
Standard Method of Test for

**Determining Asphalt Binder Bond
Strength by Means of the Binder
Bond Strength (BBS) Test**

| **AASHTO Designation: TP 91-15¹**



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AASHTO

1. SCOPE

- 1.1. This test method quantifies the tensile force needed to remove a pull-off stub adhered to a solid substrate with asphalt binder. Samples are prepared at controlled environmental and moisture conditions (i.e., temperature and humidity). After conditioning, a pneumatic load is applied to a pull-off stub using an ASTM D4541 Type IV adhesion tester until failure. The pull-off tensile strength and mode of failure are used to describe the bonding properties of the asphalt binder and compatibility between aggregates and asphalt binders.
- 1.2. The values stated in SI units are to be regarded as the standard.
- 1.3. *This test may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
- M 140, Emulsified Asphalt
 - M 208, Cationic Emulsified Asphalt
 - M 316, Polymer-Modified Cationic Emulsified Asphalt
 - R 66, Sampling Asphalt Materials
 - T 315, Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)
- 2.2. *ASTM Standards:*
- D4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
 - D4753, Standard Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing
 - E77, Standard Test Method for Inspection and Verification of Thermometers
 - E145, Standard Specification for Gravity-Convection and Forced-Ventilation Ovens

3. TERMINOLOGY

3.1. Definitions:

- 3.1.1. *failure mode*—indicator of the weakest component of the asphalt/surface system. In applications to this test procedure failure can occur at three locations: within the asphalt binder, at the asphalt binder/substrate interface, or in a mixed mode.
- 3.1.2. *pull-off tensile strength*—the pressure required to remove a pull-off stub attached to a prefabricated surface by asphalt binder, with force applied in the normal direction. Used in this procedure as a parameter to evaluate the quality of the bond.
- 3.1.3. *saturated surface-dry (SSD) condition*—in this condition, the void structure of the aggregate is filled with moisture, while the main surface area of the aggregate particles remains dry.

4. SUMMARY OF METHOD

- 4.1. The adhesion tester applies a pneumatic load via a pressure ring to a pull-off stub fixed to a rigid substrate with asphalt binder, as shown in Figure 1. The binder is adhered to the substrate and subjected to different curing conditions. For curing emulsified binders, fixed levels of temperature and humidity are used. Moisture conditioning is used for both hot-applied binders and emulsion residues to evaluate the effects of moisture damage. Pressure and time are monitored during the test and the load is applied until failure. The output of the test is pressure at failure. The surface is also inspected visually to determine the nature of failure.

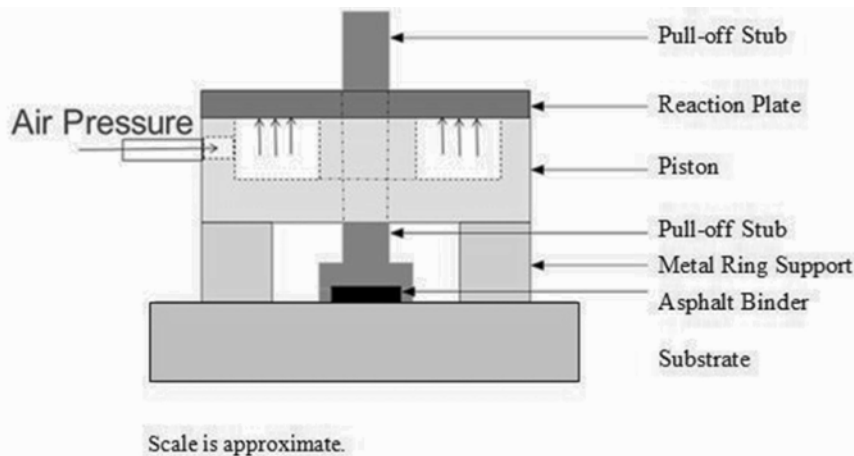


Figure 1—Schematic Representation of the Testing Assembly for the Binder Bond Strength Test

5. SIGNIFICANCE AND USE

- 5.1. Pull-off tensile strength values measured over a range of environmental conditions and curing times provide information related to the bond strength at the interface between a substrate and hot-applied or emulsified asphalt binders.
- 5.2. Evaluation of pull-off tensile strength on different aggregate substrates provides a measure of asphalt-aggregate compatibility.
- 5.2.1. Applications to emulsified binders include assessment of curing rate and ultimate tensile strength.

