I-PAVE and PaveXpress: Equitable Pavement Design?

October, 2015 – The American Concrete Pavement Association (ACPA) has long held the position that fair competition between the pavement material industries provides the highest returned value to the road agency and taxpayer. Fair competition is affected at many points in the process of infrastructure development, including pavement thickness design, specifications, bidding, and construction, and it may affect the selection and implementation of any solution (new construction, resurfacing, rehabilitation or preservation).

One of the process steps that may significantly impact pavement comparisons is pavement thickness design, which is the subject of this perspectives statement. There are a number of methods that have been developed, calibrated, tested, peer-reviewed, and validated by owner/agencies involved in designing and specifying pavements. Among these validated thickness design programs for roadway applications are:

- AASHTOWare Pavement ME Design®
- ACPA WinPAS
- ACPA StreetPave 12

ACPA is on record supporting the adoption of AASHTOWare Pavement ME Design® by state highway agencies for design of both concrete and asphalt pavements, provided that its implementation is based upon appropriate calibration factors, and its application is based on judicious and fair selection of input variables. ACPA StreetPave 12 was developed primarily for thickness design where implementation of AASHTOWare Pavement ME Design® is considered too onerous. In recent years, ACPA StreetPave 12 has been peer-reviewed by several states, and formally approved for use in Virginia and Minnesota. Similarly, ACPA WinPAS has been peer reviewed by Federal Highway Administration and others and has been determined to be consistent with the AASHTO 93 Design Method. WinPAS and its forerunner (PAS) has been around for decades, dating back to the 1990's upon the introduction of the 1993 AASHTO design method.

Recently, two new design applications have been introduced that are reported to follow the AASHTO 93 methodology. These methods include:

- PaveXpress
- I-PAVE.

Neither of these design software methods have yet undergone rigorous evaluation or validation by the pavement design engineering community. ACPA'S initial review has identified serious concerns with the applications. We have focused our review on the concrete (rigid) pavement design methods in the applications:

<u>PaveXpress</u> is a method created by Pavia Systems, under the sponsorship of the National Asphalt Pavement Association, the Asphalt Pavement Alliance, and a consortium of state asphalt pavement associations. The method is reported to be a scoping tool to create simplified pavement designs taking into account key engineering inputs. It is also reported to follow AASHTO 93 pavement design equations.

ACPA's initial review of PaveXpress for the concrete pavement design/scoping portion revealed that a number of additional inputs were required beyond those traditionally required by either WinPAS or the

AASHTO 93 Design equations. The additional inputs seemed to indicate that either the AASHTO 93 procedure had been modified or a different design methodology such as the AASHTO 98 Supplement Procedure was being utilized by the program. While many of the inputs match those required by AASHTO 98, there are a number required that do not appear in AASHTO 98 as well. There is also no mention of the AASHTO 98 procedure in any of the documentation.

Concrete pavement design runs, utilizing the same inputs, revealed PaveXpress's thickness results were as much as 2.5 inches thicker than WinPAS, the AASHTO 93 Design equations, the AASHTO 98 Supplement Procedure, and the LTTP InfoPave's concrete pavement design procedure[1]. A significant increase in thickness was noted for all PaveXpress design examples compared during our test run and evaluation.

PaveXpress requires environmental inputs, including mean wind speed, mean temperature, and mean precipitation, which are not included in the AASHTO 93 Design. ACPA disagrees fundamentally with the inclusion of any environmental adjustment to the AASHTO 93 method. AASHTO 93 is an inherently empirical procedure, with the original equations derived from measuring the response of actual pavement test cells to actual loading and environmental conditions. The test loops built for the original road test underwent all of the real-world influences (including slab curling from environmental stresses), and as such, these factors are already taken into account.

