined by Excel using the date field of a specific Department sample on the Department worksheet to "find" the sample on the Contractor worksheet made on the same day as the Department sample.
    - *Last QC Test No.* – not an entry field. This is the *Test No.* of a QC sample on the Contractor worksheet. This number is automatically determined by Excel using the date field on the Department worksheet to "find" the last applicable sample on the Contractor worksheet which is represented by the Department sample.
- *Volume*
    - *Quantity* – not an entry field. This the quantity of concrete represented by the Department sample. This number is automatically determined by Excel as the sum of the concrete quantities represented by the range of corresponding QC Test No. determined by the *First QC Test No.* and the *Last QC Test No.*
    - *Accum.* – not an entry field. This is the accumulated volume of concrete placed to date.

- *Concrete*
    - *Air Content* – entry field. Enter the total percent air content measured in the sample of concrete used to cast the cylinders.
    - *Temp.* – entry field. Enter the temperature measured from the sample of concrete used to cast the cylinders for the Department sample.
    - *Slump* – entry field. Enter the slump measure from the sample of concrete used to cast the cylinders.
- *Temperature Range for Initial Curing of Cylinders* – entry fields. Enter the minimum and maximum temperatures experienced by the cylinders for the Department sample during the period of initial curing in the field.
- *Cylinder* – entry field. Enter the compressive strength of each cylinder in the Department sample.

A.2.5 MQ Department Worksheet - Data Analysis area

Test Average (psi)	Difference b/w QC and QA (psi)	Comparison Status	Evaluate Concrete for Acceptance in the Application	Results of Evaluation of Low Strength Concrete	Pay Reduction	Pay Reduction Comments

The Data Analysis area is where calculations are performed by Excel to summarize the information from the Data Entry area and evaluate the data for compliance with the specification requirements. The following is a description of the information for each column.

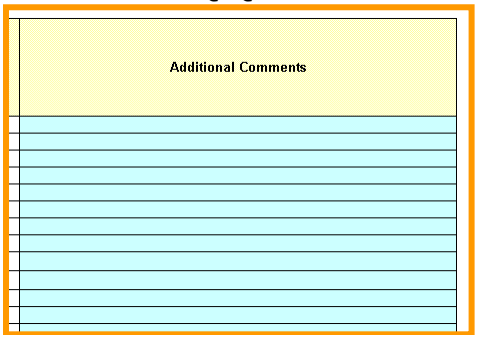
- *Test Average* – not an entry field. This is the average compressive strength for the cylinders in a Department sample. This average is automatically calculated by Excel and takes into account the consideration required if the strength result of one cylinder is greater than acceptable range of the cylinders tested. The test results of the cylinder that is greater than the acceptable range is considered to be an "outlier" and not used to calculate the average compressive strength and subsequently related calculations. Additionally, it takes into account the requirements for rounding test results to the nearest 10 psi. In Subsection 804.02.10.1.1, the test average of a Department sample is symbolized by X_i.

    For the COMPARE workbook to properly work there can be no blank cells in this column in a Test Lot on which a comparison is performed.

A blank cell in this column indicates that for the Test No. in question either the compressive strength data has not yet been input in the Cylinder column or only plastic tests were performed for the Test No. If the compressive strength data has not yet been input, do not perform a comparison on this Test No. or any Test Lot which would include it.

