CERTIFIED

CONCRETE

PLANT

TECHNICIAN

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Certification Information

CERTIFIED CONCRETE PLANT TECHNICIAN HANDBOOK

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The following can be found in the Business Center at https://www.roads.maryland.gov/pages/home.aspx

- Standard Specifications for Construction and Materials
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Part One

Presentations

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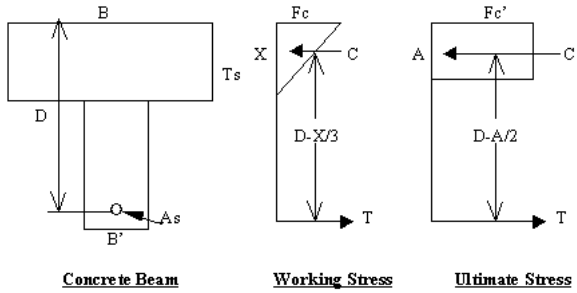
Certified Plant Technician

MRMCA / MSHA

Engineering Concrete

- f'c = Strength
- Place-ability
- Durability
  - Resistance to Freeze Thaw Damage
  - Resistance to ASR
  - Resistance to Sulfate Attack
  - Resistance to Chloride Intrusion
  - Other

Concrete Strength



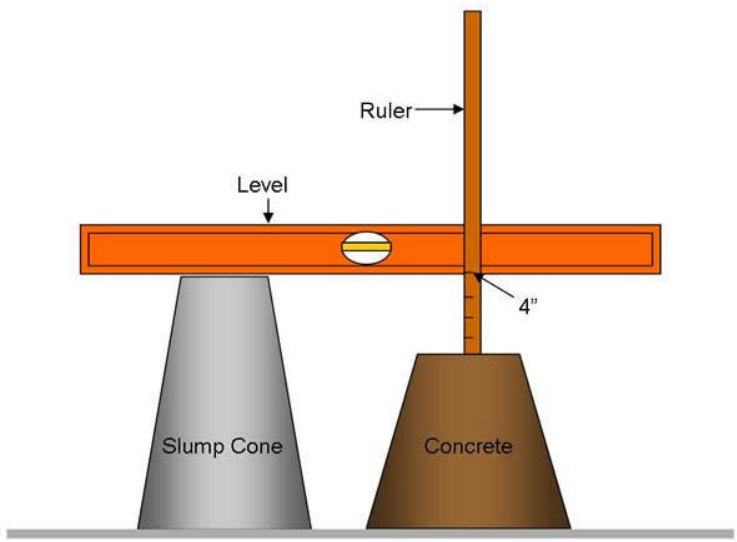
f'c = strength required to withstand live and dead loads + safety factor

State Requirements Strength

Mix No.	28 Day Specified Compressive Strength psi
1	2500
2	3000
3	3500
4	3500
5	3500
6	4500
7	4200
8	4000
9	3000 (24 hr)
10	4500
11	4200
12	4200

Strength Tests

- Lab cured cylinders measure the strength potential of the concrete as delivered by the concrete producer.
- Lab cured cylinders do not measure the strength of the structure.



State Specification
Slump

Mix No.	Slump Range in.
1	2-5
2	2-5
3	2-5
4	4-8
5	2-5
6	2-5
7	1 ½-3
8	2-5
9	4-8
10	2-5
11	2-5
12	2-5

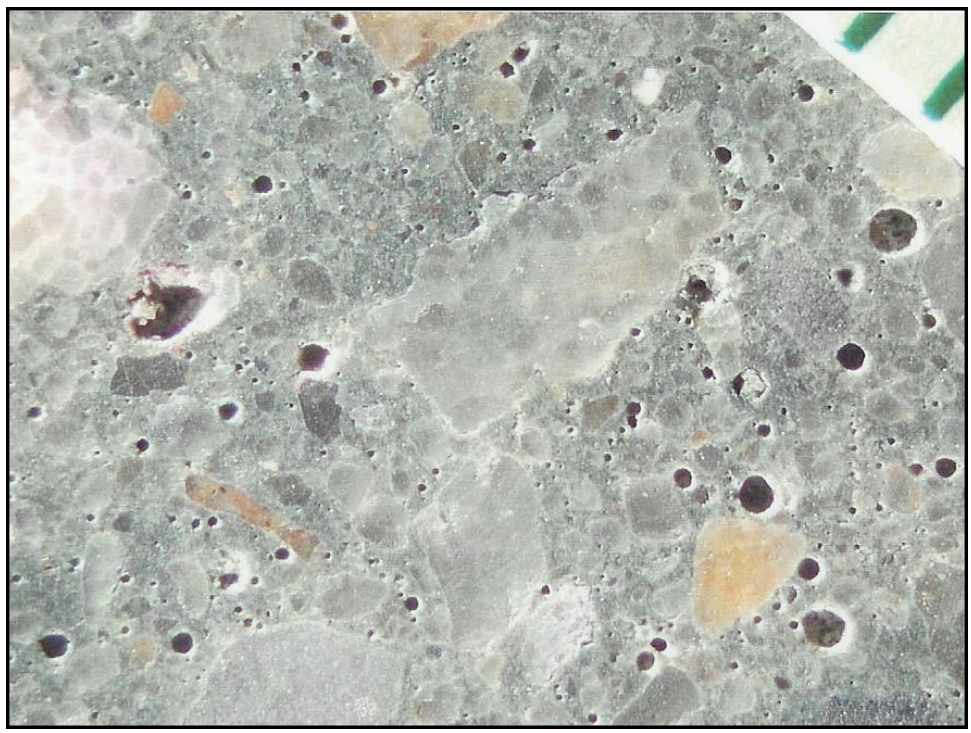
Slip-Formed mixes – 2½" Max.

Slump

- Measurement of consistency
- Measurement of place-ability
- Not a direct measurement of the amount of water in the concrete.

Wide variations in slump is an indication that something is wrong. Check to make sure admix is being dispensed correctly. Check that there is not water in trucks before batching. Check moistures in aggregate. Inform plant QC technician.

Freeze Thaw



State Requirements
Air Entrainment

Mix No.	Total Air Content %
1	5-8
2	5-8
3	5-8
4	N/A
5	5-8
6	5-8
7	5-8
8	5-8
9	5-8
10	6-9
11	5-8
12	6-9

Air

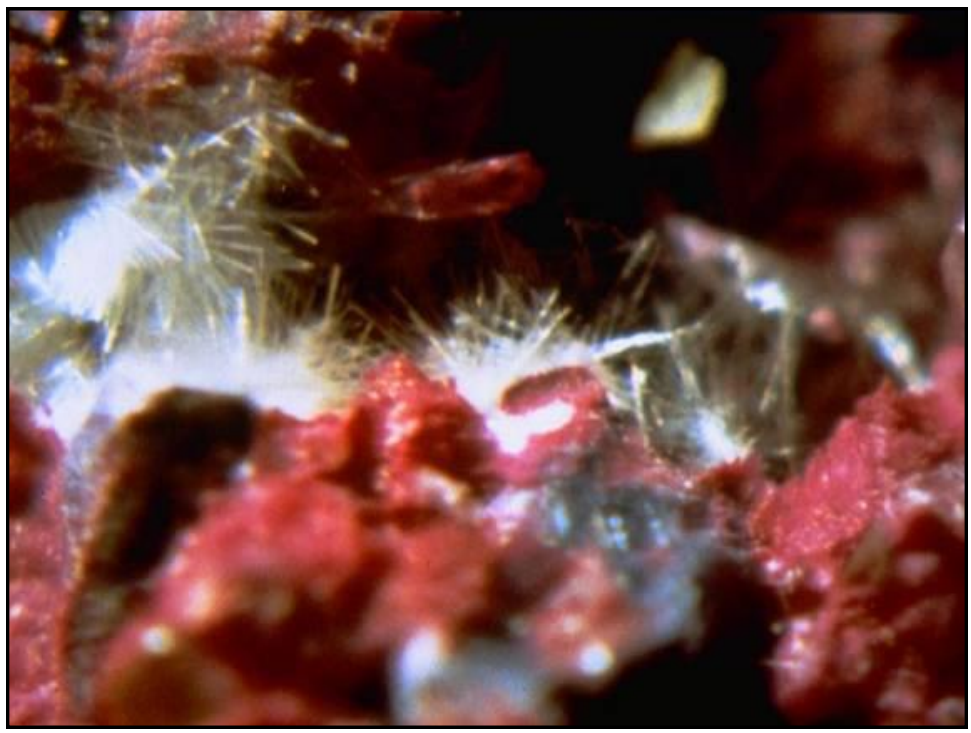
- Increases the durability of concrete in freeze thaw environments by providing spaces for freezing water to expand into
- Causes a slight decrease in concrete strength
- Increases with increasing slump
- Should not be used in interior concrete slabs that will get a hard trowel finish (non state work)

Durability (ASR)

State Requirements for ASR

- All aggregate is tested to determine whether it is reactive.
- If aggregate is not reactive, there are no restrictions on its use.
- If aggregate is reactive, producer must do one of the following:
  - Use slag cement, fly ash, or blended cement as prescribed
  - Ternary blends allowed but must test to prove mitigation is effective.
  - Change to a non-reactive aggregate

Durability
(Sulfate Attack)



State Requirements

When exposed to water exceeding 15,000 ppm sodium chloride content:

- Use Type II cement.
- Use a Type I cement with slag cement or fly ash and documentation of satisfactory sulfate resistance.

Additional Requirements for Durability

Mix No.	Min Cement Factor lb/yd^3	Max Water/ Cement Ratio by weight	Concrete Temp °F
1	455	0.55	70 +/- 20
2	530	0.50	70 +/- 20
3	580	0.50	70 +/- 20
4	615	0.55	70 +/- 20
5	580	0.50	70 +/- 20
6	615	0.45	65 +/- 15
7	580	0.50	70 +/- 20
8	750	0.42	65 +/- 15
9	800	0.45	70 +/- 20
10	700	0.45	65 +/- 15
11	-	0.45	65 +/- 15
12	-	0.45	65 +/- 15

Why the Minimum Cementitious Factor?

- Strength does not equate to durability.
- Concretes with lower cementitious contents may have durability issues such as scaling.
- Concretes with lower cementitious contents may be harder to finish.

Why the Requirements for Water / Cementitious Ratio (WCR)

Concretes with low water / cementitious ratios are generally:

- Less permeable.
- More resistant to sulfate attack.
- Less susceptible to freeze thaw damage.

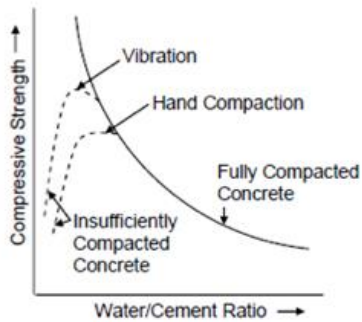
Water / Cementitious Ratio (WCR)

What is it and why is there a limit?

$$WCR = \frac{\text{Weight of Water}}{\text{Weight of Cementitious Material}}$$

Water includes any additional water from aggregate moisture and that added in any way to the truck.

Duff Abrhams' WCR Law



In general, the higher the WCR, the lower the strength.

Why the Temperature Requirements

- Hot temperatures increase water demand and cause accelerated set times
- Low temperatures retard set times and can cause excessive bleeding

Certified Plant Technician
Part II
Mix Designs

MRMCA and MSHA

Basics of Mix Designs
How much will it take to fill a hole with concrete

Basics

- Density of water = 62.4 lbs./ft^3
- Conversion factor – water volume to mass
  - One gallon of water = 8.33 lbs.
- 1 yd^3 = 27 ft^3
- Absolute Volume – volume of materials without any void spaces – volume used when calculating materials in a concrete mix
- WCR = $\frac{Water\ (lbs.)}{Cement + Fly\ Ash + Slag\ Cement\ (lbs.)}$

Specific Gravity – Conversion of Weight to Absolute Volume

- Specific Gravity – Used to convert weight to volume or volume to weight

  – SpG = $\frac{Density\ of\ Material}{Density\ of\ Water} = \frac{Density\ of\ Material}{62.4}$

  – Volume = $\frac{Weight}{Specific\ Gravity\ x\ 62.4}$

	SpG	
Portland Cement	3.15	
Slag Cement	2.93	Absorption
Coarse Aggregate	2.79	0.2
Fine Aggregate	2.68	0.7

Material	Weight / Amount	Volume
Cement	465 lbs.	$= \frac{Weight\ of\ Cement}{SpG\ of\ Cement\ x\ Density\ of\ Water} = \frac{465}{3.15\ x\ 62.4} =$ 2.37 ft^3
Slag Cement	155 lbs.	$= \frac{Weight\ of\ Slag\ Cement}{SpG\ of\ Slag\ Cement\ x\ Density\ of\ Water} = \frac{155}{2.93\ x\ 62.4} =$ 0.85 ft^3
Coarse Aggregate	1800 lbs.	$= \frac{Weight\ of\ Coarse\ Aggregate}{SpG\ of\ Coarse\ Agg\ x\ Density\ of\ Water} = \frac{1800}{2.79\ x\ 62.4} =$ 10.34 ft^3
Fine Aggregate	1240 lbs.	$= \frac{Weight\ of\ Fine\ Aggregate}{SpG\ of\ Fine\ Agg\ x\ Density\ of\ Water} = \frac{1240}{2.68\ x\ 62.4} =$ 7.41 ft^3
Water	33 gal	$= \frac{Weight\ of\ Water}{Density\ of\ Water} = \frac{33\ x\ 8.33}{62.4} =$ 4.41 ft^3
Air (%)	6%	= 0.06 x 27 = 1.62 ft^3
Total Volume		27 ft^3
Water Reducer	3 oz./cwt	
Air Entrainer	0.4 oz./cwt	

Prescriptive and Performance Specifications

- Prescriptive – Engineer specifies cement contents, types of admixtures, types of cements and cementitious materials, water cement ratios, etc.
- Performance – Engineer specifies performance criteria, such as strength, and leaves the types and amounts of materials in the mix design to the concrete producer.

State Spec / Prescriptive

Mix No.	28 Day Specified Compressive Strength psi	Standard Deviation psi	Critical Value psi	Min Cement Factor lb/yd^3	Coarse Aggregate Size M 43/M 195	Max Water/ Cement Ratio by weight	Slump Range in.	Total Air Content %	Concrete Temp °F
1	2500	375	2430	455	57, 67	0.55	2-5	5-8	70 +/- 20
2	3000	450	3010	530	57, 67	0.50	2-5	5-8	70 +/- 20
3	3500	525	3600	580	57, 67	0.50	2-5	5-8	70 +/- 20
4	3500	525	3600	615	57, 67	0.55	4-8	N/A	70 +/- 20
5	3500	525	3600	580	7	0.50	2-5	5-8	70 +/- 20
6	4500	675	4770	615	57, 67	0.45	2-5	5-8	65 +/- 15
7	4200	630	4420	580	57	0.50	1 ½-3	5-8	70 +/- 20
8	4000	600	4180	750	7	0.42	2-5	5-8	65 +/- 15
9	3000 (24 hr)	N/A	N/A	800	57, 67	0.45	4-8	5-8	70 +/- 20
10	4500	675	4770	700	¾" - No. 4	0.45	2-5	6-9	65 +/- 15
11	4200	630	4420	-	57, 67	0.45	2-5	5-8	65 +/- 15
12	4200	630	4420	-	¾" – No. 4	0.45	2-5	6-9	65 +/- 15

The State tells the producer:

- The allowable types and minimum amounts of cement to use.
- The allowable types and percentages of fly ash to be used.
- The allowable grades and percentages of slag cement to be used.
- The types and brands of admixtures that may be used.
- The acceptable gradations of aggregates that may be used.
- The maximum water cement ratio.
- The acceptable slump range, air content range, and temperature range.

Producer takes the information and develops their mix design

Material	SP GRAV	%w	SSD Wts(lbs)	Volume(cf)
Cement	3.15	~	406	2.07
GGBFS	2.95	~	174	0.95
Fly Ash	2.20	~	0	0.00
Microsilica	2.20	~	0	0.00
Stone	2.79	0.0	1825	10.48
Gravel	2.62	0.0	0	0.00
Pea Stone	2.84	0.0	0	0.00
Pea Gravel	2.61	0.0	0	0.00
Sand	2.62	0.0	1203	7.23
Water	1.00		290	4.65
Water + Admix	1.00		288	4.61
Air,%	6.50			1.7615
			Design Yield	27.10 cf

Trial Batches

- Trial batches are used to certify that mixes meet State requirements
- Approval given when strength requirements have been met
- Notify AME 2 weeks in advance of a trial batch
- Batch at least 3 yd^3 of concrete
- AME may wave trial batch if performance records show required average strength requirement has been met

Triggers for Trial Batches

- Change in cement type
- Change in coarse or fine aggregate
- Change in mixture proportions

Plant Cert IIIA
Cementitious

MRMCA / SHA

Materials

- Cementitious and Pozzolanic
- Aggregate
- Admixtures
- Water

Plant Cert IIIA
Materials / Cementitious and Pozzolanic

MRMCA / SHA

Cementitious and Pozzolanic

- Portland Cement
- Fly Ash
- Silica Fume
- Slag Cement
  (Ground Granulated Blast Furnace Slag)

- Portland Cement
- Fly Ash
- Silica Fume
- Ground Granulated Blast Furnace Slag

Certified Concrete Plant Technician Program

- Portland Cement – Raw Materials

	Source
Lime	Limestone
Silica	Clay, Fly Ash, Sand
Alumina	Bauxite, clay, Shale
Iron	Iron ore, Mill Scale
Gypsum	

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- Finished Compounds

Notation	Compounds
C_3S	Tricalcium Silicate
C_2S	Dicalcium Silicate
C_3A	Tricalcium Aluminate
C_4AF	Tetracalcium Aluminoferrite

- Types of Portland Cement

Type	Purpose
Type I	General Purpose
Type II	Moderate Sulfate Resistance
Type III	High Early Strength

Specifications

- Meets the requirements for AASHTO M85
- Maximum temperature for cementitious materials is 170^{o} Fahrenheit

Certified Concrete Plant Technician Program

When concrete is to be placed in water containing more than 15,000 ppm sodium chloride:

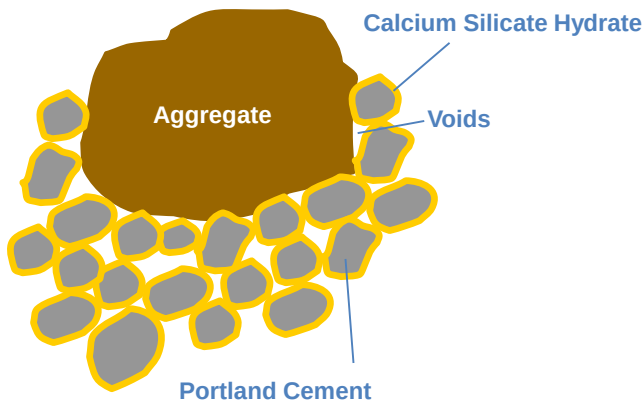
- A Type II cement shall be used , or
- A Type I cement may be used with up to 50% Ground Granulated Blast Furnace Slag or 25% Type F fly ash when data is provided showing that expansion does not exceed 0.10 percent at 180 days (when tested according to ASTM C 1012)

Certified Concrete Plant Technician Program

Cement Hydration Process

Cement + Water $\longrightarrow$ CSH + CaOH

Certified Concrete Plant Technician Program



Portland Cement Concrete System

Sampling

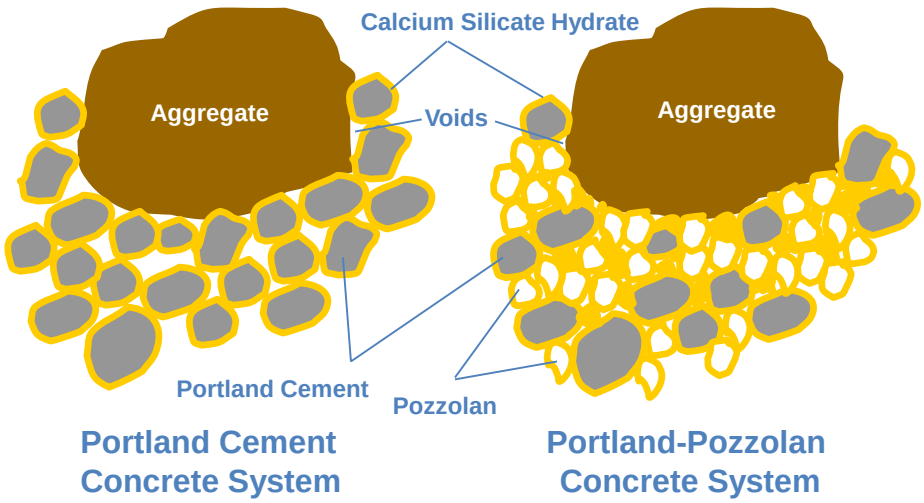
- 10 lb. Sample in a plastic jar with a screw cap approximately 4”(in) diameter
- Take one sample every two weeks when concrete is being regularly produced for State work
- Take one sample every month when little or no concrete is being produced for state work

Certified Concrete Plant Technician Program

- Modern Pozzolans
  - Fly Ash
  - Silica Fume
  - Slag Cement

Certified Concrete Plant Technician Program

Pozzolanic Reaction



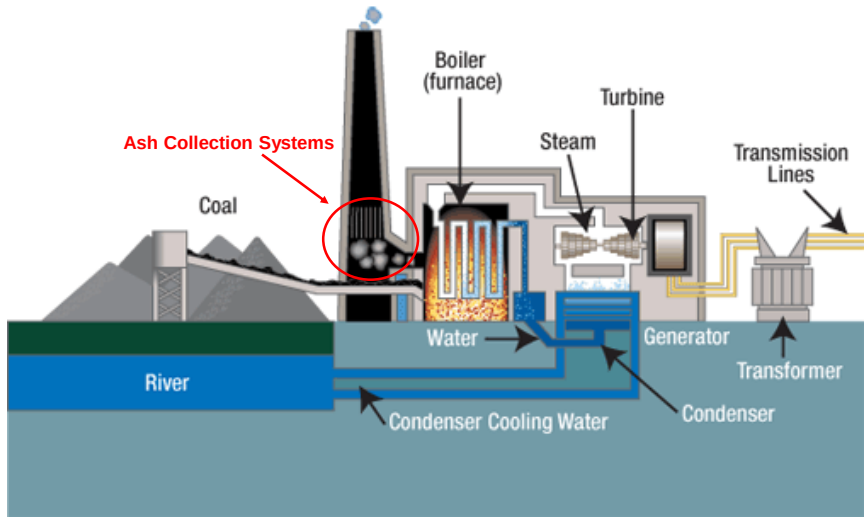
Pozzolans can improve concrete by:

- Decreasing permeability;
- Increasing resistance to sulfate attack;
- Increasing resistance to ASR;
- Increasing ultimate strength;
- In some cases, improving workability.

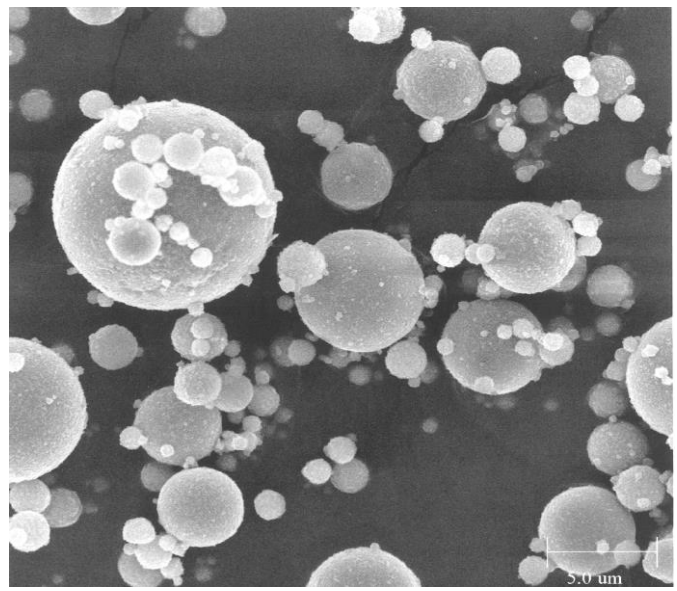
Certified Concrete Plant
Technician Program

- Portland Cement
- Fly Ash
- Silica Fume
- Slag Cement
  (Ground Granulated Blast Furnace Slag)

Basic Diagram of Coal Fired Power Generation



Fly Ash Particles



- Fly Ash
  - Type F
  - Type C

Certified Concrete Plant Technician Program

Type F - Fly Ash

- Combustion by-product from coal burning furnace
- Made up of anthracite and bituminous coals
- High percentage of SiO_2, Al_2O_3, and Fe_2O_3 (more than 70%)
- Lower percentage of CaO
- Amorphous silica combines with CaOH to form CSH

Certified Concrete Plant Technician Program

Type C - Fly Ash

- Combustion by-product from coal burning furnace
- Made up of subbituminous and lignite coal
- Lower percentage of SiO_2, Al_2O_3, and Fe_2O_3 (more than 50%)
- Amorphous silica combines with CaOH and CaO to form CSH

Certified Concrete Plant Technician Program

Sampling

- 10 lb. Sample in a plastic jar with a screw cap approximately 4”(in) diameter
- Take one sample every two weeks when concrete is being regularly produced for State work
- Take one sample every month when little or no concrete is being produced for state work

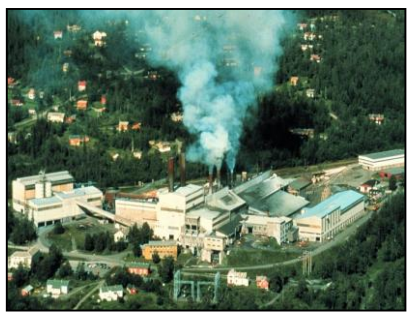
Certified Concrete Plant Technician Program

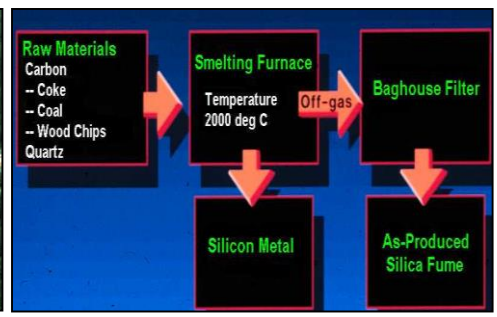
Certified Concrete Plant
Technician Program

- Portland Cement
- Fly Ash
- Silica Fume
- Slag Cement
  (Ground Granulated Blast Furnace Slag)

Silica Fume for SF Cement

- **A co-product of the manufacture of silicon metals and ferro-silicon alloys in a submerged electric arc furnace.**





Specifications

- Meets requirements for ASTM C 1240 (the oversize requirement is waived)
- The replacement level for microsilica is 5% to 7%

Certified Concrete Plant Technician Program

Sampling

- 10 lb. Sample in a plastic jar with a screw cap approximately 4”(in) diameter
- Take one sample every two weeks when concrete is being regularly produced for State work
- Take one sample every month when little or no concrete is being produced for state work

Certified Concrete Plant Technician Program

Certified Concrete Plant
Technician Program

- Portland Cement
- Fly Ash
- Silica Fume
- Slag Cement
  (Ground Granulated Blast Furnace Slag)

Slag Cement

- Byproduct of the reduction of iron ore (steel manufacturing);
- Material becomes liquid at 2500-2700°F;
- Molten slag floats on top of molten iron.

Specifications

- Meet the requirements of AASHTO M302 for Grade 100 or Grade 120
- May substitute a maximum of 50% by weight

Plant Cert III E

Admixtures

Admixtures

- Used to enhance concrete.
- Governed by ASTM
- As necessary an ingredient as cement itself!

Requirements

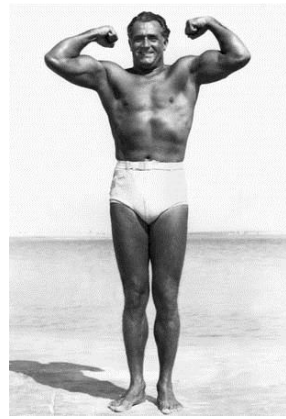
- All admixtures shall be tested and approved
- All dispensers shall be visible, easily read, and calibrated
- All additives shall be prevented from freezing in the winter months
- All dispensers shall be flushed regularly to clean them?

Did You Know?
Adding One Gallon of Water Will:

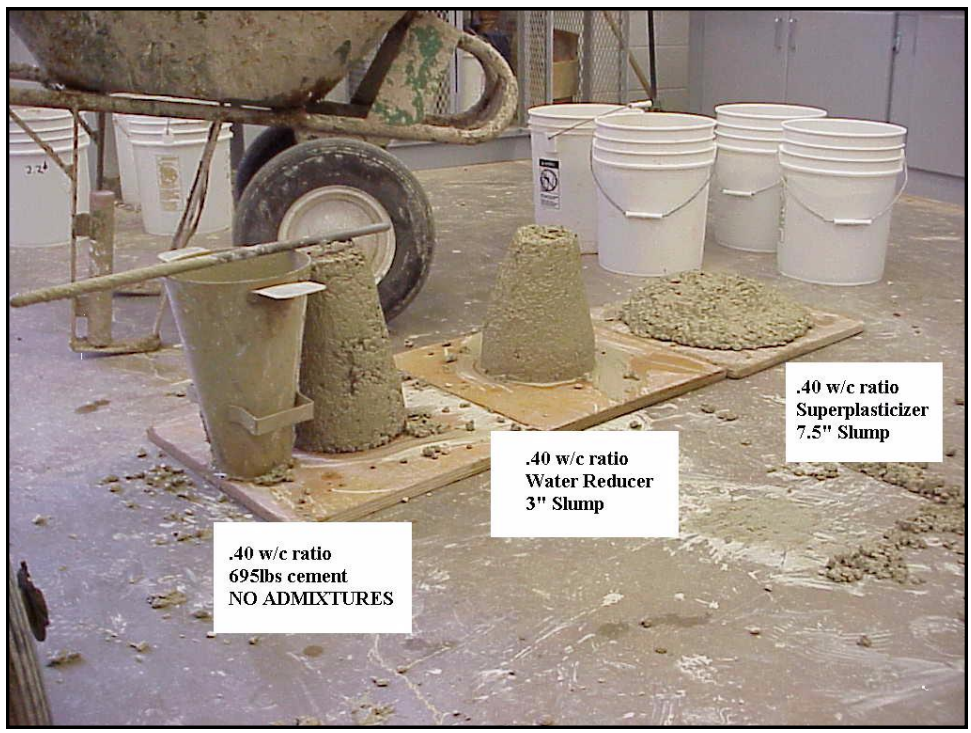
- Increase the slump about ONE INCH
- Cut the compressive strength about 200 psi
- Increase air content about 1%

Water reducers are used to:

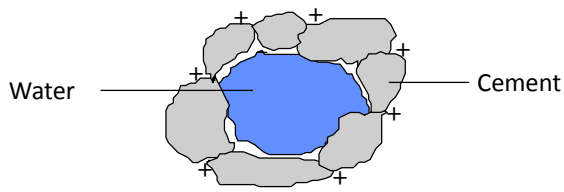
Make concrete stronger by reducing the amount of water required for a given slump / slump flow.



Type A - Normal Water Reducers
Type D – Water Reducer and Retarder

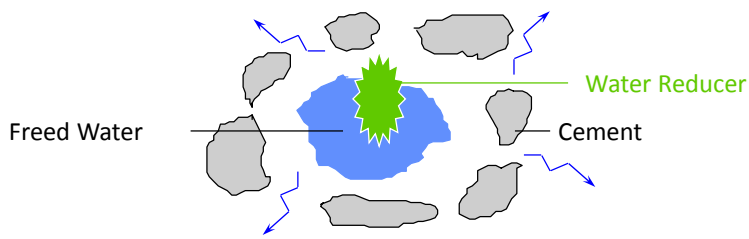


How Water Reducers Work



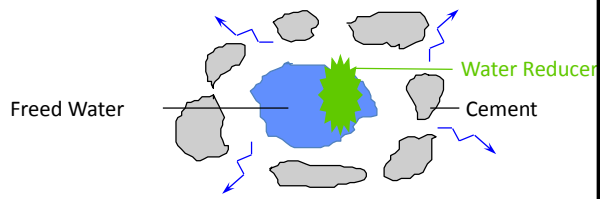
Charged Cement Particles Cling
Together And Form Flocs
Which Trap Water

Floc Busting Action Of Water Reducers



Water reducers separate flocs into individual grains. Trapped water is released and the grains slip by each other like ball bearings- improving the workability of the concrete

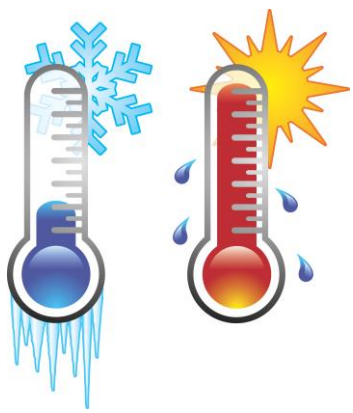
The Result:



Dramatic water cut (lower w/c ratio)
- delivers strength and quality required for the job

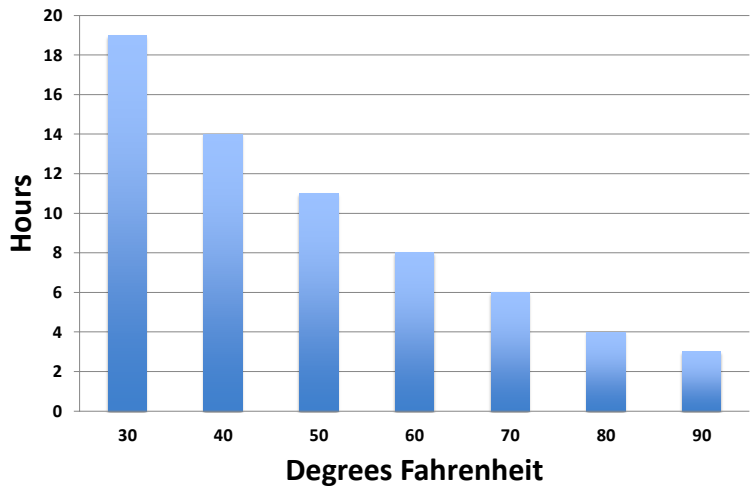
High workability
- flowing concrete means potential time and labor savings for the contractor

Quick Quiz



How does temperature effect the set time of concrete?

