FY23 Webinar #3

Importance of Materials Testing and Libraries for Use in Pavement Design

Questions and Answers

Q: For aggregate bases, is there a provision to include recycled or marginal material?

A: That would likely be an agency specific decision to include those types of materials in their material libraries. On the global calibration on a national perspective, the use of recycled and/or marginal bases for aggregate bases were not included because very few of the LTTP sections had those types of materials considered as an aggregate base.

However, if you use Pavement ME and go to aggregate base, there is an item you can consider by use of RAP as an aggregate base, different types of RAP that a user could select from. The point I want to make is the default value on the global perspective is very low, at least based on the test results seen over time.

An agency could define their own default values for these types of base materials and use that in Pavement ME. But I would suggest and recommend that the agency, or whomever is doing it, verify that the default values in terms of predicted versus measured distresses will not cause a significant bias. Right now, the global value is very low.

Q: Doesn't Pavement ME already define thick vs thin? The calibration assumes 3 bins - <5", 5" to12", and >12"

A: In the presentation, reference to thick and thin was regarding the stress sensitivity of the crushed stone materials. I think what is being referred to here is the three bins, that has to do with the fatigue coefficients and the calibration coefficients themselves, which is not directly related to the stiffness of the crushed stone. So, it does define thick versus thin from a fatigue bottom-up cracking perspective which was determined during the most recent global model calibration. These thicknesses may not match how agencies define thick versus thin pavements in their pavement design procedures.

Stress states in the unbound material also change based on thick versus thin pavements. For your material library of granular base material, you may have different resilient modulus based on pavement thickness.

Q: Will the presentation be available?

A: Yes, it will be available on the Pavement ME Design website - https://me-design.com and a report of the Q & A will also be provided.

Q: Thank you so much for the explanation.

Q: What there is limit of 2000 ft/mile in PMED?

A: The limit is based on the model assumptions. It comes out to about 1 crack every 30 feet. This is an assumption that was made originally under the NCHRP 1-37A project. That assumption has never changed so there is a limit on the maximum amount of thermal cracking predicted by the software. This was shown in the figure in the presentation, at 2112 feet per mile.

Not sure why it has been used, but it's been an assumption since Day 1. Obviously, you can measure a lot more transverse cracks over 2000 but that is the capped predicted value.

Q: For unbound/subgrade materials, why level 1 input is not available for pavement ME software?

A: Input level 1 was available in the rudimentary software from the NCHRP 1-37A project which used the finite element response program in the rudimentary software. However, using input level 1 or the K1, K2, and K3 of the constitutive equation for unbound materials required extensive run time that was found to be impractical. The finite element response model was turned off in the production software.

The Manual of Practice provides a default value for each of the AASHTO material classifications, whether that is a base, or a subgrade soil but these are input level 3. However, there is a "quasi-input level 1" for all unbound layers but that value is determined external to Pavement ME. A standard practice for determining the resilient modulus from lab test data is being submitted to the Task Force this Fiscal Year on how you determine that stress sensitive value that's structure dependent for all unbound materials. Given that you have data from AASHTO T-307, the repeated load resilient modulus test. So, if you do have test results from AASHTO T-307 or an equivalent procedure, which many agencies do, the design resilient modulus value can be estimated from AASHTO T-307 using that standard practice. As many know, resilient modulus test data from repeated load resilient modulus are available for most of the test sections within the LTPD program.

Q: How about the top-down cracking in Ver 2.6?

Q: Bottom-up fatigue cracking can be called as Alligator cracking and Top-down fatigue cracking can be considered as longitudinal cracking. However, in the presentation, Top-down cracking is mentioned as Alligator cracking. Please verify.

A: The original answer here was the definitions of cracking have not changed. In earlier versions of the software, top down fatigue cracks were defined as longitudinal cracks and bottom up fatigue cracks were defined as alligator cracks. In other words, when the software was first released under the NCHRP 137A project and AASHTOWare took it over, top-down cracking was assumed to be longitudinal cracking. Bottom-up fatigue cracking was assumed to be alligator cracking and that defined the two. It was assumed when you see a longitudinal crack, that always begins at the surface. When you had traditional alligator cracking, that was assumed to start at the bottom. That is incorrect. We've taken a lot of cores over time, cores over cracks, to see where those cracks begin. Alligator cracks can initiate at the surface, they can also initiate at the bottom. When you see longitudinal cracking starting to occur at the surface of the mix, those could be initiated at the surface, those could also be imitated at the bottom of the asphalt layer, the lower layer.

