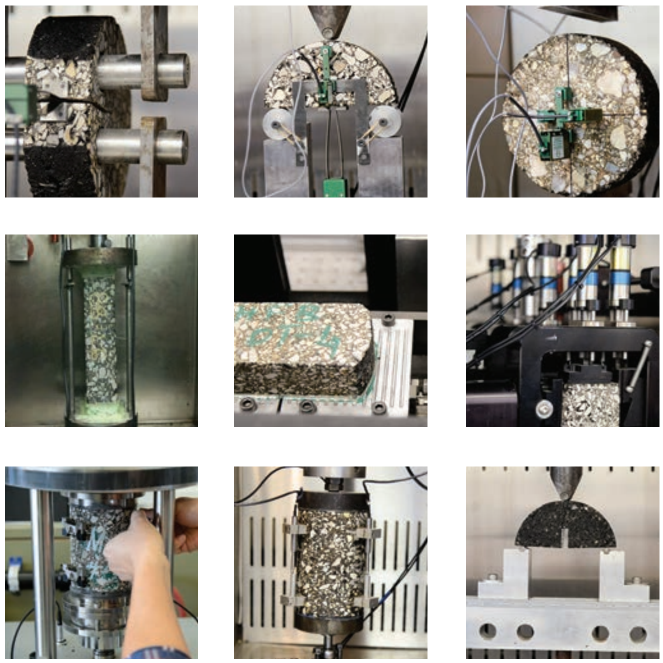
NCHRP 9-57

Experimental Design for Field Validation of Laboratory Tests to Assess Cracking Resistance of Asphalt Mixtures



CRACKING TESTS WORKSHOP

Sponsored by

National Cooperative Highway Research Program

Transportation Research Board of The National Academies

and

Texas A&M Transportation Institute

Newport Beach, CA • February 11–12, 2015

DCT

Cracking Type	Test Standard
Low temperature cracking and reflection cracking	ASTM D7313 (Monotonic test)
Specimen Geometry[1]	**Cracking Parameter**
D = 6 in. T = 2 in. 2 holes D = 1 in. ND = 2.46 in.	Fracture energy

Test Configuration

TEST COMPLEXITY

Training
Little time

Specimen Prep
4 cuts and 2 holes

Instrumentation
Gluing 2 studs; mounting 1 clip gauge

Testing
1–6 min.

Analysis
Easy with data analysis software

Interpretation
Quick and easy (pass/fail criteria)

CORRELATION TO FIELD PERFORMANCE

Good correlation with low-temperature cracking validated at MnRoad

TEST VARIABILITY

Low (COV=10–15%)

TEST SENSITIVITY TO MIX DESIGN PARAMETERS[2]

Asphalt binder, aggregate, RAP/RAS, and aging; insensitive to AV and P_b

EQUIPMENT COST AND AVAILABILITY

$ Commercially available; Cost: $49,000

ADOPTION BY STATES

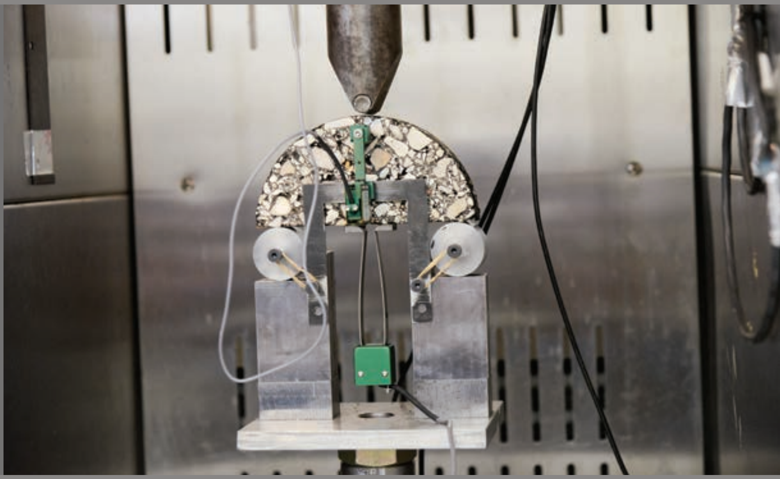
Adopted by Minnesota and Wisconsin; being considered by Colorado, South Dakota, and Montana