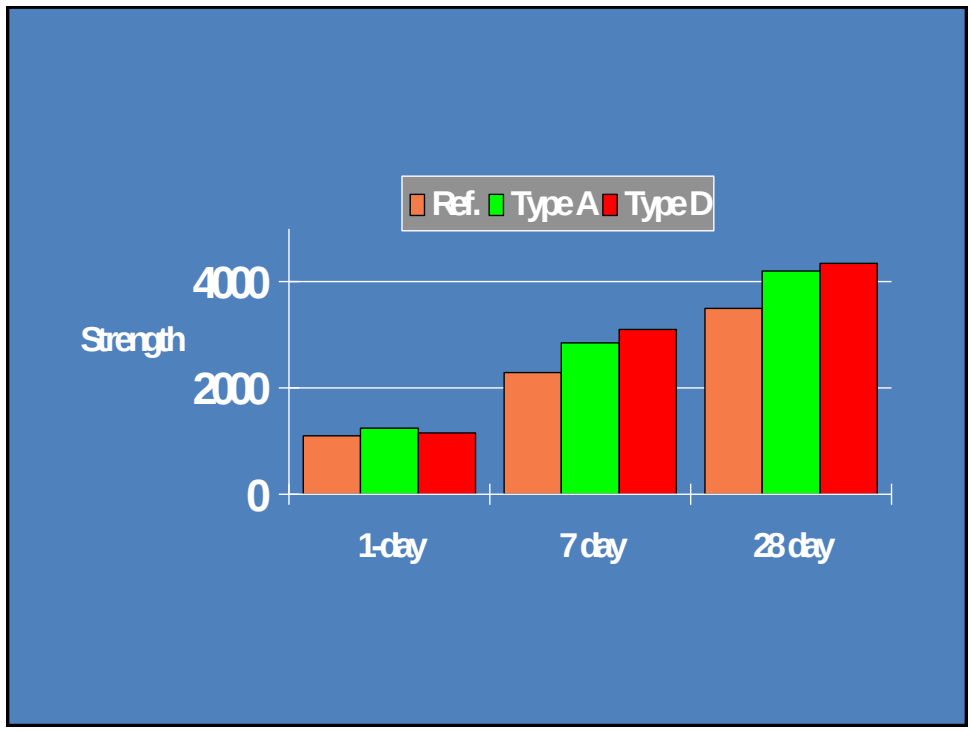
Effect of Temperature on Setting Time



Retarders are used to:

- Slow the set time of the concrete mix.
- Retarders generally also reduce water.
- Retarders usually result in higher strength concrete.

ASTM Type D – Water reducing and retarding



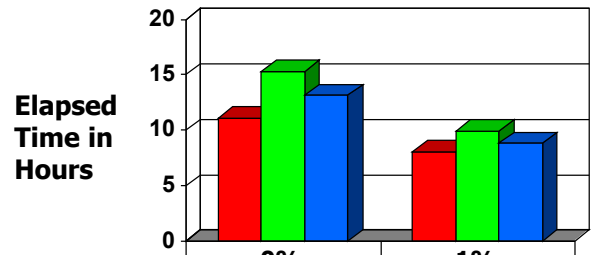
Accelerators are used to:

- Speeds up the set time of the concrete mix.
  - The State allows non chloride Type C accelerating admixtures in patching mixes.
  - Type C accelerating admixtures with <u>chlorides cannot be used in any mixes.</u>
  - Non chloride is specified because chlorides will make the reinforcing steel in the concrete corrode

Type C – Accelerating (NON CHLORIDE)

Cold Weather Set Time

470# Type I/II Cement
Slumps ≥ 7"
Temperature controlled at 50° F



Accelerator	0%	1%
OPC	11.083	8.083
Class C Ash	15.333	9.917
50% GGBFS	13.17	8.833

Quiz – Why do we have air in concrete?

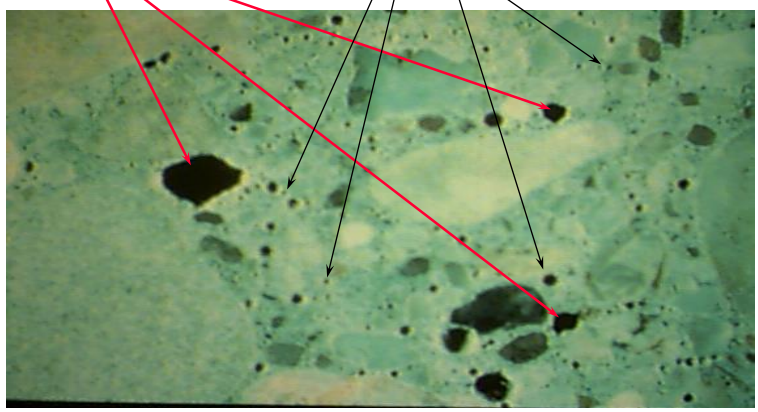
Types of Air Entrainers

- Vinsol Resins
  - Mid size air bubbles
  - Air loss with prolonged mixing
  - Compatible with all admixtures
- Synthetic detergents
  - Coarse air bubbles
  - Minor air loss with mixing
  - Not compatible with some HRWR's
- Tall Oil
  - Very small air bubbles
  - Main gain air in first ½ hour
  - Compatible with all admixtures

Concrete without air entrainment

Air in concrete

Entrapped air vs. Entrained Air

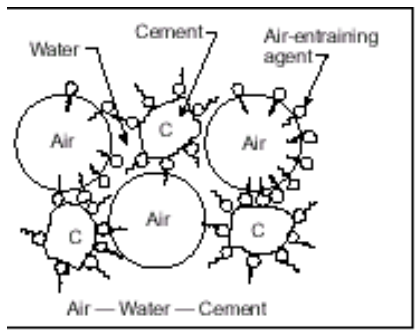


Entrapped > 0.010” Entrained < 0.010”

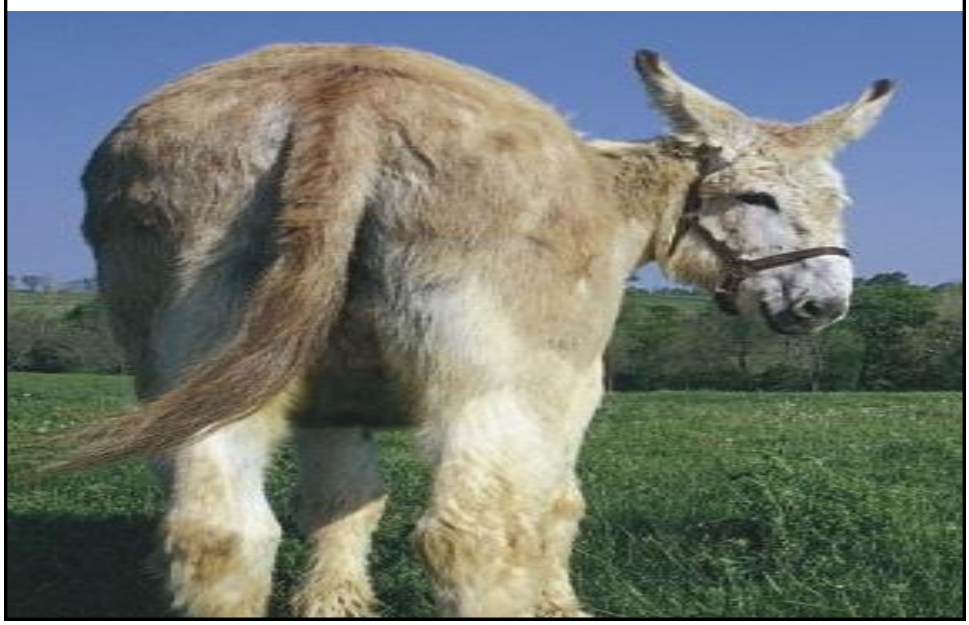
Air should never be added at the same time as other admixtures!

Why air in concrete?

- Improve durability
  - Freeze thaw durability
- Improve workability
  - Increase slump
  - Reduce segregation
  - Reduce bleeding



Air is a pain in the ……

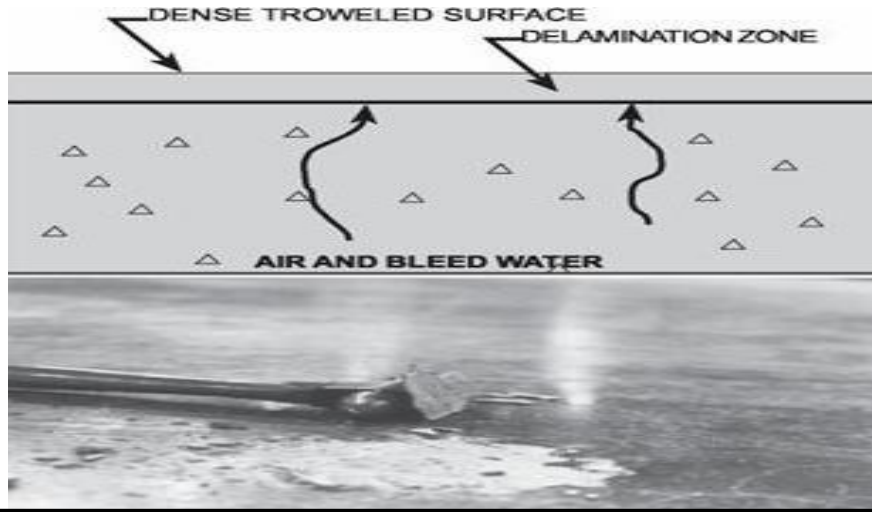


Factor	Effect on Air
• Increasing Temperature	Decreases air
• Cement alkalis	Increase in alkalis increases air
• Fineness	Increasing fineness decreases air
• Fly Ash LOI	Increase in LOI will decrease air
• Fine Aggregate (No. 30 and No. 50)	Increase in size factions will increase air
• Fine Aggregate (No. 100)	Increase in size faction will decrease air
• Admixtures	Some admixtures can dramatically increase air
• Long Haul Distances	Decreases air
• Retempering	Increases air
• Pumping Concrete	Can decrease air if not done properly
• Water / Slump	Increases with increasing slump up to about 6-8 inches, after which it decreases

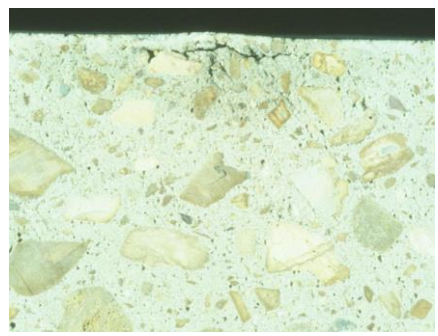
Controlling Air Content

- Do not use air unless it is specified
- Do not add air without the knowledge of the contractor
- Measure air content during all field and laboratory trial mixture evaluations
- Use consistent batching process
- Measure air content at the Concrete Plant
  - Minimum daily
  - When there is a change in materials
- Measure air content at job site
  - When test cylinders are made
  - Whenever a change is suspected

Premature finishing of concrete with bleed water on the surface seals the surface and traps the water just below the surface



Delamination



Plant Cert IIID
Water

Water Quality

Quality requirements

- Source of water shall be tested and approved by the SHA
- Shall be clear and meet the requirements of AASHTO T 26, Method B
- Chlorides shall not exceed 500 ppm
- Water meter shall be calibrated
- Water meters shall be calibrated

Temperature

- The plant shall be equipped with methods of heating and cooling the concrete
- The temperature of the plastic concrete shall meet 902.10.03
- The temperature of the mixing water shall not exceed 170 F

Batch Tickets

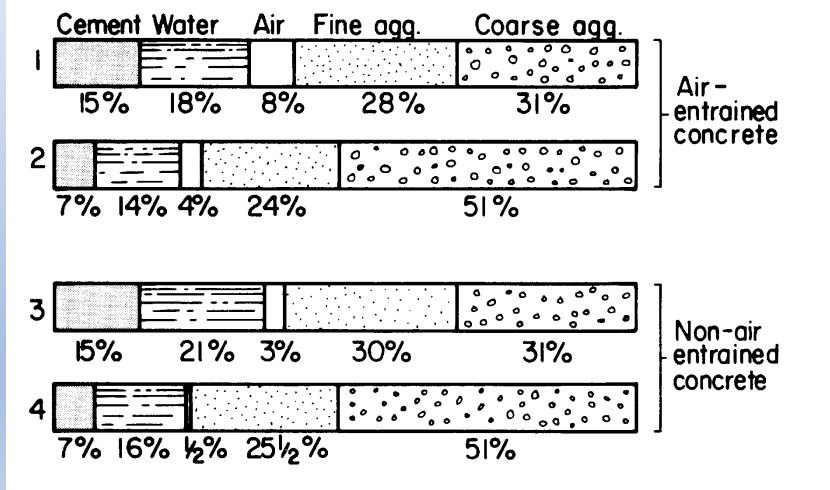
- Shall indicate maximum allowable water
- Shall indicate water allowed for slump adjustment
- Up to 3 gallons of water per yard can be added at the job site, as long as the maximum allowable water is not exceeded

Measuring Water

- Mixing water is
  - water added at plant
  - ice added
  - free water in aggregate
  - water from admixtures
  - water added at job-site

Aggregates for Concrete

Aggregates generally occupy 60 - 75% of the volume in a concrete mix (70 - 85% by weight)



Aggregate Factors that Effect Concrete

- Strength
- Hardness and Wear Resistance
- Angularity / Surface Texture / Sphericity
- Specific Gravity
- Particle Size and Surface Area
- Porosity and Absorption
- Particle Size Distribution
- Moisture Condition
- Cleanliness and Impurities
- Soundness

Typical Coarse Aggregate Strength

• Granite	26,200 psi
• Trap Rock	41,100 psi
• Sandstone	19,000 psi
• Limestone	23,000 psi

Significance of Aggregate Hardness, Wear Resistance

- Resistance to Abrasion
- Gradation Uniformity
- Dust of Fracture

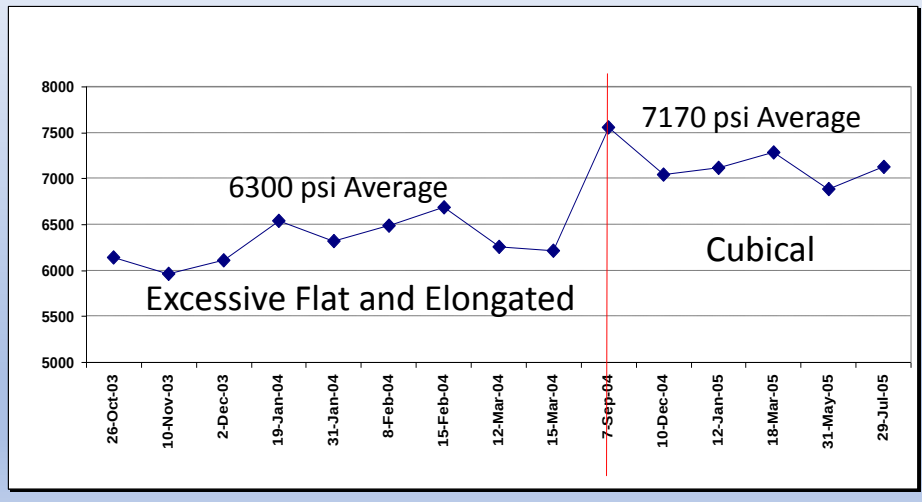
Los Angeles Abrasion T 96

- Combines effect of impact and abrasion by tumbling the aggregate with steel balls
- Aggregate and steel balls is rotated at 30 to 33 rpm for 500 revolutions
- Loss is the difference between the original and final weight of the sample expressed as a percentage of the original sample

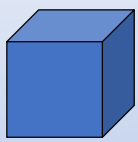
Particle Shape & Texture (Coarse & Fine Aggregate)

- Rounded Gravel (Lower Water Demand, Less Bond)
- Angular Crushed Stone (Higher Water Demand,Better Bond)(The wall story)
- Flat and elongated particles should be limited to 15% by weight of the total aggregate (They will increase water demand and sometimes make finishing difficult)
- Applies to sand also, but bond to a lesser extent

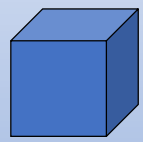
Strength Change – Two Limestone Aggregates



Specific Gravity



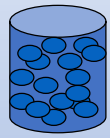
1 cubic foot block of stone weighs 156.0 lb/ft^3



1 cubic foot block of water weighs 62.4 lb/ft^3

Specific Gravity = 156.0 / 62.4 = 2.5

Specific Gravity

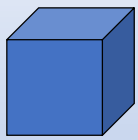


1 ft^3 of loose crushed aggregate. What is the absolute volume of the aggregate?

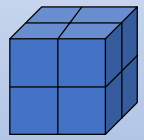
Aggregate weight = 100 lbs.
Aggregate Specific Gravity = 2.5

Abs. Volume = 100 / (2.5 * 62.4) = 0.64 ft^3

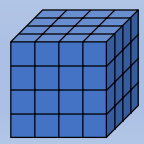
Effect of Particle Size on Surface Area



One 1" cube
Surface Area = 6 * 1*1 = 6 in^2



Eight 1/2" cubes
Area = 6 * 1/2*1/2 * 8 = 12 in^2



Sixty-four 1/4" cubes
Area = 6 * 1/4*1/4 * 64 = 24 in^2

Significance of Aggregate Porosity and Absorption

- Pumpability
- Resistance to Freeze-thaw Deterioration

Aggregate Gradation Affects

- Workability
- Mix characteristics
- Pumpability
- Economy
- Porosity
- Shrinkage
- Durability

A test is only as good as the sample

AASHTO T 2
Standard Practice for Sampling Aggregates

Sampling Aggregates

- Securing Samples - LAST POINT PRACTICAL
- Field Samples Reduced for Required Tests

Material	Sampling Size (min)	Sample Size Sieve Analysis (min)	Sample Size Moisture (min)
Sand	22 lbs.	300 g	500 g
#57	110 lbs.	22 lbs.	1000 g
#67	55 lbs.	11 lbs.	1000 g
#7	35 lbs.	4 lbs.	500 g

Sampling from Flowing Agg. Stream (Bin or Belt Discharge)

- Obtain at least 3, equal increment samples
- Take each increment from entire cross section
- Pan of sufficient size to intercept entire cross section of discharge stream without overflowing

Sampling from Conveyor Belt

- Obtain at least 3, equal increment samples
- Stop conveyor belt
- Insert two templates, shape conforms to the shape of the belt
- Carefully scoop all material between templates

Sampling from Stockpile

- Avoid sampling aggregate from stockpile
- Design sampling plan for specific case

Reducing Samples T 248

- Method A - Mechanical Splitter
- Method B - Quartering
- Method C - Miniature Stockpiling Sampling

Reducing Coarse Aggregate

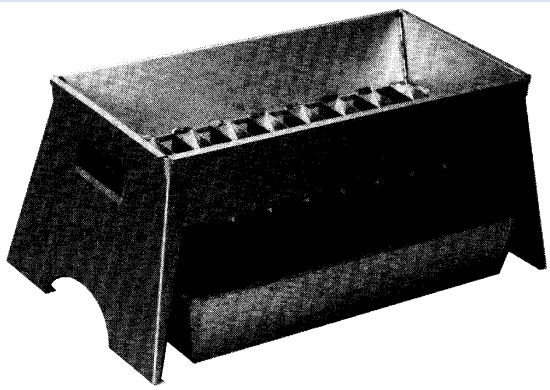
- Reduce by Method A or B
- Reducing by Method C not permitted

Reducing Fine Aggregate

- Method A - Samples that are drier than SSD
- Method B & C - Samples having free moisture
- If method A is desired, dry sample to SSD **

** F. A. having free moisture may be reduced using a splitter with large openings to not less than 5000g before drying and reducing to test size

Mechanical

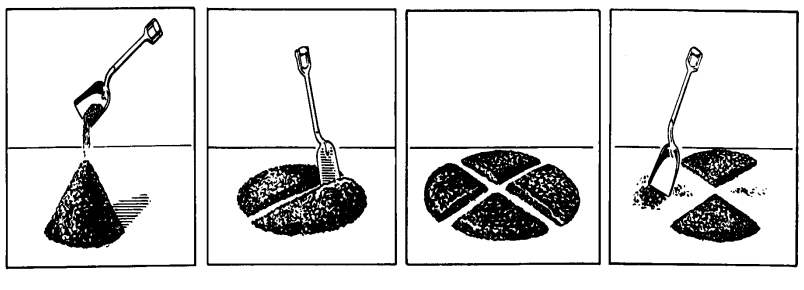


Sample Splitter

Splitter

- Even number of equal width chutes
- 8 chutes for coarse aggregate
- 12 chutes for fine aggregate
- Minimum width of chute shall be approximately 50% larger than largest particle
- Fine Agg: Maximum width is ¾” (20 mm)

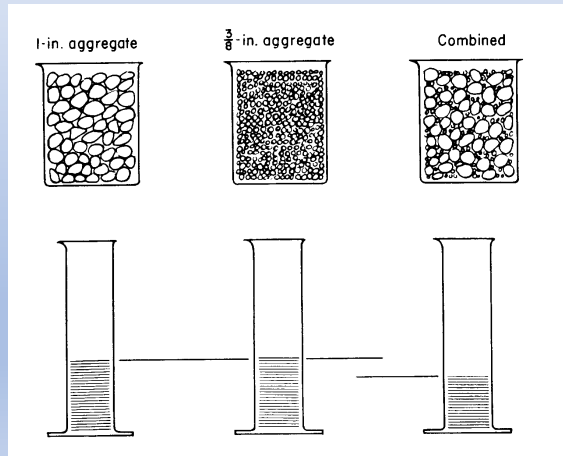
Quartering



What is Gradation?

"Gradation is the particle size distribution of an aggregate as determined by sieve analysis (AASHTO T 27)"

A complete well graded concrete utilizes the cement paste more efficiently & will decrease shrinkage while improving workability and provide slightly higher slump without additional water.



Definitions

- Maximum Size: Smallest size through which the entire sample is **required** to pass.
- Maximum Nominal Size: Smallest size through which the entire sample is **permitted** to pass.

- For a #57, the maximum size is 1 ½" and the nominal maximum size is 1", for a #67, the maximum size is 1" and the nominal maximum size is ½", and for a #7, the maximum size is ¾" and the maximum nominal size is ½."

Aggregate Grading

- Specification: Section 901 - Aggregates

  Table 902 A - Mixtures
- Test Method: AASHTO T 27
- Test Frequency: Frequency Guide, Table 3

  2 per 8 hour shift

AASHTO T 27

Sieve Analysis of Coarse and Fine Aggregate

Sieve Analysis Coarse Aggregate

Sieve	Weight Retained
1 ½”	0
1”	0.64
½”	20.91
No. 4	5.7
No. 8	0.19
Pan	0.19
Total	27.63

Sieve Analysis Coarse Aggregate

Sieve	Weight Retained	Weight Passing	
1 ½	0	27.63 – 0 =	27.63
1”	0.64	27.63 - 0.64 =	26.99
½”	20.91	26.99 – 20.91 =	6.08
No. 4	5.7	6.08 – 5.7 =	0.38
No. 8	0.19	0.38 - .19 =	.19
Pan	0.19		
Total	27.63		

Sieve Analysis Coarse Aggregate

Coarse Aggregate Gradation (#57 Stone)						
Sieve	Weight Retained	Weight Passing		% Passing		Specification
1 ½”	0	27.63 – 0 =	27.63	27.63/27.63 x 100 =	100	100
1”	0.64	27.63 - 0.64 =	26.99	26.99/27.63 x 100 =	97.7	95-100
½”	20.91	26.99 – 20.91 =	6.08	6.08/27.63 x 100 =	22.0	25-60
No. 4	5.7	6.08 – 5.7 =	0.38	0.38/27.63 x 100 =	1.4	0-10
No. 8	0.19	0.38 - .19 =	.19	0.19/27.63 x 100 =	0.7	0-5
Pan	0.19	* Note that gradation does not meet specification limits				
Total	27.63					

% Passing = Weight Passing / Total Weight x 100

Sieve Analysis / Fine Aggregate

Sieve	Weight Retained (g)
3/8	0
No. 4	14.8
No. 8	44.0
No. 16	153.9
No. 30	153.9
No. 50	32.2
No. 100	83.3
Pan	12.9
Total	495.0

Sieve Analysis Fine Aggregate

Sieve	Weight Retained (g)	Weight Passing (g)	
3/8	0	495	495
No. 4	14.8	495 – 14.8 =	480.2
No. 8	44.0	480.2 – 44.0 =	436.2
No. 16	153.9	436.2 – 153.9 =	282.3
No. 30	153.9	282.3 – 153.9 =	128.4
No. 50	32.2	128.4 – 32.2 =	96.2
No. 100	83.3	96.2 – 83.3 =	12.9
Pan	12.9		
Total	495.0		

Sieve Analysis Fine Aggregate

Weight Passing (g)		Total % Passing Each Sieve	
495	495	=495/495 x 100 = 100	100
495 14.8 =	480.2	= 480.2/495 x 100 = 97.0	97.0
480.2 44.0 =	436.2	= 436.2/495 x 100 = 88.1	88.1
436.2 153.9	282.3	= 282.3/495 x 100 = 57.0	57.0
282.3 153.9	128.4	= 128.4/495 x 100 = 25.9	25.9
128.4 32.2 =	96.2	= 96.2/495 x 100 = 19.4	19.4
96.2 83.3 =	12.9	= 12.9/495 x 100 = 2.6	2.6

% Passing = Weight Passing / Total Weight x 100

Sieve Analysis Fine Aggregate

Fine Aggregate Gradation						
Sieve	Weight Retained (g)	Weight Passing (g)		Total % Passing Each Sieve		Specification % Passing
3/8	0	495	495	=495/495 x 100 = 100	100	100
No. 4	14.8	495 – 14.8 =	480.2	= 480.2/495 x 100 = 97.0	97.0	95 - 100
No. 8	44.0	480.2 – 44.0 =	436.2	= 436.2/495 x 100 = 88.1	88.1	
No. 16	153.9	436.2 – 153.9 =	282.3	= 282.3/495 x 100 = 57.0	57.0	45 – 85
No. 30	153.9	282.3 – 153.9 =	128.4	= 128.4/495 x 100 = 25.9	25.9	
No. 50	32.2	128.4 – 32.2 =	96.2	= 96.2/495 x 100 = 19.4	19.4	10 – 30
No. 100	83.3	96.2 – 83.3 =	12.9	= 12.9/495 x 100 = 2.6	2.6	0 - 10
Pan	12.9					
Total	495.0					

No more than 45% passing and retained on the next consecutive sieve

Effects of FA Gradation on Entrained Air Content

- Middle fractions (No. 30 to No. 100 sieves) of fine aggregate promotes air entrainment
- Increasing fine fractions (below No. 100 sieve) increases required AEA

Effect of No. 30-50 mesh sand particles on air content

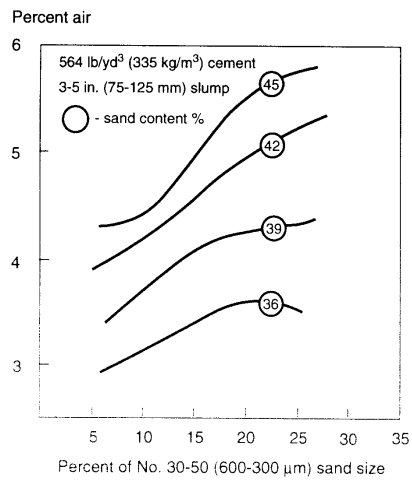


Fig. 4-1. Effect of increasing percentage of No. 30-50 (600-300 µm) material on air content. Craven, 1948. (#SK20603)

Hand-finished floors where smooth texture is desired: at least 15% should pass the No. 50 sieve and 3% pass the No. 100 sieve.

Pumped concrete: 15% to 30% should pass the No. 50 sieve and 5% to 10% should pass the No. 100 sieve.

Fineness Modulus

- Indirect measure of the fineness of the sand
- Smaller fm's indicate a finer sand and larger fm's indicate a coarser sand
- As fm decreases (sand becomes finer), there might be an increase in water demand and the concrete may be easier to finish (until it gets too fine and is sticky)
- As fm increases, (sand becomes coarser), there may be lower water demand resulting in concrete with higher strength

FM Calculation

FM = 700 – Sum of mass percent passing on all sieves 3/8" and smaller divided by 100

Example:

$$FM = \frac{700 - 100 - 97.0 - 88.1 - 57.0 - 25.9 - 19.4 - 2.6}{100} = 3.10$$

Fineness Modulus (FM) Calculation	
Sieve	% Passing
3/8	100
No. 4	97.0
No. 8	88.1
No. 16	57.0
No. 30	25.9
No. 50	19.4
No. 100	2.6
Total	390.0
FM	= (700 – 390)/100 = 3.10 (700 is a constant)
Specification	= Between 2.3 and 3.1 and +/- 0.20 of the base FM

Base FM - average of 10 preceding tests (all samples if less than 10)

Fineness Modulus

Concrete Property	Decreasing FM Finer Sand	Increasing FM Coarser Sand
Water Requirement	More	Less
Water-Cement Ratio	Higher	Lower
Strength	Lower	Higher
Finishability	Easier	More Difficult

Example

SIEVE	WT. PASS.	% PASS.	WT. PASS.	% PASS.	WT. PASS.	% PASS.	SPEC. REQUIRE.	Moisture Content		Moisture Content		Moisture Content	
3/8"	495	100	516	100	540	100	100	Wet	517	Wet	497	Wet	540
#4	480	97.0	506	98.1	525	97.2	95 - 100	Dry	495	Dry	453	Dry	510
#8	436	88.1	449	87.0	472	87.4		Diff.	22	Diff.	44	Diff.	30
#16	282	57.0	317	61.4	325	60.2	45 - 85	Result	4.4	Result	9.7	Result	5.9
#30	128	25.9	137	26.6	150	27.8		(-Abs.)	0.8	(-Abs.)	0.8	(-Abs.)	0.8
#50	96	19.4	108	20.9	113	20.9	10 - 30	% Moist.	3.6	% Moist.	8.9	% Moist.	5.1
#100	13	2.6	17	3.3	15	2.8	0 - 10						
F.M.		3.10		3.03		3.04	+/-0.20 of Base F.M.						

No. 57 Aggregate

TIME>>	6:00 AM		10:00 AM		10:45 AM			6:00 AM		10:00 AM		1:30 PM	
SIEVE	WT. PASS.	% PASS.	WT. PASS.	% PASS.	WT. PASS.	% PASS.	SPEC. REQUIRE.	Moisture Content		Moisture Content		Moisture Content	
1½"	19.36	100	27.63	100	26.17	100	100	Wet	1113	Wet	1044	Wet	1057
1"	19.27	99.5	26.99	97.7	25.92	99.0	95 - 100	Dry	1093	Dry	1024	Dry	1040
½"	6.93	35.8	6.08	22.0	7.82	29.9	25 - 60	Diff.	20	Diff.	20	Diff.	17
#4	0.32	1.7	0.38	1.4	0.26	1.0	0 - 10	Result	1.8	Result	2.0	Result	1.6
#8	0.14	0.7	0.19	0.7	0.17	0.6	0 -5	(-Abs.)	0.7	(-Abs.)	0.7	(-Abs.)	0.7
								% Moist.	1.1	% Moist.	1.3	% Moist.	0.9

No. 67 Aggregate

Aggregate Moisture

Mix Water in Concrete - Sum Of

- Free water in aggregates
- Ice added
- Water added at batch plant
- Free water in admixture
- Water added at job-site

Free Water in Aggregate

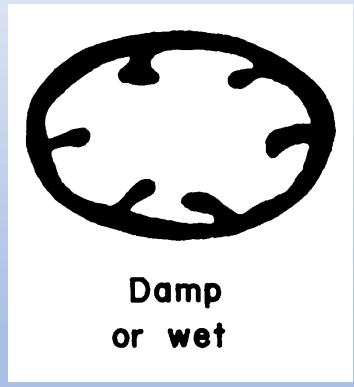
- Free Water in Aggregate = Total Water less Water in Aggregate Pores
- Water in Aggregate Pores = Absorption

Four Moisture Conditions

- Damp or wet
- Saturated surface-dry
- Air-dry
- Oven-dry

Damp or Wet

Aggregate in which the pores connected to the surface are filled with water and free water is found on the surface and between the grains of the aggregate particles.

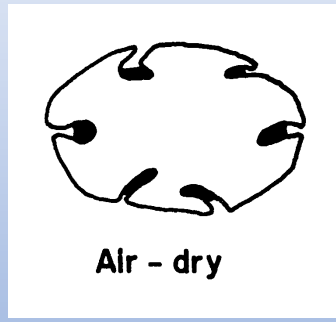


Saturated Surface-Dry

Aggregate in which the pores are connected to the surface are filled with water but no free water is found on the surface.

