GEORGIA DOT RESEARCH PROJECT 17-24

FINAL REPORT

GEORGIA LONG-TERM PAVEMENT PERFORMANCE (GALTPP) PROGRAM – MAINTAINING GEORGIA'S CALIBRATION SITES AND IDENTIFYING THE POTENTIAL FOR USING MEPDG FOR CHARACTERIZATION OF NON-STANDARD MATERIALS AND METHODS, PHASE 2

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16. Abstract:
The Georgia Department of Transportation (GDOT) has initiated a Georgia long-term pavement performance (GALTPP) program to provide data for the calibration of the Mechanistic-Empirical Pavement Design Guide (MEPDG) and to monitor sites for evaluating the effect of various materials and treatment methods on pavement performance. Phase 2 of the project has 1) expanded the GALTPP database with concrete pavement sites used in the local calibration of the MEPDG, 2) identified and managed special test sites of GDOT's interest, 3) documented and analyzed the data collected from the cold in-place recycling (CIR) and open-graded interlayer (OGI) test sites on State Route 16, and 4) conduct the soil cement pavement performance analysis by comparing the observed pavement performance and the predicted pavement performance. First, the tables and fields for concrete pavement were designed and populated in the GALTPP database. Concrete pavement data collected by ARA from the Georgia calibration (GaCal) sites were acquired, processed, and populated into the corresponding tables designed in the GALTPP database. Second, eighty-seven special test sites, including selected soil cement sites, cold in-place recycling (CIR), open-graded interlayer (OGI), micromilling and thin overlay, etc., were identified, georeferenced, and entered into the GALTPP database. Third, the CIR and OGI test sites on State Route 16 were documented, and the performance prior to the treatment was analyzed using historical COPACE Finally, the soil cement pavement performance was analyzed using historical COPACES data and compared to the predicted pavement performance predicted by the using the MEPDG. The results show fair correlation between the predicted and measured fatigue cracking (R2 = 0.92). The MEPDG mostly overpredicts transverse cracking when the observed cracking is less than 1500 ft per mile and underpredicts when the observed cracking is greater than 1500 ft per mile. The latter case occurs because the MEPDG predicts the maximum transverse cracking at about 1500 ft per mile.

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Final Report

GEORGIA LONG-TERM PAVEMENT PERFORMANCE (GALTPP) PROGRAM – MAINTAINING GEORGIA'S CALIBRATION SITES AND IDENTIFYING THE POTENTIAL FOR USING MEPDG FOR CHARACTERIZATION OF NON-STANDARD MATERIALS AND METHODS PHASE 2

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EXECUTIVE SUMMARY

The Georgia Department of Transportation (GDOT) has initiated a Georgia Long-term Pavement Performance (GALTPP) program to provide data for calibrating the Mechanistic-Empirical Pavement Design Guide (MEPDG) and, more importantly, to monitor sites of GDOT's interest for evaluating the effect of materials and treatment methods on pavement performance. This supports subsequent long-term performance analysis and life-cycle cost analysis for GDOT to use in critically assessing and justifying the application of different pavement maintenance and rehabilitation (M&R) methods for cost-effective annual M&R planning and prioritization. The GALTPP program includes LTPP sites, Georgia's calibration (GaCal) sites, and special test sites, and a GALTPP database serves as a centralized source of the data on these sites. The objectives of Phase 2 are 1) to expand the GALTPP database with concrete pavement sites used in the local calibration of the MEPDG, 2) to identify and manage special test sites of GDOT's interest, 3) to document and analyze the data collected from the cold in-place recycling (CIR) and open-graded interlayer (OGI) test sites on State Route 16, and 4) to conduct the soil cement pavement performance analysis by comparing the observed pavement performance (acquired from historical COPACES data) and the predicted pavement performance (analyzed using the MEPDG). The AASHTOWare Pavement ME Design (hereafter referred as ME Design) software was used for predicting pavement performance in this project. Below are the findings from Phase 2:

1) The GALTPP database tables and fields for concrete pavement sites were designed to store and manage the data collected by ARA at GACal for the initial MEPDG local

calibration (Harold et al., 2016). A GIS project was used with the GALTPP database for visualizing the sites. They are summarized below:

a. A relational GALTPP database with location reference information was designed to host the LTPP, GaCal, and special test sites and store the data related to these different sites. Tables, fields, and relationships among tables (i.e., primary keys and foreign keys) were designed to store and manage the input parameters used in the MEPDG calibration and testing data collected at GaCal sites for easy query and data integrity.

b. Twenty-three concrete pavement sites, including LTPP and GaCal sites, used for previous MEPDG local calibration were stored in the GALTPP database. The MEPDG inputs, as well as the measured distresses, can be easily accessed in support of future validation and calibration of the MEPDG.

c. A GALTPP geodatabase containing the three types of sites was developed; it can be integrated into GDOT's GIS systems.

2) Special test sites with different materials and treatment methods, including soil cement base, cold in-place recycling (CIR), open-graded interlayer (OGI), micromilling and thin overlay, fog seal, crack filling, high friction surface treatment (HFST), and light weight aggregates (alternative treatment of HFST with bauxite and resin) were identified and entered into the GALTPP database. In addition, beyond the scope of this project, the spatial location information of these additional efforts were made to identify and locate special these sites by searching the GeoPI for project numbers and locating projects. Eighty-seven special test sites were georeferenced and entered into the GALTPP database.

3) Field test data, including prior CIR and OGI pavement surface condition data, FDW data, coring data, etc., from the CIR and OGI test sites on State Route 16 were acquired, documented, and entered into GALTPP. The 3D pavement surface data before CIR and OGI application were collected, and the detailed distresses were analyzed to provide a pavement condition reference to support subsequent analysis for treatment timing. Historical COPACES data was analyzed to reveal the long-term pavement performance prior to CIR and OGI application. It shows a pavement has 7 to 8 years of life between a rating of 100 to a rating of 70. This performance can be used as a reference with which to compare the long-term performance of CIR and OGI applications. With the unit cost, the life cycle cost analysis or the new treatment methods can be critically evaluated in the future.
4) The soil cement pavement performance analysis was conducted by comparing the observed pavement performance (acquired from historical COPACES data) and the predicted pavement performance analyzed using the ME Design software. Conclusions are as follows:
    a. Bias has been found in all distresses (transverse cracking, rutting, and IRI) except fatigue cracking.
    b. The ME Design predicts little or no fatigue cracking for these soil cement sites. The results show fair correlation between the predicted and measured fatigue cracking (R2 = 0.92).
    c. The ME Design mostly overpredicts transverse cracking when the observed cracking is less than 1500 ft per mile and underpredicts when the observed

cracking is greater than 1500 ft per mile. The latter case occurs because the ME Design predicts the maximum transverse cracking at about 1500 ft per mile.

d. The ME Design predicted little rutting on these soil cement sites. Poor correlation (R2=0.1) was found between the predicted and measured rut depths.

e. The ME Design overpredicted the IRI. The initial IRI was about 50 in per mile, and, on average, IRI was overpredicted by 70%. Poor correlation ($R2$= 0.07) was found between the predicted and measured IRI.

The following recommendations are made:

1) The GALTPP geodatabase can be integrated into GDOT's existing GIS systems, such as GeoPI, for disseminating the information and better coordinating the work on the GALTPP sites.

2) Pavement distresses on CIR and OGI test sites should continue to be monitored even though the preliminary performance shows that the project rating is 100, and there are no pavement distresses one year after the application of CIR and OGI.

3) There are two changes in the flexible pavement design in the new release of AASHTOWare Pavement ME Design version 2.5. Instead of a constant value, C2 in fatigue cracking is now dependent on the asphalt concrete thickness. The lab test coefficients (B) are used in the model instead of using 1. With these significant changes and the expected calibration tool, it is recommended that GDOT verify the performance using the global coefficients included in Pavement ME Version 2.5.

4) The new ME Design (version 2.5) includes the global coefficients for semi-rigid pavement, which were, for the first time, globally calibrated. Although a large portion of semi-rigid data used for the global calibration were from Virginia, the accuracy of

the predicted distresses should be verified by comparing the predicted distresses with the distresses observed in the field.

5) Because the change to GDOT's pavement data collection approach, full-coverage, 3D pavement data will be available on state routes. The variability and representativeness of the distresses on the test sites can be evaluated using 3D pavement data.

6) Additional test sites (covering common design features used in Georgia) should be included to further verify and calibrate the predicted distresses using the MEPDG.

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1. INTRODUCTION

1.1. Background and Research Need

The Georgia Department of Transportation (GDOT) is in the process of implementing the AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG) developed under the National Cooperative Highway Research Program (NCHRP) Project 1-37A (NCHRP, 2004) for the design of new and rehabilitated pavement structures. The MEPDG models pavement responses (stresses, strains, and deflections) using traffic loading, material properties, and environmental data to compute incremental damage over time, and it empirically relates the cumulative damage to observed pavement distresses using pavement distress and smoothness transfer functions. Therefore, validating and calibrating the transfer functions to local conditions (e.g., designs, materials, and environment) is a crucial step in implementing the MEPDG. As part of the initial implementation efforts, GDOT has undertaken several projects to establish the groundwork for the MEPDG calibration. These include 1) conducting tests to characterize material properties, 2) studying traffic load spectra, 3) establishing a Georgia Long-term Pavement Performance (GALTPP) program to provide data for the MEPDG calibration, and 4) developing user manual for the AASHTOWare Pavement ME Design (hereafter referred as ME Design) software (AASHTO). The GALTPP program includes LTPP sites in Georgia and additional Georgia's calibration sites (referred as GaCal sites) to cover common design features used in Georgia for support of the MEPDG calibration (ARA, 2015a). Besides MEPDG calibration and validation, it is important for GDOT to track special test sites with different pavement designs, materials, and treatment methods to provide the basic information of site location and site characteristics; this test site information enables GDOT to assess the long-term performance of alternative treatment methods in support of GDOT's efforts to achieve cost-effective pavement maintenance and rehabilitation (M&R) planning.

This project consists of three consecutive one-year phases with each phase focusing on one component for maintaining the data collected for the GALTPP program and one specific method and material identified by GDOT. Table 1-1 lists the work by phases. This allows GDOT to prioritize the methods and materials to study in this project and provides the flexibility to study the sites that are relatively new in later phases. Phase 1 of this project focused on developing a GALTPP database for maintaining the data collected from the flexible pavement sites and evaluating the design of pavement structure of Georgia's interstate highways based on the MEPDG (using the ME Design software). Phase 2 focuses on extending the database to the concrete pavement sites and studying the performance of soil cement pavement. Phase 3 will focus on the procedures for incorporating additional special test site data (e.g., performance data). The potential topics for Phase 3 will be determined at the end of Phase 2.

Table 1-1 Work by Phases

	Maintaining GALTPP data	Potential Topics
Phase 1	Flexible pavement sites	Interstate highway
Phase 2	Concrete pavement sites and special test sites	Soil cement pavements
Phase 3	Incorporating research sites	To be determined

While the initial calibration was completed in 2016, it is recognized that the recalibration of the MEPDG is needed as the models are improved, as more distress data become available over time, as new pavement methods and materials are implemented in Georgia, and as testing methods and MEPDG models (e.g., the coefficient of thermal expansion) are improved.

Especially, the initial calibration is based on the sites that have a limited set of standard methods and materials, and it does not cover all materials used by GDOT. For example, soil cement base, one of the bases commonly used in southern Georgia, did not have enough information to be included in the initial calibration. In addition, over the years, GDOT has built test sections with new methods and materials, such as the use of micromilling and thin overlay, cold in-place recycling (CIR), open-graded interlayer (OGI), fog seal, crack filling, and high friction surface treatment (HFST). There is a need to incorporate these special test sites into the GALTPP program to monitor their performance so research outcomes can be used to improve GDOT's practices of pavement design, construction, and maintenance. In addition, these special test sites need to be considered in the implementation of the MEPDG. To pave the way for future calibration efforts, GDOT has identified the following needs:

1) Inclusion of concrete pavement sites used in the MEPDG local calibration;
2) Inclusion of special test sites built with non-standard methods and materials into the GALTPP program in support of GDOT’s long-term performance analysis and life-cycle cost analysis (LCAA) for GDOT’s cost-effective pavement maintenance and rehabilitation planning;
3) Inclusion of pavement techniques that have been critically assessed as alternative maintenance and rehabilitation methods in Georgia, e.g., CIR and OGI, in the GALTPP program to evaluate their performance and benefits and to study the feasibility of applying them as the alternative pavement maintenance and rehabilitation methods in Georgia;

4) Identification of the potential for the characterization of non-standard methods and materials or materials not adequately covered in local calibration (e.g., soil cement base) using the ME Design to provide suggestions on the calibration of these sites.

1.2. Significance of Research

Maintaining the data collected for the GALTPP program will allow GDOT to track and share data collected from sites that have different designs, materials, construction methods, and maintenance levels; this will support GDOT's long-term pavement performance analysis and life-cycle cost analysis for pavement maintenance and rehabilitation planning and pavement management. The GALTPP database and GIS project will serve as one of the most important sources of data for further validation and calibration of the MEPDG models and for evaluating the effects of different pavement designs, materials, etc. The outcomes/findings can be used to improve GDOT's practices for pavement design, material selection, construction methods, and maintenance strategies. In addition, the outcomes' impact on the potential for characterizing non-standard (special) methods and materials used in Georgia will enable GDOT to better utilize the MEPDG for understanding distresses based on different designs and materials. The terms "non-standard" and "special test sites" are used interchangeably in this report.

1.3. Research Objectives and Scope

The objectives of Phase 2 of the project are 1) to expand the GALTPP database with concrete pavement sites used in the local calibration of the MEPDG, 2) to identify and manage special test sites of GDOT's interest, 3) to document and analyze the data collected from the cold in-place recycling (CIR) and open-graded interlayer (OGI) test sites on State Route 16, and 4) to conduct the soil cement pavement performance analysis by comparing the observed pavement performance (acquired from historical COPACES data) and the predicted pavement performance (analyzed using the ME Design). Four research tasks are included in Phase 2. The specific activities to be performed under each work task are presented below:

1) Work Task 1: Manage the data collected at GACal concrete sites and incorporate additional special test sites.

   In this task, the Georgia Tech research team acquired the data, including FWD, LTPP distress survey data, and coring data collected at GACal sites, and processed and integrated the data into a geodatabase that can be easily integrated into GDOT's existing GIS systems.

2) Work Task 2: Collect, process, and manage the data collected at the CIR and OGI test sites, including the analysis of the historical COPACES data, on State Route 16.

   To study the performance of two pavement techniques (CIR and OGI) GDOT has conducted a test project on State Route 16 in Coweta County, Georgia. Five sites were selected to assess these two types of pavement techniques. OGI was applied in all travel lanes in this project. CIR, on the other hand, was only applied to a small portion of this section in passing and/or left turn lanes. The Georgia Tech research team collected, processed, and managed the data, collected at the CIR and OGI test sites.

3) Work Task 3: Characterize Georgia's cement-treated base materials to support a local calibration of the distress transfer functions in the MEPDG

   This work task is to critically assess the applicability of the global coefficients for soil cement pavement designs and to develop a detailed plan for a local calibration for soil cement-flexible pavement. The distresses predicted using the MEPDG were compared to the observed distresses (based on COPACES data) to assess applicability of the MEPDG for soil cement pavements in Georgia, and recommendations will be made for further local calibration.

4) Work Task 4: Summarize research findings.

This task documents, organizes, summarizes, and disseminates research findings obtained in the previous work tasks. The GAPLTPP database is in a geodatabase format that can be opened using desktop ArcGIS.

1.4. Organization of This Report

This report is organized as follows:

1) Chapter 1 introduces the background, significance, scope, objectives, and work tasks of this project.
2) Chapter 2 presents the management of GALTPP data, especially the addition of special test sites into the GALTPP geodatabase. It includes the spatial location reference and general description of these special test sites.
3) Chapter 3 presents the data collection, processing, and management of CIR and OGI test sites on State Route 16 in detail, which will support the subsequent long-term performance analysis to critically assess and justify the suitability of applying CIR and OGI on Georgia roadways. This chapter presents the test sites information, including route, location, lane, and direction. Before and after pavement performance using COAPCES ratings is also analyzed. The detailed pre-treatment conditions, including field tests and data collected, such as cores, falling weight deflectometer (FWD), and LCMS, are presented. The 3D pavement surface data on the pavement distresses prior to CIR and

OGI treatments is also presented. The procedures for the CIR and OGI on SR 16 are summarized.

4) Chapter 4 presents the soil cement pavement analysis. First, the soil cement pavement sites are presented. Second, the observed pavement performance is analyzed using historical COPACES data. Third, the pavement performance is predicted using the MEPDG. Finally, the observed and predicted pavement performance are compared and discussed.
5) Chapter 5 summarizes the findings of this project and makes recommendations.

2. MANAGEMENT OF GALTPP DATA

2.1. Overview of the GALTPP Program

The Georgia Long-term Pavement Performance (GALTPP) program was initiated by GDOT to provide a sufficient number of sites for the initial MEPDG local calibration, and, more importantly, to conduct long-term performance monitoring on the sites of GDOT's interest to support the performance evaluation and/or future MEPDG recalibration. The GALTPP program comprises three type of sites: LTPP sites in Georgia, Georgia's calibration (GaCal) sites, and special test sites. Both LTPP and GaCal sites were used for the initial location calibration of the MEPDG conducted by ARA (Harold et al., 2016). Though the initial calibration was completed, it is recognized that the recalibration of the MEPDG is still needed in the future as MEPDG performance models (e.g., reflective cracking model) are improved, as more distress data becomes available over time, and as new pavement methods and materials are implemented in Georgia. The rich data collected on the GALTPP sites (both LTPP and GaCal sites) are valuable to GDOT and essential for support of MEPDG recalibration in the future. Therefore, the GALTPP program includes both LTPP and GaCal sites. Besides these sites, the GALTPP program includes special test site(s) for evaluating the effects of different designs, materials, construction methods, maintenance levels, etc., on pavement performance. Phase 2 of this project have 1) expanded the GALTPP database with concrete pavement sites used in the local calibration of the MEPDG and 2) identified and managed special test sites of GDOT's interest. Figure 2-1 shows a map of the sites included in the GALTPP program, and Table 2-1 summarizes the three types of sites.

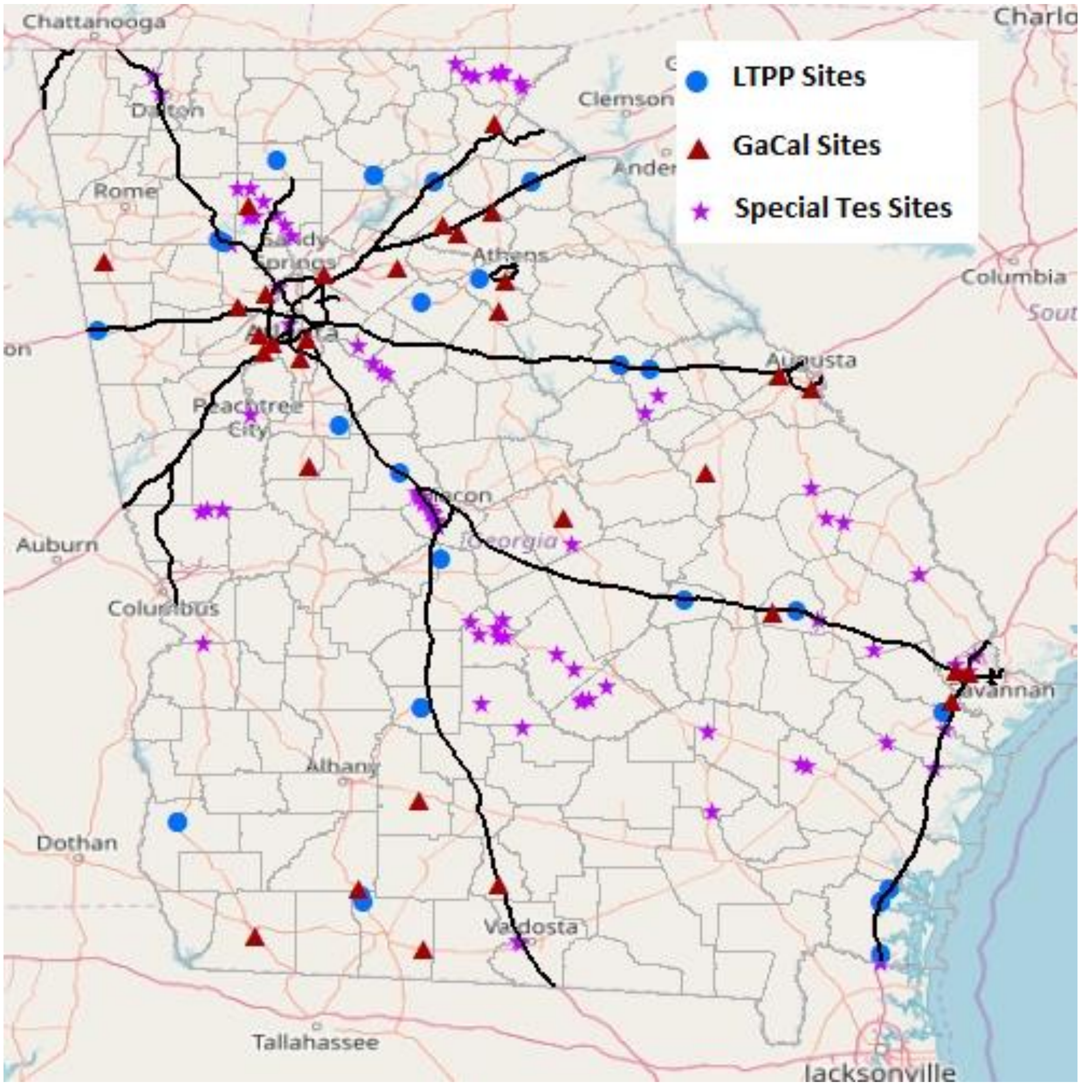


Figure 2-1 A map of the GALTPP sites

Table 2-1 Summary of the GALTPP sites

Site Type	Flexible pavement sites	Rigid pavement sites		Sub total
		Jointed plain concrete pavement (JPCP)	Continuous reinforced concrete pavement (CRCP)	
LTPP sites	17	9	2	28
GaCal sites	21	12	0	33
Sub total	38	21	2	
Special test sites	87			87

Currently, the GALTPP program comprises 28 LTPP sites and 33 GaCal sites. The 28 LTPP sites include 17 flexible pavement sites and 11 concrete pavement sites located in Georgia;

each site is about 500 ft long. Comprehensive information, including site information, construction history, traffic load, pavement design (i.e., layer structure), material properties, and distresses, on LTPP sites are available in the LTPP program. It is noted that distress surveys were conducted by the LTPP contractor based on the LTPP Distress Identification Manual (FHWA, 2003).

The 28 LTPP sites are insufficient to cover the range of pavement structures, materials, and other design features commonly used by GDOT, and the levels of distress exhibited on these LTPP sites are inadequate for the MEPDG local calibration. Therefore, additional 33 GaCal sites (21 flexible pavement sites and 12 concrete pavement sites) were selected in 2014 based on the pavement design and distresses to support the local calibration. Limited field and laboratory testing, including condition surveys in accordance with LTPP Distress Identification Manual (FHWA, 2003), core, falling weight deflectometer (FWD), dynamic cone penetration (DCP) tests of the base and subgrade, bulk specific gravity measured on each layer, etc., were conducted on the GaCal sites to obtain the layer thickness and material properties for the MEPDG inputs. It is noted that the pavement condition survey based on the LTPP distress protocol (FHWA, 2003) was conducted only once in 2014 by ARA (Harold et al., 2016). Historical COPACES data on GaCal sites were converted into the distresses predicted by the MEPDG (including fatigue cracking, transverse cracking, etc.) for the validation and calibration of the MEPDG (Tsai and Wu, 2016).

Special test sites refer to sites GDOT constructed with specific materials (e.g., HFST), construction methods (e.g., micromilling), and treatment methods (e.g., crack filling, fog seal, CIR, and OGI) for evaluating their long-term performance. Compared to LTPP and GaCal sites, there are very limited data available on these sites. Some sites may be associated with research project(s). There is a need to keep track of these special research projects so their long-term performance can be evaluated.

2.2. Design of the GALTPP Database

A database is used to store and organize various data collected for the GALTPP program and to manage the data efficiently. A GALTPP database has been established to serve as a centralized source of the GALTPP data. The GALTPP database is a relational database composed of separate, but related, tables of data. All data is stored in a simple row/column format. Each row is uniquely identified by a primary key (often a combination of columns, e.g., GALTPP_ID and CONSTRCTION_NO). In addition, relationships exist among the tables. Relationships are associations between tables that enable you to retrieve and combine data from one or more tables. For example, many tables contain a GALTPP_ID column used to locate data for a specific site in different tables. The GALTPP database was designed to do the following:

- Store and manage LTPP, GaCal, and special test sites that serve different purposes;
- Provide easy access to the inputs and measured distresses used for the MEPDG local calibration;
- Provide spatial information for each site so it can be integrated into a GIS geodatabase;
- Add additional sites in the future when available;
- Be consistent with the LTPP database where possible.

While the GALTPP database was designed to be consistent with the LTPP database when possible, the GALTPP database is not intended to duplicate the completed LTPP database. Instead, it was designed to provide easy access and management of the inputs and distresses used for the MEPDG calibration and to provide the flexibility to track the long-term performance of the special test sites. The design of the GALTPP database involved identifying data elements to be stored, designing a database architecture that relates foreign and primary keys and table structures. Figure 2-2 describes the schema and relationships of the GALTPP database. Appendix A lists the tables in the GALTPP database.

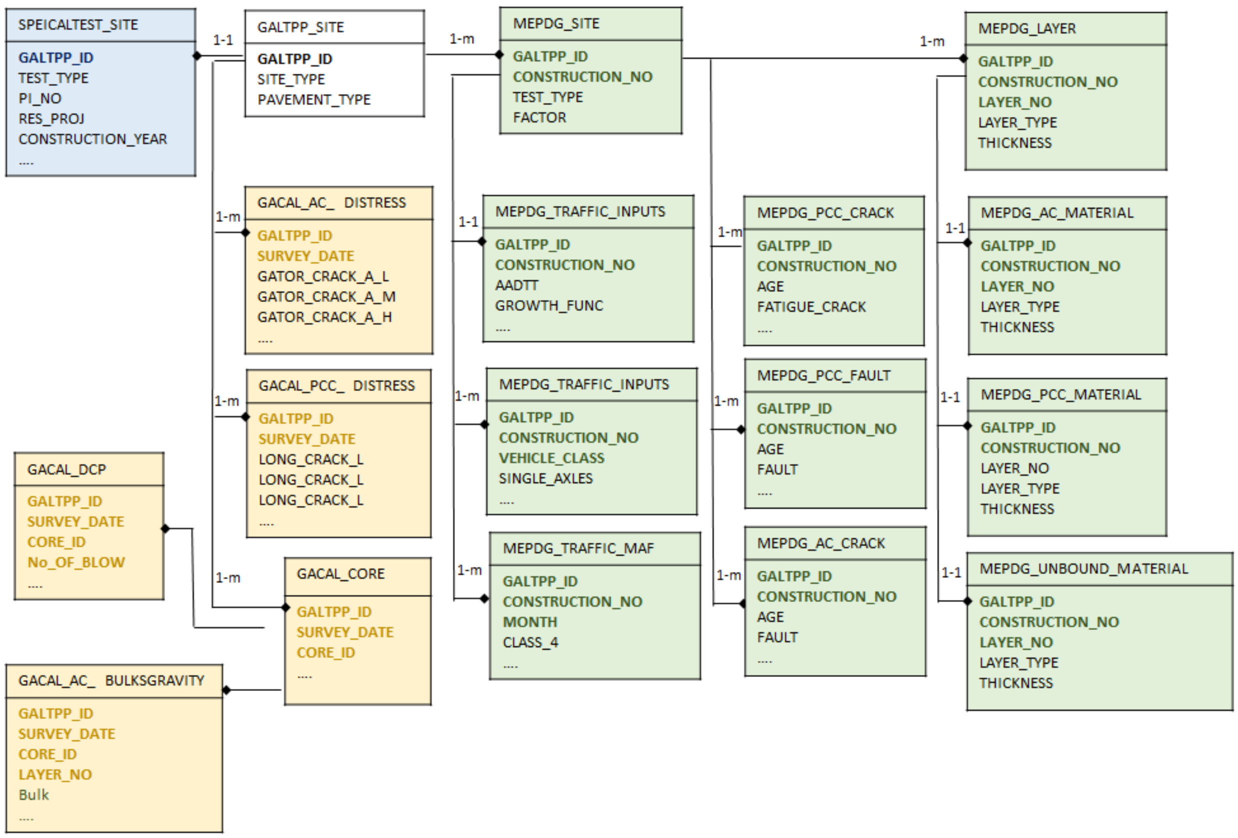


Figure 2-2 Illustration of GALTPP database schema

- A master table (GALTPP_SITE) serves as a container for all three types of sites (LTPP, GaCal, and special test sites); it includes the basic information of these sites, such as site type, pavement type, and location information (e.g., route number, county, milepoint, and coordinates). A primary key, GALTPP_ID, uniquely identifies a site in the GALTPP database.

