

GEORGIA DOT RESEARCH PROJECT 14-27

FINAL REPORT

**IMPLEMENTATION OF AN ENHANCED COPACES
FOR GEORGIA'S COUNTIES AND CITIES**



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16. Abstract: The Georgia Department of Transportation (GDOT) has been successfully carrying out IT-based pavement management and maintenance on its 18,000-centerline-mile highways since 1998. To leverage GDOT's knowledge and experience and extend it to Georgia's local governments (LGs), the Georgia Institute of Technology (Georgia Tech) has developed a Computerized Pavement Condition Evaluation System for Counties and Cities (COPACES-CC) using the most up-to-date cloud computing and mobile technologies. GDOT's pavement distress protocol, PACES, was adopted to facilitate the transfer of GDOT's knowledge and experience to LGs. In the meantime, a windshield-survey-based distress protocol, PASER, was also incorporated as an alternative survey method. To make sure the developed system could be successfully implemented in all LGs, a user group formed by three pilot counties has conducted comprehensive testing and implementation. A total of 300 miles of pavements have been surveyed by these pilot counties using COPACES-CC. Their successful experience has been shared with other counties and cities in a statewide workshop that is organized by GDOT's Local Technical Assistance Program (LTAP). Further study and development are also suggested.			
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GDOT Research Project No. 14-27
Final Report

IMPLEMENTATION OF AN ENHANCED COPACES FOR
GEORGIA'S COUNTIES AND CITIES

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Contract with
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In cooperation with

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EXECUTIVE SUMMARY

The Georgia Department of Transportation (GDOT) has been successfully carrying out IT-based pavement management and maintenance on its 18,000-centerline-mile highways since 1998. To leverage GDOT's knowledge and experience and extend it to Georgia's local governments (LGs), the Georgia Institute of Technology (Georgia Tech) has developed a Computerized Pavement Condition Evaluation System for Georgia's Counties and Cities (COPACES-CC) using the most up-to-date cloud computing and mobile technologies. GDOT's pavement distress protocol, PACES, was adopted to facilitate the transfer of GDOT's knowledge and experience to LGs. In the meantime, a windshield-survey-based distress protocol, PASER, was also incorporated as an alternative survey method. To make sure the developed system could be successfully implemented in all LGs, a user group formed by three pilot counties has conducted comprehensive testing and implementation. A total of 300 miles of pavements have been surveyed by these pilot counties using COPACES-CC. Their successful experience has been shared with other counties and cities in a statewide workshop that was organized by GDOT's Local Technical Assistance Program (LTAP). Further study and development are also suggested.

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CHAPTER 1 INTRODUCTION

1. Research Background and Research Need

To leverage the knowledge and experience of pavement condition data collection, pavement management, and pavement maintenance in the Georgia Department of Transportation (GDOT) and benefit local governments' public works (for simplicity, referred to local governments (LGs), or counties and cities, thereafter), the Georgia Institute of Technology (Georgia Tech) has developed a prototype computer program for Georgia's counties and cities to conduct a computerized pavement condition survey and pavement management. The above research was sponsored by GDOT through a Special Research Study (SRS) project, RP 11-35 (Tsai & Wang, 2012). The developed program (COPACES-CC) adopted GDOT's existing data collection procedures using the Computerized Pavement Condition Evaluation System (COPACES); adjustments, such as the location references of survey projects and segments, have been made to meet the requirements of a general county or city. FIGURE 1.1 shows a screenshot of the prototype COPACES-CC that was developed in a previous SRS project, RP 11-35.

In the development of the prototype of COPACES-CC, the representatives from several counties and a city attended the initial discussion for defining the business requirements. A preliminary field test was also conducted. After that, a statewide workshop ("Managing Pavement Assets Cost-Effectively Using COPACES-CC") was organized by GDOT's Local Technical Assistance Program (LTAP) on August 14, 2014, and conducted by Georgia Tech to demonstrate the developed COPACES-CC. Numerous

counties showed great interests in this system. For example, Chatham County has used this system to conduct pavement condition survey on their county roads.

After the completion of COPACES-CC, several meetings were held with the GDOT Office of Research, the GDOT Office of Local Grants, and the GDOT LTAP. The following consensus has been reached:

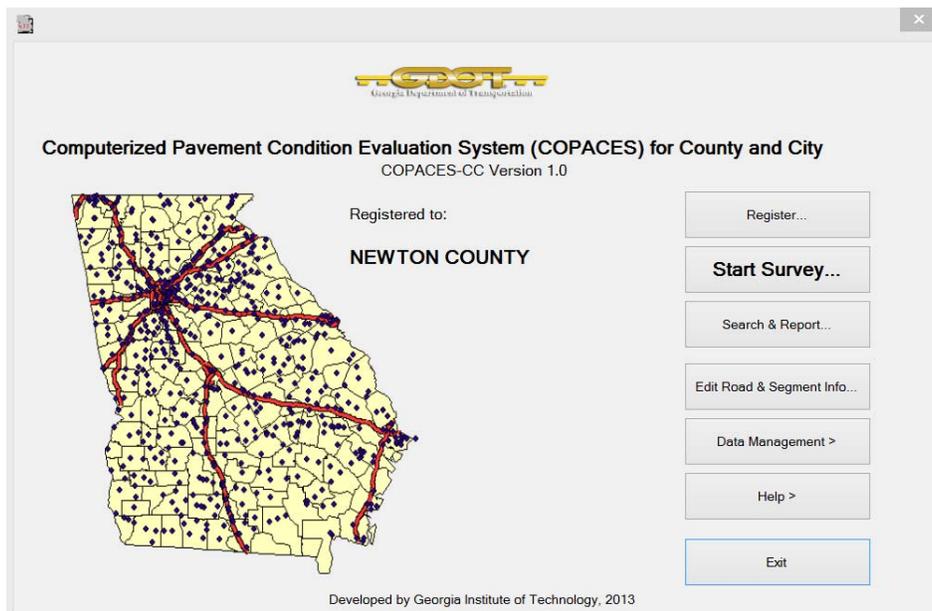


FIGURE 1.1: Prototype COPACES-CC

1) The developed program provides a quantifiable way for counties and cities to look at roadway conditions and objectively assess all roads. Based on the automatically computed rating, roadway maintenance needs can be addressed by prioritization or other optimization programming. Thus, better pavement maintenance strategies can be adopted by LGs to do more with less money, and money can be allocated and used where it is most needed.

2) Though the program has been comprehensively evaluated in Newton County, the experience cannot be simply extended to other counties or cities because of the variations of pavement conditions and pavement management and maintenance practice among different counties and cities. Thus, broader testing and implementation are needed before this system can be distributed to all other LGs.

3) Other than the pavement condition data collection, the objective of the developed program is to improve the efficiency and effectiveness of LGs' decision-making on pavement maintenance and pavement management. This can only be achieved after data collection is completed and if the decision-makers have strong asset management knowledge and capabilities. To make this program a success and beneficial for all the LGs in Georgia, a two-stage strategy was suggested by GDOT in the meetings. In the first stage, we will conduct a workshop for all interested LGs. In the workshop, the concept of asset management, the use of the developed program, and pavement survey protocols will be introduced. From the attendees, a small, diverse user group formed by several counties will be selected for further pilot testing of the enhanced version of the COPACES-CC. In the second stage, the Georgia Tech research team will closely work with the selected user group to further implement the developed program, including field data collection, data management, and data utilization (for pavement management and maintenance purposes). Finally, several successful cases for diverse end users can be established. Then, the program will be ready to be disseminated to all other LGs.

2. Research Objectives

To address the needs discussed in the above section, the objective of this SRS is to enhance the developed COPACES-CC and implement it for diverse LGs in Georgia. The major tasks include the following:

- Conduct workshop on asset management and COPACES-CC;
- Enhance COPACES-CC based on end users' comments and suggestions;
- Conduct system implementation and develop successful cases;
- Summarize research findings.

3. Report Organization

This report is organized into five chapters. Chapter 1 introduces the research background, need, research objective, and tasks. Chapter 2 introduces GDOT's practices and a general framework of implementing a pavement management system (PMS). Chapter 3 presents the architecture and major functions in COPACES-CC. Chapter 4 presents implementation of COPACES-CC in three pilot counties. Chapter 5 summarizes the project, presents conclusions, and offers recommendations for future study.

References

Tsai, Y., Wang, Z. (2012) "A Pavement Condition Survey Procedure and Program for Georgia's Counties and Cities", Final Report RP 11-35, Georgia Department of Transportation.

CHAPTER 2 PAVEMENT MANAGEMENT IN LOCAL GOVERNMENTS

As an integral part of transportation asset management (TAM), pavement management systems (PMS) have been widely accepted by state highway agencies in the United States. The needs of a PMS lie in the following aspects (FHWA, 1999). First, to meet the public's demands for safer and more comfortable roads, highway agencies need to efficiently maintain the existing pavements. However, due to the aging pavements and the shortage of highway budgets in recent years, there are increasing needs for pavement maintenance, rehabilitation, and reconstruction (MR&R). Second, budget shortages require highway agencies to better use their highway budgets and incorporate pavement preservation into their pavement maintenance practices. Third, accountability to the public requires highway agencies to more objectively and cost-effectively maintain the highway pavements. For a LG, a process and/or tool is needed to transparently communicate with their citizens and legislature on roadway maintenance and rehabilitation decisions. Finally, to minimize the safety risks of poor roadways, caused by delayed maintenance and rehabilitation, an effective PMS is needed for future planning and performance maximization.

FIGURE 2.1 shows a typical pavement health curve, which follows an “S” trend. As illustrated, the pavement condition drops 40% during the first 75% of its service life; then, it drops another 40% in the next 12% of its service life. It can be seen that if a pavement cannot be renovated at the end of 75% of its life, a much more expensive rehabilitation will be needed later. Using GDOT's case as an example, pavement resurfacing is normally applied when pavement conditions drop to “fair.” However, due

to budget shortfalls, an accumulating number of resurfacing projects cannot be funded. This has made the MR&R situation even worse because more expensive correction will be needed for the unfunded projects when their conditions drop to “poor” in a short period of time.

One solution to this deadlock is to apply very inexpensive and cost-effective pavement preservation treatments when a pavement is still in good condition (as shown in red in FIGURE 2.1). It will postpone the timing for the major pavement maintenance, such as resurfacing. This concept of “good repair” has been accepted by all highway agencies and, for the first time, was coded in the Moving Ahead for Progress in the 21st Century (MAP-21) bill. A “good repair” is to repair a pavement with a low cost treatment method to prolong its life while it is still in its good condition.

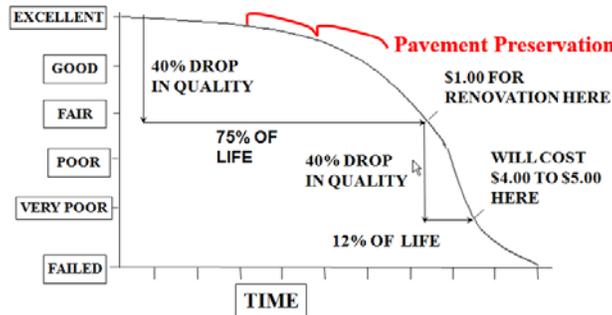


FIGURE 2.1: Typical Pavement Health Curve

1. GDOT’s Pavement Maintenance Practice

GDOT is maintaining 18,000 centerline miles of highway pavements in Georgia. To improve the efficiency and effectiveness of pavement maintenance activity, GDOT has adopted an IT-based approach since 1998, which has resulted in the current Georgia Pavement Management System (GPAM). GPAM has been the indispensable tool for

GDOT to manage and maintain the statewide pavements, which consists of three major components, including data acquisition, data management, and decision support.

FIGURE 2.2 shows the three components and the corresponding programs in each of them.

GDOT divided the entire state into seven working districts. Each working district is responsible for annually collecting pavement surface condition data using COPACES. After data collection is accomplished, each working district combines the data from all of its area offices. After checking of data quality, the data is uploaded to the central database. In the meantime, each district office will also suggest maintenance projects for the upcoming fiscal year using the ProjectSelection software. After all the working districts submit suggested maintenance projects, the General Office (GO) will start to finalize the maintenance projects based on the available budget. Due to the large area of GDOT's jurisdiction, a client-server architecture was used to develop GPAM. Data transfer is accomplished through GDOT's intranet.

As shown in FIGURE 2.2, seven major programs have been routinely used by GDOT to perform the annual pavement maintenance and management. COPACES is a laptop-based computer program used by GDOT to conduct its statewide pavement condition survey in accordance with GDOT's Pavement Condition Evaluation System (PACES) manual, which provides the key data source for the following data management and decision support. The COPACES Data Quality Insurance program (CoPaDQI) is used for data quality checking before the collected PACES data can be uploaded into the central database. The GPAM central database has accumulated historical pavement condition data back to Fiscal Year (FY) 1986. This abundant data is very valuable for

establishing the pavement performance models that can be used in a pavement management system to forecast the long-term pavement conditions and predict the long-term pavement maintenance needs. The Network module is a program for data management. By using this program, engineers can access the central database and retrieve the historical pavement condition data through various customizable query functions. Some tools, also, are provided in this program to analyze the historical pavement performance. In addition, numerous reporting functions provide convenience for engineers in support of their daily work. The GIS module is a standalone program to spatially visualize the pavement condition data with spatial query capabilities. The final goal of GPAM is to support the decision-making of pavement maintenance project selection and funding allocation. Two major programs are included in this component: ProjectSelection and Network-Level Long-term Performance Forecasting and Simulation (LP&S). By using ProjectSelection, the engineers in each District Office (DO) prioritize and select projects that need to be maintained in terms of the preset treatment criteria. After that, the results are sent to GO, where a final list of maintenance projects is programmed and prepared for funding allocation. It is note that a set of risk-based project selection strategies have been implemented recently for both DO and GO, which consider the impact of population, AADT, and truck percent. LP&S is a computer program that predicts network-level, long-term pavement performance and maintenance needs. Several strategies have been developed in this program for the liaison engineers in OM to perform various what-if analyses. The results are used for the critical communication with higher management levels.

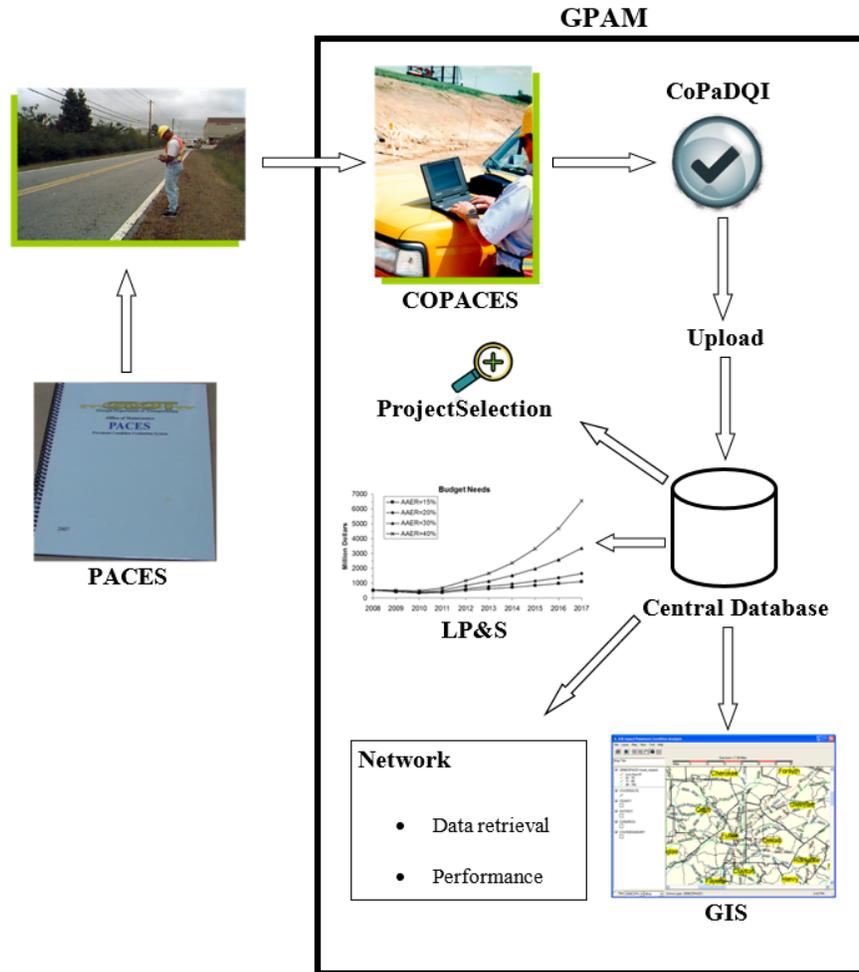


FIGURE 2.2: GPAM Components and Major Programs

2. Leverage GDOT's Practice in Local Governments

GDOT helps LGs, including counties and cities, to improve the state's roadway network through a Local Maintenance and Improvement Grant (LMIG) program, which grew out of the previous Local Assistance Road Program (LARP) and State-Aid Program. Under the new program, GDOT allocates funds to each county or city using a formula based on its total population and total roadway mileage. However, a county or city needs to submit a project list with a total value of the formula allocation plus the required 10% to 30% match according to the Transportation Investment Act (TIA) (GDOT, 2014). The

new program reduces the workforce needed in GDOT. However, each LG needs a means to manage the roadway network in its jurisdiction, i.e. a PMS to inventory roadway conditions, determine treatment methods, and select candidate projects. Though some counties and cities do periodically collect pavement surface conditions, few of them have a comprehensive PMS to effectively manage their roadway networks within their stringent budgets. Because GDOT has been successfully maintaining its 18,000-centerline-mile highway system through its established, comprehensive PMS since the late 1990s (Tsai, et al., 2000; Tsai & Lai, 2001; Tsai & Lai, 2002; Tsai et al., 2004; Tsai & Gratton, 2004; Tsai, et al., 2008; Wang, et al., 2009), LGs have sought assistance from GDOT through LTAP. As a result, GDOT has worked with LTAP board members, the State-Aid Program, and Georgia Tech to provide a simplified version of GDOT's PMS so local agencies can effectively manage their pavement assets by leveraging GDOT's existing pavement management practices.

Though smaller agencies have the same operational and organizational needs of larger agencies such as state DOTs, there are still many LGs that have not implemented a PMS because they lack resources and technical expertise (Wolters, et al., 2011; Adjo, et al., 1996). Thus, it is critical for Georgia's counties and cities to leverage GDOT's successful experiences and resources. A commercially available software, such as MicroPAVER, RoadSoft GIS, StreetSaver, Utah LTAP TAMS, etc., could be adopted by a LG. However, it is difficult to leverage of GDOT's experience and knowledge on pavement management and maintenance, and other resources because different pavement distress protocols and pavement treatment decision criteria are used in the commercial software. The advantages of using COAPCES-CC that implements GDOT's pavement

distress protocol, instead of the pavement distress protocols adopted by other software are as follows:

- Unlike a generic, comprehensive national pavement distress protocol, GDOT's pavement distress protocol, PACES, has better consideration of the major pavement distresses that are related to Georgia's local environment, including temperature, precipitation, soils, pavement materials, etc.
- GDOT has more than 30 years of experience on pavement maintenance and rehabilitation that is based on PACES, i.e. different types of pavement distresses with different extents and severity levels. This knowledge can be easily transferred to LGs if COPACES-CC is adopted.
- GDOT's successful experience on the maintenance and rehabilitation decision making has been proved with long-term practice in Georgia. A commercial software often provides comprehensive distress measurements that might not be suitable for Georgia's roads. The corresponding maintenance and rehabilitation decision making might not be tailored for Georgia's environment, which could be less effective in some cases.

3. Challenges of Using GDOT's Existing PMS in a Local Government

It is not a trivial task to migrate GDOT's knowledge and experience on pavement management to LGs. Some challenges exist and need to be addressed in order for a successful implementation. First, there are 159 counties and more than 500 cities in Georgia. It is difficult to make a PMS suitable for all of them. It is also infeasible to make a customized tool for each of them with the limited resources. Second, the

Geographic Information Systems (GIS) is not available in all the LGs. Thus, it is not suitable to use GIS as a default functionality. However, the counties and cities who own GIS do need a link between their PMS data and their GIS maps for spatial visualization and analysis. Third, GDOT hopes to use its pavement condition survey protocol in local agencies. However, this protocol might be complicated and may not be suitable for all types of roads, e.g. the local roads in sub-divisions, in LGs because of the limited workforce for field data collection. Thus, a simpler alternative pavement distress protocol is needed to provide sufficient flexibility for a LG. For example, PACES can be used for major arterials while a simple PASER rating can be used for local roads in sub-divisions. Finally, the milepost/milepoint-based Linear Referencing Systems (LRS) used in GDOT for defining project locations cannot be extended to local agencies because their road networks do not have the same LRS. Thus, a flexible location reference, based on either street blocks or other permanent land markers, is needed.

The following highlights some of the specific technical challenges in migrating GDOT's PMS to LGs:

- GDOT's distributed client-server-based PMS is too resource demanding for a LG. This type of architecture needs significant hardware investment and IT support, such as database management and network maintenance. In contrast, the Public Works department in a county or city is generally much smaller than GDOT, and there is no need for a distributed architecture for PMS. In addition, few LGs can afford a comprehensive IT support system for a large PMS. Thus, a downscaled, non-resource-demanding PMS is more suitable for use in a county or city.

- GDOT's roadway network partition is not suitable for a county or city. To rate the network-level pavement conditions, the roadway network needs to be partitioned into small projects (Haas & Hudson, 1994). The pavement structure, roadway geometry, and pavement conditions should be uniform in each project. Each project is further divided into smaller segments. The typical length of a segment is one mile, except for the starting and ending segments, which may vary in length. The actual pavement condition survey is performed for each segment, and, a project-level survey result can be obtained by averaging all segment-level survey results. This type of roadway partition is suitable for a large roadway network, but in a county or city, the basic pavement maintenance unit is much shorter than a project unit in GDOT's practice. For example, a local street block could be a maintenance unit, and, so, a pavement condition survey needs to be performed for each street block. Because COPACES is designed for GDOT's large project-segment structure, it is not suitable for direct use in a county or city.
- GDOT's RCLINK-milepoint-based LRS cannot be used in a county or city. An LRS is normally used to spatially locate a linear feature, such as a roadway section. It defines a point using the measurement from a starting point on a roadway. In COPACES, pavement projects and segments are spatially defined by using GDOT's LRS, which uses RCLINK and milepoints. An RCLINK is a 10-digit code defined to identify each roadway segment in Georgia; it consists of route type (1 digit), county (3 digits), route number (4 digits), and route suffix (2 digits). This practice may not be applicable in a county or city. Some counties and cities have no GIS maps, let alone a defined LRS. Some local agencies do have their own GIS maps, but few of

them define an LRS. Therefore, an LRS-based location designation capability, using RCLINK and milepoint, is not suitable for a county or city. A general method to define a project or segment that is flexible enough to be usable by all counties and cities is needed. Based on the extensive discussion with various counties and cities, a street block was used as the basic unit for pavement condition survey. A street block ID is used for its unique identity. The intersecting street names are used to identify the starting point and ending point of a street block. The street block ID can be uniquely assigned by the software or predefined by an end user. For example, in some counties, street block IDs have been defined in the GIS maps. They can be directly used for pavement condition survey. In the meantime, this ID can be used to set up a link between pavement condition data and GIS maps for spatial visualization and analysis.

4. A General Framework of Implementing a PMS

FIGURE 2.3 shows a general framework used to implement a PMS for a LG. Three modules are needed. In Module I, a comprehensive road and segment inventory needs to be established first. Then, pavement condition data can be collected, analyzed, and reported in terms of predefined pavement distress protocols. In Module II, a decision tree, based on the successful experience established by GDOT, will be used to determine the proper treatment candidates for each road/segment. In the meantime, cost estimation can be done based on the treatment methods and the corresponding item mean values. In the next step, different strategies, such as cost-effectiveness-based prioritization or optimization, can be applied to recommend treated projects under the constraints of budget and agencies' policy. In Module III, tools are needed to perform long-term

pavement performance forecasting under different budget scenarios. In this SRS, we focused on the development and implementation of Module I. Since Module II and Module III are heavily dependent on the data from Module I, we suggest developing it in the next stage when the pavement condition data is accumulated and available. The following introduces the consideration in developing each step.

- **Road/Segment Inventory**

The first step in implementing a PMS in a county or city is to partition the entire pavement network in a jurisdiction into projects and/or segments. These projects or segments are not necessarily the same as construction projects. The purpose is to evaluate the pavement conditions at the network level. Each project or segment should be uniform in terms of pavement type, material, geometry (number of lanes, lane width, etc.), and overall pavement conditions. More importantly, each project or segment should be spatially identifiable. As mentioned above, GDOT defines the locations of projects and segments using an RCLINK-milepoint-based LRS, which can be conveniently linked to a GIS map. However, this convenience does not exist in LGs because not all of them have GIS data and few of them have defined LRS. As a generic tool for all the counties and cities in Georgia, COPACES-CC adopted a more flexible design for the spatial reference of a project or segment. Three items, Road ID, Project From (or Segment From), and Project To (or Segment To), are used to define a project (or segment) spatial location. If a linear reference system is available, the corresponding information can be used for these three items.

Otherwise, other information can be used. For example, street names can be used for Road ID, and, the intersecting streets or address numbers can be used for the starting

point and ending point of a project or segment. If the length of a road between two intersecting streets is too long, e.g., a county road in rural area, mileposts can be used to define the project or segment termini.

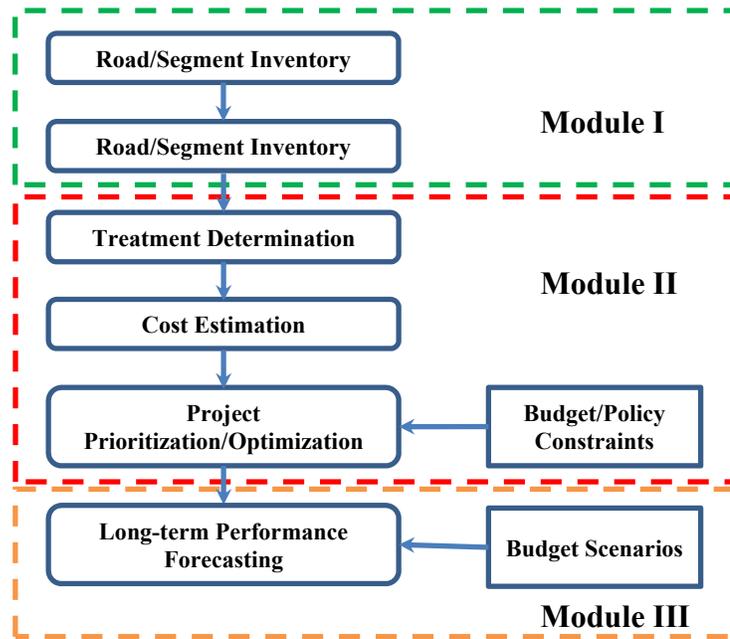


FIGURE 2.3: A General Framework of a PMS

Though the road/segment inventory needs only to be established once and some minor modification thereafter, it could be a very tedious process if manual typing is applied. Fortunately, the counties and cities who have GIS maps can greatly speed up this process by automatically converting the GIS map to road/segment inventory. Some programming work might be needed. However, the converted data should be carefully checked and verified.

- **Pavement Condition Survey**

The key thing for pavement condition survey is to select a proper pavement distress protocol that is indispensable in a PMS. A pavement distress protocol defines

pavement surface distresses, such as cracking, rutting, and raveling. It also defines the procedures and methods for rating different distresses with extents and severity levels. A scoring system is then used to rate the overall pavement conditions.

The popular pavement distress protocols include the Pavement Condition Index (PCI) (PCI has been incorporated in ASTM D6433), the Pavement Surface Evaluation and Rating (PASER), and the Condition Rating Survey (CRS) (Wolters, et al., 2011).

Pavement condition survey software normally implements one type of pavement distress protocol. For example, PCI was used in MicroPAVER, and the PASER rating system was used in RoadSoft GIS. Because the selection of a pavement distress protocol largely depends on how it can facilitate pavement engineers in identifying pavement conditions and determine proper treatment methods, there is no a standard method that can be used to fit each agency's practice. For example, it is difficult to find any two state DOTs that adopt an exact, similar pavement distress protocol in the U.S. The reason is that each state DOT has built solid knowledge about pavement treatments and the survey method based on unique local environment. In addition, a national standard covering comprehensive types of distresses might not be suitable in a local area. We chose GDOT's pavement distress protocol, PACES (GDOT, 2007) (for convenience, PACES manual is attached in Appendix I; it is similar to the GDOT PACES manual, 2007 version), for developing COAPCES-CC because it is based on Georgia's local environment and road conditions. More importantly, GDOT has successful experience and knowledge to utilize PACES for supporting pavement maintenance and rehabilitation decision-

making. Using PACES in COPACES-CC will help LGs to better leverage GDOT's experience and resources.

