

## Tennessee Department of Transportation Division of Materials and Tests

### Submittal and Approval of Concrete Mixture Designs (SOP 4-4)

**Purpose:** This document establishes a process for submitting and approving all ready-mixed, prestressed, precast, and volumetrically batched concrete mixtures.

**Background:** Concrete designs submitted to Tennessee Department of Transportation (TDOT) for approval must exhibit certain physical performance properties indicated in TDOT Standard Specifications including, but not limited to, slump/slump flow, air content, temperature, unit weight, yield, and other specific contract information. Additionally, the hardened concrete must meet compressive strength requirements.

**Procedure:** A concrete mix design shall be subject to the following procedures prior to being approved for use in TDOT work:

A TDOT certified Concrete Mix Design Technician shall use volumetric mix design procedures. The proportions of all materials shall be in accordance with the appropriate Standard Specification sections (**204.06, 501.03, 604.03, 615.09, 619.03, 622.03, 702.02**) contract documents, and departmental procedures.

A trial batch shall be mixed per **604.03.A.2** and according to specified proportions, including appropriate admixtures. Tests for the freshly mixed concrete shall be conducted to determine the following properties as applicable (other tests may be required depending on the class of concrete):

Test	ASTM	AASHTO
Slump	C143	T 119
Temperature	C1064	T 309
Air Content - Pressure	C231	T 152
Compressive Strength	C39	T 22
Unit Weight / Yield	C138	T 121
Air Content - Volumetric	C173	T 196

**\*See Appendix D for additional test references**

Gradations and specific gravities for coarse and fine aggregates used in the trial batch shall reflect the characteristics of the stockpiles to be used in the mix. The hardened specimens, after proper curing, shall then be tested for compressive strength.

Approval:

**New Designs:** Producers shall submit a concrete mix design to Headquarters Materials and Tests (HQMT) with proportions that meet specification requirements and test results meeting field performance tolerances. Submissions shall be made no less than fourteen (14) working days prior to mix production. All submittals must be listed on the current version of the Concrete Mix Design Template. All designs shall be sent to [TDOT.Concrete.Email@tn.gov](mailto:TDOT.Concrete.Email@tn.gov) except precast designs which shall be sent to [TDOT.PrecastMTR@tn.gov](mailto:TDOT.PrecastMTR@tn.gov) (see Appendix A: Email Submission Example).

**Temporary Approval:** Designs submitted prior to their 28-day strength results may be approved on a temporary basis provided break data meets or exceeds the 28-day strength requirement **and any early age requirements at the specified time**. The approval will be temporary pending receipt of 28-day test results.

**Contract Association:** Once approved by HQMT, the new designs may be associated to another contract via the Concrete Design Contract Association Request Form. Association requests for Classes SCC, P-SCC, SH-SCC, Grout, Shotcrete and Class X require specific information in addition to the TDOT mix design number and contract. Class X, Shotcrete, and Grout mixes are subject to the same justification process they are originally approved under as described in Class Details.

**Backup:** New designs with **Supplementary Cementitious Materials** will have a straight cement version delivered automatically upon approval. These designs will only be certified to meet the original 28-day strength requirement and shall be permitted by the Engineer prior to use. The design will be generated by converting the total cementitious material to the selected hydraulic cement without subsequent modifications to the original design proportions. This action will not apply to PEM designs and any Maturity data will not be applicable to the backup design.

**Annual Renewal:** Approved concrete mix designs will expire at the end of each calendar year (i.e., December 31<sup>st</sup>). Starting October 3<sup>rd</sup> a query of the department's break data will be made to select designs for renewal. Designs that have been used within 90 days of this query will be selected for renewal provided they have 5 break sets within that timeframe. Further, designs used after this date will be renewed. The query will be repeated on the last business day for the year to capture any mixes used at the close of the year. Once approved, the new designs will be distributed to the Producer and Regional M&T. See Appendix E for a flowchart detailing this process.

**Expiration:** Mix designs will be subject to expiration if design strength or field requirements are not met. Designs with constituent materials that have failed quality testing will be expired. Temporary approvals which have not supplied 28-day break data will be expired **30 days after approval**.

**Material Change:** Any change to a constituent material in a mix requires a new mix design submission complete with trial batch and compressive strength data. Exceptions to this policy are listed under each material in the Materials section below.