- For special test sites, a separate site information table (SPECIALTEST_SITE) was designed to store the characteristics of the site, such as the type of test (e.g., CIR, OGI, HFST, etc.), project number, associated research project(s), year of construction, etc.The table can be expanded to include additional information identified later.
- For LTPP and GaCal sites, a table (MEPDG_SITE) was designed to store the site information, including the type of test (e.g., new design or rehabilitation), sampling factors (e.g., PMA vs. Neat, thickness, etc.), the date open to traffic, etc. A field, CONSTRUCTION_NO, is used to differentiate the pavement cycle on the same site. A value of 1 typically represents a new construction; a value greater than one represents rehabilitation. The combination of GALTPP_ID and CONSTRUCTION_NO is the primary key for uniquely identifying a specific new design or rehabilitation on a site.
- A set of tables with a MEPDG prefix stores 1) the inputs (including traffic, layer structure, and layer properties) for predicting the distresses and 2) the measured distresses for validation and calibration. While much of the data is derived from the LTPP database, the MEPDG tables were created for easy access and management of the ME Design inputs. First, a table (MEPDG_LAYER) was designed to store layer structure modeled in the ME Design. Second, a set of tables were designed to store layer properties used in the ME Design. For example, the asphalt concrete properties of air void and gradation are stored in different tables in the LTPP database. It would provide the user easy access if all the material properties were stored in limited table (e.g., MEPDG_AC_MATERIAL and MEPDG_UNBOUND_MATERIAL). Third, a set of tables were designed to store various traffic inputs used in the ME Design (e.g., MEPDG_TRAFFIC_INPUT, MEPDG_TRAFFIC_AXLES, MEPDG_TRAFFIC_MAF, etc.). In addition, the

distresses predicted by the ME Design can be a combination of LTPP distresses. Fatigue cracking predicted by the MEPDG includes both fatigue cracking and longitudinal cracking in the wheelpaths defined in the LTPP distress protocol. Therefore, a set of tables were designed to store in the observed distresses that were converted from the LTPP distress data or historical COPACES data.

- A set of tables with a GaCal prefix are included to store field tests conducted on the GaCal sites, including dynamic cone penetration tests (GACAL_DCP), cores (GACAL_CORE, GACAL_CORE_MEASURE, etc.). Additional tables can be added for different tests.
- Additional tables (e.g., GACAL_FILE, GACAL_IMAGE, etc.) were designed to store the images, documentation, and files related to each site.

2.3. Populating GALTPP Database

The data of the 33 GaCal sites (21 flexible pavement sites and 12 concrete pavement sites) were acquired from the ARA. The majority of the data are stored in Excel files. Additional efforts were made to go through each file, organize and extract the data needed for site, and enter the data into the associated tables. For example, nine dynamic cone penetration test data were stored on one work sheet with figures for each site. The data were extracted and organized into one table format so the data can be imported into the GALTPP database.

The MEPDG inputs for LTPP and GaCal sites used for the initial location calibration by ARA were obtained by manually going through the input values specified in the report (ARA, 2016) and the MEPDG files. Traffic, layer structures, layer properties, and distress data were populated in corresponding tables (e.g., MEPDG_LAYER, MEPDG_PCC_MATERIAL,

MEPDG_AC_MATERIAL, MEPDG_UNBOUND_MATERIAL, MEPDG _TRAFFIC, MEPDG_TRAFFIC, etc.

The special test site data gathered in Phase 2 include cold in-place recycling (CIR), open graded interlayer (OGI), micromilling and thin overlay, fog seal, crack filling, high friction surface treatment (HFST), light aggregate asphalts, and soil cement sites. Table 2-2 lists the special test sites. Additional efforts were also made to search the project number and, more importantly, the special test sites using GeoPI. The project location information was typically available in text format (e.g., SR 27/US 341 FM 4700' SE/CR 266 TO WEST CL/CHAUNCEY) without RCLINK and milepoints for georeferencing the site. For soil cement sites, a list of projects with old or sometimes incomplete project numbers was provided. Using available information, the research team searched GeoPI for the project number and project location information. Then, the project location was determined by manually identifying the intersecting routes on a map. Figure 2-2 shows the GIS map of the special test site locations. The test sites include alternative maintenance and rehabilitation, such as micromilling and thin overlay, CIR, OGI, fog seal, crack filling, HFST, and soil cement base. The GIS map and the information above provide important information for GDOT to use when studying the long-term performance of these alternative treatment methods. The long-term performance and life-cycle costs of these treatment methods are critical for GDOT's cost-effective annual maintenance and rehabilitation planning and pavement management.

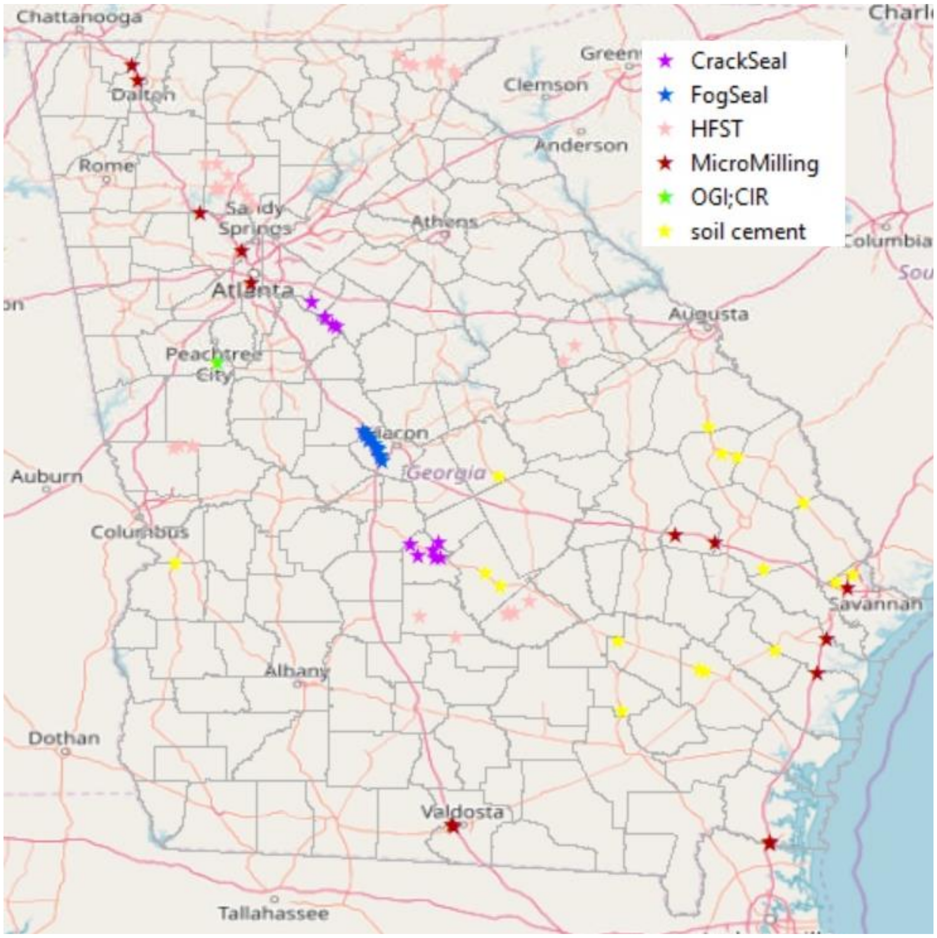


Figure 2-2 Special test site locations

2.4. GALTPP GIS Integration

With the geodatabase, the GALTPP sites can be easily integrated into GDOT's GIS systems (such GeoPi) and/or GIS software (such as ArcGIS). The integration allows the users to visualize the geographic distribution of candidate sites and to perform spatial query/selection on the sites. The integration into GDOT's GIS systems can, also, facilitate the communication among different parties and streamline coordination among GDOT's offices. The functions in the GIS systems are described below:

- Case 1: Visualize various data

Using GDOT's LRS and the dynamic segmentation function in GIS, COPACES and CPACES data were spatially integrated onto a map with other data, such as traffic data and soil data. GDOT's engineers can navigate the map to visualize information on the map, as shown in Figure 2-2. With their knowledge of Georgia's soil, weather, and pavement conditions, GDOT engineers can effectively identify any issue in the geographic distribution of the GALTPP sites. For example, the distribution of the sites in northern and southern Georgia may be a concern for the GALTPP sites because of the significant differences in the geologic conditions. In addition, a cluster of sites in certain areas (e.g., in one district) can be identified effectively

- Case 2: Facilitate the communication among different offices

  Coordination among GDOT's offices is essential for maintaining the GALTPP sites. For example, it is likely some of the sites will be resurfaced in the near future, and these activities should be coordinated among the Office of Materials and Testing, and the Office of Maintenance. Integrating GALTPP geodatabase into GDOT's GIS systems, such as GeoPi, can help facilitate the communication among different offices. For example, using GeoPi, the users can overlay project and GALTPP sites to identify (or flag) any GALTPP sites within a specific project and coordinate the work on the GALTPP sites. The Office of Materials and Testing can check the coming work on the GALTPP sites and conduct data collection in advance.

- Case 3: Extract information using spatial analysis

  One of the advantages of GIS is its capability to perform spatial analysis. For example, the subgrade soil characterization can be extracted by superimposing the GALTPP sites on the soil maps (e.g. NCHRP 9-23A soil maps) to find the corresponding alphanumeric soil unit code. This function can be extended to extract other information if the data is available.

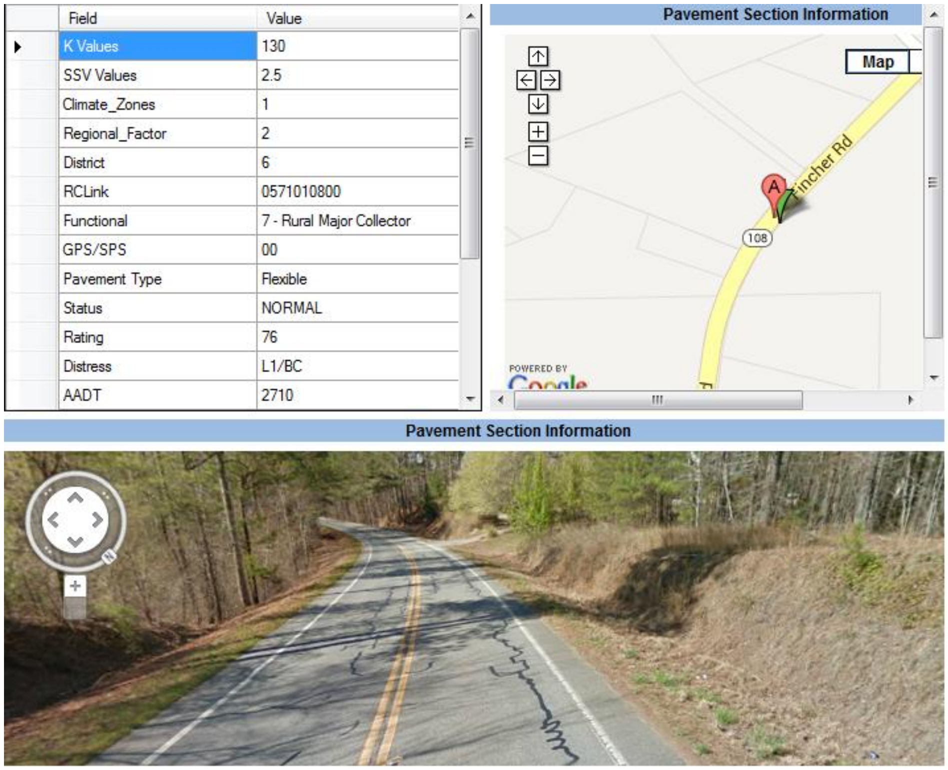


Figure 2-3 An example of roadway images that can be accessed using GIS function

3. COLD IN-PLACE RECYCLING (CIR) AND OPEN-GRADED INTERLAYER (OGI) TEST SITES ON SR 16

GDOT has tested two pavement maintenance and rehabilitation methods, cold in-place recycling (CIR) and open-graded interlayer (OGI), on State Route 16 in Coweta County, Georgia to evaluate the suitability of applying OGI and CIR to Georgia roadways. This chapter presents the data collection, processing, and management of CIR and OGI test sites on State Route 16. The goal is to document the detailed pavement design, construction information, tests, and pavement condition data in support of the subsequent long-term performance analysis to critically assess and justify the suitability of applying CIR and OGI on Georgia roadways. This chapter first describes the information from the test sites, including route, location, lane, and direction. The second section presents the pavement performance prior to CIR and OGI treatment and summarizes the data collected for pre-treatment conditions, including field tests, such as cores, falling weight deflectometer (FWD), and 3D pavement data. Pavement ratings of road segments in which these sites located are also summarized. The third and fourth sections summarize the procedures for the CIR and OGI, respectively. The fifth section summarizes the data collected after CIR and OGI treatment.

3.1. Site Information

GDOT has tested CIR and OGI on a small section of State Route 16 in Coweta County, Georgia. OGI was applied in all travel lanes in this project. CIR, on the other hand, was only applied to a small portion of this section in the passing and/or left turn lanes. During a field visit with GDOT's engineers, five sites were selected for monitoring the performance of CIR and OGI on

State Route 16. The five selected sites span a 1.5-mile section on State Route 16 between Milepoints 25 and 26.5, as shown in Figure 3-1. Detailed site information, including route, direction, milepost, lane, and treatments are summarized in Table 3-1.

Figure 3-1 Test site location

Table 3-1 Test Site Information

Site #	Route	Direction	Milepoint	Lane	M&R method
1	SR16	WB	26.5	Travel Lane	OGI
2	SR16	WB	26.3	Left Turn Lane	CIR (Control)
3	SR16	WB	26.1	Passing Lane	CIR (Test)
4	SR16	WB	25.6	Center/Left Turn Lane	CIR (Test)
5	SR16	EB	24.9	Travel Lane	OGI

Pavement designs of this section are shown in Figure 3-3. As shown in the figure, this road section was built in the late 1930’s and was later widened in the 1990’s. The asphalt layer thickness ranges from 8 in. to 10 in.

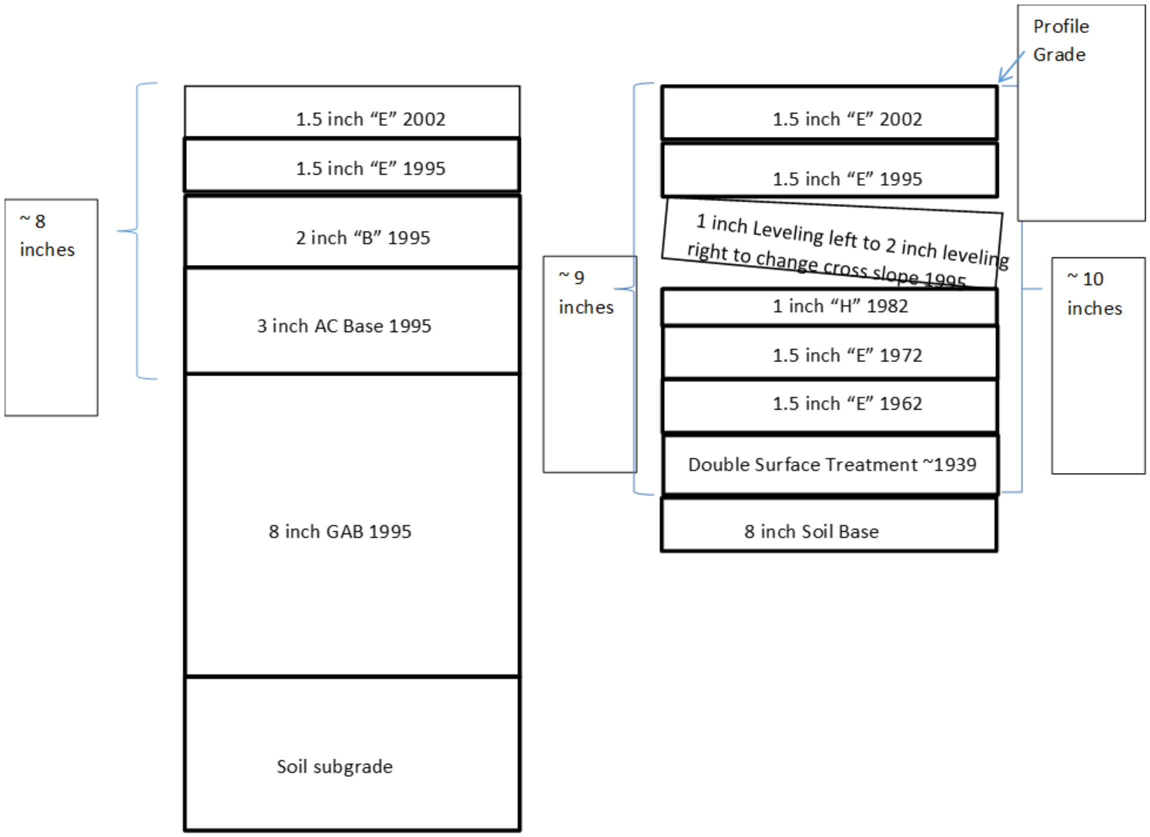


Figure 3-2 Illustration of pavement designs of travel lane (left) and passing lane (right)

3.2. Data Collected before CIR and OGI

This section presents historical COPACES data and various field test data collected on the sites prior to CIR and OGI treatment. Historical COPACES data were analyzed to evaluate the pavement performance on State Route 16 prior to CIR and OGI treatment. This performance can be used as a reference with which to compare the long-term performance of CIR and OGI applications. In addition, field test data, including 3D pavement data, core, and FWD data were documented.

3.2.1. Performance base on historical COPACES data

Historical COAPCES data were acquired and analyzed to evaluate the performance on this section of pavement. It is noted that there is no COPACES data yet after the completion of CIR and OGI treatment in 2016; a rating of 105 (i.e., under construction) was recorded in 2017 and 2018. A review of historical COPACES data shows this section of pavement was last resurfaced in 2000. The rating dropped below 75 in 2007. It took approximately 7 to 8 years for the project rating to drop from 100 in 2000 to 70 in 2007 or 2008. This provides a performance reference for evaluating the performance after applying CIR and OGI. However, this section of pavement was not resurfaced until 2016 when the rating was in the 40s. The treatment has been delayed significantly for almost 8 years (from 2008 to 2016). Thus this section is ideal for assessing the performance of CIR and OGI as severe crack relief and as an effective crack treatment.

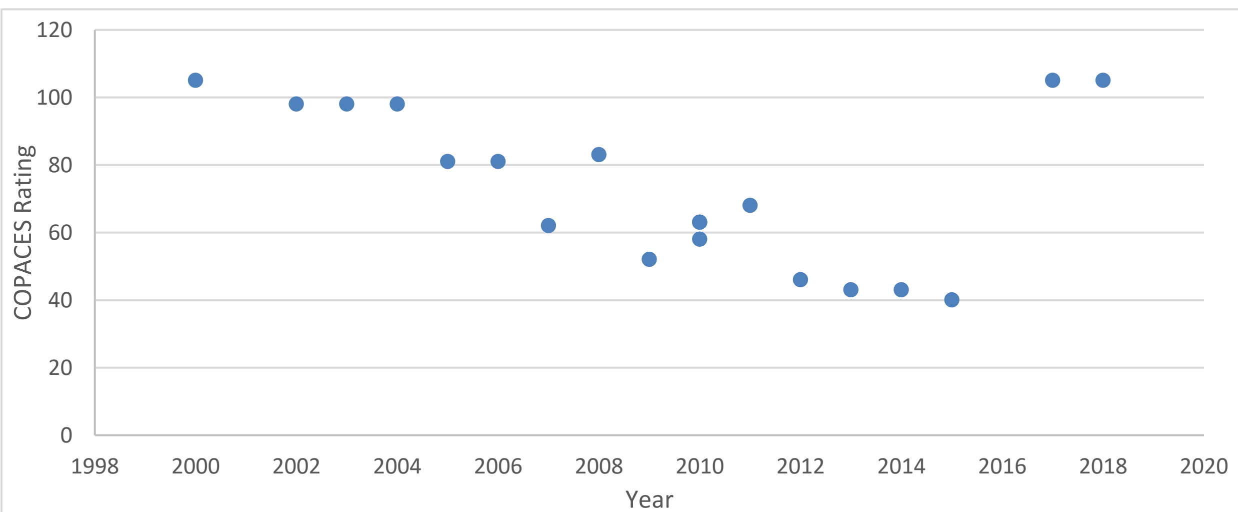
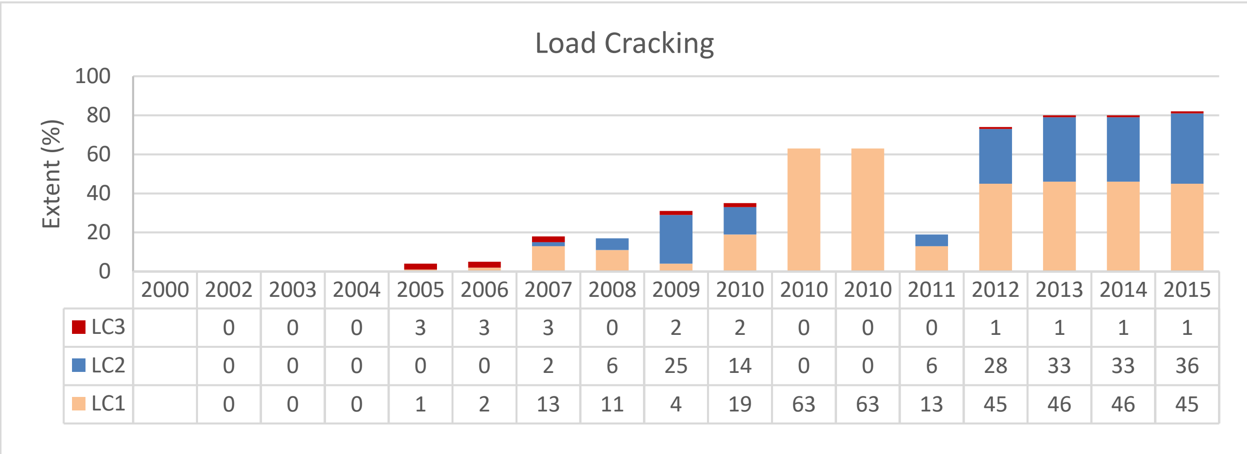


Figure 3-3 Historical COPACES data on State Route 16

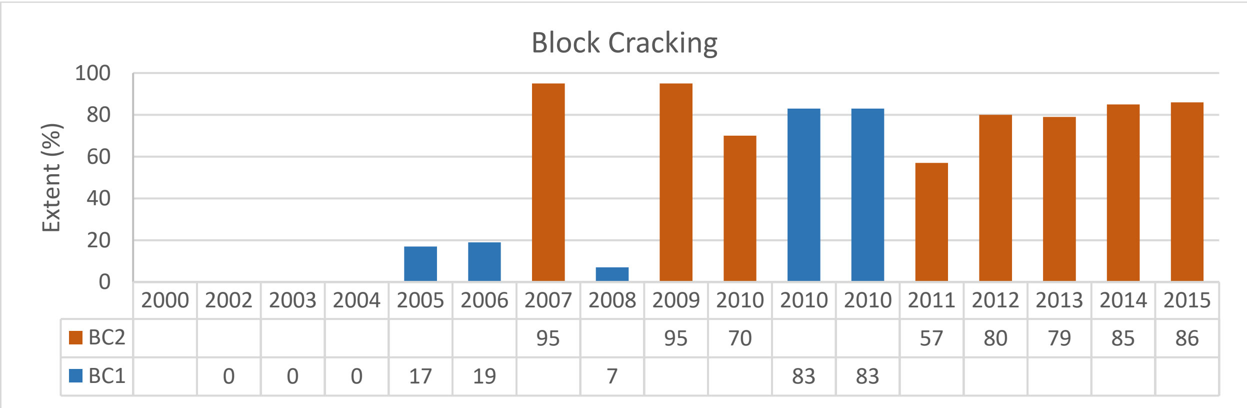
The extents of load cracking and block cracking are shown in Figure 3-4 and Figure 3-5. Limited load cracking was first reported in 2005 (5 years after resurfacing). Level 2 load cracking had been reported since 2007. Prior to CIR and OGI treatment, 80% of load cracking

(Levels 1, 2, and 3) was reported on the section. Block cracking was first reported in 2005. Extensive block cracking had been reported since 2007. Extensive Level 2 block cracking was reported in 2015 prior to CIR and OGI treatment.



	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010	2010	2010	2011	2012	2013	2014	2015
LC3		0	0	0	3	3	3	0	2	2	0	0	0	1	1	1	1
LC2		0	0	0	0	0	2	6	25	14	0	0	6	28	33	33	36
LC1		0	0	0	1	2	13	11	4	19	63	63	13	45	46	46	45

Figure 3-4 Load cracking before CIR and OGI treatment



	2000	2002	2003	2004	2005	2006	2007	2008	2009	2010	2010	2010	2011	2012	2013	2014	2015
BC2							95		95	70			57	80	79	85	86
BC1		0	0	0	17	19		7			83	83					

Figure 3-5 Block cracking before CIR and OGI treatment

Pavement conditions of the segments in which the test sites located are depicted in Figure 3-6. All segments selected have extensive pavement cracks, including load cracking, transverse and block cracking, and some reflective cracking. The segment between Milepoints 26 and 27 (e.g., Sites 1 and 2) has worse pavement conditions than other selected sites. Severe load cracking and block cracking can be observed in this segment. Similar but better conditions can be observed in the segments between Milepoints 24 and 26 (e.g., Sites 3, 4, and 5).