Notes
1. D = diameter; L = length; W = width; T = thickness; ND = notch depth
2. AV = air voids; Pb = percent binder

SCB AT LOW TEMPERATURE

Cracking Type	Test Standard
Low temperature cracking	AASHTO TP105 (Monotonic test)
Specimen Geometry[1]	**Cracking Parameter**
D = 6 in. T = 1 in. ND = 0.6 in.	Fracture energy

Test Configuration



TEST COMPLEXITY

Training
Medium time

Specimen Prep
4 cuts

Instrumentation
Gluing 3 studs; mounting 1 extensometer and 1 clip gauge

Testing
30 min.

Analysis
Easy with data analysis software

Interpretation
Quick and easy (pass/fail criteria)

CORRELATION TO FIELD PERFORMANCE

Good correlation with low-temperature cracking validated at MnRoad

TEST VARIABILITY

Medium (COV=20%)

TEST SENSITIVITY TO MIX DESIGN PARAMETERS[2]

Asphalt binder, aggregate, RAP/RAS, AV, and P_b

EQUIPMENT COST AND AVAILABILITY

$ Commercially available; Cost: $52,000

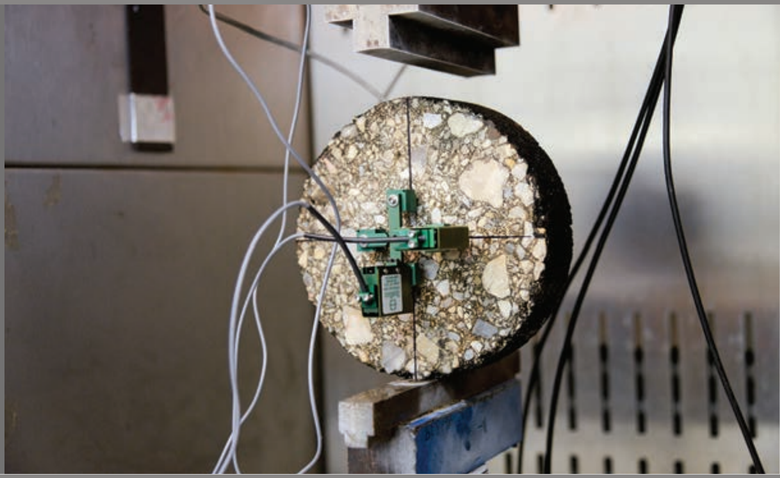
ADOPTION BY STATES

Being considered by Utah, South Dakota, Pennsylvania, and Montana

IDT FOR LOW TEMPERATURE CRACKING

Cracking Type	Test Standard
Low temperature cracking	AASTHO T322
Specimen Geometry[1]	**Cracking Parameter**
D = 6 in. T = 1.5–2.0 in.	Creep compliance and tensile strength

Test Configuration



TEST COMPLEXITY

Training
Medium time

Specimen Prep
2 cuts

Instrumentation
Gluing 8 studs with a template; mounting 4 sets of extensometers

Testing
4–6 hours

Analysis
Easy with data analysis software

Interpretation
Longer time with cracking model to predict performance

CORRELATION TO FIELD PERFORMANCE

Creep compliance and tensile strength inputs to TCMODEL; calibrated and validated through original SHRP and MEPDG

EQUIPMENT COST AND AVAILABILITY

Hydraulic test machines can be used and may cost more than $100,000

TEST VARIABILITY

Low (COV<11%)

ADOPTION BY STATES

AASHTO T322 is required by AASHTOWare

TEST SENSITIVITY TO MIX DESIGN PARAMETERS[2]

Asphalt binder, aggregate, RAP/RAS, aging

Notes

1. D = diameter; L = length; W = width; T = thickness; ND = notch depth
2. AV = air voids; Pb = percent binder

TSRST/UTSST

Cracking Type	Test Standard
Low temperature cracking	AASHTO TP10/University of Nevada at Reno (Monotonic test)
Specimen Geometry[1]	**Cracking Parameter**
L = 10 in. W = 2 in. T = 2 in. (D = 2.25 in. L = 5.25 in.)	Fracture temperature (coefficient of thermal contraction from UTSST)

