

CHAPTER 604

Pavement Testing and MEPDG

Design Memorandum	Revision Date	Sections Affected
20-01	Jan. 2020	Previously 304-13.0 and 14.0

The design memorandum applicable revision date is noted in brackets next to each section heading below.

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PAVEMENT TESTING AND MEPDG

604-1.0 PAVEMENT TESTING

INDOT does pavement testing to determine strength, cause of failures, and basic forensics. These tests include, but are not limited to:

1. Falling Weight Deflectometer (FWD)
2. Ground Penetrating Radar (GPR)
3. Friction
4. 3D Laser Pavement Condition Survey
5. Coring
6. Geotechnical

604-1.01 Falling Weight Deflectometer (FWD) Testing

The pavement designer should evaluate the need for FWD testing pertaining to concrete, asphalt, or composite pavement. The FWD data is used, but not limited to, evaluating the structural adequacy of an existing pavement section, evaluating pavement shoulder adequacy for temporary traffic, or providing an estimated quantity of underseal to be included in the plans for an existing PCCP over dense graded subbase. The INDOT Deflection Testing Request Form is available on the ITAP website at <https://itap.indot.in.gov/> - Research and Development Testing Website application.

FWD testing must be requested at no later than the 30% stage of plan development (Stage 1). FWD testing cannot be performed during the winter months, typically between late October and late April. This must be considered when requesting the testing. The district should coordinate traffic-control activities for the FWD testing.

604-1.02 Ground Penetrating Radar (GPR) Testing

The pavement designer should evaluate the need for GPR testing pertaining to concrete, asphalt, or composite pavement. The GPR data is used to detect anomalies and moisture under the pavement structure. It is also used to detect drainage systems and reinforcing steel locations. GPR

works best where moisture is present. The INDOT GPR Request Form is available on the Department's ITAP website.

604-1.03 Pavement Friction

Wet weather pavement friction is one of the most important components providing safety on the nation's highways. Pavement friction is provided through two primary characteristics of the pavement surface; microtexture and macrotexture.

“The microtexture is the fine scale texture of the aggregate particles themselves, usually defined as less than 0.5 mm. Microtexture determines the friction of the pavement surface at low speeds. Macrotexture is large scale texture, on the order of 0.5 to 50 mm, provided between the aggregate particles. Macrotexture provides channels through which surface water can flow, providing surface drainage and improving the contact between vehicle tires and the pavement. This texture helps to decrease the chances for a vehicle to hydroplane in wet weather. In general, as the speed of the vehicle increases, the friction decreases, but the rate at which it decreases depends on the pavement macrotexture and how quickly water can be forced out of the tire-pavement interface. Higher macrotexture allows for more rapid drainage of the water and therefore a higher friction value.”

(McDaniel, R. S., *Investigating the Feasibility of Integrating Pavement Friction and Texture Depth Data in Modeling for INDOT PMS*, JTRP SPR-2936, October 2012, p.2.)

The INDOT Research Division annually conducts approximately 6,700 lane-miles of friction testing using ASTM E274 *Standard Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire*, (towed friction trailer). The towed friction trailer uses smooth tires and applies water just in front of the tires as the test progresses at a constant speed, 30, 40, and 50 mph. When the friction number (FN) is below a so-called friction flag value, the District is informed, and the site is visited to determine if remediation is needed. Friction testing may be requested of the INDOT Research Division if the District Pavement Engineer or District Maintenance personnel deem it necessary to help evaluate the pavement for proper treatment

604-1.04 3D Laser Pavement Condition Survey

The pavement designer should evaluate the need to conduct a 3D Laser Pavement Condition Survey based on the condition of the existing concrete, asphalt, or composite pavement. A 3D Laser Condition survey is the process of collecting data to determine the structural integrity, distresses, skid resistance, and overall riding quality of the pavement. A 3D Laser Pavement

Condition Survey provides information to make data driven decisions regarding pavement treatments. The data provided includes:

1. crack density of the pavement to determine pavement rehabilitation candidates;
2. crack severity and GPS location;
3. rutting of asphalt pavements;
4. roughness of pavement and pavement textures;
5. measurement of existing superelevation;
6. pavement geometrics for drainage purposes; and
7. other pavement distresses and their severity

The INDOT 3D Laser Pavement Condition Survey Request Form is available on the Department's ITAP website.

604-1.05 Pavement Coring

The pavement designer should evaluate the need for pavement coring. Cores are required for all pavement rehabilitation projects and the information should be requested in advance of the date it is required for project selection. Cores are used to verify the thickness, composition, structural condition of the existing pavement. They are also used in forensic evaluation of the existing pavement. Forensic cores may need to be tested by INDOT Materials Management for material quality. These tests are to be arranged by the district or Central Office Pavement Engineer. Cores for history or thickness verification should be taken in locations of sound pavement. Cores must be obtained during non-freezing temperature periods due to equipment and safety concerns.

The district should coordinate traffic-control activities for the coring as much as possible. For an LPA project, the LPA is responsible for coring and traffic control. A Core Report should be produced that discusses the findings of the cores and core photographs should be included.

Cores should be located as follows:

1. at least every 0.5 mile in each lane;
2. at select joints with distresses;
3. in existing widened areas where it is obvious there is a different pavement structure than the mainline;
4. at cracks to determine top-down or bottom-up cracking; and
5. at predominant distress locations.

Shoulder cores should be included at each location when:

1. the project is scoped as a Thin Concrete Overlay; and
2. shoulders are to be used for MOT or mainline pavement shifts.