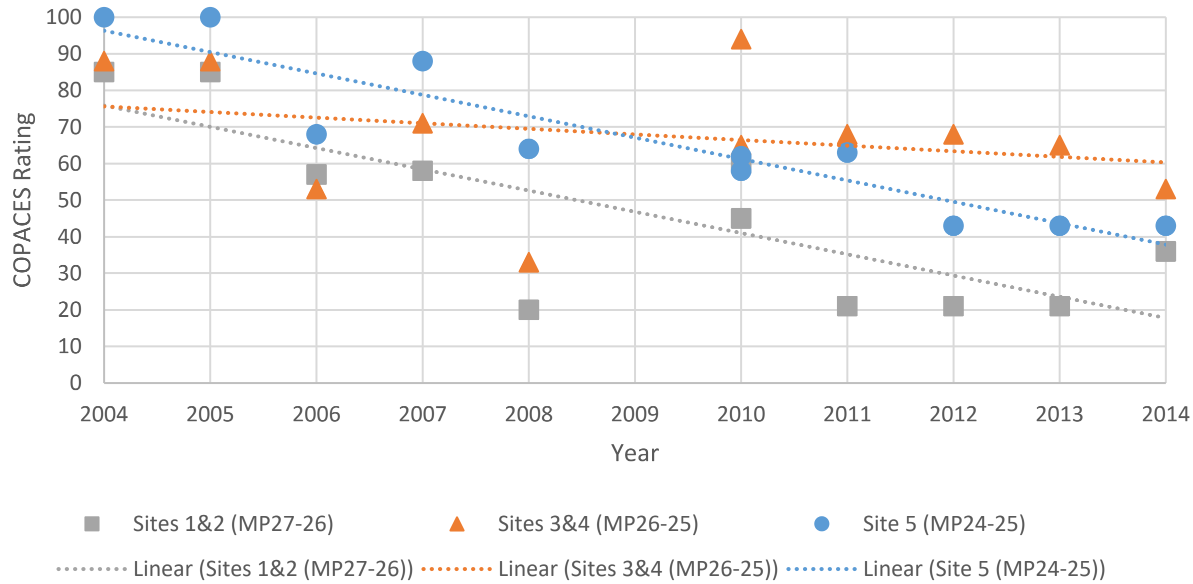


Figure 3-6 Segment-level COPACES Ratings on State Route 16

3.2.2. Field Test Data

- 3D pavement data

  The 3D laser technology is a line laser system that collects high-resolution 3D range data of pavement surfaces. Using the collected 3D pavement data, pavement surface distresses can be closely evaluated. Pavement distresses, including rut depth, load cracking, block cracking, and transverse cracking, were inspected. Table 3-2 summarizes the results.

Table 3-2 Pavement conditions based on 3D pavement data

Site #	Average Rut Depth (mm)	Load Cracking Severity/Extent (Level, %)	Block/Transverse Cracking Severity/Extent	Converted COPACES Rating

			(Level, %)	
1	8.11	1, 40% 2, 20% 3, 5%	2, 100%	20
2	4.79	N/A	1, 100%	77
3	5.57	N/A	1, 100%	77
4	4.06	N/A	1, 100%	77
5	4.59	1, 25% 2, 15% 3, 5%	1, 100%	60

- Falling Weight Deflectometer

  For each site, 5 falling weight deflectometer tests were performed, and the results were averaged into layer moduli of the hot-mixed asphalt and the soil base layer. Table 3-3 summarizes the back-calculated modulus.

Table 3-3 FWD Back-calculation results

Site #	HMA Modulus (ksi)	Soil Modulus (ksi)
1	120	7
2	120	19
3	150	28
4	110	20
5	130	12

- Cores

  Table 3-4 summarizes the detailed information of the cores taken at each site, including the location in the lane, the thickness of the asphalt concrete (AC) layer, and how deeply the cracks (if any) propagate downward. Some bottom-up cracks were observed in a few cores, and their depths, measured from the bottom of the cores, are summarized. Detailed pictures of each core are shown in Appendixes B and C. Appendix B lists the 3D pavement surface images on different test sites showing the pavement condition.

Appendix C lists the pavement coring pictures showing the subsurface conditions of each test core.

Table 3-4 Core information on State Route 16

Site #	Core #	Core Location	AC Thickness	Top-Down Crack Depth	Bottom-Up Crack Depth
1	A3	Lane Center	9.5”	3”	N/A
	A4	Right Wheelpath	7.75”	7.75”	N/A
2	C2	Lane Center	9”	9”	N/A
	C4	Right Wheelpath	9.5”	N/A	5.5”
	C5	Lane Center	10.5”	3.5”	N/A
	C6	Left Wheelpath	10”	10”	N/A
	C7	Lane Center	10”	N/A	N/A
	C8	Lane Center	10.5”	N/A	N/A
3	4-1	Left Wheelpath	11”	11”	N/A
	4-2	Lane Center	11”	N/A	N/A
	5-1	Lane Center	11”	3.5”	N/A
	6-1	Left Wheelpath	10”	N/A	4.75”
	6-2	Lane Center	9.75”	5.5”	N/A
4	R1	Left Wheelpath	10.5”	4.5”	N/A
	R2	Right Wheelpath	12.5”	N/A	N/A
	R3	Left Wheelpath	10.5”	N/A	N/A
	R5	Left Wheelpath	10.5”	N/A	6.5”
	R6	Lane Center	10.5”	3.5”	3.5”
5	N/A				

3.3. Cold In-Place Recycling (CIR)

Cold in-place recycling is a pavement M&R technique in which the existing pavement material is recycled and mixed with chemical additives without heating. The CIR process is done in-place by a train of equipment. The complete CIR process carried out on State Route 16 is summarized below.

- **Milling:** A milling machine removes a 1.5-in surface layer of pavement as shown in Figure 3-8. The thin layer removed is disposed of because the CIR process typically causes a bulking effect of the material, and the removal of this layer would ensure an even surface after CIR process is finished.

Figure 3-7 Removal of a Thin Layer of Pavement

- **Applying lime:** A dumper towed by a tractor applies a layer of hydrated lime to the milled surface, as shown in Figure 3-8. This lime is incorporated into the final pavement as an anti-stripping agent.

Figure 3-8 Application of Lime on the Milled Surface

- **Incorporating additive:** A miller then mills a 3-in layer of pavement and mixes the pulverized pavement and lime with emulsified asphalt, as shown in Figure 3-10.

Figure 3-9 Mixture of Pavement and Additives

- **Mixture placement:** The mixture is then discharged into a paver that puts the material back into the 3-in deep milled trench, as shown in Figure 3-11.

Figure 3-10 Compaction of Recycled Material

- **Compaction:** A rubber-tire roller and a vibratory steel-wheel roller compacts the recycled material into the desired density, as shown in Figure 3-12.

Figure 3-11 Compaction of Recycled Material

- **Overlay:** The entire road will be covered with a 1.5-in layer of polymer modified Superpave asphalt after 3 days of curing.

3.4. Open-Graded Interlayer (OGI)

Using an open-graded interlayer (OGI) is a pavement maintenance and rehabilitation technique that involves the application of an interlayer with open graded material to minimize the transfer of stresses in the surface layer. Also known as a crack reliever layer, OGI mitigates reflective cracking from the underlying layers and thermal cracking. The complete OGI process carried out on SR 16 is summarized below.

- **Milling and cleaning:** A milling machine removes a 1.5-in surface layer of pavement, and a sweeper and an excavator removes the milled material, as shown in Figure 3-13.

Figure 3-12 Removal of the Existing Pavement Surface

- **Applying asphalt binder:** Asphalt is applied onto the milled surface, as shown in Figure 3-14.

Figure 3-13 Application of Asphalt

- **Applying the open graded interlayer:** A thin layer of open-graded material, usually under 1 in is applied to the pavement, as shown in Figure 3-15. After the installation of the interlayer, the section can be opened to traffic.

Figure 3-15 Application of 1” OGI

- **Overlay:** A final 1.5-in hot-mixed asphalt will be placed on top of the interlayer to complete the OGI process.

3.5. Data Collected after CIR and OGI

Cores and international roughness index (IRI) data were collected in March 2018, two years after the CIR and OGI treatments, to assess the condition of the treated pavements. A visual field inspection shows no distresses on either CIR or OGI sites. IRI data were collected on three lanes (east-bound travel lane, west-bound travel lane, and passing lane) between Milepost 25 and 27. Both east- and west-bound lanes were constructed with OGI, and CIR was used in the passing lane, which starts at Milepoint 25.8. Figure 3-16 shows the half-car simulation (HCS) IRIs on three lanes at every 0.02 mile. The majority of the IRIs are between 800 mm/km and 1200 mm/km with some outliers. There are no significant differences observed between CIR (passing lane) and OGI (east- and west-bound travel lanes). The section between Milepoints 25.2 and 25.4 has relatively higher HCS IRI (1000 mm/km and 2000 mm/km) in both directions. The can be further investigated.

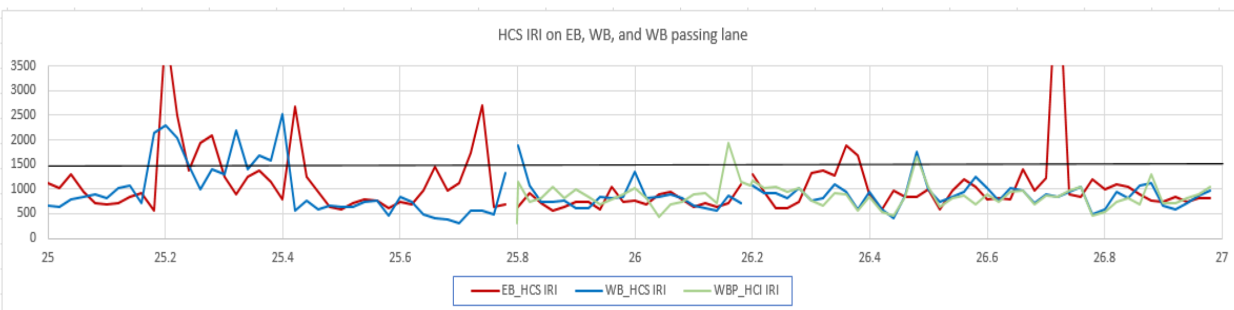


Figure 3-15 Historical COPACES Data Before and After CIR and OGI Application

In addition, cores were taken on both CIR and OGI sites for Hamburg Wheel Tracking Device (HWTD) testing. HWTD measures the combined effects of rutting and moisture damage by rolling a steel wheel across the surface of an asphalt concrete specimen that is immersed in hot water. HWTD testing was conducted on the surface layer of cores taken from both CIR and OGI sites and on the second layer of CIR sites. Results show the surface layer of both CIR and OGI pass the rut depth testing with an average rut depth of 3 mm and 5 mm at 20,000 cycles. The CIR layer did not pass the rut depth testing; it failed at 15 mm at 8,000 cycles. It is recommended that, the rutting on these two test sites be closely monitored.

3.6. Summary

GDOT has tested CIR and OGI on State Route 16 to critically evaluate the suitability of applying CIR and OGI to Georgia roadways based on its long-term performance. This chapter documented and analyzed the following to support subsequent long-term performance analysis on CIR and OGI sites:

1) Documented site information and pavement design on SR 16, pre-treatment conditions, including field tests and data collected, such as cores, FWD, 3D pavement data, and the CIR and OGI procedures applied.
2) Analyzed long-term pavement performance prior to CIR and OGI applications using historical COPACES data. It shows that this project has 7 to 8 years of life before dropping from a rating of 100 to a rating of 70. This performance can be used as a reference with which to compare the long-term performance of CIR and OGI applications. With the unit cost, the life cycle cost analysis of the new treatment methods can be critically evaluated in the future. It should be noted that the treatment of this project has been delayed significantly (approximately 8 years from 2008 to 2016). This should be taken into account when comparing the roadway's performance. In addition, significant cracking occurred due to delayed treatment. This project is ideal for assessing the performance of OGI and CIR for severe crack relief and an effective crack treatment.

3) It is recommended that the progress of pavement distresses be monitored to support long-term performance evaluation, even though the preliminary performance shows that the project rating is 100 and there are no pavement distresses one year after the application of CIR and OGI.

4. ANALYSIS OF SOIL CEMENT PAVEMENT PERFORMANCE

This chapter analyzes the pavement performance on the soil cement sites. First, the soil cement pavement sites are presented. The observed soil cement pavement performance is then analyzed using historical COPACES data. The predicted pavement performance is obtained using the ME Design software. The observed and predicted pavement performances are then compared and then discussed.

4.1. Soil Cement Sites

A total of 38 sites were used for calibrating Georgia's transfer coefficients for flexible pavements; among them, there are six soil cement sites, including four LTPP sites (4092, 4093, 4096, and 4220) and two GaCal sites (on State Routes 1 and 38). Figure 4-1 shows these six sites located in southwestern Georgia, including three sites on State Route 300 and one site each on State Routes 1, 25, 38, and 67C. In addition, sixteen soil cement sites were identified and incorporated into the GALPP program as special test sites. These sixteen sites are located on State Routes 4, 17, 21, 27, 29, 67, and 121 in southern Georgia. Table 4-1 lists the locations and the pavement designs of the six soil cement sites, which were used in the initial calibration of the MEPDG. Four sites were built in the 1980s and two sites were built in the 1990s. They were built with 6-8 inches of soil cement base and 4-13 inches of dense-graded hot mix asphalt (HMA) on top of it.

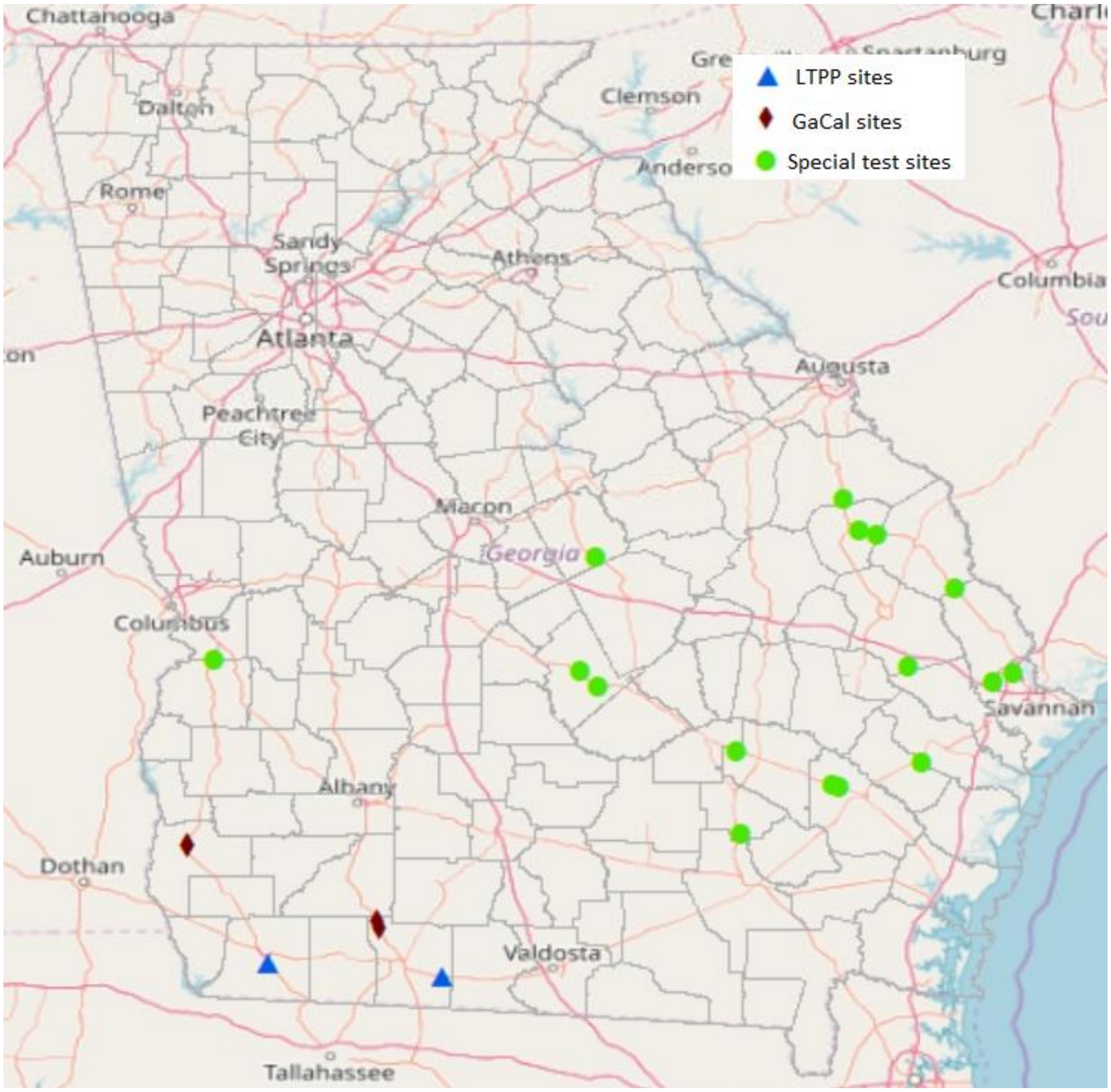


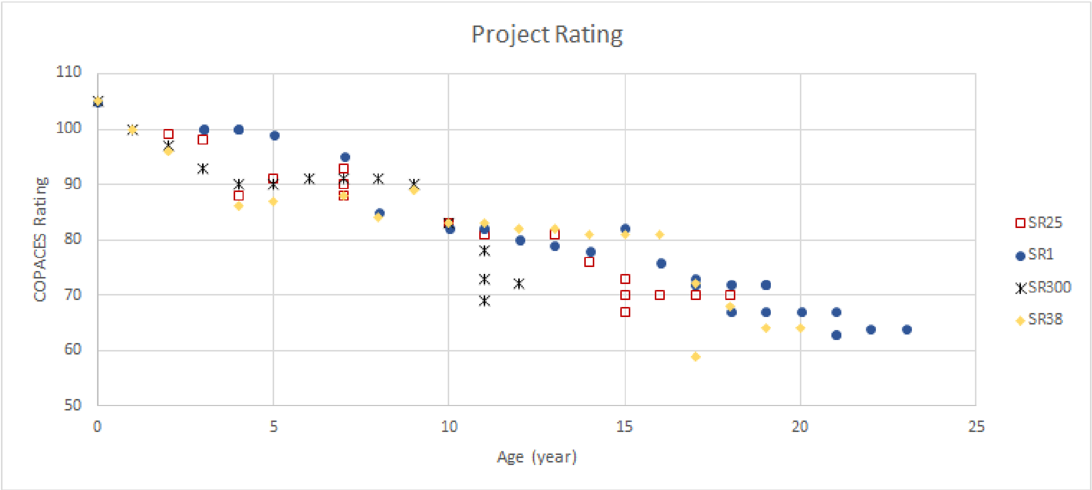
Figure 4-1 Selected Soil Cement Pavement Sites

Table 4-1 Locations of Selected Sites and Pavement Designs

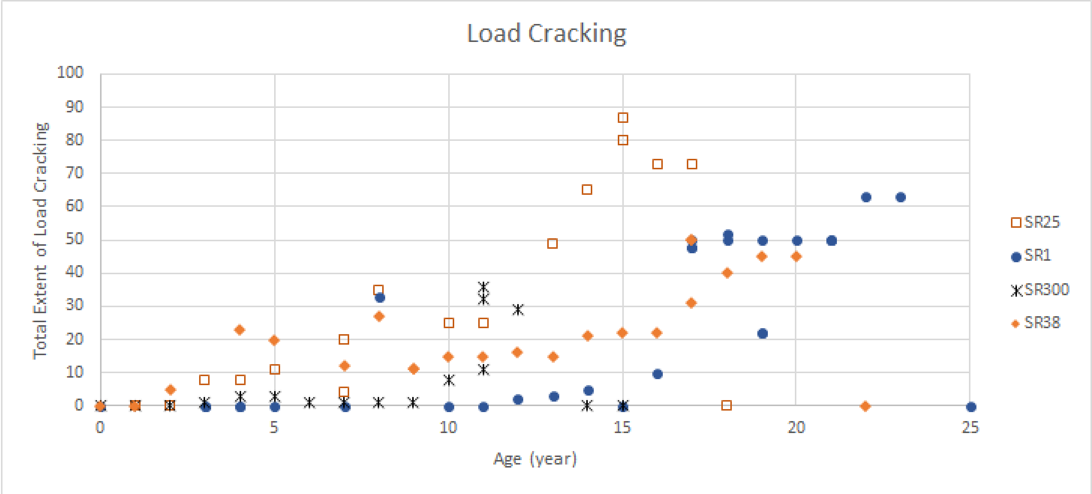
Route	SR 300	SR 300	SR 67C	SR 25/ US 17	SR 1	SR 38
County	Thomas	Thomas	Early	Bryan	Decatur	Thomas & Brooks
Construction Year	1986	1986	1985	1984	1991	1994
Pavement Design	1.2 in HMA	1.2 in HMA	1.3 in HMA	1.7 in HMA	5.5 in HMA	5.5 in HMA
	4.5 in HMA	4.6 in HMA	2.8 in HMA	2.9 in HMA		7.5 in HMA
	8.3 in soil cement	7.8 in soil cement	6.3 in soil cement	7.9 in soil cement	6.0 in soil cement	5.5 in soil cement
	Subgrade	Subgrade	Subgrade	Subgrade	Subgrade	Subgrade

4.2. Observed Pavement Performance using Historical COPACES Data

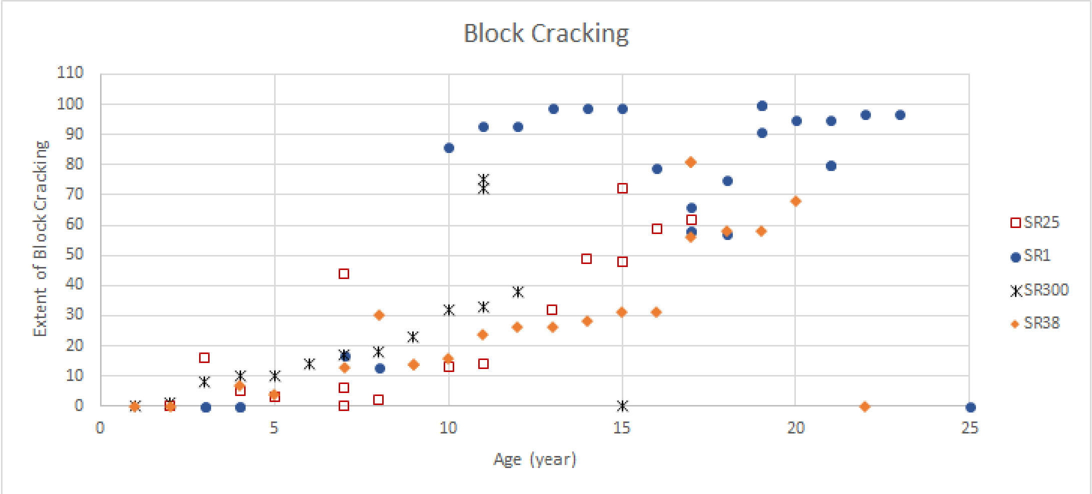
This section presents the observed distresses on the soil cement sites based on the historical COPACES data. First, the distresses on multiple projects with soil cement bases were presented to provide overall performance. Second, distresses on selected sites were discussed. Figure 4-2 shows the pavement rating, load cracking, and block cracking, on four projects on State Routes 1, 25, 38, and 300 with soil cement bases. In general, it took approximately 15 years to reach a rating of 70, as shown in Figure 4-2 (a), and the predominate distresses were load cracking and block cracking. Level 1 load cracking was typically reported in 2-3 years, and the extent increased slowly each year. Load cracking extent increased at a fast pace (approximately 7%) after 12-13 years, and a 50% of load cracking was reported at 20 years, as shown in Figure 4-2 (b). A review of the data shows Level 2 load cracking was reported on most of the segments within each project, but there were very few segments with load cracking at Levels 3 or 4. Block cracking was observed on all the projects, typically after 2-3 years. The extent increased more rapidly after 10 years at a rate of 8% per year, as shown in Figure 4-2 (c). Level 1 block cracking was mostly reported within the first 10 years; 40% of the segments exhibited Level 2 block cracking after 10 years. According to the historical COPACES data, rutting was not reported as an issue; all projects had less than 3/8 in of rut depth after 10 years.



(a) Project rating



(b) Load cracking



(c) Block cracking

Figure 4-2 COPACES rating and distresses on selected soil cement projects

It is noted that the COPACES and LTPP distress protocols are different in terms of distress definition, severity, and extent. COPACES defines load cracking as the type of cracking that is caused by repeated heavy loads and always occurring in the wheelpaths. Load cracking has four severity levels, ranging from single longitudinal cracking (Level 1) to alligator cracking (Level 4). Load cracking is recorded as the percent of the length of two wheelpaths (200 ft). The LTPP records longitudinal cracking in wheelpaths (in length) and fatigue cracking (in percent of total area) separately. A function, as depicted in Figure 4-3, was developed by ARA (Harold et al., 2016) to convert COPACES loading cracking into the fatigue cracking predicted in the MEPDG model. Using the conversion function, 40% and 80% of load cracking are approximately 6.5% and 14% of fatigue cracking, respectively. It is noted that the conversion function was developed based on limited data collected in 2014. Similarly, there are differences in block/transverse cracking. COPACES identifies block and transverse cracking as the type of crack that is caused by weathering of the pavement or shrinkage of cement-treated base materials (not load related). Three levels of block and transverse cracking (ranging from a single transverse crack to polygon-patterned block cracking) are defined, but only the predominant severity level is recorded. Block cracking is recorded as a percentage of total area. The LTPP defines block and transverse cracking separately and records the number and length of transverse cracks. Similarly, a conversion function was developed to match the block cracking reported in COPACES into transverse cracking in the LTPP. Note that the variation is larger than the load cracking conversion.

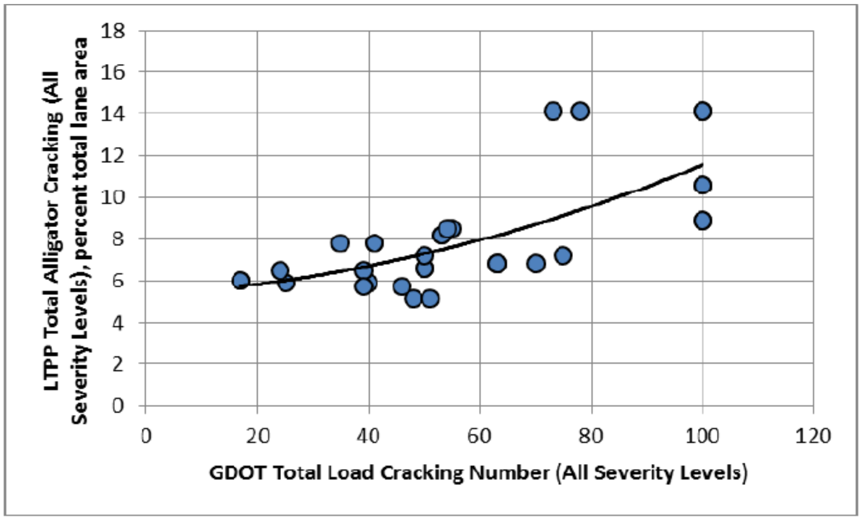


Figure 4-3 Relationship between load cracking from GDOT COPACES and alligator cracking from LTPP (Harold et al., 2016)

The observed fatigue cracking, thermal cracking, and rutting on the six soil cement sites are presented in Figures 4-4, 4-5, and 4-6. Figure 4-4 shows the observed fatigue cracking on all of the six soil cement sites. It is noted the last measurements on these projects were at age 8, 13, 19, 19, and 22 years. According to previous research (Tsai and Wu, 2016), most of the pavements in Georgia are resurfaced approximately every 11.6 years. This resurfacing would remove distresses (e.g., cracking and rutting) on the surface layer, which makes it difficult to accumulate cracking data. However, these six soil cement sites have lives longer than the typical resurfacing life of 11.6 years. There were either no fatigue cracks or just little fatigue cracks recorded until the 15-year point. This means these sites had not been resurfaced in more than 15 years, which is much longer than GDOT's average resurfacing years (Tsai and Wu, 2016). Only one site (4420) recorded 9% and 21% fatigue cracking after 7 or 8 years.