**Maturity:** Break data provided from a strength maturity relationship may be used for design approval provided it represents adequate strength at the appropriate time per specification. See Appendix G for more details.

Class Details: **Self-Consolidating Concrete (SCC):** Any designs for SCC (including SCC, SH-SCC, and P-SCC) should be reviewed by HQMT prior to lab trials. Upon review, Regional Materials and Tests (M&T) shall be notified such that they may observe the trial batch in-person. SCC mixes must simulate an hour of travel time during the trial batch.

**Grout:** Grout designs will be reviewed based on the standard specification or plan/shop drawing requirements. If a compressive strength is specified (Structural), the design shall be reviewed and approved by HQMT. If no compressive strength is specified (Non-Structural), the design shall be furnished to the Project Supervisor and will be reviewed and approved by Regional M&T.

**Shotcrete:** Shotcrete designs require preconstruction test panel core data to be submitted with the design per **622.03**. This applies each time the design is requested from a new concrete plant or assigned to a new contract.

**Class X:** Any submission that deviates from prescribed contract specifications shall be evaluated as Class X requiring justification in the form of plans, specifications, or a statement of need from Regional M&T. Any form of justification should describe the necessary properties for the mix, properties for field acceptance based on tolerances, and the location or situation in which it will be used. Designs for local programs and bridge grants that come under Class X shall be approved by the Local Authority administering the project.

**Performance Engineered Mixture (PEM):** Any design submitted must have a trial batch performed in the presence of HQMT. Regional Materials and Tests (M&T) shall be notified such that they may observe the trial batch in-person. Proper documentation must be submitted before the design can be reviewed, approved, and issued to the producer. This documentation will be submitted for data collection purposes only and will include Super Air Meter (SAM) number, Resistance of Concrete to Rapid Freezing and Thawing, Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration, Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction, and Optimized Aggregate Gradations. See Appendix F for a flowchart diagram detailing this process.

Materials: **Hydraulic Cement:** The source and location must be listed on the Producer List and conform to the requirements in **901.01**.

**Fly Ash:** The source and location must be listed on the Producer List and meet the requirements outlined in **921.15** of the Standard Specifications. Portland Cement replacement by fly ash shall be in accordance with **604.03.A** of the Standard Specifications. In the event that a project may be delayed due to a fly ash allocation, the source of fly ash may be changed to another fly ash source listed on the Producer List

**Slag Cement:** The source and location must be listed on the Producer List and meet the requirements outlined in **921.16** of the Standard Specifications. Portland Cement replacement with slag cement shall be in accordance with **604.03.A**.

**Silica Fume:** The source and location must be listed on the Producer List and shall meet the requirements of AASHTO M 307.

**Water:** Refer to **921.01** of the Standard Specification. Non-municipal water sources shall provide their most recent water quality test results following the requirements of Table **921.01-1** and **921.01-2** along with the mix design submittal.

**Coarse Aggregate:** The source and location must be listed on the Producer List and meet the requirements in **903.03**. Where approved surface aggregates are required as per **903.03**, coarse aggregates must be listed on the Approved Surface Aggregates List and meet **903.24**. In the event that a project may be delayed due to an interruption in the supply of coarse aggregate, the source of coarse aggregate may be changed to another approved source of like material (e.g., limestone for limestone, or granite for granite) without trial batching provided the specific gravity of the new material is within 0.15 of the original material.

**Fine Aggregate:** The source and location must be listed on the Producer List and meet the requirements in **903.01**. Manufactured sand shall not be used in mixes designed as riding surfaces.

**Chemical Admixtures:** All admixtures must be listed on the Qualified Products List (QPL-4) and meet the requirements **921.06**. Admixture dosage rates used in the trial batch shall be submitted on the Concrete Mix Design Template. If the producer requests to use admixtures from multiple manufacturers in one mix design, a 3-month history of use in private or commercial work must be provided indicating compatibility between the admixtures. Before approval, a trial batch must be verified by HQMT or designee.

