

Method of Test for  
**DIAGONAL SHEAR BOND STRENGTH OF EPOXY RESIN SYSTEMS**  
DOTD Designation: TR 707-85  
**METHOD A**

DOTD TR 707-85  
Adopted 10/85  
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Method A

(Diagonal Shear Bond Strength - Dry Cured Method)

**Scope**

1. This method of test is intended to determine the dry-cured diagonal shear bond strength of hardened cement mortar bonded with epoxy to hardened cement mortar.

**Apparatus**

2. (a) *Balance* - A Type I or II, Class D balance conforming to AASHTO M 231.

(b) *Beaker* - a 250 ml (minimum) graduated disposable plastic beaker.

(c) *Mixing Tools* - Stainless steel spatulas or wooden tongue depressors.

(d) *Cement Mortar Mixing Apparatus* - Apparatus for mixing portland cement mortar conforming to AASHTO T 106.

(e) *Thermometer* - A thermometer conforming generally to the requirements for ASTM 1C or 1F thermometers.

(f) *Timer* - A clock or watch capable of measuring minutes and seconds.

(g) *Molds* - Specimen molds constructed in the form of right cylinders,  $3 \pm 1/16$  in. inside diameter and  $6 \pm 1/16$  in. high. The mold shall be made of metal not capable of being attacked by portland cement mortar.

(h) *Dummy Sections* - Metal or epoxy dummy section equal to half the volume of the cylinder mold, with an elliptical surface at a 30 degree angle from the longitudinal axis of the mold.

(i) *Testing Machine* - A compression machine conforming to the requirements of AASHTO T 106.

(j) *Roughening or Texturing Equipment* - A wire brush or sandblasting equipment capable of producing a lightly rough finish on hardened portland cement mortar specimen halves.

(k) *Tamping Rod* - A round rod of brass or plastic 3/8 in. in diameter and approximately 12 in. long, having both ends rounded to hemispherical tips.

(l) *Moist Cabinet* - A moist cabinet conforming to AASHTO M 201.

**Safety Precautions**

3. The following precautions should be observed when handling epoxy components and cleaning fluids:

(a) Persons handling these materials should use appropriate protective clothing, including rubber or

plastic gloves, and appropriate eye protection such as safety glasses.

(b) If any epoxy or cleaning material should contact the skin, the material should be removed immediately with a dry cloth or paper towel, and the affected area should be washed thoroughly with soap and water.

(c) If any material should come in contact with the eyes, flush immediately with water and contact a physician.

(d) Adequate ventilation is necessary to prevent excessive inhalation of vapors.

(e) Observe all precautions as specified by the manufacturer before handling each material.

**Sample Preparation**

4. (a) Coat three specimen molds and dummy sections with a light coat of oil. Position the dummy sections in each mold with slant side up.

(b) Mix a sufficient amount of cement mortar to fill the molds in accordance with AASHTO T 106 with the exception of using concrete sand conforming to the following gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>
No. 8	100
No. 16	45 - 90
No. 50	7 - 30
No. 100	0 - 7
No. 200	0 - 3

(c) Place the cement mortar in each mold in three layers of approximately equal volume. Rod each layer with 25 strokes of the tamping rod. Distribute the strokes uniformly over the section. Rod the bottom layer as deeply as possible and rod subsequent layers deeply enough to penetrate into the underlying layer.

(d) Strike off the surface of the top layer of each mold with the trowel and cover each specimen and mold with a glass or metal plate.

(e) Allow the half-cylinders to cure in the molds undisturbed for 24 hours. Remove the half-cylinders from the molds and cure in accordance with AASHTO T 106 for at least 28 days. Air dry the cylinder halves for at least 7 additional days.

(f) Lightly sandblast or wire brush the elliptical surface of each half-cylinder and dry-brush to remove the loose surface material.

(g) When testing adhesives having low viscosities, place two halves together leaving approximately 1/16 in. between both halves and seal the sides of the area to be bonded with a thin coat of grade C epoxy and/or masking tape. Leave approximately a 1/2 in. opening at the top to allow the adhesive to be poured in accordance with paragraph 4 (m).

(h) Prior to mixing, condition the individual epoxy components and any equipment with which they will come into contact to the test temperature of  $77 \pm 2$  °F by use of the water bath and/or laboratory temperature control.