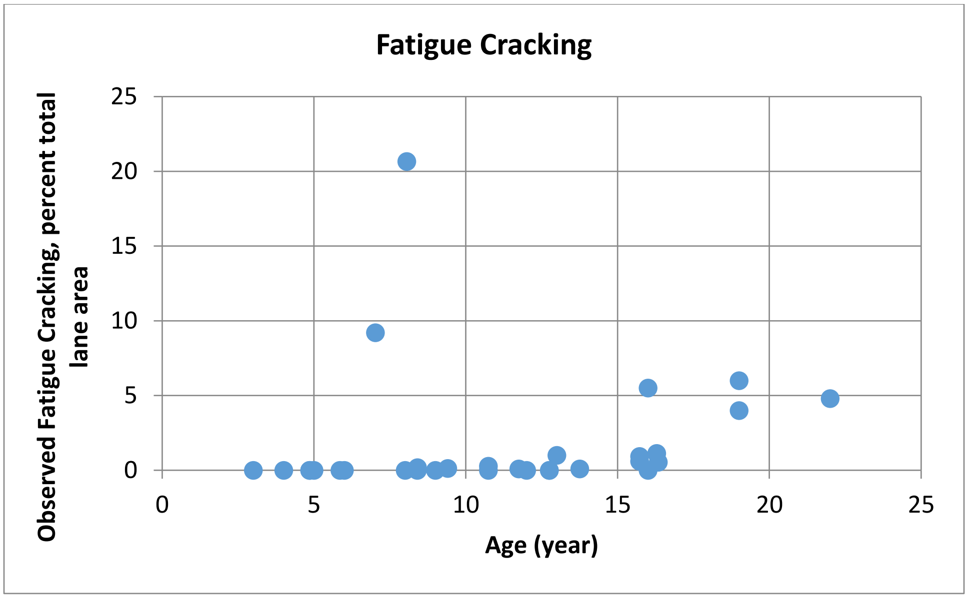


Figure 4-4 Observed fatigue cracking

Figure 4-5 shows the observed thermal cracking. There is dispersion in the thermal cracking with a range of 0 to 7,000 ft per mile among the 5 sites. It is noted that four sites did not exhibit thermal cracking in the first five years. In general, the thermal cracking shows an increasing trend; after approximately 9-10 years, thermal cracking increased significantly. Again, some sites show a minimum of thermal cracking after more than 15 years of service. Sites on State Routes 1 and 38 had the most thermal cracking.

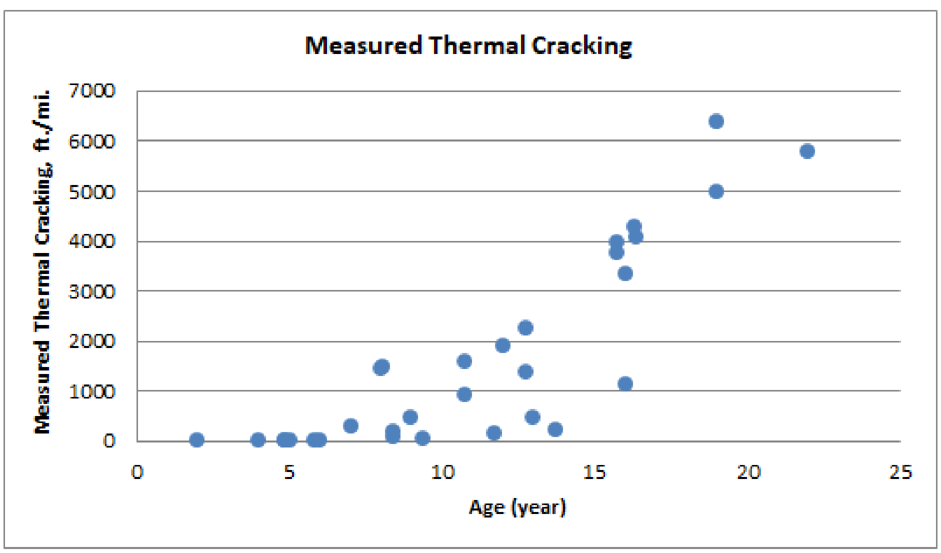


Figure 4-5 Observed longitudinal cracking (non-wheel path)

Figure 4-6 shows the observed rutting. Most of the observed rutting was between 0.05 in and 0.25 in. Four sites had rutting less than 0.25 in, even after 10 years; only one site (4420) exhibited rutting greater than 0.25 in. after 5 years.

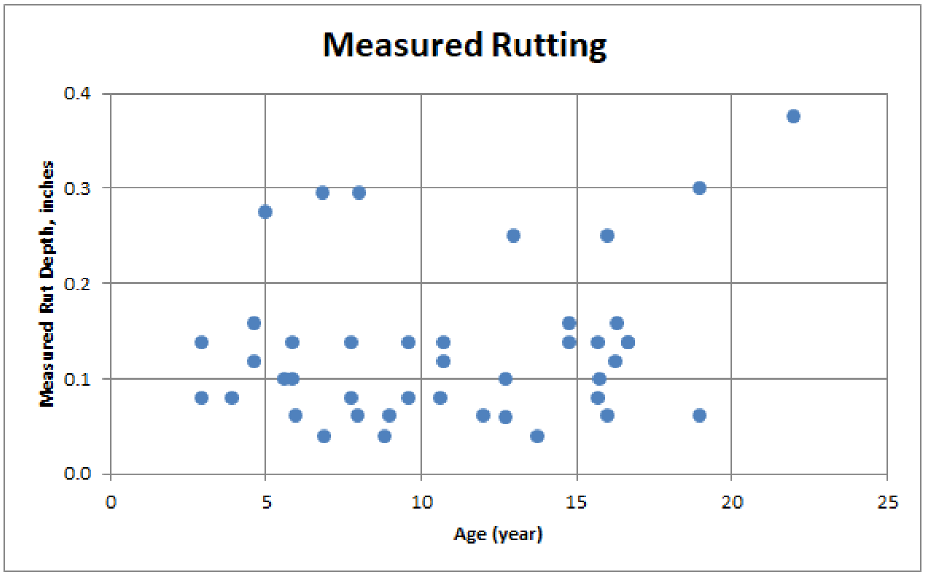


Figure 4-6 Observed rutting

4.3. Predicted Pavement Performance using MEPDG

Based on findings of a technical audit by AASHTO and due to the fact that the existing semi-rigid model in AASHTOWare Pavement ME version 2.3.1 is not globally calibrated or locally calibrated for Georgia's pavements, the semi-rigid model is not recommended for implementation in GDOT's plan. More importantly, GDOT has set a minimal compressive strength of 300 psi, which is lower than most semi-rigid pavements. It was recommended that soil cement be modeled as flexible pavements with chemically stabilized layers as base/subgrade materials that have higher resilient modulus value. Thus, the soil cement sites were modeled as flexible pavements with locally calibrated coefficients, and the performances were predicted.

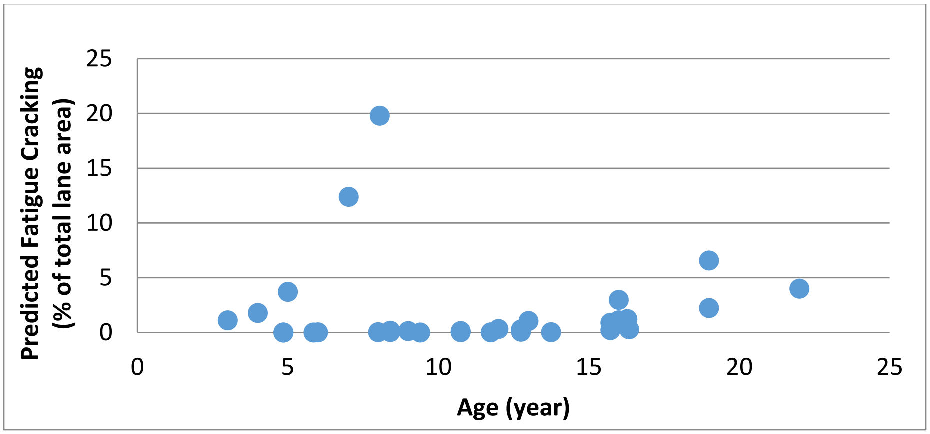
This section presents the pavement performance predicted by using MEPDG. First, Table 4-2 lists Georgia's asphalt pavement calibration coefficients.

Table 4-2 Georgia's asphalt pavement calibration coefficients (Harold et al., 2016)

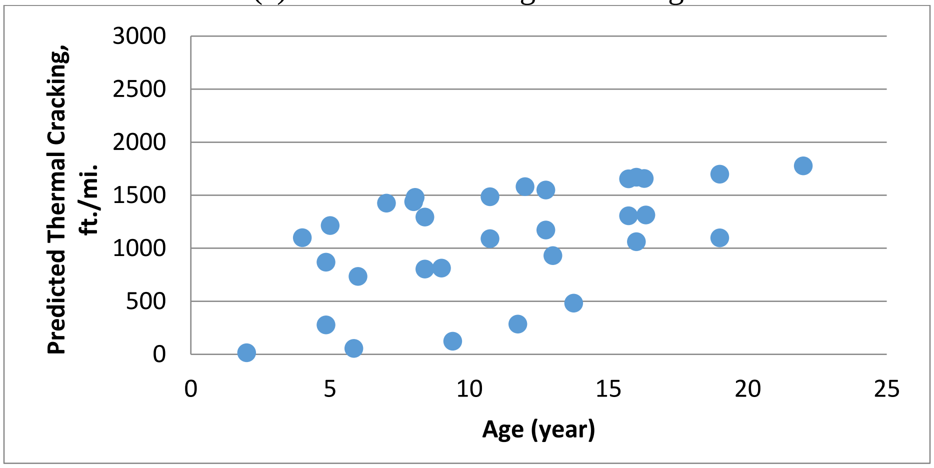
	Transfer Function Coefficient	Global Value	GDOT Value	
			Neat[1] Mixtures	PMA[2] Mixtures
AC Rutting	K1	-3.35412	-2.45	-2.55
	K2	1.5606	1.5606[3]	1.5606[3]
	K3	0.4791	0.30	0.30
Subgrade Rutting	Coarse-Grained, Bs1	1.0	0.50	
	Fine-Grained, Bs1	1.0	0.30	
AC Fatigue Cracking	K1	0.007566	0.000653	0.00151
	K2	3.9492	3.9492[3]	
	K3	1.281	1.281[3]	
Bottom-up Cracking	C1	1.0	2.2	
	C2	1.0	2.2	
	C3	6,000	6,000[3]	
Top-down Cracking	C1	7	7[3]	
	C2	3.5	3.5[3]	
	C3	0	0[3]	
Thermal Cracking	Bt1	1.5	35	45
	Bt3	1.5	35	45

1. Unmodified HMA mixtures
2. Polymer Modified Asphalt mixtures
3. Use global values

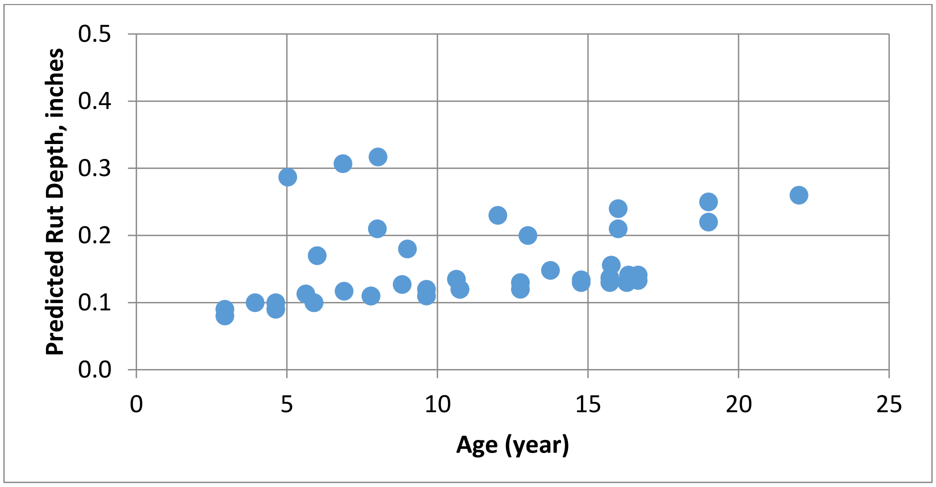
The predicted pavement distresses of soil cement pavements are presented in Figure 4-7. Figure 4-7 (a) shows limited (less than 5%) fatigue cracking are predicted on the soil cement sites. Only one site is predicted with more fatigue cracking at an age of 7 years.



(a) Predicted fatigue cracking



(b) Predicted thermal cracking



(c) Predicted rutting

Figure 4-7 Predicted distresses by the ME Design (v2.3.1)

The same pavement structure was analyzed using the ME Design software with Georgia's coefficients (ARA 2015a). Results on all five sites are similar. Figure 4-8 shows the results on the site on State Route 38. This pavement structure meets the performance criteria except for thermal cracking. The predicted distresses, including fatigue cracking, rutting, and IRI, at the specified reliability were lower than the threshold values at the end of the 20-year design life because, partly, of its accumulated use by 16 million heavy trucks. It is noted that a 95% reliability is used for fatigue cracking and rutting, as suggested in GDOT's user guide. When 50% reliability was used, the predicted distresses were much lower (0.25 in of rutting, 0.62% of fatigue cracking). When the reliability increased from 50% to 95%, the predicted fatigue cracking significantly increased from 0.62% to 8.61%. This means the selection of reliability level has a big impact on the distress threshold values, which determines whether or not the pavement structure design passes the criteria. At 95% reliability, the MEPDG predicted pavement would have fatigue cracking of 8.61%, rutting of 0.35 in, and thermal cracking of 802 ft per mile at the end of 20 years. The pavement structure can last longer than 20 years and can reach the performance criteria in 21 years with 16 million heavy trucks.

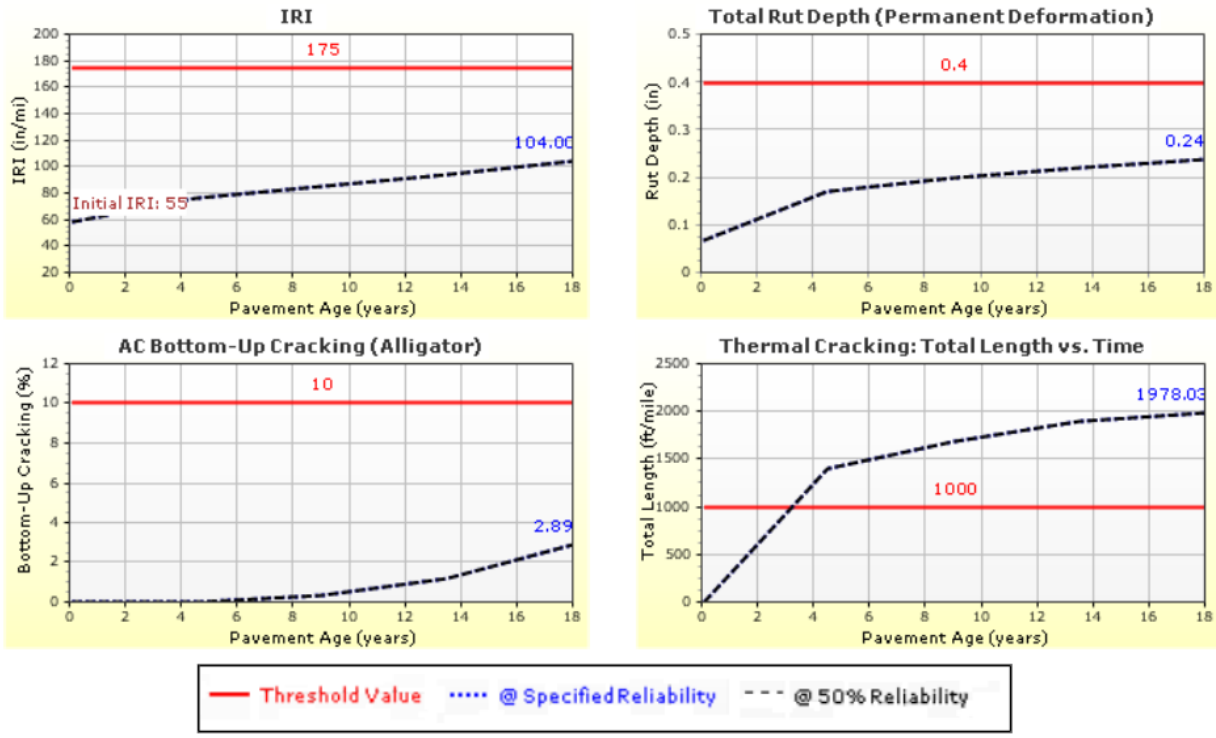


Figure 4-8 Pavement structure analysis using the ME Design (v2.3.1)

4.4. Comparison of Observed and Predicted Pavement Performance

This section compares the predicted and observed pavement performance (e.g. distresses) on the selected sites to verify the accuracy of the prediction models. Figure 4-9 shows the observed and predicted (at 50% reliability) fatigue cracking based on the data used in the calibration (Harold et al., 2016). There is no significant bias (under or overprediction), and the predicted fatigue cracking is reasonable with the data scattered around the equality line (R^2=0.92). It is noted that most of the predicted and observed fatigue cracking was less than 6% after 20 years, which meets the performance criteria of 10%. The only site with more fatigue cracking is Site 4420.

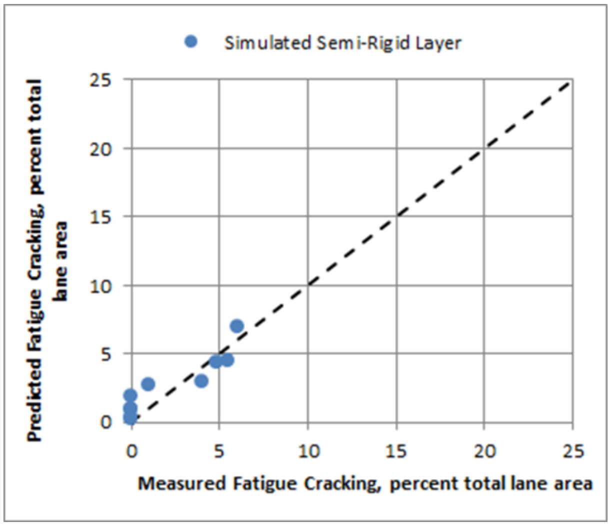


Figure 4-9 Observed vs. Predicted fatigue cracking (percent of total area)

Figure 4-10 shows the predicted and observed thermal cracking. The points are not close to the equality line, and the R^2 is about 0.41, which indicates a poor fitness between the predicted and observed values. It is noted the thermal cracking is overpredicted when the observed values are less than 1500 ft per mile, and underpredicted when greater than 1500 ft per mile. The predicted values do not exceed 1500 ft per mile given the traffic volume. It is noted there was a gap between the observed and predicted cracking for sites on State Routes 1 and 30. While more than 5000 ft per mile of thermal cracking was observed, the MEPDG file output was only 1500 ft per mile. The MEPDG inputs should be further checked for future recalibration.

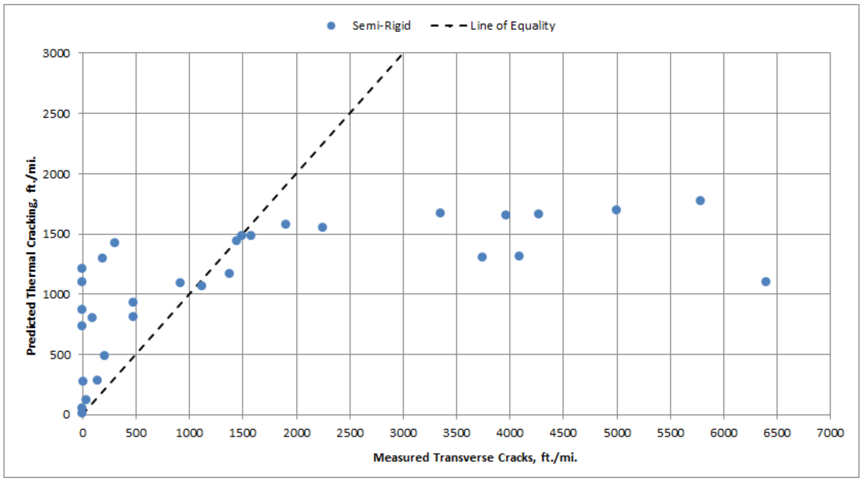


Figure 4-10 Predicted vs. Observed transverse crack (ft per mile)

Figure 4-11 shows the predicted and observed rutting. Most of the sites have less than 0.25 in of rutting; only one site exhibited more than 0.25 in of rutting. This site had higher truck traffic and thinner pavement design. Figure 4-12 shows the IRI were overpredicted (approximately 80% higher). The observed values were 40-60 ft per mile, while the predicted values are about 80-100 ft per mile.

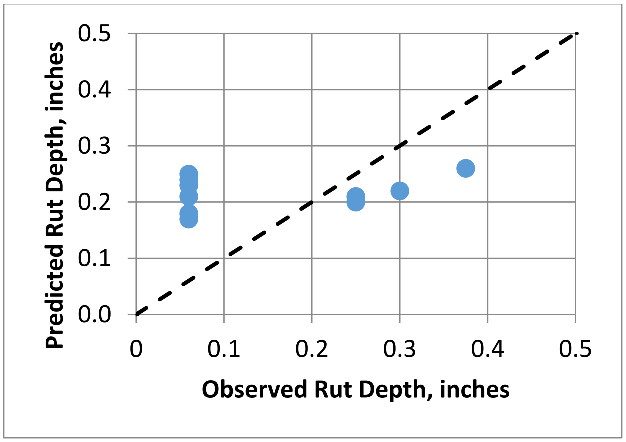


Figure 4-11 Predicted vs. Observed rut depth (in.)

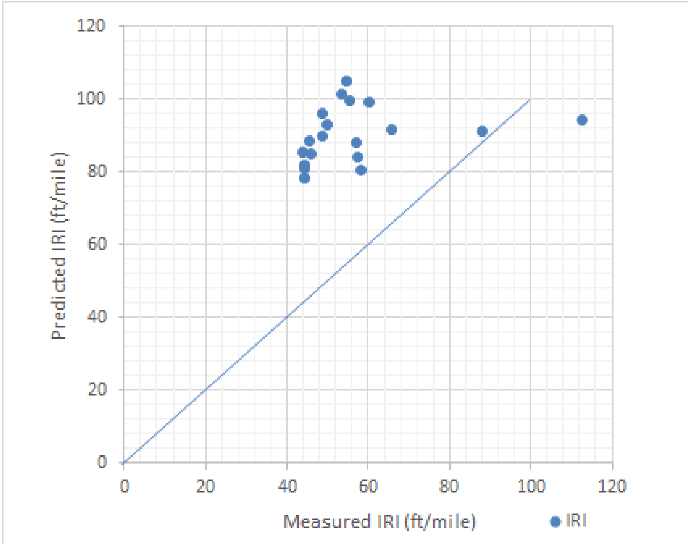


Figure 4-12 Predicted vs. Observed IRI (ft/mile)

In summary, with the locally calibrated coefficients, the MEPDG reasonably predicts fatigue cracking for soil cement pavement sites. Six percent (or lower) fatigue cracking is predicted at the end of a 20-year design life. However, the predicted thermal cracking does not fit the observation in the field. In the majority of the cases, the thermal cracking was either overpredicted or underpredicted by more than 30%. With the local coefficients, the MEPDG predicts approximately 1500 ft per mile of thermal cracking at the end of a 20-year design life. However, on some sites (State Routes 1 and 38), more than 5000 ft per mile of thermal cracking was observed. The predicted rut depth was, in general, reasonable (within 20% of the observed values). It is noted that GDOT measures rut depth in 1/8 in units, which is different from the continuous values predicted by the MEPDG. A rut depth of 0.125 in and 0.25 in is predicted after 8 and 15 years. The IRI was overpredicted at approximately 80% and needs to be further calibrated to achieve a reasonable prediction.

4.5. Summary

The following conclusions were made based on the preliminary analysis of the six selected soil cement sites and the use of the recommended local calibration coefficients:

- Bias has been found in all distresses (transverse cracking, rutting, and IRI) except fatigue cracking.
- The ME Design predicts little or no fatigue cracking for these soil cement sites. The results show fair correlation between the predicted and measured fatigue cracking (R^2 = 0.92).
- The ME Design mostly overpredicts transverse cracking when the observed cracking is less than 1500 ft per mile, and underpredicts it when the observed cracking is greater than 1500 ft per mile. The latter case is because the MEPDG predicts the maximum transverse cracking at about 1500 ft per mile.
- The ME Design predicted little rutting on these soil cement sites. Poor correlation (R2=0.1) was found between the predicted and measured rut depth.
- The ME Design overpredicted the measured IRI. The initial IRI was about 50 in per mile, and, on average, IRI was overpredicted by 70%. Poor correlation (*R*2= 0.07) was found between the predicted and measured IRI.

The following recommendations are made:

- There are two changes in the flexible pavement design in the new release of Pavement ME Version 2.5. Instead of a constant value, C2 in fatigue cracking is now dependent on the AC thickness. The lab test coefficients (B) are used in the model, instead of using 1. With these significant changes and the expected calibration tool, it is recommended that

GDOT verify the performance using the global coefficients included in of Pavement ME Version 2.

- Pavement ME Version 2.5 includes the global coefficients for semi-rigid pavement, which was, for the first time, globally calibrated. Although it is noted that a large portion of semi-rigid data used for the global calibration were from Virginia, it is recommended that the accuracy of the predicted distresses using global coefficients be verified by comparing the predicted distresses with the distresses observed in the field.
- Because the change to GDOT's pavement data collection approach, full-coverage, 3D pavement data will be available on state routes. The variability and representativeness of the distresses on the test sites can be evaluated using 3D pavement data.
- Additional test sections can be included to further verify and calibrate the predicted distresses using the Pavement ME.

5. CONCLUSIONS AND RECOMMENDATIONS

The Georgia Department of Transportation (GDOT) is evaluating the use of the MEPDG for designing its new and rehabilitated pavement structures. GDOT wants to have a central database and a GIS project to document the information from the special test sites in Georgia to support subsequent long-term performance analysis and life-cycle cost analysis. GDOT will use the information to critically assess and justify the suitability of applying different pavement maintenance and rehabilitation methods to support cost-effective annual maintenance and rehabilitation (M&R) planning and prioritization operations. The objectives of Phase 2 are 1) to expand the GALTPP database with concrete pavement sites used in the local calibration of the MEPDG, 2) to identify and manage special test sites of GDOT's interest, 3) to document and analyze the data collected from the cold in-place recycling (CIR) and open-graded interlayer (OGI) test sites on State Route 16, and 4) to conduct the soil cement pavement performance analysis by comparing the observed pavement performance (acquired from historical COPACES data) and the predicted pavement performance (analyzed using the MEPDG). Below are the findings from Phase 2:

1) The GALTPP database tables and fields for concrete pavement sites were designed to store and manage the data collected by ARA at GACal for the initial MEPDG local calibration (Harold et al., 2016). A GIS project was used with the GALTPP database for visualizing the sites. They are summarized below:
    a. A relational GALTPP database with location reference information was designed to host the LTPP, GaCal, and special test sites and store the data related to these different sites. Tables, fields, and relationships among tables (i.e., primary keys

and foreign keys) were designed to store and manage the input parameters used in the MEPDG calibration and testing data collected at GaCal sites for easy query and data integrity.

b. Twenty-three concrete pavement sites, including LTPP and GaCal sites, used for previous MEPDG local calibration were stored in the GALTPP database. The MEPDG inputs, as well as the measured distresses, can be easily accessed in support of future validation and calibration of the MEPDG.

c. A GALTPP geodatabase containing the three types of sites was developed; it can be integrated into GDOT's GIS systems.