604-1.06 Geotechnical

The geotechnical report should include the following items:

- Description of existing subsurface conditions including groundwater conditions
- Subgrade treatment recommendations
- Pavement Design Parameters (as indicated in the table below)
- Evaluation of Planned Pavement Treatment
- Boring Logs
- Pavement Core Reports
- Lab Testing Reports
- The following table should be included with all applicable data

Soil Parameters for Pavement Design	
Resilient Modulus (MR) of Natural Subgrade – Predominant Soil (psi)	
Resilient Modulus (MR) of Improved Subgrade – Predominant Soil (psi)	
Predominant Soil Type	
Critical Soil Type	
Percent Passing #200	
% Silt	
LL	
PL	
PI	
Depth to Water Table	
Natural Density (pcf) of Natural Subgrade	
% Moisture of Natural Subgrade	
Organic Content	(if encountered)
Marl Content	(if encountered)
Sulfate Content	
Rock elevation	(if encountered)
Filter Fabric Required for Underdrains	
Subgrade Treatment	

604-2.0 MECHANISTIC EMPIRICAL PAVEMENT DESIGN GUIDE

The Mechanistic Empirical Pavement Design Guide (MEPDG), latest INDOT approved version of AASHTO's pavement design guide, should be used for the design of each pavement structure. The design process is based on the predictive performance of a pavement section to be designed to predefined parameters identified as failing. The pavement design itself is an iterative process where the pavement designer selects a cross section for the pavement based on economic benefits, performance, maintenance, and constructability. The objective of pavement design analysis when using the MEPDG process is to make iterative changes to the input parameters identified as important and critical, process the inputs to determine the pavement performance prediction, and compare the pavement-performance prediction with a preset performance requirement. Therefore, more than one cross section design may satisfy the preset performance requirement. The final design must satisfy the performance-indicator criteria (threshold value) and design reliability level for the project and be economically justified.

This section discusses the typical factors and inputs to be used with the MEPDG using AASHTOWare Pavement ME Design software. The organization of the factors and inputs is based on the various sections of the software. Contact the Pavement Design Division for information regarding the currently acceptable version of the software to be used for pavement design projects.

604-2.01 MEPDG General Inputs Using AASHTOWare Pavement ME Design software

1. General Information.
 - a. Design Type. Select from one of three options that the program allows; New Pavement, Overlay and Restoration. If performing alternative analyses, save the project with a different name before changing it to a different design type.
 - b. Pavement Type. When analyzing a new pavement, choices are Flexible Pavement, Jointed Plain Concrete Pavement (JPCP), Semi-Rigid Pavement, and Continuously Reinforced Concrete Pavement (CRCP). When analyzing an overlay, choices are Asphalt Concrete (AC) over AC, AC over Semi-Rigid, AC over JPCP, AC over CRCP, various bonded concrete overlays, and unbounded concrete overlays over AC, JPCP and CRCP. The Restoration design type is for JPCP restoration analysis. The software is only capable of analyzing for one existing pavement type, so when looking at an overlay of an existing HMA over concrete pavement, otherwise referred to as composite pavement, where the existing HMA is not removed in full, there are two ways to set up the analysis as either AC over AC with concrete being seen as crushed stone, or AC over the concrete pavement representing the existing AC as new AC with the properties of the existing pavement.

- c. Minimum Tolerable Design Life for Analysis, Years. Pavement Design Life, for pavement performance periods. Set the initial design life in the program to 30 years for overlays and 50 years for new construction, this should insure the actual mode and time of failure. MEPDG output graphs and figures will depict the time of failure and the corresponding failure mode. It is the responsibility of the pavement designer to review design alternatives from a failure mode and functional life perspective (i.e. IRI, rutting, transverse cracking, and transverse reflective cracking) and ensure that the selected alternative maximizes the cost per lane-mile-year of the pavement structure. It is the ultimate goal and primary purpose of the pavement designer to determine a pavement treatment that yields the least cost of ownership to the Department unless otherwise directed by INDOT pavement staff.

- d. Base Construction/Existing Construction. This is the month and year of the scheduled construction of the granular subbase or prepared subgrade for new pavements or the existing pavement construction year for overlays or restorations. The base construction input is only for a new HMA pavement and is an important parameter used to calculate the predictive performance of the pavement. For an INDOT project, it is to be assumed that the base or subgrade will be constructed in May. The subbase for an asphalt or PCCP pavement will consist of a separation layer and a drainage layer unless otherwise directed. The existing construction month and year would be based upon the initial construction date for concrete pavements or the date for the construction of the layer that is at the bottom of the proposed mill for an HMA pavement.

- e. Pavement Construction Month. This is the month and year of the scheduled placement of the HMA or PCCP. This input is an important parameter used to calculate the predictive performance of the pavement. For an INDOT project, it is to be assumed that the pavement will be constructed in July.

- f. Traffic Open Month: This is the month and year of the scheduled opening to traffic upon completion of the project. This input is an important parameter used to calculate the predictive performance of the pavement. For an INDOT project, it is to be assumed that the pavement will be opened to traffic in September. Traffic Open Month must be more than one month after Pavement Construction Month.