Test Configuration

TEST COMPLEXITY

Training
Longer than medium time

Specimen Prep
4 cuts for long beam specimen; 2 cuts, 1 coring for cylinder specimen; gluing top and bottom platens

Instrumentation
Mounting 2 LVDTs

Specimen Testing
3–5 hours

Data Analysis
Easy with data analysis software

Data Interpretation
Short and easy (pass/fail criteria)

CORRELATION TO FIELD PERFORMANCE

Validated with test sections during SHRP program; MnRoad test results showed moderate correlation with field performance

EQUIPMENT COST AND AVAILABILITY

Commercially available; Cost: $98,000

TEST VARIABILITY

Low (COV= around 10%)

ADOPTION BY STATES

Being considered by Nevada

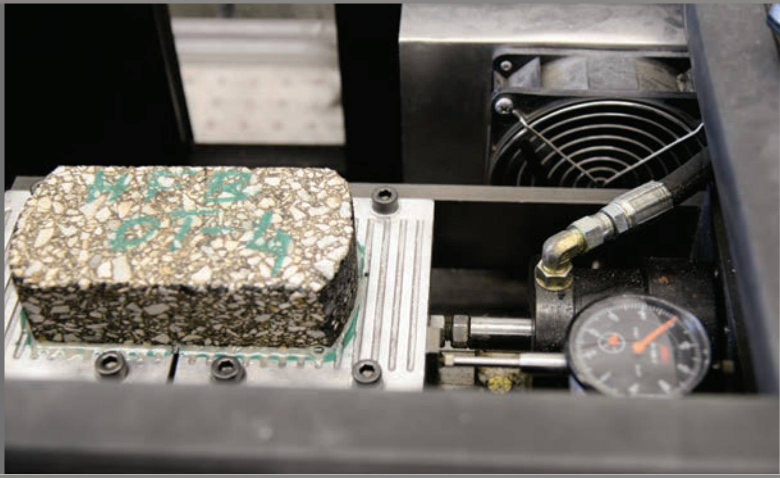
TEST SENSITIVITY TO MIX DESIGN PARAMETERS[2]

Asphalt binder, aggregate, AV, P_b, and aging

TEXAS OT

Cracking Type	Test Standard
Reflection cracking and bottom-up fatigue cracking	Tex-248-F (cyclic tests)
Specimen Geometry[1]	**Cracking Parameter**
L = 6 in. W = 3 in. T = 1.5 in.	No. of cycles (or fracture parameters: A and n)

Test Configuration



TEST COMPLEXITY

Training
Medium time

Specimen Prep
4 cuts; gluing to two bottom plates

Instrumentation
None

Testing
30 min.–3 hours

Analysis
Easy with data analysis software

Interpretation
Short and easy (pass/fail criteria)

CORRELATION TO FIELD PERFORMANCE

Good correlation with reflection cracking validated in Texas, California, and New Jersey; promising correlation with fatigue cracking validated with FHWA-ALF and NCAT test track

EQUIPMENT COST AND AVAILABILITY

$ Commercially available; Cost: $46,000

TEST VARIABILITY

Relatively high (COV=30–50%)

ADOPTION BY STATES

Adopted by Texas and New Jersey; being considered by Montana, Nevada, Florida, and Ohio

TEST SENSITIVITY TO MIX DESIGN PARAMETERS[2]

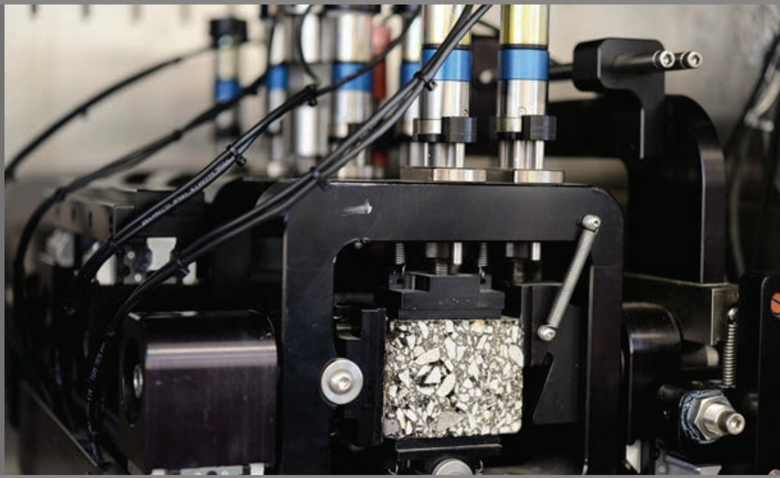
Binder, aggregate, P_b, RAP/RAS, aging, etc.