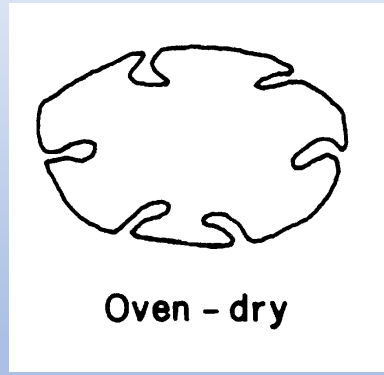
Air-Dry

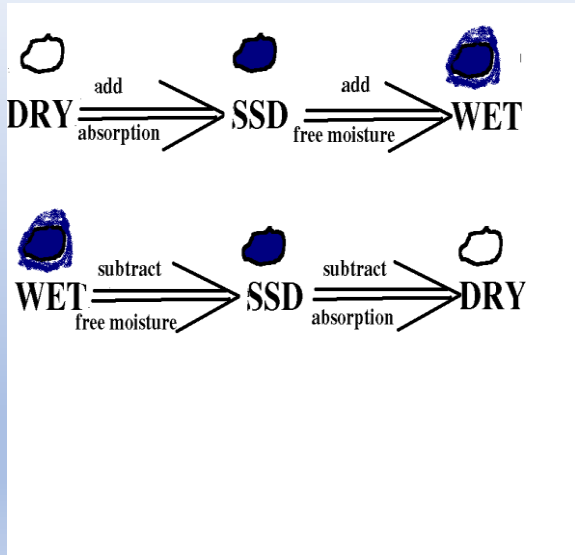
Aggregate which has a dry surface but contains some water in the pores.



Oven-Dry

- Aggregate which contains no water in the pores or on the surface.





Determination of Moisture Content MSMT 251

Sample Size

Maximum Size	Minimum Mass
2”	1000 g
3/4”	500 g
No. 4	250 g

Weigh to the nearest 0.1 g

Determination of Moisture Content MSMT 251

- Place container with sample on stove or hot plate, and while drying, mix the sample
- Cool and weigh
- Reheat, cool and reweigh
- If weight difference is less than 0.1%, sample is dry.
- Record weight to nearest 0.1g

Determination of Moisture Content MSMT 251

$$P = \frac{W - D}{D - C} * 100$$

P = percent moisture, to nearest 0.1%
W = wet weight of aggregate + container
D = dry weight of aggregate + container
C = container weight

I think it's easier to say…

Total moisture is equal =

$$\frac{Wet\ Weight - Dry\ Weight}{Dry\ Weight} \text{ x } 100$$

Calculation - Moisture Content

Wet Weight of Aggregate, less container
= 847.3 g
Dry Weight of Aggregate, less container
= 792.7 g

$$\text{Moisture} = \frac{847.3 - 792.7}{792.7} * 100 = 6.9\%$$

Calculation of Free Water in Aggregate

Total Moisture Content =	6.9 %
Absorption =	2.2 %
	======
Free Moisture =	4.7 %

Correcting Batch Weights for Free Moisture

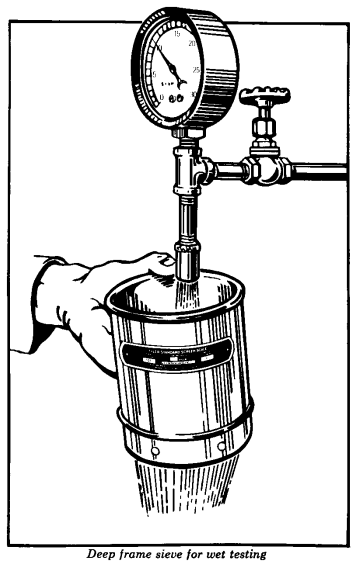
Free Moisture in the Stone = 0.1%
Free Moisture in the Sand = 4.4%

Material	Batch Weight per yd^3	Batch Weight per 10 yd^3
Cement	465 lbs.	= 465 x 10 = 4650 lbs.
Slag Cement	155 lbs.	= 155 x 10 = 1550 lbs.
Coarse Agg	= 1800 + 1800 x 0.001 = 1802 lbs.	= 1802 x 10 = 18020 lbs.
Fine Agg	= 1241 + 1241 x 0.044 = 1296 lbs.	= 1296 x 10 = 12960 lbs.
H_2O	= 33 x 8.33 – 1800 x .001 – 1241 x 0.044 = 218 lbs.	= 218 x 10 = 2180 lbs.
H_2O Reducer	= 3 x $\frac{620}{100} = 18.6\ oz.$	=18.6 x 10 = 1860 oz.
Air Entrainer	= 0.4 x $\frac{620}{100} = 2.5\ oz.$	= 2.5 x 10 = 25 oz.

If your moistures were off on your sand by 1% (3.4% instead of 4.4%), the difference in water would be 124 lbs. or 15 gallons.

15 gallons of water would result in about an inch and a half additional slump, 1.5% additional air, and 300 psi strength decrease.

T 11 Material Finer Than No. 200 Sieve



Deep frame sieve for wet testing

Significance of Aggregate Cleanness

- Aggregate:paste Bond - Strength
- Water Content - Strength and Durability
- Air Content - FA with over 3% passing the No. 200 sieve will cause increase in required AEA
- Clay and silt increases required AEA, may retard set time, slow strength development

Wash Loss Test - T 11

- T-11, Material Finer than 75-um, (No. 200) Sieve in Mineral Aggregates by Washing
- Sample Size

  Fine Aggregate: 300 g

  No. 67/57 Stone: 2,500 g
- Wet Agent: Plain water suitable for coarse aggregate, wetting agent required for FA with clay coatings.

Specification: Material Finer than No. 200 Sieve

- Coarse Aggregate: 1.0% maximum, 1.5% maximum if material is dust of fracture and not clay and silt.
- Fine Aggregate: 4.0% maximum, 5.0% for concrete not subject to abrasion

"Dust of Fracture"

- There may be fines as a result of crushing and mechanical processing of aggregate. If this material adheres to the coarse aggregate particles, it can create problems if it provides too much anticipated fines to the concrete during mixing (requiring more water) or may result in poor "bonding" of the mortar fraction to the coarse aggregate

Harmful Substances - Fine Aggregates

- No. 200 Sieve - 4% maximum, 5.0% for concrete not subject to abrasion
- Organic Impurities - 3% maximum
- Clay Lumps, Friable Particles - 3.0% maximum
- Coal and Lignite - 1.0% maximum

Harmful Substances Coarse Aggregate

- No. 200 Sieve - 1.0% maximum, 1.5% if dust of fracture
- Clay, Friable Particles - 2.0% maximum
- Chert less than 2.40 SG - 3.0 % maximum
- Clay, Friable Particles, Chert - 3.0%, max.
- Coal and Lignite - 0.5% maximum

Organic Impurities in Sand T 21

- Sodium Hydroxide is poured over sand sample in a bottle
- Bottle is stoppered and shaken
- Bottle allowed to stand for 24 hours
- Color is compared to standard
- If color is darker than standard, sand is considered to contain impurities

Significance of Aggregate Soundness

- Durability
- Resistance to Weathering

Soundness by T 104

- T 104 Soundness of Aggregate by Use of Sodium Sulfate or Magnesium
- Test consists of a number of immerison cycles for a sample in sulfate solution
- Creates a pressure through salt-crystal growth similar to that produced by freezing water.

Plant Cert V

Testing

ASTM C 172 / AASHTO R 60

Sampling Freshly Mixed Concrete

5.2.3 Sampling (Revolving truck mixer or agitators)

- Before sampling make sure all water is added (that includes admixtures)
- ***Regulate the rate of discharge of the concrete by the rate of revolution of the drum and not by the size of the gate opening***
- Sample the concrete @ least two regularly spaced intervals (not exceeding 15 minutes between first and final portions of composite sample) from the middle of the batch (not before 10% or after 90% of batch has been discharged)

Slump - Filling the Mold

- Fill the mold in three approximately equal layers (***by volume***)
  - 1st layer: 2-5/8”
  - 2nd layer: 6-1/8”
  - 3rd layer to just over top of the mold

Measure to the nearest 1/4 inch the slump from the top of mold to the displaced original center of the top surface of the specimen. Perform the test within 2-1/2 minutes.

ASTM C 138

Determine the mass of empty measure

Place concrete in the measure in 3 equal layers of approximately equal volume / consolidating each layer

Strike off concrete level with the surface and clean off all excess concrete.

Determine the mass of the full measure.

Determine the unit weight (density)

- Bucket Volume = .25 cubic foot (approx. volume of pressure meter bucket)
- Weight of empty bucket = 8 pounds
- Weight of bucket plus concrete = 45 pounds

This question is in your handout so do the math in the space provided!

And the answer is:

45 (full w/ concrete) – 8 (empty) = 37(wgt. of concrete only)

37 (wgt. of concrete) / .25(volume of bucket) =

148.0 LBS/FT^3

Determine the Air

- Pressure Meter
- Volumetric Meter

ASTM C 231 - 97

Standard Test Method for Air Content by the Pressure Method (Type B)

Some Comments

- Aggregates must be relatively dense or ***No light weight aggregates or porous aggregates can be in the test concrete.***
- Maximum Aggregate size 2” sieve over 1-1/2”
- ***Must determine Aggregate Correction Factor (G)***

ASTM C 173 - 01

Standard Test Method for Air Content of Concrete by the Volumetric Method

Strength Test Specimens

Procedures for 6 x 12 in. cylinders using concrete with a slump greater than or equal to 1 inch

- Place concrete in the mold in three equal layers, consolidating each layer.

Strength Test Specimens

Strike off excess concrete from the surface with a tamping rod and float or trowel as required. Use a minimum amount of manipulation necessary to produce a flat, even surface.

Strength Test Specimens (4x8)

Fill mold in 2 layers of equal volume. Rod each layer 25 times with the rod, uniformly distributing strokes. On the 2nd layer, penetrate the previous layer by about one inch.

Standard Curing

- *Initial Curing:* Immediately store the specimens for up to 48 h in a temperature range between 60 to 80°F and in a moist environment to prevent moisture loss. Specimens must not be exposed to direct sunlight or radiant heating devices. If 6000 psi or higher range changes to 68-78
- *Final Curing:* Upon completion of initial curing and within 30 min after removing the molds, cure specimens with free water maintained on their surfaces at all times at a temperature of 73.5 ± 3.5°F
- During transport cylinders must be protected from Jarring, Freezing and Moisture Loss.

Plant Cert VI

Plants

Plants

Quality Control Plan

- A current Quality Control Plan exists and is approved
- All QC Personnel are listed with an approved number
- QC Plan is accessible to QA Inspectors and plant personnel
- Changes to the Quality Control Plan are reported to SHA
- Plant Quality Control Procedures are established and followed
- Quality requirements of raw materials are specified
- Sampling and Testing requirements are described

Certified Plant Technician

- Shall supervise all plant production
- Shall ensure that the Quality Control Plan is followed
- Shall
  - Perform moisture tests
  - Adjust proportions for free moisture
  - Sign batch or approval tickets
- Shall sample materials according to the Sample Frequency Guide

Quality Control Laboratory

- Plants shall have a QC lab on site
- Lab shall have sufficient space to perform tests correctly and efficiently
- Testing equipment shall be in good working condition
- Test records shall be maintained and available for review

Approved Material Sources

- All materials used in producing concrete shall come from a SHA approved source
- The production plant shall keep on file all material sources and certification documents
- Records shall be made available to the QA Inspector for review

Aggregate Stockpiles and Bins

- Stockpiles and bins shall be kept separate for each type of aggregate
- Stockpiles and bins should be accessible to loaders and to trucks bringing aggregate from the supplier
- Aggregates need to be maintained at above SSD conditions
- Aggregates need to be maintained to ensure uniform moisture conditions throughout the pile
- There needs to be different compartments for each aggregate

Aggregate Stockpiles and Bins

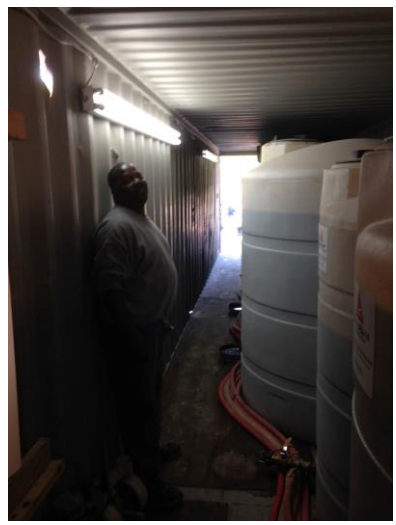
- Aggregates need to be stored in such a way as to prevent intermingling of different aggregates
- Aggregate need to be stored and maintained in such a way as to prevent segregation
- *Plants*
- In cold weather, aggregates need to be protected from freezing (no froze lumps) and aggregate should not be subjected to live steam
- Aggregate bins should freely discharge

Material Storage / Storage Facilities

- Storage facilities shall be in good condition
- Silos and storage tanks shall be corrosion free, and weather-tight

Material Storage / Admixtures

- Admixtures shall be properly stored as per manufacturer label
- **SHA will issue Corrective Action or Suspension notices to a plant if non-compliance is identified through any QA Inspection.**



Measuring Admixtures

- Volumetric measurement shall be made within 3% of the total amount required or plus or minus the volume of dose required for one sack of cement, whichever is greater
- One sack of cement = 94 lb (one bulk ft^3)
- Most liquid admixture, dose in oz./cwt (hundredweight) that is oz./100# of cement.

Batching Control

- Scales should be zeroed out once at the beginning of the day's work.
- Scales should stay zeroed but batch operator should check this before batching each load
- Gates should be closed before batching (do not dump materials if charge gate is open)
- Do not dump if material weights / doses are not within tolerance

Measuring Devices

- All measuring devices, meters and dispensers shall be calibrated and certified annually by an approved testing agency
- All measuring devices, meters and dispensers shall be calibrated and certified monthly by the producer
- Balance and zero conditions shall be checked daily and when requested by SHA personnel

MD SHA Requirements for Plant Measuring Devices

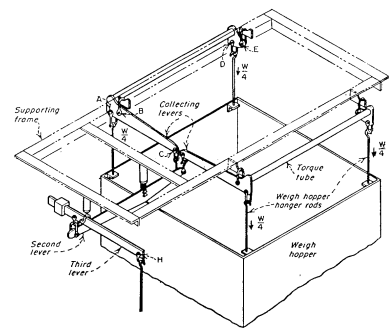
- Certification - Approved testing agency or SHA personnel
- Producer conducts “checks”. Corrections by approved agency
- Producers shall have ten 50 lb test weights. Test weights certified yearly
- Producers notify SHA 2 days prior to check

Section 915.01.04
Measuring Devices

- Before operations, measuring devices inspected, tested and certified by agency approved by Engineer.
- During operation, devices checked monthly.
- Engineer notified two working days in advance of monthly scale check.
- Balance and zero condition of scales checked daily or as requested.

Scale Certifications

- Make and Model
- Maximum Capacity
- Overall scale condition
- Calibration report
- Minimum Graduation Size
- Ensure scales and measuring devices have been inspected by a certified testing agency
- Records of inspections and calibrations are available for review by the QA inspector



Freefall

- How much does this woman weigh if the scale is on the ground?
- The same amount that aggregate does as it freefalls into the weigh hopper.

Maintenance Tolerance

Material	Maintenance Tolerance*	Unit of Measure
Aggregate	0.2%	Weight
Cement	0.2%	Weight
Water	1.5%	Wt or Vol
Additives	0.5%	Wt or Vol

* % of total scale capacity or smallest grad. whichever is greater

Operating Tolerance

Material	Operating Tolerance	Unit of Measure
Aggregate	2.0%	Weight
Cement	1.0%	Weight
Water	1 gallon	Vol
Additives	0.5 %	Vol

Measuring Materials M 157

Cement

- Shall be measured by weight
- Fly ash or other pozzolan may be weighed cumulatively
- Cement weighed before pozzolan
- When exceeding 30% capacity, batch tolerance is 1%.
- Small batches, minimum 1 yd^3, not less than that required or 4% in excess

Example: Mix calls for 5800 lbs. of portland cement and 1000 lbs. of fly ash.

1% tolerance for portland cement = 0.01 x 5800 = 58 lbs so tolerance is +/- 58 lbs. (5742 lbs. – 5858 lbs.)

1% tolerance for total cementitious = 0.01 x 6800 = 68 lbs. so tolerance is +/- 68 lbs. (6732 lbs. – 6868 lbs.)

Measuring Aggregates – M 157

- Aggregates shall be measured by weight
- Batch weights based on dry weights plus the total weight of moisture
- Tolerance: +-/-2% - individual batchers
- Tolerance: +/- 1% - cumulative batchers, after each weighing, greater than 30% scale capacity

Measuring Aggregates - Example

#67 Stone = 1,800 lb-ssd/yd^3
Concrete Sand = 1,200 lb-ssd/yd^3
Batch Size = 10.0 yd^3

Stone Free Moisture = 1.0%

Sand Free Moisture = 5.0%

Tolerance for Stone

Example: Batch weight for stone (with all water included from aggregate moisture) is 18,180 lbs.

2% tolerance for stone = 0.02 x 18180 =
364 lbs. so tolerance is +/- 364 lbs.
(1744 lbs. - 18,516)

Tolerance for Sand

Batch weight for sand (with all the water from aggregate moisture added) = 12,600 lbs.

2% tolerance for sand = 0.02 x 12,600 = 252 lbs.
so tolerance is +/- 252lbs. (12,348 – 12852)

Tolerance for Sand and Stone - Cumulative

40,000 # Scale Capacity

Batch weight for stone and sand (cumulative) with all the water from aggregate moisture added is $18{,}180_{stone} + 12{,}600_{sand} = 30{,}780$ lbs. stone and sand

Batching Target 1 – Stone 18,180

1% tolerance for stone = 0.01 x 18,180 = 182 lbs.
so tolerance is +/- 182 lbs. (17,998 lbs. – 18,362 lbs.)

Batching Target 2 – Stone *and* Sand 30,780

1% tolerance for stone and sand =
0.01 x 30,780 = 308 lbs. so tolerance is +/- 308 lbs.
(30,472 lbs. – 31,088 lbs.)

Moisture Probes (Fine Aggregate Only)

- May be used in place of actual testing
- Shall be calibrated and maintained as per manufactures recommendations
- Actual tests shall be performed once a week and results compared to probe readings
  - Differences greater than 0.5% require a retest
  - Retest differences greater than 0.5% requires recalibration of the probe

Measuring Water

- Mixing water is
  - water added at plant
  - ice added
  - free water in aggregate
  - water from admixtures

Measuring Water

- Added water measured by weight or volume
- Added Water Tolerance: within 1% of required total mixing water
- Ice measured by weight
- Total Water Tolerance: within 3% of the specified total amount.

Methods of Measuring Water

- Volumetric water meter - meets standards of American Water Works Association
- Weigh batchers
- Calibrated tanks with sight glasses
- Blocks (weight)/bags - ice

MD SHA Requirements Measuring Water

- Shall not exceed maximum w/cm.
- 85% of design water must be added at plant
- Water for slump adjustment - approved truck water system under supervision of CCPT
- Maximum 3.0 gal/yd^3 added at jobsite
  (not exceed maximum w/cm)
- No water added after partial discharge

Measuring Water - Example

Design Water Content = 32 gal/yd^3
Batch Size = 10 yd^3
Maximum w/cm = 0.45
Design Portland Cement = 580 lb/yd^3
Design Fly Ash Content = 100 lb/yd^3

Maximum Water

Maximum Water Based on w/cm =
Cementitious Content * Maximum w/cm / 8.33

Maximum Water - Example

Design Cementitious Materials = 6800 lb
Maximum w/cm = 0.45
Maximum Allowable Water
6800 lb x 0.45 / 8.33 lb/gal = 367 gal

Adding Water On-the-job

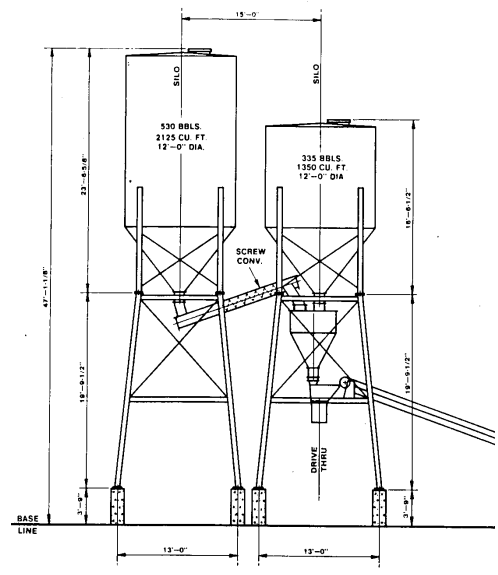
- Slump is less than specified
- Injected into mixer under pressure
- Mixer drum turned for additional 30 revolutions
- Additional water not allowed
- Discharge complete within 1-1/2 hrs or 300 revolutions after mix water contacts cement/aggregates or cement contacts aggregates
- Discharge limits *may* be waived if slump O-K without additional water

Temperature of Water and Cement

- Section 915.03.02
- Plant equipped with methods of heating or cooling concrete approved by the Engineer
- Temperature of cementitious materials and water used in mix shall not exceed 170 F (77 C)

Cement Storage

- Air and Water Tight
- Free Moving
- Isolated
- 170 ^{o}F Max.

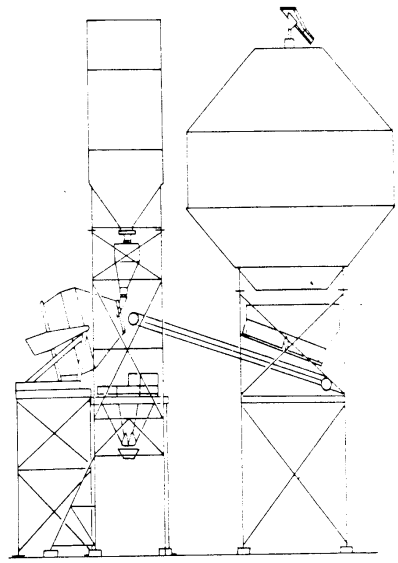


Central Mixer

- Blades shall be checked for wear
- Maximum and minimum capacity and speed adhered to
- Mixer shall have an approved timing device
- Mixer shall be an approved type
- There shall be a suitable batch counter

Central-Mixed

- Mixing time starts when all solids are in drum
- Mixing time without uniformity test - 1 min for 1st yd^3 + 15 sec for each added yd^3.



Mixer Trucks

- All trucks shall be inspected once a year
- SHA shall be notified 7 days in advance of annual inspection
- SHA shall be notified 2 days in advance of inspection of mixer trucks that are added between annual inspections
- QC Technician shall complete an inspection report and submit it to the QA Inspector for review and approval
- Mixer trucks shall comply with SHA Standard 915.03.04 and AASHTO M157

Truck Mixers

- **Inspected yearly, sticker required**
- **CCPT - Check condition, empty before batching**
- **Back-up alarm**
- **Drum capacity- rating plate**
- **Water values - No leaks**
- **Water pump - No leaks**
- **Drum knuckel - No leaks**
- **Counters - working**
- **Water Glasses - Clean**
- **Water Gauge - Clean**
- **Drum - No buildup**
- **No broken blades**

Mixer Certification Plate

- Gross volume of drum
- Capacity in terms of mixer capacity
- Minimum and maximum mixer speeds

Truck Mixer Capacity

- Truck-mixed and shrink-mixed concrete: Volume of concrete shall not exceed 63% of drum volume
- Central or plant mixed concrete (stationary mixer): Volume of concrete shall not exceed 80% of drum volume

Time Limits for Trucks

90 Minutes

A few important responsibilities

- Plant is in good order
- Materials are properly handled
- Mix design is approved for project
- Scales return to zero, do not hang-up
- Batch quantities are correct
- Delivery trucks are certified, drum empty, counters working

Part Two

Specifications

- **SHA Specifications**

  - Section 900 – Materials
  - Section 901 – Aggregates
  - Section 902 – Portland Cement Concrete & Related Products
  - Section 915 – Production Plants

- **Recommended AASHTO / ASTM Standards**

900 GENERAL

From MDOT Policy Manual

900.01 GENERAL.

Sample, test, and inspect all materials included in this Category as specified in the most recently published cited standards. The specification limits for each material are established and deviations from these limits are prohibited except when, in the judgment of the Engineer, the deviation will not be detrimental to the work. In these cases, refer to the appropriate specification governing price adjustments for nonconformance.

Within 30 days after receipt of notification of award of the Contract, submit in writing, to the Office of Materials Technology (OMT), the proposed sources of all materials to be incorporated into the project. Update and submit all nursery stock sources to OMT 45 days prior to the planting season in which the planting is to begin. Do not introduce material into the work until sources are approved. The Administration reserves the right to completely or partially test any material for Specification compliance.

Sample according to the Administration's Sample Testing and Frequency Guide unless otherwise directed. All source approvals are made subject to continuing production of materials conforming to these Specifications. Material sources may be rejected where it is evident that the material tends to be of marginal quality when compared to the Specification limits in any of its specified properties.

900.02 TECHNICIAN QUALIFICATION REQUIREMENTS.

Technicians performing Quality Assurance (QA)/Quality Control (QC) sampling and testing shall be qualified through the certification program provided by the Administration. Private laboratories performing testing shall be in the AASHTO Accreditation Program or approved by the Administration.

Technicians include those who work for inspection agencies, Contractors, consultants, producers, private laboratories, and State and local government employees.

900.03 RECYCLED MATERIALS.

900.03.01 CERTIFICATION. All recycled or rehandled material furnished or supplied for use may require testing and certification to ensure compliance with all State and local applicable environmental and EPA regulations. The required testing may include, but not be limited to, the EPA Toxicity Characteristic Leaching Procedure (TCLP) or its successor. Provide testing and certification for all recycled materials at no additional cost to the Administration. Evaluation and interpretation of the test data will be made by an OMT QA Manager. The above requirements do not preclude the normal materials acceptance process, and the recycled material shall meet all

applicable specifications. EPA regulations governing the use of the material, certified test results, and material safety data sheets shall accompany the source of supply letter and sample submitted for approval.

Only highway demolition materials are to be used in constructing reclaimed/recycled concrete stockpiles for Administration projects. The use of building materials is prohibited.

Refer to the Contract Documents for recycled materials not covered by this specification.

900.03.02 RECLAIMED/RECYCLED CONCRETE (RC).

Usage. Use RC for the following with written approval.

(a) Graded Aggregate Base (GAB).

(b) Common, Select, or Modified Borrow.

(1) At least 2 ft above saturated soil or groundwater conditions, as determined.

(2) At least 100 ft from surface waters (streams, creeks, or rivers, ponds and lakes).

(3) At least 3 ft from exposed metal surfaces.

(4) At least 3 ft from geotextile.

(5) At least 3 ft from any water discharge locations.

Do not use RC as Capping Borrow nor as aggregate for the following.

(a) Portland cement concrete.

(b) Asphalt mixes.

(c) Drainage systems.

(d) Mechanically stabilized earth (MSE) systems.

(1) MSE walls.

(2) Reinforced soil slopes (RSS).

(3) Reinforced earth slopes (RES).

(e) In embankment construction as follows.

(1) Within 1.5 ft of the top surface of any area to be vegetated.

(2) Within 2 ft of saturated soil or groundwater conditions, as determined.

(3) Within 100 ft of any surface water course (streams, creeks, or rivers, ponds and lakes).

(4) Within 3 ft of any metal pipe or shoring.

(5) Within 3 ft of any water discharge locations.

(6) Under permeable or porous surfaces.

Grading Requirements. The grading requirements for the use of RC.

(a) Table 901 A when used as GAB or for any other application within the pavement structure.

(b) 204.02 when used in embankment construction.

(c) 916.01 when used as Borrow material.

RC shall not contain more than 5 percent brick and asphalt mix material by mass except when used as Common Borrow.

pH Requirements. RC pH shall be less than 12.4 for all applications. RC usage shall not cause any outfall and infiltration water leaving the site to exceed a pH of 8.5. Acid sulfate, sulfur or any other environmentally safe organic material may also be used to control the pH.

pH Testing.

(a) Plant: The producer is required to test pH at the plant per T 289 every 1,000 tons shipped or once a day, whichever yields the greater frequency. Plant pH testing shall be recorded as specified and a history shall be kept at the producer's laboratory. The producer may be required to present TCLP and any other tests conducted by an independent laboratory as directed.

The Administration reserves the right to test the producer's RC at the plant for pH. Material delivery may be terminated if the test results repeatedly meet or exceed a pH of 12.4. In case of high pH the producer is require to use shorter stock pile by spreading the material at around the plant or mixing the RC-GAB with the natural GAB to reduce the pH issue.

(b) Construction Site: The OMT representatives will perform QA testing to monitor, test, for the pH levels for any discharge associated with RC placement as directed. This includes monitoring and testing during periods of precipitation or dampness. In cases of high pH, the producer shall provide a reduction control plan for the pH.

Quality Control. The producer shall submit a Quality Control Plan and obtain approval prior to production. The plan shall include, but not be limited to, the operational techniques and procedures proposed to produce the RC product. QC includes the sampling, testing and data recording performed to validate the quality of the product during production operations.

Quality Assurance. OMT QA personnel will perform quality assurance inspection, sampling, and testing at the RC plant and construction site. Additional inspection, testing and compaction control will be performed by the Engineer.

900.03.03 RECYCLED ASPHALT PAVEMENT (RAP).

Usage. Use RAP for Common, Select, Capping, or Modified Borrow.

Do not use RAP as aggregate for the following.

(a) Graded Aggregate Base (GAB).

(b) Portland cement concrete.

(c) Drainage systems.

(d) Embankment construction.

(1) Within 1 ft of the top surface of any area to be vegetated.

Refer to MSMT 412 (http://www.roads.maryland.gov/OMT/msmt412.pdf) and M 323 for the use of RAP in asphalt mixes.

Grading Requirements. The grading requirements for the use of RAP.

(a) 204.02 when used in embankment construction,

(b) 916.01 when used as Borrow material,

(c) 901.02.01 when used as riprap.

Quality Control. Create a captive stockpile for storing the RAP prior to use. Create a new captive stockpile and take new acceptance samples for gradation approval whenever the source of the RAP changes.

Quality Assurance. OMT QA personnel will sample and test the RAP stockpiles to ensure that they meet the above gradation requirements. The completed test results will be reviewed by the OMT Soils and Aggregate Division for approval.

Construction of Control Test Strip. The location, equipment, and methods used to construct the control test strip shall be as directed; prior to approval. The equipment and methods used to construct the control test strip shall be the same as those used in subsequent construction. Place and test the control test strip when the RAP is 32 F or higher to establish the maximum density. RAP is temperature sensitive, which may affect the density.

Construct the control test strip that shall be at least 100 ft long, 12 ft wide and a maximum compacted lift thickness of 6 in. Prepare the subgrade for the control test strip in accordance with 204.03.07. Do not construct the control strip, or perform any subsequent construction, on frozen subgrade.

Compact the RAP for the control test strip with one pass of the roller. Measure the density after one pass with a nuclear density gauge (backscatter method) at the frequency for capping material at five random locations distributed across the length and width of the control test strip, as directed. Record the measurements and mark the locations for future reference.

Compact the RAP for the control test strip with a second pass of the roller. Measure and record the density again at the exact locations previously tested and as described above. Prepare a plot of

density versus the number of roller passes. Continue this process until the maximum dry density of the control strip is established.

There should be no drop in average density during construction of the control test strip for each lift. A drop in the average density of greater than 2 pcf during construction of the control test strip is an indication that the material is not properly compacting, and a new test strip shall be constructed.

The Engineer may require the Contractor to cut into the control test strip for visual inspection. All material, labor, equipment, tools, and incidentals necessary to provide an approved control test strip shall be at no additional cost to the Administration.

Compaction Control. Use the roller pattern and number of passes determined from the construction of the test strip to compact the RAP for production placement. The density of the RAP compacted for production work shall be at least 97 percent of the maximum density obtained from the control test strip. Recheck the density of the production work if it is less than 97 percent of the maximum density obtained from the control test strip. Construct a new control test strip if the second density does not meet the 97 percent requirement. Construct a new control test strip if the measured density of the compacted RAP for production work exceeds 105 percent.

Establish one rolling pattern to achieve maximum density for each use based on the control test strips. Samples or results produced prior to the construction of any new stockpiles will not be considered.

Category: 2017 Standard Specifications For Construction And Materials

901 AGGREGATES

From MDOT Policy Manual

Contents

- 1 **901.01**
- 2 **901.02 STONE FOR RIPRAP, CHANNELS, DITCHES, SLOPES, AND GABIONS.**
- 3 **901.03 STONE FOR CHANNELS AND DITCHES.**
- 4 **901.04 STONE FOR SLOPES.**
- 5 **901.05 STONE FOR GABIONS.**

901.01

This Section includes the material details, quality requirements, and test methods applicable to aggregates. Grading requirements are outlined in Tables 901 A and 901 C; physical properties in 901 B and 901 D. Force drying may be used in the preparation of samples for grading tests conducted in the field.