(i) Thoroughly stir the individual components, for at least one minute, immediately before testing.

(j) Combine and mix sufficient quantities of components A and B, in accordance with the manufacturer's recommendations, such that a minimum sample quantity of 200 ml is obtained. If the manufacturer does not recommend a mixing time, mix the sample for at least 3 minutes. Use separate mixing tools when obtaining and mixing the desired quantities of each component to avoid contamination.

(k) When testing adhesive having medium to high viscosities, apply the mixed adhesive to each diagonal face of the cylinder half. Press the diagonal surfaces of each cylinder together by direct pressure and remove the excess adhesive.

(l) Place several horizontal and vertical wraps of masking tape around each bonded cylinder. Place additional masking tape along each joint. Keep the bonded joints horizontal for 24 hours at  $77 \pm 2$  °F, then remove all masking tape. Allow to cure an additional 24 hours at this temperature.

(m) When testing adhesives having low viscosities, carefully pour the mixed adhesive into the pre-sealed mortar halves. Tap lightly to remove entrapped air. After the cylinder is filled, allow the cylinder to cure in a vertical position for 24 hours at  $77 \pm 2$  °F. Allow the specimen to cure an additional 24 hours at this temperature.

(n) Prepare three specimens in accordance with paragraphs (k) through (m).

(o) Cap the three specimens immediately after removal from curing, in accordance with AASHTO T 231.

#### Procedure

5. (a) Center each specimen on the lower head of the testing machine and test the specimens by applying a compressive load at the rate of 5000 lbf/min.

(b) Record the maximum load indicated by the testing machine as (L).

#### Calculations

6. Calculate the diagonal shear strength of each specimen according to the following formula:

$$DS = \frac{L}{7.1}$$

where:

DS = diagonal shear strength, psi  
L = maximum total load, lbf.

#### Report

7. (a) Report the average diagonal shear strength to the nearest 10 psi.

(b) Note the mode of failure as being either:

- (1) in the mortar
- (2) in the adhesive
- (3) in the mortar/adhesive interface

*NOTE: Should any of the bonded test specimens fail in the mortar at a strength less than that required, a retest shall be conducted for that specimen.*

Normal testing time is seven days.

Method of Test for  
**DIAGONAL SHEAR BOND STRENGTH OF EPOXY RESIN SYSTEMS**

DOTD Designation: TR 707-85

**METHOD B**

(Diagonal Shear Bond Strength - Moist-Cured Strength)

DOTD TR 707-85

Adopted 10/85

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Method B

**Scope**

1. This method of test is intended to indicate the moisture sensitivity characteristics of an epoxy by measuring the moist-cured diagonal bond strength of hardened cement mortar bonded with epoxy to plastic cement mortar.

**Apparatus**

2. (a) *Balance* - A Type I or II, Class D balance conforming to AASHTO M 231.

(b) *Beaker* - A 250 ml (minimum) graduated disposable plastic beaker.

(c) *Mixing Tools* - Stainless steel spatulas or wooden tongue depressors.

(d) *Cement Mortar Mixing Apparatus* - Apparatus for mixing portland cement mortar conforming to AASHTO T 106.

(e) *Thermometer* - A thermometer conforming generally to the requirements for ASTM 1C or 1F thermometers.

(f) *Timer* - A clock or watch capable of measuring minutes and seconds.

(g) *Molds* - Specimen molds constructed in the form of right cylinders,  $3 \pm 1/16$  in. inside diameter and  $6 \pm 1/16$  in. high. The mold shall be made of metal not capable of being attacked by portland cement mortar.

(h) *Dummy Sections* - Metal or epoxy dummy section equal to half the volume of the cylinder mold, with an elliptical surface at a 30 degree angle from the longitudinal axis of the mold.

(i) *Testing Machine* - A compression machine conforming to the requirements of AASHTO T 106.

(j) *Roughening or Texturing Equipment* - A wire brush or sandblasting equipment capable of producing a lightly rough finish on hardened portland cement mortar specimen halves.

(k) *Tamping Rod* - A round rod of brass or plastic  $3/8$  in. in diameter and approximately 12 in. long, having both ends rounded to hemispherical tips.

(l) *Moist Cabinet* - A moist cabinet conforming to AASHTO M 201.