2) Special test sites with different materials and treatment methods, including soil cement base, cold in-place recycling (CIR), open-graded interlayer (OGI), micromilling and thin overlay, fog seal, crack filling, high friction surface treatment (HFST), and light weight aggregates (alternative treatment of HFST with bauxite and resin) were identified and entered into the GALTPP database. In addition, beyond the scope of this project, the spatial location information of these additional efforts were made to identify and locate special these sites by searching the GeoPi for project numbers and locating projects. Eighty-seven special test sites were georeferenced and entered into the GALTPP database.

3) Field test data, including prior CIR and OGI pavement surface condition data, FDW data, coring data, etc., from the CIR and OGI test sites on State Route 16 were acquired, documented, and entered into GALTPP. The 3D pavement surface data before CIR and OGI application were collected, and the detailed distresses were analyzed to provide a pavement condition reference to support subsequent analysis for treatment timing.

Historical COPACES data was analyzed to reveal the long-term pavement performance prior to CIR and OGI application. It shows a pavement has 7 to 8 years of life between a rating of 100 to a rating of 70. This performance can be used as a reference with which to compare the long-term performance of CIR and OGI applications. With the unit cost, the life cycle cost analysis or the new treatment methods can be critically evaluated in the future.

4) The soil cement pavement performance analysis was conducted by comparing the observed pavement performance (acquired from historical COPACES data) and the predicted pavement performance analyzed using the ME Design software. Conclusions are as follows:
    a. Bias has been found in all distresses (transverse cracking, rutting, and IRI) except fatigue cracking.
    b. The ME Design predicts little or no fatigue cracking for these soil cement sites. The results show fair correlation between the predicted and measured fatigue cracking (R2 = 0.92).
    c. The ME Design mostly overpredicts transverse cracking when the observed cracking is less than 1500 ft per mile and underpredicts when the observed cracking is greater than 1500 ft per mile. The latter case occurs because the ME Design predicts the maximum transverse cracking at about 1500 ft per mile.
    d. The ME Design predicted little rutting on these soil cement sites. Poor correlation (R2=0.1) was found between the predicted and measured rut depths.

e. The ME Design overpredicted the IRI. The initial IRI was about 50 in per mile, and, on average, IRI was overpredicted by 70%. Poor correlation ($R2$= 0.07) was found between the predicted and measured IRI.

The following recommendations are made:

1) The GALTPP geodatabase can be integrated into GDOT's existing GIS systems, such as GeoPi, for disseminating the information and better coordinating the work on the GALTPP sites.

2) Pavement distresses on CIR and OGI test sites should continue to be monitored even though the preliminary performance shows that the project rating is 100, and there are no pavement distresses one year after the application of CIR and OGI.

3) There are two changes in the flexible pavement design in the new release of AASHTOWare Pavement ME Design version 2.5. Instead of a constant value, C2 in fatigue cracking is now dependent on the asphalt concrete thickness. The lab test coefficients (B) are used in the model instead of using 1. With these significant changes and the expected calibration tool, it is recommended that GDOT verify the performance using the global coefficients included in Pavement ME Version 2.5.

4) The new ME Design (version 2.5) includes the global coefficients for semi-rigid pavement, which were, for the first time, globally calibrated. Although a large portion of semi-rigid data used for the global calibration were from Virginia, the accuracy of the predicted distresses should be verified by comparing the predicted distresses with the distresses observed in the field.

5) Because the change to GDOT's pavement data collection approach, full-coverage, 3D pavement data will be available on state routes. The variability and representativeness of the distresses on the test sites can be evaluated using 3D pavement data.

Additional test sites (covering common design features used in Georgia) should be included to further verify and calibrate the predicted distresses using the MEPDG.

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(2) AASHTO, Pavement ME DesignTM (access: http://www.medesign.com/MEDesign/Index.html).

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(6) Tsai, Y. and Wu, Y. 2016. Study of Georgia's Pavement Deterioration /Life and Potential Risks of Delayed Pavement Resurfacing and Rehabilitation. FHWA-GA-16-1405. Georgia Department of Transportation, Atlanta, GA.

(7) Tsai, Y. and Wu, Y. 2015. Georgia Long-Term Pavement Performance (GALTPP) Program –Maintaining Georgia's Calibration Sites and Identifying The Potential for Using MEPDG for Characterization Of Non-Standard Materials and Methods (Phase 1). Georgia Department of Transportation, Atlanta, GA.

APPENDIX A GALTPP DATABASE TABLES

GALTPP_SITE

Field Name	Units	Field Type	Description
GALTPP_ID		CHARACTER	An identification number
SITE_TYPE		CHARACTER	Site type (LTPP, GaCal, or special test site
PAVEMENT_TYPE		CHARACTER(6)	Pavement type
COUNTY		CHARACTER(3)	County in which the test section is located.
ROUTENO		CHARACTER(4)	The route number for the route that the section is located on.
ROUTE_SUFFIX		CHARACTER(2)	The route suffix for the route that the section is located on.
Milepoint_FROM		NUMBER	Beginning mile point
Milepoint_TO		NUMBER	Ending mile point
Milepost_FROM		NUMBER	Beginning mile post for interstate highways
Milepost_TO		NUMBER	Ending mile post for interstate highways
DIRECTION_OF_TRAVEL		CHARACTER(1)	E for East, W for West, N for North, S for South base on the direction of travel within the lane for which data is being collected.
LANE_NUMBER		NUMBER(1,0)	The number of the lane on which data is being collected. 1 is the outside lane. The others are numbered consecutively as you move to the inside edge of the pavement.
FUNCTIONAL_CLASS		CHARACTER	Functional class of roadway on which section is located.
TOT_LANES		NUMBER(1,0)	Total number of lanes in one direction.
DIVIDED		CHARACTER(1)	Y or N indicating that the roadway does or does not have a median.
LATITUDE	Degrees	NUMBER(5,3)	Latitude of the test section in degrees.
LONGITUDE	Degrees	NUMBER(5,3)	Longitude of the test section in degrees.
ELEVATION	Ft	NUMBER(4,0)	Estimate of the elevation of the test section relative to sea level.
RCLINK		CHARACTER(10)	
LOCATION_INFO		CHARACTER(100)	Description of the location of the test section.

SPECIALTEST_SITE

Field Name	Units	Field Type	Description
GALTPP_ID		CHARACTER	An identification number
PAVEMENT_TYPE		CHARACTER(6)	Pavement type
TEST_TYPE		CHARACTER	Test site type (e.g., CIR, OGI, HFST, etc.)
PI_NO		CHARACTER	PI number if available
RES_PROJ		CHARACTER	Research project if available
CONSTRUCTION_YEAR		NUMBER(4,0)	Year of the testing material or treatment being applied
SITE_DESC		CHARACTER	Description of the test site

MEPDG_SITE

Field Name	Units	Field Type	Description
GALTPP_ID		CHARACTER	Test section identification number (one for each site).
CONSTRUCTION_ID		CHARACTER	Construction event in sequence
PAVEMENT_TYPE		CHARACTER(6)	Pavement type
TEST_TYPE		CHARACTER(4)	New design or rehab
ROUTE_SUFFIX		CHARACTER(2)	The route suffix for the route that the section is located on.
LANE_WIDTH	ft	NUMBER(2,0)	Width of the lane the test section occupies.
SHOULDER_TYPE		CHARACTER(7)	Indication of whether the shoulder is “paved,” “unpaved,” or “none.”
SHOULDER_WIDTH	ft	NUMBER(2,0)	The width of the shoulder in feet.
DIVIDED		CHARACTER(1)	Y or N indicating that the roadway does or does not have a median.
DATE_EARTHWORK		DATE	Date the earthwork was completed in the construction of the project.
DATE_HMA_PLACED		DATE	Date the hot-mix asphalt was placed in the construction of the project.
TRAFFIC_OPEN_DATE		DATE	Date the test section was opened to traffic.

GACAL_AC_ BULKSPECIFICGRAVITY

Field Name	Units	Field Type	Description
GALTPP_ID		CHARACTER	Test section identification number.
Core_ID		CHARACTER	Core ID.
Date		Date	Date of coring.
Bulk			
Gmm			
Gmm_Bulk			
Air_void			

GACAL_AC_DISTRESS

Field Name	Units	Field Type	Description
GALTPP_ID		CHARACTER	Test section identification number.
SOURCE		CHARACTER	Source of the distress data (COPACES, LTPP)
CONSTRUCTION_NO		CHARACTER	1 stands for new construction, 2 stands for rehabilitation
SURVEY_DATE		DATE (mm/dd/yyyyh h:mi:s)	Date of distress survey.
GATOR_CRACK_A_L	ft^2	NUMBER(5,1)	Area of alligator (fatigue) cracking of low severity
GATOR_CRACK_A_M	ft^2	NUMBER(5,1)	Area of alligator (fatigue) cracking of moderate severity may be evident).
GATOR_CRACK_A_H	ft^2	NUMBER(5,1)	Area of alligator (fatigue) cracking of high severity may be evident).
BLK_CRACK_A_L	ft^2	NUMBER(5,1)	Area of block cracking of low severity
BLK_CRACK_A_M	ft^2	NUMBER(5,1)	Area of block cracking of moderate severity
BLK_CRACK_A_H	ft^2	NUMBER(5,1)	Area of high severity block cracking (mean crack width greater than 19 mm or under 19 mm with moderate to high severity random cracking).
EDGE_CRACK_L_L	ft	NUMBER(4,1)	Length of low severity edge cracking (cracks without break up or loss of material).
EDGE_CRACK_L_M	ft	NUMBER(4,1)	Length of moderate severity edge cracking (cracks with some break up and loss of material for up to 10 percent of the affected length).
EDGE_CRACK_L_H	ft	NUMBER(4,1)	Length of high severity edge cracking (considerable break up and loss of material for more than 10 percent of the affected length).

Field Name	Units	Field Type	Description
LONG_CRACK_WP_L_L	ft	NUMBER(4,1)	Length of low severity, longitudinal cracking in wheel path (cracks of unknown width well sealed or with mean width of 6 mm or less).
LONG_CRACK_WP_L_M	ft	NUMBER(4,1)	Length of moderate severity, longitudinal cracking in wheel path (mean crack width from 6 to 19 mm or under 19 mm with adjacent low severity random cracking).
LONG_CRACK_WP_L_H	ft	NUMBER(4,1)	Length of high severity, longitudinal cracking in wheel path (mean crack width greater than 19 mm or under 19 mm with adjacent moderate to high severity random cracking).
LONG_CRACK_WP_SEAL_L_L	ft	NUMBER(4,1)	Length of low severity, well-sealed longitudinal cracking in wheel path (cracks of unknown width or with mean width of 6 mm or less).
LONG_CRACK_WP_SEAL_L_M	ft	NUMBER(4,1)	Length of moderate severity, well-sealed longitudinal cracking in wheel path (mean crack width from 6 to 19 mm or under 19 mm with adjacent low severity random cracking).
LONG_CRACK_WP_SEAL_L_H	ft	NUMBER(4,1)	Length of high severity, well-sealed longitudinal cracking in wheel path (crack mean width greater than 19 mm or under 19 mm with adjacent moderate to high severity random cracking).
LONG_CRACK_NWP_L_L	ft	NUMBER(4,1)	Length of low severity, non-wheel path longitudinal cracking (cracks of unknown width well sealed or with mean width of 6 mm or less).
LONG_CRACK_NWP_L_M	ft	NUMBER(4,1)	Length of moderate severity, non-wheel path longitudinal cracking (mean crack width from 6 to 19 mm or under 19 mm with adjacent low severity random cracking).
LONG_CRACK_NWP_L_H	ft	NUMBER(4,1)	Length of high severity, non-wheel path longitudinal cracking (mean crack width greater than 19 mm or fewer than 19 mm with adjacent moderate to high severity random cracking).
LONG_CRACK_NWP_SEAL_L_ L	ft	NUMBER(4,1)	Length of low severity, well-sealed non-wheel path longitudinal cracking (cracks of unknown width or with mean width of 6 mm or less).
LONG_CRACK_NWP_SEAL_L_ M	ft	NUMBER(4,1)	Length of moderate severity, well-sealed non- wheel path longitudinal cracking (mean crack width from 6 to 19 mm or under 19 mm with adjacent low severity random cracking).
LONG_CRACK_NWP_SEAL_L_ H	ft	NUMBER(4,1)	Length of high severity, well-sealed non-wheel path longitudinal cracking (mean crack width greater than 19 mm or fewer than 19 mm with adjacent moderate to high severity random cracking).

Field Name	**Units**	**Field Type**	**Description**
REFL_CRACK_TRANS_NO_L		NUMBER(3,0)	Number of low severity, transverse reflection cracks (cracks of unknown width well sealed or with mean width of 6 mm or less).
REFL_CRACK_TRANS_NO_M		NUMBER(3,0)	Number of moderate severity, transverse reflection cracks (mean crack width of 6 to 19 mm or under 19 mm with adjacent low severity random cracking).
REFL_CRACK_TRANS_NO_H		NUMBER(3,0)	Number of high severity, transverse reflection cracks (mean crack width greater than 19 mm or under 19 mm with adjacent moderate to high severity random cracking).
REFL_CRACK_TRANS_L_L	ft	NUMBER(5,1)	Length of low severity, transverse reflection cracking at joints (cracks of unknown width well sealed or with mean width of 6 mm or less).
REFL_CRACK_TRANS_L_M	ft	NUMBER(5,1)	Length of moderate severity, transverse reflection cracking at joints (mean crack width of 6 to 19 mm or under 19 mm with adjacent low severity random cracking).
REFL_CRACK_TRANS_L_H	ft	NUMBER(5,1)	Length of high severity, transverse reflection cracking at joints (mean crack width greater than 19 mm or fewer than 19 mm with adjacent moderate to high severity random cracking).
REFL_CRACK_TRANS_SEAL_L_L	ft	NUMBER(5,1)	Length of well-sealed, low severity transverse cracking (cracks of unknown width or with mean width of 6 mm or less).
REFL_CRACK_TRANS_SEAL_L_M	ft	NUMBER(5,1)	Length of well-sealed, moderate severity transverse cracking (mean crack width from 6 to 19 mm or under 19 mm with adjacent low severity random cracking).
REFL_CRACK_TRANS_SEAL_L_H	ft	NUMBER(5,1)	Length of well-sealed, high severity transverse cracking (mean crack width greater than 19 mm or under 19 mm with adjacent moderate to high severity random cracking).
REFL_CRACK_LONG_L_L	ft	NUMBER(4,1)	Length of low severity, longitudinal reflection cracking at joints (cracks of unknown width well sealed or with mean width of 6 mm or less).
REFL_CRACK_LONG_L_M	ft	NUMBER(4,1)	Length of moderate severity, longitudinal reflection cracking at joints (mean crack width from 6 to 19 mm or under 19 mm with adjacent low severity random cracking).
REFL_CRACK_LONG_L_H	ft	NUMBER(4,1)	Length of high severity, longitudinal reflection cracking at joints (mean crack width greater than 19 mm or fewer than 19 mm with adjacent moderate to high severity random cracking).

Field Name	**Units**	**Field Type**	**Description**
REFL_CRACK_LONG_SEAL_L_L	ft	NUMBER(4,1)	The length of well-sealed, low severity longitudinal reflection cracking at joints (cracks of unknown width or with mean width of 6 mm or less).
REFL_CRACK_LONG_SEAL_L_M	ft	NUMBER(4,1)	The length of well-sealed, moderate severity longitudinal reflection cracking at joints (mean crack width from 6 to 19 mm or under 19 mm with adjacent low severity random cracking).
REFL_CRACK_LONG_SEAL_L_H	ft	NUMBER(4,1)	The length of well-sealed, high severity longitudinal reflection cracking at joints (mean crack width greater than 19 mm or under 19 mm with adjacent moderate to high severity random cracking).
TRANS_CRACK_NO_L		NUMBER(3,0)	Number of low severity transverse cracks (cracks of unknown width well sealed or with mean width of 6 mm or less).
TRANS_CRACK_NO_M		NUMBER(3,0)	Number of moderate severity transverse cracks (mean crack width from 6 to 19 mm or under 19 mm with adjacent low severity random cracking).
TRANS_CRACK_NO_H		NUMBER(3,0)	Number of high severity transverse cracks (mean crack width greater than 19 mm or under 19 mm with adjacent moderate to high severity random cracking).
TRANS_CRACK_L_L	ft	NUMBER(5,1)	Length of low severity transverse cracking (cracks of unknown width well sealed or with mean width of 6 mm or less).
TRANS_CRACK_L_M	ft	NUMBER(5,1)	Length of moderate severity transverse cracking (crack mean width from 6 to 19 mm or under 19 mm with adjacent low severity random cracking).
TRANS_CRACK_L_H	ft	NUMBER(5,1)	Length of high severity transverse cracking (mean crack width greater than 19 mm or under 19 mm with adjacent moderate to high severity random cracking).
TRANS_CRACK_SEAL_L_L	ft	NUMBER(5,1)	The length of well-sealed, low severity transverse cracking (cracks of unknown width or with mean width of 6 mm or less).
TRANS_CRACK_SEAL_L_M	ft	NUMBER(5,1)	The length of well-sealed, moderate severity transverse cracking (mean crack width from 6 to 19 mm or under 19 mm with adjacent low severity random cracking).
TRANS_CRACK_SEAL_L_H	ft	NUMBER(5,1)	The length of well-sealed, high severity transverse cracking (mean crack width greater than 19 mm or under 19 mm with adjacent moderate to high severity random cracking).
PATCH_NO_L		NUMBER(3,0)	Number of patches/patch deteriorations with low severity distress of any type.
PATCH_NO_M		NUMBER(3,0)	Number of patches/patch deteriorations with moderate severity distress type.

Field Name	Units	Field Type	Description
PATCH_NO_H		NUMBER(3,0)	Number of patches/patch deteriorations with high severity distress of any type.
PATCH_A_L	ft^2	NUMBER(5,1)	Area of patching with low severity distress or patch deterioration.
PATCH_A_M	ft^2	NUMBER(5,1)	Area of patching with moderate severity distress or patch deterioration.
PATCH_A_H	ft^2	NUMBER(5,1)	Area of patching with high severity distress or patch deterioration.
POTHOLES_NO_L		NUMBER(3,0)	Number of low severity potholes (less than 25 mm deep).
POTHOLES_NO_M		NUMBER(3,0)	Number of moderate severity potholes (from 25 to 50 mm deep).
POTHOLES_NO_H		NUMBER(3,0)	Number of high severity potholes (more than 50 mm deep).
POTHOLES_A_L	ft^2	NUMBER(5,1)	Area of low severity potholes (less than 25 mm deep).
POTHOLES_A_M	ft^2	NUMBER(5,1)	Area of moderate severity potholes (from 25 to 50 mm deep).
POTHOLES_A_H	ft^2	NUMBER(5,1)	Area of high severity potholes (more than 50 mm deep).
SHOVING_NO		NUMBER(3,0)	Number of areas where shoving exists.
SHOVING_A	ft^2	NUMBER(5,1)	The area of shoving, localized longitudinal displacement of the pavement surface.
BLEEDING	ft^2	NUMBER(5,1)	Presence of excess asphalt on the pavement surface, which may create a shiny, glass-like reflective surface.
POLISH_AGG_A	ft^2	NUMBER(5,1)	Area of polished aggregate (binder worn away to expose coarse aggregate).
RAVELING	ft^2	NUMBER(5,1)	Wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder.
PUMPING_NO		NUMBER(3,0)	Number of occurrences of water bleeding and pumping.
PUMPING_L	ft	NUMBER(4,1)	Length of pavement affected by water bleeding and pumping.
OTHER		CHARACTER (80)	A description of other surface distress.

GALTPP_PCC_DISTRESS

Field Name	Field Type	Description
GALTPP_ID	CHARACTER	A unique identifier for GALTPP
SOURCE	CHARACTER	Source of the distress data (COPACES, LTPP).
CONSTRUCTION_NO	CHARACTER	1 stands for new construction, 2 stands for rehabilitation
SURVEY_DATE	DATE	Date survey was performed.
SURVEYOR	CHARACTER	Person who conducts the survey.
BEFORE_TEMP	NUMBER	Pavement surface temperature at the beginning of the distress survey.
AFTER_TEMP	NUMBER	Pavement surface temperature at the end of the distress survey.
AVG_FAULTING	NUMBER	Average edge faulting calculated per site per survey.
MIN_FAULTING	NUMBER	Minimum edge faulting per site per survey.
MAX_FAULTING	NUMBER	Maximum edge faulting per site per survey.
STD_FAULTING	NUMBER	Standard deviation for edge faulting calculated per site per survey.
BROKEN_SLABS	NUMBER	Total number of broken slabs.
CORNER_BREAKS_NO_L	NUMBER	Number of low severity corner breaks. (Notspalled for more than 10 percent of length; no measurable faulting; corner piece not broken in two or more pieces.)
CORNER_BREAKS_NO_M	NUMBER	Number of moderate severity corner breaks. (Spalled at low severity for more than 10 percent; or faulting less than 13 mm; corner piece not broken in two or more
CORNER_BREAKS_NO_H	NUMBER	Number of high severity corner breaks. (Spalled at moderate to high severity for more than 10 percent of crack; or faulting exceeds 13 mm or corner piece in two or more pieces.)
LONG_CRACK_L_L	NUMBER	Length of low severity longitudinal cracking. (Crack widths less than 3 mm, no spalling or measurable faulting.)
LONG_CRACK_L_M	NUMBER	Length of well-sealed, moderate severity longitudinal cracking. (Crack widths between 3 and 13 mm or spalling less than 75 mm or faulting up to 13 mm.)
LONG_CRACK_L_H	NUMBER	Length of high severity longitudinal cracking. (Crack widths greater than 13 mm or spalling greater than 75 mm or faulting greater than 13 mm.)
LONG_CRACK_SEAL_L_L	NUMBER	Length of well-sealed, low severity longitudinal cracking. (Crack widths less than 3 mm, no spalling or measurable faulting.)
LONG_CRACK_SEAL_L_M	NUMBER	Number of transverse cracks for which moderate severity distress is the highest level observed for at least 10 percent of the crack.
LONG_CRACK_SEAL_L_H	NUMBER	Length of well-sealed, high severity longitudinal cracking. (Crack widths greater than 13 mm or spalling greater than 75 mm or faulting greater than 13 mm.)

Field Name	Field Type	Description
TRANS_CRACK_NO_L	NUMBER	Number of low severity transverse cracks. (No spalling exceeding 10 percent of length).
TRANS_CRACK_NO_M	NUMBER	Number of transverse cracks for which moderate severity distress is the highest level observed for at least 10
TRANS_CRACK_NO_H	NUMBER	Number of transverse cracks for which high severity distress exceeds 10 percent of the length.
TRANS_CRACK_L_L	NUMBER	Length of low severity transverse cracking. (Crack widths less than 3 mm, no spalling and no measurable faulting.)
TRANS_CRACK_L_M	NUMBER	Length of moderate severity transverse cracking. (Crack widths between 3 and 6 mm or spalling fewer than 75 mm or faulting up to 6 mm.)
TRANS_CRACK_L_H	NUMBER	Length of high severity transverse cracking. (Crack widths greater than 6 mm or spalling over 75 mm or faulting over 6 mm.)
LONG_SPALLING_L_L	NUMBER	Length of low severity spalling of longitudinal joints. (Spalls less than 75 mm measured to center of joint with no loss of material.)
LONG_SPALLING_L_M	NUMBER	Length of moderate severity spalling of longitudinal joints. (Spalls between 75 and 150 mm wide measured to center of joint with loss of material.)
LONG_SPALLING_L_H	NUMBER	Length of high severity spalling of longitudinal joints. (Spalls greater than 150 mm measured to center of joint with loss of material.)
TRANS_SPALLING_NO_L	NUMBER	Number of transverse joints with low severity spalling. (Spalls less than 75 mm wide measured to center of joint.)
TRANS_SPALLING_NO_M	NUMBER	Number of transverse joints with moderate severity spalling. (Spalls between 75 and 150 mm wide measured to center of joint.)
TRANS_SPALLING_NO_H	NUMBER	Number of transverse joints with high severity spalling. (Spalls more than 150 mm wide measured to center of joint.)
TRANS_SPALLING_L_L	NUMBER	Length of low severity spalling of transverse joints. (Spalls less than 75 mm measured to center of joint or with no loss of material.)
TRANS_SPALLING_L_M	NUMBER	Length of moderate severity spalling of transverse joints. (Spalls 75 to 150 mm wide measured to center of joint with loss of material).
TRANS_SPALLING_L_H	NUMBER	Length of high severity spalling of transverse joints. (Spalls more than 150 mm wide measured to center of joint with loss of material.)
SCALING_NO	NUMBER	Number of areas with scaling.
SCALING_A	NUMBER	Area of scaling (Deterioration of upper slab surface between 3 and 13 mm).
POLISH_AGG_A	NUMBER	Area of polished aggregate (Surface worn away to expose coarse aggregate).
BLOWUPS_NO	NUMBER	Number of blowups.
PATCH_FLEX_NO_L	NUMBER	Number of flexible patches showing at most low severity distress of any type and no settlement at the perimeter.

Field Name	Field Type	Description
PATCH_FLEX_NO_M	NUMBER	Number of flexible patches showing moderate severity distress of any type or settlement of up to 6 mm at the perimeter.
PATCH_FLEX_NO_H	NUMBER	Number of flexible patches showing high severity distress or settlement of 6 mm or more at the perimeter.
PATCH_FLEX_A_L	NUMBER	Area of flexible patching showing, at most, low severity distress of any type and no settlement at the perimeter.
PATCH_FLEX_A_M	NUMBER	Area of flexible patching showing moderate severity distress of any type or settlement of up to 6 mm at the perimeter.
PATCH_FLEX_A_H	NUMBER	Area of flexible patching showing high severity distress of any type or settlement of 6 mm or more at the perimeter.
PATCH_RIGID_NO_L	NUMBER	Number of rigid patches showing, at most, low severity distress of any type and no settlement at the perimeter.
PATCH_RIGID_NO_M	NUMBER	Number of rigid patches showing moderate severity distress of any type or settlement of up to 6 mm at the perimeter.
PATCH_RIGID_NO_H	NUMBER	Number of rigid patches showing high severity distress of any type or settlement of 6 mm or more at the perimeter.
PATCH_RIGID_A_L	NUMBER	Area of rigid patching showing, at most, low severity distress of any type and no settlement at the perimeter.
PATCH_RIGID_A_M	NUMBER	Area of rigid patching showing moderate severity distress of any type or settlement of up to 6 mm at the perimeter.
PATCH_RIGID_A_H	NUMBER	Area of rigid patching showing high severity distress of any type or settlement of 6 mm or more at the perimeter.
PUMPING_NO	NUMBER	Number of occurrences of water bleeding and pumping.
PUMPING_L	NUMBER	Length of pavement affected by water bleeding and pumping.