- *Difference b/w QC and QA* – not an entry field. This field calculates the difference in compressive strength between the Department sample and the corresponding Contractor sample.
- *Comparison Status* – not an entry field. This field performs the comparison between the Department sample and the applicable Contractor sample and returns a result of "Comparison" or "No Comparison." In accordance with Subsection 804.02.13.c, if the difference between Department and Contractor is equal to or less than 990 psi, the samples compare; if the difference is greater than 990 psi, the samples do not compare.
- *Evaluate Concrete for Acceptance in the Application* – not an entry field. This is a guide for assisting in the two step analysis of 1) the comparison between the Contractor test data and the Department test data and 2) the result of comparing the Test Average for the current Department sample to the Specified Compressive Strength. This is automatically calculated by Excel.
- *Results of Evaluation of Low Strength Concrete* – entry field. This is the field to record the disposition of concrete represented by the current Department sample with a compressive strength below the Specified Compressive Strength. For concrete with a compressive strength below the Specified Compressive Strength, the color of this field turns green to indicate than an entry is required. If the evaluation of the low-strength concrete by the Department shows that the concrete is not adequate for the intended use such that it is removed and replaced, choose "Remove/Replace." No pay reduction is applied as the concrete represented by this sample will be replaced to the satisfaction of the Department and no further action is required with respect to this test. If the evaluation of the low-strength concrete by the Department shows that the concrete is adequate for the intended use such that it may remain in place, choose "Stay in place." Based on the selection of "Stay in place," the results for the current Department sample are analyzed for the criteria in Subsection 804.02.13.1.5 and a pay reduction is applied as required.
- *Pay Reduction* – not an entry field. This is a guide for a pay reduction for the current Department sample for concrete with a compressive strength below the Specified Compressive Strength.
- *Pay Reduction Comments* – not an entry field. This is a guide for the application of a pay reduction for the current Department sample. If there is a pay reduction for concrete in a Contractor sample represented by the current Department sample, this field gives direction to review the Contractor worksheet. Additionally, if there is a discrepancy between the date the Department sample was cast and the Contractor sample, this field gives a note to correct the discrepancy.

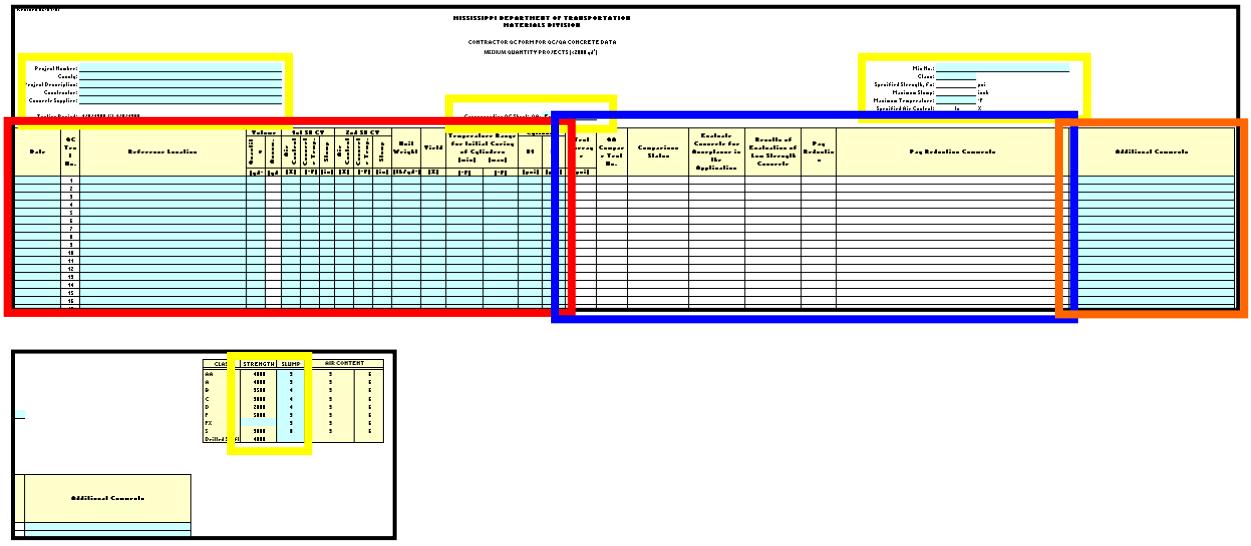
A.2.6 MQ QA Worksheet - Additional Information area



The Additional Information area is where Additional Comments may be made by the user concerning a sample.

A.2.7 MQ Contractor Worksheet - Compressive strength data

The MQ Contractor Worksheet for compressive strength data is similar to the MQ Department Worksheet, but less complex. Like the MQ Department Worksheet for compressive strength data, it also has three data entry/analysis areas. In the red box is the main Data Entry area; in the blue is the Data Analysis and summary area, in the orange is the Additional Information area. The areas in yellow are for recording general project and mixture information.



