BACKCALCULATION QUESTIONS AND ANSWERS

1) *Will this webinar be available on YouTube or to download where we can go back and watch it again?*

The webinar will be available on http://me-design.com/MEDesign/Webinars.html under the "Enhancement Review" tab.

2) *Is the Backcalculation tool offered as part of Pavement ME, or does it have to be purchased separately, and have separate licenses?*

The tool is currently available only to ME Design licensees. It is not purchasable separately, though that may change in the future.

Users of ME Design will have a number of Backcalculation tool licenses available to them as workstation licenses up to the number of ME Design licenses purchased. So, if you have purchased two workstation licenses of ME Design, you will have two BcT licenses available. If you have purchased a 9-user site license for ME Design, you will have 9 workstation licenses available for use at your agency.

3) *Is the Backcalculation module included in the AASHTOWare ME package?*

No, the download and installation package for the BcT is separate from the ME Design package.

4) *How does licensing for EVERCALC work? Will it be linked with the Pavement ME Design license?*

EVERCALC is included directly in BcT, so it is not licensed separately from BcT. The Washington DOT gave AASHTO permission to include that package into BcT. The BcT is only linked to Pavement ME Design via the file that is created from the post-processing stage.

5) *Is the version of Evercalc used different from Version 5.0?*

Version 5.0 is the version included in BcT which was provided by the Washington DOT.

6) *How can I download the backcalculation tool when we have a concurrent license?*

Any license for the Pavement ME software can download the BcT. See the answer to question #2.

7) *Can the user redefine the criteria for acceptable, atypical, and unacceptable results? Also, can the user define the modulus ranges for typical and atypical results?*

The user decides whether to accept or reject the results and can use any values for that purpose. The RMSE is provided for each test point for information purposes. The software initially plots all RMSE values less than 100 regardless of their value. The maximum RMSE is entered by the user in judging the accuracy of the results. The RMSE criterion referred to in the webinar are the values recommended for use through the FHWA backcalculation project (see references below). All RMSE values should be less than 5 percent, but the lower the RMSE the better.

The user also enters the modulus range (minimum and maximum values) for each layer for the backcalculation process. The default minimum and maximum values for each type of layer are included in Appendix B of the User Manual. In many cases, the minimum and maximum value will need to be expanded to achieve lower RMSEs.

The range of moduli used to judge the appropriateness of the resulting elastic layer moduli for a specific layer is also determined by the user in reviewing the results. These values are not entered into the program; they are used externally by the user.

- *Long Term Pavement Performance Program Determination of In-Place Elastic Layer Modulus: Backcalculation Methodology and Procedures*, Publication Number FHWA-HRT-15-036; Federal Highway Administration, Turner-Fairbank Highway Research Center; McLean, Virginia; September 2016 (Harold Von Quintus, Chetana Rao, and Lynne Irwin).
- *Back-Calculation of Layer Parameters for LTPP Test Sections; Volume II: Layered Elastic Analysis for Flexible and Rigid Pavements*, Report Number FHWA-RD-01-0113, Federal Highway Administration, Office of Engineering Research & Development, Washington, DC, December 2001 (H.L. Von Quintus and A.L. Simpson).

8) Why change the lower HMA layer minimum modulus when you're not concerned with stripping with that layer?

If stripping has not occurred, there are no other mixture defects (layer debonding), and the layer thicknesses entered in the software are an accurate representation of the in place values, the default minimum modulus listed in Appendix B of the User Manual should be used. If the elastic layer moduli of a layer are continually hitting the lower or upper limit for that layer, however, that suggests the pavement structure simulation entered may not be an accurate assessment of the in place layers.

The Idaho Transportation Department (IDT) did not know they had a stripping problem and used a higher elastic modulus for the minimum or lower limit at the beginning. This resulted in high RMSE values and the only way to reduce the RMSE was to decrease the lower limit of the AC layer because many of the solutions were hitting that lower modulus limit or boundary condition. After the lower limit was decreased, IDT realized the cores showed signs of stripping.

It is recommended that if an agency uses typical lower and upper limiting values for a layer (typical values measured in the laboratory), the user should always check to determine if the upper or lower limits are being reported from the backcalculation process. If solutions are generally hitting the upper or lower boundary moduli, then in all probability, there is an error in the pavement simulation or a discrepancy between the theory (EVERCALC) and actual in place condition. In this case, the range should be expanded or the pavement simulation checked for reality.

9) Does the tool automatically flag Unacceptable or Atypical RMSE?

No; it only flags or identifies the types of deflection basins (typical, type 1, type 2, type 3). The tool does provide a plot of the RMSE along the length of each segment. The backcalculated elastic

moduli for deflection basins with an RMSE greater than the maximum value entered by the user are not used to determine the average elastic layer modulus values (see answer to question #7).

10) If the COV is high, still you recommend using average values for design?

Yes, because of the reliability concept included in Pavement ME Design. All inputs to the Pavement ME software should be average values.