GACAL_CORE_DESCRIPTION

Name	Description
GALTPP_ID	
CORE	
Description	

GACAL_CORE_HEIGHTMEASURE

Name	Description
GALTPP_ID	
DATE	
LAYER	
NOTE	

Name	Description
Measure_1	
Measure_2	
Measure_3	
Measure_4	
Avg_in	
Avg_mm	

GACAL_DCP

Name	Description
GALTPP_ID	
DATE	
NOTE	
CORE	
No_of_Blows	
Cummulative_Penetration_cm	
Cumulative_Penetration_mm	
Penetration_Rate_mm/blow	
Resilient_Modulus_ksi	
Depth_inches	
Other_Note	

GACAL_PCC_DISTRESS

Field Name	Description
GALTPP_ID	
CORN_BREAK_L	
CORN_BREAK_M	
CORN_BREAK_H	
LONG_CRACK_L	
LONG_CRACK_M	
LONG_CRACK_H	
TRAN_CRACK_NO_L	
TRAN_CRACK_L_L	
TRAN_CRACK_NO_M	
TRAN_CRACK_L_M	

Field Name	Description
TRAN_CRACK_NO_H	
TRAN_CRACK_L_H	
SPALL_L_JOINT_L	
SPALL_L_JOINT_M	
SPALL_L_JOINT_H	
SPALL_T_JOINT_NO_L	
SPALL_T_JOINT_L_L	
SPALL_T_JOINT_NO_M	
SPALL_T_JOINT_L_M	
SPALL_T_JOINT_NO_H	
SPALL_T_JOINT_L_H	
PATCH_DET_RIGID_NO_L	
PATCH_DET_RIGID_AREA_L	
PATCH_DET_RIGID_NO_M	
PATCH_DET_RIGID_AREA_M	
PATCH_DET_RIGID_NO_H	
PATCH_DET_RIGID_AREA_H	
TOTAL_NO_SLAB	
LENGTH	
WIDTH	

MEPDG_UNBOUND_MATERIAL

Name	Description
GALTPP_ID	Test section identification number.
CONSTRUCTION_NO	1 stands for new construction, 2 stands for rehabilitation
NOTE	Note for routes
LAYER_NO	Layer number
Layer_Type	Type of layer
Material_Code	Code of material
Material_Code_and_Description	Code of material and description
Last_Layer	Identifies layer as the last layer of the pavement section
Bedrock	**Bedrock layer inputs**
Coefficient_Lateral_Earth_Pressure	Coefficient of lateral earth pressure
Layer_Thickness_in	Thickness of each layer (in)
Poisson_Ratio	Poisson's ratio
Resilient_Modulus	Resilient modulus (psi)
Type	Layer type
Liquid_Limit	Liquid limit of the non-stabilized material.
Plasticity_Index	This control allows you to define the plasticity index for non-stabilized material.
Compacted_Layer	Enable this control to indicate that the layer is compacted.
Max_Dry_Unit_Weight	Maximum dry unit weight. (pcf)
User_Defined_MDUW	
Saturated_Hydraulic_Conductivity	
User_Defined_SHC	
Gravity_of_Solids	
User_Defined_GS	
Water_Content	
User_Defined_WC	
User_Defined_SWCC	User-defined Soil Water Characteristic Curve (SWCC)
af	
bf	
cf	

Name	Description
hr	
Gradation	**Gradation inputs for each unstabilized/stabilized layer**
THREE_AND_HALF_PASSING	Mean percent passing 3-½ in screen
THREE_PASSING	Mean percent passing 3 in screen
TWO_AND_HALF_PASSING	Mean percent passing 2-½ in screen
TWO_PASSING	Mean percent passing 2 in screen
ONE_AND_HALF_PASSING	Mean percent passing 1-½ in screen
ONE_PASSING	Mean percent passing 1 in screen
THREE_QUARTER_PASSING	Mean percent passing ¾ in screen
HALF_PASSING	Mean percent passing ½ in screen
THREE_EIGHTH_PASSING	Mean percent passing ⅜ in screen
NO_4_PASSING	Mean percent passing #4 screen
NO_8_PASSING	Mean percent passing #8 screen
NO_10_PASSING	Mean percent passing #10 screen
NO_16_PASSING	Mean percent passing #16 screen
NO_20_PASSING	Mean percent passing #20 screen
NO_30_PASSING	Mean percent passing #30 screen
NO_40_PASSING	Mean percent passing #40 screen
NO_50_PASSING	Mean percent passing #50 screen
NO_60_PASSING	Mean percent passing #60 screen
NO_80_PASSING	Mean percent passing #80 screen
NO_100_PASSING	Mean percent passing #100 screen
NO_200_PASSING	Mean percent passing #200 screen
0_02MM_PASSING	Mean percent passing 0.020 mm screen
0_002MM_PASSING	Mean percent passing 0.002 mm screen
0_001MM_PASSING	Mean percent passing 0.001 mm screen
PI	Plasticity index
LL	Liquid limit
Compacted_Layer	Compacted layer
Stabilized	**Inputs for stabilized layer**
Unit_Wght	Unit weight (pcf)
Poisson_Ratio	Poisson’s ratio

Name	**Description**
Elastic_Resilient_Mod	Elastic/resilient modulus (psi)
Minimum_Mod	Minimum elastic/resilient modulus (psi)
Mod_of_Rupture	Modulus of rupture (psi)
Therm_Cndctvty	Thermal conductivity (BTU/hr-ft-°F)
Heat_Capacity	Heat capacity (BTU/lb-°F)
Strength (for each layer)	**Strength inputs for each unstabilized/stabilized layer**
k1	Regression constants (used for Level 1 calculation of MR)
k2	Regression constants (used for Level 1 calculation of MR)
k3	Regression constants (used for Level 1 calculation of MR)
Poisson_Ratio	Poisson's ratio
Ltrl_Pressure	Lateral pressure
Modulus	Resilient modulus (psi)
CBR	California Bearing Ratio
R_Val	R-Value
Lyr_Coefnt	AASHTO layer coefficient
DCP	Dynamic Cone Penetrometer (mm/blow)

MEPDG_PCC_MATERIAL

Name	**Description**
GALTPP_ID	Test section identification number.
CONSTRUCTION_NO	1 stands for new construction, 2 stands for rehabilitation
NOTE	Note for routes
LAYER_NO	Layer number
CTE	Coefficient of thermal expansion (per °F x 10-6)
Existing_Layer	Existing layer as opposed to a new layer
Poisson_Ratio	Poisson's ratio
Thickness	Layer thickness
Unit_Weight	Unit weight (pcf)
Thermal_Expansion	PCC coefficient of thermal expansion (in/in/deg F x 10-6)
Heat_Capacity	Heat capacity (BTU/lb-°F)
Therm_Conduct	Thermal conductivity (BTU/hr-ft-°F)
Mix	**Mix design properties**
Aggregate_Type	Aggregate type
Cmntitious_Cntnt	Cementitious content
Cmnt_Typ	Cement type
W_C_Ratio	Water-cement ratio
Curing_Type	Curing type
Reverse_Shrink	Reverse shrinkage
Ultimate_Shrinkage	Ultimate shrinkage
Strength	**Strength properties**
Age	Age (yrs)
Modulus_of_Rupture	Modulus of rupture (psi)
Elstc_Modulus	Elastic modulus (psi)
Comp_Strength	Compressive strength (psi)
Design	**Concrete pavement design features**
PCC_Surface_Shortwave_Absorbtion	PCC surface shortwave absorptivity, the fraction of solar energy (sunshine) at the PCC surface.
Dowel_Spacing	Dowel bar spacing (in)
Dowel_Diameter	Dowel bar diameter (in)
Erodibility_Index	Using an index on a scale of 1 to 5, 1 for extremely erosion resistant, 5 for very erodible
Base_Slab_Friction_Coefficient	Base/slab friction coefficient

Name	Description
Joint_Spacing	Joint spacing (ft)
Curl_Warp_Effective_ Temperature_Difference	Permanent curl/warp effective temperature difference (°F)
Sealant_Type	Joint sealant type
Tied_PCC	Identifies the presence of a tied concrete shoulder
Tied_LTE	Load transfer efficiency of the tied concrete shoulder
Widened_Slab	Identifies the presence of a widened lane
Slab_Width	Width of the widened slab (ft)
PCC_Base_Interface	Level of friction between the base and PCC
Loss_of_Friction	Loss of full friction (age in months)
Steel_Reinforcement	Percent steel (%)
Reinforcement_Steel_Diameter	Bar diameter (in)
Depth_of_Reinforcement	Steel depth (in)
Crack_Spacing	Mean crack spacing (in)
Shoulder_Type	Tied vs untied PCC or asphalt concrete

MEPDG_AC_CRACK

Field Name	Units	Field Type	Description
GALTPP_ID		CHARACTER	A unique identifier for GALTPP
CONSTRUCTION_NO		CHARACTER	1 stands for new construction, 2 stands for rehabilitation
NOTE		CHARACTER	Note of routes
SOURCE		CHARACTER	Source of the distress data (COPACES, LTPP)
SURVEY_DATE		DATE	Date of distress survey.
FATIGUE_CRACK	ft/mi	NUMBER(4,1)	Total length of fatigue cracking per lane-mile.
THERMAL_CRACK	ft/mi	NUMBER(4,1)	Total length of thermal cracking per lane-mile.

MEPDG_AC_RUT

Field Name	Units	Field Type	Description
GALTPP_SEC_CON_ID		CHARACTER	A unique identifier for GALTPP
CONSTRUCTION_NO		CHARACTER	1 stands for new construction, 2 stands for rehabilitation
NOTE		CHARACTER	Note of routes
SOURCE		CHARACTER	Source of the distress data (COPACES, LTPP)
SURVEY_DATE		DATE	Date of distress survey.
WIRELINE_RUT	in	NUMBER(3,2)	Rut depth for the 500-ft test section

MEPDG_PCC_CRACK

Field Name	Units	Field Type	Description
GALTPP_ID		CHARACTER	A unique identifier for GALTPP
CONSTRUCTION_NO		CHARACTER	1 stands for new construction, 2 stands for rehabilitation
NOTE		CHARACTER	Note of routes
LTPP_SECTION_ID		CHARACTER(6)	LTPP test section identification.
SURVEY_DATE		DATE	Date of distress survey.
CRACKING	%	NUMBER(3,1)	% slabs cracked

MEPDG_PCC_FAULT

Field Name	Units	Field Type	Description
GALTPP_ID		CHARACTER	A unique identifier for GALTPP
CONSTRUCTION_NO		CHARACTER	1 stands for new construction, 2 stands for rehabilitation
NOTE		CHARACTER	Note of routes
LTPP_SECTION_ID		CHARACTER(6)	LTPP test section identification.
SURVEY_DATE		DATE	Date of distress survey.
FAULTING	in	NUMBER(3,1)	Mean joint faulting

MEPDG_AC_MATERIAL

Name	Description
GALTPP_ID	Test section identification number.
CONSTRUCTION_NO	1 stands for new construction, 2 stands for rehabilitation
NOTE	Note of routes
LAYER_NO	Layer number
Layer_Type	Type of layer
Material_Code	Code of material
Material_Code_and_Description	Code of material and description
Layer_Thickness	Layer thickness (in)
Air_Voids	Percent air voids
Effctv_Bndr_Cntnt	Effective binder content (by weight)
Poisson_Ratio_Calculated	Calculated Poisson’s ratio
Poisson_Ratio	Poisson’s ratio
ParameterA	
ParameterB	
Unit_Weight	Total unit weight (pcf)
Existing_Layer	Existing layer as opposed to a new layer
Binder	**Asphalt binder properties (Level 3).**
Binder_Type	Binder Type
Binder_Grad	Binder grade
Creep	Creep
Load_Time	Load time
Creep	**Creep compliance properties (thermal cracking).**
Load_Time	Loading time (sec).
Creep_-4F	Low temperature (-4 °F).

Name	Description
Creep_-14F	Mid temperature (14 °F).
Creep_-32F	High temperature (32 °F).
E	**Dynamic modulus of asphalt mixture (Level 1)**
Temperature	Temperature (°F)
E_0_1	Dynamic modulus (psi) at 0.1 Hz
E_1	Dynamic modulus (psi) at 1 Hz
E_10	Dynamic modulus (psi) at 10 Hz
E_25	Dynamic modulus (psi) at 25 Hz
HMA_Model	Hot Mix Asphalt (HMA) model
Reference_Temp	Reference temperature (°F)
Indirect_Tensile_Strength	Indirect tensile strength
Heat_Capacity	Heat capacity (BTU/lb-°F)
Thermal_Conductivity	Thermal conductivity. (BTU/hr-ft-°F)
Thermal_Contraction	A direct entry of the coefficient or allow the program to compute as a function of thermal contraction coefficient of the aggregates.
Aggregate_Coefficient_Thermal_Contraction	Coefficient of thermal contraction of the aggregates (in./in./˚F)
Mix_Coefficient_Thermal_Contraction	Coefficient of thermal contraction of the AC mix(in./in./˚F)
Voidsin_Mineral_Aggregate	Voidsin Mineral Aggregate
RTFO_SP	**Superpave binder test data (Level 1 and Level 2)**
Temperature	Temperature (°F)
G	Binder dynamic modulus (Pa)
Delta	Phase angle
RTFO_Conv	**Conventional binder properties (Level 1 and Level 2)**
Temp	Temperature (°F)
Softening_Pnt	Softening point (P)
Abslt_Vscsty	Absolute viscosity (P)
Knmtc_Vscsty	Kinematic viscosity (CS)
Spcfc_Grvty	Specific gravity
Penetration	Penetration
Brkfld_Vscsty	Brookfield viscosity
Gradation	**Gradation properties of asphalt mixture (Level 2 and Level 3)**
Retained_3_4	Cumulative percent retained on the ¾ in sieve.
Retained_3_8	Cumulative percent retained on the ⅜ in sieve.

Name	**Description**
Retained_ No_4	Cumulative percent retained on the #4 sieve.
Passing_No_200	Percent passing the No. 200 sieve.
ThermCrk	**Thermal cracking properties**
Tnsl_Strngth	Average tensile strength at 14 °F (psi)
VMA	Mixture voids in mineral aggregate (%)
Aggrgt_CTC	Aggregate coefficient of thermal contraction (in/in/°F)
Mix_CTC	Mix coefficient of thermal contraction (in/in/°F)

MEPDG_TRAFFIC_INPUTS

Field Name	Description
GALTPP_ID	A unique identifier for GALTPP and Georgia test sites
Construction_No	1 stands for new construction, 2 stands for rehabilitation
FunctionalClass	Classification of pavement function
MEPDFTTCGROUP	Truck traffic classification
AADTT	Initial two-way average annual daily truck traffic
Direction	Direction of traffic
No_Design_Lane	Number of lanes in the design direction
Percent_Trcks_Dsgn_Dir	Percent of trucks in the design direction (%)
Percent _Trcks_Dsgn_Lane	Percent of trucks in design lane (%)
Speed	Operational speed (mph)
Growth_Rate	Traffic growth rate (%)
General Traffic Inputs	
Wheel_Location	Mean wheel location (inches from the lane marking)
Trffc_Wander_Stdev	Traffic wander standard deviation (in)
Design_Lane_Width	Design lane width (ft)
Axle Configuration	
Avg_Axle_Width	Average axle width (edge-to-edge), outside dimension (ft)
Dual_Tire_Spacing	Dual tire spacing (in)
Tire_Pressure	Tire pressure (psi)
Axle_Spcing_Tandem	Tandem axle spacing (in)
Axle_Spcing_Tridem	Tridem axle spacing (in)
Axle_Spcing_Quad	Quad axle spacing (in)
Wheelbase	
Wheelbase_Short	Average short axle spacing (ft)
Percent Trucks_Short	Percent of trucks – short axle spacing (%)
Wheelbase_Medium	Average medium axle spacing (ft)
Percent Trucks_Medium	Percent of trucks – medium axle spacing (%)
Wheelbase_Long	Average long axle spacing (ft)
Percent Trucks_Long	Percent of trucks – long axle spacing (%)
Traffic Volume Adjustment Factors	
VehicleDistribution_Class_4	Vehicle class distribution
Class_4 – Class_13	AADTT distribution by vehicle class (%)
Axle Load Distribution Factors	
Single	Single axle
Month_S	Month of the year (January – December)
Class_S	FHWA truck class 1 – 13
Total_S	Sum of axle load distribution factors (must total 100%)

Field Name	Description
3000 – 41000	Percent of axles in each load interval (1000 lb increments)
Tandem	Tandem axle
Month_T	Month of the year (January – December)
Class_T	FHWA truck class 1 – 13
Total_T	Sum of axle load distribution factors (must total 100%)
6000 – 82000	Percent of axles in each load interval (2000 lb increments)
Tridem	Tridem axle
Month_Tr	Month of the year (January – December)
Class_Tr	FHWA truck class 1 – 13
Total_Tr	Sum of axle load distribution factors (must total 100%)
12000 – 102000	Percent of axles in each load interval (3000 lb increments)
Quad	Quad axle
Month_Q	Month of the year (January – December)
Class_Q	FHWA truck class 1 – 13
Total_Q	Sum of axle load distribution factors (must total 100%)
12000 – 102000_Q	Percent of axles in each load interval (3000 lb increments)

MEPDG_TRAFFIC_AXLES_NO

Number of axles/truck	
Field Name	Description
GALTPP_ID	A unique identifier for GALTPP and Georgia test sites
Vehicle_Class	FHWA truck class 4 – 13
Single_Axles	Average number of single axles per truck class
Tandem_Axles	Average number of tandem axles per truck class
Tridem_Axles	Average number of tridem axles per truck class
Quad_Axles	Average number of quad axles per truck class

MEPDG_TRAFFIC_MAF

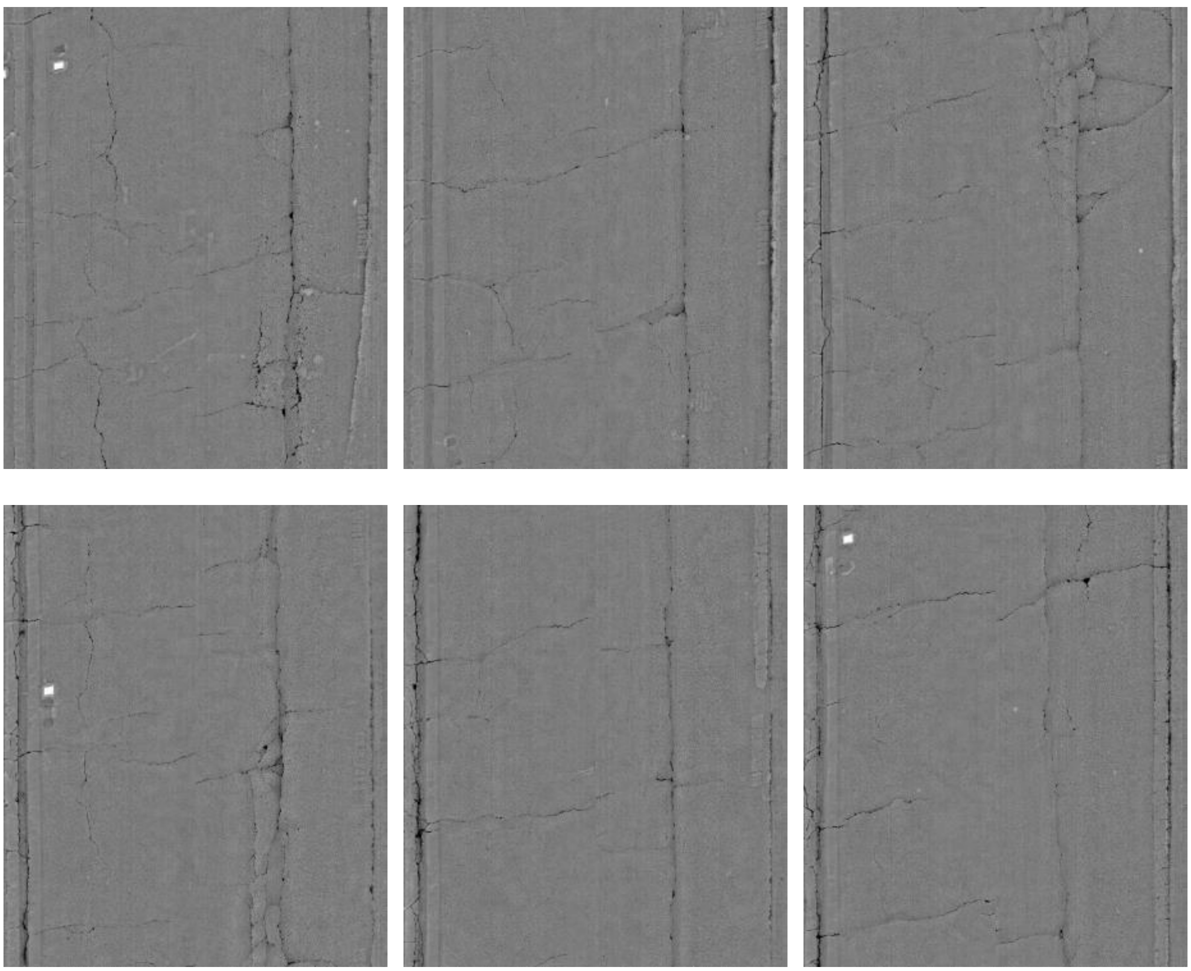
Traffic Volume Monthly Adjustment Factors	
Filed Name	Description
GALTPP_ID	A unique identifier for GALTPP and Georgia test sites
Month	Month of the year (January – December)
Class_4 – Class_13	Monthly adjustment factor for each FHWA truck class 1 – 13

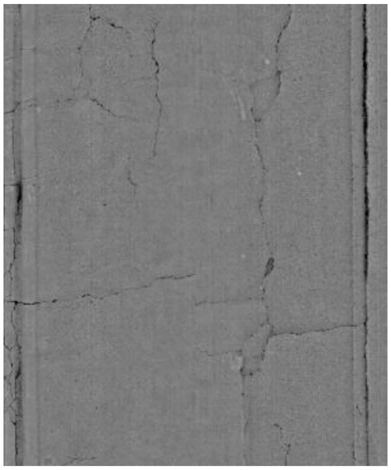
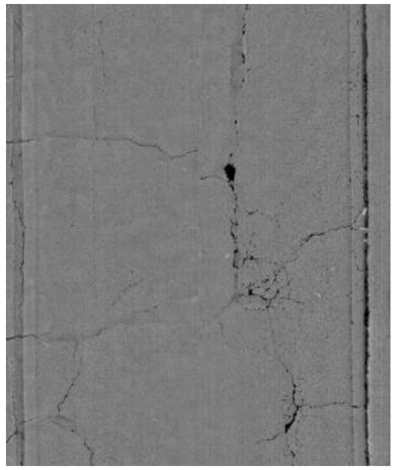
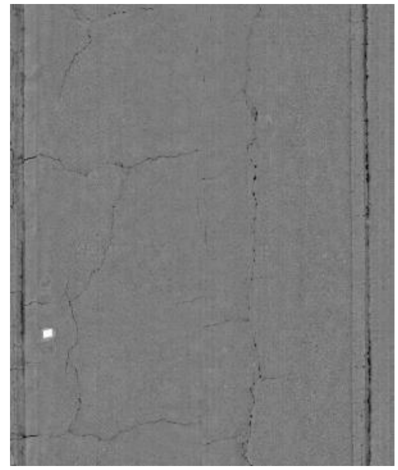
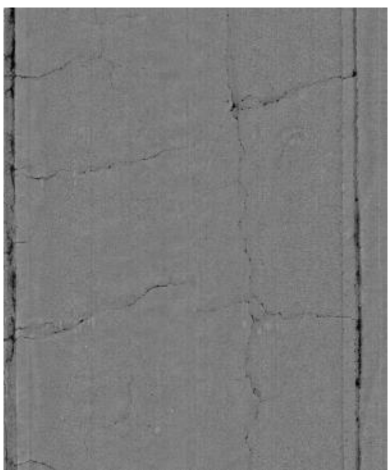
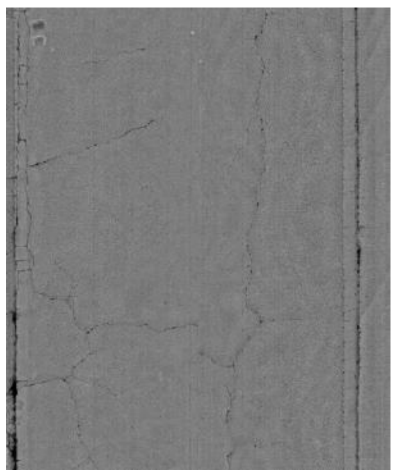
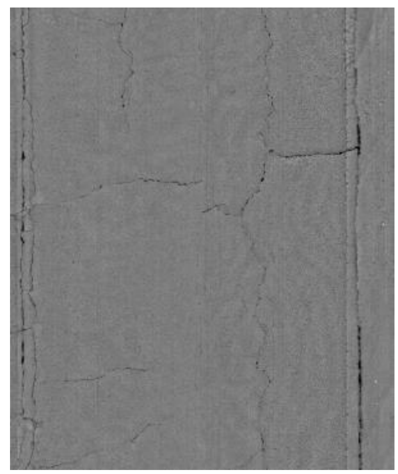
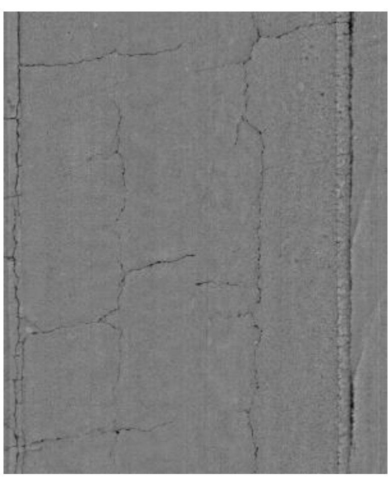
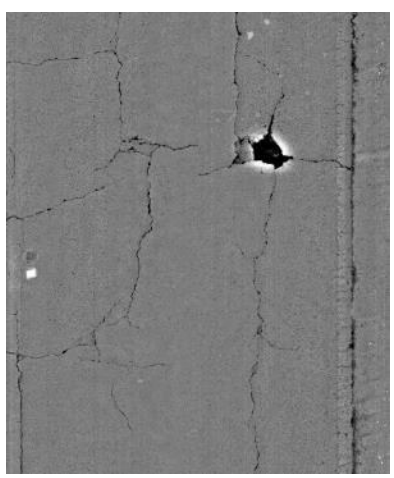
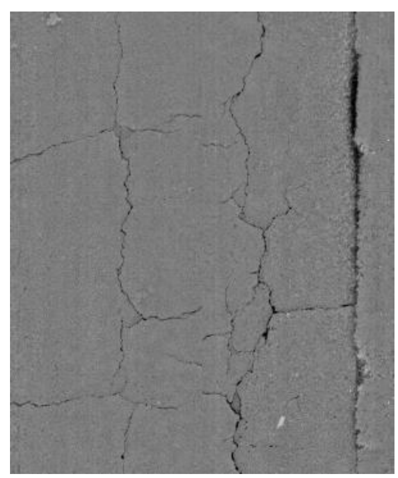
MEPDG_LAYER

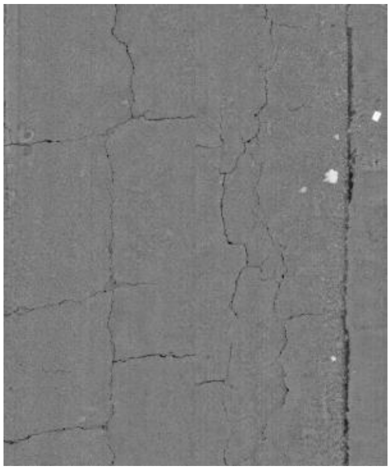
Field Name	Description
GALTPP_ID	A unique identifier for GALTPP and Georgia test sites
Layer_No	Number of layer
Layer_Type	Type of layer
Material_Code_Description	Description of material code
Layer_Thickness	Layer thickness in inch
Construction_No	1 stands for new construction, 2 stands for rehabilitation
Material_Code	Material code