TABLE 901 A
AGGREGATE GRADING REQUIREMENTS - T 27

MATERIALS		SIEVE SIZE															
		2-1/2”	**2”**	**1-1/2”**	**1”**	**3/4”**	**1/2”**	**3/8”**	**No. 4**	**No. 8**	**No. 10**	**No. 16**	**No. 30**	**No. 40**	**No. 50**	**No. 100**	**No. 200**
		63 mm	**50 mm**	**37.5 mm**	**25 mm**	**19 mm**	**12.5 mm**	**9.5 mm**	**4.75 mm**	**2.36 mm**	**2.0 mm**	**1.18 mm**	**600 µm**	**425 µm**	**300 µm**	**150 µm**	**75 µm**
CRUSHER RUN AGGREGATE CR -6 (f)(g)		—	100	90-100	—	60-90	—	—	30-60	—	—	—	—	—	—	—	0-15
BANK RUN GRAVEL — SUBBASE		100	—	—	90-100	—	60-100	—	—	—	35-90	—	—	20-55	—	—	5-25
GRADED AGGREGATE — BASE DESIGN RANGE (a)		—	100	95-100	—	70-92	—	50-70	35-55	—	—	—	12-25	—	—	—	0-8
TOLERANCE (b)		—	(-)2	±5	—	±8	—	±8	±8	—	—	—	±5	—	—	—	±3 (c)
BANK RUN GRAVEL — BASE		100	—	—	85-100	—	60-100	—	—	—	35-75	—	—	20-50	—	—	3-20
COARSE AGGREGATE - PORTLAND CEMENT CONCRETE	57 and UNDERDRAIN (h)	—	—	100	95-100	—	25-60	—	0-10	0-5	—	—	—	—	—	—	—
	67	—	—	—	100	90-100	—	20-55	0-10	0-5	—	—	—	—	—	—	—
	7	—	—	—	—	100	90-100	40-70	0-15	0-5	—	—	—	—	—	—	—
FINE AGGREGATE — PORTLAND CEMENT CONCRETE, UNDERDRAIN, and PNEUMATIC MORTAR (d)		—	—	—	—	—	—	100	95-100	—	—	45-85	—	—	5-30	0-10	—
COARSE AGGREGATE — LIGHTWEIGHT PORTLAND CEMENT CONCRETE		—	—	—	100	90-100	—	10-50	0-15	—	—	—	—	—	—	—	—
FINE AGGREGATE — LIGHTWEIGHT PORTLAND CEMENT CONCRETE (d)		—	—	—	—	—	—	100	85-100	—	—	40-80	—	—	10-35	5-25	—
FINE AGGREGATE/SAND MORTAR and EPOXIES (d)		—	—	—	—	—	—	—	100	95-100	—	—	—	—	—	0-25	0-10
MINERAL FILLER		—	—	—	—	—	—	—	—	—	—	—	100	—	95-100	—	70-100

(a) To establish target values for design.
(b) Production tolerance.
(c) ±2 for field grading (omitting T 11).
(d) Fine aggregate includes natural or manufactured sand.
(e) Crushed glass shall not contain more than one percent contaminants by weight.
(f) Not to be used in the structural part of any Administration project.
(g) Recycled asphalt pavement may be used as a component not to exceed 15 percent and is not subject to aggregate physical property requirements in TABLE 901 B.
(h) Recycled concrete is prohibited in drainage applications.

TABLE 901 B
AGGREGATE PHYSICAL PROPERTY REQUIREMENTS

MATERIAL	TEST METHOD				
	SPECIFICATION	T 90	T 11	T 96	T 104
		PI MAX	MATERIAL FINER THAN No. 200 SIEVE %MAX	LOS ANGELES ABRASION %MAX	SODIUM SULFATE SOUNDNESS %MAX
CRUSHER RUN AGGREGATE CR-6	D 1241(a)	6	—	50	—
BANK RUN GRAVEL — SUBBASE	D 1241	6	—	50	—
GRADED AGGREGATE — BASE	D 1241	6	—	50	—
BANK RUN GRAVEL — BASE	D 1241	6	—	50	—
COARSE AGGREGATE — PCC (b)	M 80 CLASS A	—	1.0(c)	50	12
FINE AGGREGATE — PCC (b)(d)	M 6 CLASS B	—	4.0(e)	—	10
COARSE AGGREGATE — LIGHTWEIGHT PCC	M195	—	—	—	—
FINE AGGREGATE — LIGHTWEIGHT PCC (f)	M195	—	—	—	—
FINE AGGREGATE/SAND MORTAR and EPOXIES	M45	—	—	—	10
MINERAL FILLER (g)	M17	4	—	—	—
GLASS CULLET (h)	M 318	—	—	—	—

(a) Other approved inert materials of similar characteristics may be used provided they meet these provisions. For crushed reclaimed concrete, the soundness loss shall not exceed 18 percent after magnesium sulfate testing as specified in T 104.
(b) Test coarse and fine aggregate for PCC for alkali silica reactivity (ASR) per 902.10.
(c) 1.5 if material passing No. 200 sieve is dust of fracture, free of clay or shale.
(d) In areas exposed to traffic, manufactured sand shall have a minimum ultimate Dynamic Friction Value (DFV) of 40, based on the parent rock.
(e) 5.0 for concrete not subject to surface abrasion.
(f) Fine aggregate meeting M 6 may be used if the lightweight concrete does not exceed the maximum unit weight specified in the Contract Documents.
(g) Fly ash shall not exceed 12 percent loss on ignition.
(h) For use as a granular road base material. Not intended for use in locations where surfacing will not be placed over the base.

TABLE 901 C
ASPHALT MIXES AGGREGATE GRADING REQUIREMENTS, % PASSING FOR MIX DESIGN
T 27

MATERIAL		SIEVE SIZE									
		3/4in.	1/2in.	3/8in.	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
		19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	1.18 mm	600 µm	300 µm	150 µm	75 µm
GAP GRADED STONE MATRIX ASPHALT MIX - 9.5mm		100	100	75–90	30–50	20–30	—	—	—	—	8–13
GAP GRADED STONE MATRIX ASPHALT MIX -12.5mm		100	90–99	70–85	28–40	18–30	—	—	—	—	8–11
GAP GRADED STONE MATRIX ASPHALT MIX -19.0mm		100	82–88	60 max	22–30	14–20	—	—	—	—	9–11
OPEN GRADED FRICTION COURSE – 9.5mm (a)		—	100	85–100	20–40	5–10	—	—	—	—	2–4
OPEN GRADED FRICTION COURSE – 12.5 mm (a)		100	85–100	55–75	15–25	5–10	—	—	—	—	2–4
OPEN GRADED FRICTION COURSE – 12.5mm (b)		100	80–100	35–60	10–25	5–10	—	—	—	—	1–4
SLURRY SEAL (SS) AND MICRO -SURFACING (MS)	TYPE II	—	—	100	90–100	65–90	45–70	30–50	18–30	10–21	5–15
	TYPE III	—	—	100	70–95	45–70	28–50	19–34	12–25	7–18	5–15
CHIP SEAL SURFACE TREATMENT	7	100	90–100	40–70	0–15	0–5	—	—	—	—	—
	8	—	100	85–100	10–30	0–10	0–5	—	—	—	—

(a) Less than Design Level 4 (ESAL)
(b) Porous European Mix (PEM) – Design Level 4 (ESAL)

TABLE 901 D
AGGREGATE PHYSICAL PROPERTY REQUIREMENTS FOR ASPHALT MIXES

MATERIAL	TEST METHOD					
	SPECIFICATION	T 11	T 96	T 104	D 4791	MSMT 216 (http://www.roads.maryland.gov
		MATERIAL FINER THAN No. 200 SIEVE % max	LOS ANGELES ABRASION (LA) % max	SODIUM SULFATE SOUNDNESS % max	FLAT and ELONGATED (a) % max	DYNAMIC FRICTIO (DFV) (b) (c min
SURFACE COURSE 4.75mm, 9.5mm, 12.5mm, and 19.0mm	M323	—	45	12	10	25
SURFACE COURSE — HIGH DFV 4.75mm, 9.5mm, 12.5mm, and 19.0mm	M323	—	45	12	10	40 (e)
BASE COURSE 19.0mm, 25.0mm and 37.5mm	M323	—	45	12	10	—
GAP GRADED STONE MATRIX ASPHALT 9.5mm, 12.5mm, and 19.0mm	M323	—	30	12	20/5 (g)	40 (e)
OPEN GRADED FRICTION COURSE 9.5 mm, 12.5 mm, 12.5 mm PEM (h)	MSMT 409 (http://www.roads.maryland.gov/OMT/msmt409.pdf)	0.5	30	12	20/5 (g)	40 (e)
SLURRY SEAL (SS) and MICRO-SURFACING (MS)	—	—	—	12	—	40 (f)
CHIP SEAL SURFACE TREATMENT	M 80, CLASS A	1.0 (d)	45	—	—	—

(a) Testing for flat and elongated particles shall be conducted on the blended aggregates. Dimensional ratio of calipers shall be 5:1.
(b) The minimum Dynamic Friction Value (DFV) shall be based on a single aggregate source or a blend of aggregates used. Determine proportions of blended aggregates using MSMT 416 (http://www.roads.maryland.gov/OMT/msmt416.pdf).
(c) DFV and British Pendulum Number (BPN) determined on parent rock. Reclaimed asphalt pavement (RAP) shall have a DFV of 30.0.
(d) 1.0 for samples taken at the point of production. Samples taken at any point after shipment shall have no more than 1.5 percent finer than 0.075 mm sieve.
(e) Carbonate rock shall have a minimum of 25 percent insoluble residue retained on the 0.075 mm sieve.
(f) No blending allowed.
(g) Testing conducted on particles retained on the 4.75 mm sieve. . Dimensional ratio of calipers shall be 3:1/5:1.
(h) Porous European Mix

901.01.01 Steel Slag. Steel slag may be used for chip seal surface treatment, but not for any other aggregate.

901.02 STONE FOR RIPRAP, CHANNELS, DITCHES, SLOPES, AND GABIONS.

Use field or quarry stone of approved quality. Stone may be certified from a source previously approved. Ensure that maximum dimension does not exceed four times the minimum dimension.

901.02.01 Stone for Riprap. Ensure that stone for riprap is uniformly graded from the smallest to the largest pieces as specified in the Contract Documents. The stone will be accepted upon visual inspection at the point of usage, as follows:

CLASS OF RIPRAP	SIZE	PERCENT OF TOTAL by weight
0	Heavier than 33 lb Heavier than 10 lb Less than 1 lb	0 50 10 max
I	Heavier than 150 lb Heavier than 40 lb Less than 2 lb	0 50 10 max
II	Heavier than 700 lb Heavier than 200 lb Less than 20 lb	0 50 10 max
III	Heavier than 2000 lb Heavier than 600 lb Less than 40 lb	0 50 10 max

Note: Optimum gradation is 50 percent of the stone being above and 50 percent below the midsize. Reasonable visual tolerances will apply.

901.03 STONE FOR CHANNELS AND DITCHES.

Meet the size requirements of Class I Riprap and the following:

QUALITY REQUIREMENTS	
TEST AND METHOD	SPECIFICATION LIMITS
Apparent Specific Gravity T 85, min	2.50
Absorption T 85, % max	3.0
Sodium Sulphate Soundness - 5 cycles, 2-1/2 to 1-1/2 in. Aggregate T 104, % loss max	20

901.04 STONE FOR SLOPES.

M 43, size number 1 omitting T 11. The stone shall also meet the quality requirements specified in 901.03.

901.05 STONE FOR GABIONS.

Meet the quality requirements specified in 901.03 except the loss by sodium sulfate shall not be greater than 12 percent:

DEPTH OF BASKET in.	SIZE OF INDIVIDUAL PIECES * in.
6	3-6
9	4-7
12	4-7
18	4-7
36	4-12

*Size of pieces will be determined visually.

Category: 2017 Standard Specifications For Construction And Materials

▪

CATEGORY 900
MATERIALS

665 **DELETE:** SECTION 902 — PORTLAND CEMENT CONCRETE AND RELATED PRODUCTS in its entirety.

INSERT: The following.

SECTION 902 — PORTLAND CEMENT CONCRETE AND RELATED PRODUCTS

902.01 STORAGE. Storage of materials shall conform to the Contract Documents and as directed by the Engineer.

902.02 CERTIFICATION OF PORTLAND CEMENT AND BLENDED HYDRAULIC CEMENT. The manufacturer shall furnish certification as specified in TC-1.03. The certification shall also include:

(a) The mill shall report its quality control procedures, and submit a new report whenever there is a procedural change.

(b) The mill's control laboratory shall be inspected by the Cement and Concrete Reference Laboratory of the National Institute of Standards and Technology on their regularly scheduled visits. The Engineer shall be provided with copies of the reports of these inspections along with an account of the action taken to correct cited deficiencies.

(c) Records of data accumulated by the quality control procedures shall be produced upon request.

(d) A certified document shall accompany each shipment stating that the contents conform to all applicable requirements. Additionally, the document shall show the producer's name, mill location, carrier number, date loaded, weight contained in carrier, silo number, consignee, destination, Contract number, and type of cement. The signature and title of the signer shall be shown on the document.

(e) The mill shall, upon request, supply certified chemical and physical test values that can be associated with any sample representing cement drawn from a particular silo on a given date.

(f) Acceptance of cement by certification will be terminated if test results differ from mill results by more than the precision limits given in the test method. The acceptance procedure will then revert to storage testing and approval prior to shipment.

902.03 HYDRAULIC CEMENT.

902.03.01 Portland Cement. M 85, with the fineness and the time of setting determined using T 153 and T 131, respectively.

902.03.02 Slag Cement. M 302, Grade 100 or 120. The Contractor may request to substitute up to a maximum of 50 percent of the weight of cement with slag cement. When slag cement is used, the minimum cement factor and water/cement ratio will be determined on the basis of the combined weight of the portland cement and slag cement.

902.04 BLENDED HYDRAULIC CEMENT. M 240 Type IP containing 15 to 25 percent Fly Ash by weight of cement or Type 1S containing 25 to 50 percent slag cement by weight of cement. Maximum loss on ignition is 3.0 percent. The requirement for a manufacturer's written statement of the chemical composition is waived.

902.05 MASONRY CEMENT. C 91, except the water retention and staining tests are waived.

902.06 CONCRETE ADMIXTURES. Do not use concrete admixtures that contribute more than 200 ppm of chlorides based on the cement content when tested per MSMT 610. Use only prequalified admixtures.

902.06.01 Air Entraining Admixtures. M 154.

902.06.02 Chemical Admixtures. M 194, Type A, D, or nonchloride C.

902.06.03 High Range Water Reducing Admixtures. M 194, except that it shall be a liquid, the water content shall be a maximum of 85 percent of that of the control, and the durability factor shall be a minimum of 90. Use Type F for early strength, which shall produce a minimum compressive strength in 12 hours of 180 percent of that of the control. Use Type G when early strength is not specified. The manufacturer shall furnish certification as specified in TC-1.03. The certification shall include curves indicating the fluid ounces of admixture per 100 lb of cement as related to water reduction and strength gain for 12 hours when used with a minimum cement factor of 700 lb.

902.06.04 Pozzolans. When a pozzolan is used, determine the minimum cement factor and water/cement ratio on the basis of the combined weight cement and pozzolan. Do not use pozzolan and Blended Hydraulic Cement in the same mix.

(a) Fly Ash. M 295, pozzolan Class C or F, except that the maximum permissible moisture content shall be 1.0 percent, and when used in concrete Mix Nos. 3 and 6 the maximum loss on ignition 3.0 percent. Fly Ash may be substituted up to a maximum of 25 percent of the weight of cement.

(b) Microsilica. C 1240, except that the oversize requirement is waived. Microsilica may be substituted up to a maximum of 7 percent of the weight of cement.

902.06.05 Corrosion Inhibitors. Corrosion inhibitors shall be calcium nitrite based and contain a minimum of 30 percent active ingredients by mass. The gallonage of corrosion inhibitor used in the concrete mixture shall be included as water when determining the water/cementitious materials ratio.

902.07 PORTLAND CEMENT CONCRETE CURING MATERIALS. Use burlap cloth, sheet materials, liquid membrane forming compounds, or cotton mats.

902.07.01 Burlap. M 182, Class 1, 2, or 3.

902.07.02 Sheet Materials. C 171 with the following exceptions:

(a) White Opaque Burlap Polyethylene Sheeting. Tensile strength and elongation requirements are waived. Use sheeting having a finished product weight of not less than 10 oz/yd^2.

(b) White Opaque Polyethylene Backed Nonwoven Fabric. 902.07.02(a), with the thickness requirement waived. Use material having a finished product weight of not less than 5 oz/yd^2.

(c) White Opaque Polyethylene Film. Tensile strength and elongation requirements are waived.

902.07.03 Liquid Membrane. C 309. Field control testing of the white pigmented curing compounds is on the basis of weight per gallon. The samples shall not deviate more than ± 0.3 lb/gal from the original source sample.

902.07.04 Cotton Mats. Cotton mats consist of a filling material of cotton bats or bats covered with unsized cloth and tufted or stitched to maintain the shape and stability of the unit under job conditions of handling.

Use coverings of either cotton cloth, burlap or jute having the following properties:

(a) Cotton cloth covering shall weigh not less than 6.0 oz/yd^2 and have an average of not less than 32 threads/in. of warp and not less than 28 threads/in. of filling. Use raw cotton, cotton comber waste, cotton card strip waste, or combinations thereof as the raw material used in the manufacture of the cotton cloth.

(b) Burlap or jute covering for cotton mats shall weigh not less than 6.4 oz/yd^2 and shall have not less than of 8 threads/in. of warp and not less than 8 threads/in. of filling. Use the grade known commercially as "firsts" and they shall be free from avoidable imperfections in manufacture and from defects or blemishes affecting the serviceability.

Use a cotton bat, or bats made of raw cotton, cotton waste, cotton linters, or combinations thereof, as the filling material for the mats. Mats shall weigh not less than 12 oz/yd^2.

902.08 FORM RELEASE COMPOUNDS. Use form release compounds that effectively prevent the bond of the concrete to the forms. Form release compounds shall not cause discoloration of the concrete or adversely affect the quality or rate of hardening at the interface of the forms.

The flash point of the form release compound shall not be less than 100 F when tested per D 93.

902.09 PARAFFIN WAX. Use clear paraffin wax for use as a bond breaker for concrete. The flash point shall not be less than 380 F when tested under D 92.

902.10 PORTLAND CEMENT CONCRETE. Section 915 and as specified herein.

902.10.01 Proportioning. Prior to the start of construction, submit to the AME the source and proportions of materials to be used for each concrete mix. The mixture shall meet 902.10.03.

The concrete, with the exception of water and chemical admixtures, shall be proportioned by weight. Water and chemical admixtures may be proportioned by volume or weight. The mix shall be uniform and workable.

902.10.02 Materials.

Coarse Aggregate	901.01
Fine Aggregate	901.01
Cement	902.03 and 902.04
Concrete Admixtures	902.06
Synthetic Fibers	902.15
Water	921.01

902.10.03 Portland Cement Concrete Mixtures.

The concrete mixes shall conform to the following:

TABLE 902 A

PORTLAND CEMENT CONCRETE MIXTURES										
MIX NO.	SPECIFIED ACCEPTANCE COMPRESSIVE STRENGTH psi	COMPRESSIVE STRENGTH ACCEPTANCE TEST AGE days	STD. DEV. psi	CRITICAL VALUE psi	MIN CEMENT FACTOR lb/yd^3	COARSE AGGREGATE SIZE M 43 / M 195	MAX WATER/ CEMENT RATIO by wt	SLUMP RANGE in.	TOTAL AIR CONTENT %	CONCRETE TEMP. °F .
1	2500	28	375	2430	455	57, 67	0.55	2 - 5	5 - 8	50 - 95
2	3000	28	450	3010	530	57, 67	0.50	2 - 5	5 - 8	50 - 95
3	3500	28	525	3600	580	57, 67	0.50	2 - 5	5 - 8	50 - 95
4	3500	28	525	3600	615	57, 67	0.55	4 - 8	N/A	50 - 95
5	3500	28	525	3600	580	7	0.50	2 - 5	5 - 8	50 - 95
6	4500	28	675	4770	615	57, 67	0.45	2 - 5	5 - 8	50 - 80
7	4200	28	630	4420	580	57	0.50	1½ - 3	5 - 8	50 - 95
8	4000	28	600	4180	750	7	0.42	2 - 5	5 - 8	50 - 80
9	3000	(a)	N/A	N/A	800	57, 67	0.45	4 - 8	5 - 8	60 - 100
10	4500	28	675	4770	700	¾" – No. 4	0.45	2 - 5	6 - 9	50 - 80
11	4200	28	630	4420	—	57, 67	0.45	2 - 5	5 - 8	50 - 80
12	4200	28	630	4420	—	¾" – No. 4	0.45	2 - 5	6 - 9	50 - 80
HE	3000	(b)	N/A	N/A	N/A	N/A	N/A	3 - 9	5 - 8	60 - 100
PC (c)	N/A	N/A	N/A	N/A	450	7, 8	0.45	N/A	15 - 25	N/A
WT	2500	(d)	NA	NA	650	57	0.45	5 max	5 - 8	50 - 95

Note 1: When concrete is exposed to water exceeding 15,000 ppm sodium chloride content, Type II cement shall be used. In lieu of Type II cement, a Type I cement may be used in combined form with an amount of up to 50 percent replacement with slag cement, or an amount of up to 25 percent replacement with Class F fly ash. The Contractor shall submit to the Engineer the proposed mix proportions and satisfactory test results per C 1012 showing a sulfate resistance expansion not exceeding 0.10 percent at 180 days

Note 2: The temperature of Mix No. 6 when used for other than superstructure work as defined in TC-1.03 shall be 50 - 95 F.

Note 3: Type A or D admixture shall be added to bridge, box culvert, and retaining wall concrete.

Note 4: Nonchloride Type C admixtures may be used when approved by the Engineer.

Note 5: Other Slump Requirements:
When a high range water reducing admixture Type F or Type G is specified, the slump shall be 4 to 8 in.
When synthetic fibers are specified, the slump shall be 5 in. maximum.
When concrete is to be placed by the slip form method, the slump shall be 2-1/2 in. maximum.
When the absorption of the coarse aggregate is greater than 10 percent, the slump shall be 3 in. maximum.

Note 6: Mix 9 shall contain a Type F high range water reducing admixture.

Note 7: Mix 10 and 12 shall be proportioned as specified in 211.2 of the ACI's Recommended Practices for Selection Proportions for. Structural Lightweight Concrete. The maximum average Density of Cured Concrete shall be 118 lb/ft^3. Control testing for Density of Cured Concrete shall be two companion cylinders for each 100 yd^3, or fraction thereof, as specified in M 195.

Note 8: Mix 11 and 12 shall also conform to all requirements as specified in Table 902 C.

Note 9: Add Polyolefin Macro Fibers to Mix No. 8, Mix No. 9 and High Early Strength Patch Mix (HE). The dosage rate shall be per the manufacturer's recommendations.

(a) Mix 9 is for concrete pavement repair only . Match cure of the samples is permissible in accordance with AASHTO PP 54. Strength tests shall be scheduled accordingly on weekdays and acceptance will be based on a minimum compressive strength of 3000 psi in 24 hours or 3600 psi in 3 days. Acceptance testing shall conform to 902.10.08 except that cylinders shall be field cured

and remain in the molds until tests are conducted. Mix 9 when specified for incidental work and not requiring traffic control in conformance with 522.03.15 will not require the addition of fibers.

(b) Match cure the samples in accordance with AASHTO PP 54. Design approval will be given based on trial batch obtaining a minimum compressive strength of 2500 psi in 6 hours. Strength tests shall be scheduled accordingly on weekdays and acceptance will be based on a minimum compressive strength of 3000 psi in 24 hours or 3600 psi in 3 days. Acceptance testing shall conform to 902.10.08 except that cylinders shall be field cured and remain in the molds until tests are conducted.

(c) Pervious Concrete (PC) shall be proportioned as specified in 522R of the ACI's Recommended Practices for Pervious Concrete Mixture Proportions. Acceptance of freshly mixed Pervious Concrete shall be made based on Density and Total Void Content. Density and Total Air Voids of Freshly Mixed Pervious Concrete shall be performed per C 1688

(d) Whitetopping (WT) mix shall contain a high range water reducing admixture, macro-fibers at 3 lbs/yd^3 Max, and acceptance will be on a minimum compressive strength of 2500 psi in 24 hours.

Preventive Measures for Aggregate Alkali-Silica Reactivity (ASR). All aggregate, both coarse and fine, intended for use in concrete shall be tested for ASR in accordance with C 1260. Testing shall be performed by an accredited laboratory. Coarse and fine aggregate from the same source shall be tested separately. Testing shall be performed once every 3 years.

The following limitations apply for C 1260 results:

EXPANSION @ 14 DAYS	CLASS AND REACTIVITY STATUS	MITIGATION NOTE
≤ 0.10%	R0- Innocuous	No mitigation required
>0.10 but ≤0.20%	R1- Potentially Reactive	Mitigation Required*
>0.20 but ≤0.30%	R2- Reactive	Mitigation Required*
>0.30%	Highly Reactive	Shall not be used in PCC

*See Table 902 B for the minimum Supplementary Cementitious Material (SCM) replacement levels for ASR mitigation

Optional C 1293 Concrete Prism Testing. Testing in accordance with C 1293 is non-mandatory but recommended. The test may be used to verify the ASR class status of aggregate having C 1260 result greater than 0.10 percent expansion. If C 1293 testing is not performed, then compliance is assessed based entirely on the C 1260 result.

The requirements for compliance when using C 1293 are as follows;

(a) Test frequency is once every 3 years.

(b) The Administration will not perform this test. Testing must be performed by an accredited laboratory.

(c) Coarse and Fine aggregate from the same source shall be tested separately

(d) Each sample shall be split and tested in accordance with both C 1260 and C 1293. This is required to provide comparable data for future reference. Scheduling of the testing is at the producer's discretion, but both results must be submitted together for approval review.

(e) The C 1293 result will supersede the C1260 result for compliance status.

The following limitations apply for C 1293 results:

EXPANSION AT 1 YEAR	CLASS AND REACTIVITY STATUS	MITIGATION NOTE
≤ 0.04%	R0- Innocuous	No mitigation required
>0.04 but ≤0.12%	R1- Potentially Reactive	Mitigation Required*
>0.12 but ≤0.24%	R2- Reactive	Mitigation Required*. **No structural use allowed.**
>0.24%	Highly Reactive	May not be used in PCC

*See Table 902 B for the minimum Supplementary Cementitious Material (SCM) replacement levels for ASR mitigation

TABLE 902 B

MINIMUM MITIGATION REQUIREMENTS				
SCM Type	**Low** Alkali Cement (≤0.7% Na_20 equiv.) **R1**	**Normal** Alkali Cement (≤1.0% Na_20 equiv.) **R1**	**Low** Alkali Cement (≤0.7% Na_20 equiv.) **R2**	**Normal** Alkali Cement (≤1.0% Na_20 equiv.) **R2**
Class F Fly Ash	20%	25%	25%	25%
Slag (GGBFS)	35%	50%	50%	50%
Ternary Blends	Approval Required	Approval Required	Approval Required	Approval Required

Ternary blends using two SCM's will require C 1567 testing by an accredited laboratory. The expansion test results shall not be greater than 0.10 percent to be considered acceptable. Changes to the SCM blend percentages will require retesting.

TABLE 902 C

MIX PHYSICAL PROPERTIES		
TEST PROPERTY	**TEST METHOD**	**SPECIFICATION LIMITS**
Minimum Cementitious Materials Factor, lb/yd^3	—	580
Maximum Content of Portland Cement, lb/yd^3	—	550
Water/Cementitious Materials Ratio by Wt.	—	0.45
Corrosion Inhibitor, gal/yd^3	902.06.05	2.0
Synthetic Fibers, lb/yd^3	902.15	1.5
Permeability of Field Concrete, moving average of three tests, coulombs max	T 277	2500
Permeability of Field Concrete, individual test, coulombs max	T 277	3000
Shrinkage at 28 days, microstrains	C 157	400

Note 1: Only Type I or II Portland cement shall be used.

Note 2: Mixes shall contain slag cement, fly ash or microsilica.

Note 3: The water to cement ratio shall be based upon the total water to cementitious materials ratio. The gallonage of the corrosion inhibitor shall be included in the water/cementitious materials ratio.

Note 4: The permeability test value of field concrete shall be the average of two test specimens representing production concrete. Test specimens shall be molded on the project site in 4 x 8 in. molds conforming to M 205. Test specimens shall be handled in accordance with T 277 - Accelerated Moist Curing. Test for the geometry of test specimens will be waived.

Note 5: Shrinkage tests will be performed on trial mixes only.

Note 6: High range water reducing admixture may be used except the water reducing requirements will be waived.

Note 7: A sealer conforming to 902.12 shall be used on the finished surface.

902.10.04 Trial Batch. A trial batch shall be prepared to certify that each mix meets 902.10.05 and 902.10.06 except for mix 9. Approval will be given when the test results meets the minimum required average strength. Mix 9 design approval will be given based on trial batch obtaining a minimum compressive strength of 2500 psi in 12 hours.

Make arrangements with the AME at least two weeks in advance, to have an authorized representative present during the batching and testing. Each trial batch shall consist of at least 3 yd^3 of concrete. Laboratory testing in lieu of plant trial batches may be conducted when approved by the AME. Supply all equipment, and labor required to produce the trial batches and conduct the required tests at no additional cost to the Administration.

The AME may waive the requirement for a trial batch when past performance records show that the required average strength requirement has been met.

902.10.05 Design Required Average Strength.

Specified compressive strength, f_c', psi	Required average compressive strength, f_{cr}', psi
$f_c' \leq 5000$	Use the larger value computed from Eq. (A-1) and (A-2) $f_{cr}' = f_c' + 1.34s$ (A-1) $f_{cr}' = f_c' + 2.33s - 500$ (A-2)
Over 5000	Use the larger value computed from Eq. (A-1) and (A-3) $f_{cr}' = f_c' + 1.34s$ (A-1) $f_{cr}' = 0.90\, f_c' + 2.33s$ (A-3)

where:

f_c' = the 28 day specified compressive strength.
s = the standard deviation as specified in 902.10.06.

A test is defined as the average strength of two companion cylinders.

902.10.06 Standard Deviation.

(a) When past performance records are available, a standard deviation will be established from documented performance records of the producer consisting of a minimum of 15 consecutive 28 day compressive strength tests obtained within the last 12 months.

The standard deviation will be established as the product of the calculated standard deviation and multiplier.

NUMBER OF TESTS	MULTIPLIER FOR STANDARD DEVIATION
15	1.16
20	1.08
25	1.03
30 or more	1.00

Interpolate for intermediate number of tests.

(b) When past performance records are not available, the required average strength shall meet to the following:

Specified compressive strength, f_c', psi	Required average compressive strength, f_{cr}', psi
$f_c' < 3000$	$f_{cr}' = f_c' + 1000$
$3000 \leq f_c' \leq 5000$	$f_{cr}' = f_c' + 1200$
$f_c' > 5000$	$f_{cr}' = 1.10\, f_c' + 700$

902.10.07 Standard of Control. The average of all sets of three consecutive strength tests shall equal or exceed the critical value as specified in 902.10.03 which shall be computed using the following formula:

Critical Value = $fc' + (1.14 \text{ X } S) - 500$

Failure to conform to this criterion shall be cause for immediate investigation and remedial action up to and including suspension of production. A design standard deviation equal to 15 percent of the specified strength shall be used for calculation until a minimum of 15 test results are obtained.

The actual average strength and standard deviation shall be computed upon the availability of 28 day strength data comprising a minimum of 15 tests. Should this determination indicate an excessive margin of safety, the concrete mix may be modified to produce lower average strength as approved by the Engineer. If these calculations indicate a coefficient of variation greater than 15, the quality of the concrete and testing will be evaluated.

902.10.08 Testing. Sampling per R 60. Testing as follows:

TEST	METHOD	MINIMUM TEST FREQUENCY	RESPONSIBILITY
Temperature (e)	T 309	1 per 50 yd^3 (or fraction thereof)	Project Engineer
Slump (a)(e)	T 119	1 per 50 yd^3 (or fraction thereof)	Project Engineer
Air Content (a)(e)	T 152 T 196	1 per 50 yd^3 (or fraction thereof)	Project Engineer
Compression (b)(c)(d)	T 23	1 per 50 yd^3 (or fraction thereof)	Project Engineer
Compression (b)(c)(d) Mix No. 7 Only	T 23	3 per Day	Project Engineer

(a) A second test will be made when the first slump or air content test fails. Acceptance or rejection will be based on the results of the second test.
(b) Compressive strength tests are defined as the average of two companion cylinders.
(c) The Contractor shall be responsible for the making of all early break cylinders and furnishing the molds, stripping, curing/delivery of all cylinders, including 28 day cylinders, to the testing laboratory.
(d) The Project Engineer will be responsible for making, numbering and signing the 28 day cylinders.
(e) When constructing plain and reinforced concrete pavements, the testing frequency for slump, air content, and temperature shall be 1 per 100 yd^3 or fraction thereof.

902.10.09 Acceptance. Concrete will be acceptable if both of the following requirements are met:

(a) The average of all sets of three consecutive strength tests equal or exceed the specified design strength.

(b) No individual strength test (average of two companion cylinders) falls below the specified design strength by more than 500 psi.

902.10.10 Price Adjustment. A price adjustment will be based on the Contract unit price per cubic yard of concrete. If the unit is a lump sum item, the price per cubic yard for the concrete will be determined by dividing the cubic yards into the Contract lump sum price.

(a) Test Results More Than 500 psi Below the Specified Design Strength. Failing strength tests will be considered individually with a price adjustment being applied on the percentage basis as shown below.

(Price per yd^3) X (quantity of yd^3 represented by the failing concrete strength) X (percent of failure).

Example:

$400.00 per yd^3 X 50 yd^3 X [1-(3600/ 4500 psi)] = $4,000.00

No payment will be allowed when the test results fall below 50 percent of the specified design strength for structural concrete or 40 percent for incidental concrete.

The Engineer will determine when the strength of the concrete represented by the failing tests is sufficient to remain in place or whether it must be removed and replaced with Specification concrete.

(b) Test Results 500 psi or Less than the Specified Design Strength. Strength failures 500 psi or less than the specified design strength will be averaged with the next two consecutive tests. If those two tests include a failure greater than 500 psi, those tests will be evaluated as in 902.10.10(a) and replaced with the next consecutive test. If the resulting average falls below the specified design strength, a price adjustment will be applied as specified in the table below. Any failure will only be included in one grouping.

STRENGTH BELOW THE SPECIFIED (avg of 3 tests) DESIGN LEVEL, psi	**ADJUSTMENT FACTOR**
MIX NO. 1 THRU MIX NO. 12 EXCLUDING MIX 9	
1 – 100	0.005
101 – 200	0.01
201 – 300	0.02
301 – 400	0.04
401 – 500	0.08

Adjustment price equals (price per yd^3) X (quantity of yd^3 represented by the failing cylinders) X (the adjustment factor).