If a high coefficient of variation is calculated from the backcalculated values, this could indicate that the pavement simulation is incorrect, the pavement temperatures are highly variable, the AC layer has extensive damage or cracking, etc. The user needs to determine the reason for the high COV and make an appropriate decision for the rehabilitation design.

11) How is the standard deviation or CoV used in the Pavement-ME for design?

The standard deviation and coefficient of variation are not used within Pavement ME for rehabilitation design. These statistical values are only used to determine the amount of variability in the backcalculated elastic layer moduli. No guidance is provided in the BcT User Manual in terms of defining if the values are too high. The greater the standard deviation and coefficient of variation simply implies that the deflection basins and/or pavement structure are highly variable (see answer to question #10).

12) Does the user have to make a manual segmentation or can they just use what's been automated?

The user can use the automated segmentation; the user makes the decision on the segments. The user can identify up to three sensors for the automatic segmentation process, but only one set of segments will go forward to the next step for backcalculation. If a user prefers to use the results from the automated segmentation process, it is recommended that only one sensor be used for the segmentation (that sensor being the one in the loading plate or d_0).

13) In the segmentation portion, are those raw deflections or have they been adjusted for temperature?

The deflections are not adjusted for temperature; the actual measured deflections are used in the segmentation.

14) What method is used for temperature correction of the raw deflection data?

The measured deflections are not corrected for temperature.

15) Does the program adjust the deflection at the center of the load to standard load?

No. The actual measured deflections are used along with the measured load or pressure from the FWD loading plate. The target load levels are entered by the user for each drop height, but these are only used in terms of using the deflections for specific categories.

16) If pavement temperature is not included in the imported FWD data, does the program have a way to compute the layer's average temperature? (Layer average temperature from surface temperature?)

No. If temperatures are not included in the FWD data file, the average temperature imported into the Pavement ME file is "0". The user will need to enter a value manually into the Pavement ME file created from the backcalculation process. Temperature is a required input into the Pavement ME for rehabilitation input level 1 and must be determined by the user.

17) Have you looked at the implications of using average AC modulus and average AC temperature when the relationship between modulus and temperature is not linear? Wouldn't it be better to correct on a basin-by-basin basis, and then use the average corrected modulus?

The backcalculation process is independent of temperature. The interpretation of the results, however, needs to take into account temperature during FWD deflection testing. In most cases, deflection testing is completed over a limited time frame (less than a day) where the temperature does not change that much from the beginning to the end of testing for a data file. If temperature does vary significantly during the FWD testing, the FWD deflection data should be manually sorted by temperature to create different data files. The average backcalculated elastic AC modulus can be determined for the specific temperature range for each file and those values used in the Pavement ME runs. The BcT does not have an option to internally sort the deflection data by temperature.

A follow-on question that could be asked is: what defines "significant variation" in temperature within the FWD data file? Significant variation in temperature is left to the user but is dependent on the site condition and pavement structure or simulation. In general, a temperature differential during FWD testing of 20 F is considered significant, but that differential is dependent on the magnitude of temperatures during testing. As an example, 40 F to 60 F and 100 F to 120 F are less significant than 60 F to 80 F, because of the shape of the asphalt concrete dynamic modulus master curve relationship (modulus versus reduced frequency).

18) Is there a way to estimate AC mid-depth temperature (using BELLS or some other algorithm)? If not, is there a way to import such estimates?

The average mid-depth temperature is a required input to Pavement ME for rehabilitation input level 1. Yes, the BELLS relationship can be used to estimate the AC mid-depth temperature, but the air or surface temperature need to be measured during FWD testing. If the air or surface temperatures are available, the mean temperature is determined for each segment by the BcT in the post-processing portion of the software. The user would simply revise the mean air or surface temperature to a mid-depth value after importing the backcalculation results into the Pavement ME. If no temperatures were measured during FWD testing, the user will need to estimate the mid-depth temperature external to the BcT and enter that value into Pavement ME after the rehabilitation design file has been created (see answer to questions #16 and #17).

19) How do you select just one or two sensors for the segmentation?

One to three sensors can be used for the segmentation. The sensors used for segmentation are identified by the user. The three sensors recommended for use are the sensor in the loading plate or d_0, the last sensor of the deflection basin (typically representative of the subgrade or deeper layers), and the sensor located at a distance from the loading plate that is equal to the thickness of the pavement layers. The intent for developing the software was to allow the user to review the results

from the automated segmentation process and then make a final decision on the manual segmentation that would consider other physical features along a project.

20) Is there a key for the colors? [In reference to Drop (Load Level) on the Segmentation Sensors screen].

No there is no key for the colors. However, a key can be added relative to the load levels.

21) How is the speed of backcalculation?

The backcalculation process itself takes very little time to complete; only a couple of seconds.

22) Is there an option to export the individual layer moduli by station? Generally, we like to plot this up as part of our evaluation process for potential rehab.

Yes, the user can import the results into Pavement ME for each station, but needs to define a segment for each station. The backcalculation results are plotted by station, as part of the interpretation of the results for the post-processing stage.