So when the top-down cracking model and transfer function in the earlier versions of the software was replaced with the recommendations from NCHRP 1-51 project, the definition did change. Both top down and bottom up fatigue cracks can initially start out as longitudinal cracks that propagate to area alligator cracking. So the crack definition has not changed with the exception that top down fatigue cracks can represent the alligator cracking pattern.

We did a webinar on top-down cracking, and this was explained in detail during that webinar when it was added to the software. (10/10/2021 FY 22 Webinar 1: Reflection Cracking https://me-design.com/MEDesign/Webinars.html). Alligator cracking refers to both top down and bottom-up cracking. Longitudinal cracking can refer to both bottom-up and top-down cracking. If you look in the LTPP database and you track longitudinal cracks, in many cases those end up being alligator cracking. In fact, if you look at the measurement errors for alligator cracking and longitudinal cracking are large, because some distress observers, documenting the distress that exists on the surface, one time they call it longitudinal crack, and another time they call it alligator crack. Because the longitudinal cracks typically are eventually going to be changed to alligator cracking in the wheel path.

In the current version of Pavement ME, starting with Version 2.6 and 3.0, top-down and bottom-up cracking can be longitudinal and alligator cracks. Going to the webinar where we presented top-down cracking, there is a suggested method to segregate top-down versus bottom-up cracking. Both of those have been confirmed by coring, not just taking visual observations of the surface, but by taking cores and defining where that cracking initiated from. I follow that method of categorizing when we're doing calibration and trying to separate top-down and bottom-up, but there is additional error. Because we don't always take cores on pavements for every site, especially if it is going to be used for calibration.

-Matias Mendez Larrain (matiasm@estinc.com) - 11:50 AM
Q: What method was used to measure the longitudinal, alligator, fatigue, etc cracking? Any traffic device?

A: We are unsure about the traffic device for measuring longitudinal and alligator cracks. For most of the calibration studies that I am familiar with and for the global calibration, longitudinal and alligator cracks are measured in accordance with the LTPP program. The manual distress survey data stored in the LTPP database was used calibration of the fracture models.

Q: In field you can measure higher TC!

A: I believe this is a statement. To confirm, yes you can measure much greater lengths of transverse cracks in the field or along the roadway, than the 2,112 ft. per mile included in the presentation.

Q: Are you capping the measured thermal cracking to 2112? It appears so in the graph.

A: The PMED software does cap the maximum length of transverse cracks that it predicts as 2,112 ft. per mile. This cap or maximum prediction length has always been in the case since the software was delivered to AASHTOWare. This cap was discussed and debated by the NCHRP Panel under NCHRP 1-37A. Please refer to our response to a previous question above on this cap on calculated length of transverse cracks.

Q: Also, if you're capping thermal cracking, then is this capping at a per data point basis or per the section average result? If you're capping at the per datapoint basis, then your average will be lower than the cap.

A: The cap applies to the predicted value by the PMED software. For calibration and other comparisons between the measured and predicted values, the measured values should also be capped at 2,112 ft. per mile when comparing the field and predicted values. It would be inappropriate to compare the actual measured length of transverse cracks to a capped predicted value. The size or length of the test section is based on whatever segment length the agency is using. As an example, the length of transverse cracks reported in a LTPP test sections (500-feet in length) were converted to a feet per mile basis on a lane basis.

Q: If you are indeed capping the measured thermal cracking to 2112 - would you recommend that agencies do so for their calibration?

A: Absolutely. As noted in the answer above, you should not compare the actual length of measured transverse cracks to a predicted capped value. The actual measurement should be capped to the same value used to predict the crack length.

-Prajwol Tamrakar (ptamrakar@tensarcorp.com) - 11:16 AM
Q: Even after using Level-1 inputs (or by running local calibration), it seems there is a bias in measured vs predicted distresses. In my opinion, the bias is likely due to the limiation of the numerial model (transfer function).

