Performance Centered Concrete Construction

STUDY DESCRIPTION

A Performance Centered Concrete Construction initiative will assure that any new concrete pavement or overlay will last for the intended period, with a minimum of distress, at a low life-cycle cost in an increasingly sustainable way. Reducing the need to replace or repair any concrete pavement will provide the direct benefits of saving money, decreasing CO2 footprint, and easing traffic delays – all of which are beneficial to sustainability. Fewer closures over the life of the pavement also enhances the safety of the traveling public and roadworkers.

The Performance Engineered Mixtures (PEM) program, TPF-5(368), addressed the need to specify, measure and deliver concrete paving mixtures that perform as intended for their design lifetime and beyond. The work included helping agencies:

- Choose the critical performance parameters needed for the environment
- Apply tests that assess those parameters
- Select appropriate pass/fail criteria
- Conduct the right tests at the right time

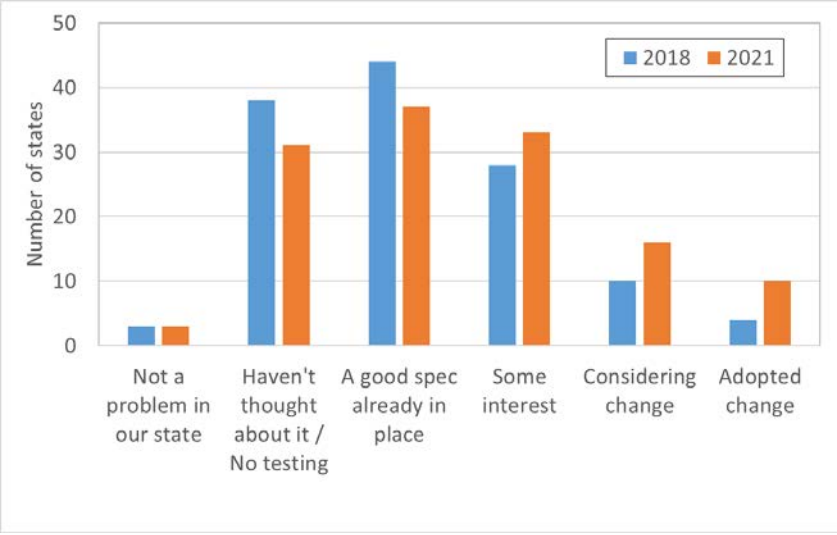
Support was also provided to contractors to:

- Develop sustainable, economic mixtures that would be able to comply with the new specifications
- Implement quality control plans to reduce the risk of premature failures

A deliberate decision was made to focus PEM TPF-5(368) to addressing the mixture up to the point of delivery.

The PEM project was supported by 19 State Highway Agencies, along with matching contributions from FHWA and Industry. Their combined resources helped fund development of the guidance documents (AASHTO R101), test methods, and training programs to adopt PEM.

Surveys conducted for the past 5 years indicate that a number of states have changed or are in the process of changing their specifications in response to the PEM initiative.



It is time to consider "what's next?" The intent of this proposed work is to answer that question.

The fundamental philosophy is unchanged; the ability to specify, measure, and deliver concrete paving mixtures that perform as intended for their design lifetime and beyond. Having the capability to consistently prepare reliable, high-performing mixtures at the batch plant naturally leads to the need to evaluate what happens to the concrete through the stages of transportation, placement, finishing and sawing. Actions between the batch plant and the grade that potentially influence the longevity of a mixture include:

- Transport
- Handling
- Water / admixture addition
- Vibration
- Finishing / texturing
- Curing
- Sawing
- Opening to traffic

Properties that may be affected by these actions include:

- Uniformity
- Consolidation
- Air void system stability
- Durability and strength
- Segregation
- Smoothness
- Cracking

It is intended to follow the previous PEM model to:

- Establish a sound understanding of these properties and how they are affected by workmanship
- Develop / select appropriate test methods for evaluation at or behind the paver
- Select pass / fail criteria
- Provide tools for contractors to ensure that compliance is practical
- Provide documentation and training resources to encourage agencies and contractors to adopt performance based specifications reflecting PEM and related construction practices.
- Assist agencies and industry in the transition to realistic performance based specifications

SCOPE OF WORK

Input from Agencies, Contractors, Machine Manufacturers and Researchers

While a suggested work plan is included, the first action will be a brainstorming session with stakeholders, including those engaged in construction and inspection on the grade. The objective will be to review what actions can be taken on the grade that affect sustainable pavement performance, and what data is needed to guide these actions. Tools needed to provide a feedback loop between the batch plant and the paver operator will be discussed, along with tools that can be used to assure that

the finished concrete will perform satisfactorily with a focus on sustainability, for the design life of the pavement. The work plan will be refined following the brainstorming session.