Distribution:

Once the design approval or expiration, the design will be distributed as follows:

- An electronic copy will be kept on file at HQMT.
- An electronic copy will be sent to the Producer.
- An electronic copy will be sent to Regional Materials and Tests.
  - Regional Materials and Tests will forward copies to the Project Supervisor (Project Supervisor will ensure that the Project Inspector receives a copy)

Links:

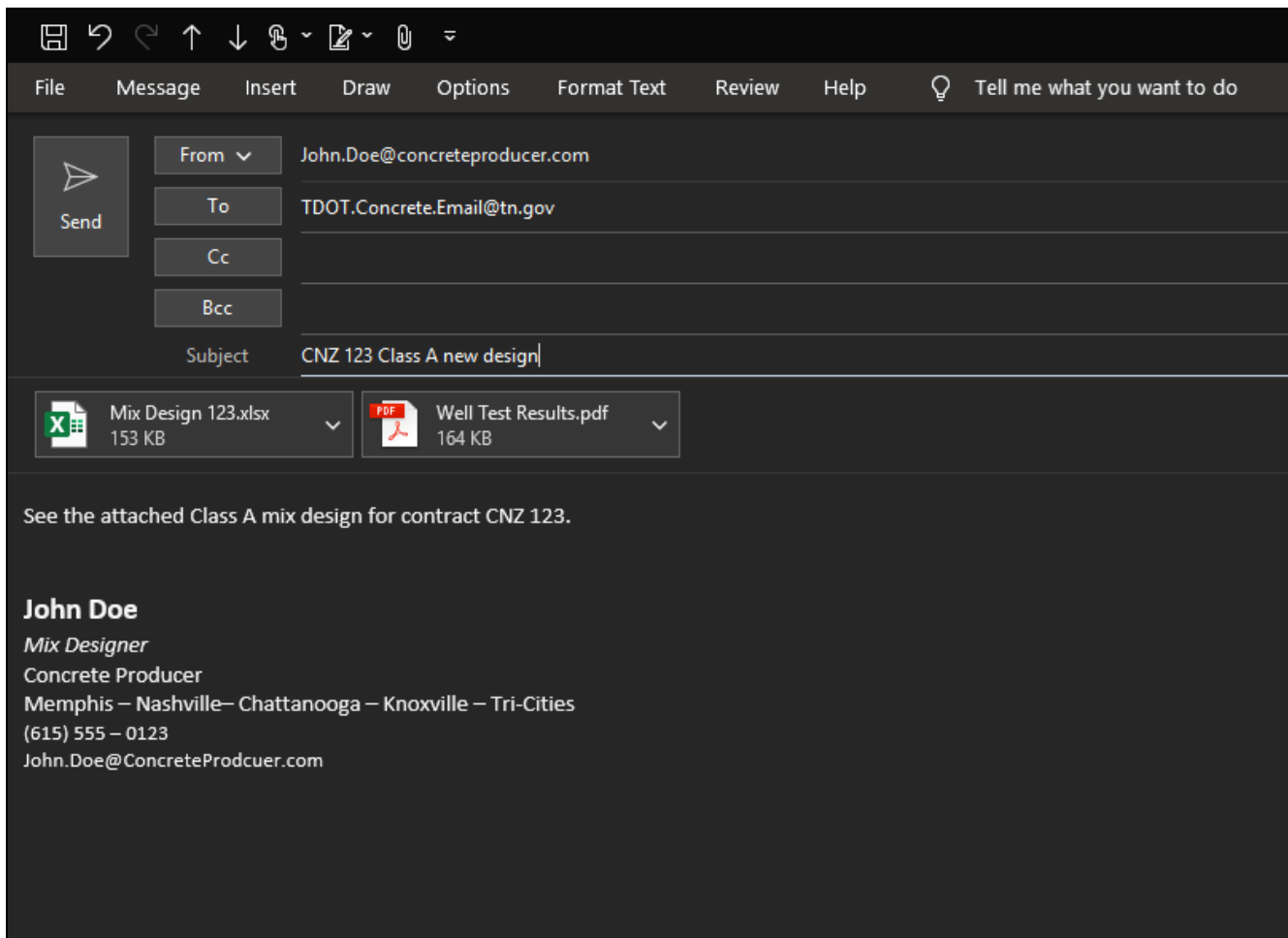
- [TDOT Standard Specifications](#)
- [Standard Operating Procedures](#)
- [Concrete Mix Design Template](#)
- [Design Contract Association Request Form](#)
- [TDOT Producer List](#)
- [Surface Aggregate List](#)
- [Qualified Products List \(QPL\)](#)
- [Contract Break Data](#)

## Appendix A: Email Submission Example

Emails should indicate whether the design is a new submission or an association and provide a contract or PIN in the subject line.