2. Analysis Parameter. The inputs in this section are important and sensitive to the analysis and the final design of the project.
 - a. Initial IRI (in./mi). This is the predictive International Roughness Index for newly-constructed pavement. A typical value is 70 in./mi for both HMA and PCCP surfaces.
 - b. Performance Criteria for Pavement Design. These are the performance criteria used for acceptability of the iterative trials. The threshold values and reliability required for analysis of each project are related to the expected performance of the pavement. These are the most important inputs that the trial design must achieve or exceed. Performance criteria is divided into two types, functional and structural performances. For HMA pavement, unacceptable structural performance is when AC Bottom-Up Fatigue Cracking or Total Rutting does not meet criteria. For PCCP, unacceptable structural performance is when Transverse Slab Cracking or Mean Joint Faulting does not meet criteria. All other performance criteria are considered to be functional.
3. Traffic Inputs. Determine Truck Weight Road Group (TWRG) A, B, C, or D from Item 4.a. below. Prior to importing the AADTT and other inputs such as the number of lanes in the design direction, import the site-specific traffic group data from the traffic input files. See Item 4 for more information related to traffic. Check to make sure the value from the import is correct for the specific project.
4. INDOT Default Traffic-Distribution Input Files. These are available to an INDOT designer within the Citrix drive location for the software through a shortcut under the user name of each designer. The information is also available to a pavement designer outside of INDOT on the Department's website. The user of the software will be able to import the Traffic Volume Adjustment, Axle Load Distribution Factor, and the General Traffic Inputs. Single Axle traffic data should be checked to ensure that the "Total" equal 100 for all rows. If it does not, the Single Axle Distribution file should be re-loaded.

- a. Initial Two-Way AADTT. This value is the Average Annual Daily Truck Traffic (AADTT) after the roadway is opened to traffic or the rehabilitation has been completed. It represents both directions and all lanes. For intersections and roundabouts, the AADTT for the mainline and S-Line are combined. For ramps, one-way roads, and roundabouts, double the AADTT input or increase the % trucks in design direction to 100%. When available, in depth traffic data from a traffic impact study may be used to supplement traffic count information. Traffic is divided into four Truck Weight Road Groups (TWRG), based on the AADTT, as follows:

- 1) TWRG A, $AADTT \leq 3,000$
- 2) TWRG B, $3,000 < AADTT \leq 6,000$
- 3) TWRG C, $6,000 < AADTT \leq 20,000$ AADTT
- 4) TWRG D, $AADTT > 20,000$

The TWRG traffic import should be made before any actual traffic information is entered because it will be overwritten at the time of the import.

- b. Number of Lanes in Design Direction. This is the number of traveled main lanes in the design direction, not including the acceleration, deceleration, or turn lanes.

Example: 4-lane road with 2 lanes east bound and 2 lanes west bound. The input is 2. Check to make sure the value from the import is correct for the specific project.

- c. Percent of Trucks in the Design Direction. This value represents the percentage of trucks in the design direction relative to all trucks using the roadway in both directions. The percent of trucks in the design lane is percent of trucks in the design direction that are expected to travel in the design lane. The design lane, as noted below, is the travel lane for which analysis is being performed. The recommended values are as follows:

- 1) 2-Lane Road, 52%
- 2) 4-Lane Road, 55%
- 3) 6-Lane Road, 55%
- 4) 8-Lane Road, 57%
- 5) 10-Lane Road, 55%
- 6) 12-Lane Road, 54%
- 7) One-Way Road, 100% (Do not double AADTT)

Check to make sure the value from the import is correct for the specific project.

- d. Percent of Trucks in the Design Lane. This value represents the percent of trucks that are FHWA Class 4 and above in the design lane in the design direction relative to all trucks using the roadway in both directions. For multi-lane highways the design lane is the travel lane that is being analyzed. In most cases where the designer chooses the most conservative lane to design for, the design lane is the driving lane as they tend to carry more truck traffic. However, the design lane may be an inside or passing lane in some situations as well (i.e. newly constructed added travel lane). The recommended values for design are as follows:
- 1) 2-Lane Road, 100%
 - 2) 4-Lane Road, 90%
 - 3) 6-Lane Road, 60%
 - 4) 8-Lane Road, 45%
 - 5) 10-Lane Road, 40%
 - 6) 12-Lane Road, 40%
 - 7) 1-Lane Ramp or Street, 100%
 - 8) Multi-Lane Ramp, 90%
 - 9) Multi-Lane One-Way Street, 90%

Check to make sure the value from the import is correct for the specific project.

- e. Operational Speed. This value represents the posted truck speed limit. The posted speed limit should be used for all traffic groups. For intersections and other locations of slow-moving traffic use 10 to 25 mph.
- f. Growth Rate. This value represents the growth of truck traffic during the pavement life. Assuming that the growth rate is uniform over time, the rate of increase remains the same throughout the design period.

The recommended growth method is linear growth. The project-specific Traffic Growth Factor should be used. If the growth rate from the import does not match the given growth rate for the project, the corrected growth rate must be entered for each class of truck. For trafficked pavement shoulder the truck traffic should be 25% of the design lane truck traffic.

If the traffic forecast comes back with a 0% growth rate, use 0.5% for design analysis.