Test Methods and Limits

The intent is to identify means to measure, or inspect the following properties:

Uniformity

While it is commonly accepted that uniform concrete from load to load is critical for achieving smoothness goals, there are no standard approaches for assessing this, except perhaps the slump test. Uniformity is primarily controlled at the batch plant and is influenced by moisture contents in the aggregates resulting in workability variations. Work is needed to review and recommend approaches to:

- Monitor aggregate moistures in the stockpile / belt and to make appropriate adjustments
- Monitor the workability of the batch early and reporting it to the paver operator
- Evaluate batch plant techniques (such as power draw and torque on the drum) to measure workability

Segregation

Segregation of the concrete ingredients has a negative effect on long-term pavement performance. Segregation normally occurs during transport, handling, and spreading activities and is primarily controlled by the amount of fine material in the mixture, and the means of handling (conveying and depositing) the mixture on grade. Approaches to measuring its occurrence in marginal mixtures during the proportioning stage and, if necessary before the concrete enters the paver, need to be developed.

Consolidation

While consolidation is not presently considered to be a critical parameter in the US market, it is specified and monitored in other countries indicating it has value. While some entrapped air may be considered acceptable or normal, the limit of acceptability has been questioned. Therefore, there is value in reviewing the literature, quantifying the effects of poor consolidation and developing guidance and limits.

Degree of consolidation is influenced by the workability of the mixture and the amount and form of energy used in the paving machine. Stiff mixtures that do not respond well to vibration are more likely to be problematic. Evaluation by tests (such as the VKelly) at design stage can flag the risk of this being an issue, and the mixture proportions can be modified accordingly. If it is observed to be a problem at the time of placement, then additional modifications to the mixture or the vibrator operation may be required.

Air void system

The air void system is established in a mixture in the batch plant. Deterioration of the system may occur if the air-entraining admixture is unstable or incompatible. Inappropriate transportation, handling, or vibration can also affect the system. The foam drainage test has demonstrated the ability to assess the sensitivity of a paste system to deteriorating the air void system. Although the air void system is not always affected during transportation or placement, it is a common enough problem to warrant establishing test methodologies and protocols for monitoring and remedial actions to use when needed.

Non-destructive, instantaneous evaluation of the in-situ air void system would be valuable in monitoring a mixture through the construction process. One such device has been reported and should be investigated for its acceptability.

Durability and strength

The ability of a concrete slab to resist damage due to traffic and environmental loading is primarily controlled by the water/cement ratio of the mixture as addressed in the R101 guidance. The Phoenix test, and microwave test are used to monitor w/cm at the site, and other tests are in development.

Smoothness

Real time smoothness sensing tools are commercially available and have been adopted by several contractors. While these tools are relatively mature, ongoing work is needed to integrate them with the whole paving operation.

Cracking

Early age cracking in concrete slabs can be caused by a large number of factors including excess paste content, moisture loss, and warping. While PEM has addressed shrinkage, there is still a need to specify and measure curing activities. The other activity related to early age cracking is saw-cutting. Several tools are available to help predict when saw cutting should occur, however, these tools (such as Hiperpav) should be refreshed with guidance to assist with their use.

Guidance on How To Do It Right

Some of the technologies are more mature than others, but in many cases, specifications are needed. In all cases, guidance tools such as videos, written documents, and training programs should be developed to ensure proper applications, as well as preventative and remedial actions that can be employed.

PRODUCTS

- Specification language
- Tech Briefs
- Manuals
- Videos
- Workshops
- Webinars
- In-person training

TIMELINE AND BUDGET

Desired minimum commitment from each partner is $20,000 per year for 5 years = $100,000 total between 2023 and 2027. Ideally, 15 or more partners are desired to achieve the entire scope of work for a total funding of $1,500,000 plus contributions from Industry and FHWA. At a minimum, at least 5 partners are needed for a total funding of $500,000 to initiate the pooled fund.

REFERENCES

AASHTO R101, Standard Practice for Developing Performance Engineered Concrete Pavement Mixtures