In the body, include other information like test results (SCC, shotcrete, etc.), surface aggregate requirements, or extra information if unfamiliar with job designation. Contact information is also useful for a quick turn-around if there is an issue with the submission or further information is needed.

Attach the completed design template or association form and any other documents like well water test results or plans and specifications as needed for the submission. Please note any attachments in the body of the message. The design should be in Excel format (.xlsx) and other items may be submitted in other common formats (.docx, .jpeg, .pdf, etc.).



## Appendix B: Concrete Mix Design Example

This example template shows the basic required information for a Class A mix.

Each material that is used with the mix should be entered and its line should be filled all the way across (certain cells cannot be interacted with like the red cells and will populate automatically). All mixes should include admixture dosage rates.

Break data may be required and can be entered down to the minute (time is displayed in 24-hour notation but is entered in normal 12-hour notation).

Specific test data or usage notes may be entered in the remarks section at the bottom (SCC, shotcrete, etc.).

Altered or manipulated templates will not be reviewed and shall be returned to sender. If the template does not contain an expected material or product is not available, please notify the team at [TDOT.Concrete.Email@tn.gov](mailto:TDOT.Concrete.Email@tn.gov).

CONCRETE MIXTURE DESIGN TEMPLATE															VERSION 1.22					
Contract Number		CNZ 123			Pin Number			Project Ref. No.			Plant Number				12345678					
Plant Producer/ Location		Concrete Producer			Class of Concrete			Class A			Strength (psi)		3000		at 28 DAYS		Early Str.			
Contractor																				
P/S Code	Cementitious Materials (cm)			Type/Class/Grade	Source			G <sub>s</sub> (SSD)	Weight, lbs.	Volume, ft <sup>3</sup>										
23300023	Cement			Blended Cement Type II	Buzzi Unicem - Chattanooga TN			3.11	423.0	2.180										
59900369	Flyash			Pozzolans (Fly Ash Class F)	Boral Resources - Ghent KY			2.68	141.0	0.840										
0	Slag Cement																			
P/S Code	Aggregates			Type/Size	Source			G <sub>s</sub> (SSD)	Weight, lbs.	Volume, ft <sup>3</sup>										
59900107	Coarse Aggregate 1 (CA1)			Crush Stone #57	Barrette Paving Materials Inc - Fairborn OH			2.50	1800.0	11.540										
0	Coarse Aggregate 2 (CA2)																			
0	Coarse Aggregate 3 (CA3)																			
11000001	Fine Aggregate 1 (FA1)			Manufactured Sand	Blue Water Industries - Watauga			2.80	1100.0	6.780										
0	Fine Aggregate 2 (FA2)																			
P/S Code	Air-Entraining Admixture			Brand Name - Product		Dosage (oz/cwt)		% Air	Weight, lbs.	Volume, ft <sup>3</sup>										
89900105				Master Builders - Mastercell 25		1		6.0	---	1.620										
P/S Code	Water			w/cm =	City Water															
0				0.45					1	254.0	4.070									
P/S Code	Chemical and Other Admixtures			Brand Name - Product		Dosage (oz/cwt)		Design Parameters												
89900105	Type A - Water Reducer			Master Builders - Master Poly/Heed 1020		1		Total cm Weight, lbs.				564.0								
89900105	Type B - Retarder			Master Builders - MasterSet R 300		2		Total Aggregate Volume, ft <sup>3</sup>				18.320								
89900105	Type C - Accelerator			Master Builders - MasterSet AC 122		3		%FA of Total Agg. Vol.				37								
89900105	Type D - Reducer/Retarder			Master Builders - MasterPozzolith 700		0		Theoretical Unit Wt., pcf				137.6								
89900105	Type E - Reducer/Accelerator			Master Builders - MasterSet FP 20		0		Freshly-Mixed Properties												
89900105	Type F - High-Range Water Reducer			Master Builders - MasterGlenium 7500		5		Air Content, %				4.1								
0	Type G - High-Range/Retarder							Temperature, °F				68.0								
0	Misc Admixtures for Concrete							Slump/Flow, in.				6.5								
0	Misc Admixtures for Concrete							Unit Weight, pcf				141.31								
0	Type S - Specific Performance							Yield				27.0								
0	Precast																			
AGGREGATE DATA																				
CA/FA	4"	3-1/2"	3"	2-1/2"	2"	1-1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200	FM	Absorption	
CA1	100	100	100	100	100	100	99	81	32	17	4	2	0	0	0	0	0.0	---	1.6	
CA2																		---		
CA3																		---		
FA1	100	100	100	100	100	100	100	100	100	100	95	80	78	27	15	10	1	2.95	4.8	
FA2																		10.00		
COMPRESSIVE STRENGTH DATA																				
Sample No.	Date Made	Date Tested	Age, days	Length, in.	Dia., in.	L/D	C	Area, in <sup>2</sup>	Load, lbs.	Strength, psi	Average, psi									
1	1/27/22 0:00	2/24/22 0:00	28	8.00	4.00	2.00	1.00	12.57	45000	3581	3620									
2	1/27/22 0:00	2/24/22 0:00	28	8.00	4.00	2.00	1.00	12.57	46000	3661										
			0			0.00		0.00		0	0									
			0			0.00		0.00		0	0									
			0			0.00		0.00		0	0									
			0			0.00		0.00		0	0									
			0			0.00		0.00		0	0									
			0			0.00		0.00		0	0									
			0			0.00		0.00		0	0									
			0			0.00		0.00		0	0									
Remarks: design notes, special test results...										Mix ID:										
Technician Name: D Black										Certification Number: 1234										

