INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

HYDRAULIC FRACTURE TEST
ITM No. 223-15

1.0 SCOPE

1.1 This method sets forth the control procedures used for determining the capacity of aggregates to withstand changes in internal stress using the Hydraulic Fracture Test (HFT).

1.2 Aggregate is sieved to a specified gradation, the initial weight on each sieve size is determined, and the recombined aggregate is placed in the HFT chamber. The chamber is flooded with water and pressurized. The pressure in the chamber is held for a prescribed time and then released quickly. The pressurization-release cycle is repeated for a total of 10 cycles. The aggregate is oven dried, sieved and the weight loss on each sieve is recorded. This process is repeated until a total of 50 cycles have been completed.

1.3 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.

T 11 Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
T 27 Sieve Analysis of Fine and Coarse Aggregate
T 248 Reducing Samples of Aggregate to Testing Size
M 92 Wire Cloth and Sieves for Testing Purposes
M 231 Weighing Devices Used in the Testing of Materials

2.2 ITM Standards.

203 Control Procedures for Classification of Aggregates
207 Sampling Stockpiled Aggregates
210 Class AP Coarse Aggregate
211 Certified Aggregate Producer Program

3.0 TERMINOLOGY.

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

4.0 SIGNIFICANCE AND USE. This ITM will be used to provide additional information to ITM 210 for the classification of AP aggregates from carbonate stone sources. Also, the ITM will be used for determining the AP status of recycled concrete when used as an aggregate in concrete.

5.0 APPARATUS.

5.1 Balance, G2, in accordance with AASHTO M 231

5.2 Mechanical Sieve Shaker, in accordance with AASHTO T 27

5.3 Oven, appropriate size capable of maintaining a uniform temperature of 230 ± 9°F

5.4 Sieves, 12 in., in accordance with AASHTO M 92

5.5 Hydraulic Fracture Test equipment

5.6 Rock Tumbler

5.7 Strainer, 20 qt.

5.8 Digital stopwatch, readable to 1 s

5.9 Pans, sieve brushes, and scoop as needed

6.0 Reagents.

6.1 A water-based silane

7.0 SAMPLING. A coarse aggregate sample of the material to be tested will be obtained in accordance with ITM 207 and shall meet the sieve weight requirements of 8.1.

8.0 PREPARATION OF AGGREGATE TEST SAMPLE.

8.1 The sample shall be reduced in accordance with AASHTO T 248 and separated into the required sieve sizes in accordance with AASHTO T 27. The quantity from each sieve size shall be recombined to obtain the gradation in Table 1. Approximately 28 lb of aggregate is required to fill the HFT chamber.

Sieve Size	Percent Passing	Weight, g
1 in.	100	0
3/4 in.	89	1430 ± 20
5/8 in.	40	6370 ± 15
1/2 in.	0	5200 ± 10

Table 1. Aggregate Gradation

8.2 Decant the sample in accordance with AASHTO T 11 until the water is clear. Dry the sample to a constant weight (Note 1) in an oven at a temperature of 230 ± 9° F. Cool to room temperature.

Note 1 - Constant weight is defined as the weight at which further drying at the required drying temperature does not alter the weight by more than 0.05 percent.

8.3 Submerge the sample in the pot with a nested strainer (Figure 1) filled with a water-based penetrating silane solution for 60 s in a well-ventilated room.

Figure 1.Pot with Nested Strainer

8.4 Lift the nested perforated pot of the strainer containing the aggregate to drain.

Note 2 - The silane solution may be reused; however, the solution should be stored in a sealed container between uses and not used if the solution thickens.

8.5 Empty the aggregate into a pan and air dry the sample for a minimum of 1h in a well ventilated room.

8.6 Dry the aggregate to a constant weight in an oven at 230 ± 9° F. Cool to room temperature.

8.7 Place the aggregate in the rock tumbler to approximately half full and tumble the aggregate for 30 revolutions of the tumbler. Remove the aggregate from the tumbler and repeat the process for the remaining aggregate until all of the aggregate sample has been tumbled.

8.8 Sieve the aggregate over the 1/2 in. sieve and discard the aggregate that is passing the 1/2 in. sieve.

9.0 HYDRAULIC FRACTURE TEST PROCEDURE

9.1 Two pressurized nitrogen tanks are required to conduct the HFT test. The higher pressure tank (Tank No. 1) is required to maintain a minimum pressure of 1300 psi throughout the test and the lower pressure tank (Tank No. 2) is required to maintain a minimum pressure of 175 psi throughout the test.

With Valve E closed (Figure 2), open the valve to Tank No. 1 on the higher pressure cylinder attached to the HFT chamber to check the available pressure in that cylinder. If the pressure is less than or equal to 1500 psi, close the cylinder valve and replace the cylinder.

