WHRP

Wisconsin Department of Transportation
Wisconsin Highway Research Program

Request for Proposal

Evaluation of Current WI Mixes Using Performance Engineered Mixture (PEM) Testing Protocols

Questions submitted to research@dot.wi.gov regarding the content of this RFP are due no later than 4:30 PM (CST) on December 12, 2016

Responses to questions will be posted to the WisDOT Research and Library website http://wisdotresearch.wi.gov/rfps-and-proposals by 4:30 PM (CST) on December 19, 2016

Proposers must submit a PDF version of their proposal by 4:30 PM (CST) on January 20, 2017 to: research@dot.wi.gov

Researchers will be notified of the proposal review decision by May 1, 2017

For more information regarding this RFP contact the WisDOT Research Program at: research@dot.wi.gov. This RFP is posted to the Internet at: http://wisdotresearch.wi.gov/rfps-and-proposals

Wisconsin Highway Research Program
Request for Proposals
Rigid Pavement Technical Oversight Committee

Evaluation of Current WI Mixes Using Performance Engineered Mixture (PEM) Testing Protocols

I. Background and Problem Statement

Specifications for concrete pavement mixtures have traditionally been prescriptive, with State Highway Agencies (SHA) specifying means and methods for both constituent materials and specific requirements for proportioning. The result of this places the majority of the performance risk on the SHA and limits innovation. Recent trends of blending cementitious materials, reducing paste content, using innovative additives and admixtures, and other innovations in the industry open the opportunity to move towards specifying the performance characteristics of concrete mixtures and allowing design mixtures that address specific performance requirements. New test methods to evaluate concrete have been developed that can result in improved performance and economics.

The trends made MAP-21 legislation focus on pavement performance and implementation of Performance Engineered Mixture (PEM) is desired by public agencies and industry. As a part of the implementation efforts, FHWA has been working with State Departments of Transportation and industry to develop and deploy standard specifications for Performance Engineered Concrete Pavement Mixture. Transportation Pooled Fund (TPF) Program also supports the acceleration of implementation of PEM specifications financially and technically by FHWA, State Departments of Transportations and industry.

A significant barrier to performance-based specifications is the lack of effective test methods that assess the ability of a concrete mixture to resist the environment to which it is exposed. New testing methods that measure performance-related parameters have been developed and need to be evaluated on current WI concrete mixtures.

II. Goals and Objectives

The goal of this project is to 1) use performance based testing methods on current Wisconsin (WI) mixtures and 2) collect a comprehensive database of results on several WI mix designs and assess how they compare to proposed Performance Engineered Mixture (PEM) specifications.

The objectives of this project are to:

A. Perform field-testing of fresh concrete at the plant and in front and behind the paver using PEM test methods.

B. Perform lab testing on hardened concrete specimens using PEM test methods.
C. Evaluate how current WI mix designs fit into proposed PEM specifications.

III. Scope of Work

Task 1: Researcher will review current approved WI slip-form concrete mix designs and work with the Project Oversight Committee (POC) chair to determine which mixes will be evaluated as part of this research. Selected mix designs should include both Northern and Southern aggregate sources.

Task 2a: Researcher will obtain the test results from the project QC and QV for all routine testing. These test results should include unit weight, air content, slump and temperature. Researcher will also obtain the project mix design for each mix tested.

Task 2b: Researcher will sample and test fresh concrete at the plant and perform the tests listed in article IV concurrent with project QC or QV testing.

Task 2c: Researcher will sample and test fresh concrete on the grade in front and behind the paver and perform tests list in article IV concurrent with project QC or QV testing.

Task 2d: Researcher will perform hardened sample tests in the lab as defined in article IV.

Task 3: Researcher will analyze and summarize how test results from this study compare to proposed PEM specifications.

Task 4: Researcher will provide a draft final report, analyzing the work in Task 2 and include conclusions from Task 3. The final report will include, but not be limited to, project QC/QV test results, study test results and conclusions related to proposed PEM specifications. The draft final report will be submitted to the Rigid Pavement Technical Oversight Committee (TOC) three months before the end of the contract period. The researcher will present the results of this project to the Rigid Pavement TOC in person. The researcher is expected to submit the final report after addressing or incorporating any TOC comments.