APPENDIX B SITE 3D PAVEMENT SURFACE IMAGES SHOWING PAVEMENT DISTRESS CONDITIONS

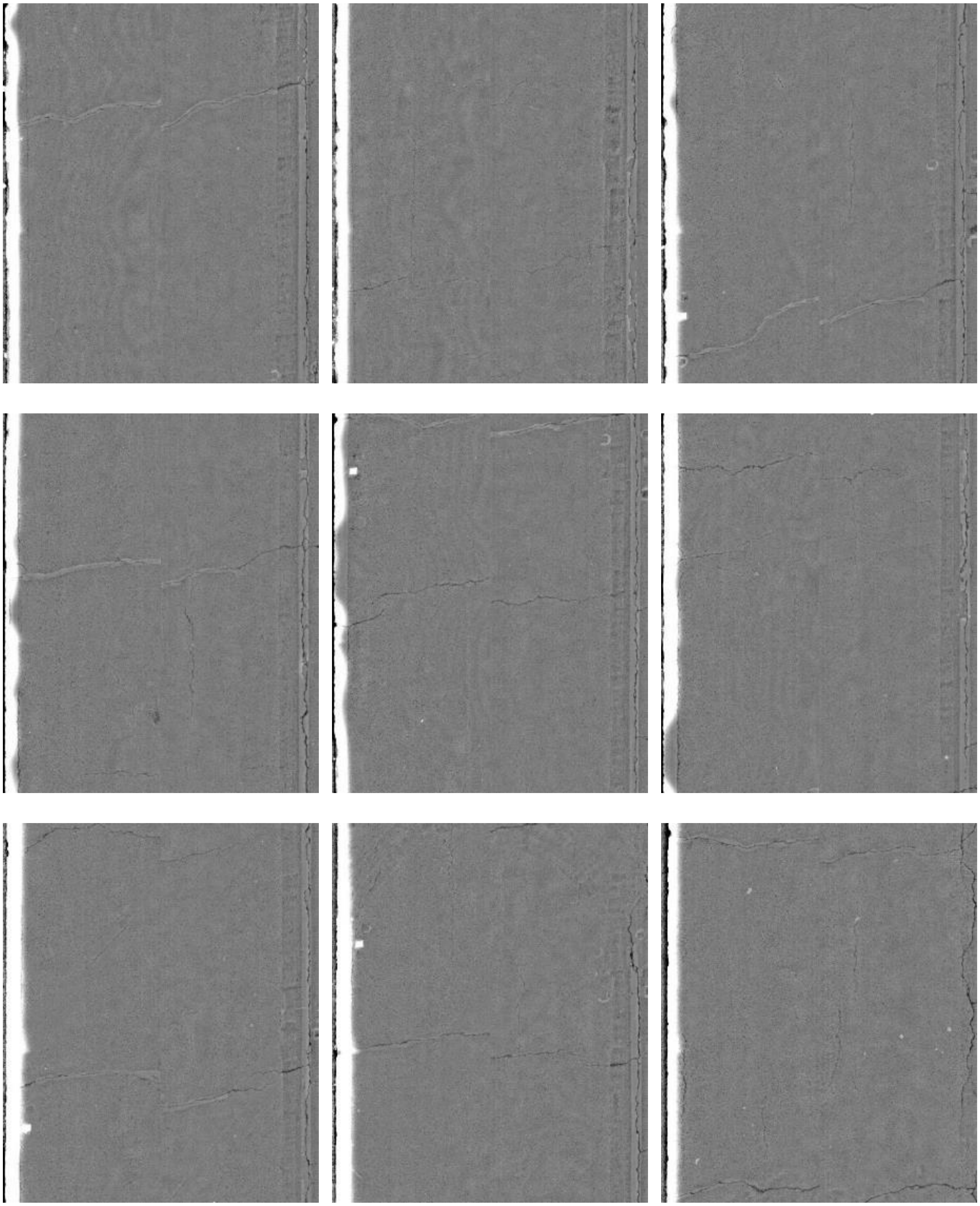
- **Site #1**

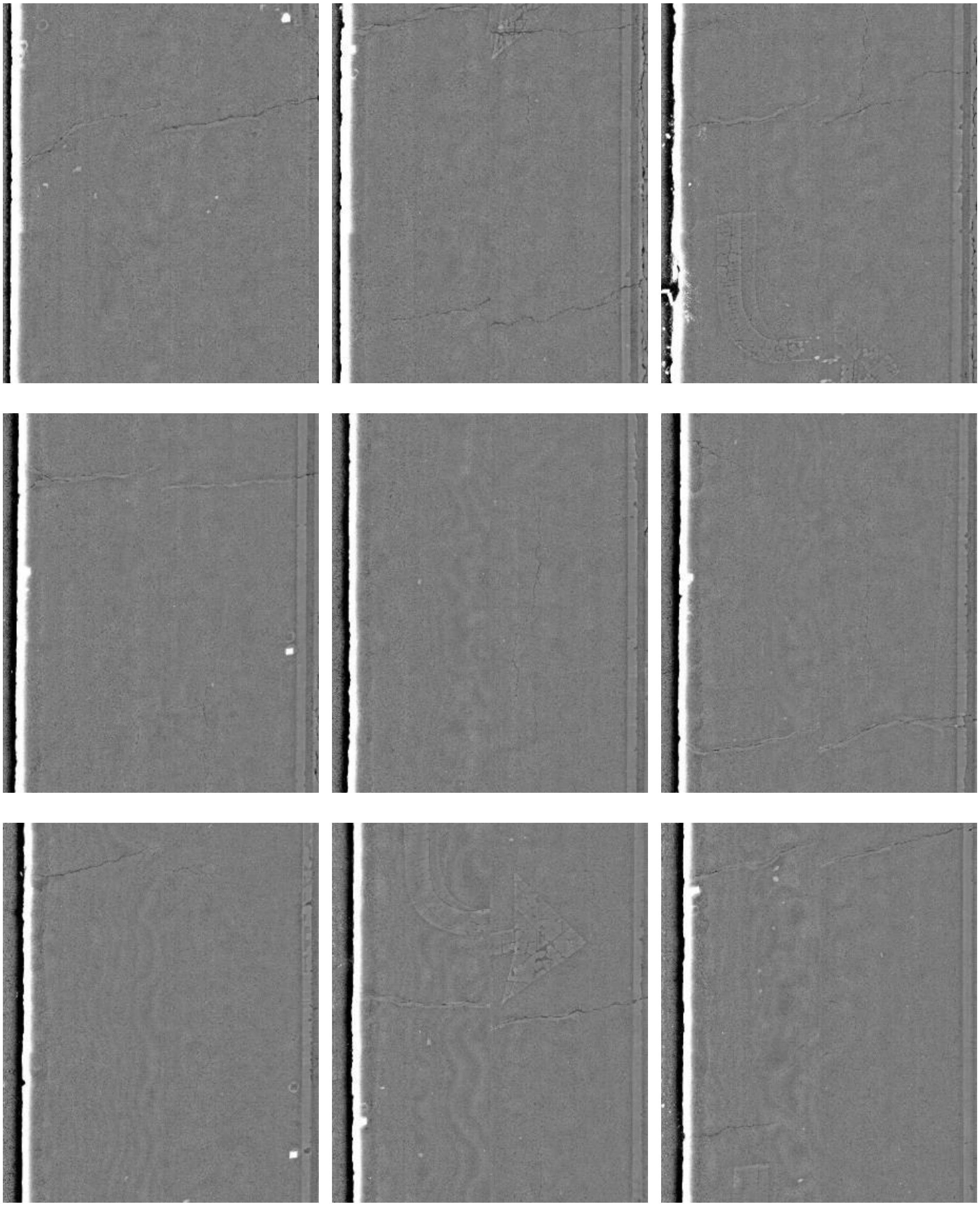




- **Site #2**





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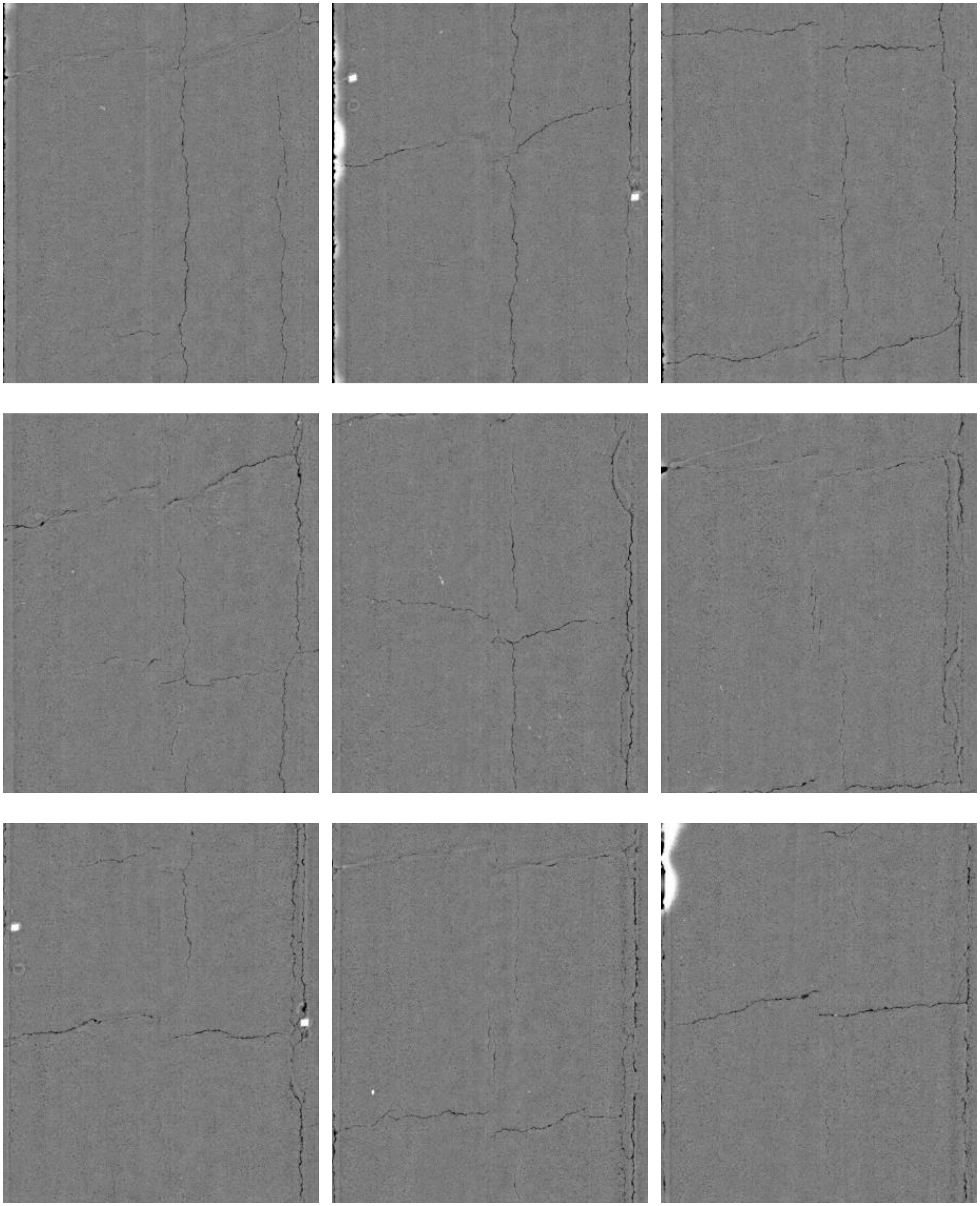
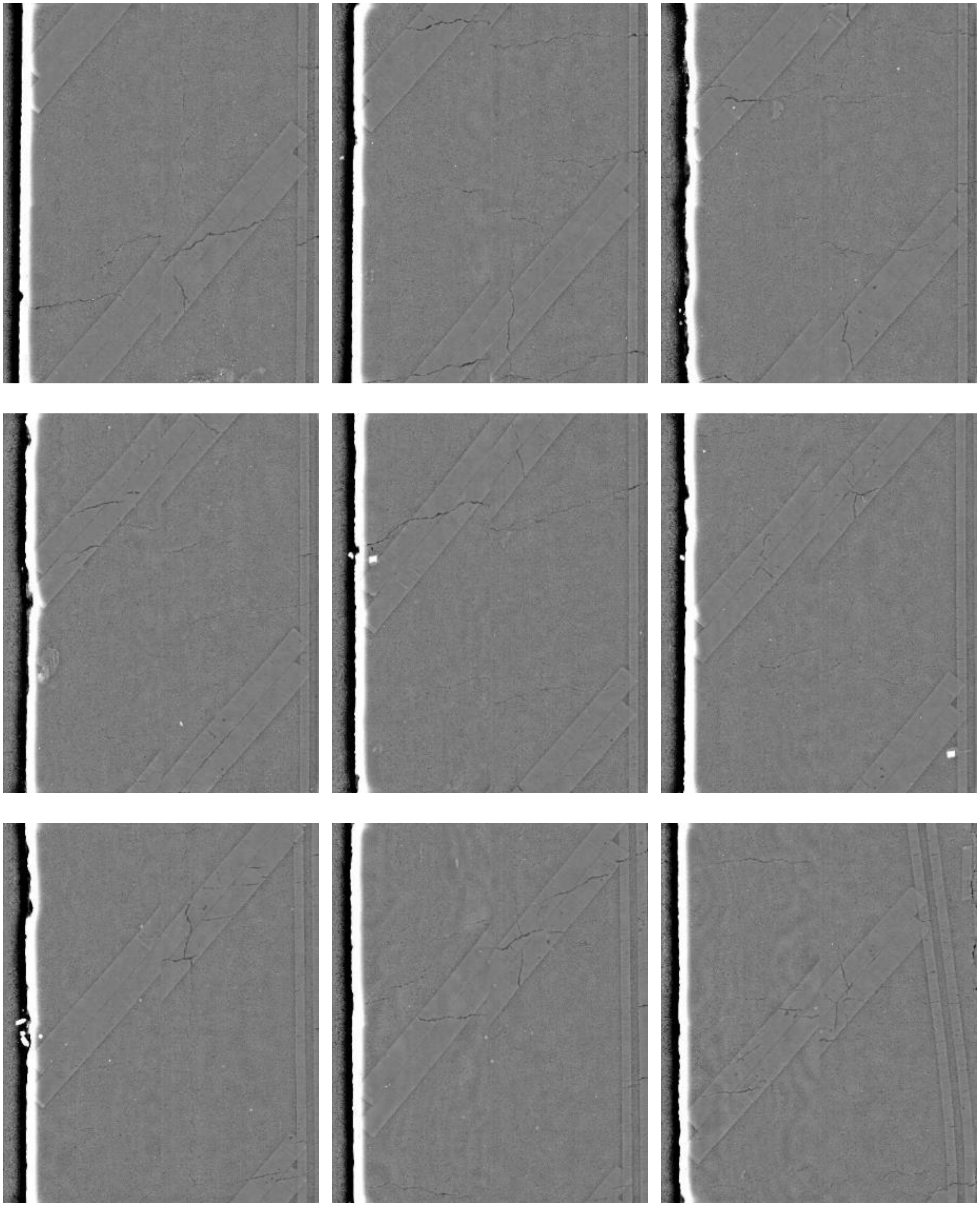
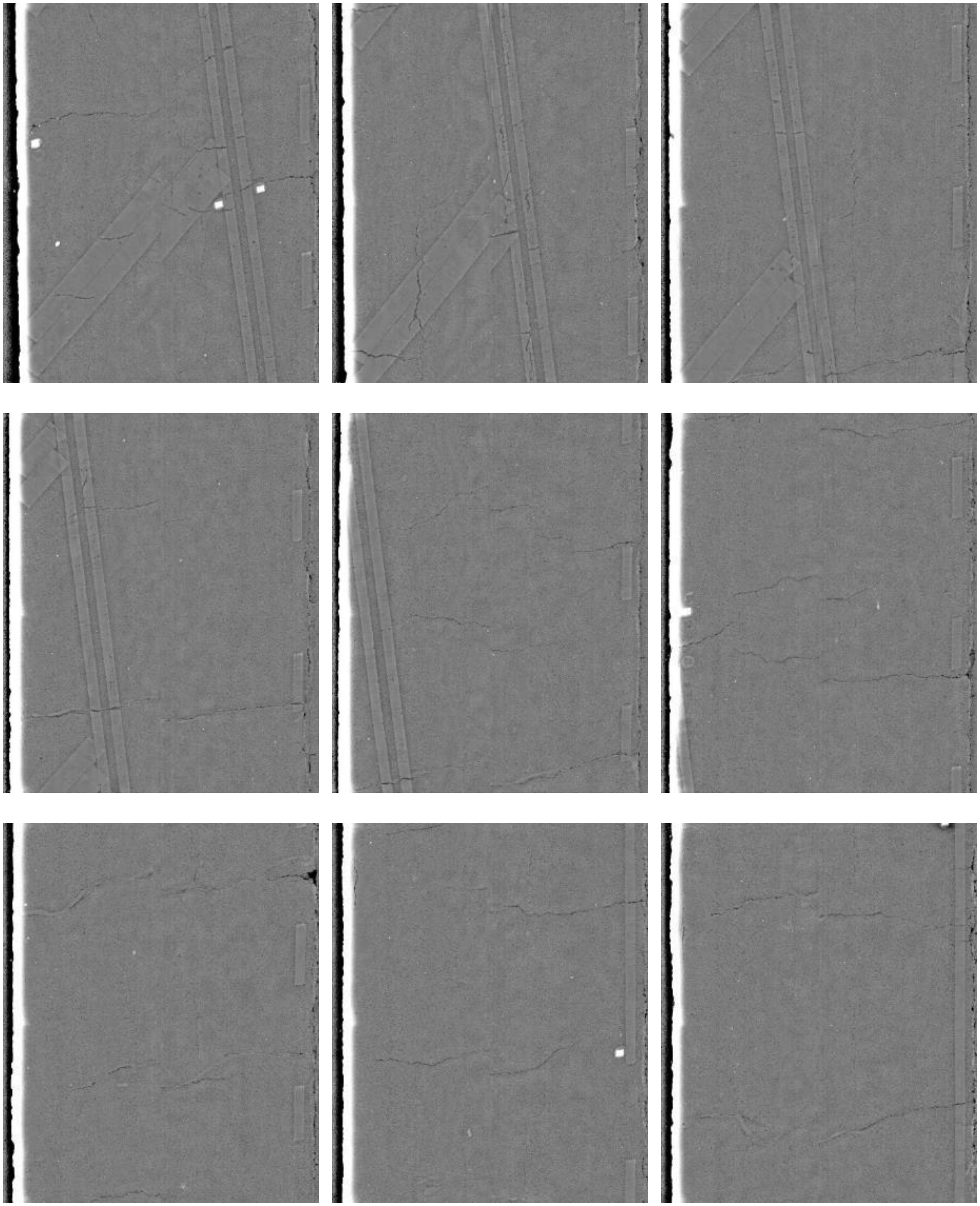
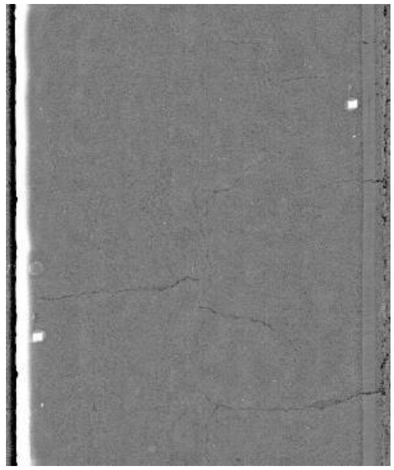
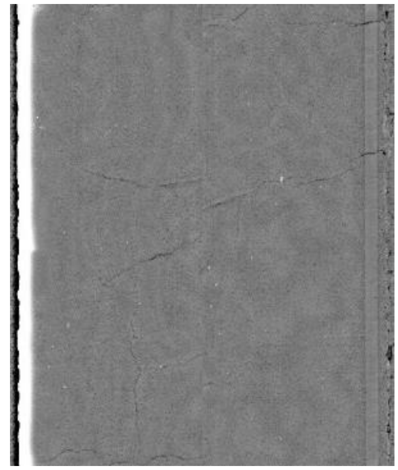
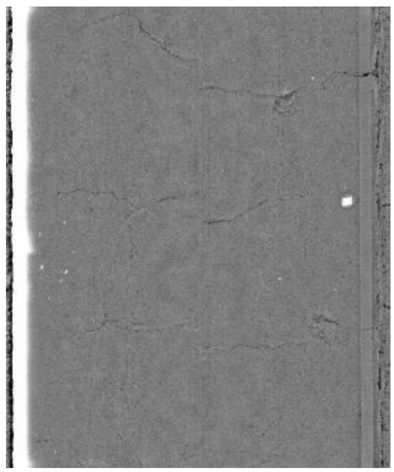


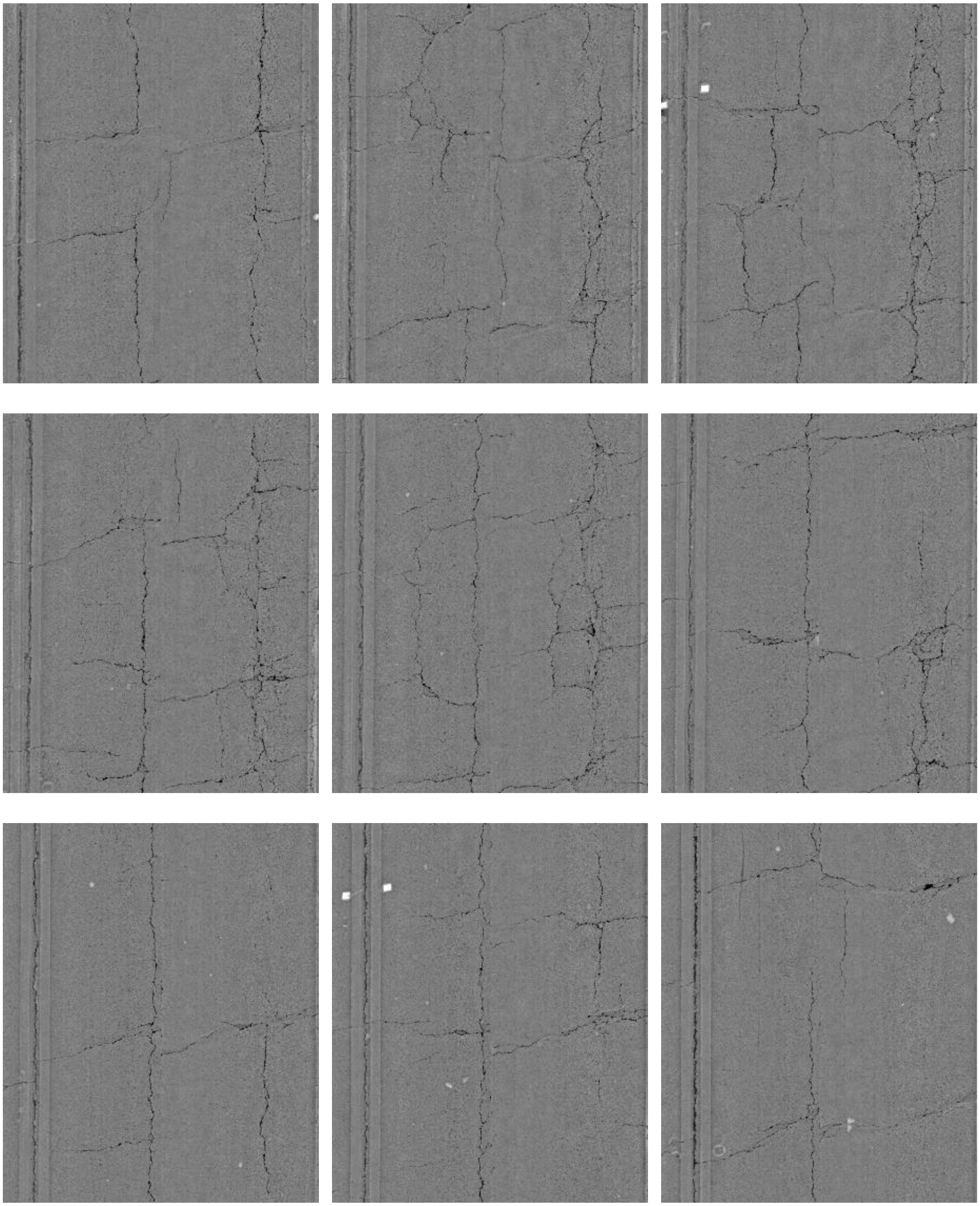
- **Site #4**

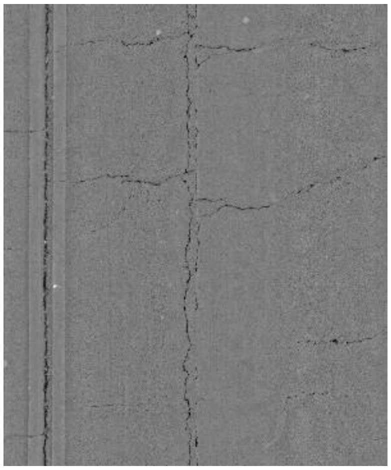
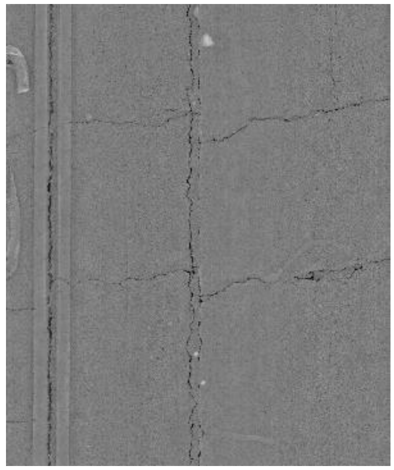
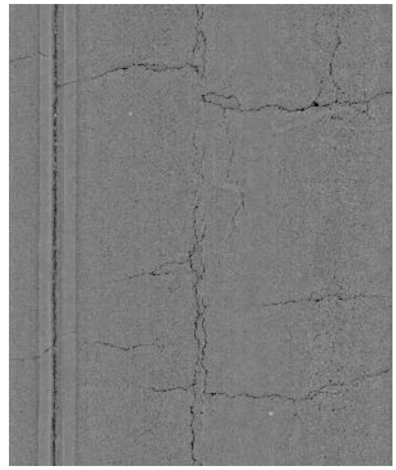
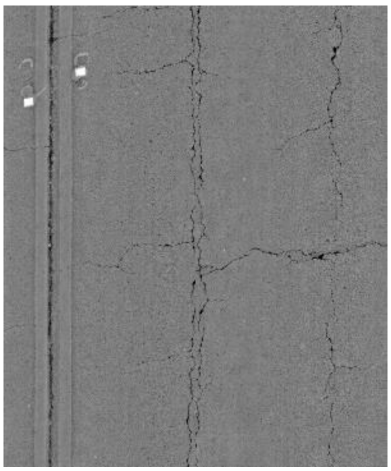
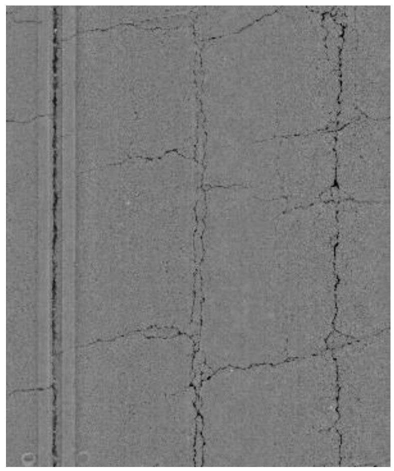
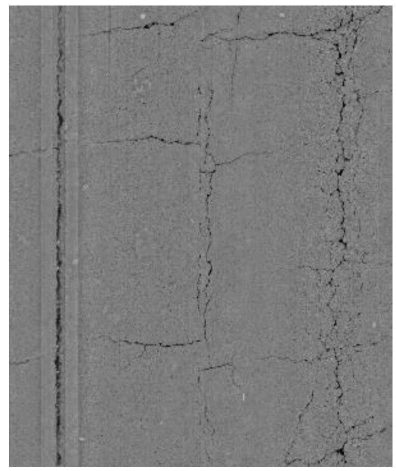