In PACES, ten types of distresses are defined: rutting, load cracking, block/transverse cracking, reflection cracking, raveling, edge distress, bleeding and flushing, corrugation or pushing, loss of pavement section, and patches and potholes. FIGURE 2.4 shows examples of load cracking at different severity levels, which are based on the crack patterns in both wheelpaths. For example, Severity Level 1 load cracking is defined as the "tight single longitudinal cracks in the wheelpaths" (GDOT, 2007). In a county or city, a street block is normally much shorter than one mile. Thus, a street block can be fully covered in a survey for all types of distresses. Based on the severity level and extent of a distress, GDOT uses a deduct system to discount each distress from a score of 100. In COPACES, deducts are automatically calculated, as are the ratings after deduction. The advantages of using GDOT's pavement distress protocol lie in the following two aspects:

- GDOT has a long history of successfully using COPACES. Many engineers are very familiar with PACES. Using the same distress protocol, a LG can better utilize the existing resources in GDOT through the LTAP program. In addition, an automatic distress detection application using 3D laser technology has also been developed using COPACES distress protocol.
- GDOT's current maintenance and preservation decision-making is based on COPACES ratings. Many experienced pavement maintenance engineers have built their knowledge based upon the COPACES ratings. By using the same

distress protocol, it would be easier for a local transportation agency to leverage GDOT's experience and knowledge for pavement maintenance and preservation.

Though GDOT's pavement distress protocol is comprehensive, it might, considering the very limited resources in a county or city, overburden a LG when all the roads are surveyed. Thus, a simpler rating system is needed as an alternative. In COPACES-CC, the PASER rating system is also included, which is a score between 1 and 10. A score of 10 indicates the pavement is in excellent condition, while a score of 1 means the pavement is in a failed condition. The advantage of using the PASER rating system is that the process is fast and needs the least manpower. However, the treatment methods based upon it might not be as accurate as in PACES. For example, Newton County only uses PACES on pavements with fair or worse conditions that are determined by using a PASER windshield survey. Whitfield County uses a PASER survey only on subdivision roads; it uses PACES on other major arterials and collectors. Though a county or city could determine its own strategy to incorporate these two protocols into their pavement condition survey, the strategy applied by Whitfield County is recommended because a consistent rating protocol used on a road will help establish a reliable historical trend for pavement deterioration, which is very critical in determining pavement performance and forecasting future needs of maintenance and rehabilitation.



(a) Severity Level



(a) Severity Level



(a) Severity Level



(a) Severity Level

FIGURE 2.4: Example Load Cracking Defined in PACES

- **Treatment Determination**

This step is to be developed in COPACES-CC soon with GDOT's support. To the best of our knowledge, many counties and cities have no a systematic method to determine treatment methods. Most of the time, engineers' experience or rule of thumb works. In addition, major rehabilitation treatments, such as resurfacing or deep pathing, are commonly used in a county or city, while preventive maintenance methods, e.g. crack sealing and microsurfacing, are not often used due to the lack of experience on treatment timing.

FIGURE 2.5 shows a treatment decision tree that was implemented in GPAM in GDOT. It can be seen that preventive maintenance methods and major rehabilitation methods are all included. Based on pavement distresses and COPACES ratings, different candidate methods can be selected. In the next stage of COPACES-CC development, this decision tree will be implemented first. Then, the trigger values and treatment methods can be adjusted based on a local agency's needs.

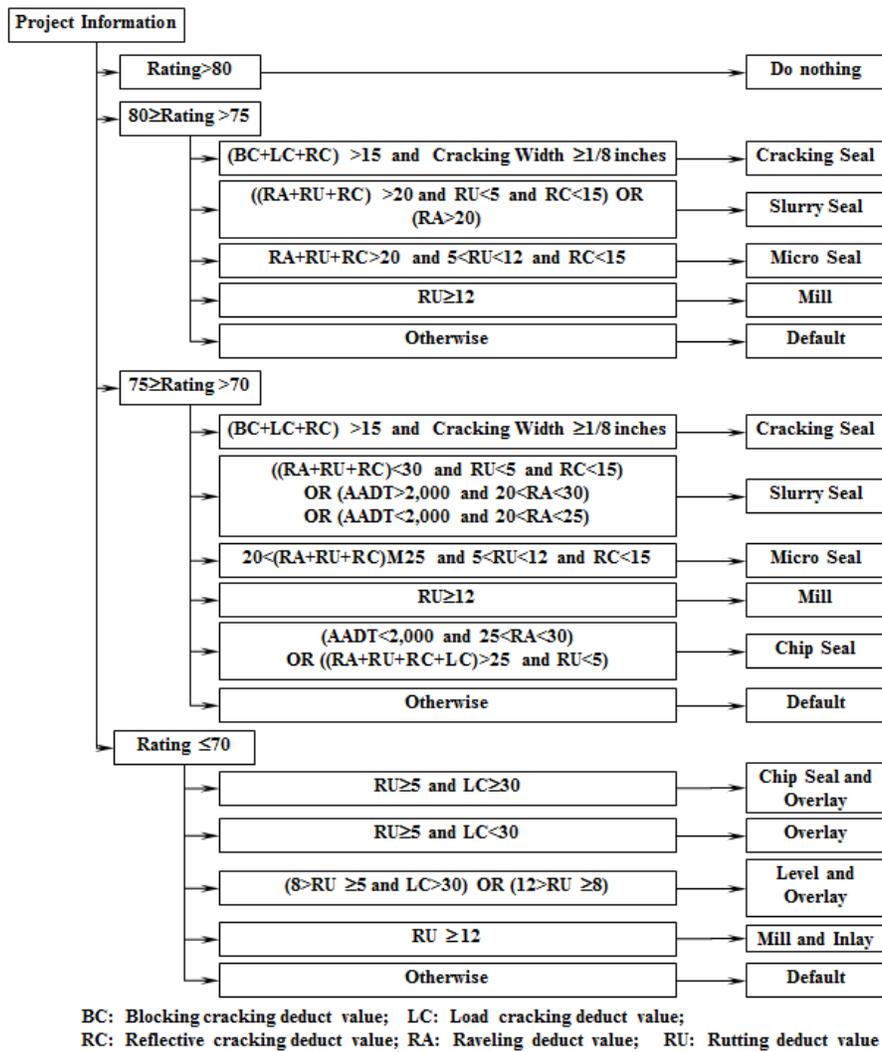


FIGURE 2.5: Pavement Maintenance Decision Tree in GPAM

- **Cost Estimation**

This step is straightforward when candidate treatments are determined for each project or segment. GDOT's item mean values can be used for this purpose, and they can be adjusted by end users.

- **Project Prioritization/Optimization**

This step will prioritize all the candidate projects based on a certain criteria.

Currently, most LGs use the worst-first strategy to determine construction projects.

As shown in FIGURE 2.1, this strategy is very inefficient, especially when the budget is limited. A better strategy should be adopted to maximize the performance of pavement network as a whole.

The currently available methods for project selection can be categorized as prioritization and optimization. A prioritization method sorts candidate projects based on their cost-effectiveness; an optimization method employs mathematical programming to optimally determine treatments with the given performance goal and budget/policy constraints. Before either method can be implemented, a priori knowledge about pavement performance predication and treatment performance should be available. The knowledge can be acquired from GDOT's experience. However, the most accurate means is to study the historical pavement conditions with or without treatment, which requires continuous pavement condition surveying over time.

- **Long-term Performance Forecasting**

Long-term pavement performance forecasting under different budget scenarios is important for LGs to evaluate the sufficiency of current budget level and propose

future budget needs in order to achieve a certain level of pavement performance. In the meantime, the risk of budget shortage can also be evaluated. This tool is very useful for LGs to transparently communicate with the public and legislature in order to request sufficient pavement budgets for now and future.

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CHAPTER 3 ARCHITECTURE AND FUNCTIONS OF COPACES-CC

It should be noted that COPACES-CC was thoroughly re-designed and re-developed in this SRS to better utilize the most up-to-date cloud computing and mobile technologies. The previous version of COPACES-CC, shown in FIGURE 1.1, is a standalone, laptop-based application; using a mouse and keyboard is the major input method and data is stored in the local hard drive. When we start to implement this version of COPACES-CC, the following shortcomings are identified. First, a laptop is not easy to carry in the field. Though a Windows-based tablet computer can be used to run the previous application, the operation and data input is still the same as the one used in a laptop. Thus, data input in the field is inconvenient because of using mouse and keyboard. Second, the previous version of COPACES-CC stores data in the local hard drive. If two or more persons are using the application for data collection, it is difficult to integrate data and share data with others. The only way is to send data to a person who will do the data integration. Storing data in a local hard drive also has potential data safety issues. If the hard drive malfunctions, the data would be lost. Finally, the previous COPACES-CC does not support capture of photographs in field. In recognizing the shortcomings of the previous version of COPACES-CC, we decided to re-design and re-develop it using the most update-to-date cloud computing and mobile technologies to make COPACES-CC more user friendly and maintenance-free. The following sections will introduce the system architecture and major functions of the new COPACES-CC.

1. System Architecture

FIGURE 3.1 illustrates the system architecture of the current version of COPACES-CC.

From an end-user's point of view, field data collection and data management are separated. In the field, a Windows-based tablet PC will be used for data collection. The program is not a desktop application, but uses Microsoft Metro interfaces. Program operation and data input can be done by using one's fingers. With the support of GPS (embedded or external GPS), field-captured photographs with spatial locations can be stored. In the office, a web-based application, i.e. a website, will be used for data management and reporting. Microsoft Azure services, which is invisible to end users, is used to link these two operations together through the following procedures:

- The road/segment inventory data is stored in cloud database, which is maintained by Microsoft. Through WiFi, data can be downloaded to a tablet PC.
- The data collected in the field, i.e. pavement condition data along with georeferenced photographs, using a tablet PC will be uploaded to the cloud database. A local hard drive is not used for permanent data storage. It will dramatically improve data safety and make it effortless for data integration.
- The website will directly access the data stored in the cloud database for data management, data analysis, and reporting. As long as the field-captured data is uploaded, the manager in the office can immediately access it. It will dramatically improve the efficiency of data sharing.

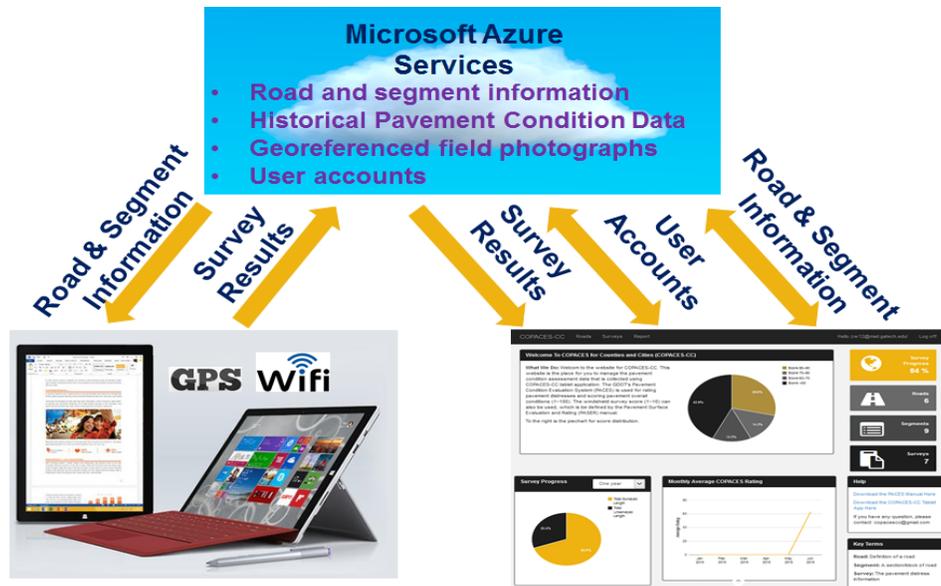


FIGURE 3.1: Pavement Maintenance Decision Tree in GPAM

The advantages of using cloud computing and mobile technologies lie in the following:

- A tablet PC is easy to carry, and the use of Metro interfaces make it easy for program operation and data input.
- Data transfer and data integration become effortless with one-button clicking.
- Because the data and website are hosted by Azure services, there is no need of a dedicated data server and web server. Accordingly, the need of IT support could be minimized.
- Data is not stored in a local hard drive. Therefore, there is no concern about data size and storage limitation.
- Microsoft Azure services are commercial products with sufficient safety. It will eliminate the burden on end-users for data safety concern.

- The use of a website makes it easy for data access and data management.

2. Operation Flow

The detailed user's guide can be found in Appendix II. In this subsection, the system operation flow and some major functions are presented. FIGURE 3.2 lists the major steps for operating COPACES-CC, including both tablet PC and website. Please note that Steps 1, 2, and 6 will be operated on the website; Steps 3, 4, and 5 will be operated on a tablet PC. In addition, a WiFi connection is needed for Steps 3 and 5 when a tablet PC is used.

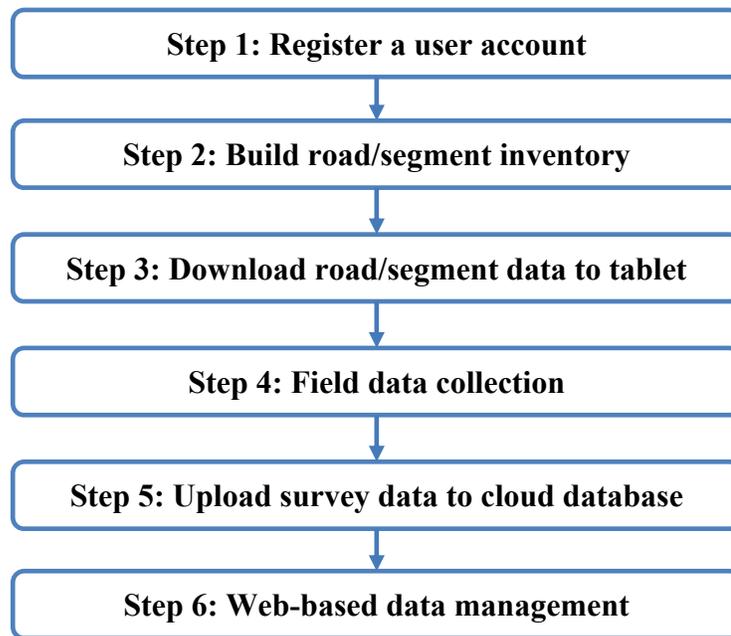


FIGURE 3.2: Operation Flow of Using COPACES-CC

2.1 Registration

For safety concerns, each user in a county or city needs to register on the website of COPACES-CC. FIGURE 3.3 shows the registration form. Currently, there are 159

counties and 567 cities listed in the *Jurisdiction Type* dropdown list box. To avoid unintended account registration, an invitation code is needed for each registration. Based on the invitation code, two types of users can be defined: administrator user and non-administrator user. The difference between these two types of users is that only an administrator has the authority to delete any data. Non-administrator users can only create data and view data.

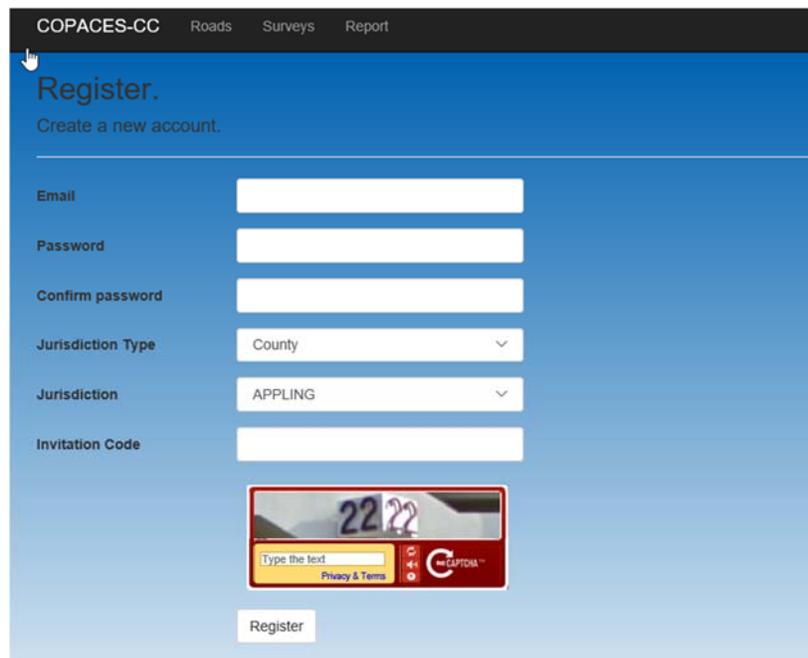
The image shows a web browser window displaying the registration page for COPACES-CC. The page has a dark blue header with the text 'COPACES-CC' and navigation links for 'Roads', 'Surveys', and 'Report'. Below the header, the main content area is light blue and features the heading 'Register.' followed by the subtext 'Create a new account.'. The registration form consists of several input fields: 'Email', 'Password', 'Confirm password', 'Jurisdiction Type' (a dropdown menu currently showing 'County'), 'Jurisdiction' (a dropdown menu currently showing 'APPLING'), and 'Invitation Code'. Below these fields is a CAPTCHA challenge showing the number '2222' with a 'Type the text' prompt and a 'CAPTCHA' logo. At the bottom of the form is a 'Register' button.

FIGURE 3.3: Registration Form

2.2 Road/Segment Inventory

As discussed in the previous chapter, a comprehensive, accurate road/segment inventory is very important and a must-have for field data collection and network-level pavement maintenance programming. The COPACES-CC website provides a convenient tool for end-users to manually input road/segment inventory, as shown in FIGURE 3.4. This tool can also be used to edit existing road/segment data. To facilitate the data editing in the

office, a GIS map that has been filtered with the selected county or city is also provided. Thus, when a road name is searched, the same road in other counties will not be selected.

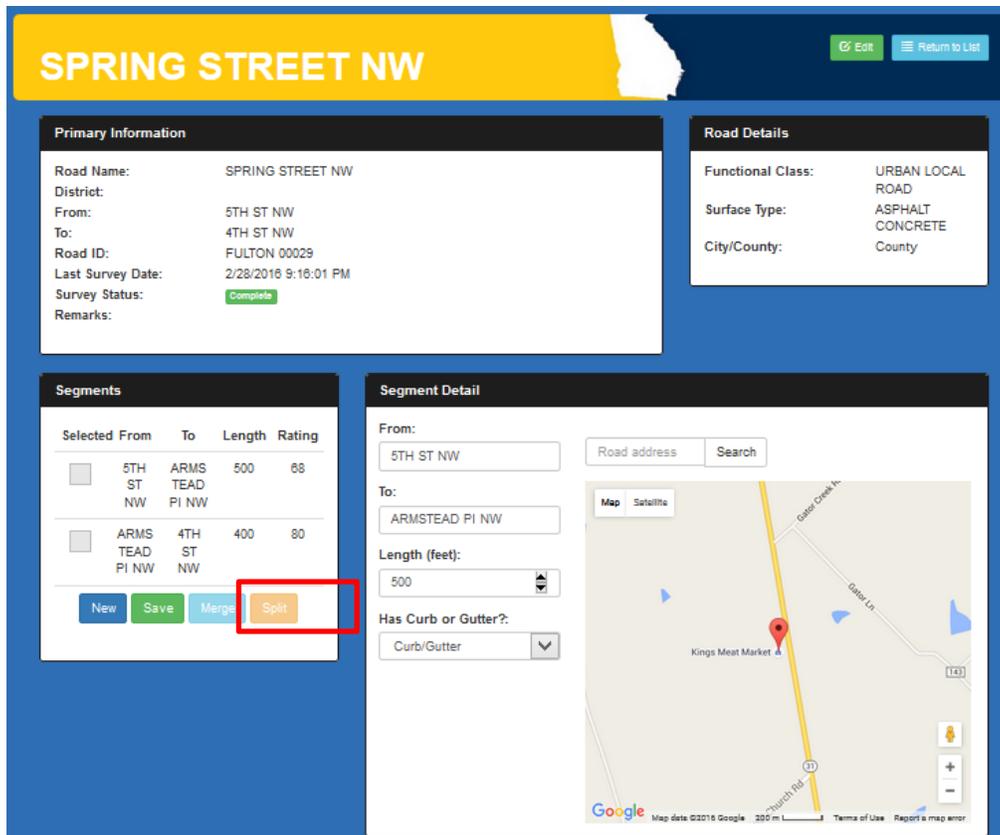


FIGURE 3.4: Road/Segment Inventory

As mentioned before, if roadway GIS data is available, the road/segment inventory could be automatically generated by converting the GIS data to the desired road/segment data in the cloud database. This process might need some data conversion effort. In the implementation of COPACES-CC, we have successfully generated the road/segment inventory data for all the pilot counties. However, a careful quality check is needed. For example, if the starting and/or ending points (we normally use intersecting road names to identify the starting and ending points) of a road/segment are missed, they should be manually corrected. In addition, if several consecutive segments (e.g. street blocks) are

very short, it might be meaningful to combine them together to form a longer segment. In contrast, if a segment is too long, e.g. more than one mile, it should be split into shorter ones to account for the change of pavement conditions. COPACES-CC provides functions to merge and split segments as shown in the red rectangle in FIGURE 3.4.

2.3 Data Downloading

After road/segment inventory data is ready, field pavement condition survey can be conducted. The first step is to download the road/segment inventory data into a tablet PC. A WiFi connection is needed. Please note that this step is only needed for the first-time data collection or when the road/segment inventory data is changed on the website. Otherwise, there is no need to download the inventory data each time before field data collection. FIGURE 3.5 shows the button on the tablet PC for data downloading (highlighted in the red rectangle).

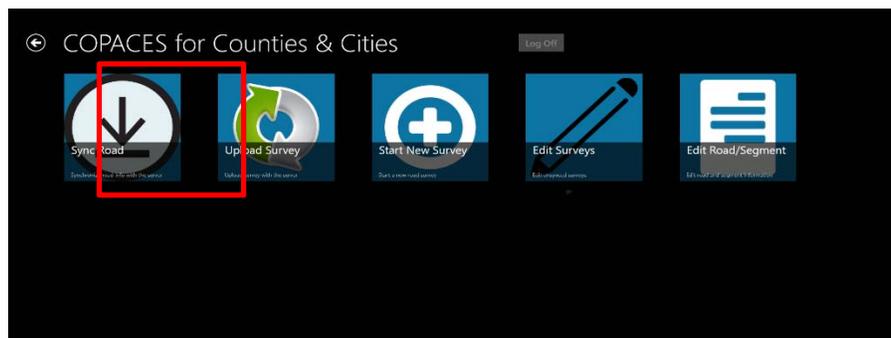


FIGURE 3.5: Road/Segment Data Downloading

2.4 Field Data Collection

Field data collection is to use tablet PCs to collect pavement condition data for each road and each segment. Starting a survey from the first segment, as recorded on a road, is suggested. After the first segment is done, click the next one to start a new survey. The

previous survey will be automatically saved. FIGURE 3.6 shows the form for field data collection. Other than the general information, such as rater's name, pavement treatment year and treatment method, and lane direction and location, the major items are related to the selected pavement distress protocol. In COPACES-CC, two protocols are provided: GDOT PACES and PASER. PASER is just a score between 0 and 10. The input is straightforward. GDOT PACES needs the input of ten types of distresses with the proper extent and severity level. The PACES manual in Appendix I can be used as a reference. COPACES-CC also provides an online help when the label of distress is clicked. Annual training on PACES is normally held in GDOT; engineers in LGs could also attend the training by registration through GDOT's LTAP.

FIGURE 3.6: Field Data Collection

FIGURE 3.6 only shows three types of distresses, rutting, load cracking, and block cracking. To input other distresses, just slide the screen to the left. As mentioned before,

GDOT PACES calculates a rating between 0 and 100 by deducting all distresses that occur in the current segment. When a distress is input, the COPACES rating will be automatically calculated in a real-time manner.

COPACES-CC also provides functions to capture field photographs when GPS (embedded or external) is available. Photographs are useful to record the localized issues on pavements and bring them to managers' immediate attention.

Normally, a street block is the basic survey unit like a pavement segment in GDOT's practice. When a road has many street blocks with uniform pavement conditions, it is unnecessary to conduct survey on each of them. COPACES-CC provides a function for end-users to copy the pavement survey data of a street block to all other street blocks on the same road, or the selected street blocks on the same road as shown in the red rectangle in FIGURE 3.6. This function greatly improves the productivity of field pavement condition survey.

2.5 Data Uploading

After field data collection is done, the survey data can be uploaded to a cloud database and immediately accessed by the COPACES-CC website. Before data uploading, the end user has the chance to edit the survey data using the functions provided by COPACES-CC (refer to Appendix II). Again, a WiFi connection is needed for data uploading.

FIGURE 3.7 shows the button on the tablet PC for data uploading (highlighted in the red rectangle).

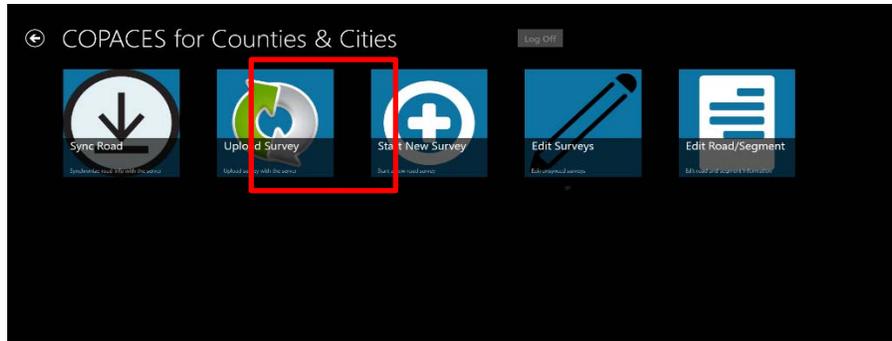


FIGURE 3.7: Survey Data Downloading

2.6 Web-based Data Management

After field-collected data is uploaded, it can be immediately accessed by using the website. The following lists the major data management functions.

- **Dashboard Information**

The Dashboard page is the place to get the big picture of the status in a county or city. As shown in FIGURE 3.8, the upper pie chart shows the pavement condition distribution based on the collected pavement condition data in a current data collection cycle. In GDOT, a data collection cycle is normally the same as a fiscal year. However, in a LG, the data collection cycle could be longer due to limited resources. Thus, to accurately summarize the network-level pavement condition, end users need to determine the current data-collection cycle by selecting the starting and ending dates. The lower pie chart in FIGURE 3.8 shows the current progress of pavement condition survey. In the example shown in FIGURE 3.8, the two roads have been surveyed in the current data-collection cycle; thus, the progress is 100%.