- g. Design Lane Width. This value represents the width of the through lane. The input entry is in the Lateral Wander section of the traffic inputs. The default lane width is set to 12 ft. If the lane width for a specific project is less than 12 ft., enter the correct width. If the lane is a widened lane that is more than 12 ft., e.g., on a single lane ramp, then leave this entry as 12 ft.
 - h. Mean Wheel Location. This value represents the distance from the outer edge of the wheel to the edge of the travel lane. A change in design lane width requires changes to the mean wheel location. If the design lane width is less than 12 feet, the mean wheel location is 12 in. Otherwise, the mean wheel location is 18 in.
 - i. Axle Distributions. Single, tandem, tridem and quad-axle distributions are available for each TRWG and must be imported. The single axle distribution design file should be loaded last.
5. Climate. The climate inputs in the AASHTOWare Pavement ME Design software are based on the project location. Climate files for the United States and Canada are available on the AASHTOWare website. In addition, climate files for each county in Indiana are available to download on the Departments website under the Pavement Division section. A climatic data file must be imported for each specific pavement design project. There are 7 specific climate inputs from 7 weather stations in Indiana, and most are in major cities. There are also weather stations in surrounding states that might be closer to a project. Virtual weather stations can be created. When the latitude and longitude of the project are entered, the software will present the closest weather stations. If a weather station has missing data, this can be corrected.
6. Depth of Water Table. Use the water table depth as shown in the pavement design parameter summary table in the Geotechnical Report, appropriately adjusted for soil types whose capillary action may raise the water table and climactic conditions. An example of climactic conditions would be if soil boring was taken during a drought which would not accurately represent the typical water table. Water table depth is one of the most important parameters in the design that will influence the pavement predicted performance. Therefore, it should be entered as accurately as possible if the water table is shallower than 6 feet. If the water table depth was determined by soil exploration, it might not be the “final water level”, especially in the case of “fill area”. For example, if a roadside ditch line is more than 6 feet deep, the water table cannot be shallower than 6 feet.

604-2.02 Flexible Pavement Layer Design

A flexible pavement system consists of HMA, i.e., Surface, Intermediate, or Base, on a drainage layer, if required, and a separation layer, if required, on a prepared subgrade. A final pavement structure design in the AASHTOWare Pavement ME Design software should include all of the necessary pavement layers shown in typical pavement sections, see Section 602-3.0, Pavement Types. Iterations should be conducted to minimize the HMA thickness of the final pavement design while satisfying the pavement performance prediction for the design life. The optimal design and one failure iteration must be submitted for review for each design.

Each flexible pavement structure design using AASHTOWare Pavement ME Design software should be performed using the specific imports for the District that the project is within. The inputs for the specific PG grade and mixture type being used for each layer is available to an INDOT designer within the Citrix drive location for the software with a shortcut to the files under the user name of each designer. The information is also available to a pavement designer outside of INDOT on the Department's website.

1. Structure.

- a. Surface Shortwave Absorptivity. Use the software default value of 0.85.
- b. Layers. The layer inputs should be based on the INDOT *Standard Specifications* and the figures listed in Section 602-3.0, Pavement Types. A maximum of 6 input layers is supported. The maximum number of input layers that can be asphalt layers is 3. The layer thicknesses should be in accordance with the figures in Section 602-3.0, Pavement Types.
 - 1) Type, Material, and Thickness. These are determined based on the INDOT *Standard Specifications* and the figures listed in Section 602-3.0, Pavement Types.
 - 2) The thickness of any HMA layer should not be at the minimum or maximum lay rate for that material. The designer should target the total thickness of each layer in increments of 2 to 4 times the maximum particle size, preferably 3 times the maximum particle size (4 times the nominal maximum aggregate size).
 - 3) Bedrock. This can be ignored where the depth to it is greater than 20 ft.

- 4) Geosynthetic (e.g., [geotextiles](#), [geogrids](#), [geonets](#), [geomembranes](#), [clay liners](#), [geofoam](#), [geocells](#) and [geocomposites](#), etc.). A geosynthetic layer does not need to be included in the pavement structural analysis unless otherwise directed.
2. Material Properties. The Division of Pavement will maintain input files associated with material properties. For HMA pavement designs, material properties inputs should be set at Level 2 and Level 3 analysis levels. Level 1 analysis is for site specific pavement investigation only. The input files will be available to an INDOT designer within the Citrix drive location for the software with a shortcut to the input files under the user name of each designer. The information is also available to a pavement designer outside of INDOT on the Department's website. The user of the software will be able to import the following from each file:
 - a. dynamic modulus;
 - b. SuperPave Asphalt Binder Test data; and
 - c. asphalt general inputs for 25.0 mm, 19.0 mm, 12.5 mm, 9.5 mm NMAAS, or SMA 9.5 mm NMAAS.
 3. Thermal Cracking. For aggregate coefficient of thermal contraction, the range is from 4×10^{-6} to 8×10^{-6} . Typically, the value for limestone is 6.05×10^{-6} .
 4. ME Design Calibration Factors. Default calibration factors should be used for all performance criteria except AC rutting and Subgrade rutting. AC rutting and Subgrade rutting calibration factors can be found on the Department's Pavement Engineering webpage.

604-2.03 Rigid Pavement Layer Design

A rigid pavement system consists of Portland Cement Concrete Pavement (PCCP) on a drainage layer, if required, and separation layer on a prepared subgrade. A final pavement structure design using the AASHTOWare Pavement ME Design software should include all the necessary layers described Section 602-3.0, Pavement Types. Iterations should be conducted to optimize the structural thicknesses while satisfying the pavement performance prediction for the design life. The optimal design and tone failure iteration must be submitted for review for each design. If the optimization functionality in the software is used, then a screenshot of the optimization results must be submitted with the optimized result. The optimization option only optimizes the PCCP thickness, so separate optimized designs should be created for varying joint spacing or dowel bar sizes. A new rigid-pavement trial should be started by first creating a template identifying all subgrade and pavement layers.