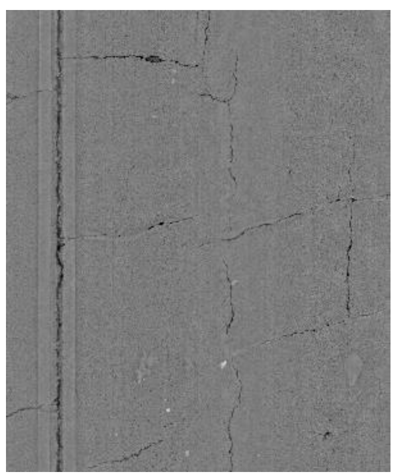
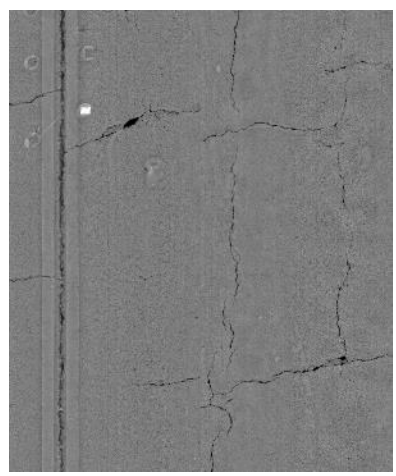


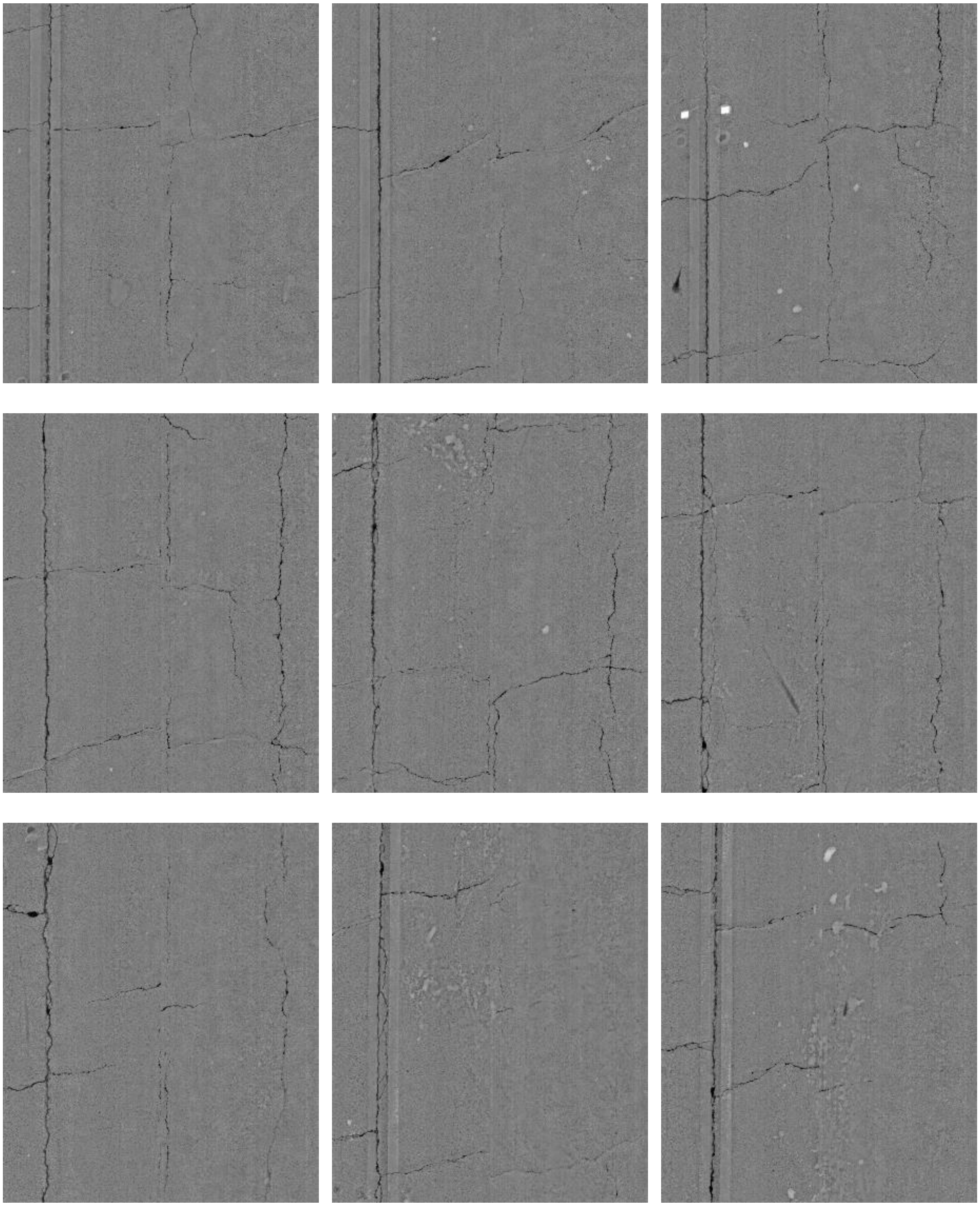





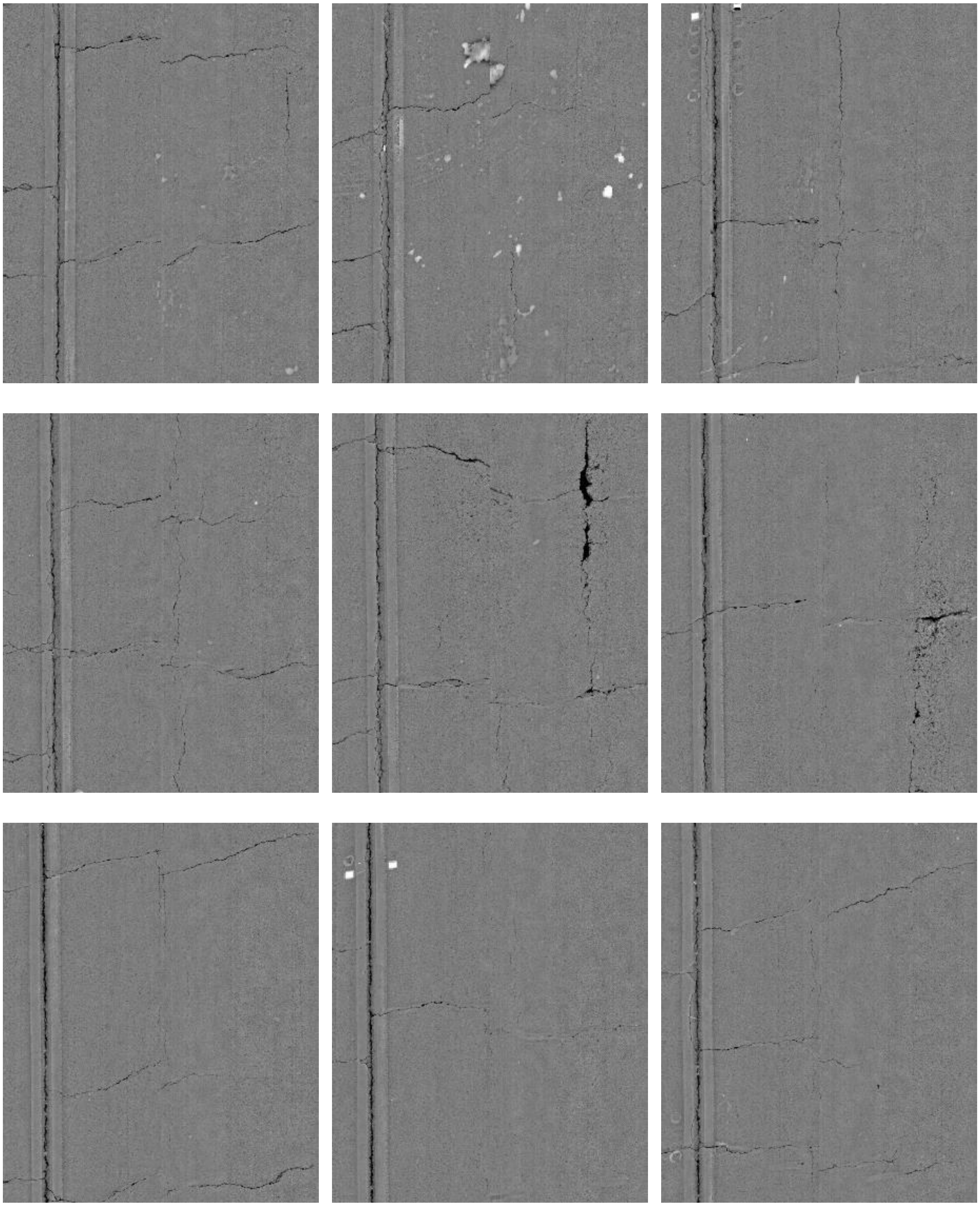
- **Site #5**

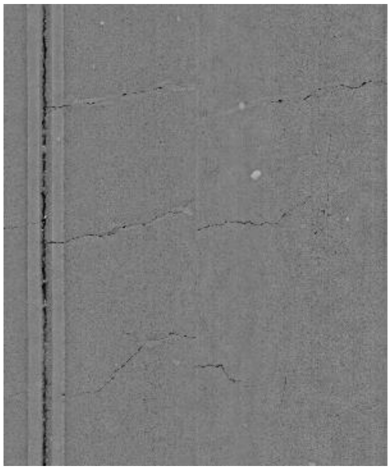
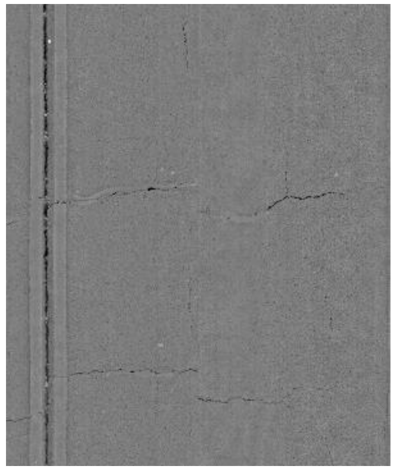
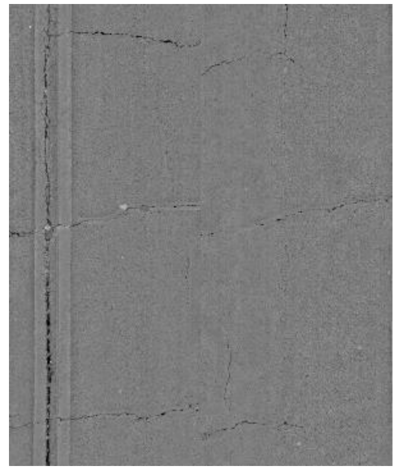
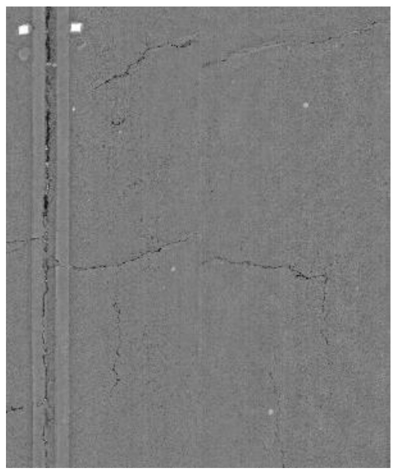


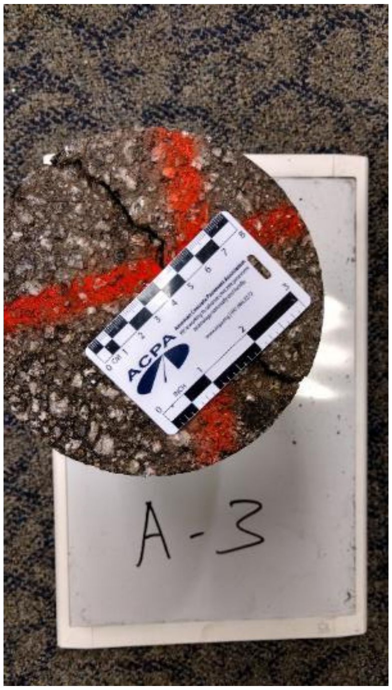


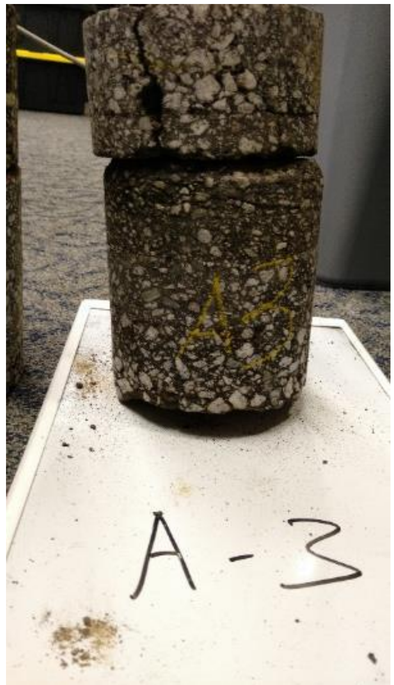


APPENDIX C CORE PICTURES SHOWING SUBSURFACE CONDITIONS

- **Site #1 - Core #A3**





- **Site #1 - Core #A4**


A-4

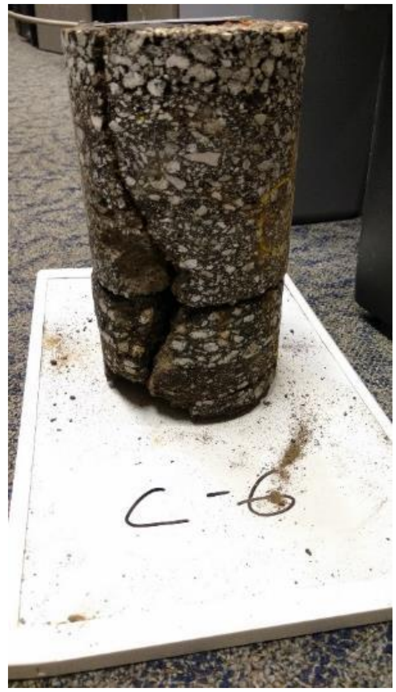

ACPA
A-4

- **Site #2 - Core #C2**

- **Site #2 - Core #C4**

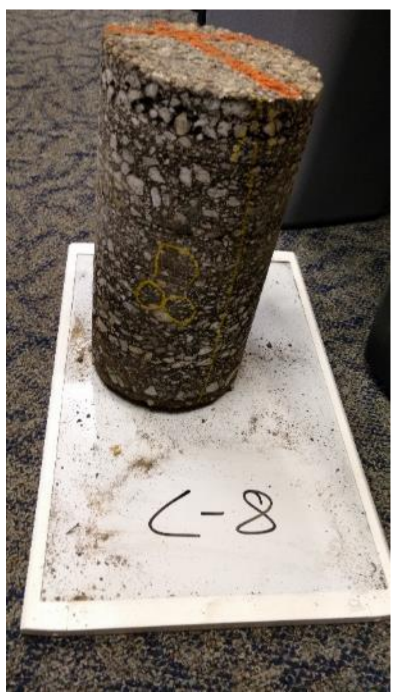
- **Site #2 -** Core #C5

- **Site #2 -** Core #C6

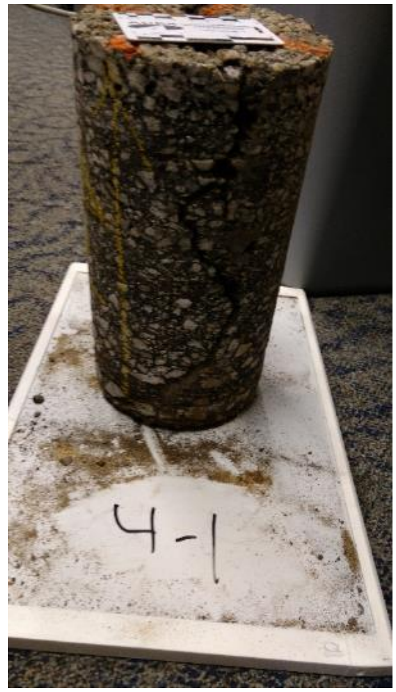


- **Site #2 -** Core #C7

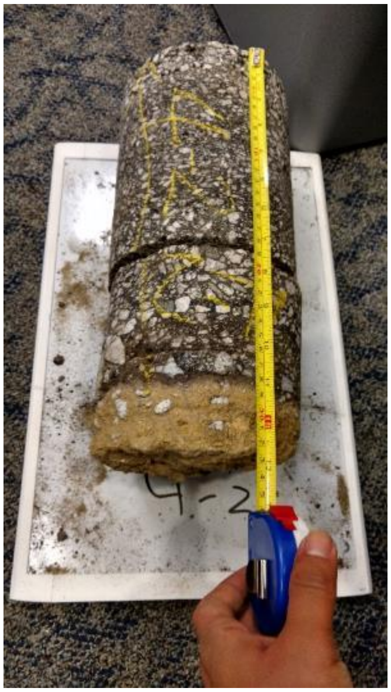
- **Site #2 -** Core #C8

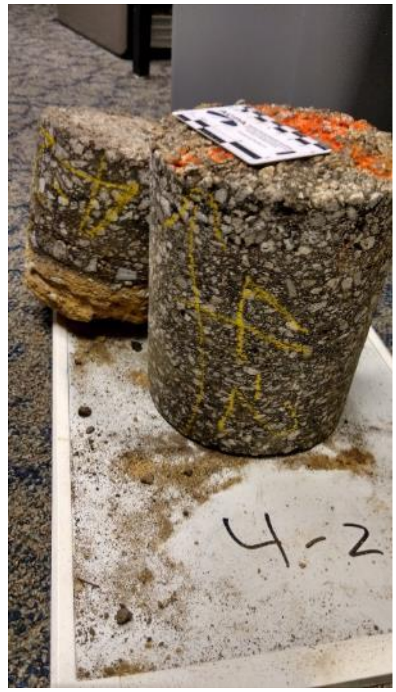


- **Site #3 -** Core #4-1



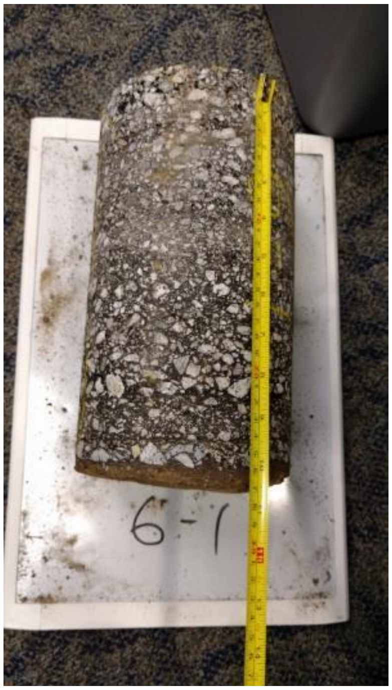
- **Site #3 -** Core #4-2



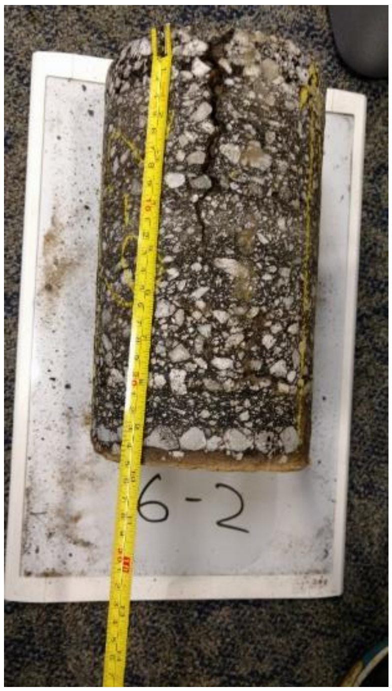


- **Site #3 -** Core #5-1

- **Site #3 -** Core #6-1

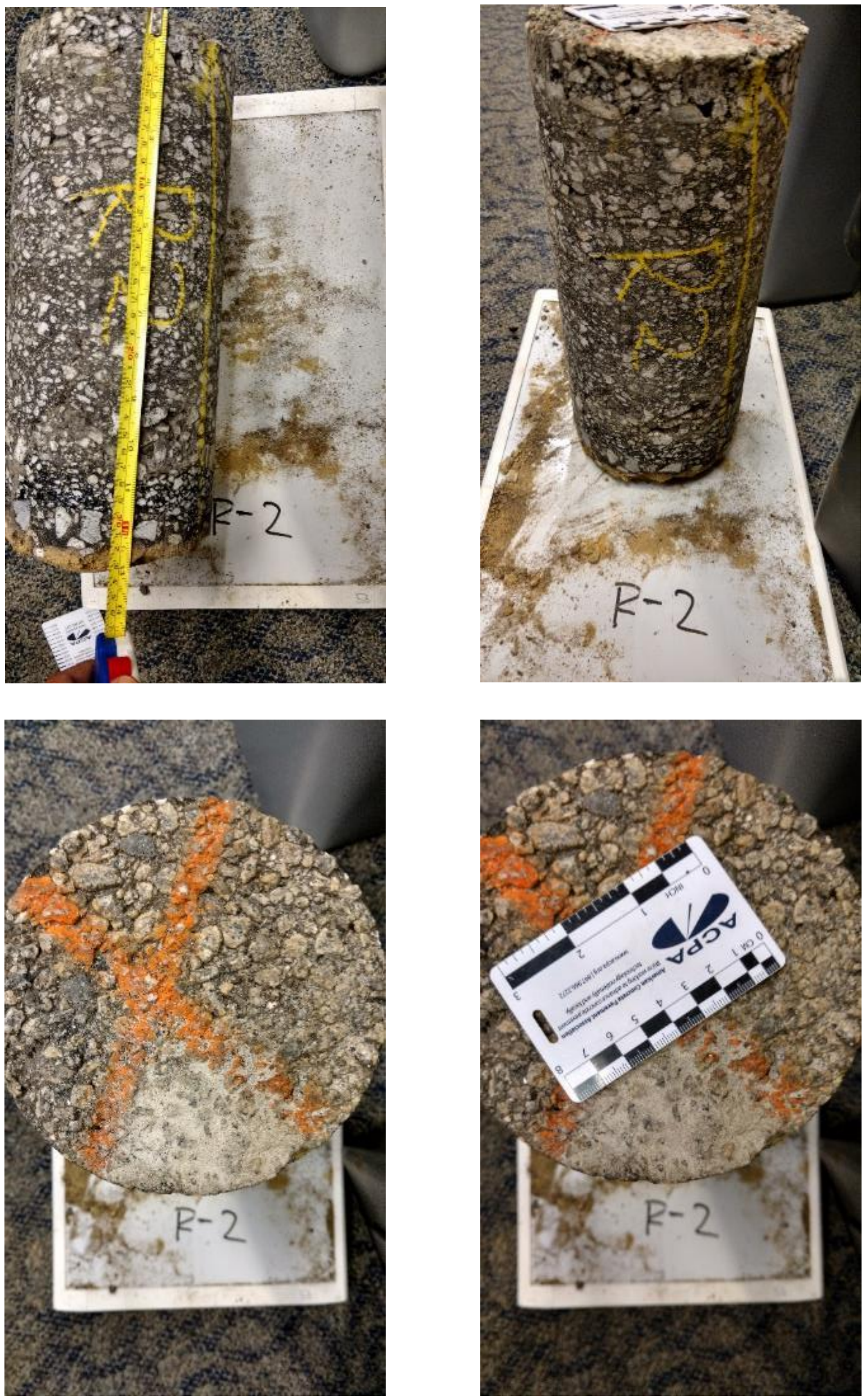


- **Site #3 -** Core #6-2



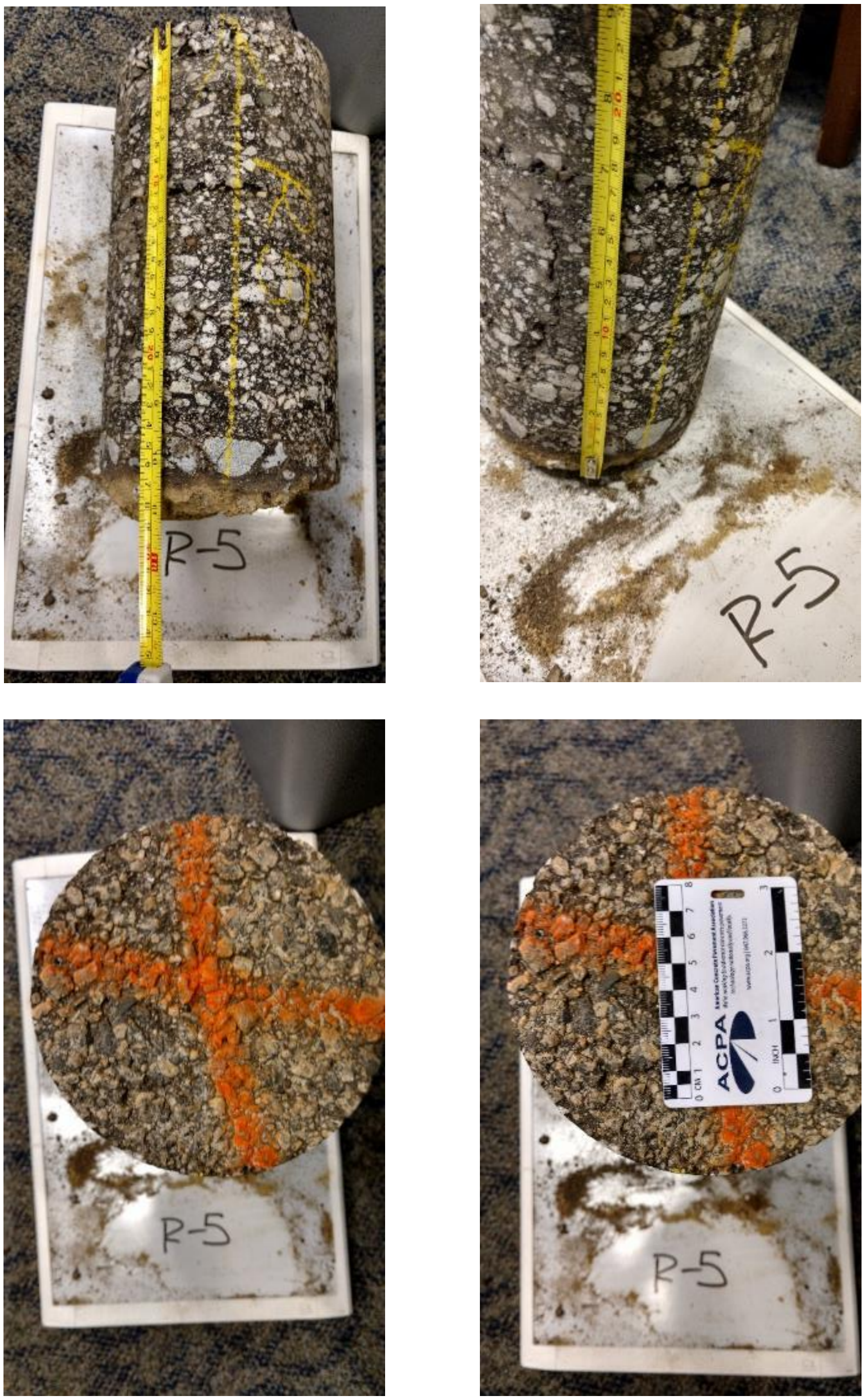
- **Site #4 -** Core #R1

- **Site #4 -** Core #R2



- **Site #4 -** Core #R3

- **Site #4 -** Core #R5



- **Site #4 -** Core #R6