23) Evercalc allows layer thickness to be varied on a basin-by-basin basis. Can this tool do that, or are the layer thicknesses only section averages?

The average layer thicknesses are entered for each segment. If a station is a segment, then the layer thicknesses can be used on a station-by-station basis.

24) Can this application load thicknesses from GPR?

No; not directly. Layer thickness can be entered into the software on a station by station basis, but each station needs to be a separate segment. The original intent in preparing the BcT was to determine the locations or segments with similar pavement structures and deflection basins and then backcalculate the elastic layer moduli for each segment using the average layer thicknesses for each segment.

25) Can lanes be used to allow different structures to be inputted for different lanes in the same test file?

If lane or direction is included in the data file, the data can be sorted by lane and direction, and backcalculation completed separately for each segment and/or lane.

26) Can we use LWD for backcalculation?

LWD deflections and loads can be entered in the BcT, but the accuracy of the calculated elastic layer moduli is dependent on the number of sensors used to measure the deflection basin, as well as the spacing of the sensors. It is recommended that the number of sensors used to define the deflection basin exceed the number of layers included in the pavement simulation by at least 2.

27) Can users use this tool to compute subgrade k-value for rigid pavements, an input for rigid pavement rehab design?

No. The BcT only determines the elastic modulus for each layer, because that is the value used in the Pavement ME software. The k-value can be calculated separately from BcT and that value can be entered into the Pavement ME for rehabilitation design purposes for rigid pavements.

28) Is a field to lab adjustment factor applied?

No. The c-factor or ratio of the laboratory resilient modulus to backcalculated elastic layer modulus is only entered into the Pavement ME software.

29) Are these results saved so they can be reviewed again, or do you go through the backcalculation process again?

The results are saved in a separate file for each project and segment. The files are saved as an intermediate file.

30) Do you need to enter gradation and index properties for the unbound base and subgrade?

Yes. These properties are needed for the Pavement ME runs but not for the BcT runs, so they have to be entered but in the Pavement ME file.

31) Can you use the output from the BcT outside of the AASHTOWare ME? say for viewing the general FWD results?

Yes. The user can review the BcT results separately. The results do not need to be entered into the Pavement ME directly. That is the decision of the user.

32) What was the methodology to determine bound vs unbound material behavior? (Emulsion stabilized reclaim?)

Bound versus unbound layer response is an interpretation of the data itself. We do not believe there are any rules to designate whether a layer is considered a bound or unbound layer. As a rule of thumb, unbound layers typically have elastic moduli less than 80,000 psi, while bound layers exhibit elastic moduli in excess of 100,000 psi. However, unbound layers are typically stress-dependent, while bound layers are usually stress-independent. If the user is trying to determine the layer stress-dependency from the FWD testing, significantly different drop heights must be used in the FWD test program.

33) Can you load a standard EVERCALC deflection file in addition to the FWD files?

Not directly. However, modifications can be made to the BcT program to accept different types of files.

34) What did Idaho DOT use to measure load transfer of transverse cracks on HMA?

FWD testing was completed in accordance with the LTPP test standards for measuring the load transfer efficiency of joints and cracks. A trailing sensor behind the loading plate (-12 inches) was used within the IDT test program.

35) Can LTE and void analysis be redefined by the user?

Yes for load transfer efficiency, but no for the void analysis. The software allows the agency to determine which sensors are to be used for measuring or estimate the load transfer across a joint or crack, for both rigid and flexible pavements. The voids analysis is completed in accordance with the procedure included in the 1993 AASHTO Design Guide.

36) Is there a way to save out pavement sections in the backcalulation tool that could be re-referenced later?

Yes. All files are saved separately. These are included in the intermediate files.

37) Could you re-explain the compensating layer effect and what you are looking for?

Compensating error is defined as the elastic modulus of an unbound layer that is inversely proportional to the elastic modulus of an adjacent unbound layer. It is only used for unbound layers. Two adjacent layers can both increase or decrease because the layers are drying out or becoming wetter. However, it is uncommon for the elastic modulus of one unbound layer to increase and the elastic modulus of an adjacent layer to decrease proportional to the increase of the other layer. This condition suggests that the backcalculation package is within a localized minimum optimization for reducing the standard error between the calculated and measured deflection basins. In other words, EVERCALC is finding a localized solution where the standard error is slightly decreasing continually by decreasing the elastic modulus of an unbound layer while increasing the elastic modulus of the adjacent unbound layer.

38) Can locally developed pavement materials (defaults) be used with BcT? That way the correct materials properties are included in the exported ME file.

Yes, but the program would need to be modified to import the layer properties from the local material library for the designated layer.

39) (Feature request) - It would be nice if you could just copy the layers from the previously identified segment in "structure definition" area.

That feature would be advantageous for the situation or condition where every station is a segment. Few agencies complete a rehabilitation design for every station. This request, however, will be included as an item to be considered in future updates.

40) Is there a limit to the number of drops at a single test location?

No. The user can use as many drops needed from a practical standpoint.