1. **Design Features.** The design feature inputs in the software should be as follows:
 - a. Surface Short-Wave Absorptivity, which is the concrete surface absorptivity value from sunlight. The typical value is 0.85.
 - b. Joint Spacing. This is the parameter in the design that determines the pavement performance predictions as a requirement for the design. A typical range for the joint spacing is 15 to 18 ft. The most economical design is a balance between joint spacing and pavement thickness that satisfies the performance criteria. Ramps pose a unique challenge due to the potential for shorter joint spacing than slab width.
 - c. Sealant Type. Hot-pour asphalt sealant only should be used unless otherwise directed.
 - d. Random Joint Spacing. This technique is no longer used.
 - e. Doweled Transverse Joint. This parameter should be selected in PavementME to reduce joint faulting. A minimum 3 in. concrete cover over dowel bars must be maintained.
 - f. Dowel Diameter. These should be as specified by the pavement designer. The dowel diameter is limited to 1 in., 1 .25 in., and 1 .5 in. The pavement designer must design the dowel diameter to meet joint faulting performance while maintaining 3 in. concrete cover.
 - g. Dowel Bar Spacing. Dowel bar spacing must be 12in. See *Standard Drawing E 503-CCPJ-01*.

- h. Widened Slab. This option should be used if the pavement slab is wider than the travel lane width, such as with a 14 ft slab striped at a 12-ft width. Widened slabs reduce edge stress which in turn reduces the required pavement thickness. For monolithically poured PCC pavement with concrete shoulder, the maximum slab width between longitudinal joints and the pavement edge, or between two longitudinal joints, should not exceed 14 ft. The slab width should be input into the software.
 - i. Tied PCC Shoulder or Curb. This is a project-specific input. For a curb with a minimum 3-ft tie width, analyze in the software as “tied shoulder” if the curb is tied to the adjacent concrete pavement.
 - j. Long Term LTE (Load Transfer Efficiency). This should be 50% to 70% for a sawed joint with tie bar, 30% to 50% for a construction joint with tie bar, or 0% for no tie bar. Use 60% as the typical value. For curb LTE use 50%.
 - k. PCC-Base Interface. Unless specified otherwise, the interface is full-friction contact. This parameter is based on the presence of a drainable granular layer (see AASHTO 1993).
 - l. Erodibility Index. The value for any aggregate subbase is Fairly Erodible (4). The value for cement or asphalt stabilized base is Very Erosion Resistant (2).
 - m. Loss of Full Friction. Use 600 as the typical value (50-year life cycle times 12 months per year).
2. PCC Material Properties. This section requires inputs for the thickness, thermal and mix properties of concrete.
- a. Layer Thickness. This is the thickness of the concrete layer for trial design. The pavement designer should select a trial design thickness based on experience from past projects. The selected trial design thickness should be tested in 0.5-in. increments. If optimization is used, the range of analysis must also be presented. A screen shot of the optimization panel works as sufficient documentation.
 - b. Unit Weight. This is the dry unit weight of concrete based on AASHTO T 121. A typical value is 145 lb/ft³.
 - c. Poisson Ratio. This is based on samples tested using AASHTO C 469. A typical value is 0.20.

- d. Coefficient of Thermal Expansion (CTE). This is the coefficient based on samples tested using AASHTO T336 (for AASHTOWare Pavement ME Design software). A typical range of Indiana CTE for the concrete mix varies from 4.7×10^{-6} to 6.1×10^{-6} . A typical value for concrete mix is 5.4×10^{-6} .
- e. Thermal Conductivity. This is for concrete samples tested using ASTM E 1952. A typical value is 1.25 BTU/h-ft-°F.
- f. Heat Capacity. This is for concrete samples tested using ASTM D 2766. A typical value is 0.28 BTU/lb.-°F.
- g. Cement Type. Select the appropriate cement type that is expected to be used in the project. A recommended selection is Type I cement.
- h. Cementitious Material Content. This value is from a typical mix design in accordance with the INDOT *Standard Specifications*. A typical value of Portland cement content is 400 lb/yd³, the minimum value per *Standard Specifications*. The minimum total cementitious material content is typically 510 lb/yd³. This typically includes supplemental cementitious materials such as fly ash and other SCMs.
- i. Water/Cement Ratio. This value is from a typical mix design from a previous concrete pavement project in accordance with the INDOT *Standard Specifications*. A typical value is 0.42 including supplemental cementitious materials such as fly ash.
- j. Aggregate Type. Select the type of aggregate to be potentially used in the project limits. Limestone is the most common type of aggregate.
- k. PCC Zero-Stress Temperature. This value depends on the Mean Monthly Temperature and Cement content to determine the temperature of PCC zero stress during concrete hardening. The software provides a calculator option to calculate the typical temperature which should be set to True.
- l. Ultimate Shrinkage at 40% Relative Humidity. This value represents the ultimate shrinkage of a concrete sample in 40% relative humidity. The software calculates this value internally. The typical value is 483 microstrain.
- m. Reversible Shrinkage. This value represents the reversible shrinkage of a concrete sample as a percentage of the ultimate shrinkage. The typical value is 50%.

- n. Time to Develop 50% of Ultimate Shrinkage. This value represents the time to develop 50% of the ultimate shrinkage. The typical value is 35 days.
- o. Curing Method. This option depends on the curing method during construction of the concrete pavement. The typical option is Curing Compound.
- p. PCC Strength Properties. This section requires input based on the hierarchical inputs from Level 3 (lowest) to Level 1 (highest). Level 1 is a site-specific input used for pavement investigation only. The strength input for Level 3 is Modulus of Rupture. The value for 28-day Modulus of Rupture is 700 psi. The elastic modulus checkbox should not be checked because the software calculates the elastic modulus internally.