Example:

$400.00 per yd^3 X 50 yd^3 X 0.01 = $200.00

902.11 MORTAR FOR GROUT. Mortar used for grouting anchor bolts, pipe, handrail posts, and miscellaneous items shall be composed in accordance with one of the following:

(a) One part Portland cement or blended hydraulic cement and one part mortar sand by dry loose volume.

(b) Prepared bag mixes consisting of Portland cement or blended hydraulic cement and mortar sand. The prepared mixes shall produce a mortar meeting the strength requirements specified in the Contract Documents.

(c) Use nonshrink grout when specified. The grout shall have a minimum compressive strength of 5000 psi in seven days when tested as specified per T 106, except that the cube molds shall remain intact with a top firmly attached throughout the curing period. The

nonshrink grout shall have a minimum expansion of 0.0 percent after seven days when tested as specified per T 160.

(d) Epoxy grout shall consist of sand and epoxy mixed by volume in per the manufacturer's recommendations. The grout shall be capable of developing a minimum compressive strength of 6500 psi in 72 hours when tested per MSMT 501. Sand for epoxy grout as specified in 901.01.

(e) An epoxy or polyester anchoring system may be used when approved by the Engineer in accordance with the manufacturer's recommendations. Strength values shall be as specified in the Contract Documents.

902.12 LINSEED OIL. Shall consist of a 50-50 mixture (by volume) of boiled linseed oil meeting Federal Specification TT-L-190 and kerosene per D 3699.

902.13 LATEX MODIFIED CONCRETE. Portland cement concrete containing prequalified Laboratory approved styrene butadiene latex emulsion is defined as Latex Modified Concrete (LMC).

Latex emulsion shall have a minimum of 90 percent of the nonvolatiles as styrene butadiene polymers. The latex emulsion as specified in Table 902.13 A. The material shall be stored in suitable containers and be protected from freezing and exposure to temperatures in excess of 85 F.

LMC shall be proportioned using volumetric mixing and designed as follows:

LATEX MODIFIED CONCRETE	
MATERIAL	**SPECIFICATION LIMITS**
Portland Cement, CWT/yd^3, min	6.6
Latex Emulsion/Cement Ratio	0.31 – 0.34
Water/Cement Ratio, max	0.22
Entrained Air, %	6.0 ± 3
Slump, in.	5 ± 1

The physical properties of LMC shall conform to Table 902.13 B. The Contractor shall furnish the necessary 3 X 6 in. molds per M 205 to be used for the fabrication of compressive strength cylinders.

Control and Acceptance Sampling.

(a) Submit a two quart minimum sample, of the styrene butadiene latex emulsion to the AME daily for each lot of material used in a day's production.

(b) A batch for LMC is defined as the capacity of the equipment being used on the project. Slump and air samples will be taken and tested before the placement of a batch is

permitted. The slump shall be measured four to five minutes after discharge from the mixer. The test material shall be deposited off the deck and not be disturbed during this waiting period. One additional sample for slump and air will be taken randomly during the placement of each batch. For seven day compressive strength, two tests each per batch are required. A test is defined as consisting of two companion cylinders. The samples for these tests will be taken at random while the placement is in progress.

TABLE 902.13 A

REQUIREMENTS FOR CHEMICAL PROPERTIES OF LATEX EMULSION MATERIALS

PROPERTY	SPECIFICATIONS		QUALITY ASSURANCE TESTS	
	LIMITS	TOLERANCE	PREQUALIFICATION TESTS	CONTROL AND ACCEPTANCE
Color	White	—	X	X
pH	9.0 – 11.0	—	X	X
Weight, lb/gal	8.40 – 8.47	—	X	X
Solids Content, %	46 – 53	—	X	X
*Butadiene Content, % of polymer	30 – 40	—	—	—
Viscosity @ 10 rpm-cps	Match Original	± 20	X	X
*Surface Tension, dynes/cm max	50	—	—	—
*Mean Particle Size, polymer – Å	1400 – 2500	—	—	—
Coagulum, % max	0.10	—	X	X
*Freeze-Thaw Stability, coagulum, % max	0.10	—	X	X
Infrared Spectra of Latex Film	Match Original	—	X	X
Infrared of Alcohol, Soluble Portion of Latex	Match Original	—	X	X
Shelf Life, min	1 yr	—	X	—

Note 1: Quality assurance tests shall be conducted as specified in MSMT 612 except those denoted by an * shall be conducted as specified in FHWA RD – 78-35.

Note 2: The original or prequalification sample shall be accompanied by the producer's certification on all of the tests and properties noted above and as specified in TC-1.03. The certification shall contain actual test values of the product and the infrared spectrograph.

Note 3: A separate certification is required for each lot of material. The certification shall note the date of manufacture, lot size, and whether or not the material is identical to the formulation of the original sample.

TABLE 902.13 B

LATEX MODIFIED CONCRETE PHYSICAL PROPERTIES			
TEST PROPERTY	**TEST VALUES**	**QUALITY ASSURANCE TESTS**	
		PREQUALIFIED TESTS	**CONTROL AND ACCEPTANCE**
7 Day Compressive Strength, psi min	3000	X	X
28 Day Compressive Strength, psi min	3500	X	—
42 Day Compressive Strength, psi min	3500	X	—
7 Day Flexural Strength, psi min	550	X	—
28 Day Flexural Strength, psi min	650	X	—
42 Day Shear Bond Strength, psi min	2000	X	—
Durability Factor, 300 cycles, % min	85	X	—
Chloride Permeability, Ppm max	510	X	—
Scaling Resistance, 50 cycles, max	3	X	—

Note 1: Quality assurance tests shall be conducted as specified in MSMT 721.

Note 2: Seven Day Compressive Strength Test will be used for Control & Acceptance of the material. The minimum specified design strength is 3000 psi at seven days. The mix design approval and acceptance will be based on a coefficient of variation of 10 percent with a probability of 1 in 10 tests falling below the specified strength. Only test values 80% or greater than the specified strength will be accepted

902.14 RAPID HARDENING CEMENTITIOUS MATERIALS FOR CONCRETE PAVEMENT REPAIRS. Materials shall be a dry, packaged cementitious mortar having less than 5 percent by weight of aggregate retained on the 3/8 in. sieve and meet the following requirements:

Classification.

Class I — For use at ambient temperatures below 50 F.
Class II — For use at ambient temperatures of 50 to 90 F.
Class III — For use at ambient temperatures above 90 F.

Chemical Requirements. C 928 except that no organic compounds such as epoxy resins or polyesters as the principal binder.

Physical Requirements. Meet the following when tested per MSMT 725:

COMPRESSIVE STRENGTH, psi min				
CLASSIFICATION	**< 2 hr**	**2-6 hr**	**6 hr**	**28 days**
Type I — Slow	—	—	2000	4500
Type II — Rapid	—	2000	—	4500
Type III — Very Rapid	2500	—	—	4500

TEST RESULTS	
TEST PROPERTY	**LIMITS**
Bond Strength, 7 days, psi min	2000
Length Change, increase after 28 days in water, based on length at 3 hr, % max	+ 0.15
Length Change, decrease after 28 days, % max	- 0.15
Freeze Thaw, loss after 25 cycles in 10% $CaCl_2$ solution, % max	8
Initial Setting Time, minutes min	10

Marking. All packages delivered to the project shall be marked with the following information:

(a) Date material was packaged.

(b) Approximate setting time.

(c) Recommended dosage of water or liquid component.

(d) Mixing instructions.

(e) Class or temperature range.

Certification. The manufacturer shall furnish certification as specified in TC-1.03 showing the actual test results for each class and type of material submitted to the Laboratory.

902.15 SYNTHETIC FIBERS. When synthetic fibers are specified in the Contract Documents, the fibers shall be 1/2 to 1-1/2 in. long and conform to C 1116, Type III. The manufacturer shall furnish certification as specified in TC-1.03. The quantity of fibers used and their point of introduction into the mix shall conform to the fiber manufacturer's recommendations.

902.15.01 Macro Polyolefin Fibers. D 7508 with a minimum length of 1-1/2 in.

902.16 CONTROLLED LOW STRENGTH MATERIAL.

902.16.01 Usage. Controlled Low Strength Material (CLSM) shall consist of the types described below:

Type A – Used where future excavation of the CLSM may be necessary (e.g. utility trenches, pipe trenches, bridge abutments, and around box culverts).

Type B – Used where future excavation of the CLSM is not anticipated (e.g. filling abandoned conduits, pipes, tunnels, mines, etc. and replacing unsuitable soils below roadway and structure foundations where extra strength is required).

902.16.02 Materials.

Coarse Aggregate	901.01*
Fine Aggregate	901.01
Cement	902.03 and 902.04
Concrete Admixtures	902.06
Fly Ash	902.06.04
Water	921.01

*maximum size of 3/4 in.

Produce CLSM in conformance with the applicable portions of Section 915 and the following:

902.16.03 Proportioning. Submit the sources and proportions of materials, and certified test data as specified in TC-1.03 for each CLSM mixture prior to construction. CLSM shall be proportioned, on the basis of field experience and/or laboratory trial mixtures, to produce a flowable and self-compacting mixture meeting the requirements of 902.16.04.

CLSM shall be proportioned by weight; with the exception of water and chemical admixtures. Water and chemical admixtures may be proportioned by volume or weight.

902.16.04 CLSM Mixtures. Proportion CLSM with sufficient amounts of Portland cement, fly ash, or slag cement; individually or in combination, to produce a cohesive, non-segregating mixture that conforms to the physical properties in the following table:

CLSM Mix	28 Day Compressive Strength, (psi) D 4832	Flow Consistency, (in.) D 6103
Type A	50 - 200	8 min.
Type B	500 min.	8 min.

902.17 SELF CONSOLIDATING CONCRETE (SCC). The SCC mixture must meet the following requirements.

SELF-CONSOLIDATING CONCRETE PROPERTIES		
	PRESTRESS BEAMS	**PRECAST**
Compressive Strength C1758 / T 23	As per Contract Documents	As per Contract Documents
Min. Cement Factor lbs./yd^3	700	615
W/C ratio	.32 -.45	.32-.50
Total Air Content	5.5 +/- 1.5	6.5 +/- 1.5
Concrete Temperature F	65 +/- 15	70 +/- 20
Slump Flow C 1611	22 – 28 in.	22 – 28 in.
Visual Stability Index (VSI)	0 to 1	0 to 1
T20(T50)	2 – 10 sec.	2 – 10 sec.
J-Ring C 1621	+/- 2 in. design slump flow	+/- 2 in. design slump flow
Column Segregation C 1610	12 % maximum	-
Rapid Chloride Permeability	Coulombs maximum 2500	-
Freeze Thaw C 666	Minimum durability factor 80	-
Shrinkage at 28 Days C 157	400	-

Note 1: Column Segregation (C 1610), Rapid Chloride Permeability (T 277), Freeze Thaw (C 666), and Shrinkage at 28 Days (C 157) are required only at time of trial batch for mix approval or any time there is a change in materials.

Note 2: Report water/cement ratio, aggregate moistures and cement temperature on each batch ticket.Note 3: Mold a minimum of one set of Compressive Strength Test Cylinders for each trial batch and for each day's production or each 50 CY lot. Take the temperature of the mix once for each day's production or each 50 CY lot. Slump Flow, T20 and VSI testing shall be performed at trial batch and at the beginning of each day's production or each 50CY lot. Conduct J-Ring testing during each trial batch or on the next batch following a failure of either the spread or VSI test.

Note 4: For ASR Mitigation see 902.10.03 - Preventive Measures for Aggregate Alkali-Silica Reactivity

Note 5: High Range Water Reducing admixtures must be Type F or Type G and meet M 194.

Note 6: Viscosity modifying admixtures may be used only with prior approval by the Administration.

902.18 CONCRETE STAIN.

The material shall conform to the following requirements:

TEST PROPERTY	TEST METHOD	SPECIFICATION LIMITS
Accelerated Weathering	G7	Passing results
Mildew Resistance/fungus growth	Fed. Test Method STD.141, Method 6271	Resistance
Weatherometer, 1000 hours minimum	ASTM G26	No crazing, cracking, chipping, or flaking. Light chalk and color change. No other deterioration.
Total Non Volatile Vehicle, %	D2369	Mfr. Stated Value +/- 2%
Viscosity, Krebs Units, 77 deg. F	D562	Mfr. Stated value +/- 10 KU
Drying time (to touch)	D1640	1 hour minimum
Recoat dry time	D1640	Able to recoat within 24 hours
Infrared Spectrogram	D2621	n/a
Color	Fed. Std. 595	As specified in contract documents
Weight/gallon, lb.gal	D1475	Mfr. State value +/- 0.3 lb/gal
Shelf life		6 months minimum

Material more than six months old shall be retested. Material must be VOC compliant for Maryland.

915 PRODUCTION PLANTS

From MDOT Policy Manual

Contents

- 1 **915.01 GENERAL.**
- 2 **915.02 ASPHALT PLANTS.**
- 3 **915.03 PORTLAND CEMENT CONCRETE PLANTS.**
- 4 **915.04 BASE COURSE PLANTS**
- 5 **915.05 CERTIFIED PRECAST CONCRETE PLANTS.**

915.01 GENERAL.

These specifications are applicable to all batching and proportioning plants.

915.01.01 Approval. The plant from which the Contractor proposes to obtain material shall be approved by the Office of Materials Technology (OMT) before starting deliveries.

915.01.02 Lead Time. Notify OMT at least two working days prior to the start of operations. OMT shall be kept informed of plant operational procedures and be notified when a change is planned. Inspectors shall have safe access to all areas of the plant for the performance of their duties. All equipment, tools, machinery, and parts of the plant shall be maintained in a satisfactory working condition at all times.

915.01.03 Storage. The storage and handling of aggregates in stockpiles and bins shall be done in a manner that will prevent segregation, intermingling, and contamination by foreign material or equipment. Bins discharging to feeder systems shall be equipped with accessible calibrated devices to vary the quantity of material being fed.

915.01.04 Measuring Devices. Measuring devices shall meet the current edition of the National Institute of Standards and Technology Handbook 44, except as modified by Table 915. The producer shall provide all personnel and equipment for calibrating measuring devices.

Before the plant starts any proportioning operation, and at least once each year thereafter, all measuring devices, meters, dispensers, test weights, and other measuring devices shall be inspected, tested, and certified to be in proper operating condition by an approved testing agency. During the period of operation, all measuring devices, meters, dispensers, and other measuring devices shall be tested monthly and certified for accuracy and operating condition by the producer or an approved testing agency. Any weighing device by which materials are sold by weight as a basis of payment shall be tested monthly and certified by an approved testing agency. The Engineer shall be notified at least two working days in advance of monthly scale inspections. The certifications shall state capacities, minimum graduations, loads applied, degree of accuracy, and magnitude.

Balance and zero conditions of scales shall be checked daily, and at any other time requested by OMT. The Engineer may, at any time, direct that any measuring device be tested by the producer or an outside agency if there is any doubt about the accuracy of the measuring device. Certificates of inspection shall be posted in a prominent place in the plant, and a copy shall be promptly submitted to the Engineer.

Production plant tolerances shall meet the following table:

TABLE 915

MATERIAL	*MAINTENANCE TOLERANCE	UNIT OF MEASURE
Aggregate	0.2%	Weight
Portland Cement or Blended Hydraulic Cement of Ground Iron Blast Furnace Slag or Fly Ash	0.2%	Weight
Asphalt	0.2%	Weight or Volume
Water	1.5%	Weight or Volume
Additives	0.5%	Weight or Volume

∗Maintenance tolerance shall be the specified percent of the total capacity of the scale or the smallest scale graduation, whichever is greater.

If during the monthly check, the measuring devices are found to deviate from the allowable tolerance, they will be suspended from use until recalibrated to the Specification requirements. A price adjustment will apply to materials sold and accepted by weight that are supplied during the measuring device malfunction period when the malfunction resulted in an overpayment. The measuring device malfunction period is defined as the elapsed time between the two successive monthly checks.

915.01.05 Sampling Equipment. The producer shall provide all personnel and equipment for obtaining samples.

(a) Refer to M156 and D140. Sample liquid binder from a tap located at the last practical and safe point between the binder control unit and the plant.

(b) Sample and split asphalt mixes per R47.

(c) Sample and process aggregate per T2.

915.01.06 Quality Control Laboratory. The producer shall provide an Administration-approved laboratory at proportioning or batching plants suitable for conducting the various tests required. An off-site laboratory may be used with Administration approval. Approval of the QC laboratory and testing personnel will be subject to periodic inspection. Correct any deficiencies to the satisfaction of the Administration or approval will be withdrawn.

CATEGORY 900
MATERIALS

SECTION 915 — PRODUCTION PLANTS

915.02 ASPHALT PLANTS

DELETE: The second sentence in 915.02 (f)(2).

915.02.03 Responsibilities of the Administration.

DELETE: Dispute Resolution in its entirety.

INSERT: The following.

Dispute Resolution. Following is the procedure to resolve conflicts resulting from discrepancies between test results from the Office of Materials Technology's (OMT) Asphalt Technology Division or their designated AASHTO accredited third-party testing laboratory and the producer.

Verification. The producer and/or Project Engineer will provide a written dispute to OMT'S ATD Chief describing the nature of the dispute along with any pertinent information. Also provide OMT's Deputy Director for Material Quality with a copy of the written dispute.

The written dispute must be filed within five business days after receiving QA data from OMT. If the dispute was filed by the producer only, then OMT will inform the Project Engineer. The dispute will only be considered for review if test results are outside the multi-lab or operating tolerance limits for any particular test of concern.

ATD's Assistant Division Chiefs will review the pertinent information and report to the Chief. The Chief will report the findings of their review to the producer. This process will take three business days from the day written notification was received. This level will identify if further investigation or retesting is required.

Check Testing. Check testing will be performed on a split sample from the next day's production by the producer and OMT's Central Laboratory to determine any sampling/testing errors. The Producer and/or OMT can witness the testing performed by each laboratory if requested.

Verification and Check Testing will be completed within three to five business days from the day of the agreement and will focus on the questionable test results. If the issue is still not resolved, refer to Third-party Testing.

Third-party Testing. The producer and OMT will employ an AASHTO accredited laboratory to perform testing using split of the original sample. The lab whose test results vary the most from the test performed by the third-party lab will pay for the testing. The new test results will replace the original test results in the pay factor calculations. Third-party results will be considered binding unless the dispute is resolved without third-party testing, then mutually agreed upon test results will be considered binding. Testing shall be completed by the third-party testing laboratory within ten (10) business days of sample receipt.

Dispute Resolution Process for Discrepancies Related to Non-Test Results: The resolution process for non-test related disputes (pay factor calculations, turnaround times or mix design approvals) of sufficient magnitude to impact payment is as follows:

(a) When a non-test related dispute arises, the producer or Project Engineer will file a written dispute with the ATD Chief describing the nature of the dispute along with the pertinent information. The OMT Deputy Director of Material Quality will be copied on all written disputes. The written dispute must be filed within five business days from when the issue arises.

(b) The ATD Chief or Deputy Director of Material Quality will appoint a panel of three members to provide recommendations to resolve the dispute. The panel will include a member selected by the asphalt industry.

(c) The panel will make recommendations to the ATD Chief within five business days from the appointment.

(d) The ATD Chief or Deputy Director of Material Quality will decide the disposition of the dispute based on the panel's recommendations.

(e) A written report from the panel describing all subsequent actions and final disposition of the dispute shall be included in the project records.

(f) The process will be completed within ten business days from the date of notification. If subsequent disputes arise on the same issue, the written report will be included as a resource during the resolution process.

DELETE: SECTION - 915.03 PORTLAND CEMENT CONCRETE PLANTS in its entirety.

INSERT: The following.

915.03 PORTLAND CEMENT CONCRETE PLANTS. M 157, except as modified herein, including the applicable requirements of 915.01

915.03.01 Aggregate Storage. All aggregate used in portland cement concrete shall be maintained at a uniform moisture content in excess of its saturated surface dry condition. Water used shall meet 921.01.

915.03.02 Moisture Probes. Moisture probes may be used in place of actual daily moisture testing of fine aggregate. Calibrate and maintain moisture probes per the manufacturer's recommendations.

(a) Perform actual moisture tests for fine aggregate weekly and as directed. When the actual tests of the fine aggregate indicate a difference of greater than 0.5 percent free moisture than the moisture probe readings, immediately perform a second actual test.

(b) If the second test indicates a moisture difference of greater than 0.5 percent, recalibrate the moisture probe and verify. Records of all calibrations and weekly tests shall be maintained and made available.

915.03.03 Mixing Temperatures. The plant shall be equipped with approved methods of heating and cooling the mix. The temperature of the plastic concrete shall meet 902.10.03. The temperature of the cementitious materials and water during mixing shall not exceed 170 F.

915.03.04 Load Tickets. M 157. Provide an approved computer generated batch ticket indicating the pertinent information for each load in duplicate. The ticket shall indicate maximum allowable water and maximum water allowed for jobsite slump adjustment.

Distribute load tickets as specified in 915.03.06 (c)(2). The producer's copy shall be readily available for inspection upon request. Issue a Form 116 for each load in the event a computer generated batch ticket cannot be provided.

915.03.05 Mixers and Agitators. M 157 except as follows.

(a) Operate drums during transit at agitating speed only. Mixing during transit is prohibited.

(b) Add at least 85 percent of design water requirement at the plant through the certified plant water meter.

(c) Water for slump adjustment may be added at the plant through truck water system under the supervision of the certified concrete technician, provided the maximum specified water/cement ratio is not exceeded.

(d) A maximum of 3 gal of water per cubic yard of concrete may be added at the point of discharge provided it does not exceed the maximum specified water/cement ratio.

(e) No water may be added after partial discharge of the load.

(f) Loading of mixers or agitators that contain wash water in the drum is prohibited.

(g) When the concrete is specified or permitted to be produced by volumetric batching and continuous mixing, the batching and mixing unit shall meet C 685. Calibration shall meet MSMT 558.

(h) The minimum mixing time is 75 seconds for stationary mixers not subject to mixer performance tests.

915.03.06 Certified Concrete Plant. The producer shall be responsible for quality control of plant operations to ensure that the material meets as specified. The quality control process will be subject to unannounced periodic inspection by representatives of the Concrete Technology Division (CTD). Full participation in the inspection by the plant's certified technician is required.

Initial and Annual Inspection. Any plant initially setting up and annually thereafter will be subject to a comprehensive inspection to determine whether the plant equipment and personnel meet all applicable requirements. The Administration will accept certification that the plant facilities meet all applicable requirements from either of the following:

(a) National Ready Mixed Concrete Association (NRMCA) Plant Certification Program. The Administration will review NRMCA Plant Certification Data and annually issue a written Plant Certification Approval. The Administration will perform QA visits as needed to validate the plant certification.

(b) A Professional Engineer registered in the State of Maryland with at least 5 years operational or technical experience in concrete production. The Administration will review the Engineer's inspection report and issue a written Plant Certification Approval.

(c) The Administration will conduct the inspections only if (a) and (b) are not feasible or applicable. The cost for inspection will be charged to a current Contract if applicable or to the ready mix producer if a current Contract is unavailable.

Responsibilities of the Concrete Producer.

(a) Notification. Notify CTD one working day prior to producing materials for Administration projects. Notify CTD at least five working days in advance of scheduling the comprehensive inspection.

(b) Quality Control. Have the certified concrete plant technician present while concrete is being batched and delivered to Administration projects. This technician shall supervise concrete production.

(1) Develop and use an acceptable Quality Control Plan (QCP) that addresses all elements necessary for plant quality control. Submit the QCP for review and approval at the time of the annual comprehensive inspection. The QCP shall include the names, qualifications and responsibilities of a Quality Control Manager and Quality Control Technicians.

(2) Control tests shall be performed by or under the direct supervision of the certified concrete plant technician. The technician shall perform moisture tests, adjust proportions of aggregate for free moisture, complete and sign batch or approved delivery tickets, and ensure quality control of the batching operations.

(3) Concrete Plant Technician certification will be awarded upon satisfactory completion of examinations administered by the Administration.

(4) Supply all necessary test equipment.

(5) Sampling and testing shall meet the procedures and frequencies outlined in the Material Quality Assurances Processes, Details and Frequencies manual.

(c) Reports. The following reports shall be processed by the producer.

(1) Administration Form 113, daily. Provide a copy for the producer's plant file for review.

(2) Load Tickets for each load. Provide a copy for the project and producer's file.

(3) Administration forms for all concrete materials sampled at the plant.

(4) Test Worksheets for all tests performed daily at the plant.

(5) Provide a Monthly Production Report to CTD via e-mail to concrete@sha.state.md.us by the 10th of each month. Report the total cubic yards and the total weight of each type of supplementary cementitious material used in concrete production for Administration projects for the previous calendar month.

(d) Inspectors Office. The producer shall provide an onsite office meeting the basic requirements of Section 103 Type A - Engineers Office for the exclusive use of SHA Engineers and Inspectors, as approved by the Engineer. The requirement for a mobile office trailer is waived.

Responsibilities of the Administration.

(a) Comprehensive Inspection and Acceptance Inspection and Testing.

(1) The Quality Control Manager will be notified immediately to correct any deficiencies found during an Administration inspection to the satisfaction of the Engineer. Production will be suspended for deficiencies where the quality of the product is affected, as determined by the Administration.

(2) If critical deficiencies are found or consecutive inspections reveal identical or additional deficiencies, a Non-Compliance Report (NCR) will be issued to the Quality Control Manager detailing the findings and actions to be taken by the producer.

(3) The Administration reserves the right to assign an Inspector to monitor operations for a maximum of five Administration production days. If at the end of this period the quality control process is not satisfactory, a NCR will be issued and plant approval will be rescinded. The plant shall be recertified before Administration production can continue.

(b) Recertification of Concrete Plant. Documentation of corrective action shall be submitted to the CTD by a professional engineer registered in the State of Maryland. A comprehensive inspection will be conducted by the Administration to recertify the concrete plant once the documentation is approved.

(c) Independent Assurance Audits (IAA). The Administration will evaluate the equipment and the proficiency of QC technicians through audits performed on a random basis. The QC technician shall cooperate with the IAA technician in the evaluations.

(d) Technician Certification. Conducted per the Mid-Atlantic Region Certification Program (MARTCP) and the Maryland Technician Certification Program.

DELETE: SECTION - 915.05 CERTIFIED PRECAST CONCRETE PLANTS in its entirety.

INSERT: The following.

915.05 CERTIFIED PRECAST CONCRETE PLANTS Shall meet the applicable requirements of 915.01, 915.03 and the following.

Certified Precast Concrete Plant. The producer shall be responsible for quality control of plant operations to ensure that the material meets specification requirements. The quality control process will be subject to unannounced periodic inspection by representatives of the Concrete Technology Division (CTD). Full participation in the inspection by the plant's certified technician will be required.

All plants producing precast concrete items of any description for Administration contracts shall be certified as appropriate by one or more of the following at the time of their Annual Inspection:

(a) The American Concrete Pipe Association (ACPA)

(b) The National Precast Concrete Association (NPCA)

(c) The Precast/Prestressed Concrete Institute (PCI).

Plants may be required to hold multiple certifications in order to produce a variety of products.

Initial and Annual Inspection. The Administration will perform comprehensive initial and annual inspections on all plants to ensure that the plant equipment and personnel meets all applicable specification requirements. The Administration will accept certification that the plant facilities meet all applicable requirements from a professional engineer registered in the State of Maryland with at least 5 years operational or technical experience in concrete production. Final acceptance and approval will be as determined by the Administration.

The cost for inspection will be charged to a current Contract if applicable or to the precast producer if a current Contract is unavailable.

915.05.01 Responsibilities of the Precast Concrete Producer.

(a) Notification. Notify CTD 14 days prior to producing any precast items for each Administration project. Notify CTD at least five working days in advance of scheduling the comprehensive inspection.

(b) Quality Control. Have the certified quality control technician present while concrete is being batched and cast. The technician shall supervise all aspects of precast concrete production.

(c) Quality Control Procedures. Quality control procedures shall be detailed in the Quality Control Plan and include the following:

(1) The method of inspecting reinforcement steel placement and forms prior to pouring concrete.

(2) The method of curing the concrete.

(3) The method of maintaining accurate quality control records.

(4) Samples of documents approved by the Engineer.

(5) Patching procedures.

(6) Methods of preparing the concrete units for shipment.

(7) A method of identifying each piece as tested and approved by quality control.

(d) When required, the producer shall submit a repair procedure for the precast product for approval that conforms to PCI Manual 137 and all other applicable specifications. All materials used for repairs shall be supplied from approved sources.

(e) Develop and use an acceptable Quality Control Plan (QCP) that addresses all elements necessary for plant quality control. Submit the QCP for review and approval at the time of the annual comprehensive inspection. The QCP shall include the names, qualifications and responsibilities of a Quality Control Manager and Quality Control Technicians.

(1) All precast concrete products shall meet the Standards or approved working drawings. All materials shall be from an Administration approved source and meet all applicable specifications.

(2) The plan shall indicate how the producer intends to handle all of its materials.

(3) Sample and testing frequency and certification of materials shall meet the Material Quality Assurances Processes, Details and Frequencies manual.

(4) The producer shall submit a repair procedure for approval conforming to PCI Manual 137 and all other applicable specifications. All materials used for repairs shall be supplied from approved sources.

(f) Quality Control Technician. Certified Quality Control Technicians shall hold the following certifications:

(1) Maryland State Highway Administration – Office of Materials Technology Certified Concrete Plant Technician (Certified Plant Technician)

(2) American Concrete Institute (ACI) Level I

Technicians shall also hold one of the following certifications as required:

(1) PCI Level I,

(2) NPCA Production & Quality School (PQS) Level I,

(3) ACPA Q-Cast Certified Technician.

(g) Test Equipment and Facilities. Supply all necessary test equipment and provide Administration-approved facilities suitable for conducting the various tests required. Off-site test facilities shall be approved by the Engineer.

(h) Reports. The following reports shall be processed by the producer:

(1) Load Tickets for each load. Provide a copy for producer's file for review.

(2) Administration Forms for all concrete materials sampled at the plant.

(3) Test Worksheets for all tests performed daily at the plant.

(4) Provide a Monthly Production Report to CTD via e-mail to concrete@sha.state.md.us by the 10th of each month. Report the total cubic yards and the total weight of each type of supplementary cementitious material used in concrete production and the total number of precast items shipped to Administration projects for the previous calendar month.

(i) Inspectors Office. The producer shall provide an onsite office meeting the basic requirements of Section 103 Type A - Engineers Office for the exclusive use of SHA Engineers and Inspectors, as approved by the Engineer. The requirement for a mobile office trailer is waived.

915.05.02 Responsibilities of the Administration

(a) Comprehensive Inspection.

(b) Verification Testing.

(1) Verification of certification will be performed a minimum of once per year at the Administration's discretion.

(2) The Administration reserves the right to discontinue acceptance of precast units if verification indicates that materials or test procedures do not meet the Contract Documents.

(c) Acceptance Inspection and Testing.

(1) If deficiencies are found during an Administration inspection, the Quality Control Manager will be notified immediately to correct the deficiencies to the satisfaction of the Engineer. Production will be suspended for critical deficiencies where the quality of the product is affected as determined by the Administration.

(2) If critical deficiencies are found or consecutive inspections reveal identical or additional deficiencies, the Engineer will issue a Non-Compliance Report (NCR) to the Quality Control Manager detailing the findings and actions to be taken by the producer.

(3) The Administration reserves the right to assign an Inspector to monitor plant operations for a maximum of five Administration production days. If at the end of this period the quality control process is not satisfactory, a NCR will be issued and plant approval will be rescinded. The plant shall be recertified before Administration production can continue.

(d) Recertification of Precast Concrete Plant. Documentation of corrective action shall be submitted to the CTD by a Professional Engineer registered in the State of Maryland. After approval of the

corrective action documentation, a comprehensive inspection will be conducted to recertify the concrete plant.

(e) Independent Assurance Audits (IAA). The Administration will evaluate the equipment and the QC technicians' proficiency through audits performed on a random basis. The QC technician shall cooperate with the IAA technician in the evaluations.

(f) Technician Certification. Conducted per the Mid-Atlantic Region Technician Certification Program (MARTCP) and the Maryland Technician Certification Program.

Recommended AASHTO / ASTM Standards

The following is a list of specification standards every technician should obtain

* Fine Aggregate for Hydraulic Cement Concrete
  AASHTO M-6 / ASTM C 33

* Coarse Aggregate for Hydraulic Cement Concrete
  AASHTO M-80 / ASTM C 33

* Ready-Mixed Concrete
  AASHTO M-157 / ASTM C94

Part Three

Sampling and Testing Procedures

- **Maryland Standard Method of Test (MSMT)**

  - Determination of Moisture Content of Aggregates MSMT – 251
  - Sampling Air Entraining and Chemical Admixtures for Concrete MSMT – 550

- **Sampling and Testing Frequency Guide**

- **Recommended AASHTO / ASTM Standards**

Recommend Approval:	Maryland Department of Transportation State Highway Administration Office of Materials Technology MARYLAND STANDARD METHOD OF TESTS	
Team Leader: J. W. Hall III Date: 9/21/2011 Division Chief: M. Spear Date: 09/21/2011		
Approved: Director: Tim Smith Date: 10/31/11	**DETERMINATION OF MOISTURE CONTENT OF AGGREGATES**	**MSMT 251**

SCOPE:

This procedure is used to determine the moisture content of aggregates in the field.

REFERENCES:

T 255 Total Evaporable Moisture Content of Aggregate by Drying

MATERIALS AND EQUIPMENT:

1. An electric hot plate or a gas burner.
2. Scale or balance conforming to M 231, Class G2.
3. Metal container, such as a large pie pan or equivalent.
4. Pointed trowel or large spoon.