A: We agree there is a bias between the measured and predicted distress values demonstrated in the slides included in the presentation. However, I know of no pavement prediction software that predicts the measured distresses without bias. There are too many parameters that are not actually known. So, we would respectfully disagree that the bias exists simply because of the numerical model or transfer function.

Q: Maybe now we have to investigate modify the structure of Transfer function (equation) or utilize some sort of ANN model to predict distress. Agree? or any other thought?

A: This is a very difficult question to answer. I am confident that the PMED transfer functions do exhibit a good representative of the measured distresses. Can they be improved with the use of ANN, possibly. However, ANN mathematical models are used within the PMED software for many of the distresses, so they are already included in terms of functionality. If you are referring to the use of Artificial Intelligence (AI), in my opinion AI can provide some improvement depending on how it is set up and where the data comes from.

Q: Are these predicted values are at 50% reliability?

A: I used 50% reliability, and I should have noted that in the presentation, for comparing the measured and predicted values. The one shown for calibration, as well as in the examples for cracking, rutting, and faulting over time were all done at a 50% reliability.

Q: How will level 1 versus level 3 impact reliability?

A: The local calibration guide suggests that the best available data be used, so the best available data should also be used for design. The presentation demonstrated a greater difference in results between using input level 3 versus quasi-input level 1 for asphalt versus concrete pavements.

However, I first want to come back to the point made for Summary Takeaway #7 in terms of what we showed in the examples. If you use default level 3, versus “quasi-input level 1” you may see differences. Those differences may affect calibration and the standard error for residuals. If they affect the standard deviation for residuals, they are going to affect the reliability calculations. If they affect the bias, they are going to impact the calibration coefficients. Thus, agencies need to be consistent in how they calibrate and do their design. There has to be consistency between the calibration inputs and design, unless the agency confirmed that the default input level 3 and lab derived input level 1 resulted in no bias and no change in the standard deviation of the residuals.

For concrete, the difference in measured and predicted values between using quasi-input level 1 and default input level 3 was much smaller in comparison to asphalt pavements. A reason for that is because we have had those mechanical properties available and being measured over such a longer period of time. I stress caution to the user, that should be verified if they have been using defaults and then all of a sudden go to using and developing an XLM library with “quasi-input level 1”. You need to verify that those XLM libraries are not deflating or result in a significant decrease in the standard deviation of the residual error. Because fi they do, you need to take that into account and if they are readjusting the bias, or causing bias, if the original calibration was done based on the default value. Suggest agencies need to be cautious there.

Q: If the Mr for bases allowed to vary according to the EICM, the predictions can either be double or half of the input value based on whether predicted moisture is wet or dry of optimum. Can you comment on this? Or are you using constant Mr?

Q: (reworded by moderator): When you were doing some of your unbound materials and some of your outputs were allowing the EICM to vary moisture content or was it the fixed?

A: Good question. Yes, it did vary depending on the predictions from EICM. I entered a design value and then allowed or permitted the EICM to vary that modulus over time, over the 20 years as the design period. The comment about the initial base material and/or subgrade value being double or half the input value, that can occur even over a short period of time. That's why the design value for resilient modulus that you enter in Pavement ME at the time of construction needs to be compatible with the density and water content that you are entering for that property.

In other words, the water content and density that the user enters in the Pavement ME needs to be compatible with the value that the user is entering for resilient modulus.

Q: This is also something to be addressed in the work product you were talking about, just how to determine which value to use based on the stress data?

A: The standard practice that I previously referred to, I think that is what the question is, that defines if we do resilient modulus tests. Because you are going to have 15 modulus values at 15 stress states, how do you determine the design value in Pavement ME that you enter into the software. Obliviously, water content and density need to be compatible-and tied together with the resilient modulus as an entry in Pavement ME. The standard practice I previously referred to, provides guidance on how to determine that value for different temperatures on the asphalt and different load levels from the trucks because only one design resilient modulus is entered into the program. So the standard practice provides some guidance on what axle load to select, as well as what season should be selected.

Q: How were the distresses measured? I'm assuming that's covered in the calibration reports?
What method was used to measure the longitudinal, alligator, fatigue, etc. cracking? Any traffic device?