604-2.04 Aggregate Pavement Layer Design

1. Aggregate – Drainage Layer. Denoted as Non-Stabilized Base in PavementME, the purpose of this pavement layer is to move water from underneath the pavement surface and to provide a platform on which to construct the subsequent pavement.
 - a. Non-Stabilized Material. This input is related to the type of granular material to be used in the drainage layer. The typical option is crushed stone, although other materials can be utilized based on geographical area and availability.
 - b. Coefficient of Lateral Pressure, K_o . This is for a representative sample of crushed stone. The typical value is 0.5.
 - c. Thickness. This is the thickness of the drainable granular layer only. The thickness is based on the maximum aggregate size and should be 2 to 4 times the maximum aggregate size.
 - d. Poisson ratio. This is for a representative sample of crushed stone. The typical value is 0.35.
 - e. Resilient Modulus.
 - 1) Input Level. This option requires input based on the hierarchical inputs from Level 3 (lowest) to Level 1 (highest). Level 1 is a site-specific input used for pavement investigation only. Level 2 is to be used when input values are based on testing results. Level 2 combines correlations between

modulus and easily measured material characteristics with detailed condition survey data. Level 3 input values are to be used when input values are typical agency values. Level 3 uses typical published or recommended values for modulus. The typical value is Level 3.

- 2) Analysis Type – Annual Representative Value. This is an option to select a representative sample value for the resilient modulus in this unbound layer. Select this option and input the value shown.
- 3) Material Property – Resilient Modulus. This is the average resilient modulus for the expected in-place granular material based on representative samples. The typical value for Level 3 is 15,000 psi if the layer is unstabilized and is 80,000 psi for a stabilized layer.

2. Aggregate – Separation Layer. Listed as Non-Stabilized Base in Pavement ME, the purpose of this pavement layer is to provide a separation layer, typically compacted aggregate, between the drainage layer and the subgrade soil to eliminate migration of fine particles from the subgrade soil if the pavement includes a drainage layer, or to seal off the subgrade from moisture if using a dense graded compacted aggregate. A geotextile separation layer may be used in lieu of or in addition to an aggregate separation layer based on project needs.

- a. Non-Stabilized Material. This input is related to the type of granular material to be used in the separation layer. The typical option is crushed stone.
- b. Coefficient of Lateral Pressure, K_o . This is for a representative sample of crushed stone. The typical value is 0.5.
- c. Thickness. This is the thickness of the separation layer only. The thickness is based on the maximum aggregate size and should be 2 to 4 times the maximum aggregate size.
- d. Poisson Ratio. This is for a representative sample of crushed stone. The typical value is 0.35.
- e. Resilient Modulus.
 - 1) Input Level. This option requires input based on the hierarchical inputs from Level 3 (lowest) to Level 1 (highest). Level 2 is to be used when input values are based on testing results Level 2 is to be used when input values are based on testing results. Level 2 combines correlations between

modulus and easily measured material characteristics with detailed condition survey data. Level 3 input values are to be used when input values are typical agency values. Level 3 uses typical published or recommended values for modulus. The typical value is Level 3.

- 2) Analysis Type – Annual Representative Value. This is an option to select a representative sample value for the resilient modulus in this unbound layer. Select this option and input the value shown.
 - 3) Material Property – Resilient Modulus. This is the average resilient modulus for the expected in-place granular material based on representative samples. The typical value for Level 3 is 30,000 psi. There should be no adjustment of the modulus due to the addition of geotextile or geogrid in the soil, subbase, or base layers.
- f. Gradation and other engineering properties. The check box indicating that this layer is compacted should be checked.

604-2.05 Subgrade Treatment Layer Design

1. Subgrade Material – Prepared Subgrade Layer and Natural Subgrade Layer. These pavement layers are the bottom layers in the MEPDG pavement design. The function of these layers is to provide a foundation for the subsequent pavement layers. The natural subgrade layer is the untreated in-situ material beneath the fill and subgrade treatment. For chemically modified materials, such as lime or cement modification, these materials are not classified as stabilized materials in MEPDG, rather such materials are treated as compacted subgrade soil with increased modulus values that comes from the Geotechnical Report. If an A-7-6 soil is modified, it should be entered as an A-6 soil in the prepared subgrade layer in MEPDG to approximate the chemical change. The following are the guidelines for inputs in the AASHTOWare Pavement ME Design software.
 - a. Subgrade Material. This option is related to the type of expected soil in the project limits. The type of soil should be obtained from the Geotechnical Investigation Report. The typical type is based on AASHTO classification.
 - b. Coefficient of Lateral Pressure, K_o . This is for a representative sample of crushed stone. The typical value is 0.5.
 - c. Thickness. For the compacted subgrade layer the input value should be in accordance with the Geotechnical Report recommendation and the corresponding

section in *INDOT Standard Specifications*. The natural subgrade is always the bottom most layer and is shown with infinite thickness regardless of any entry for thickness.