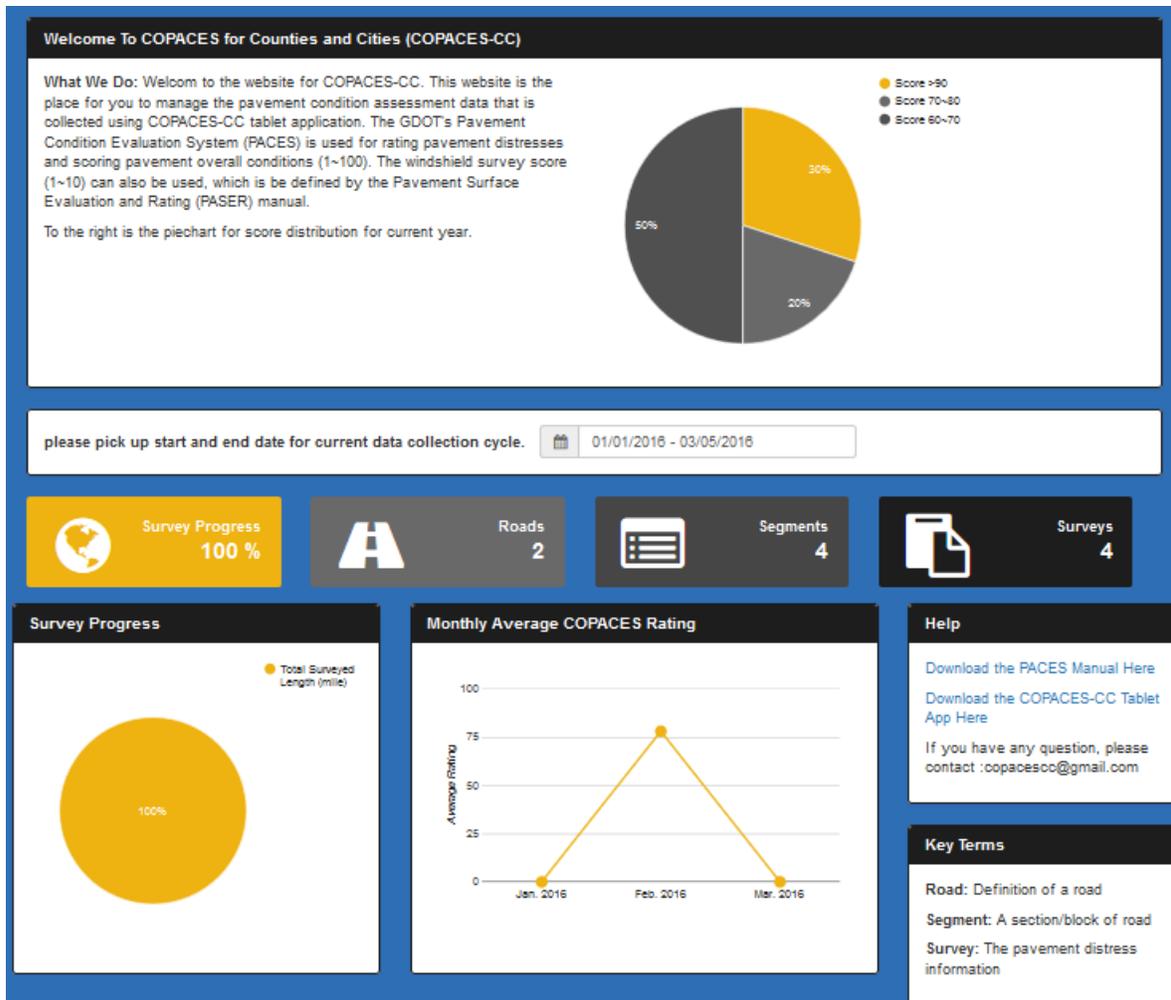


FIGURE 3.8: COPACES-CC Dashboard Page

- **Detailed Survey Data**

The detailed survey data of a segment can be accessed through the dashboard page (the most recently surveyed data) or the *Surveys* page (see Appendix II). FIGURE 3.9 shows an example survey. All the field-collected data can be accessed including general information, the detailed distress data, and the overall rating. If photographs were captured in the field, a bubble symbol would be displayed at each location. FIGURE 3.9 shows two images captured on Spring Street near the Georgia Tech campus, which can be downloaded to view in a full size.

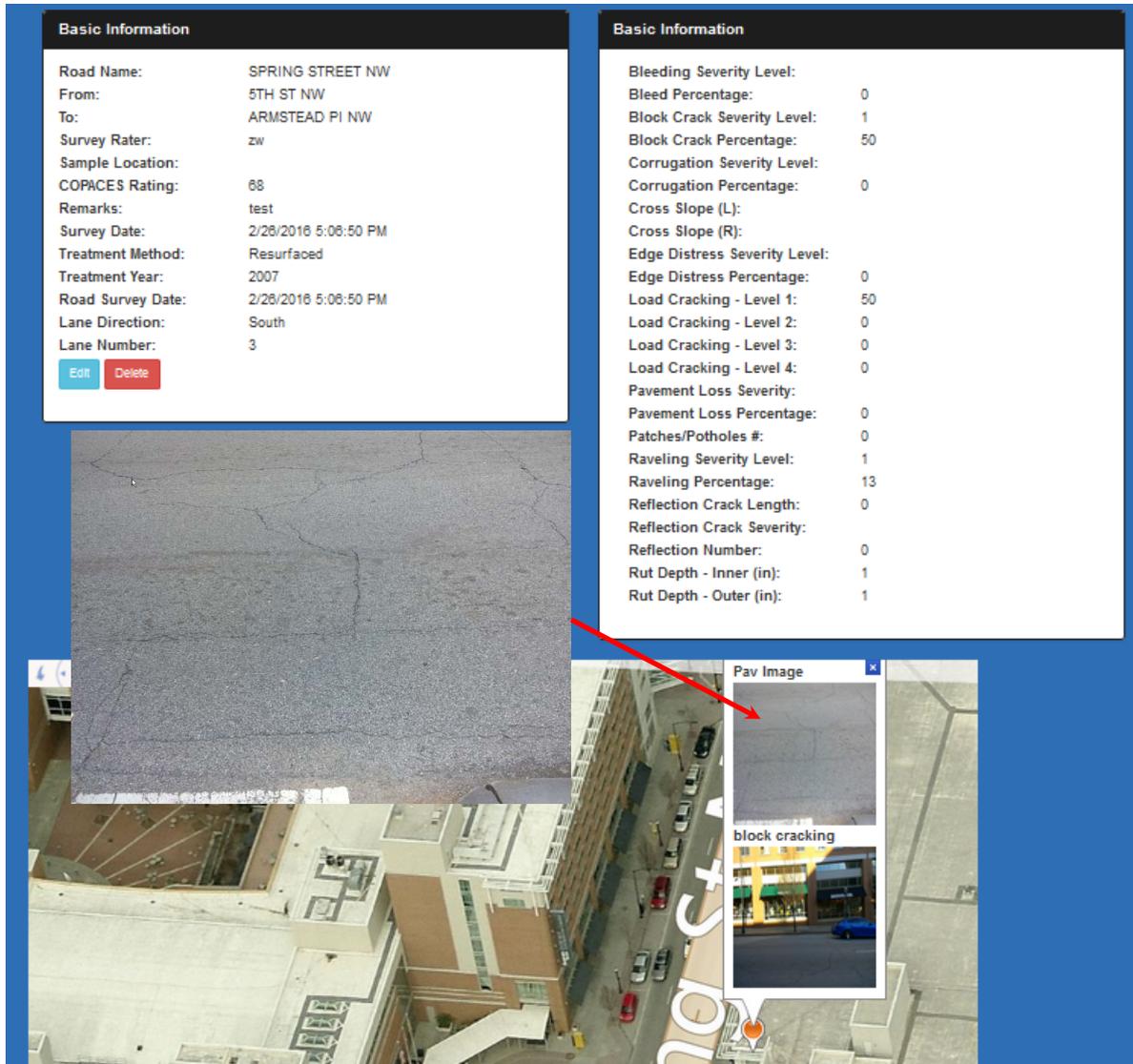


FIGURE 3.9: Detailed Survey Data

- **Data Search and Analysis**

COPACES-CC provides convenient functions for survey data search and analysis.

FIGURE 3.10 shows the search functions on the **Report** page (refer to Appendix II).

First, a search date range should be defined. The default data range is equal to the current data collection cycle. If more historic data needs to be extracted, end users can customize the analysis date range. The left panel in FIGURE 3.10 list all the

roads that contains the survey that was conducted in the predefined analysis date range. One or more roads can be selected for analysis or reporting. If a road is selected, all segments on it will be shown in the right panel.

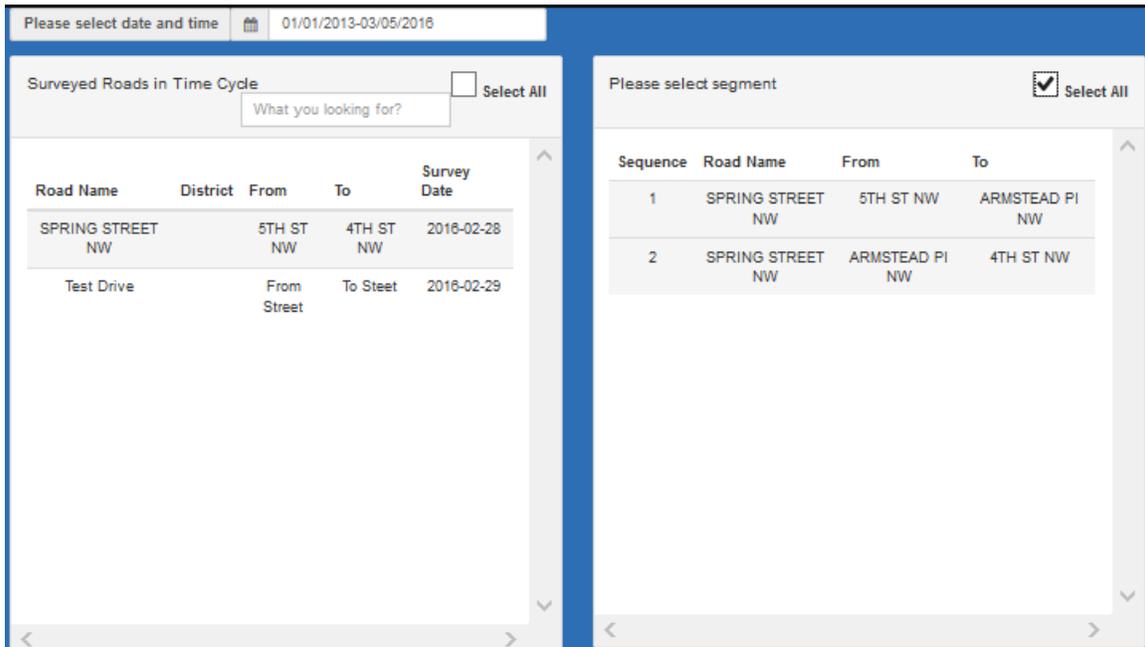


FIGURE 3.10: Data Search

After road and segments are selected, the bottom panel on the *Report* page shows various analysis results, including the rating distribution, segment rating, history of segments, and history of roads, as seen in FIGURE 3.11. The pie chart shown in FIGURE 3.11 is the rating distribution based on the selected road and segments.

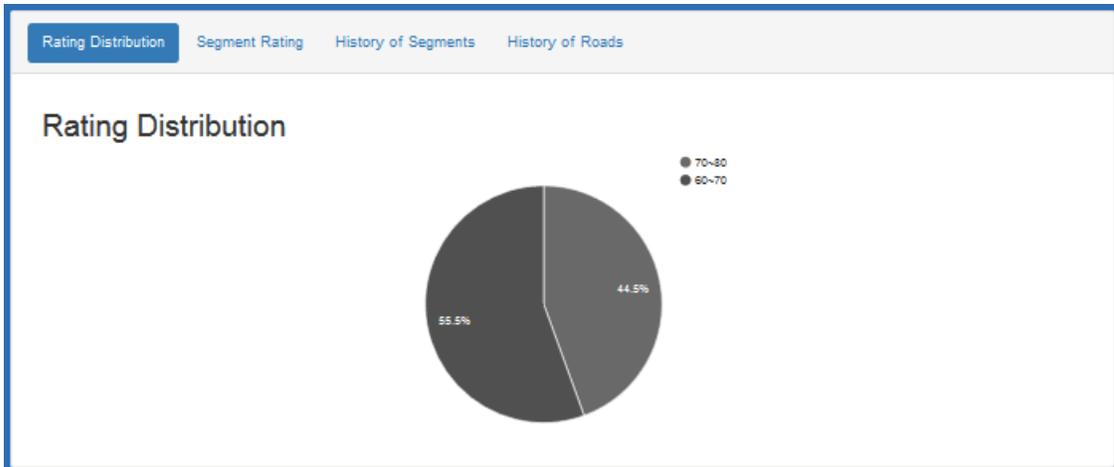


FIGURE 3.11: Data Analysis-Rating Distribution

FIGURE 3.12 shows the segment rating along a road and over time. In this example, there are two segments on Spring Street NW. Each segment has four years' of survey data. This analysis tool can be used to identify isolated segments in bad condition along a long road.

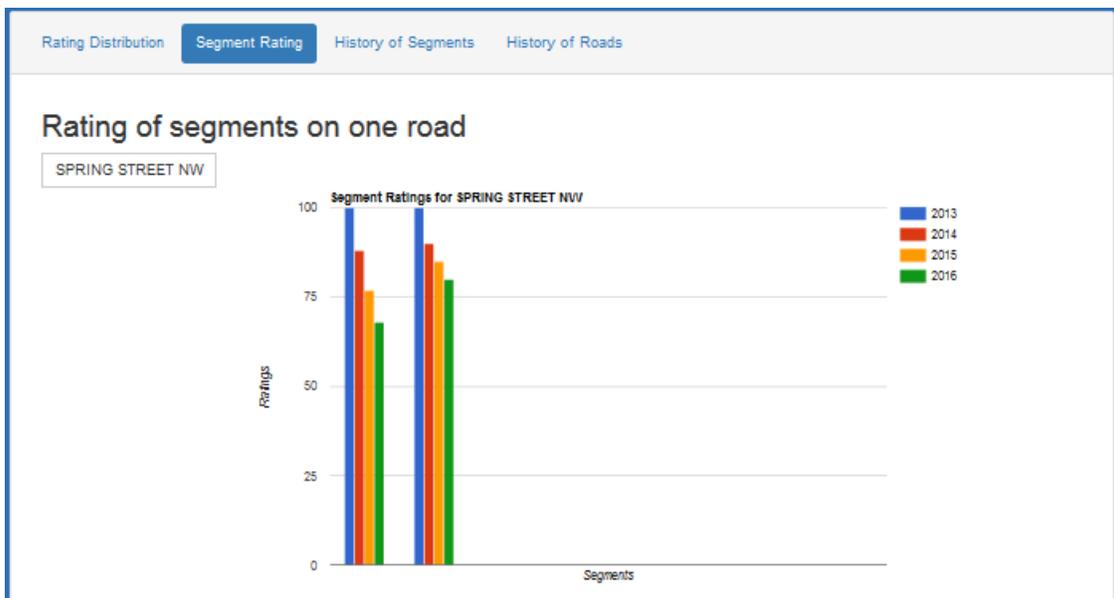


FIGURE 3.12: Data Analysis-Segment Rating on a Road

FIGURE 3.13 shows the historical segment rating. In this example, two segments have the same rating of 100 in 2013. However, these two segments have different deterioration trends. The segment shown as a red line apparently outperforms the one shown as a blue line. Further forensic investigation is needed to explore the possible reasons for this difference. Thus, proper treatment methods can be determined.

FIGURE 3.14 shows the historical project rating. A project can be a combination of several segments, depending on how the segments shown in FIGURE 3.10 are selected. Because segments have various lengths, two methods are provided for calculating a project rating: a simple average and a length-weighted average.

FIGURE 3.14 shows an example of weighted average.

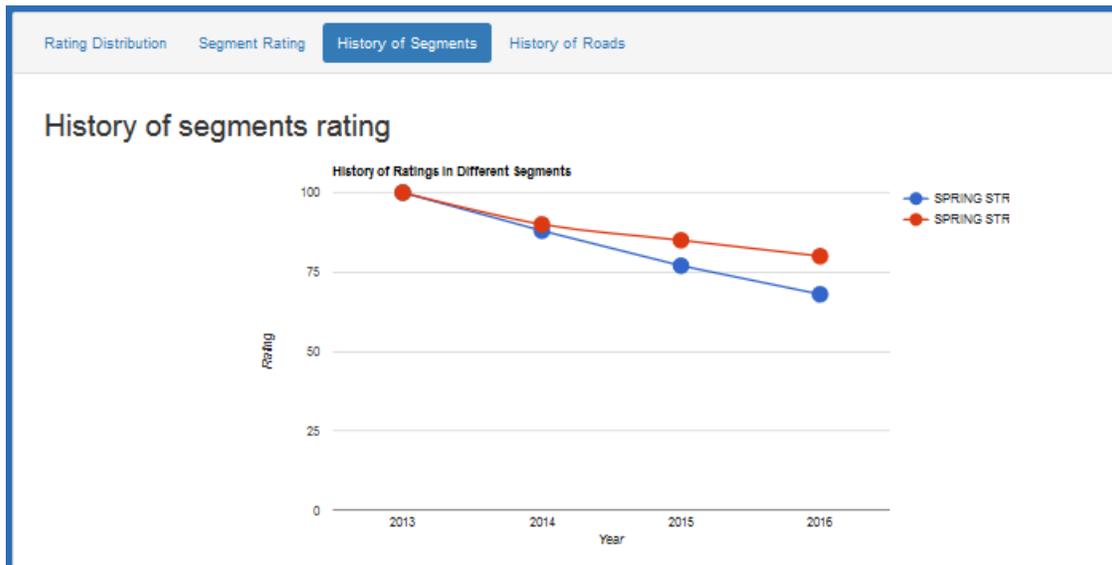


FIGURE 3.13: Data Analysis-Historical Segment Rating

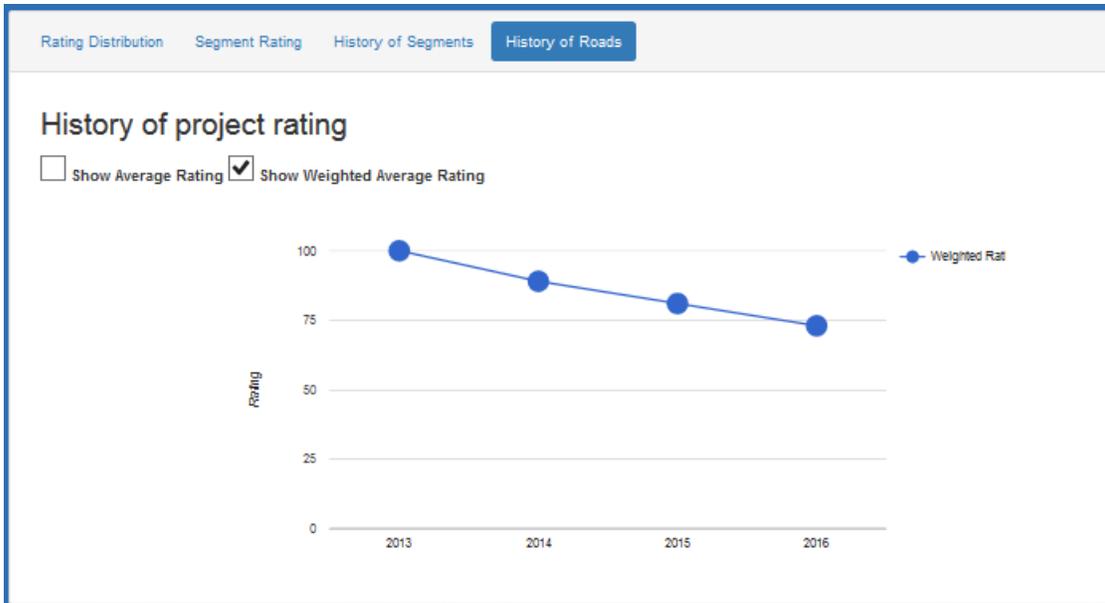


FIGURE 3.14: Data Analysis-Historical Project Rating

- **Reporting**

The selected segments can be extracted and reported as an Excel file or PDF file.

FIGURE 3.15 shows an example of an Excel report. Two worksheets are included: summary report and detailed report. In the summary report, only ratings are listed. In the detailed report, all the detailed distresses are listed.

Segment Condition Summary for FULTON COUNTY								
Total Road Mileage: 0.38 miles						Report generated on 3/5/2016 5:29:42 AM		
District	Road ID	Road Name	Inventory ID	From	To	Survey Date	COPACES Rating	Windshield Score
	FULTON 00029	SPRING STREET NW	6260061	5TH ST NW	ARMSTEAD PI NW	2/26/2016	68	
	FULTON 00029	SPRING STREET NW	6260062	ARMSTEAD PI NW	4TH ST NW	2/26/2016	80	
	FULTON 00029	SPRING STREET NW	6260061	5TH ST NW	ARMSTEAD PI NW	2/28/2015	77	
	FULTON 00029	SPRING STREET NW	6260062	ARMSTEAD PI NW	4TH ST NW	2/28/2015	85	
	FULTON 00029	SPRING STREET NW	6260061	5TH ST NW	ARMSTEAD PI NW	2/28/2014	88	
	FULTON 00029	SPRING STREET NW	6260062	ARMSTEAD PI NW	4TH ST NW	2/28/2014	90	
	FULTON 00029	SPRING STREET NW	6260062	ARMSTEAD PI NW	4TH ST NW	2/28/2013	100	
	FULTON 00029	SPRING STREET NW	6260061	5TH ST NW	ARMSTEAD PI NW	2/28/2013	100	

Detailed Pavement Condition Survey for FULTON COUNTY																										
Report Period: Lastest																										
Total Road Mileage: 0.38miles Total Surveyed Mileage: 0.38 miles												Report generated on 3/5/2016 5:29:42 AM														
Location			Rut Depth		Load Cracking				Block Cracking		Refection Cracking		Raveling		Edge Distress		Bleeding /		Corrugation / Pushing		Loss Pavemen		COPACES Rating	Windshield Survey	Windshield Score	
Road Name	Survey Date	Inventory Id	Outside WPI(1/8in)	Inside WPI(1/8)	Severity1	Severity2	Severity3	Severity4	% of Sample	Severity(1,2,3)	No. of Cracks	Total Length	Severity(1,2,3)	% of Sample	Severity(1,2,3)	% of Sample	Severity(1,2,3)	% of Sample	Severity(1,2,3)	% of Sample	Severity(1,2,3)	Severity(1,2,3)	Patches & Potholes			
SPRING STREET NW	2/26/2016	6260061	1	1	50	0	0	0	50	1	0	0	0	13	1	0	0	0	0	0	0	0	0	68	No	
SPRING STREET NW	2/26/2016	6260062	0	0	0	0	0	0	60	2	0	0	0	0	0	0	0	0	0	0	0	0	0	80	No	
SPRING STREET NW	2/28/2015	6260061	0	0	41	0	0	0	48	1	0	0	0	0	0	0	0	0	0	0	0	0	0	77	No	
SPRING STREET NW	2/28/2015	6260062	0	0	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	No	
SPRING STREET NW	2/28/2014	6260061	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	88	No	
SPRING STREET NW	2/28/2014	6260062	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	No	
SPRING STREET NW	2/28/2013	6260062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	No	
SPRING STREET NW	2/28/2013	6260061	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	No	

FIGURE 3.15: Data Reporting

CHAPTER 4 IMPLEMENTATION OF COPACES-CC

1. Implementation Procedures

There are numerous public and private software tools for local transportation agencies on the market; thus, software development is not the major objective of this SRS. Instead, we focused on how to leverage GDOT's valuable knowledge on pavement distress characteristics, treatment determination, and pavement management practices in Georgia to help LGs to use COPACES-CC in their pavement management and maintenance practices because they have similar local weather and roadway environments.

Throughout the software development and implementation, GDOT and local agencies were kept closely involved. FIGURE 4.1 illustrate the three-stage procedures, prototype development, small-scale testing and refinement, and large-scale implementation. GDOT has sponsored the development of stage I and stage II through two SRS programs. We are now ready for Stage III, large-scale implementation.

In stage I, the business requirements were determined through the project kickoff meeting. The representatives from two counties, one city, and GDOT were involved. Major challenges in leveraging GDOT's existing PMS software tools were discussed, and preliminary solutions were determined. After that, a prototype software tool was developed quickly (less than six months), and the two counties and one city started testing the prototype software tool. During the testing, the software tool was continually refined based on feedback. At later stages, the development team only worked with Newton County to refine the software tool. This strategy proved effective and efficient because of limited resources.

After a comprehensive test performed by Newton County, through GDOT's LTAP program, a statewide workshop was held on August 14, 2014 to train other LGs on use of the developed software. After the workshop, a user group was formed by several pilot counties. Initially, there were six counties in the user group. Over time, three of them did not continue for various reasons. We finally closely worked with three pilot counties, Chatham County, Fayette County, and Whitfield County, to build successful demonstration cases. One thing that we did not expect before we started this SRS is that we spent significant effort to re-design and re-develop COPACES-CC using the most up-to-date cloud computing and mobile technologies, as discussed in Chapter 3. Even though it cost us much more effort and many more resources, the results made it a wise decision because the new COPACES-CC is much more viable and fits better in with LGs' situations.

For each pilot county, we started with in-house training and a field demonstration, as shown in FIGURE 4.2. After that, one or two dedicated engineers in each county started to use COPACES-CC for field data collection. During the process, comments and recommendations were collected, and the application was refined, which is an iterative process. We also visited each county to observe the implementation process, discuss the issues, and collect comments and suggestions. This mutual communication helped keep both developers and pilot counties on the same page.

After the implementation by the pilot counties, several successful demonstration cases were established. To share their experience and demonstrate the application to more LGs, another statewide workshop was just held on February 29, 2016 through the help of GDOT LTAP and the Maintenance Office (some photographs from the workshop can be

seen in FIGURE 4.3). More than 40 representatives from 12 counties and 5 cities attended the workshop, and most of them showed great interest. Next, a large-scale, statewide implementation is ready.

The development and implementation procedures shown in FIGURE 4.1 were applied to ensure the developed software tool can meet local agencies' needs and that GDOT's existing resources and knowledge can be fully leveraged. In addition, the procedures can help mitigate the risk of possible failure because each step was sound and required only minimal resources.

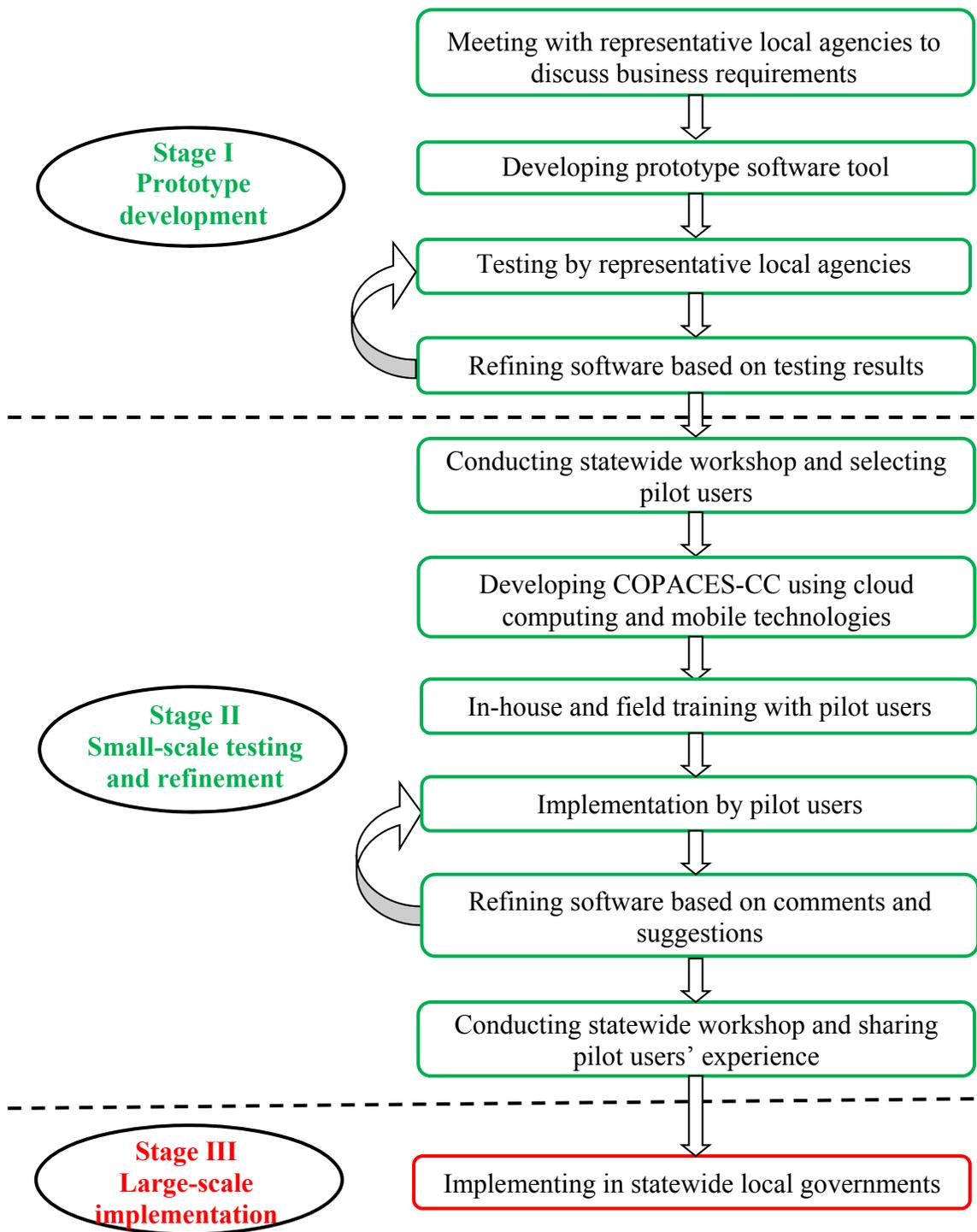


FIGURE 4.1: Development and Implementation Procedures



FIGURE 4.2: Working with Pilot Counties



FIGURE 4.3: COPACES-CC Workshop in Macon (February 29, 2016)

2. Introduction to Pilot Counties

Chatham County, Fayette County, and Whitfield County were three pilot counties who enthusiastically attended the implementation of COPACES-CC. Thanks to their valuable comments and suggestions, COPACES-CC became a product that is ready for implementation by statewide LGs. FIGURE 4.4 shows the geographic locations of these pilot counties. Chatham County is located in the southeast of Georgia where Savannah is one of its municipalities. Fayette County is near the Greater Atlanta area. Whitfield County is located in the north of Georgia and adjacent to Tennessee. These three pilot counties roughly covered all regions of Georgia from north to south. TABLE 4.1 lists the population, total centerline miles, and county-maintained centerline miles

In Chatham County, almost \$400,000 SPLOST and over \$900,000 GDOT LMIG funds have been spent for resurfacing over 6 miles of roadways in the past 3 years. The engineering department in Chatham County is preparing to spend \$600,000, on average, every year in the next 5 years from SPLOST funds. Currently, worst-first is the major strategy for pavement maintenance. Thus, Chatham County needs to develop a proactive and systematic approach, getting away from the current reactive approach. In addition, there is also a need of PMS due to accountability with residents. For example, residents need to know why their roads are not being resurfaced.