TEST PROCEDURE:

1. Select a representative quantity of material having a minimum weight conforming to the following:

MAXIMUM PARTICLE SIZE	MINIMUM SAMPLE MASS
2 in.	1000 g
¾ in.	500 g
No. 4	250 g

2. Weigh a clean, dry container to the nearest 0.1 g.
3. Place the sample in the container and weigh to the nearest 0.1 g.
4. Place the container on the burner or hot plate and mix the sample continuously to expedite drying and to prevent burning the material.

5. When the sample looks dry, remove it from the heat, cool, and weigh. Place the sample back on the heat, continue drying for another 2 to 3 minutes, cool, and reweigh. The sample is dry when there is less than 0.1 percent difference between the weights. Record the weight of the sample and container to the nearest 0.1 g.

CALCULATIONS:

1. Moisture content of aggregate:

$$P = \frac{W - D}{D - C} \times 100$$

where:

P = percent moisture,

W = weight of wet aggregate and container,

D = weight of dry aggregate and container, and

C = container weight.

REPORT:

Report the moisture content to the nearest 0.1 percent.

Recommend Approval: Assistant Division Chief — Date: 2-8-12	Maryland Department of Transportation State Highway Administration Office of Materials Technology MARYLAND STANDARD METHOD OF TESTS	
Division Chief — Date: 2/8/12		
Approved: Director — Date: 03/12/12	**SAMPLING AIR ENTRAINING AND CHEMICAL ADMIXTURES FOR CONCRETE**	**MSMT 550**

SCOPE:

This procedure is used for sampling admixtures added to concrete mixes at a production plant or in the field.

MATERIALS AND EQUIPMENT:

All plants shall provide equipment satisfactory for obtaining liquid admixture samples from the last practical point prior to mixing with other ingredients.

TEST PROCEDURE:

1. Obtain liquid admixture samples in a single operation. Non-liquid admixture samples shall be of the commercial package size supplied to the plant or project.

2. Agitate the liquid admixture thoroughly prior to sampling. Sample the admixture from the last practical point prior to the admixture entering the mixer drum.

3. Store samples to provide protection from dampness, extreme heat, and extreme cold. Use 1-quart metal screw top cans as containers for liquid admixture samples. Samples shall be delivered within 30 days of collection.

4. Samples must be accompanied with a completed Form 88 - *General Materials Sample.*

TABLE 1

SMALL QUANTITY EXCEPTIONS

These guidelines exempt small quantities of material from testing when the material is used in noncritical parts of the project. When small quantities of materials are used in major items, prior approval for their use without testing shall be obtained from the Area Materials Engineer. Small quantity exception shall apply regardless of basis of measurement/payment. Small quantity exceptions are as follows:

MATERIAL	QUANTITY DESIGNATED AS `SMALL' NOT TO EXCEED
Aggregate, Coarse, For Drainage	100 T/day or 500 T /project
Aggregate, Chip Seal	100 T/day or 500 T /project
Aggregate, Fine, For drainage	100 T /day or 500 T /project
Bank Run Gravel For Base & Subbase Courses	200 yd^2 /day or 1000 yd^2/project
Block, Masonry Concrete	200/day or 1000/project
Brick, Clay	200/day or 1000/project
Cement, Masonry	10 bags
Cement, Portland	10 bags
Fabric, Wire(For Pneumatically Applied Mortar)	1 roll
Fence, Fabric(Chain Link)	5 rolls
Turf Establishment – Nutrient Management Plan	30 yd^3 *

* For all areas except, for topsoil placed at residential, commercial or Administration facilities where permanent seeding/sodding is to be placed. For these areas all topsoil used shall be tested. For nontopsoiled areas the minimum is 5000 ft^2.

TABLE 1

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
Aggregate, Hot Mix Asphalt	6	1 / 4 months or 1 / year *	50 lb	Soils bag	12	* Based on performance records
Aggregate, Coarse for Drainage	6	1 / 4 months or 1 / year *	50 lb	Soils bag	12	* Based on performance records. See small quantity exception, Page 1.
901.01	12				14	
Aggregate, Coarse for Portland Cement Concrete	6	1 / 4 months or 1 / year	50 lb	Soils bag	12	* Based on performance records
901.01	5	2 / day	50 lb	Soils bag		
Aggregate, Chip Seal	6	1 / 4 months or 1 / year *	50 lb	Soils bag	12	* Based on performance records. See small quantity exception, Page 1.
901.01	12				14	
Aggregate, Fine for Drainage	6	1 / 4 months or 1 / year *	40 lb	Soils bags	12	* Based on performance records. See small quantity exception, Page 1.
901.01	12				14	
Aggregate, Fine for Epoxies 901.01	4 B 12				14	
Aggregate, Fine for Portland Cement Concrete	6	1/4 months or 1/year *	40 lb	Soils bag	12	* Based on performance records
901.01	5	2/day	10 lb			
Aggregate, Graded Base Courses	6	1/4 months or 1/year *	150 or 75 lb each component	Soils bag	12	* Based on performance records
901.01	5	2/day	75 lb	Soils bag		
Project Compaction	13	SEE TABLE 2 & 3 Aggregate for Base Courses & Shoulders	75 lb	Soils bag	34	

TABLE 1

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
Aggregate, CR-6 (For M.O.T. & Shoulder Backup Only)	6	1 / 4 months or 1 / year *	150 or 75 lb each component	Soils bag	12	*Based on performance records
901.01	12				14	
Aggregate, Lightweight	6	1 / 4 months or 1 / year *	35 lb	Soils bag	12	*Based on performance record
901.01	5	2 / day	35 lb	Soils bag	113	
Air Entraining Admixtures 902.06	5	Monthly	1 qt	Screw top can	88	Report kept at plant & Regional Laboratory
Aluminum Signing Material 950.08.01	1 A *					* Note: for fabrication only
950.08.02	4 A					Sheet aluminum
Anchor Bolts (Signing & Lighting) 909.07	1B & 4A	1 / size/heat	2 each / 2 ft		88	
Asphalt Cements (Performance Graded Binder)	4 A			Friction top		
904.02	5	1 / production day	1 qt	can	88	
Asphalt, Emulsified	2 & 4A (Project)	1 / delivery *	1 gallon	Widemouth plastic jar	88	*When used as tack or to tie mulch no sample necessary
904	4A & 5 (Plant)	1 / delivery	1 gallon	Widemouth plastic jar	88	
Asphalt Release Agents	*					* Qualified products list
Barbed Wire 915.02 914.05	12		3 ft.		88* 14	*If sampled

TABLE 1

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
Bearing & Expansion Plates (bronze or copper) (include inserts) 910.01	1B & 4A					
Block, Masonry Concrete 903.04 903.05	2 & 4B	Per shipment of 6000 or fraction thereof *	6 blocks		88	*See small quantity exception Page 1
Borrow, Capping	3	Prior to use	35 lb	Soils bag	27B	
916.01 .02	2	2 / 2 lane miles	35 lb	Soils bag	27B	*See TABLE 2, Embankment, Capping
for compaction	13	*			31	Material, Subgrade, or Tamped Fill
Borrow, Common	3	Prior to use *	35 lb	Soils bag	27B	*Sample at source
916.01.04	13				31	Compaction
Borrow, Select and Modified	3	Prior to use	35 lb	Soils bag	27B	
916.01.01 916.01.03	2	*	35 lb	Soils bag	27B	*See TABLE 2 Embankment,Capping
for compaction	13	*			31	Material, Subgrade,or Tamped Fill
Breakaway Bases and Stubs for Signing and Lighting 821	8					
Brick, Clay 903.01 903.02 903.03	2 & 4B	Each shipment of 50 000 or fraction thereof *	10 bricks		88	* See small quantity exception Page 1
Bridge Mounts for	1B & 4A					

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
Signing & Lighting 412	facility only					
Bronze Inserts, Bridge Accessories 910.01.01	1B &4A					
Burlap, Plain and Polyethylene Backed 902.07	12				14	
Cable, Electrical (Signing & Lighting) 950.06	8					
Cable Rings (Signing & Lighting) 819	8					
Calcium Chloride or Magnesium Chloride 921.02	4A*		1 gallon	Plastic Jar		* Cert. required when used for stabilization or patching
	4A	**	1 gallon	Plastic Jar		** See TABLE 3 Aggregate for Base Courses & Shoulders
Casings, Steel for Cast-In-Place Concrete Piles 907.02	4 B		18 x 18 in.		88*	* If sampled
Pile tips 407.03.04	4B					
Cement, Masonry						See small quantity exception

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
902.05	2 & 4B	Per shipment *	10 lb	Plastic Jar	88	Page 1
Cement, Portland	4A & 5 (Plant)	1 every 10 production days	10 lb	Plastic Jar	88	
902.03	2 & 4 A (Project)	Per shipment *	10 lb	Plastic Jar	88	*See small quantity exception Page 1
Chemical Additives for Concrete 902.06	4A & 5 (Plant)	*	1 qt	Screw top can	88	*SEE TABLE 3 Portland Cement Concrete for Structures & Pavements
High Range Water Reducers 902.06	2 & 4A (Project)	*	1 qt	Screw top can	88	
Clamps (Signing & Lighting)	8					
Clay, Impervious Base	3	Per job	35 lb	Soils bag	27B	
Coating Systems for Structural Steel Steel Primer 912	4A					
Sealer Coat Intermediate Coat Finish Coat 912	4A					
Concrete, Portland Cement Pavements and Structures	SEE TABLES 2 & 3, PORTLAND CEMENT CONCRETE FOR STRUCTURES AND PAVEMENTS					
902 Additives-	SEE CHEMICAL ADDITIVES FOR CONCRETE					
Conduit & Fittings, Metallic & Nonmetallic 921.07.01 921.07.02	12 *				14	* Confirmation of UL or NEMA labels by Project Engineer
Connector Kits,	8					

TABLE 1

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
Electrical 950.14.01 950.14.02						
Control Cabinets, Electrical 950.13	8					
Cotton Mats 902.07.04	12		1 mat *		(88*)	* If sampled
Crack Filler, Hot Pour & Silicon 911.01	SEE JOINT SEALER AND CRACK FILLER					
Crash Cushions 614	4B					
Cribwalls (Precast Items) 819	4B					
Curing Compounds White & Clear* 902.07	4A *					* Qualified products list
Damproofing &Cold applied	4B*					* Qualified products list
Waterproofing Asphaltic Hot Applied 913.01 913 Cold Applied MSMT 423	4B					
Procedure A Membrane-913.04	4A					
Delineators –	Flexible					*Flexible type qualified

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
Flexible, Post Mounted & Barrier Mounted	Others – 4B					material by OOTS. Project Engineer to verify source when material is received
Detectors, Electrical Items 810.03.06	8					
Disconnects, Electrical Items 950.14.03	8					
Dowel Bars, Steel 908.02	4A					
Dresser Couplings, Utilities	8					
Epoxy Protective Coating for Concrete	4A					
Fusion Bonded Epoxy Powder Coating for Steel 917.01 917.02	* 4B – (Stand, alone material)					* Qualified products list
Fusion Bonded Polyester Coating 917.03	4A – (Stand alone material) 4B (After applied)					
Epoxy Adhesives 921.04	1A & 4A*		1 qt of part A & 1 qt of part B minimum	Factory sealed container	88	* Producer's label or data sheet with complete mixing instructions shall accompany sample
Fabric, Asphalt	4B					

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
Impregnated 913.03						
Fabric, Welded Steel Wire 908.05	4B					
Fabric, Wire (for Pneumatically mortar) 908.08	4B	1 / 50 rolls, or fraction thereof *	5 longitudinal / 5 transverse wires			See small quantity exception, Page 1.
Detectable Warning Surfaces	4B *					* Qualified Products List – Highway Design
Fence Fabric, Chain Link 914.01	1A	1 / 100 rolls, or fraction thereof *	1 ft x ht of roll		88	* See small quantity exception Page 1
Fittings & Hardware 914.03	4B					
Posts, Steel 914.03	4B					
Fertilizer 920.03	4B *					* Qualified producers list.
Fiberglass Scuppers Bridge Accessories and Pile Jackets	1A					
Fly Ash 902.06.04	(Plant) 4A & 5	1 every 10 production days	10 lb	Plastic Jar	88	
	(Project) 2 & 4A	Per shipment	10 lb	Plastic Jar	88	See small quantity exception Page 1
Form Release Compounds 902.08	12 *				14	*Qualified products list
Frame and Grate (cast)	4B					

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
909.04						
Geotextile, Filter Fabric 921.09	4A					
Geotextile, Silt Fence Class "F"	4A					
Glass Beads Special Prov. Insert	4A		2-50 lb bags	Mfg. pkg.	88	Verify. Samples taken at Mfg. Loc. If possible
Ground Clamps & Rods, Signing & Lighting 950.06.04	8					
Ground Iron Blast Furnace Slag	(Plant) 4A &5	1 every 10 production days	10 lb	Plastic Jar	88	
902.06.04	(Project) 2 & 4A	Per shipment *	10 lb	Plastic Jar	88	* See small quantity exception Page 1
Ground Limestone Quick Lime 920.02	12				14	
Grout Epoxy- 902.11	1A & 4A	1 / lot or batch	1 qt each component	Can	88	
Non-shrink	4B *					* Qualified products list
Polyester-Anchoring Systems	4A					

Handboxes, Electrical Precast Items	4B					

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
811						
Hardware, Metal 909.09	4B					
Herbicides	7					
Hot Mix Asphalt 904	See TABLE 2 & 3, Hot Mix Asphalt Pavements					
Hydrated Lime for Masonry 921.03.01	4B					
Hydrated Lime for Soil Stabilization 921.03.02	4B					
Inserts (Signing & Lighting)	8					
Joint, Preformed Gasket 905.01	4B					
Joint Sealer & Crack Filler Hot Pour - 911.01	4A	1 per lot	2 panels	Flow panels	88	
Silicone 911.01.01	1A & 4A	1 per lot or batch	Original manufacturer's container	One gallon friction top can	88	
Preformed - Cork & Bituminous 911.02	4B					
Preformed Elastomer (Neoprene) 911.04	1A & 4A	1 per lot	6 ft		88	
Junction Boxes, Electrical Items 811	8					

TABLE 1

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
Kerosene 902.12	4B		1 qt	Friction top can	(88*)	* If sampled
Landscaping Items 920	7 & 12				14	
Latex Emulsion 902.13(a)	4A *	Per shipment	1/2 gallon	Plastic Jug	88	* Qualified products list
Linseed Oil (boiled) 902.12	4B		1 qt	Friction top can	88*	*If sampled
Loop Detector Sealant Two Component	4A *		1/2 gallon	Friction top can		* Qualified products list
Single Component	4A *		Mfg. Container			* Qualified products list
Luminaires (Signing & Lighting) 950.12	8					
Manhole Sections, Precast Items 305	4B					
Mortar Sand	6	1 every 4 months or 1 per year *	40 lb	Soils bag	12	* Based on performance records
901.01	12				14	
Mast Arms (Signing & Lighting) 950.07	1B & 4A					
Mercury Lamps (Signing & Lighting) 950.12.02	8					

TABLE 1

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
Microsilica	4A & 5	1 every 10 production days	10 lb	Plastic Jar	88	See small quantity exception, Page 1
Mulch	12	*			14	* Project Engineer to verify all materials inspected by Landscape Operations Division, Department of Agronomy, or qualified project personnel.
Neoprene Bridge and Road Seal	1A & 4A		(1) - 6 ft piece		88	
Pavement Markers 951.05	4B					
Pavement Marking Material 951.01 (Waterborne Traffic Paint) (Non-Toxic)	1B & 4A *	Per lot	3 pints	friction top can	88	* Qualified products list
(Thermoplastic) 951.02	1A & 4A	Per lot *	1 gallon	Plastic jar.	88	
Thermoplastic Heat Applied	4B*					* Qualified products list
Epoxy Pavement Marking Material 951.08	1B & 4A	1 per lot	3 pints per component per color per batch	Friction top can	88	

TABLE 1

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
(Tape - Permanent) 951.03	4B*					*Qualified products list
(Tape – Removable) 951.04	4B*					*Qualified products list
Peat Humus	7					
Peat Moss	7					
Pipe Corrugated Steel Arches & Underdrain 905.01	4 B					
Ductile Iron	4B					
Corrugated Aluminum Alloy 905.01	4B					
Concrete 905.01	4B					
Copper 905.01	12				14	P.E. to verify spec stamped on pipe
Polyethylene & PVC 905.01	12				14	P.E. to verify spec stamped on pipe
Structural Plate	4B					
Poles, Aluminum & Metal (Signing & Lighting)	1B & 4A					
Posts (Signing & Lighting)						
Steel – 802	1B & 4A					

TABLE 1

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
Wood – 812	12				14	
Precast Concrete: Traffic Barriers Temporary-	*					* Incidental
Permanent- 950.01	4B					
Noise Barriers (soundwalls)	1A					
Precast Curb	4B					
Precast Structures 915.05	4B					
Prestressed Structures 421	1B					
Primer, Asphalt Waterproofing & Damproofing 913.02	4A					
Pull Irons (Signing & Lighting)	8					
Reflective Sheeting (Signing) 950.03	4B					
Reinforcement Chairs, Epoxy Coated	12				14	
Seed & Sod	7					
Signing Lights (Signing & Lighting) 950.12	8					

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
Sign Structures & Supports (Signing) 950.04	1B & 4A				14	
Soil Stabilization Matting 920.06	12*					* Qualified producers list
Stain, Concrete or Architectural	4A *					* Qualified Producers List,
Steel Bearing Piles 907.03	4A					
Steel Bolts, Nuts & Washers General Use 909.06	4B					
High Strength 909.07	4A & 13 (rotational test)				14	
Steel Forms – stay in place (SIP) 909.10	4B					
Steel Grid Floors	1B & 4A					
Steel Miscellaneous 909.02	4A					
Steel Reinforcing 908.02 908.03	4A					
Steel, Sheet Pile & Accessories 907.04	4A					
Steel Stud Shear Developers	4B					

TABLE 1

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
909.05						
Steel Protective Pile Jackets	1A & 4A				88	
Stone, Rip Rap, Channel Ditches, Slopes & Gabions 901.02	6	1 every 4 months or 1 per year	35 lb	Soils bag	12	* Based on performance records
901.03 901.04	12				14	
Strand, Stress Relieved 908.11	4A (Plant)					
Structural Bearing Pads, Elastomeric 910.02.01	1B & 4A				88	
Structural Bearing Pads, Fabric 910.02.03	1B & 4A				88	
Structural Steel 909.01	1B & 4A				88	
Structural Timber & Lumber 921.05	1A					
Super Silt Fence	12				14	Fence Fabric Only
Tie Devices Expansion anchors 908.10	1B & 4A				88	See list of approved tie devices
Timber 812 921.05	See STRUCTURAL TIMBER & LUMBER or SIGN POSTS, WOOD					

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
Timber Preservatives 921.06	4A (Plant)					
Turf Establishment,			20lb	Soils bag	27B	* See small quantity exception page 1
Salvaged Topsoil	2	1 per stockpile*, 10 locations				
Furnished Topsoil	3 & 4A	1 per stockpile, 10 locations				
Salvaged Subsoil	2	1 for all areas, 10 locations				
Furnished Subsoil	3, 4B	1 per stockpile, 10 locations				
920.01						
Traffic Barrier "W" Beam, Posts, and Hardware 918.01 918.02 918.03 918.04	4B, (Must be melted and manufactured in USA) (Does not need to be split into sheet & finish)					Verification of certification test results 1/year
Trough, Neoprene & PVC (Bridge Accessories) 922 & 911.05	1A & 4A				88	
Valve Vaults (Precast Items)	4B					
Water 921.01	2 *	1 per project	1 gallon	Plastic jug	88	* Only submit when suspect
Water Reducing Admixture 902.06	2 & 4A	*	1 pt	Screw top can	88	* SEE TABLE 3 Portland Cement Concrete for Structures & Pavements
Water Reducing Admixture, High Range	2 & 4A	*	1 pt	Screw top can	88	* SEE TABLE 3 Portland Cement Concrete for Structures & Pavements

TABLE 1

MATERIAL	ACCEPTANCE PROCEDURE	MINIMUM FREQUENCY	MINIMUM SIZE of SAMPLE WHEN REQUIRED	CONTAINER	FORM NO.	REMARKS
902.06.03						
Waterstop 911.08	1A	Per lot	6 ft		88	
	2 *	Per lot	6 ft		88	* Sampled on project when not preinsp.
Welding Materials 907.05	4B Per AWS					
Wire, Cold Drawn 908.09	4A					
Wire, Electrical (Electrical Items) 950.06	8					
Wire, Gabions 906.01	4B					
Wire, Span 950.09	1B & 4A					
Wire, Stress Relieved 908.12	4A (Plant)				88 *	* When sampled
Wood Products 821 & 921.05	See STRUCTURAL TIMBER & LUMBER or SIGN POSTS, WOOD					
Wooden Stuctures (Glue & Pin Laminated)	3 & 4B					

TABLE 2

GUIDE FOR SAMPLING AND TESTING (FIELD)

DESCRIPTION	PROJECT CONTROL ACCEPTANCE SAMPLES AND TESTS
Embankment, Except for Capping (204)	1 every 15,000 yd^3 or when a change is noted:
Samples	Samples not required for Common Borrow or Class I Excavation.
Compaction	1 every 2000 yd^3
Capping Material Samples	2 per 2 lane mile
Compaction	2 per 2 lane mile
Subgrade (204) Compaction	2 per 2 lane mile
Tamped Fill (210)	
Bridge Abutment Compaction	1 every 3 ft of depth
Box Culvert Compaction	1 every 3 ft of depth
Pipe Trench Compaction	1 every 3 ft of depth per 150 feet
Chemically Treated Subgrade (Spec. Prov.)	
Compaction	1 per day or 2 per 2 lane mile – greatest frequency
Additive Application Rate	1 per day or 2 per 2 lane mile – greatest frequency
Portland Cement	See TABLE 1, CEMENT, Portland
Emulsified Asphalt	Each delivery
Lime: Hydrated/Quick	1 per shipment or whenever material is stored on site for a month or more
Aggregate for Base Courses and Shoulders (501)	
All Materials Compaction	1 per day or 2 per 2 lane mile – greatest frequency
Stabilized Aggregate Base Courses Portland Cement	See TABLE 1, Cement, Portland
Calcium or Magnesium Chloride	See TABLE 1, Calcium Chloride or Magnesium Chloride
Emulsified Asphalt (Seal Coat)	Each delivery

TABLE 2

GUIDE FOR SAMPLING AND TESTING (FIELD)

DESCRIPTION	PROJECT CONTROL ACCEPTANCE SAMPLES AND TESTS
Soil Cement Base Course (502)	
Compaction	1 per day or 2 per 2 lane mile – greatest frequency
	3 per 2 lane mile
Portland Cement	See TABLE 1, CEMENT, Portland
Mix Proportion	Each cement truck
Pulverization Proctors (For Target Density)	3 per lane mile
Emulsified Asphalt (For Curing)	Each delivery
Chip Seal Surface Treatment (503)	See table 1 aggregate chip seal
Aggregate	
Emulsified Asphalts	Each delivery
Portland Cement Concrete Pavements (520)	
Plastic Mix (Slump, Air Content, Conc. Temp)	1 per 100 yd^3 or fraction thereof per class of concrete
Curing Agents &Additives	See TABLE 1, Chemical Additives for Concrete & Curing Compounds
Compression (2 specimen per test)	3 tests per day plus optional early strength tests. Less than 150 yd^3 per day revert to 1 test per 50 yd^3 or fraction thereof
Portland Cement Concrete Structures (420)	
Plastic Mix (Slump, Air Content, Conc. Temp)	1 per 50 yd^3 or fraction thereof per class of concrete
Curing Agents & Additives	See TABLE 1, CHEMICAL ADDITIVES FOR CONCRETE & CURING COMPOUNDS
Cylinders (2 specimen per test)	Mix 3 & 6 - 1 test per 50 yd^3 or fraction there of per class of concrete. Mix 1, 2, 4, & 5 - 1 test per 50 yd^3 per accumulated mix
Slurry Seal and Latex Modified Slurry Seal (507)	1 - gallon sample of the mixture per day

TABLE 2

GUIDE FOR SAMPLING AND TESTING (FIELD)

DESCRIPTION	PROJECT CONTROL		
	QUALITY CONTROL SAMPLES AND TESTS	**ACCEPTANCE SAMPLES AND TESTS**	**VERIFICATION OF QUALITY CONTROL AND/OR CERTIFICATION SAMPLES AND TESTS**
Hot Mix Asphalt Core Method (504)		See Special Provisions For Project Specifications	
Pavement Profile		See Special Provisions For Project Specifications	
Pavement Profile Inertial Profiler 535		See Special Provisions For Project Specifications	
HMA Patching 505 535	One (1) special calibration (nuclear test) from each lift of each patch; (2 readings = 1 test)	Witnessed by Administration Personnel	
Pavement Markings For Final Surface	Test according to MSMT 729 daily by Striper	Witnessed by Administration Personnel	Each project – Administration personnel

TABLE 3

GUIDE FOR SAMPLING AND TESTING (PLANT)

DESCRIPTION	PLANT CONTROL and COMPONENTS	
	CONTROL SAMPLES and TESTS	VERIFICATION of QUALITY CONTROL and/or CERTIFICATION SAMPLES and TESTS
Aggregate For Base Courses and Shoulders (501)		1 every 10 production days/witness sampling and testing every 50 days
Grading	2 per 8 hr shift	
Calcium or Magnesium Chloride		1 per month
Liquid Bituminous Materials		Each delivery
Portland Cement		1 every 10 production days
Mix Proportion	2 per day	1 every 10 production days
Hot Mix Asphalt Pavements 915	See Special Provisions For Project Specifications	
Grading		
Asphalt Cement		
Asphalt Content Determination		
Maximum Specific Gravity		
Strip Test		
Gyratory Specimens (VTM, VMA, VFA)		
Portland Cement Concrete for Structures and Pavements (414, 520)	1 every 10 production days	Witness sampling and testing every 50 days
Cement and Cement Substitutes		
Aggregate Grading	2 per 8 hr shift	1 every 10 production days witness sampling and testing every 50 days
Moisture	Before production & every 100 yd^3 or 4 hrs (greatest frequency)	1 every 10 production days
Admixtures		1 every 30 days

TABLE 3

GUIDE FOR SAMPLING AND TESTING (PLANT)

DESCRIPTION	PLANT CONTROL and COMPONENTS	
	CONTROL SAMPLES and TESTS	VERIFICATION of QUALITY CONTROL and/or CERTIFICATION SAMPLES and TESTS
Precast Concrete and Prestressed Concrete for Structures Cement		1 per project, or 1 every 3 months
Plastic Mix (Slump, Air Content, Concrete Temperature)	1 per 50 yd^3 or fraction thereof per class of concrete	
Additives		1 per project, 1 every 3 months
Cylinders	1 per 50 yd^3 or fraction thereof per class of concrete	
Reinforcing Steel (cables, mesh etc.)		1 every 24 months at steel manufacturer

MINIMUM FREQUENCY OF VERIFICATION OF CERTIFICATION

MATERIAL	MONTHS 3	6	9	12	15	18	21	24	ADDITIONAL CRITERIA
ALUMINUM SIGNING MATERIAL				X					Phys. & Chemical
BEARING & EXPANSION PL								X	
BREAKAWAY BASES								X	
BRONZE INSERTS 910.01.01								X	Depending on frequency of use
CASINGS – CAST IN PLACE				X					Phys. & Chemical From Coupon
DAMPROOFING & WATERPROOFING PRIME\SEAL				X					
DAMPROOFING & WATERPROOFING MEMBRANE				X					Verify Stand. Spec
DOWEL BARS				X					At Supplier
EPOXY COATING, POWDER		X							At Coater
EPOXY PROTECTIVE COATING & POLYESTER				X					At Mfg.
FABRIC, ASPHALT IMPREGNATED				X					
FENCE, FITTINGS & HARDWARE				X					M 181
FENCE POSTS – STEEL				X					M 181
FRAME AND GRATE (Cast)				X					At Caster (Foundry)
GEOTEXTILE (Class F)				X					NTPEP
GLASS BEADS				X					
GROUT, NON-SHRINK		X							At Supplier
GROUT, EPOXY		X							At Supplier
HYDRATED LIME, MASONRY				X					
HYDRATED LIME, STABILIZATION									Random Frequency, Refer to Table 1 & 2
JOINT SEALER, HOT POUR		X							At Mfg
JOINT SEALER, COLD POUR		X							
JOINT SEALER, SILICONE				X					At Supplier
JOINT SEALER, CORK & FIBER		X							
KEROSENE				X					

MINIMUM FREQUENCY OF VERIFICATION OF CERTIFICATION

MATERIAL	MONTHS 3	6	9	12	15	18	21	24	ADDITIONAL CRITERIA
LINSEED OIL				X					At Mfg or Supplier
PIPE, CORRUGATED STEEL ARCHES & UNDERDRAIN						X			At Mfg
PIPE, CORR. ALUM. ALLOY						X			At Mfg
PIPE, COPPER									Random Frequency for Verification
PIPE, POLYETHYLENE, PVC				X					At Supplier
POLES, ALUMINUM AND METAL (Signing and lighting) 802						X			Random Frequency for Verification
RECYCLED MATERIAL SELECT, OR COMMON BORROW									Note 10
REFLECTIVE SHEETING						X			At Mfg
REINFORCING STEEL – DEFORMED									Random Frequency for Verification
STABILIZING CHEMICALS, CALCIUM & MAGNESIUM CHLORIDES				X					
STEEL BEARING PILES				X					Round - At Supplier H. BEAM - At Mfg
STEEL BOLTS, NUTS & WASHERS - GENERAL USE						X			At Supplier
STEEL WIRE, COLD DRAWN 908.09				X					
STEEL FORMS						X			At Mfg
STEEL SHEET PILE				X					At Mfg
STEEL STUD SHEAR DEVELOPERS								X	At Mfg
STRAND, STRESS RELIEVED								X	At Mfg
STRUCTURAL STEEL				X					At Mfg
STRUCTURAL STEEL COATINGS 912				X					
TRAFFIC BARRIER				X					At Supplier
TIMBER PRESERVATIVE								X	At Treatment Plant
WELDED WIRE FABRIC 908.05				X					
WIRE, GABIONS		X							At Gabion Mfg
WIRE, STRESS RELIEVED								X	At Mfg

Recommended AASHTO / ASTM Standards

The following is a list of testing and practice standards every technician should obtain

* Sampling of Aggregates
  ASTM D 75

* Sieve Analysis of Fine and Coarse Aggregates
  AASHTO T-27 / ASTM C 136

* Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
  AASHTO T-11 / ASTM C 117

* Making and Curing Concrete Test Specimens in the field
  AASHTO T-23 / ASTM C 31

* Sampling Freshly Mixed Concrete
  AASHTO R-60 / ASTM C 172

* Reducing Samples of Aggregates to Testing Size
  AASHTO R-76 / ASTM C 702

Part Four

Forms and Checklists

* Plant Approval Checklist
* Plant Approval Certification Form
* Mixer Truck Inspection Report
* Plant Quality Assurance Inspection Checklist
* Plant Gradation Worksheet
* Plant Daily Report, Form # 113
* Concrete Load Ticket, Form # 116
* General Materials Sample, Form # 88
* Mix Design

PORTLAND CEMENT PLANT APPROVAL CHECKLIST

PLANT NAME: _____

PLANT NUMBER & LOCATION: _____

PLANT TYPE: _____ SIZE: _____

DATE OF INSPECTION: _____ APPROVAL: _____

CEMENT

Yes	No	
☐	☐	Are storage facilities in good condition?
☐	☐	Are mechanical vibrators working?
☐	☐	Is weight hopper equipped for test weights?
☐	☐	Is there a thermometer installed to verify temperature?
☐	☐	Is type and brand of cement known? _____
		_____

ADDITIVES

Yes	No	
☐	☐	Has air entrainment been tested and approved? _____
☐	☐	Have other admixtures been tested and approved? _____
☐	☐	Are dispensers visible, easily read and calibrated?
☐	☐	Are all additives prevented from freezing in the winter months?
☐	☐	Are dispensers flushed regularly to clean them?

WATER

Yes	No	
☐	☐	Has source of water been tested and approved? _____
☐	☐	Are there means to heat water for cold weather?

AGGREGATES

Yes	No	
☐	☐	Has fine aggregates been tested and approved? _____
☐	☐	Has coarse aggregates been tested and approved? _____
☐	☐	Are stockpiles on prepared areas?
☐	☐	Are stockpiles separated to prevent intermingling?
☐	☐	Are stockpiles built in layers of not more than 5 feet?
☐	☐	Are bins separated to prevent intermingling?
☐	☐	Are stockpiles free-draining?
☐	☐	Are there means to keep aggregates at S.S.D. conditions?
☐	☐	Is weight hopper equipped for test weights?

PORTLAND CEMENT PLANT APPROVAL CHECKLIST

(CONT'D)

SCALES

Yes	No		
☐	☐	Is equipment in good condition?	
☐	☐	Have scales been checked by certified scale company?	_____
☐	☐	Are scales zeroed?	
☐	☐	Are scales visible to State Representative?	
☐	☐	Does weight hopper empty completely?	
☐	☐	Are calibrated test weights at plant? (Ten / 50 lbs. weights)	

MIXERS

Yes	No		
☐	☐	Have mixers been inspected and approved?	_____

SAMPLING

Yes	No	
☐	☐	Is plant equipped with sampling devices?
☐	☐	Do producers have personnel for obtaining samples?
☐	☐	Can samples be taken at last practical point?

Quality Control Testing

Yes	No		
☐	☐	Quality Control Plan on file?	_____

Quality Control Laboratory

Yes	No	
☐	☐	Is testing equipment in good condition?
☐	☐	Are there utility tables for test purposes?
☐	☐	Are air condition and heating installed?
☐	☐	Are sanitary facilities provided?
☐	☐	Is bulletin board provided?
☐	☐	Are files in order?
☐	☐	Are approved mix designs posted?
☐	☐	Are there approved list of mixer trucks posted?