- d. Poisson Ratio. This is for a representative sample of crushed stone. The typical value is 0.35.
- e. Resilient Modulus. Resilient modulus testing should be in accordance with AASHTO T307. The resilient modulus for the Prepared Subgrade for new pavement construction should come from the approved geotechnical report for the project. The resilient modulus for the Natural Subgrade for new pavement construction should also come from the approved geotechnical report for the project, however the Integrated Climatic Model (EICM) should be used in conjunction with the Natural Subgrade resilient modulus value provided in the geotechnical report to simulate the soil properties based on varying times of the year. Modulus of Resilience for rehabilitation projects should come from FWD data.
 - 1) Input Level. This option requires input based on the hierarchical inputs from Level 3 (lowest) to Level 1 (highest). Level 1 is a site-specific input used for pavement investigation only. If using data from Geotechnical Report, use Level 2 first. If data is not available, then use Level 3 as default.
 - 2) Analysis Type – Annual Representative Value or Modify input values by Temperature/Moisture. This is an option to select a representative sample value for the resilient modulus in this subgrade layer. Select this option and input the value shown. Annual Representative Value should be used as the input in MEPDG for the Prepared Subgrade. Modify input values by Temperature/Moisture should be used as the input in MEPDG for the Natural Subgrade.
 - 3) Material Property – Resilient Modulus. This is the average resilient modulus for the expected in-place subgrade soil based on representative samples tested at natural moisture content. The default values for Level 3 are based on the selection of the AASHTO soil classification. By selecting the type of soil, the software will provide a default value. For compacted subgrade and natural subgrade layers use Level 2 input and use the values from the Geotechnical Report. There should be no adjustment of the modulus due to addition of geotextile, geogrid, or geocell in the soil, subbase, or base layers.

- f. Gradation and other engineering properties. If the Geotechnical Report is available, the gradation of the given soil type at the project should be used. Information about the Percent Passing #200, Liquid Limit, and Plasticity Index provided in the summary table should be input at a minimum for the subgrade material. The designer has to be careful with these inputs. The PI and the materials passing #200 sieve are the two most sensitive parameters in the predicted pavement performance. The inputs must be as accurate as possible. Also, the check box indicating that this layer is compacted should be checked for prepared subgrade.

604-2.06 Aggregate Subgrade Treatment Layer Design

Non-Stabilized Base. If the Geotechnical Report specifically calls for an aggregate-only prepared subgrade treatment, then the layer is input as a crushed stone but with the modulus from the Geotechnical Report. The check box indicating that the layer is compacted in the Gradation & Other Engineering Properties should be checked.

604-2.07 Chemically Stabilized Pavement Layer Design

1. Chemical Stabilization. This type of stabilization is considered stabilized base in the AASHTOWare Pavement ME Design software. INDOT specifies this as chemical modification which should not be confused with the chemical modification described in the prepared subgrade treatment in Section 604-2.05. However, it is not typically used unless it is specifically required by the Geotechnical Report. The purpose of this pavement layer is to support the subsequent upper pavement structural layers. The strength and properties of the stabilized materials are based on the mix design of the materials. For moderately stabilized materials, such as cement or asphalt stabilizations, these materials should be tested for their strength and physical properties. See INDOT *Standard Specifications* 215.

The following are the guidelines for inputs in the software and are for information purposes only.

- a. **Material Type.** This option is related to the type of expected stabilized material to be used in the project.
- b. **Layer Thickness.** This is the thickness of the stabilized material only, as it is based on trial design. A preliminary value is based on the Geotechnical Report.

- c. Unit Weight. This is the unit weight of the stabilized material. This value is a result of the laboratory testing.
- d. Elastic/Resilient Modulus. This is the modulus of elasticity or the resilient modulus of the stabilized material specified in the Geotechnical Report.
- e. Thermal Conductivity. This is the thermal conductivity of stabilized material. This value is a result of the laboratory testing.
- f. Heat Capacity. This is the heat capacity of the stabilized material. This value is a result of the laboratory testing.

604-2.08 Overlay Design

An overlay pavement system will be constructed on:

1. Flexible (HMA);
2. Rigid (PCCP); or
3. Composite (typically HMA over PCCP).

The existing pavement needs to be evaluated structurally before designing the pavement rehabilitation. A final pavement structure design using the AASHTOWare Pavement ME Design software should include all of the necessary layers shown in Section 602-3.0, Pavement Types. Iterations should be conducted to minimize the overlay thickness while satisfying the pavement performance prediction for the design life.

An HMA overlay should be treated as a flexible pavement structure design. The pavement design analysis should be performed using the specific inputs for the District within which the project resides. The specific PG grade and the mixture type inputs necessary for the project should be used for each layer. This data is available to an INDOT designer within the Citrix drive location for the software with a shortcut to the input files under the user name of each designer. The information is also available to a pavement designer outside of INDOT on the Department's website.

General Instructions to the Designer in Overlay Design Analysis

1. For an asphalt overlay over an existing asphalt layer, on an existing severely cracked concrete layer, the existing concrete layer should be defined as a non-stabilized crushed stone layer. The Resilient Modulus of the crushed stone layer should be determined from FWD test using the average elastic modulus value. There are times when this shows an AC only permanent deformation that is not witnessed in the existing pavements. In this case, it should be looked at as existing concrete with new HMA representing existing HMA with

the existing HMA pavement properties. Both runs should be submitted with the pavement design to show that all design criteria pass testing. As an alternative, crushed stone representing existing concrete pavement may be assigned a resilient modulus of 100,000 psi when AC rutting failure is observed. Typical modulus range for severely cracked concrete pavement varies from 40,000 to 200,000 psi. For the Resilient Modulus input for a project the proposes to use PCCP Cracking and Seating use 500,000 psi, and for PCCP Rubblization use 50,000 psi. For projects the intended to overlay existing pavement that has previously been cracked and seated or rubblized, the modulus of resilience from FWD results should be used.