A.2.8 MQ Contractor Worksheet - Data Entry area

Date	QC Test No.	Reference Location	Volume		1st 50 CY			2nd 50 CY			Unit Weight	Yield	Temperature Range for Initial Curing of Cylinders		Cylinder	
			Quantity	Accum.	Air Content	Concrete Temp.	Slump	Air Content	Concrete Temp.	Slump			(min)	(max)	#1	#2
			(yd^3)	(yd^3)	(%)	(°F)	(in)	(%)	(°F)	(in)	(lb/yd^3)	(%)	(°F)	(°F)	(psi)	(psi)
	1															
	2															
	3															
	4															
	5															
	6															
	7															
	8															
	9															
	10															

The Data Entry area is where all the data for each set of compressive strength cylinders (i.e., each sample) is input using the following as either a description of the column or a guide for the information required in each column.

- *Date* – entry field. In chronological order, enter the date the cylinders for the Contractor sample were cast.
- *Test No.* – not an entry field. This is a number by which the cylinders in the Contractor sample are referenced in the comparison analysis.
- *Reference Location* – entry field. Enter information required to identify the location of the concrete placed from which the cylinders for the QA sample were cast.

- *Volume*
    - *Quantity* – an entry field. This the quantity of concrete represented by the Contractor sample.
    - *Accum.* – not an entry field. This is the accumulated volume of concrete placed to date.
- *1st 50 CY* – Because tests on plastic concrete are performed each 50 CY, but compressive strength cylinders are made each 100 CY, there are two places for recording the plastic properties of concrete. Use these fields under **1st 50 CY** to record the plastic properties of the concrete associated with the compressive strength cylinder.
    - *Air Content* – entry field. Enter the total percent air content measured in the sample of concrete used to cast the cylinders.
    - *Concrete Temp.* – entry field. Enter the temperature measured from the sample of concrete used to cast the cylinders for the Contractor sample.
    - *Slump* – entry field. Enter the slump measure from the sample of concrete used to cast the cylinders.
- *2nd 50 CY* – Use these fields under **2nd 50 CY** to record the plastic properties of the second set of plastic properties each set of cylinders if the placement exceeds 50 CY. These plastic properties should be the ones determined during the casting of concrete test specimens.
    - *Air Content* – entry field. Enter the total percent air content measured in the sample of concrete used to cast the cylinders.
    - *Concrete Temp.* – entry field. Enter the temperature measured from the sample of concrete used to cast the cylinders for the Contractor sample.
    - *Slump* – entry field. Enter the slump measure from the sample of concrete used to cast the cylinders.
- *Temperature Range for Initial Curing of Cylinders* – entry fields. Enter the minimum and maximum temperatures experienced by the cylinders for the Contractor sample during the period of initial curing in the field.
- *Cylinder* – entry field. Enter the compressive strength of each cylinder in the Contractor sample.

A.2.9 MQ Contractor Worksheet - Data Analysis area

Test Average (psi)	QA Compare Test No.	Comparison Status	Evaluate Concrete for Acceptance in the Application	Results of Evaluation of Low Strength Concrete	Pay Reduction	Pay Reduction Comments

The Data Analysis area is where calculations are performed by Excel to summarize the information from the Data Entry area and evaluate the data for compliance with the specification requirements. The following is a description of the information for each column.

- *Test Average* – not an entry field. This is the average compressive strength for the cylinders in a Contractor sample. This average is automatically calculated by Excel and takes into account the consideration required if the strength result of one cylinder is greater than 500 psi different than the strength result of the other cylinder. Additionally, it takes into account the requirements for rounding test results to the nearest 10 psi. In Subsection 804.02.10.1.1, the test average of a Contractor sample is symbolized by X_i.

  For the COMPARE macro to properly work there can be no blank cells in this column in a Test Lot on which a comparison is performed.

  A blank cell in this column indicates that for the Test No. in question either the compressive strength data has not yet been input in the Cylinder column or only plastic tests were performed for the Test No. If the compressive strength data has not yet been input, do perform a comparison on this Test No. or any Test Lot which would include it. If only plastic tests were performed for the Test No., enter the plastic test data on the MQ Contractor Worksheet - Plastic concrete data.