# Appendix C: Concrete Design Contract Association Example

The form below is an example of how to associate a design to multiple contracts. Please note that depending on the class of concrete, additional paperwork may be needed as stated in the requirements above.

### CONTRACTOR REQUEST FOR DESIGN/CONTRACT ASSOCIATION

STATE OF TENNESSEE

DEPARTMENT OF TRANSPORTATION  
DIVISION OF MATERIALS AND TESTS  
6601 CENTENNIAL BLVD.  
NASHVILLE, TENNESSEE 37243-0360



11/1/2022

Joe Concrete

0001

JC Redi-mix

Date

Requested By

Cert Number

Producer

Contract

TDOT Mix ID

229999

Contract

CNA 123

Class

Class A

Plant

Nashville Centennial

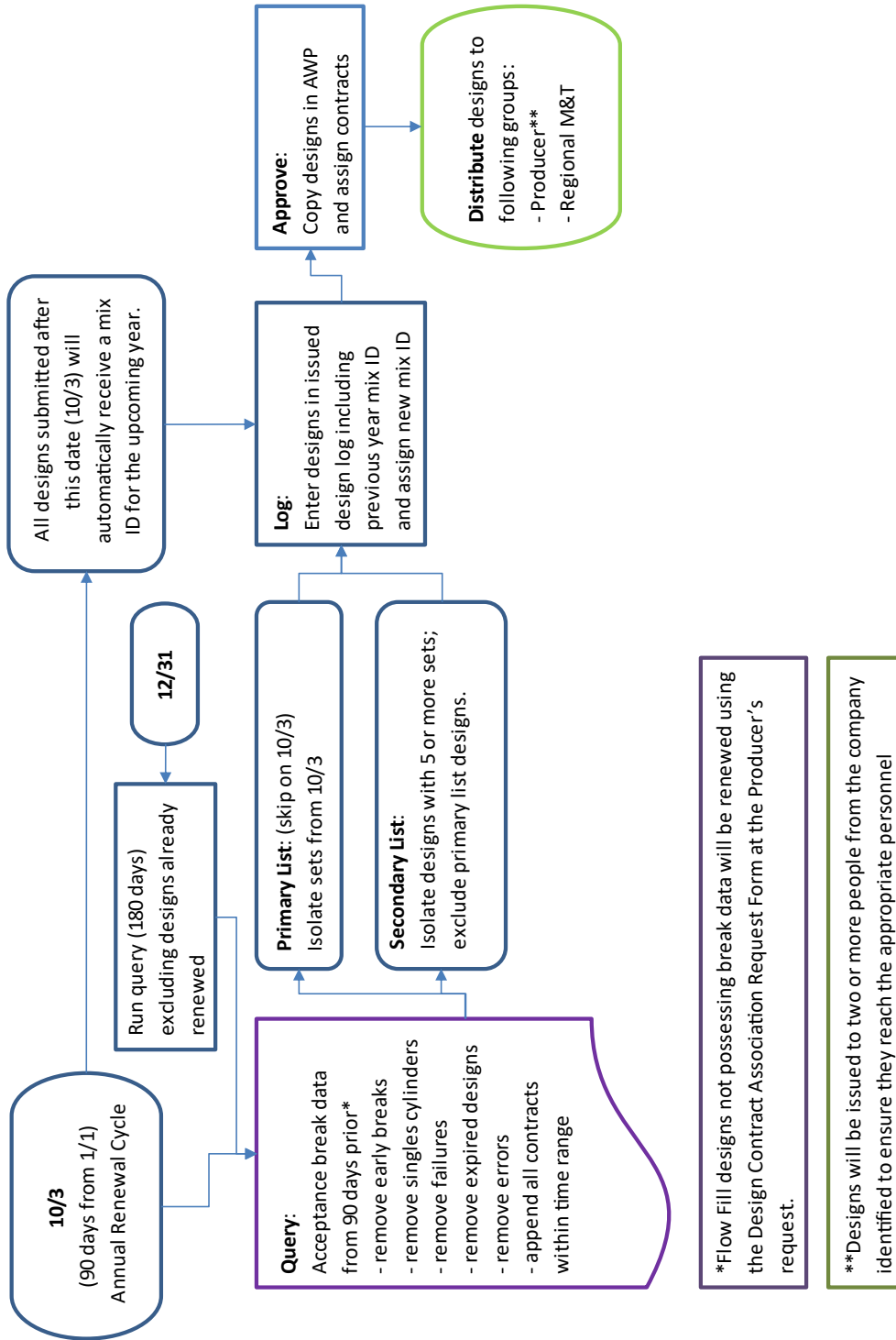
Comments

## Appendix D: Test Method Reference Table

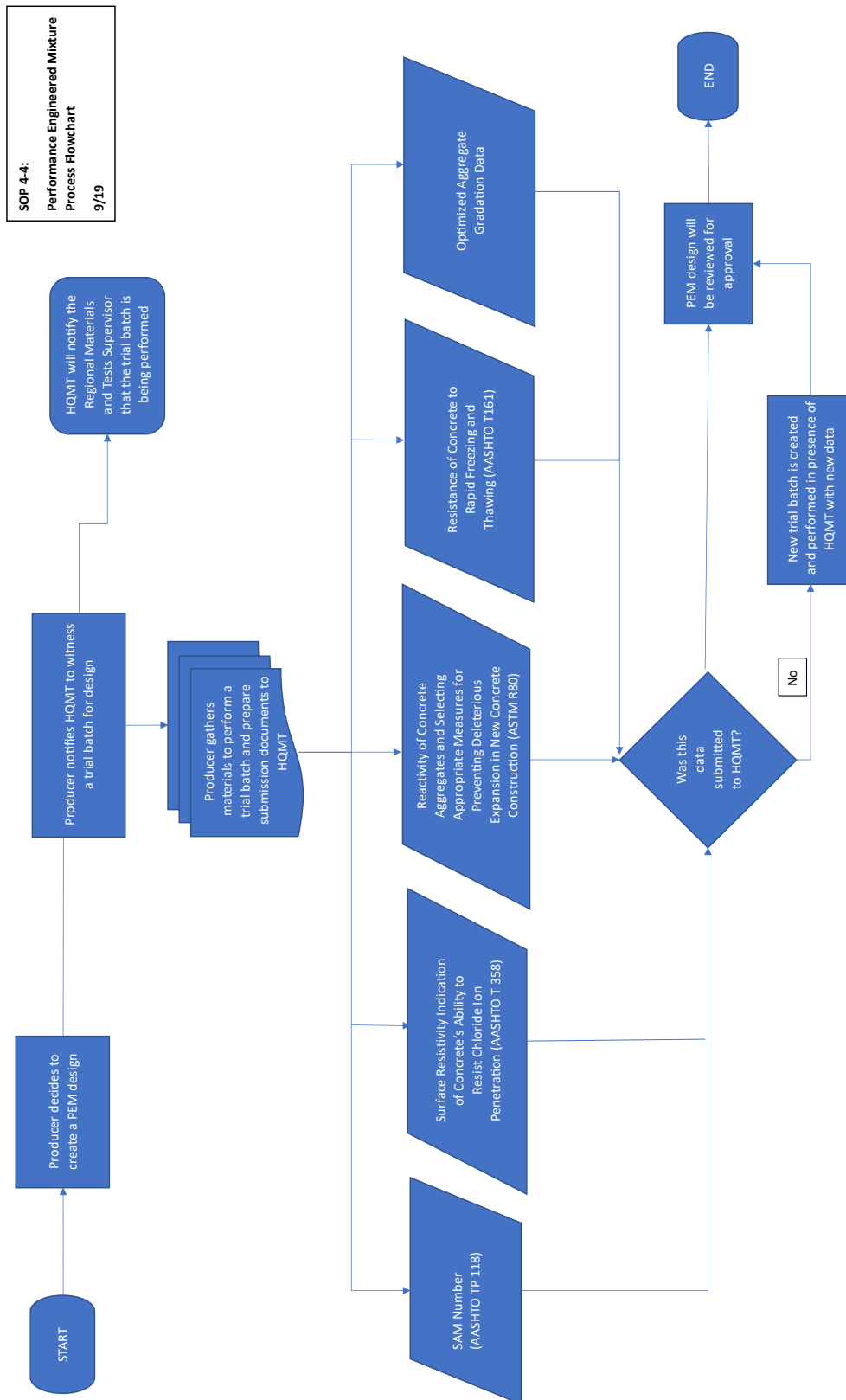
	<b>Test</b>	<b>ASTM</b>	<b>AASHTO</b>
<b>Conventional</b>	Slump	C143	T 119
	Temperature	C1064	T 309
	Air Content - Pressure	C231	T 152
	Compressive Strength	C39	T 22
	Unit Weight / Yield	C138	T 121
	Air Content - Volumetric	C173	T 196
<b>SCC</b>	Test Specimens with SCC	C1758	--
	Slump Flow/T50/VSI	C1611	T 347