- 5.2.2. Applications to hot-applied asphalt binders and recovered emulsion residues include evaluation of the effects of application temperature and moisture conditioning on pull-off tensile strength.

6. APPARATUS

6.1. Molds:

- 6.1.1. *Emulsified Binders*—For emulsified asphalt binders, use a silicone mold measuring approximately 20 mm (0.79 in.) in diameter, 5 mm (0.20 in.) in width, and 5 mm (0.20 in.) in thickness. The mold has no backing and is used to contain the emulsion on the aggregate surface. A diagram of the mold is shown in Figure 2a.

- 6.1.2. *Hot-Applied Asphalt Binders and Emulsion Residues*— Use a silicone mold measuring approximately 40 mm by 40 mm (1.6 in. by 1.6 in.) with an 8-mm (0.32-in.) diameter cavity and a 2.0-mm (0.08-in.) depth. This mold is similar to the molds used to prepare Dynamic Shear Rheometer (DSR) test samples in T 315. A diagram of the mold is shown in Figure 2b.

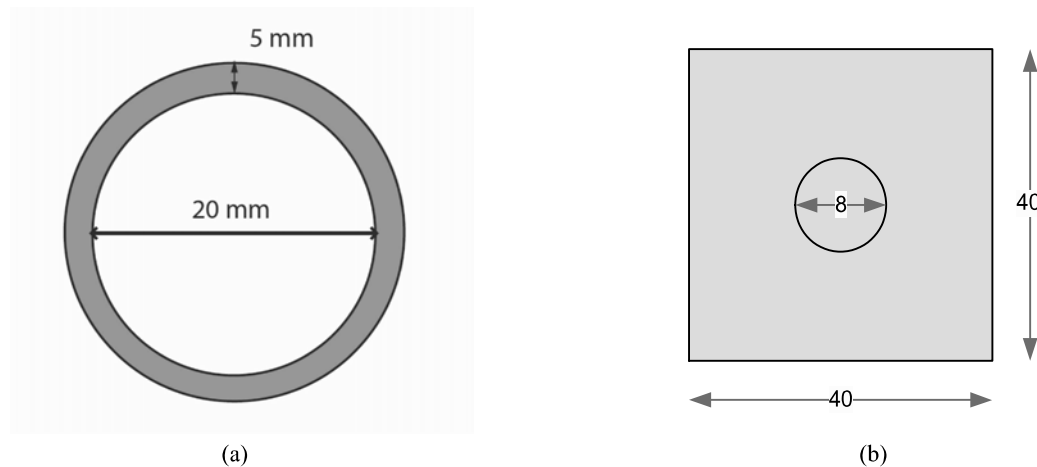


Figure 2—Mold Dimensions (mm) for Emulsified Binders (a) and Hot Binders (b)—*Drawings Not to Scale*

- 6.2. *Substrate*—Composed of solid aggregate or aggregate composite with dimensions as defined in Section 9.
- 6.3. *Testing Machine*—Use a Type IV adhesion tester as defined by ASTM D4541 for all tests. At a minimum the device must consist of the components detailed in Sections 6.3.1 through 6.3.3. An example of a testing machine is shown in Figure 3.
- Note 1**— The testing apparatus shown in Figure 3 is a commercially available device produced by GARDCO, Inc. The F-4 piston depicted in the figure has a diameter of 73.0 mm (2.88 in.). Other devices meeting the requirements of this procedure can be used.
- 6.3.1. *Control Module*—Capable of controlling the air pressure load range from 7 to 35,000 kPa (1 to 5000 psi), and equipped with a digital or analog display, loading rate control, and data acquisition software capable of monitoring air pressure over time.
- 6.3.2. *Load Assembly*—Consists of a piston, reaction plate, gasket and air hose.