2. Date of Existing Pavement Construction: This is the date of construction of the existing layer at the bottom of the proposed mill.
3. For AC over AC Overlays, Rehabilitation Level 2 or 3 should be used. The Level chosen is based on how much data is available. Required inputs for each Flexible Rehabilitation Level are as follows:
 - a. Rehabilitation Level 2, milled thickness, interface condition, rut (existing AC) through pavement condition survey, and cracking (%).
 - b. Rehabilitation Level 3, milled thickness, interface condition, and pavement rating through pavement condition survey, e.g., excellent, good, fair, poor, or very poor.
4. All interfaces should be fully bonded if tack is used, i.e., full friction interface value = 1.
5. An FWD test should be requested to be performed on the existing pavement.
6. The reflective cracking performance is presented in a chart of total cracking.
7. Input Level 3 should be used for asphalt material properties of existing asphalt layers.
8. Existing asphalt layers should be combined and input as one existing intermediate or base layer depending upon the post-milling thickness of the existing pavement.
9. For the existing asphalt layer, if measured aggregate gradation in the mix is not available, use recommended gradation information found in the file asphalt concrete (existing).xls, available to an INDOT designer within the Citrix drive location for AASHTOWare Pavement ME Design software with a shortcut to the file under the user name of each designer. The information is also available to a pavement designer outside of INDOT on the Department's website. Cumulative percent passing should be used for aggregate gradation inputs with 0.75-in, 3/8-in, No. 4 and No. 200 sieve sizes. 1/2

10. SuperPave Performance Grade (PG) should be used for asphalt binder inputs of existing asphalt layers constructed after 1996. Prior to that, asphaltic cement grade (AC) should be used.
11. For unbonded JCP over existing composite pavement, remove all existing asphalt overlays and place a minimum 1-in. bond breaker HMA layer on the existing concrete. All existing pavement layers must be structurally analyzed before selecting the pavement treatment. For PCCP over existing HMA pavement, profile milling is needed to smooth out the surface of the existing HMA pavement. Model the pavement cross section as JPCP on existing asphalt pavement. These existing asphalt pavement properties have to follow the cross-sectional properties in the original pavement. Prior to 1996 use AC properties and after 1996 use SuperPave.
12. Resilient Modulus: Do not use the average resilient modulus from the FWD report for the existing HMA layer.
13. The resilient modulus of the subgrade layers should be taken from the FWD report and should be equal to the average modulus of resilience of the subgrade soil. Input Level 2 should be used for the existing subgrade if taken from the FWD and/or Geotechnical report. Do not subtract one standard deviation. The first subgrade layer input into MEPDG should use the resilient modulus value found in FWD testing and should be listed as 12 in. thick while the second subgrade layer should use the Natural Subgrade resilient modulus value listed in the geotechnical report. The second subgrade layer will have a semi-infinite layer thickness. The resilient modulus from the FWD and Geotechnical Report should use the analysis type to Modify input values by Temperature/Moisture.
14. When performing an overlay on existing JPCP, the Foundation Support input is required. The modulus of subgrade reaction is measured if you have an FWD report. Enter the number of the month, e.g., 5 for May 9 for August, etc. in which the FWD was completed. This is found on the first page of the FWD report. The modulus of subgrade reaction is called the Dynamic K-Value of Pavement Support in the FWD report. The average value should be entered. Do not subtract one standard deviation.
15. The pavement designer should analyze and provide, within the pavement design, the expected functional and structural life of each pavement overlay alternative. The pavement designer should determine the functional life based on functional performance criteria in PavementME (i.e. IRI, rutting, transverse cracking, and transverse reflective cracking) as well as the historical performance of similar overlays within the project limits. The pavement designer should also determine the remaining structural life of pavement based on PavementME results as well.

16. Crack spacing on existing cracked CRCP INDOT pavements is generally 24 in.
17. For PCC overlay over PCC pavement, the existing PCC pavement must be structurally analyzed when selecting the pavement. The existing PCC pavement should be structurally sound, or the localized pavement deteriorated areas must be repaired first in order to avoid future premature deteriorations of the new PCC overlay. A minimum 1-in. HMA bond breaker layer must be placed over the existing PCC pavement prior to placing the PCC overlay.
18. Thin Bonded Concrete Overlays: In some instances, it may be cost-effective to overlay an existing HMA, PCCP, or Composite pavement with a Thin Concrete Overlay (TCO) rather than with an HMA overlay. Thin Concrete Overlays have functional lives of 20+ years. ESAL counts are INDOT ESALs and are based on a 20-year design life. Although they are costlier to construct initially, this increased functional life can make them an economical rehabilitation treatment. If the existing pavement structure is in fair condition, or the existing pavement structure is in fair condition after milling operations have been performed, then a TCO may be suitable. The TCO thickness to be constructed can be determined by the effective structural number of the existing pavement as shown in the below table. Thin Concrete Overlays less than 6 in. thick will not be doweled, however 6 in. overlays may be doweled. Instead TCO overlays less than 6 in. thick will require reinforcing fibers be added to the concrete mixture.

Effective Structural # = (Structural # from FWD) – (0.3 * Milling Thickness in inches)

Effective Structural Number	Concrete Overlay Thickness			
	< 1 million ESALs	1 to 3 million ESALs	3 to 5 million ESALs	5 to 10 million ESALs
2.0 - 2.5	4.5	5	5	6*
2.5 - 3.5	4.5	4.5	4.5	5
3.5 - 4.5	4	4	4.5	4.5
> 4.5	4	4	4	4.5

*may include dowels, but does not require dowels to be included