A: A similar question was asked and answered above. We assume this is not a repeat question.

We are unsure about the traffic device for measuring longitudinal and alligator cracks. For most of the calibration studies that I am familiar with and for the global calibration, longitudinal and alligator cracks are measured in accordance with the LTPP program. The manual distress survey data stored in the LTPP database was used calibration of the fracture models.

A continuation of the answer relative to calibration. The local calibration guide allows different methods to be used. For the global calibration and most of the local calibrations I am familiar with, the manual distress surveys were done in accordance with the long-term performance pavement program or the FHWA manual on measuring and defining distresses consistent with the LTTP program.

Longitudinal cracks, to summarize, the length of the longitudinal crack is multiplied by a foot, assuming there would be six inches on either side of the crack that would have an impact on the damage around that crack. That's kind of a gross assumption, but that's what has always been done on a lot of the local calibration work and this goes back to studies in the 1970's and 1980's. Longitudinal crack is simply multiplied by a foot even though it's not a foot wide, the damage is assumed to be six inches on either side of the crack and that's then defined as the area.

Q: In order to adjust local coef to quasi lvl 1, should agencies apply a clear methodology (for example the one you used in this study) to assign the "most plausible" values to the missing lab-related data of materials of all local calibration sections?

A: We are unclear about the question being asked, so we are rephrasing the question and its answer.

You do not adjust the local calibration coefficients for different layers and mixtures that might not be included in the XML library. The assumption is that the local calibration coefficients apply to all of the similar mixtures and materials. The laboratory-derived material properties can be adjusted based on laboratory testing of any new material. If you are using a totally different material, such as ground tire rubber, and have no laboratory test results, then it is up to the design for making a decision on the laboratory-derived properties – just like for any other design method. No design procedure or method that I am familiar have suggested inputs for all types of materials.

Q: Are you changing kf1, kf2, and kf3 are all mix types?

A: Do you mean changing the coefficients for each asphalt layer? If so, then no, only one set of kf1-kf3 values are defined for a particular design. Typically, the coefficients corresponding to the mix for the bottom most asphalt layer will be used. Please refer to the suggestion in the MEPDG Manual of Practice if you are using a permeable asphalt treated base layer with high air voids as the lower asphalt layer for the simulation.

Q1: For the AASHTO T 307 cyclic loading test for unbound aggregates or soils, the modulus becomes stiffer with repeated cycles, and therefore, does the AASHTO T 307 test account for stiffening due to repeated truck load compaction effects. So does this test not really account for traffic compaction rutting?

A: The stiffness increase you are referring to in T 307 is not caused by truck traffic. So, my answer to the question is no T 307 does not account for stiffening due to repeated truck loads. The initial load cycles where you see an increase in resilient modulus are the conditioning cycles at the beginning of the test, unless you are referring to really soft materials with high water contents and/or voids.

Q2: Suppose I establish a material library on a representative set of mixtures in my region. Should I consider recalibrating the local calibration coefficients (Bf), since they were previously obtained with the global calibration coefficients (kf)?

A: Yes, you should consider recalibration. However, first verify the laboratory-derived material properties do result in a significant change in the predicted distress. Do not assume that you have to recalibrate every time you have a change. First verify that the change results in a significant difference in the predicted value. Too many agencies are under the impression that if you change something, you have to recalibrate. You may or may not have to recalibrate.

Q: Please comment on the use of .XML materials files for use in seeding and analysis and then modifying some of the values to be project specific.
If the .XML material files are used as SEED FILES, then it may seem that the .xml bias issue is less important. Thanks for commenting.

A: I am not sure what you mean by "seeding files." The XML material library files should be representative of your agency's mixtures or materials and represent the project specific values as best you can determine. Since the majority of designs are done at least a year in advance of construction, you never actually know the property until the contractor places the material. The designer needs to make assumptions or select mixtures within the XML library that are available and representative of the high use mixtures within the agency. If the material/mixture has yet to be used or specified by the agency, then it is up to the designer to decide on the material property to be used. In some cases, the designer may run some laboratory tests to determine those values – generally applicable to design-build projects.