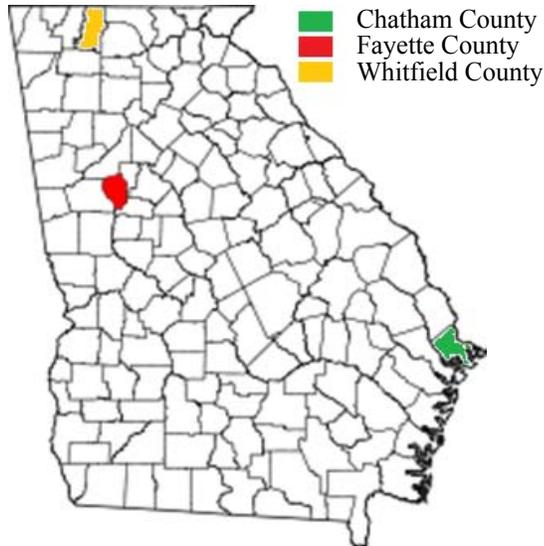


FIGURE 4.4: Locations of Three Pilot Counties

TABLE 4.1: Deterioration Rate in Terms of Total Crack Length

County	Population	Total Pavement Network Centerline Mile	County Maintain Centerline Mile
Chatham	265,128	2,300	390
Fayette	109,664	951	470
Whitfield	103,000	718	718

Fayette County has no active SPLOST. In 2016, \$600,000 in LMIG funds was acquired, and Fayette County matched around \$180,000, 90% of which will be used for resurfacing. In addition, Fayette County will allocate \$500,000 of general funds for resurfacing and \$120,000 general funds for pavement preservation. In the past, Fayette County used PASER for windshield surveys. Worst-first is also the strategy for pavement maintenance.

Whitfield County has a large number of tractor-trailers on minor and collector roads. In 2014, approximately 14 miles of paving work was done in Whitfield with about \$750,000 in LMIG funds from GDOT; the county matched about \$250,000. About \$1.5 million in

general funds was spent on minor roads and some collectors. Whitfield spent SPLOT funds for bridge and major culvert replacement. Similarly, worst-first is the major strategy for pavement maintenance. Preventive maintenance treatments, such as crack sealing and microsurfacing, have not yet been applied in Whitfield County due to the lack of a maintenance decision tree.

In summary, these three pilot counties currently have no systematic pavement management system, and pavement maintenance is mainly based on a worst-first strategy and engineers' experience.

3. Implementation of COPACES-CC in Pilot Counties

The detailed procedure of the COPACES-CC implementation can be referred to in FIGURE 4.1. In Chatham County, two pavement engineers were testing COPACES-CC; in Fayette County, other than the manager, a senior engineer was dedicated to using COPACES-CC; in Whitfield County, an experienced pavement engineer is responsible for field test.

The first step was to establish a comprehensive road/segment inventory. Since each county has GIS maps, we developed a corresponding program to automatically convert their GIS data to COPACES-CC-compatible road/segment data and import it to the cloud database. The following are general steps for converting GIS data to road/segment inventory:

- Create segments by joints of roads in ArcGIS, attaching longitude and latitude to both ending points of each segment.

- Find points with close longitude and latitude to combine them and find segments connecting to each other; use segment/road names as segment from/to information.
- Convert each road data and segment data into JSON format and upload them to Microsoft Azure database.

TABLE 4.2 lists the summary of road/segment inventory in each county. It should be noted that the data comes from the GIS map, and quality checking needs to be done. In Fayette and Whitfield Counties, the road/segment inventory might include the roads in its municipalities. Thus, each county needs to conduct data quality checking before a survey is performed. Nevertheless, the automatic conversion of GIS data to road/segment inventory saves tremendous effort for manual data input.

TABLE 4.2: Road/Segment Inventory in Pilot Counties

County	Number of Roads	Number of Segments	Total Mileage
Chatham	1,217	2,553	356
Fayette	2,567	6,176	1,028
Whitfield	2,862	8,327	1,196

FIGURE 4.5 summarizes the survey results from each pilot county. Chatham County surveyed 17 miles; Fayette County surveyed 90 miles; and Whitfield surveyed 229 miles. It should be noted that Chatham County only selected a representative segment on a road for testing COPACES-CC. Thus, its actual survey miles should be much longer than 17 miles. The condition distribution in each pie chart only reflects the surveyed data, which is not necessarily the conditions of the entire pavement network.

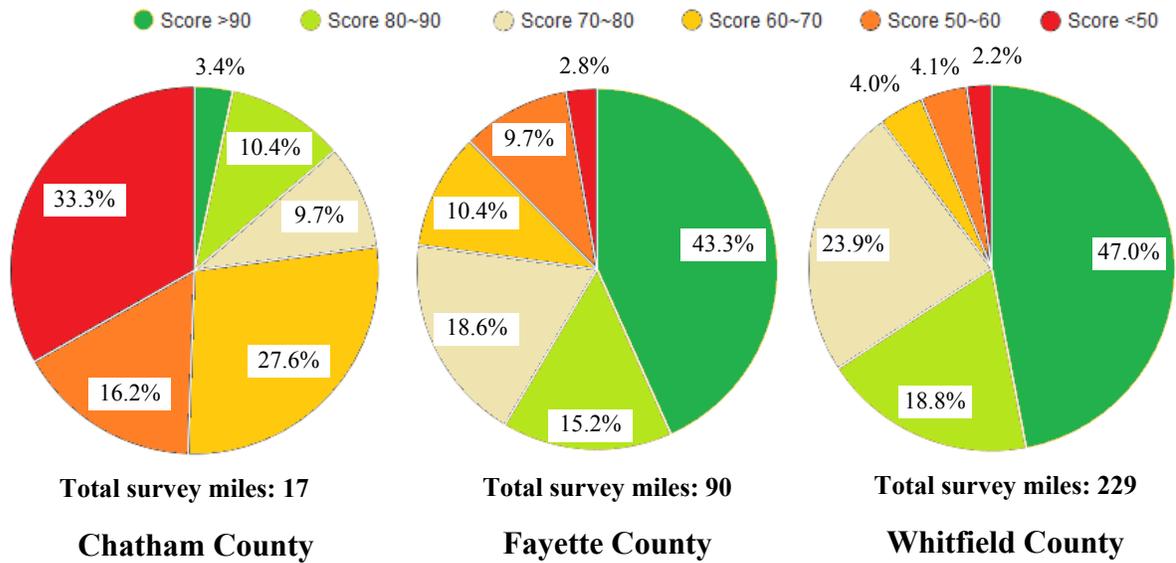


FIGURE 4.5 Summary of Survey Miles in Pilot Counties

4. Summary

After intensive testing and implementation in three pilot counties, COPACES-CC has been thoroughly tested and refined and shows very promising results that could be extended to all other LGs in Georgia. Since these pilot counties have no systematic PMS, they expressed strong interest in adopting COPACES-CC in the future to enhance the efficiency and effectiveness of pavement management and maintenance and their accountability with public.

The engineering department in Chatham County plans to spend 5 years (one day a week) to continuously collect pavement conditions using COPACES-CC and increase the overall “health” of its roads. After that, the data will be transferred to the Public Works in Chatham County. Fayette County plans to conduct pavement condition evaluation by internal staff on an annual basis. Whitfield County plans a full assessment on major roads every 3 years, collector roads every 5 years, and minor roads every 5 years.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

Better management of pavement assets is not just an emergent task for state DOTs, but it is, also, critical for LGs. However, local transportation agencies lack a systematic, developed, and effective PMS due to limited resources for IT support and pavement technical expertise. To address this need, a PMS, COPACES-CC, was developed for Georgia's LGs by leveraging GDOT's knowledge and experience on pavement management and maintenance.

COPACES-CC uses the most up-to-date cloud computing and mobile technologies to minimize the LGs' operational cost for pavement management. GDOT's pavement distress protocol, PACES, was adopted to make it convenient for transferring GDOT's practices on pavement management and maintenance to LGs. To consider LGs' past practice, a windshield survey protocol, PASER, was also incorporated.

Three pilot counties, Chatham County, Fayette County, and Whitfield County, have conducted a comprehensive testing and implementation. Their successful experience using COPACES-CC has been shared with all other counties and cities through a statewide workshop organized by GDOT LTAP.

The following summarizes further study and development:

- As the senior engineer in Fayette County testified in the statewide workshop, COPACES-CC is very robust and easy to use. However, training on pavement distress protocols and rating methods is very important for consistent data quality.

- Unlike state DOTs, LGs often lack resources to conduct in-house pavement condition evaluation. They normally outsource the work. To make sure the data quality is good and consistent, it is suggested that a certification program for pavement condition rating be developed. Thus, only certified personnel can conduct pavement condition data collection.
- When pavement condition data is available, the next step is to develop functions to support pavement management and maintenance decision making. First, a treatment decision tree is needed to select proper treatments for each road/segment. Because such a decision tree does not exist in most counties or cities, we suggest first using GDOT's current decision tree. Then, a county or city can modify it based on its own practices. Second, a cost estimation function is needed to calculate treatment costs. For this purpose, GDOT's item mean summary can be used. Finally, a prioritization or optimization function is needed to recommend maintenance projects based on available funds and agencies' policies.
- With the successful implementation of COPACES-CC in three pilot counties, it is ready to implement it in other LGs. However, financial support is still needed to make it sustainable because continuous development and maintenance is needed.

**APPENDIX A: COPACES MANUAL (REPRODUCED FROM
GDOT PACES 2007 VERSION)**

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1 Basics of the System

1.1 Introduction

The Pavement Condition Evaluation System (PACES) is designed to indicate the amount and type of surface distress on a roadway at the time the survey is made. The system standardizes the terminology for the types of defects that can be found on a pavement in Georgia and defines the various levels of severity for these defects. This system will allow roads to be rated objectively statewide.

This system only addresses the structural condition of the pavement surface. It does not include skid resistance and ride-ability because these will be measured with high speed testing equipment.

1.2 Outline

A number of distresses have been identified for flexible pavement and surface treatment which relate to the performance of the pavement. Both the presence of these distresses and the severity levels must be taken into account when rating a pavement. These distresses are as follows (also see distress definitions):

<i>Rut Depth</i>	<i>Raveling</i>
<i>Load Cracking</i>	<i>Edge Distress</i>
<i>Block Cracking</i>	<i>Bleeding/Flushing</i>
<i>Reflection Cracking</i>	<i>Corrugations/Pushing</i>
<i>Patches and Potholes</i>	<i>Loss of Section</i>

There are other types of defects which are not being considered either because they occur infrequently, or they are included in one of the above categories at a certain severity level. Transverse cracking, for instance, is considered to be an initial stage of block cracking and is, therefore, rated in that category.

Rating is done for a particular segment by selecting a sample section for cracking distresses representative of the pavement condition for that rating segment. The defects noted for each rating segment. The defects noted for each rating segment within a project are then averaged to obtain the representative pavement condition for that project. A project rating is determined from deduct values, which have been established for each defect and severity level.

1.3 Flexible Pavement Distress Definitions

The various pavement distresses are defined in this section along with descriptions and illustrations of the various levels of severity for each distress. The rater must be thoroughly familiar with the distresses and severity levels as defined in this section. The rater may or may not agree with all of the definitions and descriptions presented in this section, but all pavement sections must be rated in accordance with the criteria presented here in order for the rating system to be uniform.

Illustrations and photographs are shown for the various distresses and the severity levels which represent what typically might be seen in the field. The illustrations do not show all conditions that might be found, nor is it intended that a condition must look exactly like what is shown in this manual for it to be rated at a particular severity level. The pictures are simple illustrations of what the rater is likely to see for a certain distress at a certain severity level. The rater must use his judgment based on the descriptions and the pictures while classifying the distress and severity level found on a sample section. It is possible that a combination of distresses and severity levels are present and these combinations should be recorded on the survey sheet as they exist.

1.4 Rut Depth

Definition:

Rutting is longitudinal depressions that form under traffic in the wheelpaths and are greater than 20 feet long. Rutting is a permanent deformation of the wheelpaths caused by traffic loadings. Rutting can be caused by insufficient compaction, plastic movement of the mix, or an unstable foundation.

According to its definition, the following questions may be addressed when identifying rutting distress:

1. Compared with the pavement outside the wheelpaths, is there any depression deformation in the wheelpaths?
2. Is this deformation in the longitudinal direction?
3. Is there any cracking in the longitudinal direction which is associated with the deformation in the wheelpaths?

How to Measure:

Rut Depth will be estimated in both wheelpaths in the sample area and recorded on the survey in units of 1/8 of an inch. If rutting is extensive (more than 3/8 inch), actual measurement may be necessary.

Severity levels for Rutting are not applicable.



1.5 Load Cracking

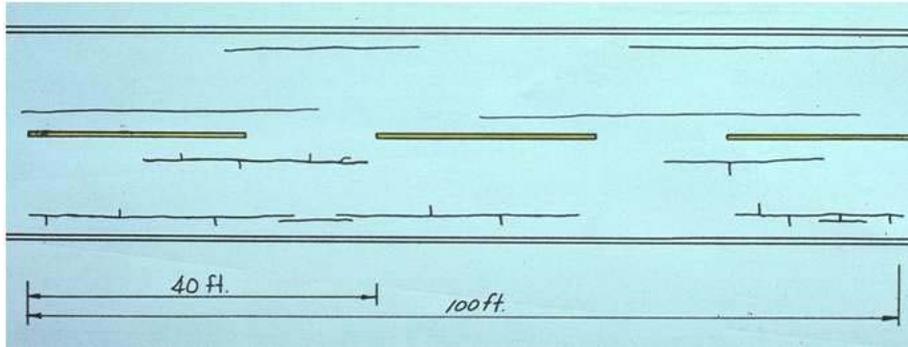
Description:

This type of cracking is caused by repeated heavy loads and always occurs in the wheelpaths. This type of cracking usually starts as single longitudinal cracks in the wheelpaths. As progression continues, short transverse cracks occur that intersect the original longitudinal cracks. Additional longitudinal cracks occur in the wheelpaths. As the number of longitudinal and transverse cracks in the wheelpaths increases, polygons are formed by the intersection of these cracks. As deterioration continues, these polygons become smaller (due to additional cracking) and, in the worst case, begin to pop out. When load cracking progresses to the point where small polygons are formed, rutting can become extensive and pumping of base material can occur.

Following are examples for each severity level of load cracking.

1.5.1 Severity Level 1 Load Cracking

Level 1 Load Crack patterns are generally tight single longitudinal cracks in the wheelpaths. A wheelpath is approximately 3 feet wide and load cracking can occur at the edge of the wheelpath. Occasional short, tight longitudinal cracks parallel to the main longitudinal cracks can also occur and still be defined as a level 1 load cracking pattern.



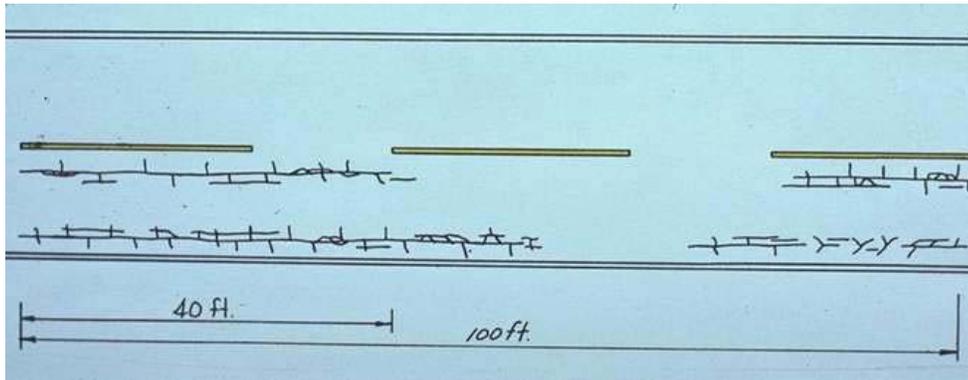
The illustration above is an example of the range in load cracking patterns to be recorded as level 1 load cracking. There is approximately 120 feet of cracking in the two wheelpaths, or 60% of the sample in lane one in the two wheelpaths, or 60% of the sample in lane one, and 130 feet (65%) of level 1 load cracking in lane two.

Examples of Level 1 Load Cracking



1.5.2 Severity Level 2 Load Cracking

The following illustration shows the general range in appearance of level 2 load cracking patterns. These cracks are wider than level 1 cracks and occur only in the wheelpaths. This level cracking has a single or double longitudinal crack with a much larger number of 0-2 ft. transverse cracks intersecting than in level 1 load cracking. Occasionally, polygons will form but are not prominent.



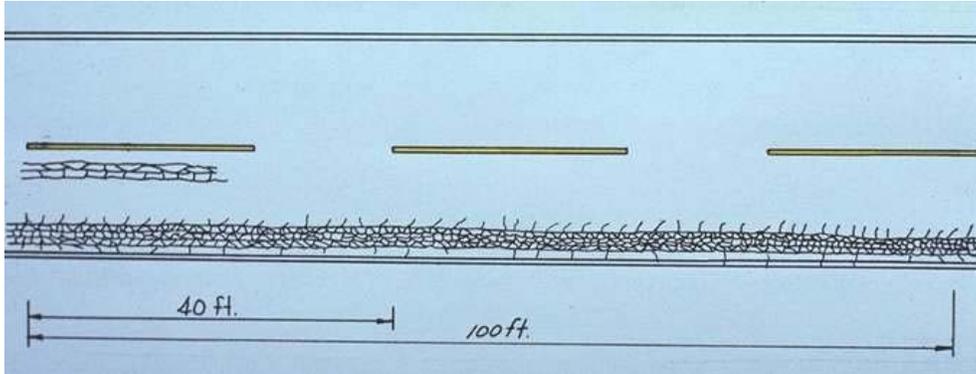
In this example, there is approximately 150 ft. of cracking in the 100 ft. sample area, or 75% of the sample area.

Examples of Level 2 Load Cracking



1.5.3 Severity Level 3 Load Cracking

The illustration shows the general appearance of level 3 load cracking patterns. This type pattern generally has three or more longitudinal cracks in the wheelpaths with many interconnecting transverse cracks. Many small polygons are formed causing the appearance of “alligator hide.” This type cracking is marked by a definite, extensive pattern of small polygons and is sometimes accompanied by severe rutting.



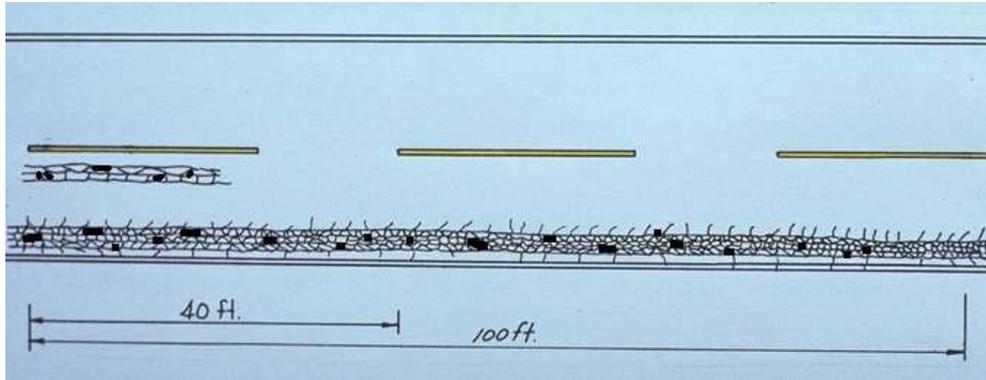
In this example, 60% of the sample has level 3 load cracking.

Examples of Level3 Load Cracking



1.5.4 Severity Level 4 Load Cracking

The following illustration shows level 4 load cracking patterns. This type pattern has the definite “Alligator hide” pattern but has deteriorated to the point that the small polygons are beginning to pop out. Rutting is usually severe and pumping of base material is sometimes evident.



In this example, 60% of the sample area has level 4 load cracking.

Examples of Level4 Load Cracking



1.6 Block/Transverse Cracking

This type cracking is caused by weathering of the pavement or shrinkage of cement treated base materials. Block/transverse cracking is not load related. The block pattern is distributed uniformly throughout the roadway and not concentrated in the wheelpaths.

Block cracking is interconnecting cracks forming a series of large blocks usually with sharp corners.

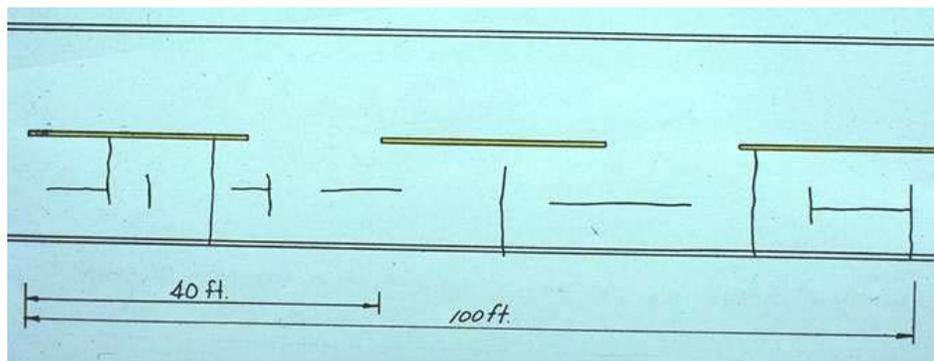
Block/transverse cracking begins as single, tight transverse, longitudinal or combinations of both types of cracks. In the beginning, block/transverse cracks may not form a recognizable block pattern, just longitudinal and/or transverse cracks that are not associated with the wheelpaths.

As this type of cracking progresses, a definite block pattern occurs, and the cracks become wider. As the cracking becomes worse, the block pattern densifies (small blocks) and/or the cracks become very wide ($> 1/8$ inch).

1.6.1 Severity Level 1 Block/Transverse Cracking

This type cracking is not load related and does not occur in the wheelpaths. Level 1 block/transverse cracking is made up of transverse, longitudinal, or a combination of both types of cracks. A definite “block” pattern has not developed yet. The longitudinal cracks are tight and not in the wheelpaths, although they may wander into the wheelpaths at times.

The illustration below would be considered to have level 1 block/transverse cracking on 100 percent of the sample area. See the Rule of 100 feet for estimating the extent of level 1 block/transverse cracking.



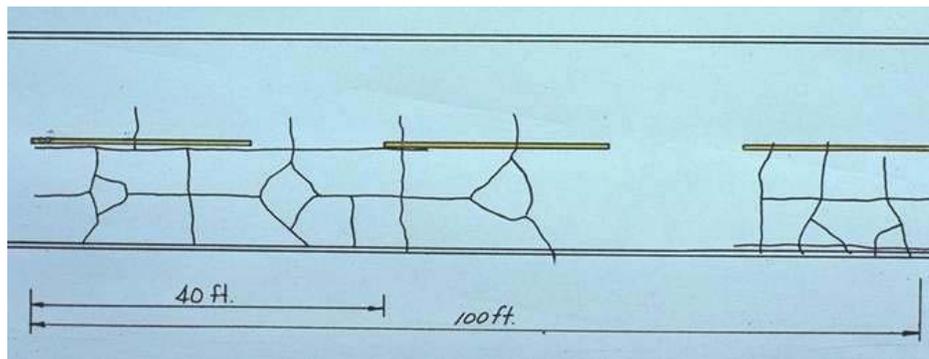
Examples of **Level 1** Block/Transverse Cracking



1.6.2 Severity Level 2 Block/Transverse Cracking

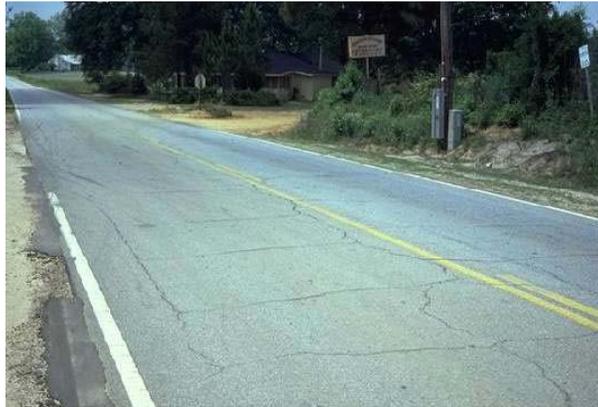
At this severity level, the cracking has developed definite block patterns. Some of the longitudinal cracks can occur in the wheelpaths for short distances without being considered load cracking when associated with a block pattern. The transverse and longitudinal cracks are wider than in level 1 but do not necessarily require sealing. The block pattern will usually be uniform across the entire roadway.

In the following example, 80% of the sample area has level 2 block/transverse cracking. However, this example is for illustrative purposes only. It is either present (100%) or not present (0%) and rarely falls in between.



Following are sample images of level 2 block/transverse cracking.

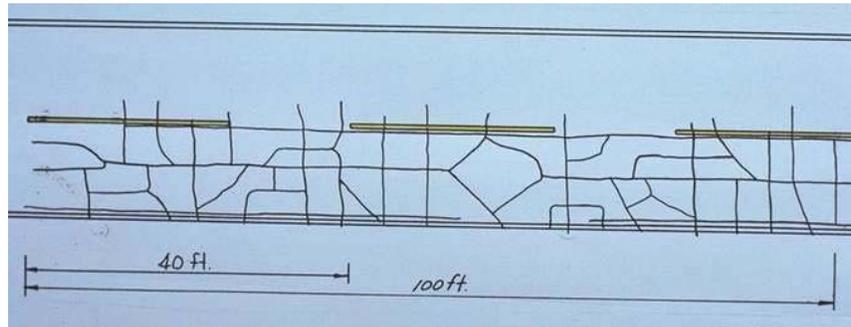
Examples of Level 2 Block/Transverse Cracking



1.6.3 Severity Level 3 Block/Transverse Cracking

At this severity level, the cracking has a definite block pattern as in level 2, but the blocks are smaller and the cracks are wider than in level 2. Level 3 block/transverse cracking is marked by cracks that are wide enough to require sealing. Block cracking that has a very large number of small blocks is also considered to be level 3 block/transverse cracking. Some of the longitudinal cracks in this pattern may meander into the wheelpaths for a short distance but are still considered block cracking because large distances of wheelpaths are not affected, and this type cracking is not caused by loading. Some spalling of the cracking may be evident.

The following example represents 100% level 3 block/transverse cracking:



Here are some sample images of level 3 block/transverse cracking.





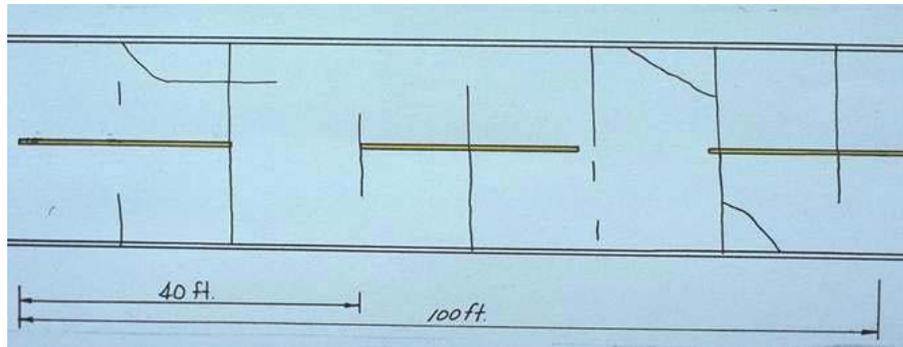
Level 3 block/transverse cracking – Notice width, subsidence and spalling of the cracks.