With Valve E closed (Figure 2), open the valve to Tank No. 2 on the lower pressure cylinder attached to the HFT actuator to check the available pressure in that cylinder. If the pressure is less than or equal to 200 psi, close the cylinder valve and replace the cylinder.

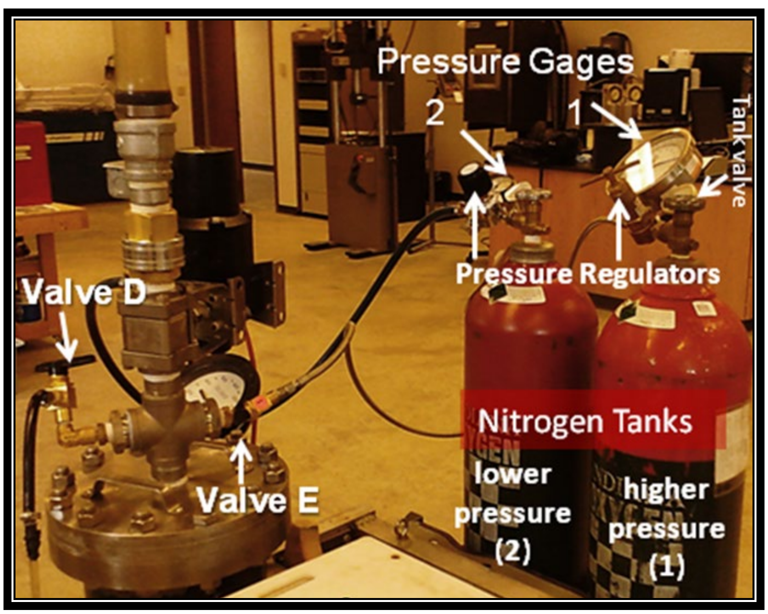

Figure 2. HFT equipment set up

9.2 Close the water inlet valves (Valve A first and then Valve B - Figure 4) and the pressure inlet valve (Valve E, Figure 2)

9.3 Place the No. 50 screen in the bottom of the HFT chamber.

9.4 Place the mesh basket in the HFT chamber and uniformly place the aggregate in the basket with a scoop. Only enough aggregate to fill the chamber is placed in the basket. (Overfilling the chamber will result in aggregate particle fracturing when the chamber lid is attached).

9.5 Remove the aggregate sample from the HFT chamber and sieve the aggregate over the 3/4 in., 5/8 in., and 1/2 in. sieves. Discard the aggregate that is passing the 1/2 in. sieve. Record the weights on each sieve to the nearest 1g. This weight is designated as the weight at zero HFT cycles for each sieve.

9.6 Place the aggregate sample in the HFT chamber and cover the top of the basket with the mesh basket screen (Figure 3).

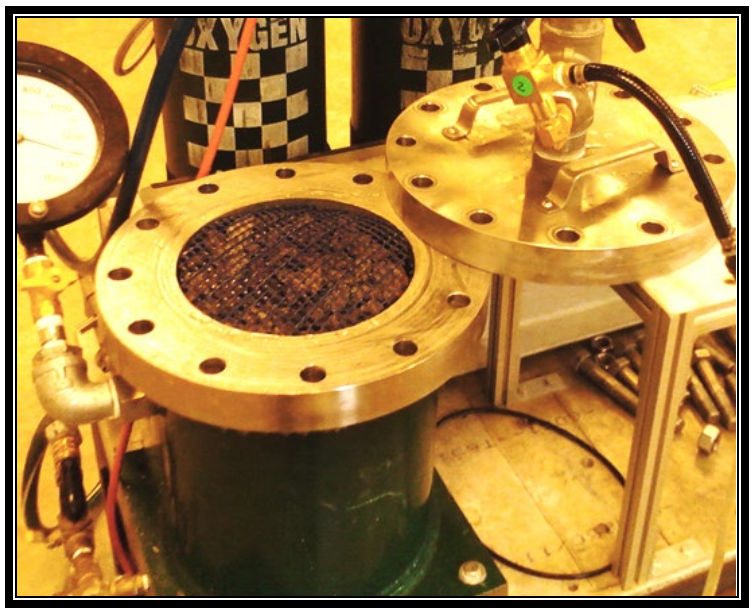

Figure 3. Aggregate specimen in HFT chamber with open mesh basket lid in place

9.7 Grease the cover assembly o-ring with a high pressure silicon grease and place the o-ring in the cover assembly. Place the cover assembly on top of the pressure chamber and bolt the cover assembly to the chamber with the 12 high strength bolts. (Note 3)

Note 3: The bolts will be tightened with a torque wrench to a minimum of 80 in-lb force and tightened in a pattern that no two adjacent bolts are tightened consecutively).