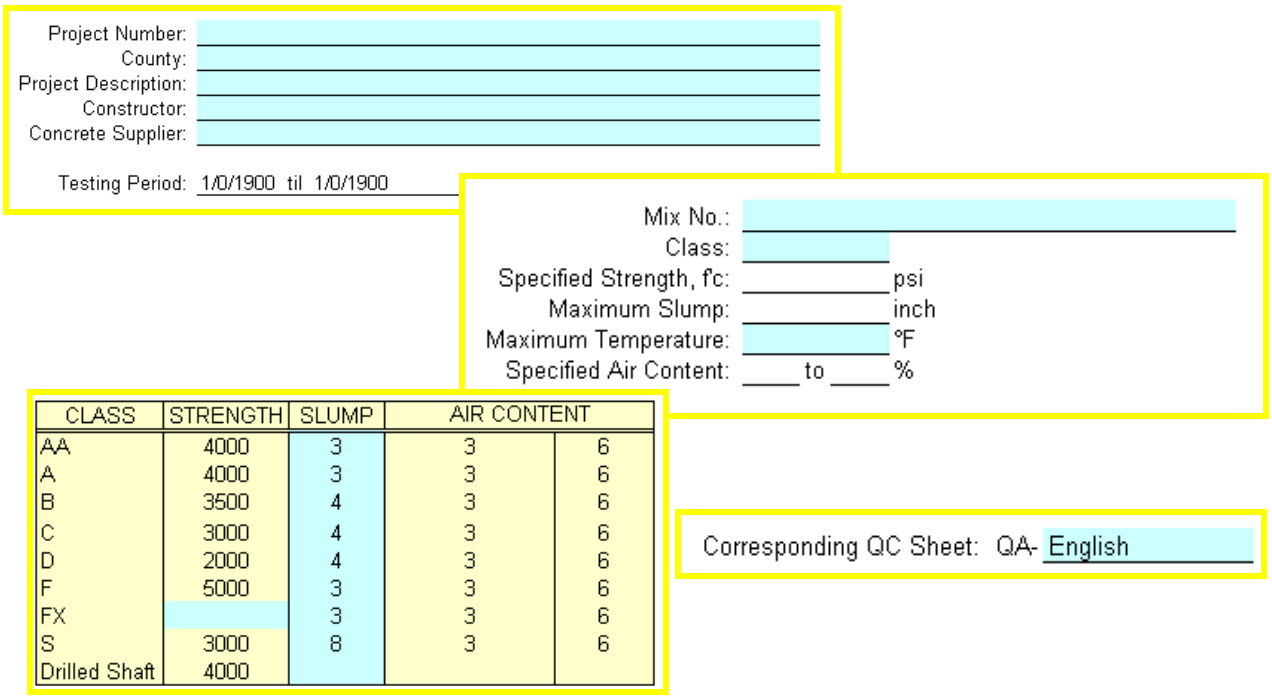
- *QA Compare Test No.* – not an entry field. This is number of the Department sample with which the comparison with the applicable Contractor sample was performed.
- *Comparison Status* – not an entry field. This field performs the comparison between the Department sample and the applicable Contractor sample and returns a result of "Comparison" or "No Comparison." In accordance with Subsection 804.02.13.c, if the difference between Department and Contractor is equal to or less than 990 psi, the samples compare; if the difference is greater than 990 psi, the samples do not compare.
- *Evaluate Concrete for Acceptance in the Application* – not an entry field. This is a guide for assisting in the two step analysis of 1) the comparison between the Contractor test data and the Department test data and 2) the result of comparing the Test Average for the current Department sample to the Specified Compressive Strength. This is automatically calculated by Excel.
- *Results of Evaluation of Low Strength Concrete* – entry field. This is the field to record the disposition of concrete represented by the current Contractor sample with a compressive strength below the Specified Compressive Strength. For concrete with a compressive strength below the Specified Compressive Strength, the color of this field turns green to indicate than an entry is required. If the evaluation of the low-strength concrete by the Department shows that the concrete is not adequate for the intended use such that it is removed and replaced, choose "Remove/Replace." No pay reduction is applied as the concrete represented by this sample will be replaced to the satisfaction of the Department and no further action is required with respect to this test. If the evaluation of the low-strength concrete by the Department shows that the concrete is adequate for the intended use such that it may remain in place, choose "Stay in place." Based on the selection of "Stay in place," the results for the current Contractor sample are analyzed for the criteria in Subsection 804.02.13.1.5 and a pay reduction is applied as required.
- *Pay Reduction* – not an entry field. This is a guide for a pay reduction for the current Contractor sample for concrete with a compressive strength below the Specified Compressive Strength.

- *Pay Reduction Comments* – not an entry field. This is a guide for the application of a pay reduction for the current Contractor sample.