1.7 Reflection Cracking

This type cracking is caused by the “reflection” of joints and cracks through an asphaltic concrete overlay from the **underlying PCC concrete pavement**. These reflection cracks begin as tight cracks and progress to very wide cracks with spalling. The transverse cracks will be right angles across the roadway and in a repeatable pattern down the roadway (i.e., every 30 feet, 40 feet, etc.). The longitudinal cracks, if present, will normally be fairly straight, continuous cracks in the travel lane near the pavement edge associated with underlying edge of narrower PCC concrete pavement which has been widened and overlaid with asphaltic concrete overlay. Longitudinal cracks that occur at the centerline, lane lines, and edge lines are not to be counted. Any other cracks will be cracks associated with failures in underlying PCC concrete pavement, and such cracks will reflect the size and shape of such failures. Construction joints and widening joints associated with the construction and/or widening of asphalt pavements are not to be counted as reflection cracking. Reflection cracking only occurs on roadways with an underlying PCC concrete pavement.

1.7.1 Severity Level 1 Reflection Cracking

Level 1 Reflection cracks are tight, single cracks that are usually transverse but are longitudinal if the underlying concrete pavement is narrower than the asphaltic concrete overlay. Irregular cracking patterns can be reflected if the underlying slabs are broken. Level 1 cracks may or may not go across the entire lane.



This illustration shows the top lane represents 9 total cracks and approximately 100 linear feet of reflection cracking.

Here are some sample images of level 1 reflection cracking:

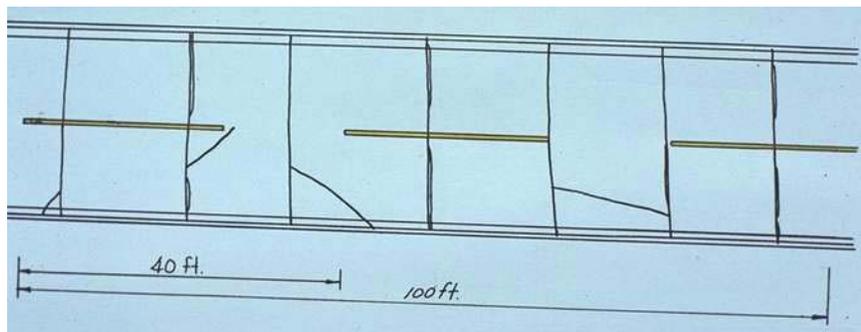




1.7.2 Severity Level 2 Reflection Cracking

This level of reflection cracking has progressed so that all underlying joints and cracks have reflected through the surface layer. The cracks are substantially wider than the level

1 cracks and may require sealing. There may be some “double” cracks over the underlying concrete pavement joints. “Double” cracks are not to be counted as two cracks but as one reflection crack. A longitudinal crack in the travel lane near the edge of pavement that is a result of widening of the underlying concrete pavement with asphalt will be counted as a reflection crack. If the underlying pavement is not concrete, it should not be counted. A widening crack is not necessarily a reflection crack.



This illustration of the bottom lane represents 12 total cracks and approximately 230 linear feet of reflection cracking.

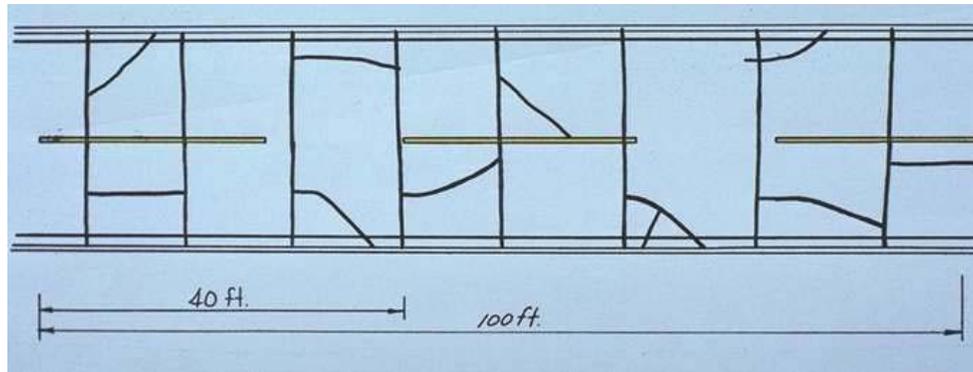
Here are some sample images of level 2 reflection cracking:



Level 2 Reflection.

1.7.3 Severity Level 3 Reflection Cracking

This level of reflection cracking will have the same pattern as level 2 reflection cracking (all underlying joints and cracks have reflected through), but the cracks will be very wide. The cracks will be marked by spalling and/or subsidence. It should be obvious that some corrective work should be performed to these cracks before counting them as level 3.



This illustration shows the bottom lane represents 16 total cracks with approximately 280 linear feet of reflection cracking.

Here are some sample images of level 3 reflection cracking:



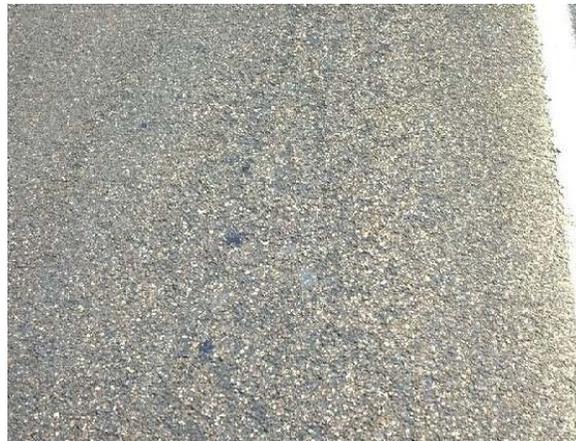
1.8 Raveling

Description:

This condition is the progressive disintegration of the pavement surface. It is caused by traffic action on a weak surface. Aggregate particles become dislodged from the binder, and this loss of material can progress through the entire layer. Raveling ranges in severity from the loss of a substantial number of surface stones to the loss of a substantial portion of the asphalt surface layer. For purposes of rating, a slurry seal that has “peeled off” is considered level 3 raveling.

How to measure:

The percent of the length of the rated segment that contains the raveling is to be recorded along with the predominant severity level. For example, if 300 feet of raveling in a 500 feet rating segment with 100 feet as level 1 severity and 200 feet at level 2 severity, it would be recorded as 60% level 2 raveling as $300/500 = 60\%$ and level 2 is more predominant (200 ft. > 100 ft.).



Level 1 – loss of substantial number of stones



Level 2 – loss of most surface



Level 3 – loss of substantial portion of surface layer ($>1/2$ depth)

1.9 Edge Distress

Definition:

Edge distress is cracking and pavement edge break-off within 1 to 2 foot of the pavement edge and not associated with the wheelpath area. The cracking can be in the form of longitudinal or transverse cracks or in many instances alligator type cracking. It may sometimes be difficult to distinguish between alligator cracking in the wheelpath and along the edge of the pavement, especially on narrow width pavements. **It must be called load cracking when it occurs in the wheelpath. It cannot be called both load cracking and edge distress.**

How to Measure:

The percent of the length of the rated segment that contains the edge distress is to be recorded along with the predominant severity level in the rater's judgment. For example, if raveling is observed on these curves (curve 1 – 300' level 1, curve 2 – 100' level 3) within a rating segment, it would be recorded as 60% level 2 raveling as $200+100 = 300/500 = 60\%$ and level 2 is more predominant (200 ft. > 100 ft.).



Level 1 – tight, hairline cracks



Level 2 – crack widths greater than $\frac{1}{4}$ inch, double cracking, tight “alligator” cracking



Level 3 – severe “alligator” cracking at edge, popouts, edge break off

1.10 Bleeding/Flushing

Definition:

Bleeding or flushing is the presence of bituminous material on the surface creating a shiny appearance. Bleeding or flushing is created by excess asphalt cement and/or low air void content.

How to measure:

The percent of the length of the wheelpaths that has bleeding or flushing in the rated segment is noted. Each wheelpath is a maximum of 50 percent of the rated segment. For example, if one wheelpath is observed with 200 feet level 1 bleeding and the other wheelpath had 100 feet level 2 bleeding in a rated segment of 500 feet, it would be recorded as 60% level 1 bleeding/flushing since $200 \text{ ft.} = 40\% + 100 \text{ ft.} = 20\%$ or 60% total both wheelpaths and level 1 is more predominant ($200' > 100'$).



Level 1 – free bitumen is noticeable on the surface along with the aggregate in the mix



Level 2 – surface is black with very little aggregate noticeable

1.11 Corrugation/Pushing

Definition:

A series of ridges and valleys in the surface which cause a rippling or washboarding effect caused by unstable asphalt on asphaltic concrete or non-uniform application of aggregate on surface treatment.

How to Measure:

The extent will be recorded as the percentage of the rated segment length that has corrugations. For example, if it is observed in a rating segment that three interchanges (No. 1 –100 feet level 1, No. 2 –300 feet level 2, and No. 3 –50 feet level 3) had corrugations/pushing, it would be recorded as 90% and level 2 corrugation/pushing, as $100 + 300 + 50 = 450 = 450/500 = 90\%$ and level 2 is more predominant ($300' > 100' > 50'$).



Level 1 – corrugations are visible and can definitely be felt in the steering wheel while driving



Level 2 – corrugations/pushing have significant effect on riding comfort, some reduction of speed may be necessary



Level 3 – noticeable discomfort, excessive vibration, reduction of speed necessary

1.12 Loss of Section

Definition:

A deviation of the pavement surface from its original typical design cross section other than those described for corrugations, pushing or shoving. Generally, loss of pavement section results from settlement, slope failure, or heavy loads on a deficient pavement system. This loss of section usually occurs in the outside half of the lane. Loss of section takes the form of dips, bumps, and undulations, all of which cause pitch and roll in a moving vehicle.

How to Measure:

The percentage of the length of rated segment that has loss of pavement section. The three severity levels are as follows:

Level 1 (Slight): Noticeable swaying of vehicle, but no effect on vehicle control.

Level 2 (Moderate): Heavy swaying of vehicle. Fair control of vehicle, driver has to anticipate dips ahead.

Level 3 (Severe): Speed of vehicle must be greatly reduced for driver to maintain control.

The predominant severity, in the rater's judgment, is also recorded on the rating form under severity. For example, in a rating segment of 500 feet, if 300 feet level 1 and 200 feet level 2 is observed, and it would be recorded as 100% level 1 loss of pavement section as $300 + 200 = 500/500 = 100\%$ and level 1 is more predominant (300' > 200').



Level 1 (slight) – Noticeable swaying of vehicle, but no effect on vehicle control



Level 2 (Moderate) – Heavy swaying of vehicle. Fair control of vehicle, driver has to anticipate dips ahead



Level 3 (Severe) – Speed of vehicle must be greatly reduced for driver to maintain control

1.13 Patches, Potholes, and Local Base Failures

Definition

Patches are repaired sections of the asphalt pavement due to localized pavement and/or base failures. Also, spot leveling is included in this category.

Potholes are sections of the asphalt pavement that have failed and formed a hole in the pavement structure. These are caused by pavement and/or base failures.

Base Failures are sections of roadway where the water has entered the base material and is rutting and shoving .

How to measure

The total number of spot overlays, patches, potholes, and local base failures must be counted for the entire rated segment and this number recorded on the COPACES survey form. Utility patches are NOT to be counted UNLESS the utility patch has failed and is affecting the structural condition of the pavement.



2 Rating Survey

2.1 Introduction

Ratings are done for each segment by selecting a sample section for cracking distresses representative of the pavement condition for that rating segment. The defects noted for each rating segment within a project ranges are then averaged to obtain the representative pavement condition for that project. A project rating is then determined from deduct values which have been established for each defect and severity level.

2.2 Conducting the Survey

The rating system has been devised so that the pavement condition of all the roads in the city or county can be assessed objectively by one rater within his assigned area on a project basis. It is suggested that the rater rates all the roads within one given area at a time to reduce driving time between routes and to keep track of what areas have been surveyed. It would be helpful to mark on the map the routes that have been completed.

The rater must clearly assign the beginning and ending of a project and should rate all the segment(s) in the project before moving on to the next project. The road that is surveyed is considered as the Road ID and the extent is determined by the beginning and ending points of the project. Each segment also is assigned a beginning and ending points, which is discussed later in this chapter.

2.3 Project Limit Selection

Pavement condition ratings will be obtained on all the city and county roads. The roads will be divided into projects for analysis of the data.

A project is a length of a roadway with a common pavement section, similar structural conditions, and logical beginning and ending points. A rater should ensure that the project limits can be easily located on the map.

General break points should be used for project limits:

- 1) Major changes in pavement condition.
- 2) Change in pavement type (not including spot overlays).

There may be certain cases in which the project limits can be different, and are required to be used:

- 1) City limits
- 2) County Lines
- 3) Change in number of lanes

Other local factors may be known to the rater which can be helpful in establishing a project limit. Once the project limits have been established during the initial rating survey, these same limits should be used during all follow-up ratings as long as the structural condition remains similar within the project limits. If structural conditions change, subdivide into 2 or more projects as appropriate. As a “Rule of Thumb,” whenever the project length is greater than 10 miles, double-check to be sure that the pavement conditions are basically similar within the limits selected. If not, separate into two or more projects.

2.3.1 Selection of Rating Segments

A project is divided in several segments, as the case may be, for rating purposes. Each segment is expected to be of almost same length. Exceptions to this are the beginning and ending segments of a project which can be of a smaller length or when drastic changes occur within a particular segment. The project limits within a city will also be shorter because of change in pavement type, number of lanes etc. As the rating conditions normally vary greatly within short distances, the segment will be reduced in length to insure getting a representative rating of pavement condition.

2.3.2 Selection of Sample Location for Cracking Distress

In rating cracking distresses (load, block/transverse, and reflection cracking) only a 100 foot sample out of each segment is rated. Hence it is important that the 100 foot section represent the majority of the cracking distresses found in the rating segment.

2.3.3 Sample Location

In rating cracking distress (load, block/transverse, and reflection cracking) only a 100-foot sample out of each rating segment will be rated, so it is very important that the 100-foot section represent the majority of the cracking distress found in the rating segment. The 100-foot section will be chosen by the rater and can be located anywhere within the rating segment. The rater should drive slowly and make two or three stops within the first half of the rating segment and look at the pavement from the car to determine what type of cracking distress and level of severity is generally present. The 100-foot sample section should be selected only after the rater is confident that he has a “feel” for the pavement condition and can select his 100-foot sample section that is representative of the cracking distress within the segment to be rated. On projects where conditions are uniform, the pavement condition may be obvious after the first stop and the sample section could be chosen early in the rating segment. On projects with variable conditions, the sample section should normally be located at the half-way point or beyond in the rating segment to be sure it is “representative” of the cracking distress. If pavement conditions change drastically within the segment being rated, the rating segment should be broken into two or more segments and 100-foot sample locations chosen to represent the smaller segments. For instance, two 100-foot sample sections could be chosen, each representing half the original segment.

For projects with cracking distress that vary widely within each rating segments, the 100-foot sample should represent the average conditions within the segment rather than the best or worst general conditions. For example, if in a given segment there is a substantial amount of cut areas and the fill areas are the worse general condition, the 100-foot sample should be chosen to represent the entire segment, not in the best or worst area.

The rater should not locate the 100-foot samples over culverts, bridge approaches, or locations that are obviously localized problems. Localized problems should be handled in “remarks.”

The purpose of the survey is to obtain a representative rating of the project pavement condition, especially cracking distress.

2.3.4 Rating the Sample Section for Cracking Distress

The COPACES for Counties and Cities is the computer program that makes use of GDOT's PACES. All the project and survey information is entered for the project while the rater is conducting the survey via a laptop computer.

Once the 100-foot sample section has been selected to represent the cracking distress, its location will be recorded in the program, under the field "sample location." The field locates the sample location to the nearest one-tenth mile.

The rater must walk the 100-foot section (three centerline stripes plus 10 feet is approximately 100 feet) and rate the lane in the worst condition on two lane and multilane undivided roads. On divided highways, each travel direction must be rated separately although only the lane in the worst condition in each travel direction is rated.

It is generally best to walk the 100 feet in one direction and determine which lane is in the worst cracking distress condition and rate this lane when walking back towards the vehicle. The rater must be aware that certain conditions, such as time of the day, sunlight, and wetness, can affect his ability to see certain cracking distress conditions. The amount (to the nearest 5%) and severity of the cracking distress is estimated to the rater's best judgment in accordance with the procedures contained in Chapter 1 of this manual and immediately recorded in the program

2.3.5 Selecting and Rating the Remaining Types of pavement Distress

As cracking distress is the most critical type of pavement distress, the length of the rating segment will be determined when rating cracking distress as described earlier.

The remaining types of pavement distresses (Rut Depth, Raveling, Edge Distress, Bleeding/Flushing, Corrugation/Pushing, and Loss of Pavement Section) are to be closely

observed and an estimate (to the nearest 5%) made of the extent and the predominant severity of the distress within the rating segment.

On two-lane and multi-lane undivided highways, the rater should determine which lane is in the worst general shape (from the standpoint of Raveling, Bleeding/Flushing, Corrugation/Pushing, Edge Distress, and Loss of Pavement Section) and base his estimate of the extent and severity of such pavement distress on what is observed in the lane selected. Likewise, on divided highways, only the lane in the worst condition in a given direction is to be rated, but rate both directions separately when rating divided highways (i.e., a separate report is to be prepared for each direction of a divided highway).

An exception to rating only the worst lane is to be made when rating patches, potholes, or local base failures, as the total number of such distress for ALL LANES within the rating segment is to be recorded.

3 Calculation of Project Rating

A general understanding of the PACES calculation of the project ratings by the rater is essential for the rater to understanding the COPACES for Counties and Cities program. The program is based on the PACES system that was manually calculated by the rater.

The project rating obtained from PACES can vary from 0 to 100 points. One hundred points is assigned to a roadway with no visible surface distresses. Points are deducted from a possible 100 based on extent and severity of each surface distress. One hundred minus the total deduct points is the project rating.

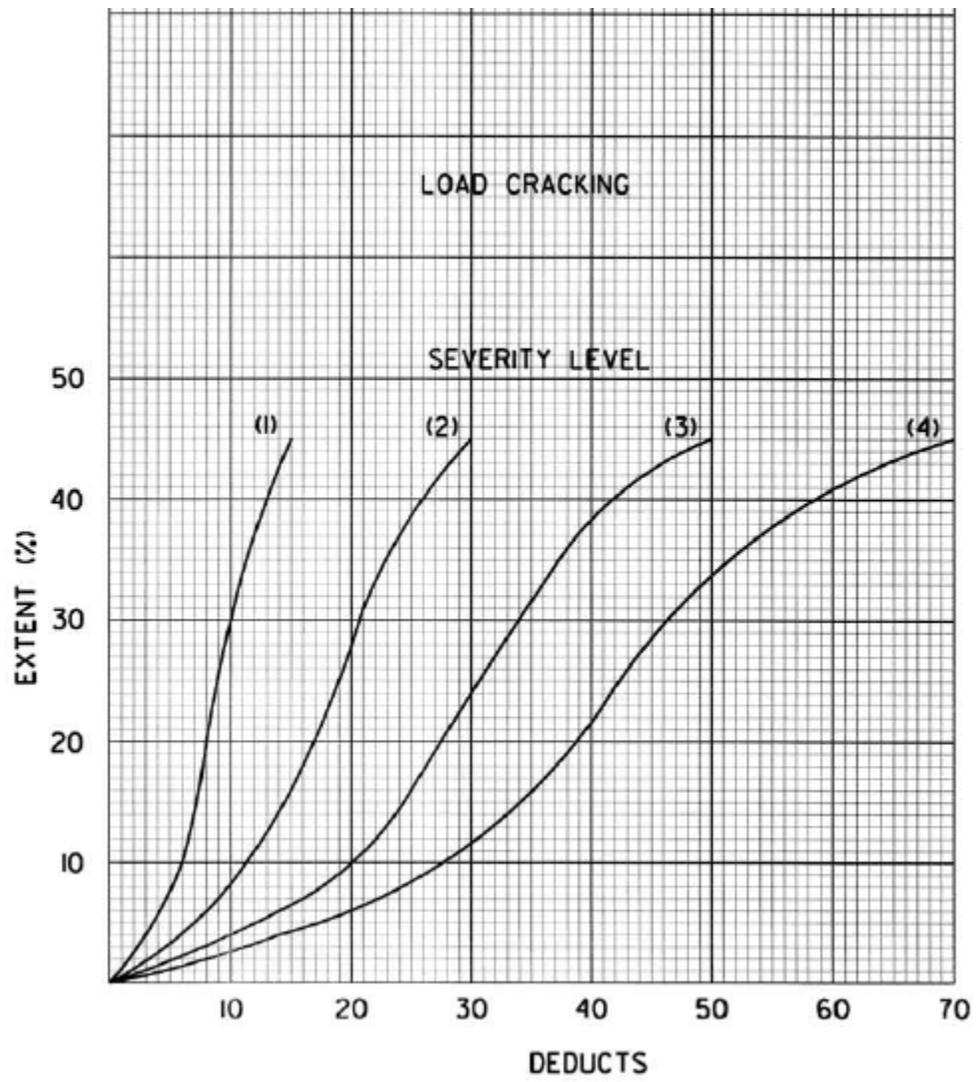
The deduct values are assigned based on average extent and predominant severity level for the entire project. **This fact points out the necessity of choosing projects properly. For example, a poor section of roadway, rated together as a project with a good section, will result in the poor section of the roadway not being adequately represented by the rating score.** After close inspection of the Detailed Project Rating Sheet obtained, it should be obvious if the project limits were chosen correctly or incorrectly. Consideration should be given to breaking the project into two projects if the conditions warrant.

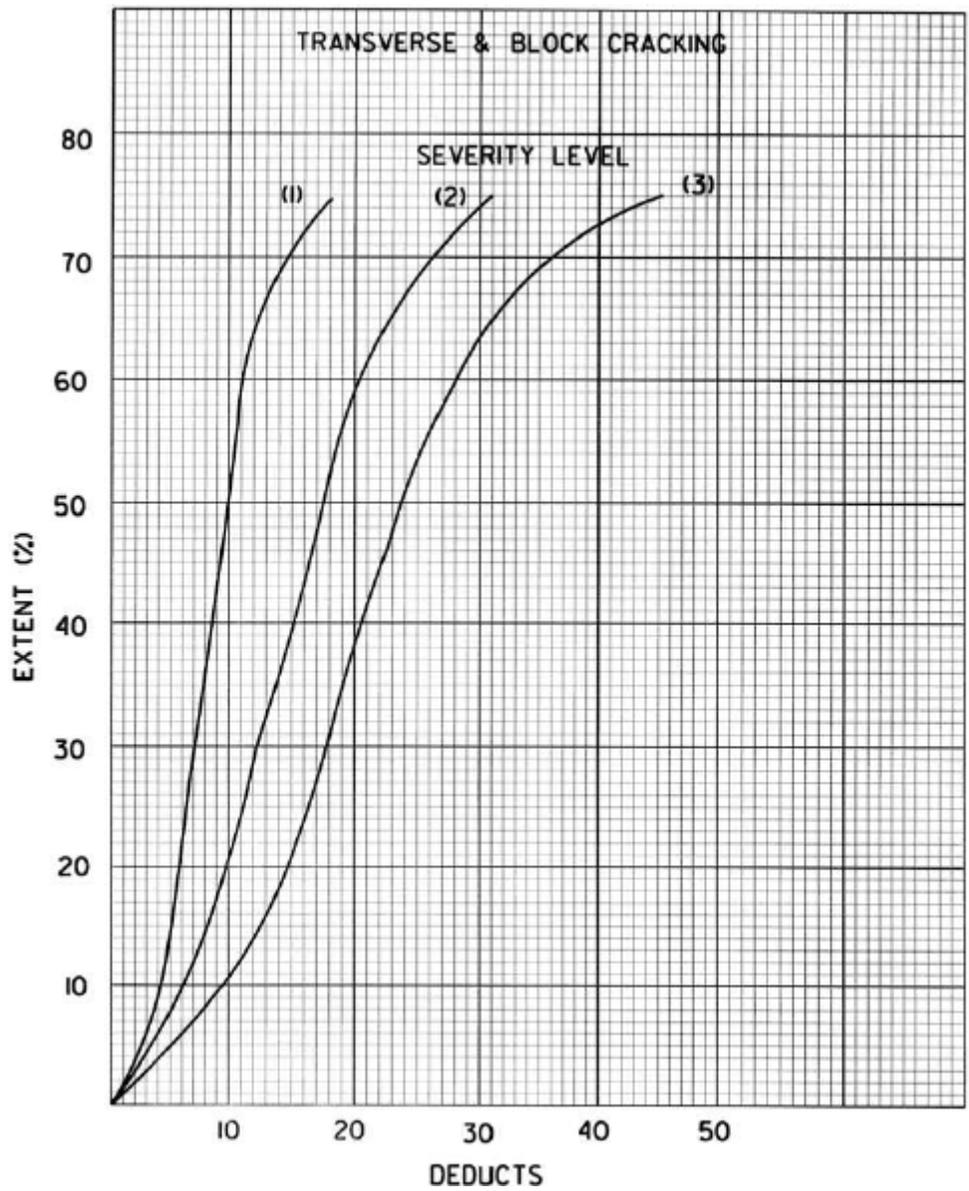
3.1 Determining Project Average for Each Distress

Simple numeric averages for each distress are used instead of prorating in this rating system. The averages are computed by totaling the values for each type of distress and dividing by the number of rating segments.

After the average values are computed for each distress for the project, deduct points are determined for each distress extent and severity. These deduct points are totaled and subtracted from 100 to determine the project rating.

The following charts, used when PACES was performed manually, are representative of the deduct point values used in COPACES.





Flexible Pavement Condition

Survey Deduct Values

Rutting Extent (inches)							
	0	1/8	1/4	3/8	1/2	5/8	3/4
Deducts	0	2	5	12	16	20	24

Patches and Potholes Extent (# per mile)					
	1-2	3-6	7-10	11-15	>15
Deducts	2	5	10	17	25

Corrugations/Pushing Extent (%)				
		1-10	11-25	>25
Severity	1	1	2	4
	2	2	4	7
	3	3	6	10

Raveling Extent (%)							
		1-5	6-15	16-25	26-35	36-45	>45
Severity	1	2	5	6	8	10	13
	2	4	8	11	14	17	21
	3	6	12	16	20	25	30

Edge Cracking Extent (%)					
		5-25	26-50	51-75	>75
Severity	1	1	2	3	4
	2	2	4	6	7
	3	3	6	8	10

Loss of Pavement (%)					
		0-25	25-50	50-75	75-100
Severity	1	0	1	2	3
	2	2	4	6	8
	3	6	5	10	12

Bleeding or Flushing Extent (%)				
		1-10	11-30	>30
Severity	1	2	5	8
	2	5	10	15

Reflective Cracking (%)						
		5-15	16-30	31-45	46-50	>51
Severity	1	3	5	6	8	10
	2	6	8	11	14	20
	3	10	15	20	25	30

APPENDIX B: USER'S GUIDE FOR COPACES-CC

User's Guide for COPACES-CC

I. Introduction

The COPACES for Cities and Counties (COPACES-CC) program is an adaptation of COPACES (Computerized Pavement Condition Evaluation System) designed with pavement evaluation in counties and cities in mind. This system is used for identifying asphalt pavement distresses, recording survey data, and calculating pavement ratings. The pavement distress types, levels of severity, and methods for calculating project ratings used in this program follow closely those defined in the PACES manual currently being used by the Georgia Department of Transportation (GDOT).

The COPACES program is a cloud program system based on the Microsoft Azure on-line database. All data is synced and stored in the cloud for collaborative and an easy-to-go work environment. It consists of two parts, a tablet application on the Windows 8 platform, used for field survey data collection, and a website used for data display and analysis.

II. COPACES-CC for Win8 Tablet

1. System Requirement

- Hardware requirements
 1. Intel Pentium 500 MHz processor or equivalent.
 2. Tablet with minimum 512MB RAM, 100MB free hard drive space, and a **rear camera**
- Software requirements
 1. Windows 8 or Windows 8.1
 2. An internet connection at the time of installation and after operation each time
 3. DPI (dots per inch) setting of 100%

2. Installing COPACES-CC from Windows App Store

Please register a free Hotmail email account if you don't have one. You need the administrator credential to install the software.

