INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

WATER-CEMENTITIOUS RATIO
ITM No. 403-21

1.0 SCOPE.

1.1 This test method covers the procedure to determine the water-cementitious ratio for a concrete mixture.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

M 231 Balances Used in the Testing of Materials
T 255 Total Moisture Content of Aggregate by Drying

2.2 ITM Standards.

207 Sampling Stockpiled Aggregates
910 Verifying Balances

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101 and as follows:

3.1 Cementitious Material. Portland cement and pozzolans

3.2 Free Water**.** The water added to the concrete mixture plus the water carried by the aggregates in excess of that held in absorption

3.3 Water-Cementitious Ratio. The ratio between the weight of free water and the weight of cementitious material in a concrete mixture

3.4 Maximum Particle Size. The smallest sieve opening through which the entire amount of the aggregate is permitted to pass

4.0 SIGNIFICANCE AND USE. This procedure is used to determine the water-cementitious ratio of a representative batch of concrete. The water-cementitious ratio is compared to the maximum allowed water-cementitious ratio to ensure the concrete meets specification requirements.

5.0 APPARATUS.

5.1 Balance, Class G20, in accordance with AASHTO M 231, with a capacity of up to 100 lb and readable to .01 lb

5.2 Heat Sources.

5.2.1 Electric skillet, with a thermostatic heat control capable of heating to at least 215°F

5.2.2 Heat lamp, capable of heating to at least 215°F

5.2.3 Stove, capable of heating to at least 215°F

5.2.4 Oven, capable of maintaining the temperature to 230 ± 9°F

5.3 Heat Shield

5.4 Pans and containers as needed

5.5 Spatulas and spoons as needed

6.0 PROCEDURE.

6.1 Obtain a representative sample of the coarse aggregate and fine aggregate. Stockpile sampling shall be conducted in accordance with ITM 207. Discharge sampling shall be in accordance with the INDOT manual entitled "Inspection and Sampling Procedures for Fine and Coarse Aggregates".

When a mechanical diversion or slide chute system does not exist at a truck mix plant, a representative sample may be obtained by charging 5000 lb or approximately 3 yd^3 of aggregate into the weigh hopper. Run the aggregate through the transit mix plant, instead of the truck mixer, and use a front end loader to obtain all of the weighed material. Roll the aggregate out of the loader bucket into a small pile and sample the aggregate in accordance with ITM 207, except that further mixing of the stockpile is not required.

Place the sample in a non-absorptive sealable container for transport to the field lab.

6.2 The minimum sample size required for testing is coarse aggregate 10 lbs. and fine aggregate 5 lbs.

6.3 Select a clean and dry pan in which to dry the aggregates. Determine and record the weight of the clean and dry pan to the nearest 0.01 lb.

6.4 Place at least the minimum sample size required for testing in the pan. Determine and record the weight of the pan and the original sample.

6.5 Dry the original sample by applying heat to the pan and sample in accordance with AASHTO T 255. The heat source may be an electric skillet, oven, stove or heat lamp. If the aggregate is altered by heat, the drying is required to be conducted using a ventilated controlled temperature oven. The sample will be considered dry when the sample weight decreases by less than 0.01 lb over five minutes of heating. Rapid heating may cause some particles to explode. Stir the sample with the spatula or spoon during drying to accelerate drying and avoid localized heating.

6.6 Determine and record the weight of the dry sample and pan to the nearest 0.01 lb. Use a heat shield to protect the balance. Tare the heat shield prior to the dry sample weight (mass) determination.

6.7 Determine the weight of water in the original sample by subtracting the weight of the dry sample and pan from the weight of the original sample and pan.

$$\text{Water, lb} = \text{Original \& Pan} - \text{Dry Sample \& Pan}$$

6.8 Determine the weight of the dry sample by subtracting the weight of the pan from the weight of the dry sample and pan.

$$\text{Dry sample, lb} = \text{Dry Sample \& Pan - Pan}$$

6.9 Determine the percent moisture content of the original sample by dividing the weight of the water in the original sample by the weight of the dry sample and multiplying by 100 percent. Record the moisture content to the nearest 0.01 percentage point.

$$\text{Moisture, \%} = \frac{\text{Water, lbm}}{\text{Dry sample, lbm}} \text{ x } 100$$

6.10 Determine the percent absorption of the coarse aggregate and fine aggregate from the CMD or contact the District Testing Engineer.

6.11 Obtain a batch ticket representative of the concrete tested.

6.12 Determine the weight of the batched coarse and fine aggregate charged into the concrete mixer as stated on the batch ticket.

6.13 Determine the weight of dry coarse aggregate and dry fine aggregate in the concrete mixture batch by the following formula. Record the dry aggregate weight value to the nearest 1 lb.

$$\text{Dry aggregate, lb} = \frac{\text{Batched aggregate}}{1.0 + \frac{\text{Percent moisture}}{100}}$$

6.14 Determine the weight of water in the coarse and fine aggregates by subtracting the weight of the dry aggregate from the weight of the batched aggregate.