A.2.10 MQ Contractor Worksheet - Additional Information area

The Additional Information area is where Additional Comments may be made by the user concerning a sample.

A.2.11 MQ Contractor Worksheet - Project and Mixture Information areas



These three areas are for recording general project and mixture information.

- Project Number – an entry field. Enter the project number.
- County – an entry field. Enter the county name in which the project is.

- Project Description – an entry field. Enter a description of the project, like a route number.
- Constructor – an entry field. Enter the name of the Prime Contractor for the project.
- Concrete Supplier – an entry field. Enter the name of the Concrete Supplier supplying the mixture.
- Mix No. – an entry field. Enter the Concrete Supplier's unique mixture identification number.
- Class – a drop-down. Select the class of concrete for the mixture.
    - Class FX concrete can have one of several different specified compressive strengths. For FX concrete, enter the specified compressive strength in the green cell to the right of "FX" under the Class heading.
    - The slumps listed are the maximum allowable slumps for each class of concrete having no Mid-Range or High Range water reducers in them. For mixture with these admixtures, the slump for the applicable class of concrete should be changed to correspond to the design slump listed on the mixture design review report from the Materials Division.
    - The air contents listed are the required total air contents required for each class of concrete. Classes DS, F, and FX do not require air-entraining admixtures unless they are exposed to seawater, in which case the required total air content would be 3-6%. For seawater exposure, the air content should be changed to 3 in the left column and 6 in the right column for the applicable class of concrete.
- Maximum Temperature – an entry field. Enter the maximum permitted slump based on the mixture design review report from the Materials Division.
- Corresponding QC Sheet: QA- – an entry field. Enter the tab name of the corresponding QA sheet from which comparisons are to be performed.

The information entered in these general project and mixture information areas will also be reflected on the MQ QA Worksheet.

Appendix B Forms

MDOT Concrete Mix design Forms My Designs Admin My Account

MISSISSIPPI DEPARTMENT OF TRANSPORTATION
Materials Division

Form for Approving Field Verification Testing of Portland Cement Concrete Mixtures

Confirmation Number: 1
Mixture Design Number:

Version Number:

Project Type:
Date Submitted for Review:
Mixture Designer's Email Address:
Primary County:
Project Number:
FMS Number:
Project Engineer:
Project District:
District Materials Engineer:
Project Office:
Contractor:
Contractor Email:
Designer:
Sulfate Exposure Results:
Associated Mix ID:

Project Units:
Project Specification:
Mixture Class:
Design Slump:
Concrete Producer:
Concrete Producer's Mixture ID:
Specified Min. Strength:
Basis of Proportioning:
Application:
Project Specified Air Content:

Remarks

Mix Design Quantities

Material	Source	Description	Bulk Specific Gravity (OD)	Unit Weight (lb/yd³)	Fineness Modulus	Quantity (OD) (lb/yd³)	Absolute Volume (yd³)
Cement:							
Fly Ash:							
GGBFS:							
Other CM:							
Water			1				
Fine #1:							
Fine #2:							
Coarse #1:							
Coarse #2:							
Coarse #3:							
AEA*							
Admixture* (A)							
Admixture*F							
Admixture*							
Admixture*							
					Total:	3900	26.93

Batch Volume: yd³ **Tolerance Type:** Cumulative **Field Verification:** Date Performed

Batch Quantities

Material	Target Batch Weight (SSD) (lb)	Actual Batch Weight (SSD) (lb)	Actual Quantity (SSD) (lb/yd³)	Total Moisture (%)	Absorption (%)	Surface Moisture (%)	(lb)	Target Quantity (OD) (lb/yd³)	Actual Quantity (OD) (lb/yd³)	Status
Cement:										
Fly Ash:										
GGBFS:										
Other CM:										
Water										
Fine #1:										
Fine #2:										
Coarse #1:										
Coarse #2:										
Coarse #3:										
AirEntraining										
Admixture*										
Admixture*										
Admixture*										
Admixture*										
Total:						Total:				

Note: * = Admixtures expressed in fluid ounces

			Status
Water Content		lb	
Slump		within minus (-) 2-1/2 in. of design	
Air Content		within minus (-) 1-1/2 percent of maximum	
Temperature		°F	
Unit Weight		lb/yd³	
Yield		within ± 2%	