**Safety Precautions**

3. The following precautions should be observed when handling epoxy components and cleaning fluids:

(a) Persons handling these materials should use appropriate protective clothing, including rubber or plastic gloves, and appropriate eye protection such as safety glasses.

(b) If any epoxy or cleaning material should contact the skin, the material should be removed immediately with a dry cloth or paper towel, and the affected area should be washed thoroughly with soap and water.

(c) If any material should come in contact with the eyes, flush immediately with water and contact a physician.

(d) Adequate ventilation is necessary to prevent excessive inhalation of vapors.

(e) Observe all precautions as specified by the manufacturer before handling each material.

**Sample Preparation**

4. (a) Prepare cylinder half sections in accordance with Method A, paragraphs 4(a) through (f).

(b) Place three of the hardened cylinder halves inside the specimen molds so that the remaining halves can be filled with fresh mortar.

(c) Prior to mixing, condition the individual epoxy components and any equipment in accordance with Method A paragraph 4(h).

(d) Thoroughly stir the individual components, for at least one minute, immediately before testing.

(e) Combine and mix sufficient quantities of components A and B, in accordance with the manufacturer's recommendations, such that a minimum sample quantity of 200 ml is obtained. If the manufacturer does not recommend a mixing time, mix the sample for at least 3 minutes. Use separate mixing tools when obtaining and mixing the desired quantities of each component to avoid contamination.

(f) Apply the mixed adhesive to the surface faces of each hardened half section and allow the adhesive to set until a tacky state is attained.

*NOTE: In no case shall this setting period exceed the specified gel time as determined by DOTD Designation: TR 703.*

(g) Support the mold so that the bonding surface of the mortar section is horizontal. Place a layer of freshly mixed portland cement mortar over the primed

surface to a depth of approximately 1/2 in. Rod the layer for 10 strokes with the tamping rod gently, so as not to disturb the layer of adhesive.

(h) Place the mold in its normal vertical position, and place additional mortar into the mold in two layers of approximately equal volume. Rod each layer with 25 strokes of the tamping rod. Distribute the strokes over the cross section, and make them deep enough to penetrate into the underlying layer. Strike off the surface of the top layer with the trowel, and cover the mold with a glass or metal plate.

(i) Repeat steps (f) and (g) to make two additional test specimens.

(j) Allow the specimens to cure for 24 hours in the moist cabinet at a minimum relative humidity of 95% and at a temperature of  $73.4 \pm 3$  °F. Remove from the molds and place the bonded specimens in the moist cabinet for an additional 13 days of moist curing.

(k) Cap the three specimens immediately after removal from curing, in accordance with AASHTO T 231.

#### Procedure

5. (a) Center each specimen on the lower head of the testing machine and test the specimens by applying a compressive load at the rate of 5000 lbf/min.

(b) Record the maximum load indicated by the testing machine as (L).

#### Calculations

6. Calculate the diagonal shear strength of each specimen according to the following formula:

$$DS = \frac{L}{7.1}$$

where:

DS - diagonal shear strength, psi  
L - maximum total load, lbf

#### Report

7. (a) Report the average diagonal shear strength to the nearest 10 psi.

(b) Note the mode of failure as being either:

- (1) in the mortar
- (2) in the adhesive
- (3) in the mortar/adhesive interface

*NOTE: Should any of the bonded test specimens fail in the mortar at a strength less than that required, a retest shall be conducted for that specimen.*

Normal testing time is 14 days.

Method of Test for  
**DIAGONAL SHEAR BOND STRENGTH OF EPOXY RESIN SYSTEMS**

DOTD Designation: TR 707-85

**METHOD C**

(Diagonal Shear Bond Strength for Type V Epoxy Resin Systems)

DOTD TR 707-85

Adopted 10/85

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Method C

**Scope**

1. This method of test is intended to determine the diagonal shear bond strength of epoxy resin systems for use in bonding raised pavement markers.

**Apparatus**

2. (a) *Molds* - Suitable molds with removable partitions located in the center such that diagonal cement mortar specimens can be cast with 2 in. square base and having diagonal faces 2 by 4 in.

(b) *Balance* - A Type I or II, Class D balance conforming to AASHTO M 231.

(c) *Beaker* - A 100 ml (minimum) graduated disposable plastic beaker.

(d) *Mixing Tools* - Stainless steel spatulas or wooden tongue depressors.