2.1 Uninstall previous COPACES-CC if it was installed before

If you have an old version of COPACES-CC installed, please uninstall it before you start to install the new software. Make sure you have **uploaded** all your survey data before you uninstall the software.

On the Start screen, find the COPACES-CC software icon. Right-click it, and click **Uninstall** (Figure 1). Then, click **Uninstall** to confirm the popup window.



Figure 1: Uninstall previous version before installation

2.2 Install the latest software from the Microsoft App Store

The link to COPACES-CC is <https://www.microsoft.com/store/apps/9NBLGGH690JV>. If you are familiar with how to install software using the App Store, you may skip the following instructions in Section 2.

Follow the link (<https://www.microsoft.com/store/apps/9NBLGGH690JV>) to find COPACES-CC in the Microsoft App Store (Figure 2), or, you may search “copaces” in the Microsoft App Store.

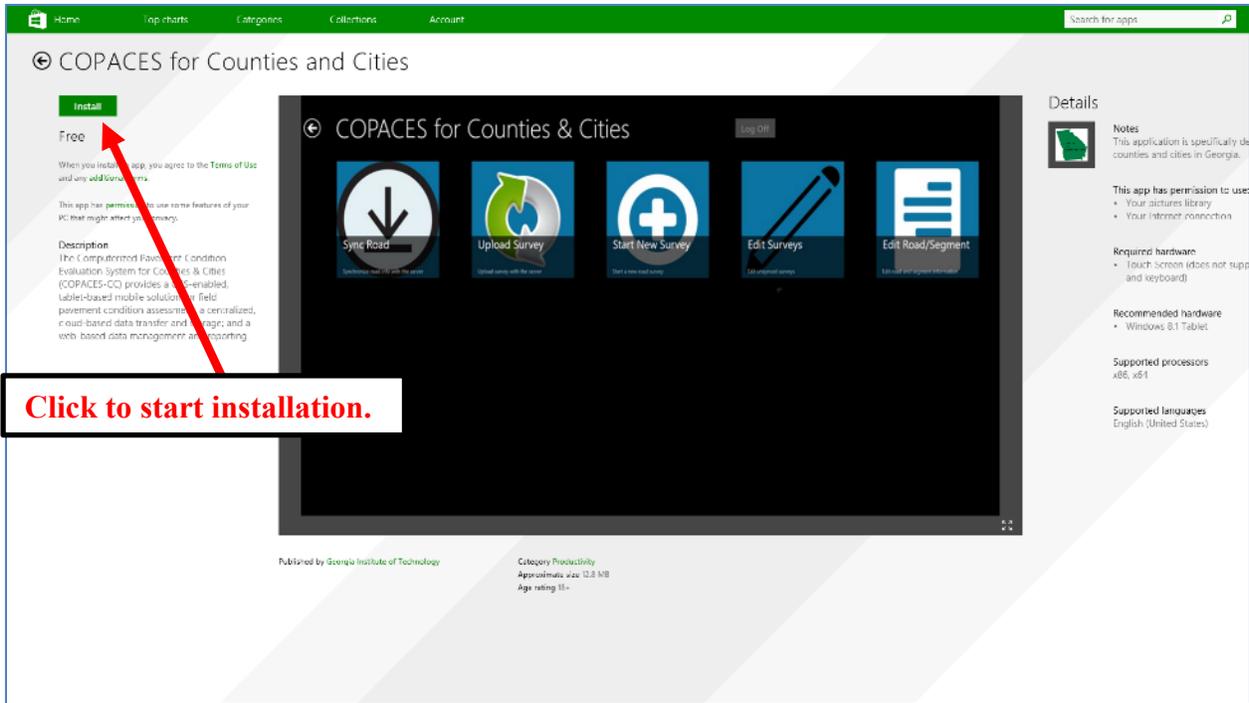


Figure 2: Install APP from Microsoft APP Store

If you install COPACES-CC on your desktop/laptop (Figure 2), the following message might pop up. Click **Continue** (Figure 3).

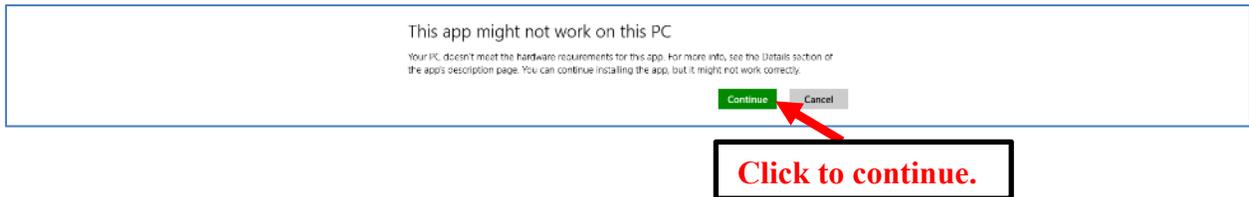


Figure 3: Click on continue to install

*If you don't want to use your Microsoft account to log onto your tablet in the future, you can click **Sign into each app separately instead (not recommended)**. (Figure 4)*

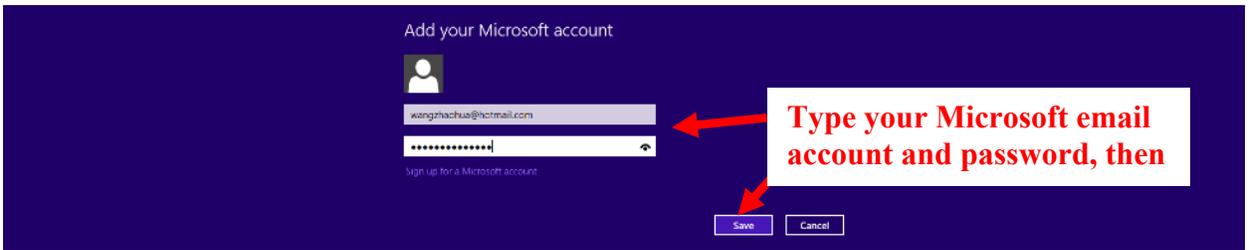


Figure 4: Log in Microsoft account

COPACES-CC is FREE. You don't need to add any payment information. Click **Ask me later** (Figure 5).

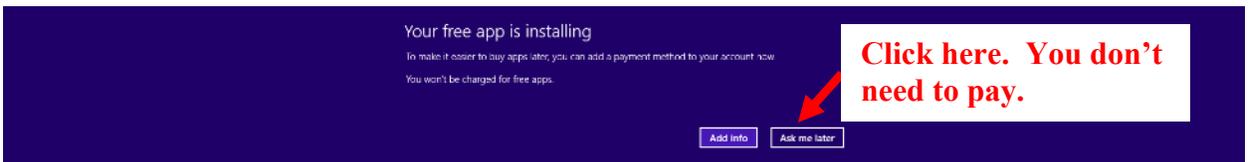


Figure 5: Add payment information later



Figure 6: App installed

2.3 Display the COPACES-CC icon on the Start screen

After installation, you may not find the software on the **Start** screen. To add it onto the **Start** screen, find **COPACES for Counties and Cities** in the **Apps** list. Right click it, and click **Pin to Start** (**Figure 7**). Now, the software is shown on the **Start** screen.

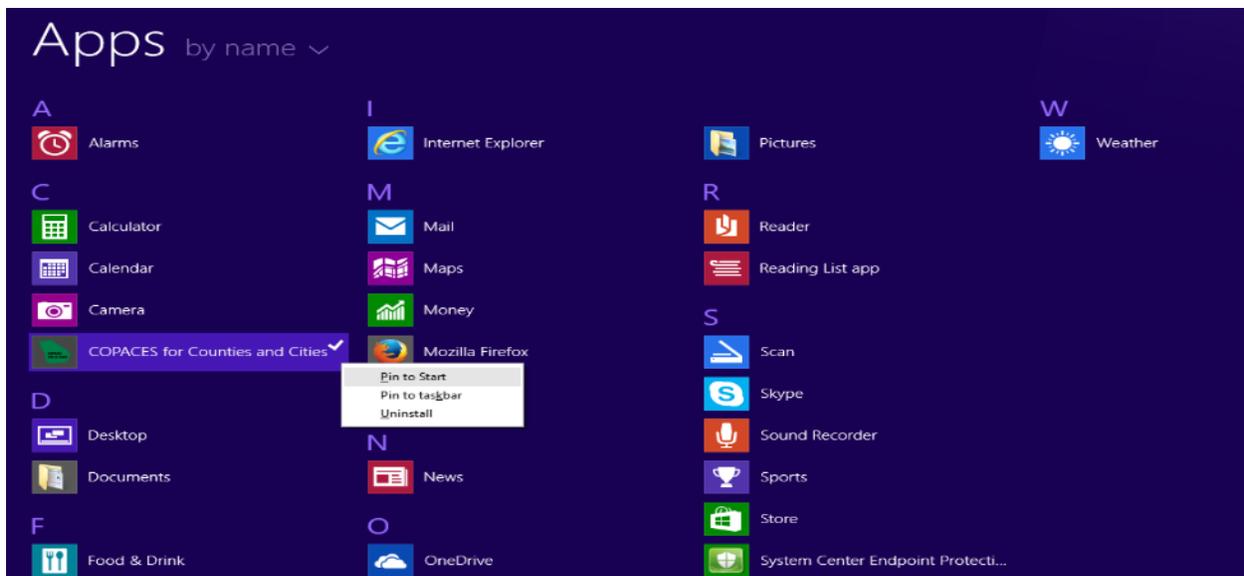


Figure 7: Pin to start
Appendix B-5

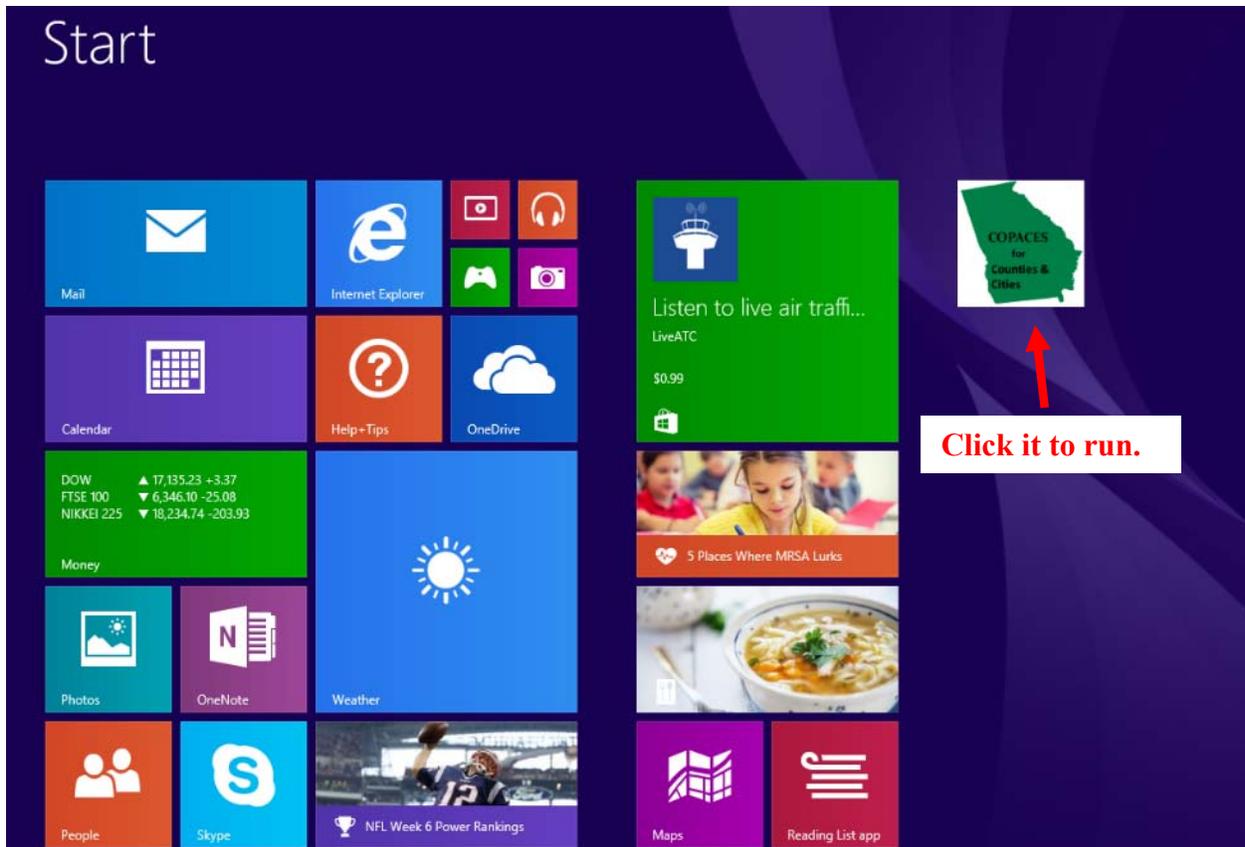


Figure 8: Click to run

3. Uninstall COPACES-CC from a Tablet Device

If you will no longer use COPACES-CC on your device, make sure you have **uploaded** all your survey data before you uninstall the software.

On the Start screen, find the COPACES-CC software icon. Right-click it, and click **Uninstall**. Then, click **Uninstall** to confirm the popup window.

4. Using COPACES for Cities and Counties

4.1 Login in and Start

Find the COPACES-CC software icon on the **Start** Screen; left **click** it to run.

You will enter the login page if you run the program for the first time.

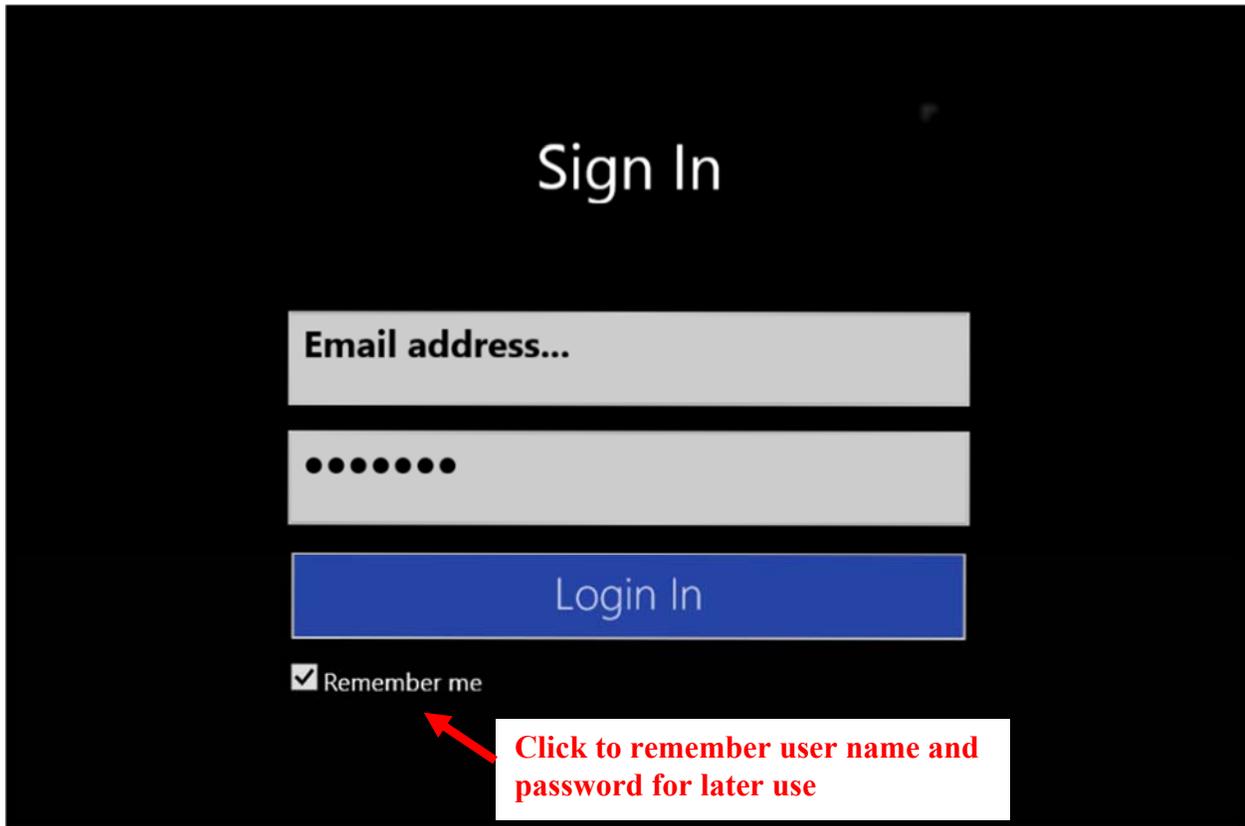


Figure 9: COPACES -- Sign in

Sign in with your personal account that has been registered on the website.

If you haven't registered an account yet, please do so on our website:

<http://copacescc.azurewebsites.net/>

Click “**Remember me**” if you are logging in your personal device and want to save the user name and password for later; the login interface **will not** appear next time you run the software.

Click “**Login in**” to jump onto the main page (Figure 10).



Figure 10: COPACES -- Main page

Note that icons may not display exactly the same way due to different tablet screen sizes, but you can **swipe left** to see icons not showing.

Clicking on the “**Log off**” button will lead you back to the login in interface to log off or change to another user.

4.2 Sync Road Service

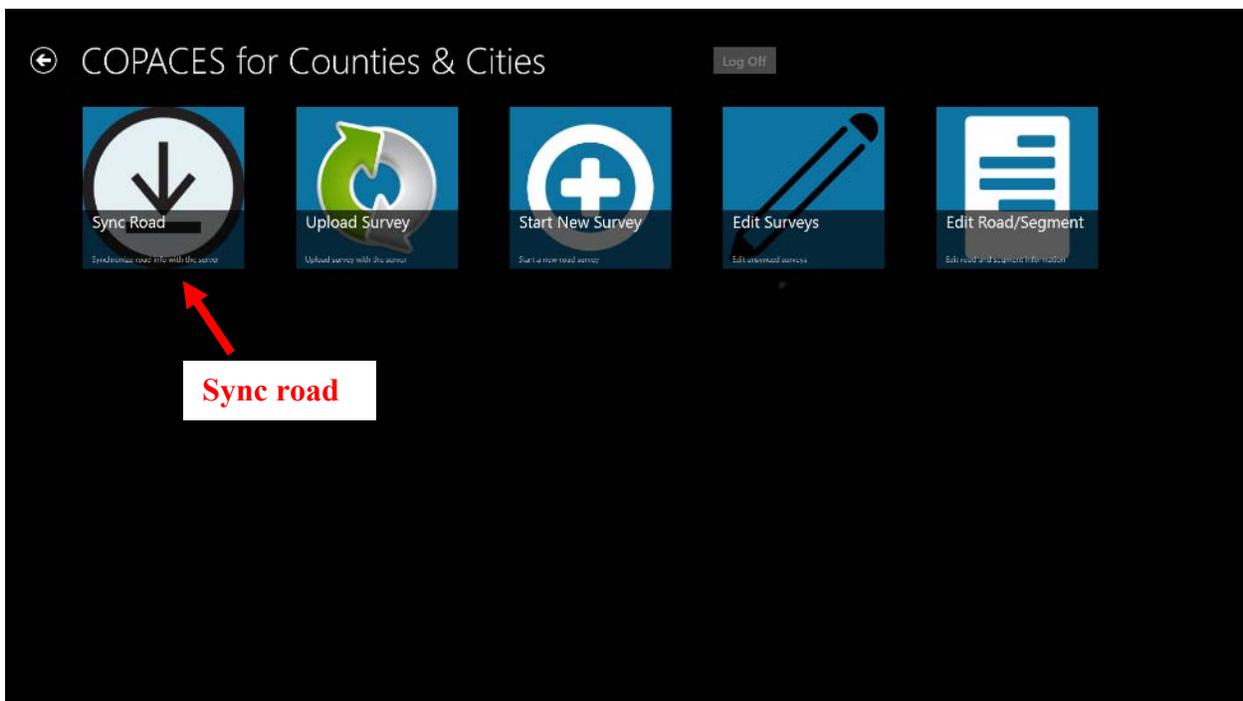


Figure 11: COPACES -- Road Sync

Before doing any other operation, click **Sync Road** (Figure 11) when running the software for the first time or changing to a new county/city database. Always remember to sync roads after road/segment information has changed. This step needs **internet connection**.

This may take some time if the database contains large amounts of road/segment information.

4.3 Edit Road/Segment Function

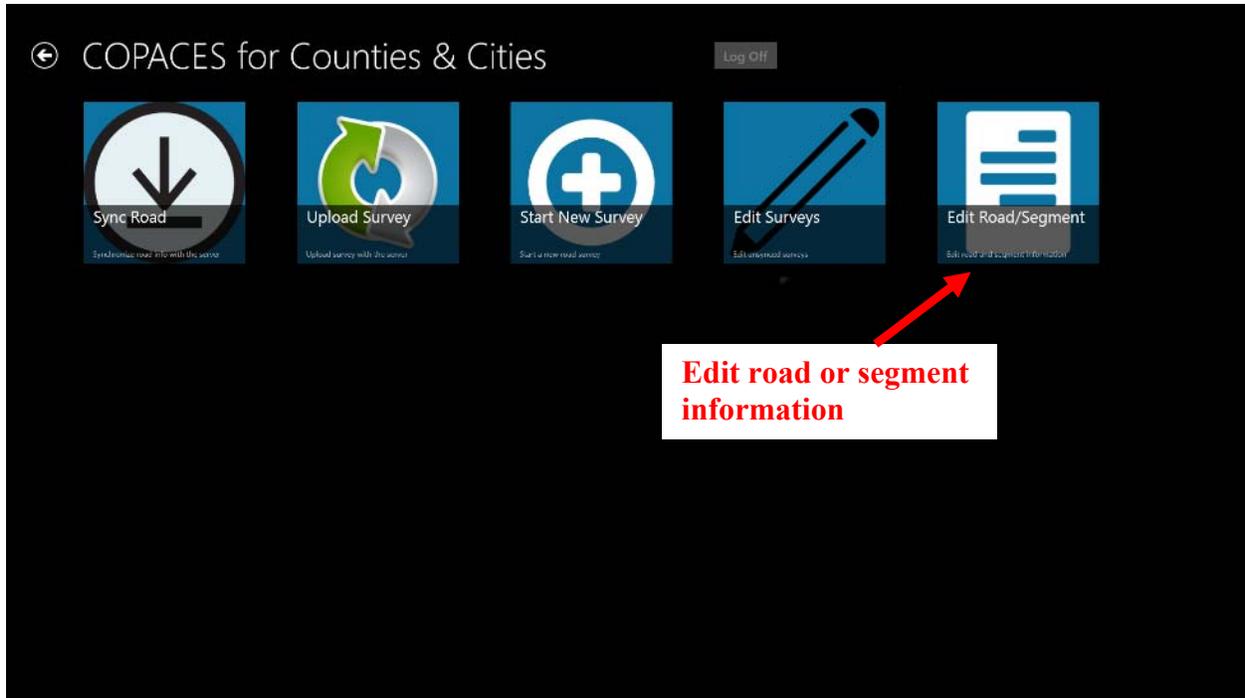


Figure 12: COPACES -- Edit road or segment

Click on “**Edit Road/Segment**” (Figure 12) when you find the road/segment information is not correct or when you want to create a new road/segment. However, you will not have the access to delete any road or segment, which can only be done from **the internet with administrator identity**.

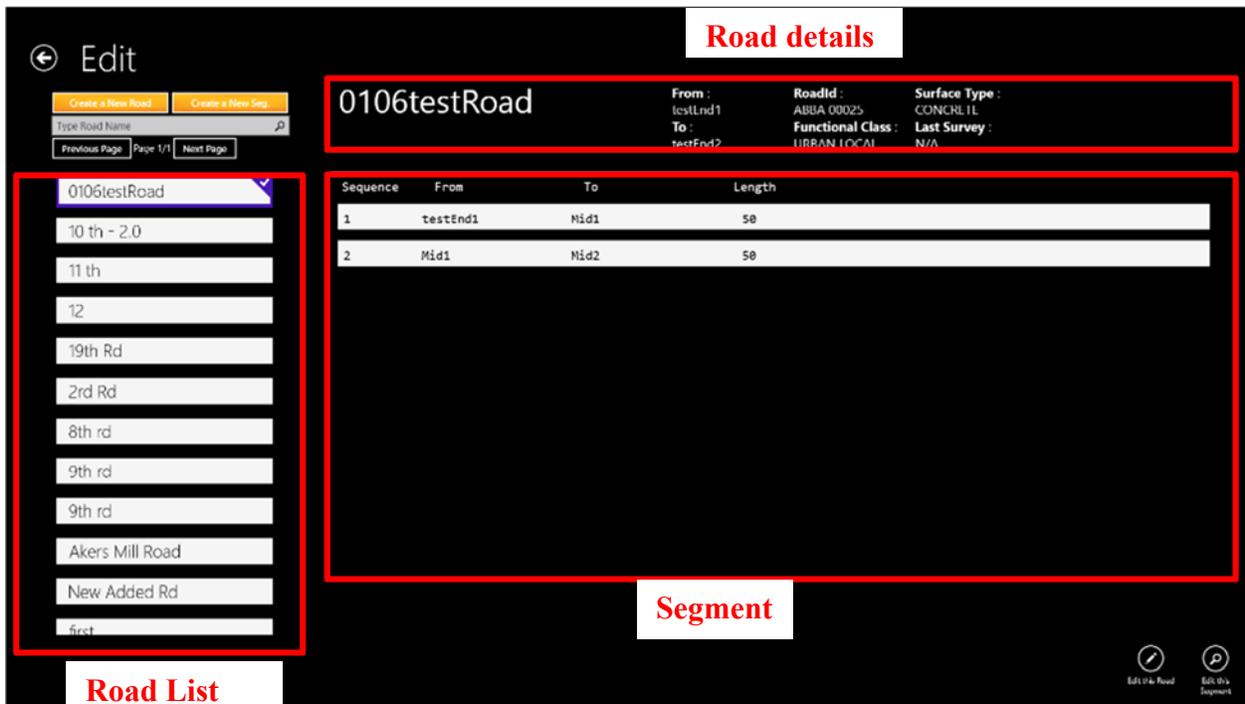


Figure 13: COPACES -- Edit page fields

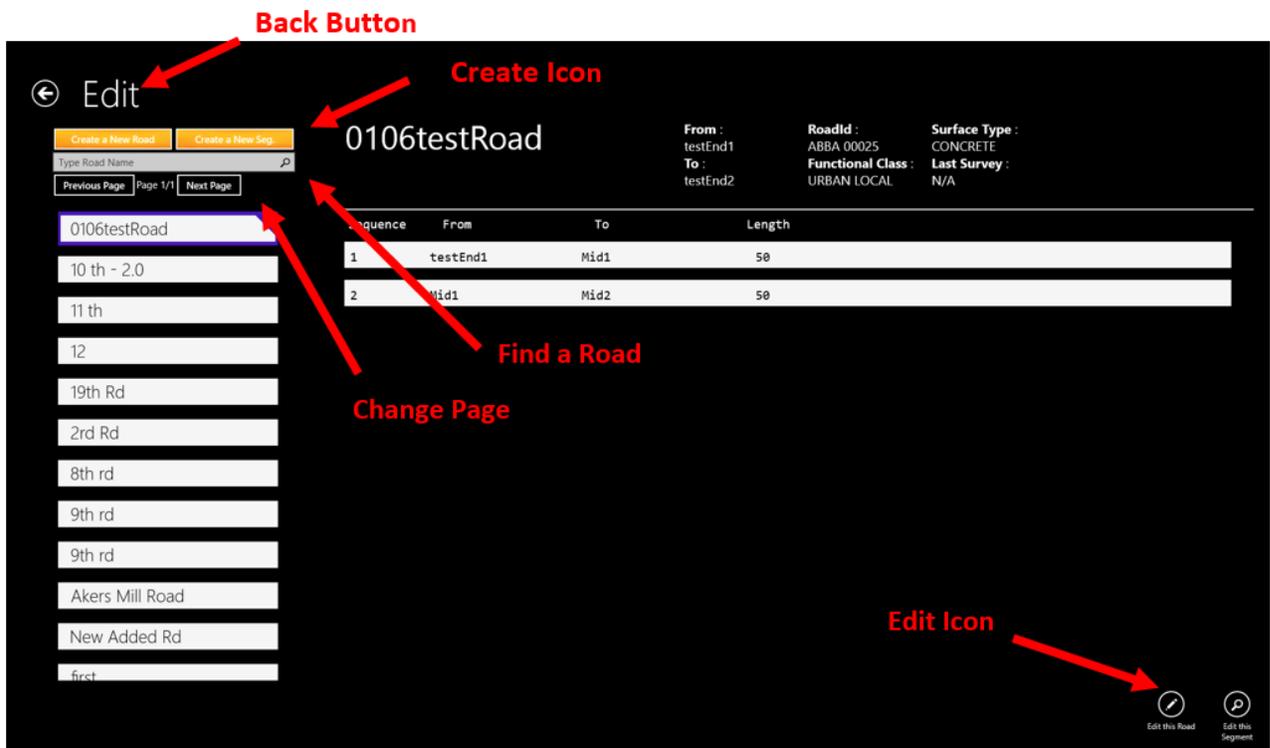


Figure 14: COPACES -- Edit page buttons

The “Edit Road/Segment” interface (Figure 13) lists all the road names of current county/city on the left side; the detailed information and corresponding segments list for selected roads is on the right side. Swipe down if you can’t see the whole list on your device. Use “Previous Road” and “Next Page” to find roads, or input the road name. You can always click on the “**Back Button**” on the uppermost left top to jump back to the previous page (Figure 14).