PORTLAND CEMENT PLANT APPROVAL CHECKLIST

(CONT'D)

Central Mixers

Yes	No	
☐	☐	Have blades been checked for wear?
☐	☐	Is maximum and minimum Capacity and speed adhered to?
☐	☐	Does mixer have approved timing device?
☐	☐	Is mixer an approved type?
☐	☐	Is ther a suitable batch counter?
☐	☐	Is water meter calibrated?

To be used in conjunction with "PLANT APPROVAL" form

STATE OF MARYLAND
STATE HIGHWAY ADMINISTRATION
OFFICE OF MATERIALS AND TECHNOLOGY

CONCRETE PLANT CERTIFICATION

PRODUCER _____ INSPECTION DATE _____

PLANT LOCATION & # _____ MAKE OF PLANT _____

MAKE OF SCALE _____ PLANT TYPE _____

CHECKED BY _____ APPROVED BY _____

	CEMENT	***G.I.B.F.S.***	***FLYASH***
NO. OF BINS			
CONDITION OF SCALE		LOAD CELLS	
TYPE OF SCALE		VIBRATORS	
CAPACITY & MIN. GRAD.		CHECKED TO (lbs.)	
CEMENTITIOUS TEMP. PROBE LOCATION(S)		ACCURACY	

AGGREGATES

NO. OF BINS _____ METHOD OF SAMPLING _____

CONDITION OF SCALE _____ LOAD CELLS _____

TYPE OF SCALE _____ VIBRATORS _____

CONDITION OF KNIFE EDGES _____

CAPACITY & MIN. GRAD. _____ CHECKED TO (lbs.) _____

SIZE OF WEIGH HOPPER(yd.3) _____ ACCURACY _____

MIXING WATER

SOURCE _____ METER / SCALE ACCURACY _____

COLD WEATHER CONCRETING METHOD _____ HOT WEATHER CONCRETING METHOD _____

HOT WATER TEMP. PROBE LOCATION _____

MISCELLANEOUS

ADMIX DISPENSER ACCURACY _____ LABORATORY _____

_____ LAB SCALES _____

NO. OF ***CERTIFIED**** TEST WEIGHTS _____ CONDITION OF TEST WEIGHTS _____

*** CALIBRATION REQUIRED ANNUALLY*

CENTRAL MIX CONCRETE PLANT INSPECTION

MAKE OF MIXER _____ CAPACITY OF MIXER _____

CONDITION _____ MIXING TIME _____

MIXER SPEED _____ WATER METERING DEVICE _____

STATE HIGHWAY ADMINISTRATION
OFFICE OF MATERIALS AND TECHNOLOGY

Truck Mixer Inspection Report

Producer: _____ Location: _____ Inspection Date: _____

Certified Technician: _____ Plant No.: _____ Expiration Date: _____

	Mixer Number	Make of Mixer	Tag Number	Drum Capacity	Water Glass	Water Gauge	Electric Counter	Blade Condition	Concrete Buildup	Water Valves	H2O Tank Capacity	Backup Alarm	Approval YES NO
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													

REMARKS: _____

(Producers Signature & Certification #)

PORTLAND CEMENT CONCRETE PLANT
INSPECTION QUALITY ASSURANCE CHECKLIST

Date: _____

Plant: _____

Inspector: _____
(Print Name) (Signature or Initial)

(√,N/C,N/A)

_____ 1. Annual plant approval prominently posted in testing laboratory.
_____ 2. Mixer Truck Inspection Report. Annual Check: _____
_____ 3. Yearly and or Monthly Scale Report. Monthly Check: _____
_____ 4. Certified Technician present on site during all SHA production and testing.
_____ 5. Quality Control Plan on file and available for review.
_____ 6. Previous PCC Quality Assurance visit.
_____ 7. Authorization Sheet for concrete placement from Concrete Technology Division.
_____ 8. Approved Concrete Mix Designs.
_____ 9. PCC Worksheets.
_____ 10. Load Tickets and or Recordation sheets.
_____ 11. Daily Plant Reports.
_____ 12. Form 88's.
_____ 13. Cement and Pozzolan certificates on file and available for review.
_____ 14. Admixtures certificates on file, available for review.
_____ 15. Admixtures properly stored.
_____ 16. Aggregate certificates on file and available for review.
_____ 17. Water source checked and approved.
_____ 18. Working Cement / Pozzolan temperature probe with a min. range of 0◦ – 200◦F.
_____ 19. Working Hot Water temperature gauge with a min. range of 0◦ – 200◦F.
_____ 20. Plant & Mixer Truck Operations: _____

_____

_____ 21. Aggregate Stockpiles.
_____ 22. Laboratory testing equipment.
_____ 23. Aggregate samples in laboratory identified and properly stored for QA Inspectors.
_____ 24. Cement, Pozzolans and admixtures samples properly identified and stored for future laboratory testing.
_____ 25. 48-hour notification of 30-day Scale checks.
_____ 26. 24-hour notification of production and cancellations.
_____ 27. Corrective action by producer since last QA visit if needed.

REMARKS: (Please explain in detail any items noted as non - compliant. Use additional pages as necessary.)

_____

_____

_____

(Producers Signature & Certification #)

√ = This item is in compliance with specification
N/C = This item is not in compliance with specification
N/A = This item was not inspected

cc: Plant File
PCC Team Leader

PCC PLANT GRADATION WORKSHEET

PLANT: _____ DATE: _____

SAND

TIME>>													
SIEVE	WT. PASS.	% PASS.	WT. PASS.	% PASS.	WT. PASS.	% PASS.	SPEC. REQUIRE.	Moisture Content		Moisture Content		Moisture Content	
3/8"							100	Wet		Wet		Wet	
#4							95 - 100	Dry		Dry		Dry	
#8								Diff.		Diff.		Diff.	
#16							45 - 85	Result		Result		Result	
#30								(-Abs.)		(-Abs.)		(-Abs.)	
#50							10 - 30	% Moist.		% Moist.		% Moist.	
#100							0 - 10						
F.M.							+/-0.20 of Base F.M.						

No. 57 Aggregate

TIME>>													
SIEVE	WT. PASS.	% PASS.	WT. PASS.	% PASS.	WT. PASS.	% PASS.	SPEC. REQUIRE.	Moisture Content		Moisture Content		Moisture Content	
1½"							100	Wet		Wet		Wet	
1"							95 - 100	Dry		Dry		Dry	
½"							25 - 60	Diff.		Diff.		Diff.	
#4							0 - 10	Result		Result		Result	
#8							0 -5	(-Abs.)		(-Abs.)		(-Abs.)	
								% Moist.		% Moist.		% Moist.	

No. 67 Aggregate

TIME>>													
SIEVE	WT. PASS.	% PASS.	WT. PASS.	% PASS.	WT. PASS.	% PASS.	SPEC. REQUIRE.	Moisture Content		Moisture Content		Moisture Content	
1"							100	Wet		Wet		Wet	
¾"							90 - 100	Dry		Dry		Dry	
3/8"							20 - 55	Diff.		Diff.		Diff.	
#4							0 - 10	Result		Result		Result	
#8							0 -5	(-Abs.)		(-Abs.)		(-Abs.)	
								% Moist.		% Moist.		% Moist.	

No 7 Aggregate

TIME>>													
SIEVE	WT. PASS.	% PASS.	WT. PASS.	% PASS.	WT. PASS.	% PASS.	SPEC. REQUIRE.	Moisture Content		Moisture Content		Moisture Content	
¾"							100	Wet		Wet		Wet	
½"							90 - 100	Dry		Dry		Dry	
3/8"							40 - 70	Diff.		Diff.		Diff.	
#4							0 - 15	Result		Result		Result	
#8							0 -5	(-Abs.)		(-Abs.)		(-Abs.)	
								% Moist.		% Moist.		% Moist.	

Tested By: _____ Cert. No. _____

SHA 73.0 - 113
Rev. 12/07

MARYLAND STATE HIGHWAY ADMINISTRATION
OFFICE OF MATERIALS TECHNOLOGY

Q.C. _____
Q.A. _____
Other _____

DAILY REPORT: Portland Cement Concrete Plant

Contract No.: _____ **DATE:** _____

Producer and Location: _____

GRADATIONS

Fine Aggregate					Intermediate Aggregate					Coarse Aggregate				
Time>					Time>					Time>				
3/8"														
#4														
#8														
#16														
#30														
#50					Moist.					Moist.				
#100														
F.M.														
Moist.														

LT. WT. AGGREGATE

Time>			
1"			
3/4"			
3/8"			
#4			
Moist.			

ADDITIONAL MOISTURES

Time>									
Size									
%									

CONCRETE SHIPPED

SHA Mix Design Number	Cubic Yards	Remarks

Truck No's _____

Temperature of Cementitious Mat'ls and Mix Water (170 ºF max.) _____

Remarks: _____

Official Visitors:

_____ _____

CCT Signature / Certification No.

_____

ORIGINAL: Plant File

SHA 73.0-1A
Form-186

STATE HIGHWAY ADMINISTRATION

CONCRETE LOAD TICKET

Load No. _____ Truck No. _____ Time Water Added _____

Mix Design No. _____ Contract No. _____ Date _____

Producer/Location _____ C.Y. _____

MAT. REQUIRED	1 CY	MATERIAL LOADED IN TRUCK DRY LBS	% MOIST	+ MOIST	MOIST AGG. LBS
CEMENT (LBS)					
* (LBS)					
		SSD LBS			
FINE AGG (LBS)					
FINE AGG (LBS)					
COARSE AGG (LBS)					
COARSE AGG (LBS)					
			BRAND		
AIR ENT (OZS)				8.33 (LBS) =	GALS
			BRAND		
WATER RED (OZS)					
			BRAND		
RETARDER (OZS)					

SPECIFICATION MAX ALLOWABLE WATER	PLANT WATER IN AGG	WATER/ICE ADDED AT PLANT	PROJECT MAX. WATER THAT MAY BE ADDED FOR SLUMP ADJ.
_____	_____	+ _____ = TOTAL	_____

SIGNATURE _____

* Other cementitious material

SHA 73.0-1A
Form-116

STATE HIGHWAY ADMINISTRATION

CONCRETE LOAD TICKET

Load No. _____ Truck No. _____ Time Water Added _____

Mix Design No. _____ (2) Contract No. _____ (1) Date _____

Producer/Location _____ C.Y. _____ (3)

MAT. REQUIRED	1 CY	MATERIAL LOADED IN TRUCK DRY LBS	% MOIST	+ MOIST	MOIST AGG. LBS
CEMENT (LBS)	(4)	(8)			
* (LBS)					
		SSD LBS			
FINE AGG (LBS)	(5)		(9)	(10)	(11)
FINE AGG (LBS)					
COARSE AGG (LBS)	(6)				
COARSE AGG (LBS)					
AIR ENT (OZS)	(7)		BRAND	(12)	(13)
WATER RED (OZS)			BRAND	8.33 (LBS) =	GALS
RETARDER (OZS)			BRAND		

SPECIFICATION MAX ALLOWABLE WATER	PLANT WATER IN AGG	WATER/ICE ADDED AT PLANT		PROJECT MAX. WATER THAT MAY BE ADDED FOR SLUMP ADJ.
(14)	(15)	+ (16)	= (17) TOTAL	(18)

SIGNATURE _____

Other cementitious material

CONCRETE LOAD TICKET

(Explanation of numbered spaces on the example Load Ticket)

1. **Contract Number -** Must be on all paperwork

2. **Mix Design No.** – Approved SHA mix number issued by the regional laboratory. This number is located on the approved concrete mix design sheet in the space labeled Mix Code No..

3. **C. Y.** – Cubic Yards The amount of concrete to be batched and loaded in the truck.

4. **Cement** – The design weight for 1 c.y. of cement. Found on the approved concrete mix design sheet under "Design Weights lbs. Per C.Y. in the space for cement. This may also include a cement replacement (ex. flyash, slag) which must be indicated in the space below.

5. **Fine Agg. (sand)** - The design weight for 1 c.y. of sand. Found on the approved concrete mix design sheet under "Design Weights lbs. Per C.Y. in the space for sand.

6. **Coarse Agg. (stone)** - The design weight for 1 c.y. of aggregate. Found on the approved concrete mix design sheet under "Design Weights lbs. Per C.Y. in the space for aggregate.

7. **Admixtures** – Dosage in ounces per c.y. concrete. This amount must be within the approved dosage range found on the SHA List of Prequalified Admixtures for Concrete. Conversion from oz/100# to oz/c.y. is obtained by the following formula:
   (wt. cementitious mat'l x admix oz/100#) ÷ 100

8. **Dry lbs./ SSD lbs.** – Take each amount in #'s 4, 5, 6, & 7 and multiply by C.Y. # 3.

9. **% Moist** – This is the % of free moisture of the stone and the sand.

10. **Moist** – This is the weight of free water in each aggregates. This is obtained by multiplying SSD lbs. #8 by % Moist #9.

11. **Moist Agg**. **lbs. –** This the total batch weight for each aggregate and is obtained by adding SSD lbs. #8 and Moist #10.

12. **Total Wt. Free Water –** Total of weights in Moist # 10.

13. **Gallons of Free Water -** This is obtained by dividing Total Wt. Free Water # 12 by 8.33.

14. **Max. Allowable Water –** Use figure from approved mix design sheet and multiply by C.Y. # 3.

15. **Water in Agg –** Gallons of Free Water # 13 rounded to the nearest gallon.

16. **Water / Ice Added at Plant –** All water and ice converted to gallons added at the plant.

17. **Total Water in the Mix –** Total of all water in the mix is obtained by adding Water in Agg # 15 and Water / Ice Added at Plant # 16. (Not to exceed Max. Allowable Water # 14)

18. **Max. Water That May Be Added for Slump Adjustment –** This is 3 gallons times C. Y. # 3 or Max. Allowable Water # 14 minus Total Water in the Mix # 17 whichever is the least amount.

SHA 73.0-1A
Form-116

STATE HIGHWAY ADMINISTRATION

CONCRETE LOAD TICKET

Load No. 1 Truck No. CT-42 Time Water Added 6:27 AM

Mix Design No. N6W-N25-44-1 Contract No. CL800-5177 Date 4/13/2005

Producer/Location ABC CONCRETE - MARRIOTTSVILLE C.Y. 9

MAT. REQUIRED	1 CY	MATERIAL LOADED IN TRUCK DRY LBS	% MOIST	+ MOIST	MOIST AGG. LBS
CEMENT (LBS)	329	2961			
G.I.B.F.S. * (LBS)	329	2961			
		SSD LBS			
FINE AGG (LBS)	1165	10485	3.6	377	10862
FINE AGG (LBS)					
COARSE AGG (LBS)	1740	15660	1.1	172	15832
COARSE AGG (LBS)					
			BRAND		
AIR ENT (OZS)	6.6	59	AE-90	549 / 8.33 (LBS) = 65.9 GALS	
			BRAND		
WATER RED (OZS)	33.0	297	200N		
			BRAND		
RETARDER (OZS)					

SPECIFICATION MAX ALLOWABLE WATER	PLANT WATER IN AGG	WATER/ICE ADDED AT PLANT		PROJECT MAX. WATER THAT MAY BE ADDED FOR SLUMP ADJ.
320	66	+ 231	= 297 TOTAL	23

SIGNATURE I. M. Technician # 777

Other cementitious material

OMT88 05/03/04

MARYLAND STATE HIGHWAY ADMINISTRATION

GENERAL MATERIALS SAMPLE

1

Original ☐
Acceptance ☐
I.A.S.T. ☐
Other ☐

Date Sampled: 2 Lab No: 3 Project Sample No: 4

Type of Material: 5 Quantity Represented: 6

Contract Number: 7 F.A.P. Number: 8

Item Number: 9 Type of Construction: 10

Sample Taken From: 11 Plant No: 12 Source: ☐ Job Site: ☐

Produced By: 13 Trade Name: 14

Source of Supply: 15

Shipped From: 16 ☐ Batch ☐ Lot ☐ Heat No: 17

Size of Sample: 18 Sampled By: 19 Witnessed By: 20

Remarks: 21

Return Original form To 22 Regional Laboratory.

This portion of form to be completed by the Lab.

Date Received: In Lab: _____ In Testing Unit: _____ Lab No: _____

Date Put Under Test: _____ Date Test Completed: _____ Tested By: _____

Test Cost: _____ Approved By: _____ Recorded By: _____

LABORATORY TEST RESULTS

PORTLAND CEMENT CONCRETE
MATERIALS SAMPLED AT THE PLANT
GENERAL MATERIALS SAMPLE **FORM "88"**

1. Acceptance: Place a check mark

2. Self explanatory

3. Not applicable

4. Not applicable

5. Example: Portland Cement Type I/II; Ground Iron Blast Furnace Slag; Water Reducer, etc.

6. If available

7. A currently active SHA contract number (Preferably one that you are currently supplying)

8. If available

9. Not applicable

10. P.C.C.

11. Example: Tanker, stockpile, dispenser, etc.

12. SHA assigned plant number

13. Example: Lehigh, BASF, Lafarge, etc.

14. Example: "Newcem", "Pozzolith 122 HE", "Sikament 86", etc.

15. Your company name and location

16. Sampled material manufacturer's location such as Cleveland, OH. Ravena, NY etc.

17. Not applicable

18. Example: 1 quart, 1 gallon, 10 lbs. etc.

19. Name of person who took sample

20. C.C.T. signature and certificate number

21. Any remarks you wish to make in reference to the sample

22. Not applicable

Please note: When doing the form "88" for cementitious materials (portland cement, blast furnace slag, flyash etc.) please attach a copy of the certification which you receive with your delivery ticket.

MARYLAND STATE HIGHWAY ADMINISTRATION
OFFICE OF MATERIALS TECHNOLOGY
CONCRETE TECHNOLOGY DIVISION
CONCRETE MIX DESIGN

Mix Code No.: _____ Date : _____

Design Strength _____ P.S.I. Slump: _____

Max. Allow. H_2O _____ Gallons / C.Y. Max. W/C Ratio _____

(1)	(2)	(3)	(4)	(5)
		[(5) x (4)] x 62.4		(3) / [(4) x 62.4
Material	**Proportion Percentage**	**Design Weights lbs. Per C.Y.**	**Specific Gravity**	**Absolute Vol. (cubic ft.)**
Cement			3.15	
G.I.B.F.S			2.95	
Sand (SSD)				
No. 57 Agg				
Water			1.00	
Estimated Air %		Air Volume = 27 x Est. Air %		
			Total Volume =	
			Theoretical Weight of Mix lbs./cu.ft.	

Producer	Plant
Cement	GIBFS
No. 57 Agg.	Sand
Air Ent.Admix	Dosage Rate
Reducing Admix.	Dosage Rate

NOTE:This mix design was evaluated by trial batch on _____
It meets all specification requirements.

REMARKS:

APPROVAL RECOMMENDED

for

Vicki R. Stewart
Assistant Division Chief
Concrete/Chemical/Cement Laboratory

Maryland State Highway Administration

Concrete Plant Technician Certification

Concrete 101

By

Henry B. Prenger P. E.

Concrete Design

Concrete is designed for:

1. Strength
2. Place-ability
3. Durability

Strength

The required strength of concrete is determined by engineers based on the loads and stresses that will be placed on the structure. Strength is very strongly related to the total amount of cementitious content in the concrete and the water to cementitious ratio (WCR). *For Maryland State Highway Administration structures, compressive strength, maximum WCR, and minimum cementitious contents can be found in Table 902A for each mix*.

Place-ability

Place-ability refers to the ability of concrete to be placed by a given method into the final form. Examples would be pumping concrete into a stem wall full of heavily congested re-bar. In this case, the concrete would need to flow readily to make it through the pump and the reinforcing steel. Another example would be a curb and gutter that was going to be placed with a slip form paver. In this example, you would need a concrete that was very tight (low slump) and did not readily flow. Place-ability is measured by slump and requirements can be found in Table 902A.

Durability

Durability of concrete is the ability of a structure to withstand chemical and physical attack. The typical types of attack on concrete structures are:

1. Sulfate attack – sulfates are found in sea water and brackish water and can cause a mineral called ettringite to form in concrete. Ettringite expands in the concrete and causes it to crack. The Maryland State Highway Administration requires that Type II cement be used in sulfate environments. Type I cement may be used if testing (ASTM C1012) is performed with fly ash or slag cement and moderate sulfate resistance is demonstrated.

2. Alkali Silica Reaction (ASR) – alkali silica reaction occurs when alkalis (from portland cement) react with silica found in some coarse or fine aggregate. The reaction forms an expansive gel which causes the concrete to crack. The Maryland State Highway Administration requires that slag cement or flyash as prescribed be used with reactive aggregates and prohibits the use of highly reactive aggregates.

3. Resistance to freeze thaw damage – freeze thaw damage occurs when water in concrete freezes and there is a poor air void system (for exterior concrete, air is intentionally entrained into the concrete) or when the concrete is too weak to withstand the forces of the freezing water. The Maryland State Highway Administration places limits on the amount of air in the concrete (Table 902A), the minimum amount of cementitious material in the concrete (Table 902A), the maximum amount of fly ash (25%) and slag cement (50%) in the concrete, and the maximum water to cementitious material (WCR) of the concrete (Table 902A).

4. Resistance to chloride intrusion – chlorides cause reinforcing steel to corrode and results in concrete cracking around the corroding steel. Fly ash, slag cement, and silica fume are all good materials for reducing the permeability of the concrete, which reduces the amount of chlorides that can get down to the reinforcing steel. The amount of cement in a concrete mix also influences the permeability of the concrete, with higher cement factors having lower permeability. Minimum limits for the amount of cementitious materials are in Table 902A.

5. Set related issues – Set time issues occur when concrete sets to quickly or to slowly. Set issues can lead to cracking, excessive water demand, and low concrete strengths. Set is related to the types and amounts of materials in the concrete mixes, but it is also very strongly associated with the ambient temperature and the temperature of the concrete. Table 902A places limits on each concrete mixture.

Concrete Mix Design Basics

Density of water
The density of water is 62.4 lb/ft^3

Conversion factor for water
One gallon of water weighs 8.33 lbs.

Specific gravity (SpGr)
Specific gravity is the ratio of the density of a material over the density of water. Specific gravity is used to convert weight to volume or volume to weight.

Example:
Convert weight (lbs) to volume (ft^3)

If your sand in the mix weighs 1400 lbs and it has a specific gravity of 2.57, the volume of the sand would be:

$$\frac{Weight\ of\ Material}{SpGr\ of\ Material\ x\ Density\ of\ Water} = \frac{1400}{2.57\ x\ 62.4} = 8.73\ ft^3\ of\ sand$$

Volume of Concrete
Concrete is sold by the cubic yard. Each cubic yard of concrete contains 27 cubic feet of concrete.

Apparent vs. Absolute Volume (Aggregate and Cementitious)
When aggregate or cementitious material is packed together, there are spaces between the particles. These spaces make the volume larger, the more and larger the spaces, the larger the volume. The volume with these materials with the voids is called the apparent volume. The volume of these materials without the voids is called the absolute volume. Concrete is designed with absolute volume of materials.

Water to Cementitious Ratio (Cementitious includes cement, slag cement, and fly ash)
One of the most important factors in designing a concrete mixture is the water to cementitious ratio (WCR). The water cementitious ratio is the weight of water in the concrete (1 gallon of water = 8.33 lbs.) divided by the weight of the cementitious material in the mix (cement + slag cement + fly ash). In general, the lower the amount of water in a mix, the lower the WCR, the higher the strength of the mix.

More water / Higher WCR = lower strength and decreased durability

Designing Mixes
Concrete mixes are designed using engineering concepts and engineering judgement based on over a century of concrete experience. Engineers and technologists follow codes, specifications, strength requirements, durability requirements, and placement considerations to determine the amount of each material that will be included in a concrete mix.

Prescriptive Specs
Maryland State Highway Administration specifications are prescriptive, meaning the state prescribes limits for many of the constituent materials in the mixes as well as the plastic and hardened properties. The limits can be found in Table 902A. This table is extremely important to study because you can find, for any given mix, the required:

1. Strength
2. Minimum cement content
3. Coarse aggregate size
4. Maximum water to cementitious ratio
5. Slump range
6. Air content range
7. Concrete temperature range

The following is a copy of the table. The full table with notes can be found in the 902 section of the MSHA specifications.

Table 902A

PORTLAND CEMENT CONCRETE MIXTURES										
MIX NO.	SPECIFIED ACCEPTANCE COMPRESSIVE STRENGTH psi	COMPRESSIVE STRENGTH ACCEPTANCE TEST AGE days	STD. DEV. psi	CRITICAL VALUE psi	MIN CEMENT FACTOR lb/yd³	COARSE AGGREGATE SIZE M 43 / M 195	MAX WATER/ CEMENT RATIO by wt	SLUMP RANGE in.	TOTAL AIR CONTENT %	CONCRETE TEMP. °F
1	2500	28	375	2430	455	57, 67	0.55	2 - 5	5 - 8	50 - 95
2	3000	28	450	3010	530	57, 67	0.50	2 - 5	5 - 8	50 - 95
3	3500	28	525	3600	580	57, 67	0.50	2 - 5	5 - 8	50 - 95
4	3500	28	525	3600	615	57, 67	0.55	4 - 8	N/A	50 - 95
5	3500	28	525	3600	580	7	0.50	2 - 5	5 - 8	50 - 95
6	4500	28	675	4770	615	57, 67	0.45	2 - 5	5 - 8	50 - 80
7	4200	28	630	4420	580	57	0.50	1½ - 3	5 - 8	50 - 95
8	4000	28	600	4180	750	7	0.42	2 - 5	5 - 8	50 - 80
9	3000	(a)	N/A	N/A	800	57, 67	0.45	4 - 8	5 - 8	60 - 100
10	4500	28	675	4770	700	¾" – No. 4	0.45	2 - 5	6 - 9	50 - 80
11	4200	28	630	4420	—	57, 67	0.45	2 - 5	5 - 8	50 - 80
12	4200	28	630	4420	—	¾" – No. 4	0.45	2 - 5	6 - 9	50 - 80
HE	3000	(b)	N/A	N/A	N/A	N/A	N/A	3 - 9	5 - 8	60 - 100
PC (c)	N/A	N/A	N/A	N/A	450	7, 8	0.45	N/A	15 - 25	N/A
WT	2500	(d)	NA	NA	650	57	0.45	5 max	5 - 8	50 - 95

Proportioning (Submittal of Mix Design and Material Sources)

Prior to the start of construction, you need to submit to the AME the source and proportions of materials to be used for each concrete mix. The mixture needs to meet 902.10.03 of the MSHA specification. The concrete, with the exception of water and chemical admixtures, are proportioned by weight. Water and chemical admixtures may be proportioned by volume or weight. The mix needs to be uniform and workable.

Trial Batches

Trial batches are used to verify that a new mix will achieve the specified criteria for a mix (strength, air content, slump, etc.). The AME should be notified 2 weeks in advance of a trial batch. Trial batches shall be composed of at least 3 cubic yards of concrete. The AMA may wave trial batches if performance records show the mix will meet the average strength requirements.

Triggers for a Verification Trial Batch

Changes in cement type, slag cement grade, coarse or fine aggregate, admixture brand, or mixture proportions can trigger a trial batch to verify that the concrete mix still meets State requirements.

Concrete Mix Example

Given: 620 lbs. total cementitious, 25% slag cement

	SpGr	
Portland Cement	3.15	
Slag Cement	2.93	Absorption
Coarse Aggregate	2.79	0.2
Fine Aggregate	2.68	0.7

Material	Weight / Amount	Volume
Cement	465 lbs.	$= \frac{Weight\ of\ Cement}{SpGr\ of\ Cement\ x\ Density\ of\ Water} = \frac{465}{3.15\ x\ 62.4} =$ $2.37\ ft^3$
Slag Cement	155 lbs.	$= \frac{Weight\ of\ Slag\ Cement}{SpGr\ of\ Slag\ Cement\ x\ Density\ of\ Water} = \frac{155}{2.93\ x\ 62.4} =$ $0.85\ ft^3$
Coarse Aggregate	1800 lbs.	$= \frac{Weight\ of\ Coarse\ Aggregate}{SpGr\ of\ Coarse\ Agg\ x\ Density\ of\ Water} = \frac{1800}{2.79\ x\ 62.4} =$ $10.34\ ft^3$
Fine Aggregate	1240 lbs.	$= \frac{Weight\ of\ Fine\ Aggregate}{SpGr\ of\ Fine\ Agg\ x\ Density\ of\ Water} = \frac{1240}{2.68\ x\ 62.4} =$ $7.41\ ft^3$
Water	33 gal	$= \frac{Weight\ of\ Water}{Density\ of\ Water} = \frac{33\ x\ 8.33}{62.4} = \frac{275}{62.4} =$ $4.41\ ft^3$
Air (%)	6%	= 0.06 x 27 = $1.62\ ft^3$
Total Volume		$27\ ft^3$
Water Reducer	3 oz./cwt	
Air Entrainer	0.4 oz./cwt	

Coarse Aggregate Moisture
Weight of Pan = 112.3 g
Weight of Pan + Wet aggregate = 4310.4 g
Weight of Wet Aggregate = 4310.4 g – 112.3 g = 4198.1 g
Weight of Dry Aggregate = 4185.9 g

%Total Moisture = $\frac{Weight\ of\ Wet\ Aggregate - Weight\ of\ Dry\ Aggregate}{Weight\ of\ Dry\ Aggregate} = \frac{4198.1-4185.9}{4185.9}\ x\ 100 = 0.3\%$
% Free Moisture = % Total Moisture - % Absorption = 0.3 - 0.2 = 0.1%

Fine Aggregate Moisture
Weight of Pan = 65.4 g
Weight of Pan + Wet Aggregate = 575.3 g
Weight of Wet Aggregate = 575.3 – 65.4 = 509.9 g
Weight of Dry Aggregate = 485.3 g

% Total Moisture = $\frac{Weight\ of\ Wet\ Aggregate - Weight\ of\ Dry\ Aggregate}{Weight\ of\ Dry\ Aggregate} = \frac{509.9-485.3}{485.3}\ x\ 100 = 5.1\%$
% Free Moisture = % Total Moisture - % Absorption = 5.1 – 0.7 = 4.4%

Mix Corrected for Moisture

Material	Batch Weight per yd^3	Batch Weight per 10 yd^3
Cement	465 lbs.	= 465 x 10 = 4650 lbs.
Slag Cement	155 lbs.	= 155 x 10 = 1550 lbs.
Coarse Agg	= 1800 + 1800 x 0.001 = 1802 lbs.	= 1802 x 10 = 18020 lbs.
Fine Agg	= 1241 + 1241 x 0.044 = 1296 lbs.	= 1296 x 10 = 12960 lbs.
H_2O	= 33 x 8.33 – 1800 x .001 – 1241 x 0.044 = 218 lbs.	= 218 x 10 = 2180 lbs.
H_2O Reducer	= 3 x $\frac{620}{100} = 18.6\ oz.$	=18.6 x 10 = 186 oz.
Air Entrainer	= 0.4 x $\frac{620}{100} = 2.5\ oz.$	= 2.5 x 10 = 25 oz.

For this example, 2 lbs. of free water were contributed by the coarse aggregate and 55 lbs. by the fine aggregate. This water needs to be subtracted by the mix water. 33 gallons x 8.33 = 275 lbs. of water – 55 lbs. from sand and 2 lbs. from the stone = 218 lbs. So for a 10 cubic yard load, you need to adjust your mix water down by 570 lbs. or 68 gallons to account for the water being added by the aggregates.

If your moistures were off on your sand by 1% (3.4% instead of 4.4%), the difference in water would be 124 lbs. or 15 gallons. 15 gallons of water would result in about an inch and a half additional slump, 1.5% additional air, and 300 psi strength decrease. It is obvious then, that determining the correct moisture in the aggregate is critical for the consistency of the concrete mix.

Materials

Cementitious Material
There are two types of cementitious materials allowed by MSHA. Cement like materials, such as portland cement and slag cement only require the addition of water to gain strength. Pozzolanic materials, like fly ash and silica fume, require a source of lime (provided from the reaction with portland cement) and water to gain strength.

Cementitious materials for State work includes:

1. Portland cement
2. Slag cement
3. Class F fly ash
4. Class C fly ash
5. Silica fume
6. Blended cements (Portland + fly ash or slag cement)

Minimum Cement Factor (Content)
The minimum cement content is the total amount of cementitious material.

Minimum Cement Factor = portland + slag cement + fly ash + silica fume

Water Cement Ratio Calculation
The water cement ratio equals the weight of all the mixing water divided by the weight of all the cementitious materials in the mix.

$$\textit{The Water Cement Ratio} = \frac{Weight\ of\ All\ Mixing\ Water\ (Added+Free+Ice+Admixture)}{Weight\ of\ Portland\ Cement\ +Slag\ Cement+Fly\ Ash+Silica\ Fume}$$

Portland Cement

Portland cement is produced by finely blending sources of silica, calcium, and iron and heating them in a huge rotating kiln at very high temperatures. The material that comes out of the kiln is called clinker. This material is ground again in a ball mill and some form of gypsum is added to control the early set of the concrete.

Typical raw materials used for the sources of lime, silica, alumina and iron are:

1. Lime – Limestone
2. Silica – Clay, fly ash, sand
3. Alumina – Bauxite, clay, shale
4. Iron – Iron ore, mill scale

There are three major types of cement:

1. *Type I – general purpose*
2. *Type II – moderate sulfate resistance*
3. *Type III – High early strength*

The major compounds in cement are:

1. Tricalcium aluminate (C3A) – responsible for early strength and set characteristics
2. Tricalcium silicate (C3S) – responsible for early and 28 day strength
3. Dicalcium silicate (C2S) – responsible for strength beyond 28 days
4. Tetracalcium Aluminoferrite (C4AF) – responsible for color in the concrete

***Blaine (Fineness)**

Cement is ground to a specified fineness referred to as Blaine. The higher the Blaine, the finer the cement. Finer cements with higher Blaines will produce higher early strengths. Generally, they will also increase shrinkage of the concrete.