9.8 Warm up the pressure release valve by turning the actuator switch on and off at least 20 times. This process is required to be repeated if the apparatus has not been used in the past one hour. End this process with the switch in the off position. Cover the top of the basket with the basket screen (Figure 3).

9.9 With drain Valve C closed, open Valve A and Valve B to fill the chamber with water, and open Valve D to the top drain line (see Figures 2 and 4). When the chamber is full, excess water will drain out through the Valve D and the top drain line. Allow water to continue to flow through the chamber and out the top drain line until clear water with no bubbles are visible flowing through the drain line (Note 4).

Note 4: Before opening the water inlet valves, check that the ball valve is closed (the actuator switch is in the off position). If the ball valve is not closed, the water will rise into the exhaust pipe once the chamber is filled.

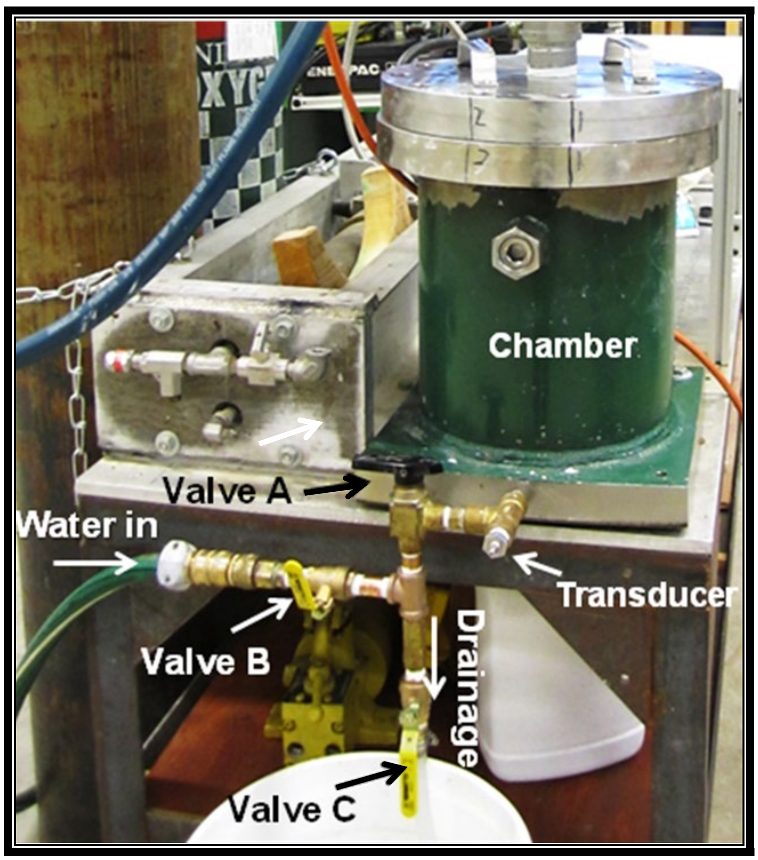

Figure 4. HFT chamber with water fill and drain Valves A, B and C

9.10 Close the drain Valve D. Wait 20 seconds and then close Valve A and Valve B.

9.11 With the actuator switch in the off position and Valve E closed, open the pressure tank valve on the high pressure cylinder (Tank 1) and adjust the pressure regulator until Gage 1 reads 1300 psi. Open the tank valve on the low pressure cylinder (Tank 2) and adjust the pressure regulator until Gage 2 reads 175 psi (Figure 2).

9.12 Pressurize the chamber by opening Valve E and leaving Valve E open for 5 min. ± 5 seconds for the first cycle. All cycle times shall be measured with a digital stop watch.

9.13 After the pressurization is completed and the 5 min. has lapsed, **quickly close Valve E**, switch the actuator on to open the ball valve, and depressurize the chamber (Note 5). Then turn the actuator switch off

Note 5: Wearing proper hearing protection during the chamber depressurization is required.

9.14 Repeat steps 9.7 to 9.11 for nine more cycles with the pressurization time at 2 minutes ± 5 seconds each for a total of 10 pressurization-depressurization cycles. The time between cycles shall not exceed 30 sec.

9.15 After completing ten cycles of pressurization, close both nitrogen tank valves then open Valve A and Valve C. Water will drain out from the chamber at a slow rate. To drain the water completely, add a small amount of pressure to the chamber by slowly opening Valve E. When the water is completely drained out of the chamber, close Valve E.

9.16 Remove the bolts and lid, place the chamber lid on the side table, and remove the aggregate sample from the chamber. Place the aggregate in a pan and oven-dry the aggregate to a constant weight at a temperature of 230 ± 9º F. -Cool the aggregate to room temperature.