Aggregate Analysis

Fine Aggregate			Coarse Aggregate		
Test Date Performed		Bulk Specific Gravity (OD) =	Test Date Performed		Bulk Specific Gravity (OD) =
Test Date Performed		Bulk Specific Gravity (OD) =	Test Date Performed		Bulk Specific Gravity (OD) =
			Test Date Performed		Bulk Specific Gravity (OD) =
Test Date Performed		Sieve Analysis	Test Date Performed		Sieve Analysis
Test Date Performed		Sieve Analysis	Test Date Performed		Sieve Analysis
			Test Date Performed		Sieve Analysis

Aggregate Analysis

Fine Aggregate			Coarse Aggregate			
	Fine #1	Fine #2		Coarse #1	Coarse #2	Coarse #3
Init Wt(g)			Init Wt(g)			
Blend(%)			Blend(%)			

Sieve	Accum. Wt. Retained	Total Passing %	Gradation Rqmt %	Accum. Wt. Retained	Total Passing %	Gradation Rqmt %
1/2			100			100
3/8			97-100			97-100
No. 4			92-100			92-100
No. 8			75-100			75-100
No. 16			45-90			45-90
No. 30			25-70			25-70
No. 50			3-35			3-35
No. 100			0-10			0-10
Pan						

Sieve	Accum. Wt. Retained	Total Passing %	Gradation Rqmt %	Accum. Wt. Retained	Total Passing %	Gradation Rqmt %	Accum. Wt. Retained	Total Passing %	Gradation Rqmt %
2			100						
1-1/2			100						
1			100						
3/4			80-100						
1/2									
3/8			20-55						
No. 4			0-10						
No. 8			0-5						
Pan									

Save Submit Evaluate

Combined Sieve Analysis Data

Sieve	Design Passing	Design Individual Retained	FV Passing	FV Individual Retained
2	100	0	0	100
1-1/2	100	0	0	0
1	100	0	0	0
3/4	94.89	5.11	0	0
1/2	71.87	23.02	0	0
3/8	55.47	16.40	0	0
No. 4	38.69	16.78	0	0
No. 8	32.30	6.39	0	0
No. 16	27.02	5.28	0	0
No. 30	20.96	6.06	0	0
No. 50	2.77	18.19	0	0
No. 100	0.52	2.25	0	0

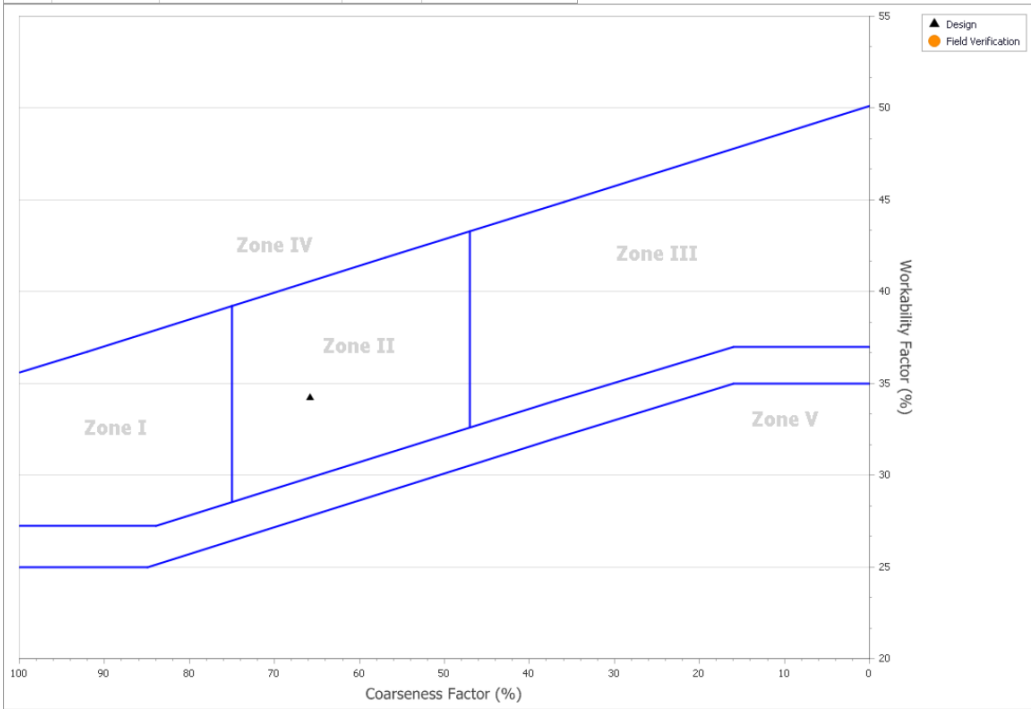


Figure 16 - Sample TMD-892 – Form for Approving Field Verification Testing of Portland Cement Concrete Mixtures