***Cement Hydration**

When cement is mixed with water, it starts a complex chemical reaction called cement hydration. The C3A, C3S, C2S, and C4AF combine with the water and form calcium silicate hydrate and calcium hydroxide. Calcium silicate hydrate (CSH) is the glue that provides strength to the concrete. Calcium hydroxide (CaOH) is a by-product that by itself creates no strength in the concrete but it can be used by slag cement, fly ash, or silica fume to form additional calcium silicate hydrate.

Cement + Water = Calcium Silicate Hydrate (CSH) + Calcium Hydroxide (CaOH)

***Requirements for Portland Cement**

1. *Meets AASHTO M85*
2. *Maximum allowable temperature is 170^{o}F*

Sampling Portland Cement

1. *10 lb. sample in a plastic screw cap (approximately 4" diameter) jar*
2. *One sample every two weeks when producing State work*
3. *One sample every month when little or no State concrete is being produced*

Fly Ash

Fly ash is a by-product of the manufacture of energy in a coal fired power plant. When coal is burned, fine material is collected before it exits the smoke stacks. This material that is collected is called fly ash and it contains silica, alumina, and calcium oxides.

There are two basic types of fly ash, Class F fly ash and class C fly ash. Class F fly ash has a much lower amount of calcium oxides that Class C. Most fly ashes on the east coast are Class F.

Class F fly ash is a pozzolan and reacts very well with the calcium in portland cement mixtures. In general, Class F fly ash mixes have about 95% of the strength of a straight portland cement mix. Class F fly ash provides the concrete with decreased permeability, increased resistance to ASR and sulfate attack, and is easier to finish then straight portland cement mixes. Fly ash slows the set of concrete.

AASHTO Requirement for Fly Ash
Must meet the requirements of AASHTO M295, pozzolan, Class C or F.

Loss on Ignition (LOI)
Loss on ignition is a measure of the amount of carbon from the coal that is still left in the fly ash. The higher the LOI, the more carbon. Carbon can dramatically affect air in concrete so a fly ash with a high or variable LOI may be a concern. Most fly ashes today are beneficiated (have the carbon removed) and have little effect on air. The state limits LOI in fly ash to 3.0 percent.

Substitution Limit
Fly ash can be substituted up to a maximum of 25% of the weight of cement.

Sampling of Fly Ash

1. *10 lb. sample in a plastic screw cap (approximately 4" diameter) jar*
2. *One sample every two weeks when producing State work*
3. *One sample every month when little or no State concrete is being produced*

Slag Cement

Slag cement is a by-product of the manufacture of iron in a blast furnace. Iron ore and limestone are heated in a blast furnace to very high temperatures until they become liquid. The furnace is tapped and the molten material flows down a channel. Iron is dense and it sinks to the bottom while all the impurities (the slag) float on the top. A gate separates the iron from the slag and the slag flows down to a runner where it is quenched with water (granulation). The granulated slag is then ground to a fineness a little greater than that of portland cement. Slag cement is high in calcium and silica.

Slag cement increases the ultimate strength of the concrete, reduces permeability, and increases the resistance to ASR and sulfate attack. Slag cement concrete is easier to finish than straight portland cement concrete. Slag cement concrete slows the set of concrete.

AASHTO Requirement for Slag Cement
Must meet the requirements of AASHTO M302, Grade 100 or Grade 120.

Substitution Limit
Slag cement can be substituted up to a maximum of 50% by weight.

Sampling

1. *10 lb. sample in a plastic screw cap (approximately 4" diameter) jar*
2. *One sample every two weeks when producing State work*
3. *One sample every month when little or no State concrete is being produced*

Silica Fume

Silica fume is the by-product of the manufacture of silicon or ferro-silicon metals in an arc furnace. When these metals are made at very high temperatures, the dust collected in the smoke stack is called silica fume. It is extremely fine and largely composed of silicon oxides. Silica fume is very good at achieving very high strength and dramatically lowers the permeability of concrete. Silica fume also can help lower the risk of ASR and sulfate attack. Because of its fineness, silica fume makes concrete sticky and dramatically reduces or eliminates bleed water, which can lead to cracking problems in the field if the concrete is not cured properly.

ASTM Requirement for Silica Fume
Must meet the requirements of ASTM C1240 (the oversize requirement is waived).

Substitution Limit
Silica Fume can be substituted between 5% and 7% by weight.

Sampling

1. *10 lb. sample in a plastic screw cap (approximately 4" diameter) jar*
2. *One sample every two weeks when producing State work*
3. *One sample every month when little or no State concrete is being produced*

Blended Hydraulic Cement

Blended hydraulic cement is an intimate and uniform blend of portland cement with fly ash or slag cement.

AASHTO and MSHA Requirements for Blended Cement
Must meet the requirement of AASHTO M 240 Type IP containing 15 to 25 percent Fly Ash by weight of cement or Type 1S containing 25 to 50 percent slag cement by weight of cement.

Maximum loss on ignition is 3.0 percent. The requirement for a manufacturer's written statement of the chemical composition is waived.

ADMIXTURES

Admixtures are used largely to enhance the performance of the concrete, either by lowering the amount of water required to achieve a given slump (thereby increasing strength) or altering the set time of the concrete (faster in winter, slower in summer).

Basic Requirements

1. Dispensers are visible, easily read, and calibrated
2. Prevent admixtures from freezing
3. All dispensers need to be flushed regularly to clean them

Main Admixture Types

1. Type A – water reducing
2. Type B – set retarding
3. Type C – set accelerating (Only non-chloride allowed)
4. Type D – Water reducing and retarding
5. Type E – Water reducing and accelerating
6. Type F – High range water reducer
7. Type G – High range water reducer and retarder
8. Air entraining admixtures

Types Allowed for Structural Work
Types A or D

Types Allowed for Work Deemed Non-Structural
Type F and G - Use Type F for early strength, which needs to produce a minimum compressive strength in 12 hours of 180 percent of that of the control. Use Type G when early strength is not specified. The manufacturer needs to furnish certification as specified in TC-1.03. The certification needs to include curves indicating the fluid ounces of admixture per 100 lb of cement as related to water reduction and strength gain for 12 hours when used with a minimum cement factor of 700 lb.

AASHTO Requirement for Type A-G Admixtures
Must meet the requirement of AASHTO M 194, Type A, D, non-chloride C, F and G.

AASHTO Requirement for Air Entraining Admixtures
Must meet the requirements of AASHTO M154.

Type A and D admixtures allows you to place concrete with a lower wcr for the same slump.

Type D admixtures also provide retardation and will generally increase the strength to a small degree over Type A admixtures.

Non-chloride Type C admixtures are used to accelerate the set time of the concrete and do not contribute to the corrosion of reinforcing steel.

Air entraining admixtures should never be added to the concrete at the same time as other admixtures.

Factors that Affect Air Entrainment – Air is one of the most difficult factors to control in concrete. It is affected by concrete and ambient temperature, aggregate type and gradation, and age of the concrete, among several other factors. Some of the factors that affect air are:

Factor	**Effect on Air**
Increasing Temperature	Decreases air
Cement alkalis	Increase in alkalis increases air
Fineness	Increasing fineness decreases air
Fly Ash LOI	Increase in LOI will decrease air
Fine Aggregate (No. 30 and No. 50)	Increase in size factions will increase air
Fine Aggregate (No. 100)	Increase in size faction will decrease air
Admixtures	Some admixtures can dramatically increase air
Long Haul Distances	Decreases air
Retempering	Increases air
Pumping Concrete	Can decrease air if not done properly
Water / Slump	Increases with increasing slump up to about 6-8 inches, after which it decreases

Corrosion Inhibitors – Need to be calcium nitrite based and contain a minimum of 30 percent active ingredients by mass. The gallonage of corrosion inhibitor used in the concrete mixture needs to be included as water when determining the water/cementitious materials ratio.

Synthetic Fibers - When synthetic fibers are specified in the Contract Documents, the fibers need to be 1/2 to 1-1/2 in. long and conform to ASTM C 1116, Type III. The manufacturer needs to furnish certification as specified in TC-1.03. The quantity of fibers used and their point of introduction into the mix needs to conform to the fiber manufacturer's recommendations.

Macro Polyolefin Fibers – Need to meet ASTM D 7508 with a minimum length of 1-1/2 in.

Water

The amount of water in a concrete mix includes the water added at the plant, ice, water from admixtures, free water from aggregate, wash water, and water added at the job site.

The source of water shall be tested and approved by Maryland State Highway Administration, shall be clear and shall meet the requirements of AASHTO T26, Method B. Chlorides in water shall not exceed 500 ppm. Water meters shall be calibrated. The temperature of mixing water shall not exceed 170 ^{o}F.

Retempering – Retempering refers to the addition of water at the jobsite. Batch tickets indicate the maximum allowable water and the amount of water that can be added based on the specified wcr. A maximum of 3 gallons of water per cubic yard can be added. No water can be added after the partial discharge of the load.

Effect of Water Addition on Concrete Properties - The addition of water has a dramatic effect on concrete properties. A good rule of thumb is that adding a gallon of water (per cubic yard of concrete) will increase slump by 1 inch, will increase air by 1%, and will decrease strength by 200 psi.

Aggregate

Aggregate, both coarse and fine, have a tremendous effect on plastic and hardened properties of concrete. They comprise 60 to 70% of the concrete mix and they affect strength, workability, finishability, pumpability, and water demand. Most of the materials that are used in concrete are pre-certified. Aggregate should arrive at the concrete plant in spec but gradations can change with handling and properties need to be verified. Also, the moisture condition of aggregate is critical for manufacturing concrete within spec and it needs to be carefully monitored.

Particle shape, texture, and size distribution has a tremendous effect on concrete properties.

Particle shape – refers, as the description implies, to the relative shapes of the coarse aggregate particles. For coarse aggregate, cubical particles make much better concrete than flat and elongated particles. Flat and elongated particles have a higher surface area and require excessive amount of paste to cover them and increase the water demand of the concrete. They also make finishing more difficult and can cause concrete pumps to block up. **For these reasons, flat and elongated particles are limited to 15% by weight of the total aggregate.**

Particle texture (Coarse Aggregate) – refers to whether the coarse aggregate is rounded and smooth, like a gravel, or angular, lie a crushed stone. Smooth rounded particles have a lower water demand but also have less bond with the paste. Concrete made with this aggregate is generally easier to pump and finish. Angular particles have higher water demand but better bond to the paste. They also usually make concrete with higher strength.

Particle texture (Fine Aggregate) – for fine aggregate, texture usually refers to whether the sand is natural or manufactured. Manufactured sand is very angular compared to natural sand. Most manufactured sands are blended with natural sand because the mixes would be too harsh if used alone.

Particle size distribution – refers to the different size of particles of the aggregate, broken down by various sieves. Particle size distribution is extremely important for almost every hardened and plastic property of the concrete. AASHTO specifies bands for each aggregate size that aggregates are required to meet.

Particle Size and Surface Area – The smaller the aggregate size the higher the surface area of the aggregate and the more paste that is required to cover the aggregate – generally the higher the shrinkage of the concrete.

Gradation

Frequency – 2 Samples per 8 hour shift

Accuracy – Calculate percent passing to the nearest 0.1 percent.

Sieve Analysis Calculation / Coarse Aggregate:

Coarse Aggregate Gradation (#57 Stone)						
Sieve	Weight Retained	Weight Passing		% Passing		Specification
1 ½"	0	27.63 – 0 =	27.63	27.63/27.63 x 100 =	100	100
1"	0.64	27.63 - 0.64 =	26.99	26.99/27.63 x 100 =	97.7	95-100
½"	20.91	26.99 – 20.91 =	6.08	6.08/27.63 x 100 =	22.0	25-60
No. 4	5.7	6.08 – 5.7 =	0.38	0.38/27.63 x 100 =	1.4	0-10
No. 8	0.19	0.38 - .19 =	.19	0.19/27.63 x 100 =	0.7	0-5
Pan	0.19	* Note that gradation does not meet specification limits				
Total	27.63					

Sieve Analysis calculation / Fine Aggregate:

Fine Aggregate Gradation						
Sieve	Weight Retained (g)	Weight Passing (g)		Total % Passing Each Sieve		Specification % Passing
3/8	0	495	495	=495/495 x 100 = 100	100	100
No. 4	14.8	495 – 14.8 =	480.2	= 480.2/495 x 100 = 97.0	97.0	95 - 100
No. 8	44.0	480.2 – 44.0 =	436.2	= 436.2/495 x 100 = 88.1	88.1	
No. 16	153.9	436.2 – 153.9 =	282.3	= 282.3/495 x 100 = 57.0	57.0	45 – 85
No. 30	153.9	282.3 – 153.9 =	128.4	= 128.4/495 x 100 = 25.9	25.9	
No. 50	32.2	128.4 – 32.2 =	96.2	= 96.2/495 x 100 = 19.4	19.4	10 – 30
No. 100	83.3	96.2 – 83.3 =	12.9	= 12.9/495 x 100 = 2.6	2.6	0 - 10
Pan	12.9					
Total	495.0					

The following is the required gradation (AASHTO T27) for each aggregate allowed for use in State Work:

Sieve Size	Coarse Aggregate				Fine	
	#57	#67	#7	LWT	NWT	LWT
	Gradation - Mass Percent Passing					
1-1/2"	100					
1"	95-100	100		100		
¾"		90-100	100	90-100		
½"	25-60		90-100			
3/8"		20-55	40-70	10-50	100	100
No. 4	0-10	0-10	0-15	0-15	95-100	85-100
No. 8	0-5	0-5	0-5			
No. 16					45-85	40-80
No. 50					5-30	10-35
No. 100					0-10	5-25

Definition of Confusing Terms

Maximum size – Smallest size through which the entire sample is required to pass.

Maximum nominal size – Smallest size through which the entire sample is permitted to pass.

So for a #57, the maximum size is 1 ½" and the nominal maximum size is 1", for a #67, the maximum size is 1" and the nominal maximum size is ¾", and for a #7, the maximum size is ¾" and the maximum nominal size is ½."

Fineness Modulus (fm) for Sand – Fineness modulus is an indirect measure of the fineness of the sand. Smaller fm's indicate a finer sand and larger fm's indicate a coarser sand. Fineness modulus is important because it can indicate a change in product that can affect concrete properties. For instance, if the fineness modulus decreases (sand becomes finer), there might be an increase in water demand and the concrete may be easier to finish (until it gets too fine and is sticky). High fm's (coarser sands) may be less easy to finish but will make concrete with higher strength.

The following table shows you how to calculate the fineness modulus:

Fineness Modulus (FM) Calculation	
Sieve	% Passing
3/8	100
No. 4	97.0
No. 8	88.1
No. 16	57.0
No. 30	25.9
No. 50	19.4
No. 100	2.6
Total	390.0
FM	= (700 – 390)/100 = 3.10 (700 is a constant)
Specification	= Between 2.3 and 3.1 and +/- 0.20 of the base FM

Base fm – Average fm for last 10 tests or average for all samples if there are less than 10 samples.

Sampling Aggregate: In order to obtain an accurate gradation, you need to get a proper sample. Samples should be gathered at the last practical point where they can be gathered. This means that you need to grab your samples as close as you safely can prior to their introduction to the mixer (in the ready mix truck or in the central mixer).

Sample sizes *(Samples should be gathered in accordance with AASHTO T2)***:**

Material	**Sampling (Min.) AASHTO T2**	**Sieve Analysis (Min.) AASHTO T27**	**Moisture (Min.) (MSMT 251)**
Sand	**22 lbs.**	**300 g**	**500 g**
#57	**110 lbs.**	**22 lbs. / 10,000 g**	**1000 g**
#67	**55 lbs.**	**11 lbs. / 5000 g**	**1000 g**
#7	**35 lbs.**	**4 lbs. / 2000 g**	**500 g**

Reducing Samples – Mix and reduce samples in accordance with AASHTO T 248

Examples:

Grabbing Samples from the flowing aggregate stream

1. Obtain 3 samples at equal intervals
2. Grab sample from entire discharge
3. Make sure pan is of sufficient size to intercept entire discharge without overflowing

Grabbing samples from conveyor belt

1. Obtain 3 samples at equal intervals
2. Stop conveyor belt before grabbing samples
3. Insert two templates whose shape conforms to that of the belt
4. Scoop out material between templates

Reducing Samples to size required for test

Splitters – When splitting samples for testing, use a splitter with an even number of chutes, 8 chutes for coarse aggregate, 12 chutes for fine aggregate. The minimum width of the chute should be 50% larger than the largest particle. The maximum width for fine aggregate is ¼ inch.

Quartering

Miniature Stockpile Sampling -

Impurities

Aggregates are dug out of the ground, are not completely uniform, and may contain substances that are harmful to concrete. The following table shows the test methods and the limits for these materials:

	Sodium Sulfate Soundness	Clay Lumps or Friable Particles	Chert Less than 2.40 SpGr	Sum of Clay Lumps, Friable Particles and Chert	Materials Finer than 200 Sieve	Coal and Lignite	Flat and Elongated	L.A. abrasion	Organic Impurities
Test Method	T104	T112	T113	T112 & T113	T11	T113	D4791 (a)	T96	T21
Coarse Aggregate	12	2.0	3.0	3.0	1.0	0.5	12	50	-
Fine Aggregate	10	3.0	-	-	4.0	0	-	-	3.0

Sodium Sulfate Soundness – Shows resistance to weathering in freeze thaw environment.

Clay Lumps or Friable Particles – Can cause pitting on surface of the concrete and water demand issues.

Chert – Highly absorptive particles that can cause pop outs on the surface of the concrete.

Material Finer that 200 Sieve – Can cause water demand and poor aggregate bond.

Coal and Lignite – Can cause discoloration on the surface of the concrete.

Flat and Elongated – Can cause excessive water demand, finishing issues, and pumping issues.

Los Angles Abrasion – Measure resistance to abrasion and wear.

Organic Impurities – May interfere with the cement hydration process.

Dust of Fracture – Dust of fracture refers to the fine dust that results from crushing the rock. A small amount is beneficial to the concrete but excessive amounts can increase water demand, affect bond strength with paste, and result in lower concrete strengths.

Wash Test – A wash test is a method of using water to wash material in the sieves to collect very fine material that may cause problems, like clay or dust of fracture. When it is expected that this might be a problem, a wash test should be performed.

Moisture Content

Aggregates are similar to sponges. They are porous and have nooks and crannies that can fill with water. The amount of water in aggregate is important because it may figure in the mix water and affect the water cementitious ratio.

Aggregate Moisture Conditions:

Saturated Surface Dry (SSD) – Condition where all the nooks and crannies in the aggregate are filled with water but the surface of the aggregate is dry. For this condition, none of the water in the aggregate counts toward concrete mixing water.

Below SSD – Condition where the nooks and crannies in the aggregate are only partly filled with water. None of this water in the aggregate is counted toward the mixing water.

Above SSD – Condition where all the nooks and crannies are filled with water and there is excess water on the surface of the concrete. The excess water is called free water and needs to be counted as part of the mixing water.

Dry – There is no water in the aggregate.

Moisture Terminology:

Absorption – The percentage of water in the aggregate when the concrete is at SSD.

Free Water – The percentage of water in the aggregate in excess of SSD. This water needs to be counted as part of the mixing water.

State Requirement for Aggregate Moisture – For State work, all aggregate will be maintained in excess of SSD and free water will need to be calculated and added as part of the mixing water.

Moisture Determination

1. Minimum sample size
    a. 1000 g for #57 stone
    b. 1000 g for #67 stone
    c. 500 g for #7 Stone
    d. 500 g for sand

2. Weigh pan (Record to the nearest 0.1g)

3. Weigh pan and aggregate

4. Heat aggregate until all moisture is driven off (sample is dry when additional heating will not cause a 0.1 percent or greater additional loss in mass).

5. Use the following procedure to calculate the free moisture (water) in the aggregate and report to the nearest 0.1%:

$$Total\ Moisture = \frac{Wet\ Weight - Dry\ Weight}{Dry\ Weight}\ x\ 100$$

$$Free\ Moisture = Total\ Moisture - Absorption$$

Remember to subtract the absorption in the end to calculate the free moisture and that the free moisture needs to be included into the calculation for the mixing water and the wcr.

Example:

Moisture Content Measurement and Calculation	
Sieve	% Retained
Pan Weight	55
Pan and Wet Agg. Weight	572
Wet Weight	= 572 – 55 = 517
Pan and Dry Agg. Weight	550
Dry Weight	= 550 – 55 = 495
% Moisture (Total)	= (517 – 495)/495 x 100 = 4.4
Absorption	0.8
Moisture Content (Free)	= 4.4 – 0.8 = 3.6

Moisture Probes: Most concrete plants use moisture probes to determine the amount of water in fine aggregate. Physical moisture tests of the aggregate needs to be **performed weekly** to make sure the probes are still reading correctly. They should also be performed to verify

moisture after significant rain storms because moisture probes don't always pick up major moisture differences quickly.

State Specification for Moisture Probes:

915.03.02 Moisture Probes. Moisture probe readings may be used in place of actual daily moisture testing of fine aggregate. Moisture probes shall be calibrated and maintained per the manufacturer's recommendations.

(a) Actual moisture tests for fine aggregate shall be performed weekly and as directed. When the actual tests of the fine aggregate indicate a difference of greater than 0.5 percent free moisture than the moisture probe readings, immediately perform a second actual test.

(b) If the second test indicates a moisture difference of greater than 0.5 percent, recalibrate the moisture probe and verify. Records of all calibrations and weekly tests shall be maintained and made available.

Testing Concrete

Sampling – Grab a representative sample of concrete consisting of 2 or more samplings from the middle portion of the load of concrete (after the first third has been discharged and before the last third is being discharged). Grab the sample completely through the discharge stream of the concrete. Remix all samples with a scoop or flat shovel before testing.

Temperature – Temperature has an important effect on so many properties of the concrete that it should always be recorded when other concrete tests are being performed.

Place a calibrated thermometer in the concrete, provide 3 inches of cover in all directions around the probe, wait until the temperature readings stabilize and record to the nearest degree F.

> **915.03.03 Mixing Temperatures.** The plant shall be equipped with approved methods of heating and cooling the mix. The temperature of the plastic concrete shall meet 902.10.03. The temperature of the cementitious materials and water during mixing shall not exceed 170 F.

Strength – Standard cured strength specimens (cylinders) are manufactured to check the adequacy of the mix proportions for the specified strength. They do not represent the strength of the structure but they do give a strong indication that the mix was batched properly and that the materials are performing as they did in the trial batch.

Slump – Slump is a measure of the consistency of the concrete.

Fill a slump cone in three equal layers by volume. Rod each layer 25 times. Pull up the slump cone in 5 +/- 2 seconds. Measure down to the displaced original center of the concrete. Record to the nearest ¼ inch.

> Slump needs to meet the requirements in Table 902 A

Unit Weight – Unit weight gives a good indication that the materials were batched out properly, that the mix is not over or under yielding, and what the percentage of air is in the mix.

Weigh the empty container with a predetermined volume. Place concrete in the container in three equal layers, rodding each layer 25 times and consolidating each time by rapping the side of the container with a rubber mallet. On the final layer, provide about ¼ inch of excess concrete over the top of the container. Use a strike off plate to bring the concrete absolutely plane and level with the top of the container. Clean the container of excess concrete. Weigh the full container. Calculate the unit weight.

Example: Container volume = .25 ft^3. Weight of the empty container equals 8 lbs. Weight of the full container equals 45 lbs.

Weight of the concrete = Weight of the container filled with concrete – weight of the container
Weight of the concrete = 45-8 = 37 lbs.

$$\textit{Unit Weight of the concrete} = \frac{Weight\ of\ the\ concrete}{Volume\ of\ the\ concrete} = \frac{37}{0.25} = 148.0\ lbs./ft^3$$

Air – Air effects strength, durability, and plastic properties of the concrete.

There are two ways to measure air, with a pressure meter or with a volumetric (roller) meter. Pressure meters are used for normal weight concrete and for plastic concrete (slump over an inch). Volumetric meters are used for light weight concrete. Pressure meters are calibrated to provide a set pressure on a carefully prepared (similar process to unit weight) pot of concrete. The pressure compresses air bubbles in the concrete and the meter indicates the total amount of air in the concrete. Volumetric meters use a much smaller pot and use water and alcohol to dissipate air bubbles. The total air is read in graduations on the neck of the Volumetric meter.

Air needs to meet the requirements of Table 902A.

Frequency of Tests - For field testing concrete on the jobsite, the following frequency is used:

TEST	METHOD	MINIMUM TEST FREQUENCY	RESPONSIBILITY
Temperature (e)	T 309	1 per 50 yd^3 (or fraction thereof)	Project Engineer
Slump (a)(e)	T 119	1 per 50 yd^3 (or fraction thereof)	Project Engineer
Air Content (a)(e)	T 152 T 196	1 per 50 yd^3 (or fraction thereof)	Project Engineer
Compression (b)(c)(d)	T 23	1 per 50 yd^3 (or fraction thereof)	Project Engineer
Compression (b)(c)(d) Mix No. 7 Only	T 23	3 per Day	Project Engineer

(a) A second test will be made when the first slump or air content test fails. Acceptance or rejection will be based on the results of the second test.
(b) Compressive strength tests are defined as the average of two companion cylinders.
(c) The Contractor shall be responsible for the making of all early break cylinders and furnishing the molds, stripping, curing/delivery of all cylinders, including 28 day cylinders, to the testing laboratory.
(d) The Project Engineer will be responsible for making, numbering and signing the 28 day cylinders.
(e) When constructing plain and reinforced concrete pavements, the testing frequency for slump, air content, and temperature shall be 1 per 100 yd3 or fraction thereof.

Plants

The Certified Plant Technician (CPT) is responsible to ensure that concrete plants and concrete trucks meet specification limits, that all materials meet specification limits, that all materials are collected and tested in accordance with State specifications, that there is testing equipment on site and that it is in working order, and that all paper work is properly filled out. The following is a list of some of the duties of the CPT to ensure that plant and truck requirements are met.

Certified Plant Technician Duties

1. Supervise all plant production
2. Ensure that the Quality Control Plan is followed
3. Sample materials according to the Sample Frequency Guide
4. Perform aggregate gradations
5. Perform moisture tests
6. Adjust proportions for free moisture
7. Sign batch tickets
8. Notify the State one working day prior to producing concrete for State projects.
9. Notify the State at least five working days in advance of scheduling the comprehensive inspection.

Quality Control Plan

Each plant is required to have a quality control plan. The following are the requirements for the Quality Control Plan:

1. A current Quality Control Plan exists and is approved
2. All QC Personnel are listed with an approved number
3. QC Plan is accessible to QA Inspectors and plant personnel
4. Changes to the Quality Control Plan are reported to SHA
5. Plant Quality Control Procedures are established and followed
6. Quality requirements of raw materials are specified

7. Sampling and Testing requirements are described

Laboratory

1. The quality control laboratory needs to be on site
2. The lab needs to have sufficient space to perform tests correctly and efficiently
3. The testing equipment needs to be in good working condition
4. The test records need to be maintained and available for review
5. An on-site office for State inspectors needs to be provided

Approved Material Sources

1. All materials used in producing concrete need to come from a SHA approved source
2. The production plant needs to keep on file all material sources and certification documents
3. Records need to be made available to the QA Inspector for review

Material Storage / Aggregate Stockpiles and Bins

1. Stockpiles and bins shall be kept separate for each type of aggregate
2. Stockpiles and bins should be accessible to loaders and to trucks bringing aggregate from the supplier
3. Aggregates need to be maintained at above SSD conditions
4. Aggregates need to be maintained to ensure uniform moisture conditions throughout the pile
5. There needs to be different compartments for each aggregate
6. Aggregates need to be stored in such a way as to prevent intermingling of different aggregates
7. Aggregate need to be stored and maintained in such a way as to prevent segregation

8. In cold weather, aggregates need to be protected from freezing (no frozen lumps) and aggregate should not be subjected to live steam

9. Aggregate bins should freely discharge

Material Storage / Cementitious

1. Silos should be in good condition

2. Silos should have no significant corrosion (Corrosion that would allow moisture into the silo or would cause contamination of materials between split silos)

3. Silos should be clearly marked (Cement / Fly Ash / Slag Cement)

Material Storage / Admixtures

1. Admixtures need to be properly stored as per manufacturer label

2. Batching accuracy for admixtures: Volumetric measurement need to be within 3% of the total amount required or plus or minus the volume of dose required for one sack of cement, whichever is greater (One sack of cement weighs 94 lbs.)

3. Most liquid admixtures will dose in ounces per 100 lbs. of cement (oz./cwt).

Batching Control

1. Scales should be zeroed out once at the beginning of the day's work.

2. Scales should stay zeroed but batch operator should check this before batching each load

3. Gates should be closed before batching (do not dump materials if charge gate is open)

4. Do not dump if material weights / doses are not within tolerance

Measuring Devices

1. All measuring devices, meters and dispensers need to be calibrated and certified annually by an approved testing agency

2. All measuring devices, meters and dispensers need to be calibrated and certified monthly by the producer or approved testing agency

3. For new plants, all measuring devices meters and dispensers need to be calibrated and certified by an approved agency

4. Balance and zero conditions need be checked daily and when requested by SHA personnel

5. Devices need to be checked monthly during operations

6. Notify the State 2 days prior to checks on calibration

Scale Certification

1. Scales need to be calibrated and certified annually by an approved testing agency

2. Scales need to be calibrated and certified monthly by the producer

3. Report should include:
    a. Calibration
    b. Maximum capacity
    c. Overall scale condition
    d. Include minimum graduation size

4. The concrete producer needs to notify the State 2 days prior to scale checks

Freefall

As aggregate falls in the weigh hopper, the weigh hopper can obviously only weigh the aggregate that is in the hopper. The aggregate in the air is the freefall aggregate, it hasn't hit the weigh hopper so it obviously hasn't been weighed yet. Estimating too much freefall (more aggregate in the air than there really is) will mean that you under weigh the aggregate. Estimating too little freefall (less aggregate in the air than there really is) will mean that you over weigh the aggregate.

Tolerances for Aggregate (AASHTO M157)

Operating Tolerances

1. Aggregate – 2.0% by weight

2. Cement – 1.0% by weight

3. Water – 1 gallon

4. Additives – 0.5% by volume

Measuring Cementitious with Tolerances

1. Cement is measured first

2. Slag cement or fly ash can be measured cumulatively but after portland cement is weighed first

Example: Mix calls for 5800 lbs. of portland cement and 1000 lbs. of fly ash.

1% tolerance for portland cement = 0.01 x 5800 = 58 lbs so tolerance is +/- 58 lbs. (5742 lbs. – 5858 lbs.)

1% tolerance for total cementitious = 0.01 x 6800 = 68 lbs. so tolerance is +/- 68 lbs. (6732 lbs. – 6868 lbs.)

Measuring Aggregate with Tolerances

1. Batch weights based on dry weight plus total moisture content

   Example: Batch weight for stone (with all water included from aggregate moisture) is 18,180 lbs.

   2% tolerance for stone = 0.02 x 18180 = 364 lbs. so tolerance is +/- 364 lbs. (17,816 lbs. - 18,544)

   Batch weight for sand (with all the water from aggregate moisture added) = 12,600 lbs.

   2% tolerance for sand = 0.02 x 12,600 = 252 lbs. so tolerance is +/- 252lbs. (12,348 – 12852)

   Batch weight for stone and sand (with all the water from aggregate moisture added is 30,780 lbs.

   2% tolerance for aggregate = 0.02 x 30,780 = 616 lbs. so tolerance is +/- 616 lbs. (30,164 lbs. - 31,396 lbs.)

Batch Tickets

Provide an approved computer generated batch ticket indicating the pertinent information for each load in duplicate. The ticket shall indicate maximum allowable water and maximum water allowed for jobsite slump adjustment.

Distribute load ticket to the project and keep one on file. The file copy needs to be readily available for inspection upon request. Issue a Form 116 for each load in the event a computer generated batch ticket cannot be provided.

Mixer Trucks

1. Truck Capacity
    a. Concrete Mixer – 63% of the total volume of the drum
    b. Concrete Agitator – 80% of the total volume of the drum

2. Inspected once a year

3. MSHA needs to be notified 7 days in advance of annual inspection and 2 days in advance of inspection of trucks added between annual inspections.

4. Certification Plate
    a. Gross volume of drum
    b. Mixer capacity
    c. Minimum and maximum mixer speeds

5. QC Technician needs to inspect trucks and keep a written report including the following inspection points
    a. Yearly inspection sticker
    b. Back up alarm – In working order
    c. Drum capacity – Rating plate
    d. Water valves – No leaks
    e. Water pump – No leaks
    f. Drum knuckle – No leaks
    g. Counters – Working
    h. Water glasses – clean
    i. Water gauge – clean
    j. Drum – No build up
    k. Blades – Not excessively worn or broken

6. Operate drums during transit at agitating speed only. Mixing during transit is prohibited.

7. Add at least 85 percent of design water requirement at the plant through the certified plant water meter.

8. Water for slump adjustment may be added at the plant through truck water system under the supervision of the certified concrete technician, provided the maximum specified water/cement ratio is not exceeded.

9. A maximum of 3 gal of water per cubic yard of concrete may be added at the point of discharge provided it does not exceed the maximum specified water/cement ratio.

10. No water may be added after partial discharge of the load.

11. Loading of mixers or agitators that contain wash water in the drum is prohibited.

12. When the concrete is specified or allowed to be produced by volumetric batching and continuous mixing, the batching and mixing unit shall meet C 685.

13. Calibration shall meet MSMT 558.

14. The minimum mixing time is 75 seconds for stationary mixers not subject to mixer performance tests.