Water carried aggregates, lb = Batched aggregate - Dry aggregate

6.15 Determine the weight of the water absorbed by the coarse aggregate and fine aggregate to the nearest 1 lb by multiplying the weight of dry aggregate by the percent absorption divided by 100 percent.

$$\text{Water absorbed, lb} = \text{Dry aggregate} \times \frac{\text{Percent absorption}}{100}$$

6.16 Determine the total weight of the water in the aggregates by adding the weight of the water in the coarse aggregate with the weight of the water carried in the fine aggregates.

Total water in aggregates, lb = WICA + WIFA

where:

WICA = Water in coarse aggregate, lb
WIFA = Water in fine aggregate, lb

6.17 Determine the total weight of the water absorbed by adding the weight of water absorbed by the coarse aggregate with the weight of water absorbed by the fine aggregate.

Total water absorbed, lb = WACA + WAFA

where:

WACA = Water absorbed by the coarse aggregate, lb
WAFA = Water absorbed by the fine aggregate, lb

6.18 Determine the weight of all water added to the batch of concrete as stated on the batch ticket to the nearest 1 lb.

$$WATM, lb = 8.33 \times WATM$$

where:

WATM = Water added to mixture, lb

6.19 Determine the weight of the total free water in the concrete mixture by adding the weight of the total water in the aggregates plus the weight of all the water added to the mixture minus the weight of total water absorbed.

Truck mix plants may hold back 3 to 5 gal. of water to be used by the driver to wash down the funnel and front drum fins during the mixing cycle. If the truck mix plant does not hold back water, the amount of water added to the truck mixer is required to be determined and used to calculate the water cementitious ratio.

$$\text{Free water, lb} = TWIA + WATM - TWA$$

where:

TWIA = Total water in the aggregates, lb
WATM = Water added to mixture, lb
TWA = Total water absorbed, lb

6.20 Determine the weight of Portland cement in the batch of concrete as stated on the batch ticket.

6.21 Determine the total weight of pozzolans in the batch of concrete by summing the weight of each pozzolan.

Total pozzolan, lb = Fly ash + GGBFS + Silica Fume

6.22 Determine the weight of cementitious material added to the concrete mixture by totaling the weight of cement and pozzolans shown on the batch ticket.

Cementitious, lb = Portland cement + Pozzolans

6.23 Determine the water-cementitious ratio to the nearest 0.001, by dividing the weight of free water in the concrete mixture by the weight of cementitious material in the concrete mixture.

$$\text{Water-cementitious ratio} = \frac{\text{Free water, lb}}{\text{Cementitious, lb}}$$

7.0 REPORT.

7.1 Record the water-cementitious ratio

WATER-CEMENTITIOUS RATIO WORKSHEET

Date: _____

Contract: _____ Weight of cement batch: _____

Project: _____ Maximum permitted w/c ratio: _____

Row	Procedure	Method	Col. 1 C.A.	Col. 2 F.A.
A	Weight original sample & pan, 0.01 lb	Weigh		
B	Weight dry sample & pan , 0.01 lb	Weigh		
C	Weight of water in sample , 0.01 lb	A-B		
D	Weight of pan, 0.01 lb	Weigh		
E	Weight of dry sample, 0.01 lb	B-D		
F	Percent moisture, 0.01 %	(C/E) 100		
G	Percent absorption, 0.01 %	CMD		
H	Weight wet aggregate in batch, 1 lb	Batch Ticket		
I	Weight dry aggregate in batch, 1 lb	H/(1.0+(F/100))		
J	Weight water in aggregate in batch, 1 lb	H-I	J1	J2
K	Weight water absorption in batch, 1 lb	I(G/100)	K1	K2
L	Total weight water in aggregate, 1 lb	J1+J2		
M	Total weight water absorbed, 1 lb	K1+K2		
M1	Hold back water, 1 lb (Note 1)	Provided by plant operator		
M2	Wash down water, 1 lb (Note 1)	Estimated by driver		
N	Total water added to batch, 1 lb	Batch Ticket (Note 2)		
O	Total free water in batch, 1 lb	N + L – M + (M2-M1)		
P	Weight Portland cement in batch, 1 lb	Batch ticket		
Q	Total weight pozzolans in batch, 1 lb	Batch ticket		
R	Total weight cementitious in batch, 1 lb	P+Q		
S	Water-cementitious ratio, 0.001	O/R		

Note 1: Truck mix plants may not actually batch all of the water shown on the ticket so that some water (approx. 3 gal) may be used by the driver to wash down the funnel and front drum fins during the mixing cycle. This is called "hold back" water. Both the amount of water added to the truck by the driver and the plant hold back amount must be determined. If the driver added less water than the hold back, then the difference should be subtracted from the total water. If the driver added more water than the hold back, then the difference should be added to the total water. If the plant does not hold back any water, then all of the water added by the driver should be added to the total.

Note 2: If the batch tickets report water in gallons (gal) multiply by 8.33 lbs/gal to convert to lbs. If water is being heated for cold weather applications multiply by 8.22 lbs/gal

Remarks: _____

_____

Signature: _____ Title: _____