

Standard Test Method for Determining the Hydraulic Fracture of Coarse Aggregate

AASHTO Designation: TP12-96^{1,2}

1. Scope

1.1 This test method covers the resistance of aggregates to fracture under the effect of internal pressure expelling water from aggregate pores. The procedure is intended to assist in the identification of aggregates that cause deterioration in concrete when exposed to repeated cycles of freezing and thawing (D-cracking).

1.2 *This procedure may involve hazardous materials, operations, and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this procedure to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 AASHTO Standards

- M92 Wire Cloth Sieves for Testing Purposes
- M231 Weights and Balances Used in The Testing of Highway Materials
- R9 Acceptance Sampling Plans for Highway Construction.
- T2 Sampling Aggregates
- T161 Resistance of Concrete to Rapid Freezing and Thawing
- T248 Reducing Field Samples of Aggregate to Testing Size

2.2 ASTM Standards

- C670 Preparing Precision and Bias Statements for Test Methods for Construction Materials.
- C802 Conducting an Interlaboratory Test Program to Determine the Precision of Test Methods for Construction Materials.
- D3152 Standard Test Method for Capillary Moisture Relationships for Fine-Textured Soils by Pressure-Membrane Apparatus

D3665 Practice for Random Sampling of Construction Materials

E105 Probability Sampling of Materials.

E122 Choice of Sample Size to Estimate the Average Quality of a Lot or Process.

E141 Acceptance of Evidence Based on the Results of Probability Sampling.

3. **Summary of Test Method** - A coarse aggregate sample is separated into appropriate sieve fractions, washed and dried, conditioned in a silane solution, dried to a constant mass, processed in a tumbler and sieved again to achieve base condition of the test specimen. The aggregate specimen is then processed through ten cycles of 7950 kPa (1150 psi) pressurization in water, dried, processed through the tumbler again, and sieved to determine the number and mass of particles passing and retained on the appropriate sieves. This process is repeated until 50 pressurization cycles have been performed. A hydraulic fracture index (HFI) is calculated from the results of the test.

4. Significance and Use

4.1 The procedure described in this method is an aid in the identification of D-cracking susceptible aggregates. Aggregates that exhibit a high percentage of fracturing under repeated pressurization cycles are more likely to cause D-cracking in field applications.

4.2 The relatively short time (approximately eight working days) required for completion of this procedure makes it appropriate for use as a screening test to identify questionable aggregates requiring additional (more time consuming) testing (such as T161) prior to approval.

4.3 This method is sensitive to the size of the aggregate pieces, and will assist in identifying maximum aggregate size reductions necessary to avoid D-cracking.

¹ This standard is based on SHRP Product 2002.

² Approved in October 1993, this provisional standard was first published in January 1994.

4.4 This method is also sensitive to the number of non-durable particles in a sample, and will aid in determining the percentage of durable aggregate that must be blended with non-durable aggregate in order to produce a blend with low enough D-cracking potential to provide acceptable performance.

5. Apparatus

5.1 Tumbling Apparatus - A tumbling apparatus (tumbler) consisting of a rubber drum for holding the sample and a motorized drive unit.

Note 1 -- A suitable tumbler is available commercially as a rock tumbler for polishing rocks. Various sizes are available.

5.1.1 The inside dimensions of the rubber drum shall be approximately 170 mm (6 3/4 in) diameter by 200 mm (8 in) deep. The inside surface shall be faceted to assist in the tumbling of the aggregate pieces. The drum shall have a removable cover, to facilitate placing the sample in the drum, designed not to interfere with the rotation of the drum when in the motorized drive unit.

5.1.2 The motorized drive unit shall rotate the drum on its side at a rate of 30 ± 5 revolutions per minute.

5.2 Pressurization Apparatus - A pressurization apparatus consisting of a pressure chamber capable of safely operating at pressures of 10,350 kPa (1500 psi), a compressed nitrogen source and adjustable pressure regulator with gauge having an output capacity of up to 10,350 kPa (1500 psi), appropriate valves and fittings to permit filling with water and draining along with pressurization/rapid pressure release.

5.2.1 The nominal inside dimensions of the pressure chamber shall be 254 mm (10 in) diameter by 50 mm (2 in) high. The chamber shall contain three parts: (1) a cylinder with three through holes tapped for 10 mm (3/8 in) NPT threaded connections from the outside, each located approximately 25 mm (1 in) from the end, and spaced circumferentially around the cylinder at 0°, 22.5°, and 180°, (2) a top plate with handle for lifting, and (3) a bottom plate. All pieces shall be at least 25 mm. (1 in) thick. These dimensions are shown in Figure 3. The inside of the top and bottom plates shall be suitably treated (See Note 2) to prevent physical fracture of aggregate by the expansion and contraction of the chamber from pressurization/pressure cycles.