(e) *Cement Mortar Mixing Apparatus* - Apparatus for mixing portland cement mortar conforming to AASHTO T 106.

(f) *Thermometer* - A thermometer conforming generally to the requirements for ASTM 1C or 1F thermometers.

(g) *Timer* - A clock or watch capable of measuring minutes and seconds.

(h) *Testing Machine* - A compression machine conforming to the requirements of AASHTO T 106.

(i) *Roughening or Texturing Equipment* - A wire brush or sandblasting equipment capable of producing a lightly rough finish on hardened portland cement mortar specimen halves.

(j) *Tamping Rod* - A round rod of brass or plastic 3/8 in. in diameter and approximately 12 in. long, having both ends rounded to hemispherical tips.

(k) *Moist Cabinet* - A moist cabinet conforming to AASHTO M 201.

**Safety Precautions**

3. The following precautions should be observed when handling epoxy components and cleaning fluids:

(a) Persons handling these materials should use appropriate protective clothing, including rubber or plastic gloves, and appropriate eye protection such as safety glasses.

(b) If any epoxy or cleaning material should contact the skin, the material should be removed immediately with a dry cloth or paper towel, and the af-

ected area should be washed thoroughly with soap and water.

(c) If any material should come in contact with the eyes, flush immediately with water and contact a physician.

(d) Adequate ventilation is necessary to prevent excessive inhalation of vapors.

(e) Observe all precautions as specified by the manufacturer before handling each material.

**Sample Preparation**

4. (a) Mix a sufficient amount of cement mortar, in accordance with AASHTO T 106, to fill six diagonal shear test molds.

(b) Place the center partition in each mold and fill the molds with cement mortar in three equal layers. Rod each layer with 25 strokes of the tamping rod. Distribute the strokes uniformly over the section and rod deeply enough to penetrate into the underlying layer. Rod the bottom layer as deeply as possible.

(c) Strike off the surface of the top layer of each mold with the trowel and cover each specimen and mold with a glass plate.

(d) Allow the blocks to cure for 24 hours in the moist cabinet at a minimum relative humidity of 95%, and at a temperature of  $73.4 \pm 3$  °F. Remove the specimens and allow them to cure an additional seven days in air.

(e) Lightly sandblast or wire brush the diagonal faces of the test blocks and remove loose surface material by dry brushing.

(f) Prior to mixing, condition the individual epoxy components and any equipment with which they will come into contact to the test temperature of  $77 \pm 2$  °F by use of the water bath and/or laboratory temperature control.

(g) Thoroughly stir the individual components, for at least one minute, immediately before testing.

(h) Combine and mix sufficient quantities of components A and B, in accordance with the manufacturer's recommendations, such that a minimum sample quantity of 100 ml is obtained. If the manufacturer does not recommend a mixing time, mix the sample for at least 3 minutes. Use separate tools when obtaining and mixing the desired quantities of each component to avoid contamination.

(i) Apply the mixed adhesive to each diagonal face of the test blocks. Press the diagonal surfaces of each block together by direct pressure and remove the excess

adhesive.

(j) The blocks shall be aligned so that the ends and sides are square and form a block  $2 \pm 0.05$  by approximately 5 in.

(k) Allow the blocks to cure in air at  $77 \pm 2$  °F for 24 hours. Randomly select three of the test blocks and immerse in water for seven days at  $77 \pm 2$  °F.

(l) Cap three specimens immediately after removal from curing in accordance with AASHTO T 231. Immersed specimens should be towel dried before capping.

#### Procedure

5. (a) Center each specimen on the lower head of the testing machine and test the specimens by applying a compressive load at the rate of 5000 lbf/min.

(b) Record the maximum load indicated by the testing machine as (L).

#### Calculations

6. Calculate the diagonal shear strength of each specimen according to the following formula:

$$DS = \frac{L}{4}$$

where:

DS = diagonal shear strength, psi

L = load, lbf

#### Report

7. (a) Report the average diagonal shear strength to the nearest 10 psi.

(b) Note the mode of failure as being either:

(1) in the mortar

(2) in the adhesive

(3) in the mortar/adhesive interface

*NOTE: Should any of the bonded test specimens fail in the mortar at a strength less than that required, a retest shall be conducted for that specimen.*

Normal testing time is nine days.