PaveXpress's inclusion of a "slab/base friction coefficient" for the concrete pavement design is another questionable factor outside of the AASHTO 93 methodology. It appears to be a multiplier that may impact the end result calculations under certain cases, particularly where the design requires a base/subbase layer. Because this factor is not thoroughly documented, it is unclear exactly how it is working within the application. It appears that slab thickness increases as the friction coefficient is reduced. However, since the Road Test pavements were built on granular materials (naturally low frictional restraint), there is no reason to include such an adjustment factor. The Road Test results inherently factor in low frictional restraint. In current practice, concrete pavement designers and contractors attempt to reduce bonding between layers of conventional concrete and stabilized subbase or base materials with naturally higher frictional resistance to avoid any complications with bonding and restraint. There is no reason to make any adjustment for slab/base friction to an AASHTO 93 design.

It is unclear whether these additional input requirements are being used to alter PaveXpress's referenced design method (AASHTO 93) or if they are being utilized in a procedure following the AASHTO 98 Supplement Procedure. There are also additional inputs required beyond those of AASHTO 98, including a drainage coefficient and a load transfer coefficient (both of which are utilized in the AASHTO 93 method). Without further documentation explaining the design method and any alterations made to the existing procedure, it is impossible to account for PaveXpress's significant increase in reported design thickness relative to the established design tools.

I-PAVE is a method created by the Department of Civil, Construction and Environmental Engineering at Iowa State University, under the sponsorship of the Asphalt Pavement Association of Iowa.

ACPA's review of I-PAVE for the concrete pavement design/scoping portion reveals several concerns that affect the validity of the results. The method does not appear to appropriately handle subgrade or pavement foundation support (k-value). The I-PAVE website[2] suggests that:

$$k = \text{Resilient Modulus} / 30$$

AASHTO 93 suggests that the k-value be derived from resilient modulus using the conversion formula:

[1] http://tools.infopave.com/Rigid/Rigid.aspx
[2] http://www.i-pave.info/Subgrade-Data-for-Iowa.aspx

k = Resilient Modulus / 19.4

This discrepancy will underrepresent foundation support and result in a thicker concrete pavement section in all cases.

I-PAVE also appears to be mixing guidance on k-value. In Pavement ME Design, a dynamic k-value is applied; in AASHTO 93, a static k-value is applied. These are different representations of the foundation support and cannot be intermingled. Any research and development work on k-value within the context of Mechanistic Empirical Pavement Design Guide (MEPDG) or Pavement ME Design has nothing to do with k-value in AASHTO 93 or prior versions. I-PAVE appears to have overlooked this important point.

Another concern regards I-PAVE's required minimum concrete slab thickness of 6 in. and an apparent additional requirement to include 1-inch diameter doweled joints in designs down to 6 inches. The industry standard for requiring dowel bars is 8 inch thick pavement, and the minimum thickness is 4 inches. I-PAVE has included these limits without consideration of industry standards.

I-PAVE also includes a rehabilitation design procedure. The concrete alternative is only a possibility when the existing pavement has low severity distresses. The thickness reported by I-PAVE could not be verified, as no equation is reported, nor is any reference material cited.

There are also a number of issues with I-PAVE's life-cycle cost analysis (LCCA). I-PAVE's LCCA is performed over the design life, not considering future costs, which violates FHWA's policy that an LCCA should be at least 35 years. I-PAVE's LCCA also assumes that the concrete pavement will need to be demolished and reconstructed after 20 years with no consideration of this pavement lasting longer or being left in place and utilized in a new pavement section. This results in a demolition cost with no salvage value for concrete pavements. Additionally, the maintenance costs are applied as a credit instead of a cost in I-PAVE's calculation of the Equivalent Uniform Annual Cost (EAUC), which results in an incorrectly calculated total cost.

CAUTION ON USING PAVEXPRESS OR I-PAVE FOR CONCRETE PAVING DESIGN

ACPA's review of both new applications revealed major concerns about their concrete (rigid) pavement design calculations. Before simply accepting results from either I-PAVE or PaveXpress, we encourage engineers to use the more accepted tools that have undergone rigorous use and validation over many years, including Pavement ME, AASHTO 93, StreetPave and WinPAS.

ACPA will continue to review I-PAVE and PaveXpress to determine how improvements can be made to their concrete (rigid) pavement methods. In the meantime, we caution against using these tools for comparable designs because of the black-box adjustment factors, arbitrary limits on input variables that do not align with industry standards, and imposition of design requirements where user-input is customary and warranted.

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