Notes
1. D = diameter; L = length; W = width; T = thickness; ND = notch depth
2. AV = air voids; Pb = percent binder

BENDING BEAM FATIGUE TEST

Cracking Type	Test Standard
Bottom-up fatigue cracking	AASHTO T321 (cyclic tests)
Specimen Geometry[1]	**Cracking Parameter**
L = 15 in. W = 2.5 in. T = 2 in.	No. of cycles (or fatigue equation)

Test Configuration



TEST COMPLEXITY

Training
Medium time

Specimen Prep
Large slab; 4 cuts

Instrumentation
Gluing 1 stud and mounting 1 LVDT

Specimen Testing
1 hour to days

Data Analysis
Easy with data analysis software

Data Interpretation
Short and easy (pass/fail criteria)

CORRELATION TO FIELD PERFORMANCE

Correlation with bottom-up fatigue cracking historically validated

EQUIPMENT COST AND AVAILABILITY

Frame (fixture) commercially available. Universal testing machine needed; could be > $100,000

TEST VARIABILITY

Very high (COV>50%)

ADOPTION BY STATES

California—special pavement design; being considered by Nevada and Georgia

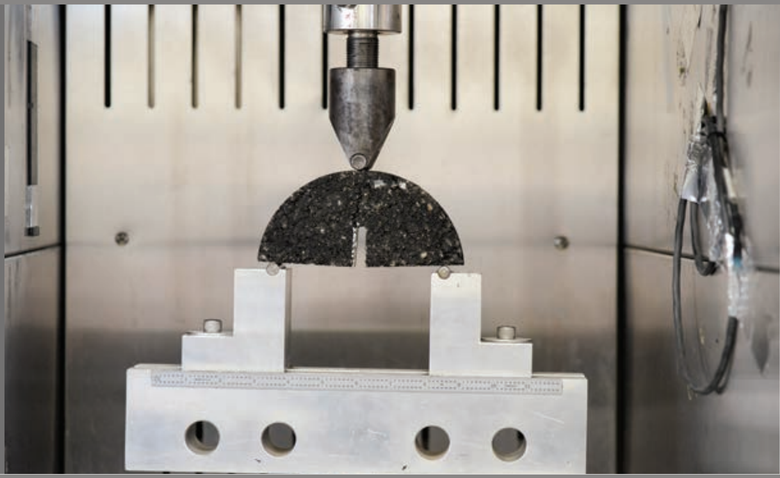
TEST SENSITIVITY TO MIX DESIGN PARAMETERS[2]

Asphalt binder, aggregate, RAP/RAS, aging, etc.

SCB AT INTERMEDIATE TEMPERATURE

Cracking Type	Test Standard
Top-down fatigue cracking and reflection cracking	LTRC (Monotonic test)
Specimen Geometry[1]	**Cracking Parameter**
D = 6 in. T = 2.25 in. ND = 1, 1.25, and 1.5 in.	Critical energy release rate

Test Configuration



TEST COMPLEXITY

Training
Very little time

Specimen Prep
5 cuts for 3 specimens

Instrumentation
None

Testing
30 min.

Analysis
Easy with data analysis software

Interpretation
Quick and easy (pass/fail criteria)

CORRELATION TO FIELD PERFORMANCE

Good correlation to field cracking reported by LTRC

EQUIPMENT COST AND AVAILABILITY

Any hydraulic or pneumatic test system can be used; cost could be low

TEST VARIABILITY

Medium (COV=20%)

ADOPTION BY STATES

Adopted by Louisiana and Wisconsin; being considered by Oklahoma and New Mexico

TEST SENSITIVITY TO MIX DESIGN PARAMETERS[2]