MISSISSIPPI DEPARTMENT OF TRANSPORTATION

TMD-324
REV. 12-12

INSPECTION REPORT OF CONCRETE BATCH PLANTS

Semi-Annual Report of Plant Facilities for the Production of Concrete for Department Work at

Concrete Producer and Plant Designation (if applicable)	District Assigned MDOT Plant No.
Latitude	Longitude
Street Address	Mailing Address (if different from Street Address)
City	District
Date of Scale Calibration	Date of Inspection from most recent NRMCA Checklist

This plant (does) (does not meet) the requirements of the Standard Specifications and the Department's *Concrete Field Manual*.

District Materials Engineer

Distribution:

State Materials Engineer
District Materials Engineer
Concrete Producer

Figure 17 - Sample TMD-324 – Inspection Report of Concrete Batch Plants

MISSISSIPPI DEPARTMENT OF TRANSPORTATION

TMD-736

SCALES CALIBRATION CERTIFICATION

Contractor _____ Date _____

Type Plant _____ Project No(s). _____

Location _____ County _____

Project Engr. _____

SCALES CALIBRATION DATA

Make _____ Type _____

Capacity and Graduations

Gravel _____ Sand _____ Cement _____

Actual Weight	Reading	Actual Weight	Reading	Actual Weight	Reading

REMARKS _____

I HEREBY CERTIFY THESE SCALES TO MEET DEPARTMENT OF TRANSPORTATION SPECIFICATION REQUIREMENTS:

CC: SIGNED: _____

_____SCALES COMPANY

Figure 18 - Sample TMD-736 – Scale Calibration Certification

PORTLAND CEMENT CONCRETE PLANT SAMPLES RANDOM NUMBERS

TMD-999

DATE _____

PROJECT NO. _____

LOT NO. _____

MDOT MIXTURE ID. _____

CONCRETE PRODUCER MIXTURE ID. _____

LOT SIZE

ANTICIPATED CUBIC YARDAGE FOR DAY (A): _____ (CY)

SAMPLING FREQUENCY (B): 50 (CY)

NUMBER OF LOTS REQUIRED (A/B) = C: _____ (round to the whole number)

LOT SIZE (A/C) = D: _____ (CY per sample)

SELECT A RANDOM NUMBER FOR EACH LOT AND ENTER BELOW. Use additional random numbers if the cubic yardage produced exceeds the anticipate production yardage.

RANDOM NO. 1 (R1)	_____	SAMPLE CUBIC YARDAGE 1 = D x R1	_____
RANDOM NO. 2 (R2)	_____	SAMPLE CUBIC YARDAGE 2 = D + (D x R2)	_____
RANDOM NO. 3 (R3)	_____	SAMPLE CUBIC YARDAGE 3 = (2 x D) + (D x R3)	_____
RANDOM NO. 4 (R4)	_____	SAMPLE CUBIC YARDAGE 4 = (3 x D) + (D x R4)	_____
RANDOM NO. 5 (R5)	_____	SAMPLE CUBIC YARDAGE 5 = (4 x D) + (D x R5)	_____
RANDOM NO. 6 (R6)	_____	SAMPLE CUBIC YARDAGE 6 = (5 x D) + (D x R6)	_____
RANDOM NO. 7 (R7)	_____	SAMPLE CUBIC YARDAGE 7 = (6 x D) + (D x R7)	_____