4.3.1 Create Road

Click on the “**Create a New Road**” button to jump into creating a road page (Figure 15).

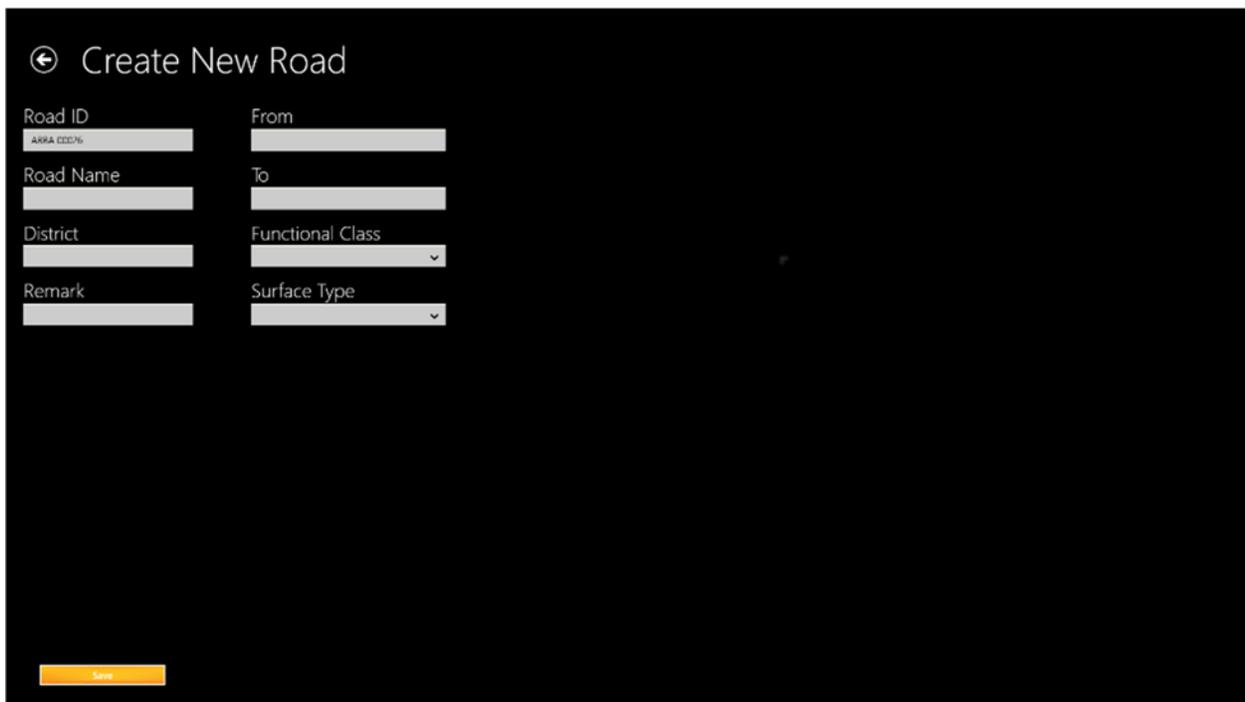


Figure 15: COPACES -- creating a road

Type in the Road Name, District, Remark, From, To, and select the Functional Class and Surface Type. Road ID is an identical index for each road, consisting of the name of the county/city and a series of numbers. It is, by default, created **automatically**. If you don’t know any item, leave it blank. **However , Road ID and Road Name can never be left blank.**

Click on the “**Save**” button when finished, or click on the “**Back**” button to discard.



Figure 16: COPACES - Road creation -- incomplete information

If some blocks are left blank when saving, the system will pop out a message asking if the blank blocks are intentional (Figure 16). Click **YES** to save the newly created road, and the page will automatically jump back to the Edit Road List page, or click the other one to complete the creating process.

4.3.2 Create Segment

This is similar to creating a road. **Select a road first** to determine where the new segment belongs. A **purple box** indicates it is selected (Figure 14). Click on the “**Create a New Seg**” button on the Edit Road List page to jump to creating a new segment page (Figure 17).

← New Segment

Inventory ID: 11222510

Sequence: 1

Length:

Remark:

From:

To:

Curb/Gutter:

Save

Figure 17: COPACES -- Create segment

The **Inventory ID** and **Sequence** are automatically filled in. You can keep it or change it as preferred, but it can't be left blank. Fill in the rest of the block. **Length should always be a valid number. Length will be 0 by default** if there is no input. Click “**Save**,” or discard as described above.

4.3.3 Edit Road

Click on the targeted road name to select. A **purple box** indicates it is selected. Then, click on the “**Edit road**” Icon in the right bottom corner. In the editing road page, follow the instructions described in 4.3.1 to edit road information. Always remember to **SAVE** after completing the editing.

4.3.4 Edit Segment

Click on the targeted road name and then **click on the targeted segment** name to select a segment that needs editing. Follow the instructions of 4.3.2 to edit segment information.

4.4 Conduct New Survey Function

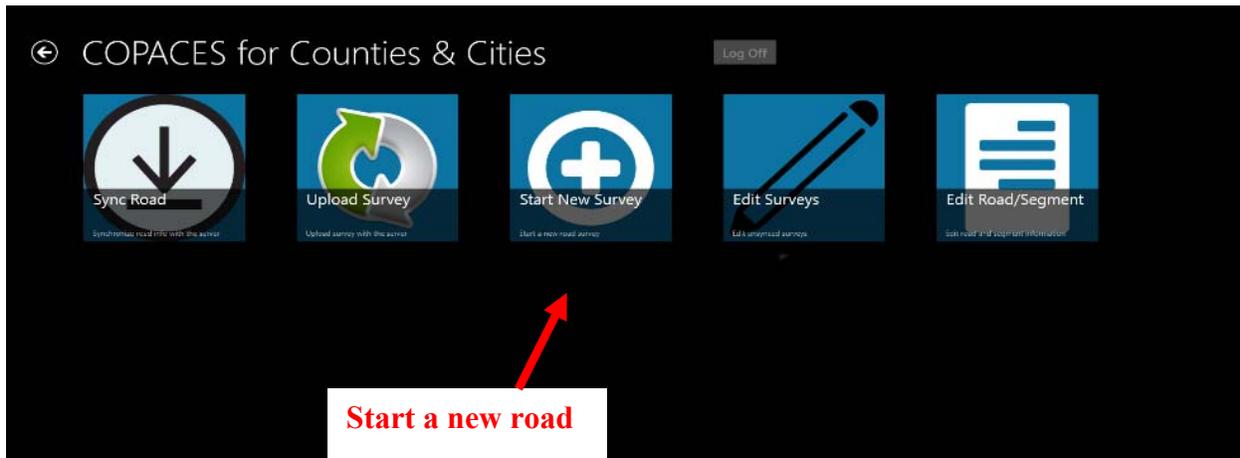


Figure 18: COPACES -- Start survey

Click on the “**Start New Survey**” icon (Figure 18) and jump into a new survey road list page (Figure 18). The page is similar to the editing road/segment list page. Instead of creating a new road/segment, above the road list, click on “**List Unfinished Roads**”; you can see the roads that have unfinished surveys, and roads where **part** of the segment survey is not done yet.

4.4.1 Road Selection Page

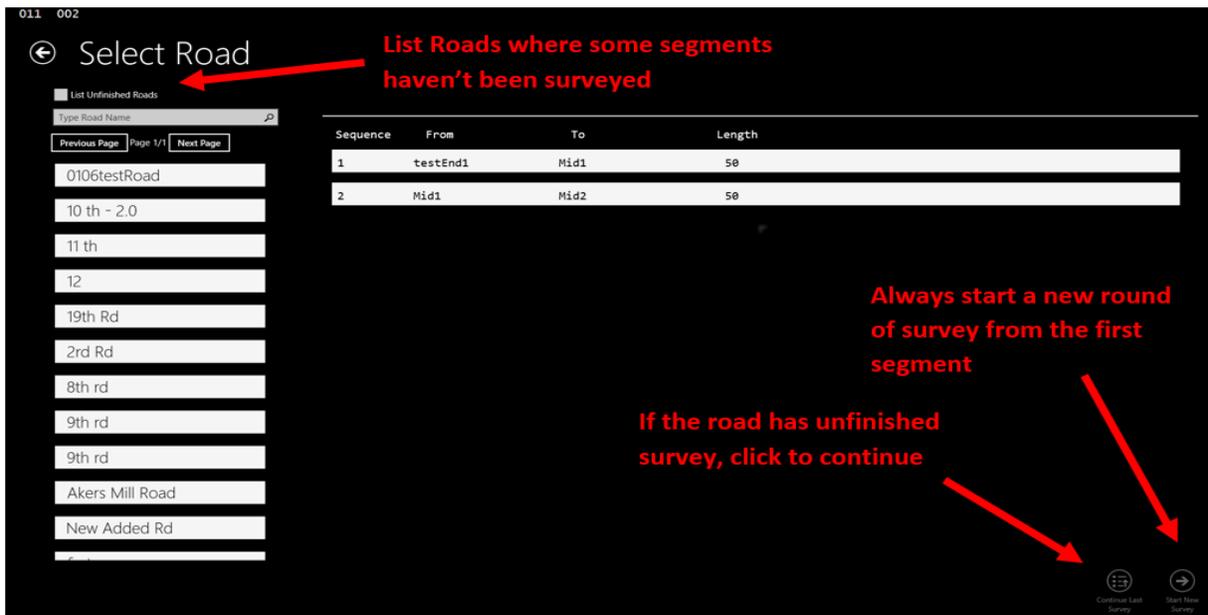


Figure 19: COPACES -- Select segment

Select the targeted road; click on the “Start New Survey” button (Figure 19), which turns bright, to start a new round of surveys from the first segment to the last. If there is still an unfinished survey for this road, the “Continue Last Survey” button will also turn bright. Clicking on it will lead you to the **un-started segment** of this road to continue the survey instead of the first segment. Still clicking on “Start New Survey” will force the last survey as “finished,” leaving some of the segment survey uncompleted. *Notice that after “Upload Survey,” all surveys stored in this device will be erased, and there will be no more “unfinished survey” in this device.*

4.4.2 New Survey Page

Swipe left and right to see the whole view of the new survey page. Fill in the survey data by segment (Figure 20), while some restriction defined by COPACES manual should always be kept. For the pavement distress value, you can either type in or swipe the scroll bar to enter the value. The sum of different levels of load cracking percent should always be less than 100. For other distress, percentage and level should be entered together.

Always remember to “Save Survey” when finishing or leaving it half-finished. Also, every time you change to another segment, the system will automatically save your current segment survey information.

Figure 20: COPACES -- New Survey

4.4.3 Extended Functions

A single left click on the distress name will show the corresponding COPACES manual distress name to assist users define pavement distress. Click on the manual picture, and then click somewhere else to make the manual disappear (Figure 21).

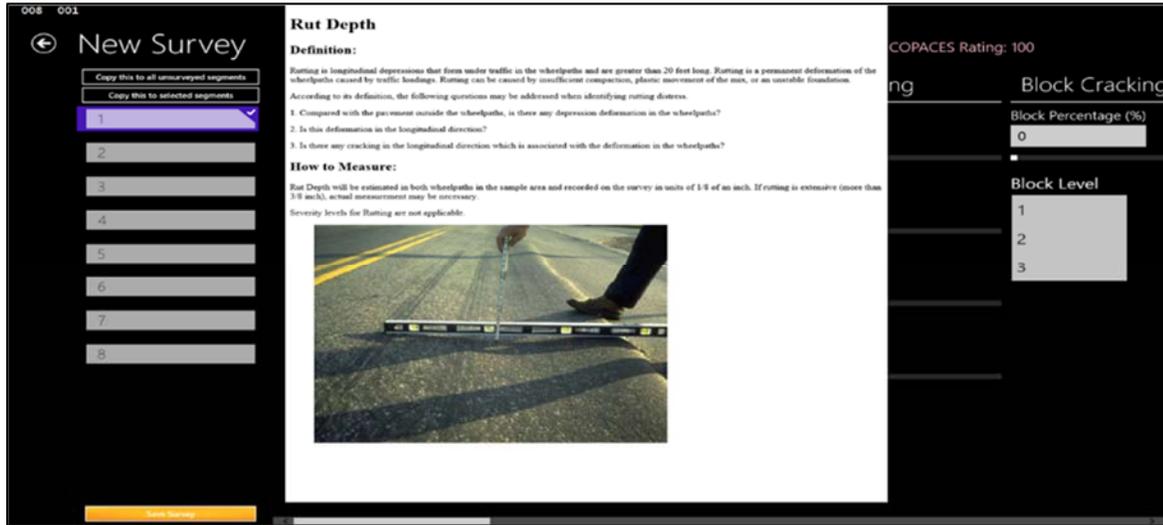


Figure 21: COPACES -- Manual example

Besides the COPACES pavement management system, we provide another faster way to keep records of pavement condition. Click on the “**Windshield Survey**” block on the top instead of entering in various types of distress values; users can just enter a single number from 0 to 10 to represent the approximate road condition (Figure 22).



Figure 22: COPACES -- New Survey page with extended features

Also, it provides **ADD PHOTO** and **MAP** services to keep track of your road survey.

If several segments' conditions are similar, you may click the “Copy this to all un-surveyed segments” or “Copy this to selected segments” to save time. However, this operation only copies the data: the data is **NOT saved** yet.

4.5 Modify Survey Function

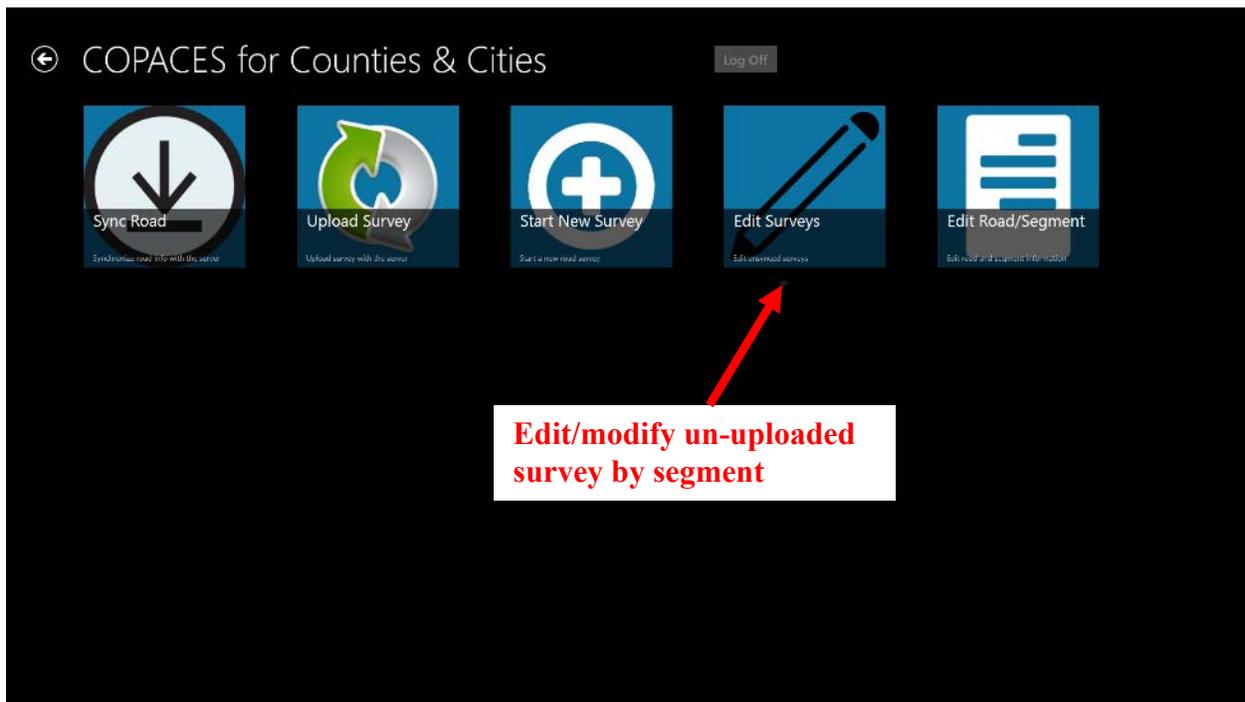


Figure 23: COPACES - Edit Survey

After completing a road survey or any segment survey, the saved surveys will show on this page. You can edit or delete any segment survey before it is uploaded to the cloud (Figure 23).

4.5.1 Road Selection Page

Surveys that haven't uploaded yet will show here, grouped as roads. However, editing a survey is based on segments (Figure 24). Select the targeted road and then select the targeted segment; click on the **"Edit Survey"** button to jump to the editing page, or click on the **"Delete Survey"** button to delete this segment survey without changing any other segment survey. Deleting a segment survey will change the current road survey to "unfinished." You can go back to the "Start New Survey" page; select the same road, and the "Continue Last Survey" should be bright. Click it; you can just do the surveys of the un-started segments and segments you just deleted.

Roads that haven't been surveyed and roads whose surveys have been uploaded will not have any survey listed on the device. Select the “**Only with Unsynchronized Surveys**” option above the road list; the system will **filter out** roads without surveys stored on the device.

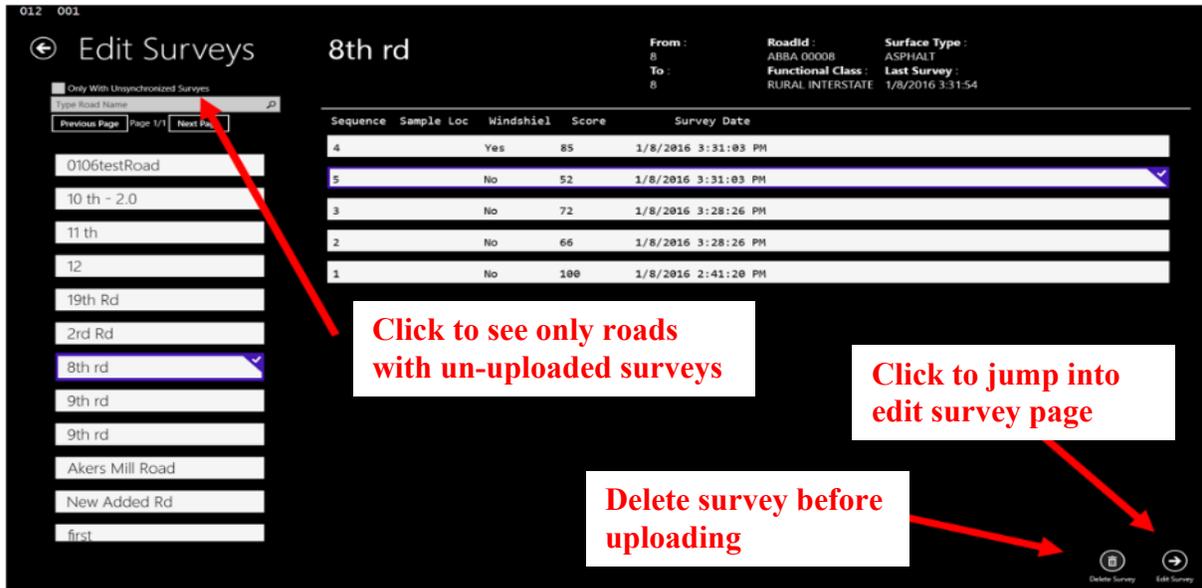


Figure 24: COPACES - Edit Surveys page

4.5.2 Edit Survey Page

On the Edit Survey page, similar to the new survey page, without a segment list, users can modify any segment information, distress value, or photo, as long as it abides in the COPACES manual (Figure 25).

005 001

← Edit Existing Survey COPACES Rating: 52 ■ Windshield Survey Save

General Information	Rut Depth (1/8")	Load Cracking	Block Cracking	Reflection Cracking
Treatment Year [Dropdown]	Rut Out WP 8	Load Level 1 (%) 0	Block Percentage (%) 3	Reflect Number 2
Treatment Method [Dropdown]	Rut In WP 0	Load Level 2 (%) 26	Block Level 1 2 3	Reflect Length 6
Lane Direction [Dropdown]		Load Level 3 (%) 0		Reflect Level 1 2 3
Lane Number [Dropdown]		Load Level 4 (%) 0		
Sample Location [Text]				
Remarks [Text]				
Rater hf0108				

Figure 25: COPACES - Edit Existing Survey

4.6 Upload Survey Service

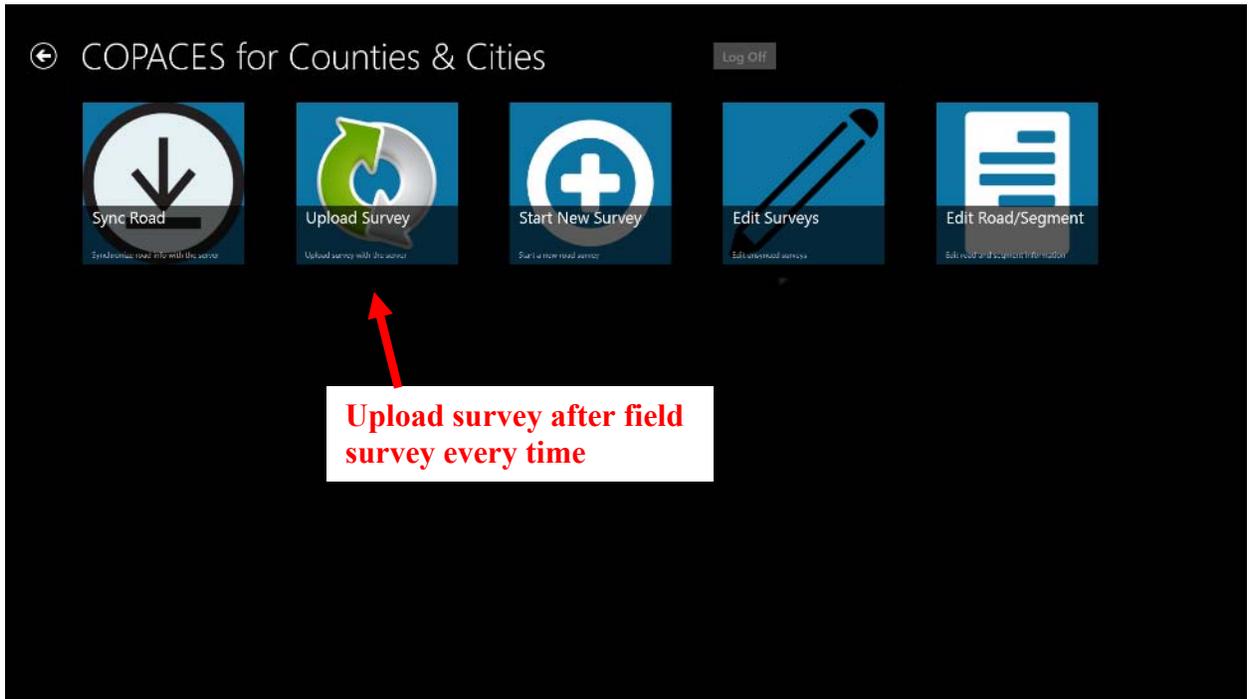


Figure 26: COPACES -- Upload Survey

Always remember to click “**Upload Survey**” before closing the software (Figure 26) or the survey data will not be stored in the cloud. This step needs an **internet connection**. Uploading a survey every time a road survey is completed is recommended if the internet is available.

When uploading a survey, a local survey will be uploaded to an on-line database and local history **will be deleted** and can never be edited from tablet software, only from the website end. **Created or modified roads/segments** will also be uploaded and **update the** original database.

III. COPACES Web Application

The COPACES website is a data visualization and analysis tool based on the Microsoft Azure cloud database. It shows road/segment and survey information and provides basic data analysis.

1. System Requirements

- Hardware Requirement: Intel Pentium 500 MHz processor or equivalent.
- Software Requirement: Windows7 or higher, Mac OS X or higher, Linux with browser. **Firefox** and **Google Chrome** are highly recommended.

2. Login and Account Management

Use the following link to open the website: <http://copacescctest.azurewebsites.net/>, or copy the URL to your browser if the link is disabled. The login page should look like this (Figure 27):

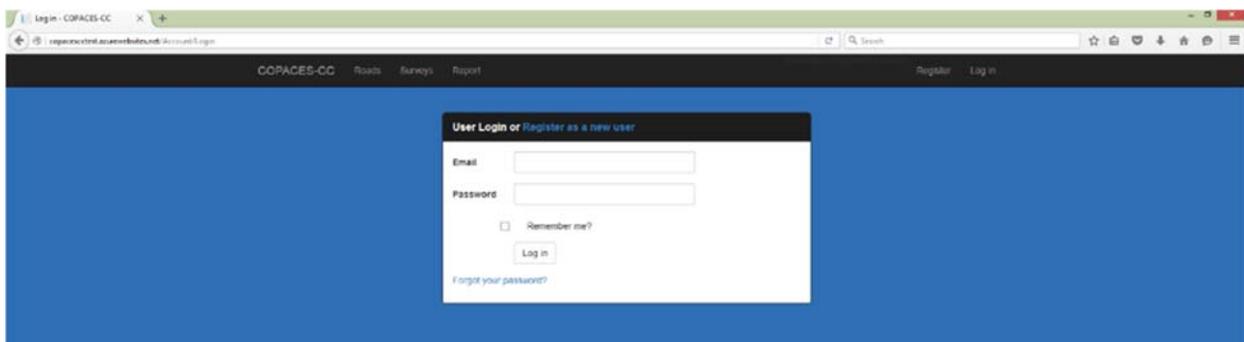


Figure 27: COPACES Website -- login page

Login in using your personal account or **register** as a new user. If you can't remember your password, click on “**Forgot your password**” and follow the instructions to retrieve your password using your email address.

New users should have an **invitation code**, which is provided by the website development team.

3. Dashboard

Login in to jump onto dashboard, the default page (Figure 28). The website consists of 4 major parts. **Dashboard, road page, survey page, and report page**. You can always jump onto the four pages by clicking on the corresponding button on the top of the site. Also, you may **management your account** by clicking on the email address on the right top of the site, or log off.

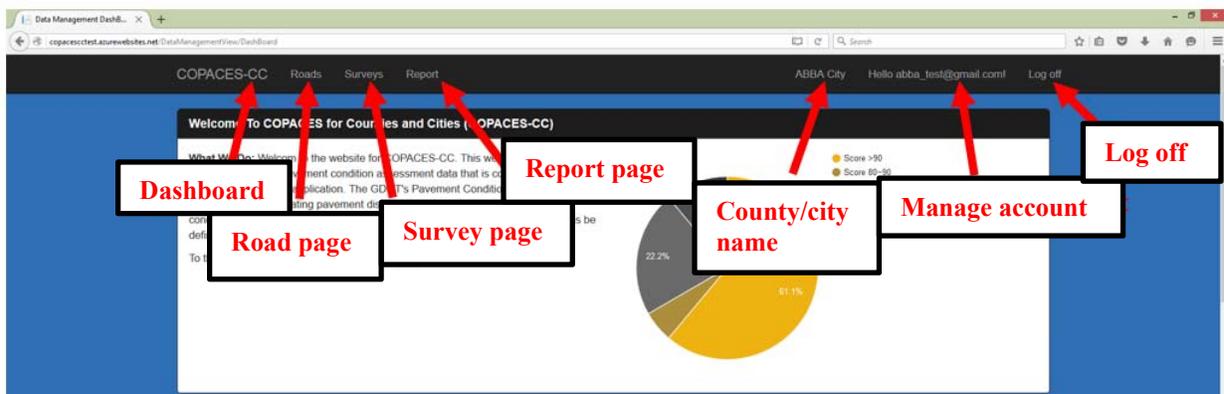


Figure 28: COPACES Website -- Home Page

The dashboard only shows some basic information about road/segment information and survey data of **selected time periods** (Figure 29). The default time setting is the start of current year to the current date. **Always remember to select time periods you want to see**. The date picker function will show a small calendar window, allowing users to either type in dates or just pick dates from the calendar. Users should always select a start date before selecting an end date.