- 6.3.2.1. *Piston and Reaction Plate*—Select a piston and reaction plate assembly with sufficient diameter to allow for loading of the sample until failure. Air pressure at failure is a function of test temperature, loading rate, and asphalt binder stiffness. Application of the device to asphalt binders and mastics indicates that a minimum piston/reaction plate diameter of 57.2 mm (2.25 in.) is required.
- 6.3.2.2. *Gasket*—Composed of polymer or other material with properties and dimensions capable of providing an air-tight seal between the piston and reaction plate. The gasket must be inspected regularly to ensure the air-tight seal is maintained and replaced when the gasket is no longer functioning.
- 6.3.2.3. *Air Hose*—Rated for a maximum kPa (psi) value that exceeds the air supply specified in Section 6.3.3.

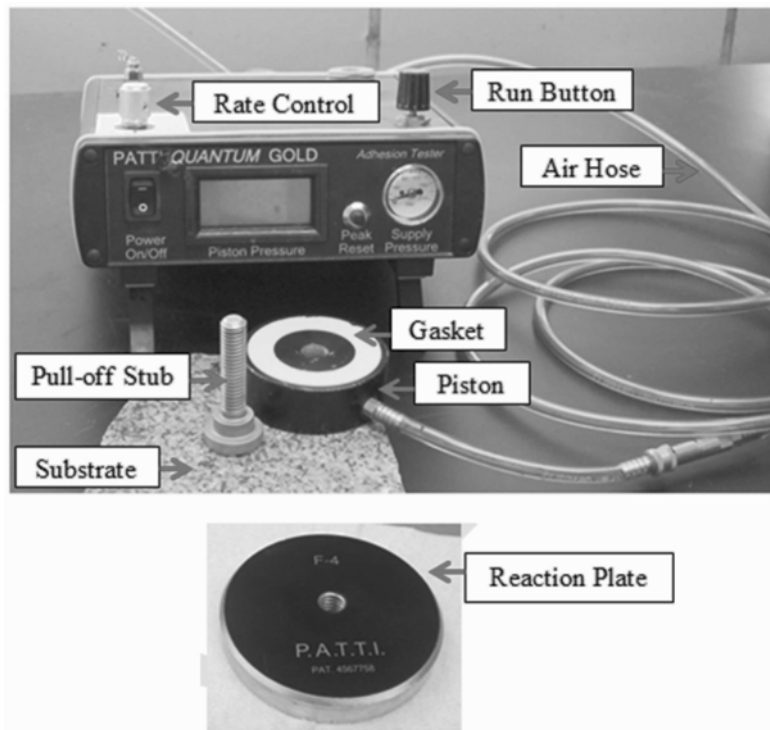


Figure 3—General Representation of Binder Bond Strength Test Apparatus

- 6.3.3. *Air Supply*—Capable of producing a consistent air pressure of at least 0.7 MPa (100 psi) as read on the supply gauge. Self-contained air cylinders, shop (bottled) air, or air from an automatic pump can be used.
- 6.4. *Pull-off Stubs*—Stainless steel or any other suitable material, with dimensions as shown in Figure 4. Stub edges are beveled to reduce the amount of binder trapped between the stub edge and substrate and to ensure a uniform film thickness. Inspect the pull-off stub edges frequently to verify that the edge is consistent along the diameter of the stub with no visible chips or dents. Discard damaged stubs. The stub surface is roughened to increase the surface area in contact with the asphalt binder.
- Note 2**—The dimensions presented in Figure 4 are specific to the device used in the development of this test procedure. If another device is used adjust the dimensions to match the pull-off stub with the load assembly of the device. Pull-off stub diameter (20 mm (0.8 in.) in Figure 4) is an