IV. Required Testing:

A. Sample and cure samples using the following procedures:
   i. Sampling freshly mixed concrete (AASHTO R60)
   ii. Making and curing concrete test specimens in the field (AASHTO T23)
   iii. Standard moist curing for concrete cylinders (AASHTO M201)

B. Perform concrete testing meeting the following specifications:
   i. Concrete compressive strength (AASHTO T22). Cast 10 - 6”x12” cylinders per mix design. Test two specimens each at test ages 3, 7, 14, 28 and 90 days.
   ii. Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading) (AASHTO T97). Cast six specimens per mix design. Test one specimen at 7, 14 and 90 days. Of the remaining three specimens randomly select two specimens to test at 28 days and compare the strengths. Determine the 28-day average strength as follows:

- If the lower strength divided by the higher strength is 0.9 or more, average the two specimens.
- If the lower strength divided by the higher strength is less than 0.9, break one additional specimen and average the two higher strength specimens.

iii. Surface Resistivity Indication of Concrete's Ability to Resist Chloride Ion Penetration (AASHTO T358). Cast 3 - 4"x8" cylinders per mix design tested. Test each cylinder at 28, 56 and 91 days.

iv. Super Air Meter (SAM) (AASHTO TP 118). Perform a minimum of three tests at each location identified in Task 2 per mix design.

v. Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete (ASTM C457). Perform one test per SAM test location in the field.

vi. Box test (See testing procedure in Appendix A). Perform a minimum of two tests per mix design.

vii. V-Kelly ball (See testing procedure in Appendix B). Perform a minimum of two tests per mix design.

viii. Coefficient of Thermal Expansion of Hydraulic Cement Concrete (AASHTO T336). Perform a minimum of two tests per mix design.

V. Wisconsin Department of Transportation (WisDOT)/TOC Contribution:

A. Expected level by staff/TOC members: Maximum of 40 hours. Project Oversight Committee (POC) members will consult with research team in selecting the projects to be sampled.
B. WisDOT Equipment: The research team will not assume the availability of WisDOT equipment in the proposal. If equipment is donated by WisDOT or another entity, a letter of commitment must be included in the proposal.
C. It is not anticipated that any WisDOT equipment will be needed as part of this study.
D. Any traffic control, if needed, will be the responsibility of the researcher to coordinate with existing construction contractors and WisDOT personnel.

VI. Required Travel

This project may require the PI to travel to Madison for a meeting to finalize the work plan with the POC, batch plant and statewide job site visits to test fresh concrete in Task 2. The PI is expected to report in person the results of the study to the Rigid Pavement TOC.

VII. Deliverables

A. Submittal and reporting of progress as required by the WHRP and WisDOT
B. Reporting Requirements. Six (6) hard copies and an electronic copy of the final report delivered to WisDOT by the contract end date.

C. Presentation Requirements. All projects require the Principal Investigator to give a closeout presentation after submittal of the draft final report.

VIII. Schedule and Budget

A. Proposed Project Duration is **24 months** starting around **June 1, 2017**.
   - Deadline for submittal of draft final report is three months prior to contract end date to allow for report review activities.
   - Deadline for research close out presentation is 4-6 weeks prior to contract end date.
   - Deadline for submittal of the Final Report is the contract end date.

B. Project Budget shall not exceed **$125,000**. Matching funds will not be considered in the proposal evaluation process.

C. The researcher is expected to submit the draft final report with quality technical writing and proper grammar. It is acceptable to include a technical editor on the research team to ensure these requirements are met.

IX. Implementation

A. This study will establish a database of test results on existing WI concrete mixtures.

B. The researcher is expected to communicate the following:
   i. Do current WI concrete mix designs meet proposed PEM specifications already?
   ii. If current WI concrete mix designs don’t meet proposed PEM specifications, where do they differ?

Appendices

A. Box Test

A.1. Perform the Box Test to evaluate the workability of concrete paving mixtures as follows:

A.2. Equipment

A.2.1. Use a 0.028 m^3 (1 ft^3) wooden formed box that consists of a 12.5 mm (0.5 in.) plywood with a length, width, and height of 300 mm (12 in.) with 50 mm (2 in.) L-brackets in two corners. Two pipe clamps with a span of 460 mm (18 in.) were used to hold the other two corners together as shown in Figures A.1 and A.2.

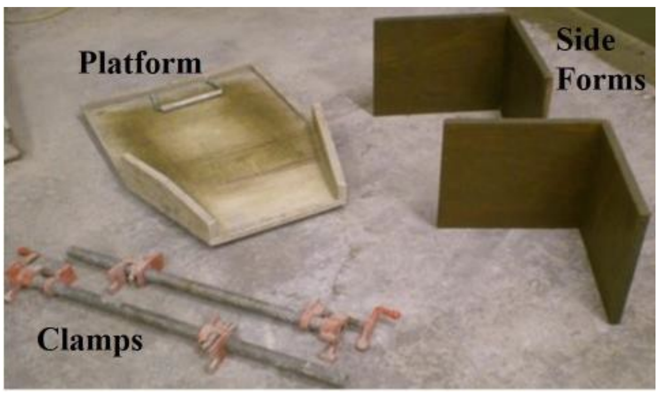


Figure A.1- Equipment

Figure A.2- Assembled Equipment

A.2.2. Assemble the components and uniformly hand scoop the mixture into the box up to a height of 240 mm (9.5 in.).