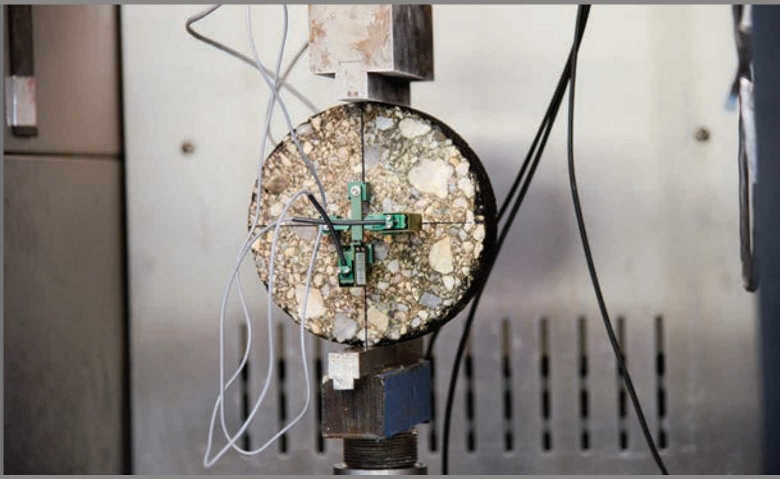
Asphalt binder, aggregate, RAP/RAS

Notes
1. D = diameter; L = length; W = width; T = thickness; ND = notch depth
2. AV = air voids; Pb = percent binder

IDT FOR TOP-DOWN CRACKING

Cracking Type	Test Standard
Top-down cracking	University of Florida: M_r test (optional), D_t test, and tensile strength test (cyclic and monotonic tests)
Specimen Geometry[1]	**Cracking Parameter**
D = 6 in. T = 1.5–2.0 in.	Energy ratio

Test Configuration



TEST COMPLEXITY

Training
Medium time

Specimen Prep
2 cuts

Instrumentation
Gluing 8 studs with a template; mounting 4 sets of extensometers

Testing
1–2 hours

Analysis
Easy with data analysis software

Interpretation
Short and easy (pass/fail criteria)

CORRELATION TO FIELD PERFORMANCE
Validated with field cores in Florida and confirmed at NCAT test track

TEST VARIABILITY
Possibly low, similar to AASTHO T322

TEST SENSITIVITY TO MIX DESIGN PARAMETERS[2]
Insensitive to change in binder viscosity

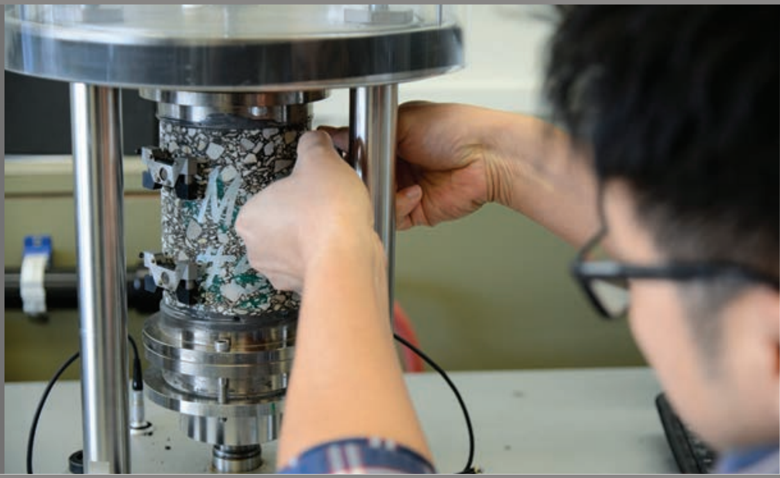
EQUIPMENT COST AND AVAILABILITY
$ Hydraulic test machines can be used and may cost more than $100,000

ADOPTION BY STATES
Being considered for adoption by Florida

S-VECD

Cracking Type	Test Standard
Bottom-up and top-down fatigue cracking	AASHTO TP107 (cyclic tests)
Specimen Geometry[1]	**Cracking Parameter**
S-VECD: D = 4 in. L = 5.1 in. (E*: D = 4 in. L = 6 in.)	Damage parameters (or predicted no. of cycles)

Test Configuration



TEST COMPLEXITY

Training

Longer than medium time

Specimen Prep

2 cuts and 1 coring; gluing top and bottom platens with a jig

Instrumentation

Gluing 6 studs with a special glue jig; mounting 3 LVDTs

Testing

1 hour to 1 day (2–3 more days if E* test is considered)