9.17 Split the aggregate into four equal samples so as not to overload the sieves, and sieve the aggregate for 10 min. using the 3/4 in., 5/8 in., 1/2 in., 3/8 in., 5/16 in., 1/4 in., and No. 4 sieves.

9.18 Weigh the aggregate retained on each sieve and the pan to the nearest 1g (Note 6). Record the weight retained on each sieve (Appendix A)

Note 6: Care should be taken that additional breakage does not occur when removing the aggregates from each sieve.

9.19 Repeat the steps 9.1 to 9.16 four more times until the aggregate sample has been tested for a total of 50 cycles of pressurization and depressurization.

10.0 CALCULATIONS.

10.1 For carbonate aggregate sources, calculate the percent change in weight retained for each sieve size as follows:

$$P\,3/4\text{ in.} = \left(\frac{W50-W0}{W0}\right) x\,100$$
$$P\,3/8\text{ in.} = \left(\frac{W50-W0}{WT}\right) x\,100$$
$$P\,1/4\text{ in.} = \left(\frac{W50-W0}{WT}\right) x\,100$$
$$P\text{ No. }4 = \left(\frac{W50-W0}{WT}\right) x\,100$$

where:

P 3/4 in. = percent change in weight for the 3/4 in. sieve
P 3/8 in. = percent change in weight for the 3/8 in. sieve
P 1/4 in. = percent change in weight for the 1/4 in. sieve
P No.4 = percent change in weight for the No. 4 sieve
W50 = weight retained at 50 cycles on a particular sieve
W0 = weight retained at 0 cycles on a particular sieve
WT = total initial weight at 0 cycles

10.2 For carbonate aggregate sources, calculate the dilation values using the P values obtained in 10.1 and the following equation:

% Predicted Dilation = 0.0825 + 0.00633(P 3/4 in.) + 0.0964(P 3/8 in.) – 3.12(P 1/4 in.) + 4.3(P No.4)

10.3 For recycled concrete aggregate, calculate the percent change in weight retained for each sieve size as follows:

$$P\,3/4\text{ in.} = \left(\frac{W50-W0}{W0}\right) x\,100$$
$$P\,5/8\text{ in.} = \left(\frac{W50-W0}{W0}\right) x\,100$$
$$P\,1/2\text{ in.} = \left(\frac{W50-W0}{W0}\right) x\,100$$
$$P\,3/8\text{ in.} = \left(\frac{W50-W0}{W0}\right) x\,100$$

where:

P 3/4 in. = percent change in weight for the 3/4 in. sieve
P 5/8 in. = percent change in weight for the 5/8 in. sieve
P 1/2 in. = percent change in weight for the 1/2 in. sieve
P 3/8 in. = percent change in weight for the 3/8 in. sieve
W50 = weight retained at 50 cycles on a particular sieve
W0 = weight retained at 0 cycles on a particular sieve
WT = total initial weight at 0 cycles

10.4 For recycled concrete aggregate sources, calculate the dilation values using the P values obtained in 10.1 and the following equation:

% Predicted Dilation = -1.447 + 0.0465(P 3/4 in.) + 0.121(P 5/8 in.) + 0.329(P 1/2 in.) + 0.924 (P 3/8 in.)

11.0 REPORT.

11.1 Test Report Data will include the following items:

11.1.1 Carbonate aggregate or recycled concrete aggregate source identification

11.1.2 Type of material

11.1.3 Gradation of production material

11.1.4 Ledges of aggregate, if applicable

11.1.5 Date sampled

11.1.6 Individual(s) obtaining sample

11.1.7 Date of test completion

11.2 The Worksheet of the test data

11.3 The calculated predicted dilation value

12.0 ACCEPTANCE OR REJECTION CRITERIA

12.1 Aggregates with predicted dilation values of .050 percent expansion or less will be acceptable. Aggregates with predicted dilation values greater than .050 and equal to or less than .060 will require testing in accordance with ITM 210 for acceptance. Aggregates with predicted dilation values greater than .060 will not be acceptable.

12.2 Recycled concrete aggregate with predicted dilation values equal to or less than .060 will be acceptable.

HYDRAULIC FRACTURE TEST WORKSHEET

Source: ____________________________________ Date Received: _______________________

Date Test Started: __________________________ Date Test Completed: __________________

Chamber Pressure: _________________________ Actuator Pressure: _____________________

Sieve Size	Initial Weight	10 Cycles	20 Cycles	30 Cycles	40 Cycles	50 Cycles
3/4 in.						
5/8 in.						
1/2 in.						
3/8 in.						
5/16 in.						
1/4 in.						
No.4						
Pan						
Weight Check						

Remarks: ____

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Tested by: ____________________________________ Date: _________________________