A.2.3. Consolidate the concrete with a 25 mm (1 in.) square head vibrator at 12,500 vibrations per minute by inserting it into the top surface of the concrete at the center of the box. Lower the vibrator straight down for three seconds to the bottom of the box and then raise straight upward for three seconds.

A.2.4. Immediately remove the clamps from the side wall forms and remove the forms.

A.2.5. The four steps of the Box Test are shown in Figure A.3

A.2.6. Inspect the sides for surface voids and report using the rubric shown in Figure A.4

A.2.7. Measure top and bottom and record edge slump to the nearest 5 mm (0.25 in.) by placing a straightedge at a corner and horizontally using a tape measure to find the length of the highest extruding point.

B. V-Kelly Test

B.1. Perform the V-Kelly to evaluate the workability of concrete paving mixtures as follows:

B.2. Equipment

B.2.1. V-Kelly test apparatus is shown in Figure B.1. The test apparatus is available in a kit from the National Concrete Pavement Technology Center as shown in Figure B.1.

Figure B.1 - V-Kelly test apparatus

B.2.2. The test apparatus requires the following assembly as shown in Figure B.2

Figure B.2 - Assembly unit from each kit

B.2.3. A rubber tub: 17 in. diameter top by 15 in. diameter bottom by 8 in. depth with a 6.5 gallons capacity

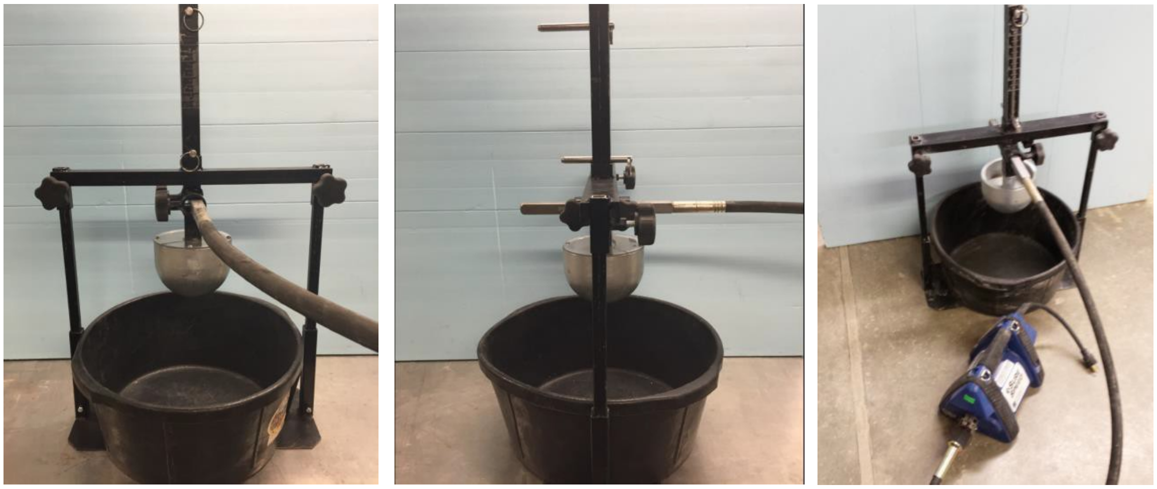
B.2.4. Four pieces of the frame for stabilizing the Kelly Ball: one base, two side bars, and one top bar

B.2.5. A WYCO square vibrator head: 13/16" square by 13 in. length (Part #W877-520), 5 ft cable, with "quick disconnect" adaptor (Part #423500)

B.2.6. A steel Kelly Ball mounted on a graduated shaft with a total weight of 30 lbs

B.2.7. Two pins and two bolts: stabilize the frame and the graduated shaft

B.2.8. Assemble the test apparatus with all the units in the kit as shown in Figure B.3.



a b c

Figure B.3. Assembled apparatus (a) front view; (b) side view; (c) final setup

B.2.9. Insert the two side bars into the base, bolt holes down

B.2.10. Assemble and tighten the two bolts to secure the base

B.2.11. Insert the graduated shaft in the yoke of the top bar with 1” protrusion upward and tighten the top bar to the side bars

B.2.12. Insert the two pins into the top and bottom holes in the graduated shaft

B.2.13. Center the square vibrator head in the yoke of the graduated shaft and tighten securely

B.2.14. The other end of the vibrator head should be assembled with a vibration motor that can provide 72 foot-pound force (lbf) energy at 8,000 vibration per minute (vpm) (i.e., Wyco Sure Speed, Model WVG1). It is noted that the vibration motor is not included in the kit but is the same as that provided for the Box test last year. It will require a 15 Amp and 120 Volt (~approximately 2000 W) power source.