	Passing Ability	C1621	T 345
	Static Segregation	C1610	--
<b>PEM</b>	Super Air Meter (SAM)	--	T 395
	Surface Resistivity	--	T 358
	ASR	--	R 100
<b>Misc.</b>	Flow Fill Consistency	TDOT 204.06.B	
	Flow Fill Air Content	D6023	--
	Flow Fill Compressive Strength	D4832	--
	Shotcrete Boiled Absorption	C642	--
	Air Dried Unit Weight	C567	--
	Maturity	C1074	T 325



# Appendix E: Annual Renewal Process



## Appendix F: Performance Engineered Mixture Process



## **Appendix G: Estimating Compressive Strength using the Maturity Method**

The Department accepts concrete strength based on the maturity method as per AASHTO T 325. This method can be used with any class of concrete.

The strength-maturity relationship (s-m curve) and all supporting documentation shall be submitted to HQMT for approval prior to implementation in field activities. Upon approval, the s-m curve will be assigned the mix ID which it represents followed by a sequential letter (ex. 229999A, 229999B...). The s-m curve will be validated periodically using the following schedule.

<b>Class</b>	<b>First set</b>	<b>Continuous production</b>
<b>A, CP</b>	100 cy	500 cy
<b>D, SH-SCC, HE*</b>	50 cy	250 cy

\* All designs with an early requirement

Validation shall consist of a pair of cylinders broken and compared with the s-m curve. Breaks that occur within 10% of the s-m curve are acceptable. Breaks outside this range will necessitate a return to physical testing and a new s-m curve.

An s-m curve submission must include the following:

- the batch weights and dosage rates used in the trial batch
- the temperature history of the trial batch
- the s-m curve generated during the trial batch
- the brand and model number of the data collection apparatus
- all other information as required by the standard

If batch information indicates the mix is substantially changed (out of tolerance, change of material...) then the s-m curve will be deemed invalid and physical testing shall be performed to determine the strength of the concrete.

When making a decision on a critical activity using the maturity method, the contractor shall submit a letter to the engineer certifying that the placement follows the requirements of AASHTO T 325.