Note 2 -- A neoprene rubber sheet with a thickness of 0.8 mm (1/32 in.) glued to the inside of the top and bottom plates have proven sufficient. No treatment is necessary for the wall of the cylinder.

5.2.2 Each end of the cylinder shall be fabricated with O-ring grooves. The top and bottom plates shall be drilled to accept high-strength bolts, used for securing the end plates to the cylinder. The diameter of the bolts shall be sufficient to provide a safety factor > 5 to 1 during pressurization.

Note 3 -- In-house fabrication of pressure chambers is not recommended due to the difficulty encountered in obtaining pressure-tight seals at the high pressures involved, as well as the hazards associated with high-pressure containers. If a pressure chamber fabricated in-house is used, it should be pressure-certified to provide a safety factor > 5 to 1.

5.2.3 The cylindrical part of the pressure chamber shall be fitted with necessary valves and fittings to permit application of pressure through a pressure valve, release of pressure through a pressure release valve, filling with water through a fill valve, and draining of water through a drain valve. Additional valves and fittings may be provided where appropriate by the equipment manufacturer in order to achieve the necessary pressure-release rate.

5.2.3.1 The apparatus shall be capable of producing a drop in pressure of at least 2050 kPa (300 psi) during the interval of 0.01 seconds when the release valve is opened. This drop in pressure is termed the pressure release rate for a time duration of 0.01 seconds. The procedure for measuring the pressure release rate is described in Appendix A.

5.2.4 A pressure regulator and gauge with a capacity of 10,350 kPa (1500 psi), and a precision of 0.25 percent of full scale attached directly to a compressed nitrogen cylinder.

5.2.5 A stand that will permit rotation of the assembled pressure chamber from the vertical to the horizontal position and permit pivoting the chamber 45° either side of vertical.

5.3 Drying Oven - A drying oven with positive free circulation of air through the oven and with the capability of maintaining a temperature of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$).

5.4 Balance - A balance conforming to the requirements of M231 for the class of general purpose balance required for the principal sample mass of the sample being tested.

6. Materials and Reagents

6.1 A solution of alkylalkoxysilane in water (referred to as silane solution).

Note 4 -- An appropriate silane solution is available commercially as Enviroseal 40 from Hydrozo, Inc.

Note 5 -- Some aggregates absorb water at a very rapid rate which prevents them from fracturing in the following test procedure. The silane treatment described in Section 10.1 reduces the absorption rate by effectively making the aggregates more hydrophobic. This treatment has been demonstrated to have no effect on the hydraulic fracture performance of aggregates with slower absorption rates.

6.2 A supply of compressed nitrogen in a commercial cylinder(s).

7. Hazards

7.1 Observe standard laboratory safety precautions and OSHA requirements when operating a pressure vessel. Use ear protectors and safety glasses at all times while operating the pressure vessel.

7.2 Use a fume hood and observe appropriate safety precautions when handling the silane solution.

8. Standardization

8.1 Calibrate the pressure gauge at least every 6 months.

Note 6 -- The pressure gauge is usually calibrated by the manufacturer or a commercial calibration service. Verification of the continued stability of the pressure gauge within the specified requirements should be done periodically by

checking against another certified pressure measurement device.

9. Sampling

9.1 Determine the number of samples required from the aggregate lot(s) or process. Use a stratified random, or random, plan which provides the number of samples needed to characterize the properties of the material under investigation (a systematic plan is used only if specific circumstances require). Additional guidance concerning sampling considerations is contained in R 9, E 105, E 122, and E 141. Collect sufficient material in each initial sample to provide the necessary number of particles in each desired size range (Section 9.4). Preliminary work has indicated that 600 to 800 particles tested by combining three to four test portions in a given size range provides a coefficient of variation of less than 10 percent in the final results.

9.2 Obtain the sample(s) in accordance with ASTM D3665, T248 and T2.

9.3 Determine the number of tests required on the aggregate sample(s). Use a random or systematic plan which provides the number of tests needed to provide the data necessary for reporting the properties of interest concerning the aggregate under investigation.

9.4 When separating samples into individual size ranges (Section 10.1.1), appropriate size ranges shall include particles passing the 32 mm (1 1/4 in) retained on the 19.0 mm (3/4 in) sieves, or passing the 19.0 mm (3/4 in) retained on the 12.5 mm (1/2 in) sieves.

10. Procedure

10.1 Sample and Test Specimen Preparation

10.1.1 Separate the sample into appropriate size ranges by sieving to refusal using wire screens meeting the requirements of M92. Obtain test specimens of each size range with sufficient mass to fill the pressure chamber.

Note 7 -- Approximately 3.0-3.5 kg are needed for a test specimen in the passing 32 mm (1 1/4 in) and retained on the 19.0 mm (3/4 in) sieve size range. This is approximately 200 particles. The actual amount depends upon the size and shape of the individual particles.