Note B — The following test procedures are recommended for the VKelly test on both static (refer to California Test 533) and dynamic measurements (Taylor et al. 2015). It is noted that the static part of the test should agree with Kelly ball test apparatus and procedures.

B.3. Test samples

B.3.1. Fresh concrete should be placed in the tub to a depth of at least 6 in. for 1-in. aggregate or smaller and 8 in. for larger aggregate.

B.3.2. Create leveled area on the concrete surface of about 1.5 ft^2 without tamping, vibrating, or consolidating the concrete manually. Do not overwork the surface or cause mortar to rise as this will resulting in erroneously high penetration readings.

B.4. Procedure

B.4.1. Pull out the bottom pin, store it into the top of one side bar and gently lower the ball until it touches the surface of the concrete. Make sure the shaft is in a vertical position and free to slide through the yoke. Take an initial reading to the nearest 0.1 in. and then gently lower the ball into the concrete. Record to Record the readings on the graduated shaft every six seconds up to 36 seconds. A digital laser measurer (Bosch Professional GLM 40 or similar) can be installed on the top bar to help record the ball penetration depth during vibration. Alternatively use a video recorder to monitor the graduated scale for the duration of the test.

B.4.3. In the laboratory: remove the tub and remix the testing concrete for about 30 seconds then repeat procedures on a new leveled concrete surface.

B.4.4. In field condition repeat the procedure using fresh concrete from the same batch.

B.4.5. Repeat again to obtain three sets of readings and report the average. Readings should agree within ½ in. of penetration at any given time.

B.5. Calculation and Reporting

B.5.1. Plot the averaged penetration readings in inches (vertical axis) against the square root of time in seconds (horizontal axis) (Figure B.5), and determine the slope of the best fit line through the data (Equation 1).

$$D_{\text{pene}} = V \times \sqrt{t} + c$$

where D_{pene} = penetration depth at time t
t = elapsed time of vibration
c = initial penetration
V = VKelly Index

B.5.2. Report the initial penetration (c) in inches and the slope (V) in in./√s.

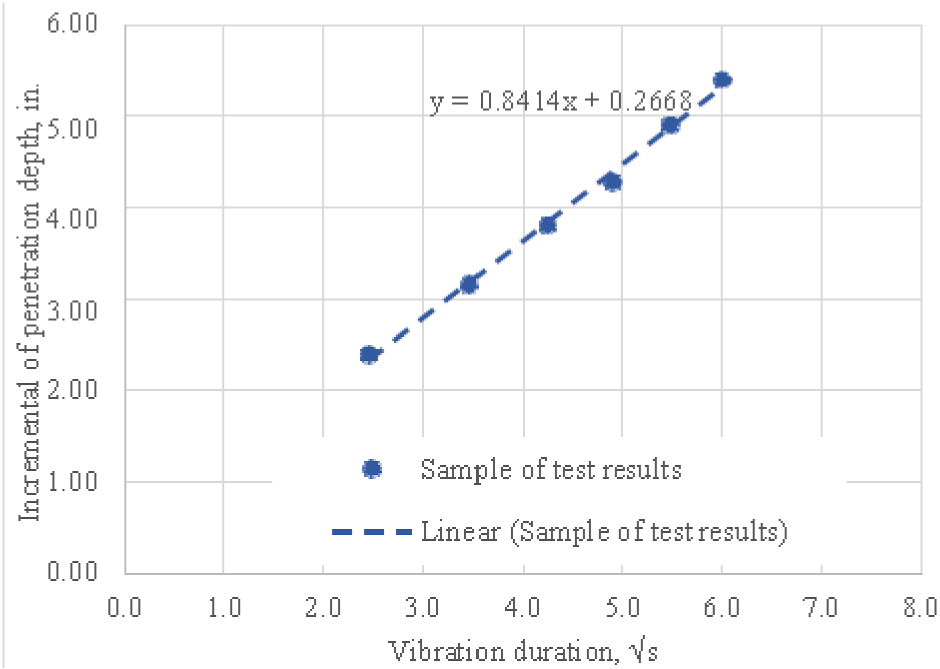


Figure B.5- Sample Plot of V-Kelly Test

B.6. References

B.6.1. California Test 553. 2014. Method of test for ball penetration in fresh Portland cement concrete. Department of Transportation, Sacramento, California.

B.6.2. Taylor, P., Wang, X., and Wang X. 2015. Concrete Pavement Mixture Design and Analysis (MDA): Development and Evaluation of Vibrating Kelly Ball Test (VKelly Test) for the Workability of Concrete. Technical Report TPF-5(205). National Concrete Pavement Technology Center, Iowa State University, Ames, Iowa.