Analysis

Easy if using ALPHA-fatigue software

Interpretation

Longer time with pavement analysis programs (LVECD and VECD-FEP++) to predict pavement fatigue life

CORRELATION TO FIELD PERFORMANCE

S-VECD used with more advanced models (LVECD and VECD-FEP++) to simulate pavement performance; validated with FHWA-ALF test lanes and verified in North Carolina

EQUIPMENT COST AND AVAILABILITY

$ Commercially available; Cost: $97,000

TEST VARIABILITY

Low in general, but need further evaluation

ADOPTION BY STATES

Being considered by Oklahoma, Georgia, Pennsylvania, and North Carolina

TEST SENSITIVITY TO MIX DESIGN PARAMETERS[2]

Sensitive to binder content, RAP, aging, etc. as reported by Richard Kim's study

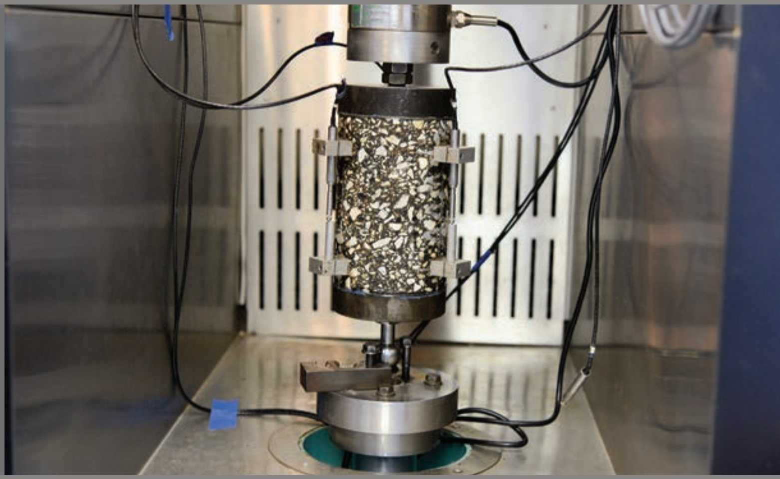
Notes

1. D = diameter; L = length; W = width; T = thickness; ND = notch depth
2. AV = air voids; Pb = percent binder

REPEATED DIRECT TENSION

Cracking Type	Test Standard
Bottom-up and top-down fatigue cracking	Texas A&M University (cyclic tests)
Specimen Geometry[1]	**Cracking Parameter**
D = 4 in. L = 6 in.	Paris' law parameters, endurance limit, healing properties, and average crack size

Test Configuration



TEST COMPLEXITY

Training

Longer than medium time

Specimen Prep

2 cuts and 1 coring; gluing top and bottom platens

Instrumentation

Gluing 6 LVDT holders; mounting 3 LVDTs

Testing

1–2 hours

Analysis

Easy with analysis software

Interpretation

Measured properties with pavement analysis system to predict pavement fatigue life

CORRELATION TO FIELD PERFORMANCE

Correlations with bottom-up and top-down fatigue cracking being developed under several research projects; model and methods being validated with LTPP data

EQUIPMENT COST AND AVAILABILITY

$

Universal test machine (MTS, AMPT) AMPT < $100,000.

TEST VARIABILITY

Low in general, but need further evaluation

ADOPTION BY STATES

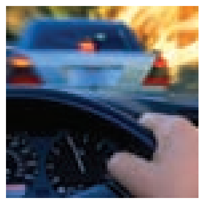
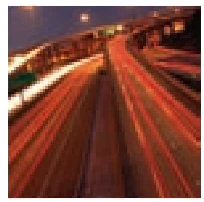
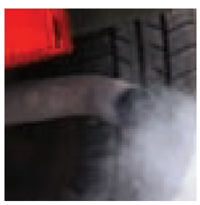
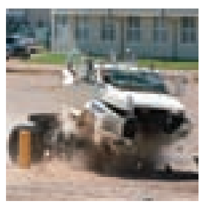
Unknown

TEST SENSITIVITY TO MIX DESIGN PARAMETERS[2]

Model coefficients functions of AV, P_b, gradation; modulus, aging, etc.



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