Figure 19- Sample TMD-999 – Portland Cement Concrete Plant Samples Random Number

Appendix C Revisions

Date	Pages	Description
May 1, 2015	Mutiple	Updated references throughout the document. Section 3 was deleted and the Materials Manual is referenced instead.
May 1, 2015	Table of contents 2, 6, 12, 24-26	Section 1.2 Terminology, Page 2, definition of MDOT Class III. Section 2.3.5, Page 6 changed maturity information Section 3.3.1.1, Page 12, changed to 6 months and added information for cementitious and admixtures materials Section 3.6.1, Page 24-26, updated concrete specification information from the new 907-804-16 information changes and other special provisions
January 1, 2015	Title Page	Changed revision date. "January 1, 2015" – WAS - "March 17, 2011"
	Table of Contents	Updated Table of Contents
	Table of Figures	Updated Table of Figures.
	23	"10" – WAS – "30"
	25	Deleted last bulleted item from Cementitious Materials information – WAS – "The test report shall list only one type, class, grade, or other form of classification for the cementitious material.
	26	Deleted last sentence and bulleted items of the first paragraph – WAS – "Additionally, the most recent performance data from the project from which the mixture is being transferred shall be submitted. This performance data shall include the following: • Compressive strength data for the individual cylinders in each of the previous 10 compressive strength test. The compressive strength data shall verify that the requirements of Subsection 804.02.10.1.1 are met. • Plastic test data for each compressive strength test, including the date sampled, slump, total air content, and temperature recorded for the plastic concrete for each strength test. For each of these tests on the plastic concrete the test data shall meet the acceptance criteria of Subsection 804.02.13.1"
	27	• Revised Paragraph title to "Considerations for Concrete Mixtures using Lightweight Aggregates for Internal Curing" – WAS – "Considerations for Concrete Mixtures used Bridge Decks"

		• Revised paragraph contents to reflect new paragraph title.
	36	• Revised "Type II" – WAS – "Type I-MS" under Cement, Type Change • Revised "Type WR" – WAS – "Type F" under Chemical Admixture(s), Source change • Revised "Type WR" – WAS – "Type A" under Chemical Admixture(s), Proportion change • Revised "Type WR" and "Type WR/RET" – WAS – "Type F" and "Type A," respectively, under Chemical Admixture(s), Type change
	42	• Revised title of paragraph 6.1.1 to "Sampling" – WAS – "Random Sampling." • Revised "ASTM D 3665" – WAS – "ASTM D 3665."
	43	• Revised title of paragraph 6.1.1.5 to "Sampling for QA Testing." – WAS – "Random Sampling for QA Testing." • Added second paragraph under paragraph 6.1.1.5.
	48	Revised maximum cylinder storage temperature to "77°F" – WAS – "76°F."
	59-62	Added new paragraph at the end of paragraph 7.3, new Figures 7 and 8, and description after Figure 8.
	64-69	Revised Figure numbers
	Appendix A	Revised Appendix A Figures showing blanks for 3 cylinders in a set – WAS – 2 cylinders in a set
	A-2	Deleted paragraph A.1.2
	A-8	• Added "if the statistical analysis determines there is not a comparison between QC and QA" to the 2nd sentence of *Results of Evaluation of Low Strength Concrete* • Added new paragraph "*Results of Flowchart for Pay Reduction Multiplier*"
	A-16	Revised "establish" – WAS – "established" in 11.
	A-22	Added new paragraph "*Results of Flowchart for Pay Reduction Multiplier*"
	Appendix B	Revised Figure numbers.
	C-2 – C-3	Revised Appendix C
March 17, 2011	Title Page	Changed revision date. "March 17, 2011" – WAS - "August 4, 2010"
	Table of Contents	Updated Table of Contents to reflect insertion of paragraph 6.1.7 and 9.2.1 on pages 45 and 67-68.
	45	Inserted paragraph 6.1.7.

	66	Added sentences 7-10 in the second paragraph of paragraph 9.1.
	67-68	Inserted paragraph 9.2.1.
	C-2	Revised Appendix C.
August 4, 2010	Title Page	Changed revision date. "August 4, 2010" – WAS – "August 15, 2008"
	Table of Contents	Updated Table of Contents to reflect insertion of paragraph 6.1.1 on pages 42-45 and addition of Appendix C
	Table of Figures	Updated Table of Figures to include Figure 17
	9	"*AASHTO Designation*" - WAS - "*AASHTO Designation*
	19	"1,000" - WAS - "2,000"
	20	"1,000" - WAS - "2,000"
	21	"1,000" - WAS - "2,000" in two places
	42-45	Inserted paragraph 6.1.1 Random Sampling and revised subsequent paragraph numbers.
	B-5	Added Figure 17
	C-1 – C-2	Added Appendix C
August 15, 2008		Original version.