Also, it provides links for downloading the PACES Manual and the COPACESCC app in the Windows Store.

The 15 most **recent uploaded surveys** will be listed in the bottom of this page.

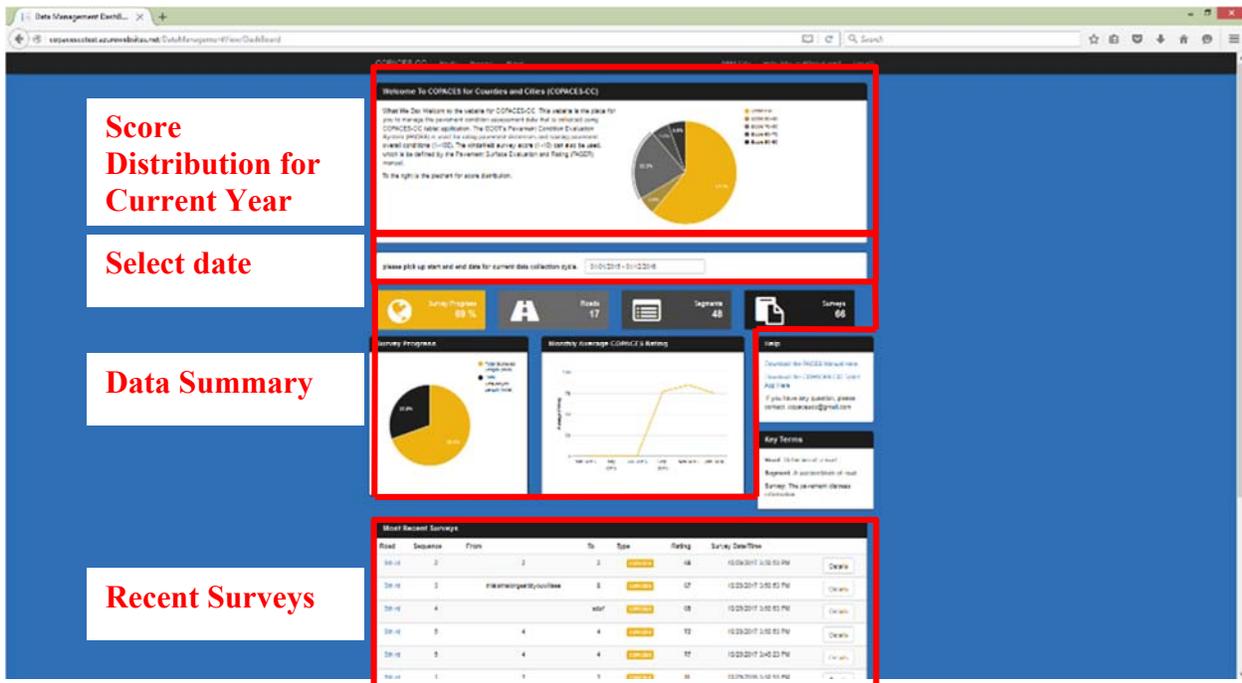


Figure 29: COPACES Website -- Home page features

4. Road Page

The road page allows users to see and edit all the roads' and segments' information (Figure 30).

The road summary data (fully surveyed, partially surveyed, un-surveyed) is extracted from the database based on the selected **date periods** you just specified on the Dashboard page. If multiple surveys exist for a single road in the selected date period, only the most recent survey data will be extracted.

Click on the **title of each column** of the road list block; the road can be listed in a specific order, such as road name, survey status, and survey date.

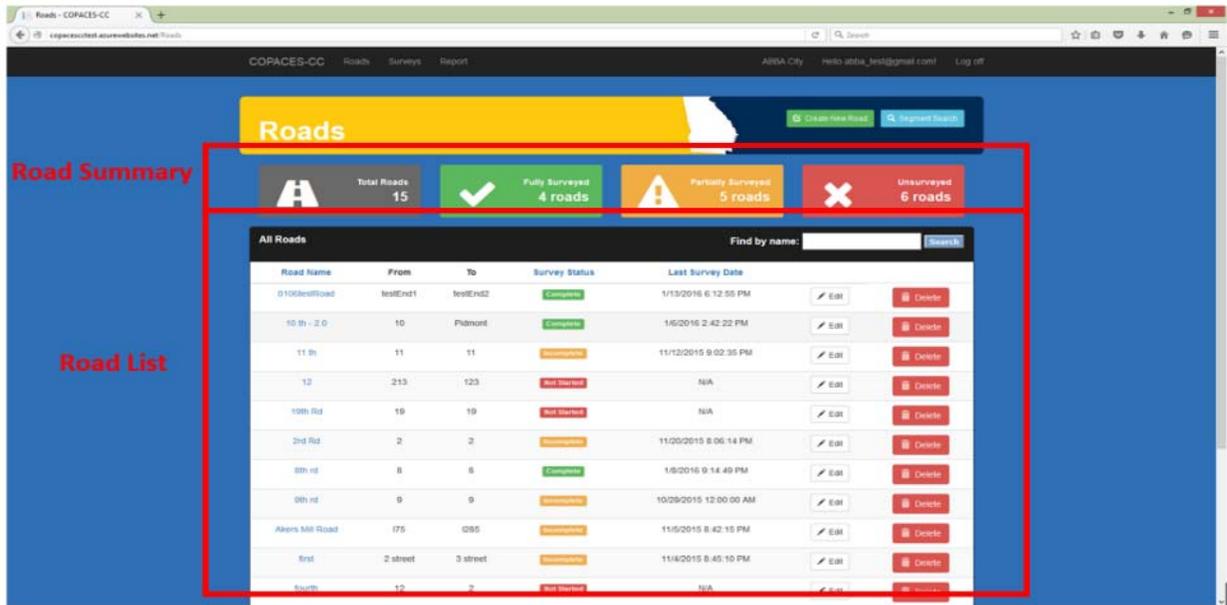


Figure 30: COPACES Website -- Road page

4.1 Road Search

On the right top of the road list block, behind “**Find by Name,**” type in part of the whole name of the road you are interested; click “**Search**” to find the targeted road.

4.2 Road Create

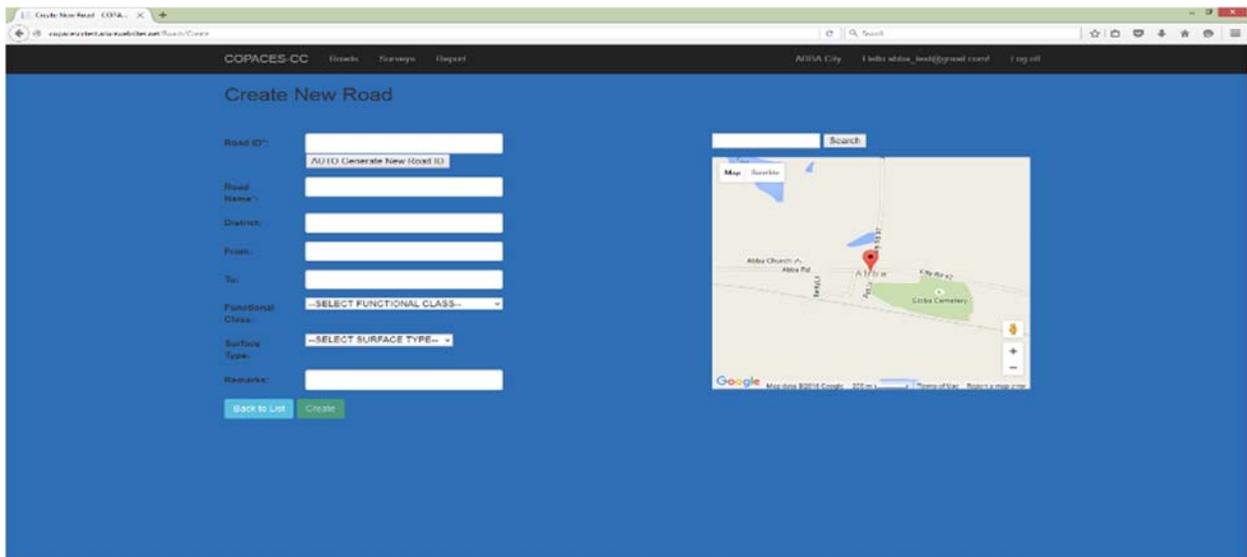


Figure 31: COPACES Website -- Create New Road

Click on the green button “Create New” on the top of the site; you will enter the page for creating a road. Click on “**AUTO Generate New Road ID**” or create an arbitrary one (Figure 31). Type in the road name and other information. Click “**Create**” to save the road, or click “**Back to List**” to go back to the road list page.

4.3 Road Edit

Clicking on the “**edit**” button on the road list block of the targeted road will lead you to the road-editing page. The page is similar to creating the road page, except precious information is stored. Click “**Save**” after completing the editing, or use the **back button of the browser** to go to the previous page. The “**Back to List**” Button will take you to the road list page, too.

You can also click on the targeted road name; the “edit” button on the right top of next site will also take you to the current road-editing page, which will be discussed in 4.6.

4.4 Segment Delete

ONLY a user with ADMINISTRATOR access can delete a road. You will never see the “delete” button on the road list page.

4.5 Segment Search

You can click on the road name to check the segments of each road, or you can use the “**Segment Search**” blue button on the right top of the road list page to search for segments of a **specific road** and **specific from/to** information.

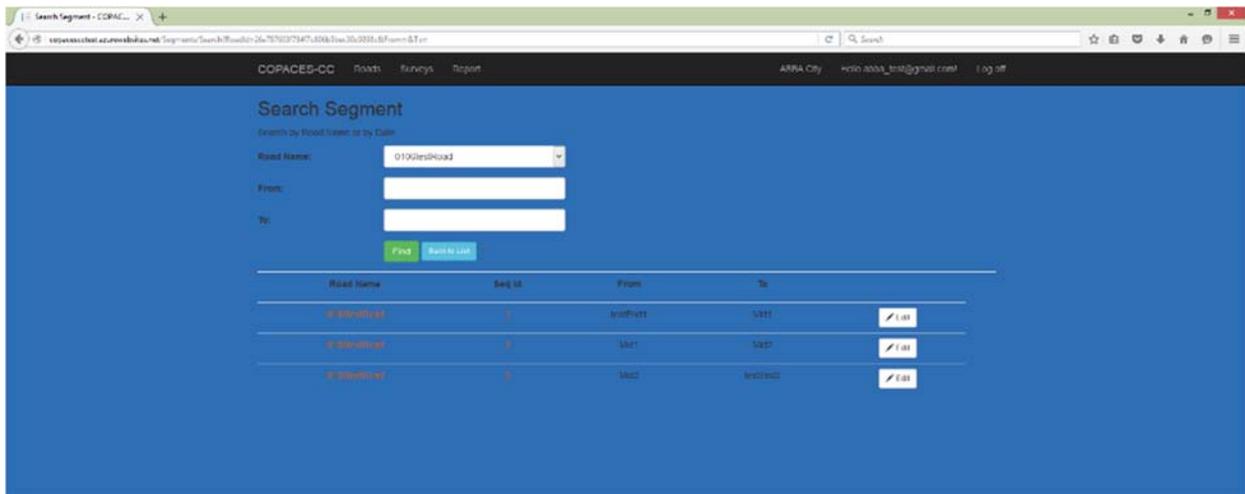


Figure 32: COPACES Website - Search Segment

From the returned segment, you will have access to edit them (Figure 32). By clicking on the **road name**, you will be taken to the segment edit page discussed in 4.6. Clicking on the **sequence ID** will take you to **Segment Details** page, where you can see the detailed information and, most importantly, **survey information belonging to this segment**. Clicking on the **edit** button will allow you to edit this single segment without seeing other irrelevant information. We will talk more about segment editing later.

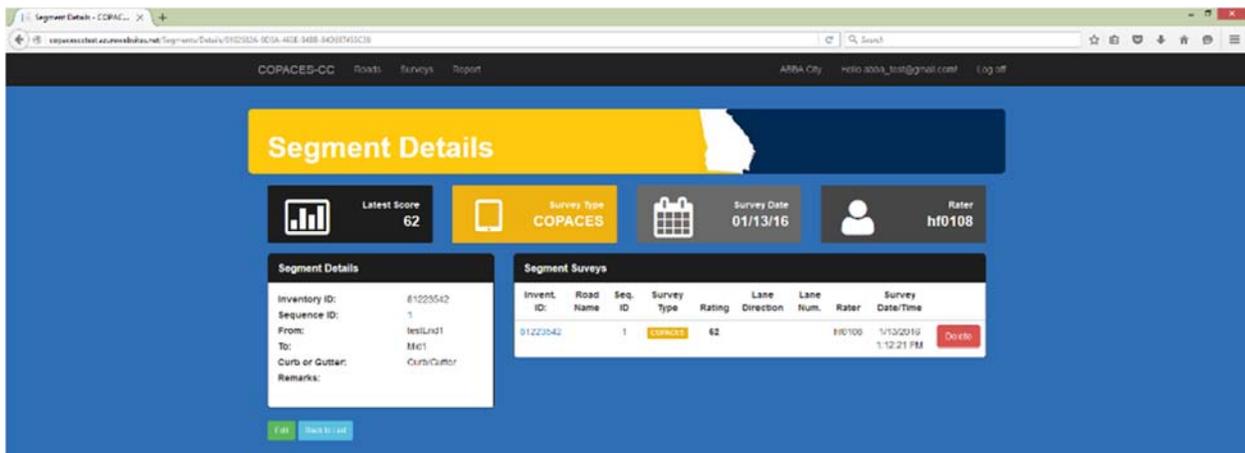


Figure 33: COPACES Website -- Segment Details

4.6 Segment Edit

Segments are grouped by roads. We provide two ways to edit segments.

4.6.1 Single Segment Editing

The Single Segment editing page looks like the road editing (Figure 34) page. You can modify each segment's data individually. Inventory ID is not recommended to be changed, while sequence ID is better to be modified using the comprehensive segment editing page. This Single Segment page can be entered from the **Edit button of the segment search page and segment details page.**

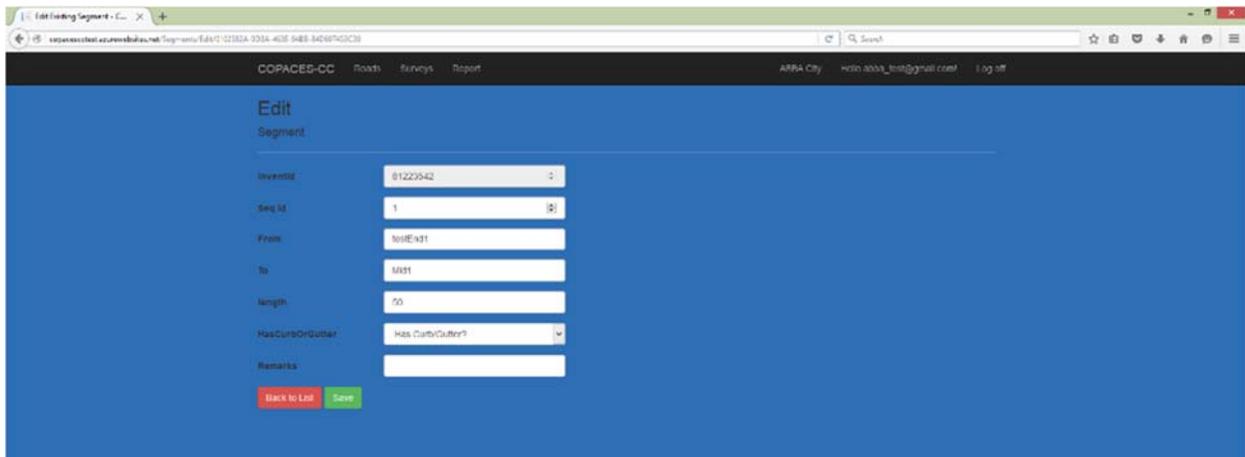
The image shows a web browser window displaying the 'Edit Segment' page on the COPACES-CC website. The page has a dark blue header with navigation links for 'Roads', 'Surveys', and 'Report'. The main content area is a form with the following fields: 'Inventory' (text input with value '01222542'), 'Seq ID' (text input with value '1'), 'From' (text input with value 'NHENR1'), 'To' (text input with value 'MRT1'), 'Length' (text input with value '70'), 'HasCurbOrDitch' (dropdown menu with value 'Has Curb/Ditch?'), and 'Remarks' (text area). At the bottom of the form are two buttons: 'Back to List' (red) and 'Save' (green).

Figure 34: COPACES Website -- Edit Segment

4.6.2 Comprehensive Segment Editing

Clicking the road name will take you to road detailed information, as well as segments information (Figure 35).

In this comprehensive segment page, we can create or edit segments.

Click on “**New**” to begin creating a new segment; then, type in from/to and length information about the new segment. **REMEMBER to select the checkmark of the newly created segment,** and click “**Save**” to complete the creation.

If some two or more segments need to be merged, select them, and click “**Merge**”; the selected ones will become a single segment, where the “from” location is the “from” location of the original first segment, the “to” location would be the “to” location of the original last segment, and length will be the sum of the merged segments length.

Also, selecting a segment and clicking “**Split**” will make the segment into two equal-length segments. You can edit the information after splitting, but don’t forget to **select the segments and then click “Save.”** Merging and splitting segments will set the Curb/Gutter condition as “null” by default. **The segments are draggable in order to change their sequence ID.**

Notice segments that have been surveyed can’t be merged or split.

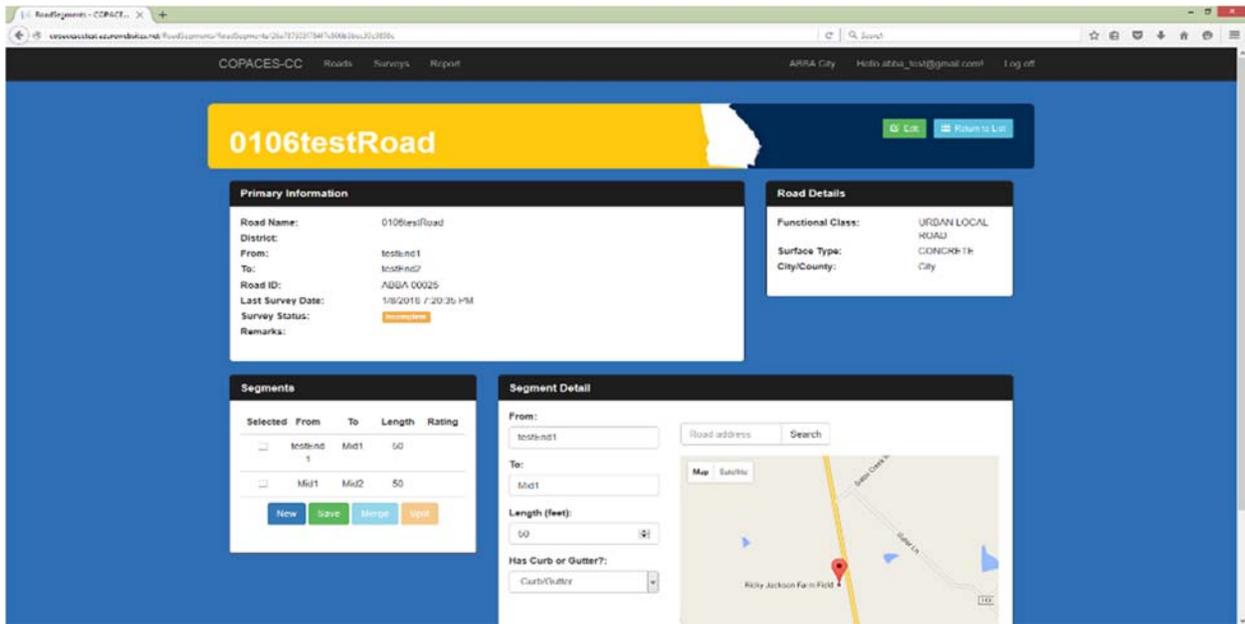


Figure 35: COPACES Website -- Road details

5. Survey Page

The survey page displays all the surveys conducted (Figure 36). Users can search, edit, or delete any survey listed here. Above the survey list, you can find a summary about current surveys, including total survey number, COPACES survey number, Windshield survey number, and the number of surveys whose rating is greater than 70.

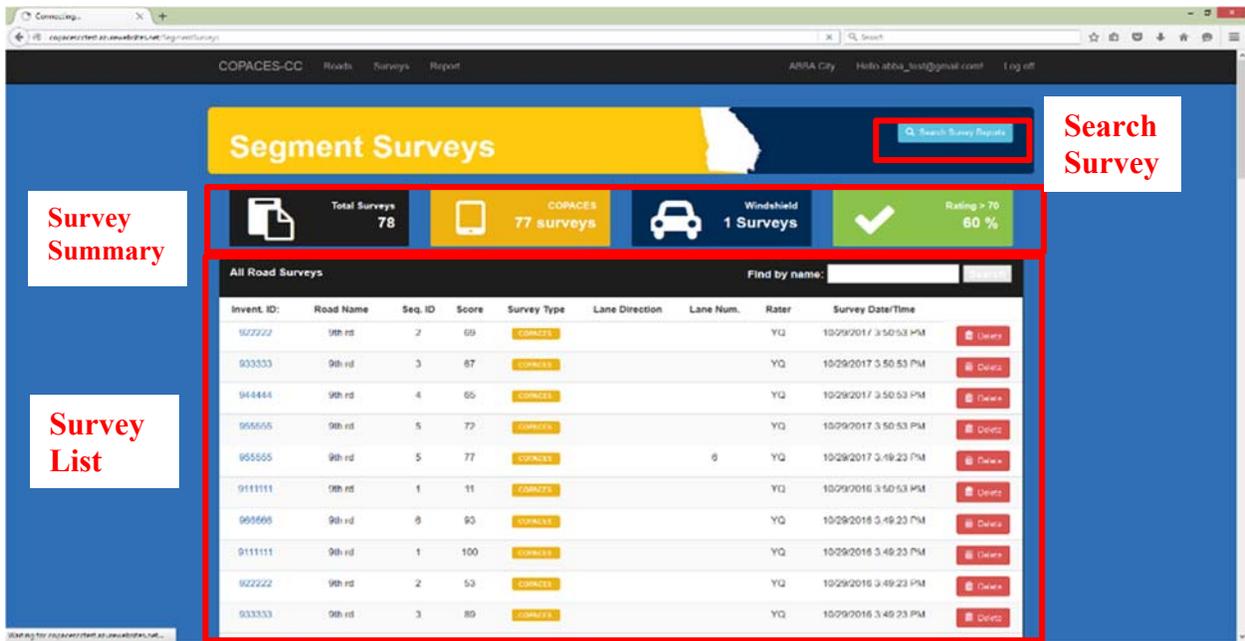


Figure 36: COPACES Website -- Segment Surveys

5.1 Survey Search

Two search methods are provided. You can either type in the road name just on the top of the survey list(behind the text “**Find by name**”) to show the survey list that only belongs to this road, or click on “**Search Survey Report**” to type in multiple conditions, such as start date, end date, road name, and minimum rating to find specified surveys (Figure 37). From the results, you will have access to the survey details, and you will edit or delete them.

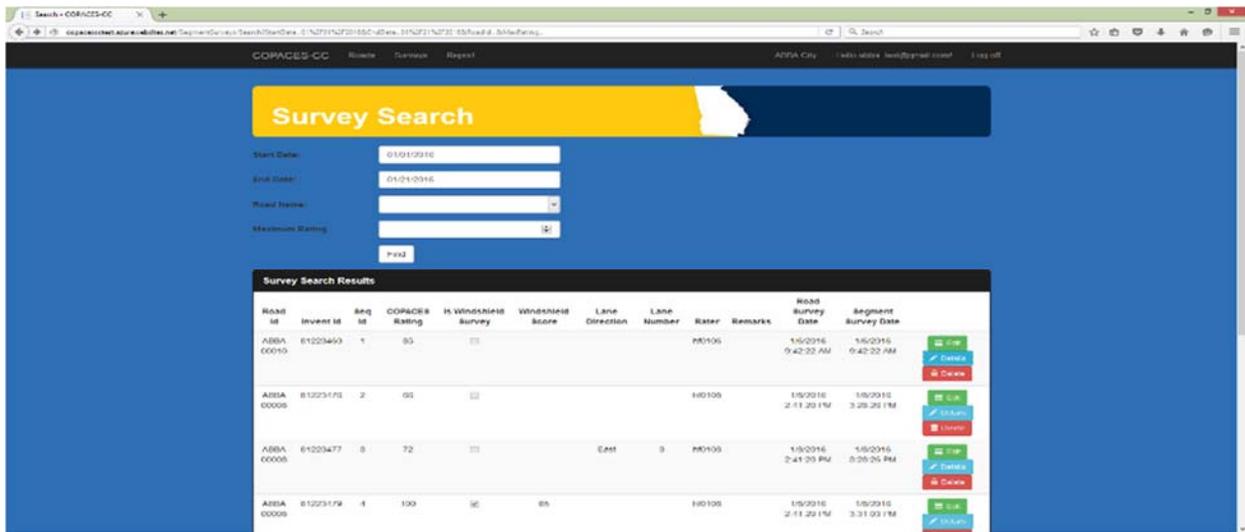


Figure 37: COPACES Website – Survey Search

5.2 Survey Edit and Delete

Another way to get access to the edit and delete surveys is from the survey list described in 5.0.

Find the targeted survey, and **click on its Inventory ID to check its detailed information**. You can click the “Edit” button to modify this survey data, or click on the “Delete” button to delete this survey. The Delete function is also provided on the right side of each survey on the survey list of the previous page (Figure 38).

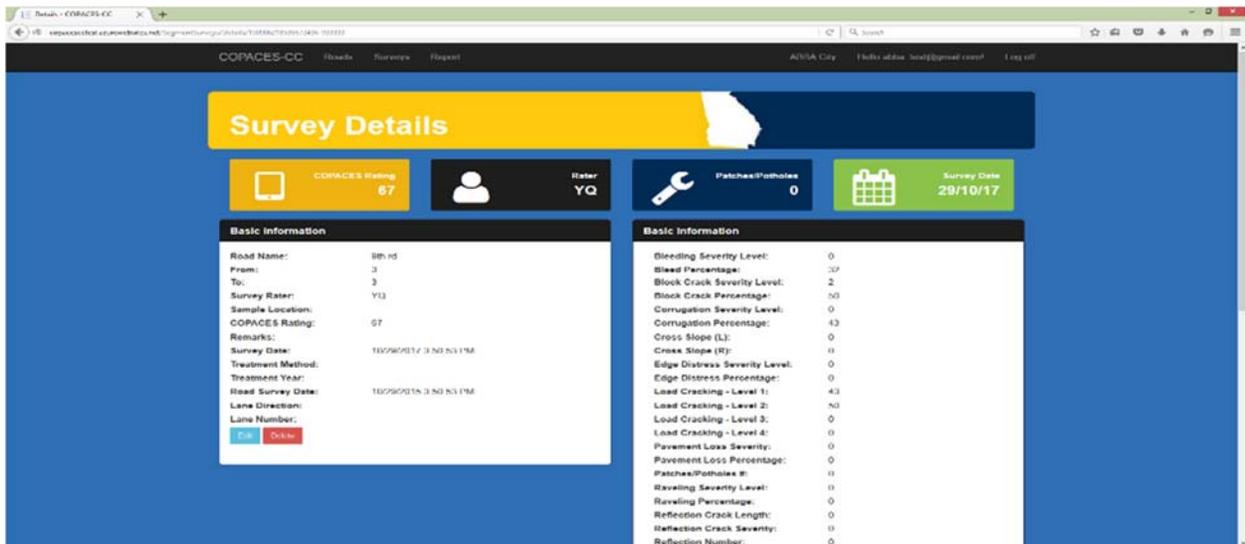


Figure 38: COPACES Website -- Survey Details

6. Report Page

The report page can make some basic analysis on survey data for users. Currently, this page can show the rating distribution, segment rating, segment rating history, and road rating history of selected roads (Figure 39).

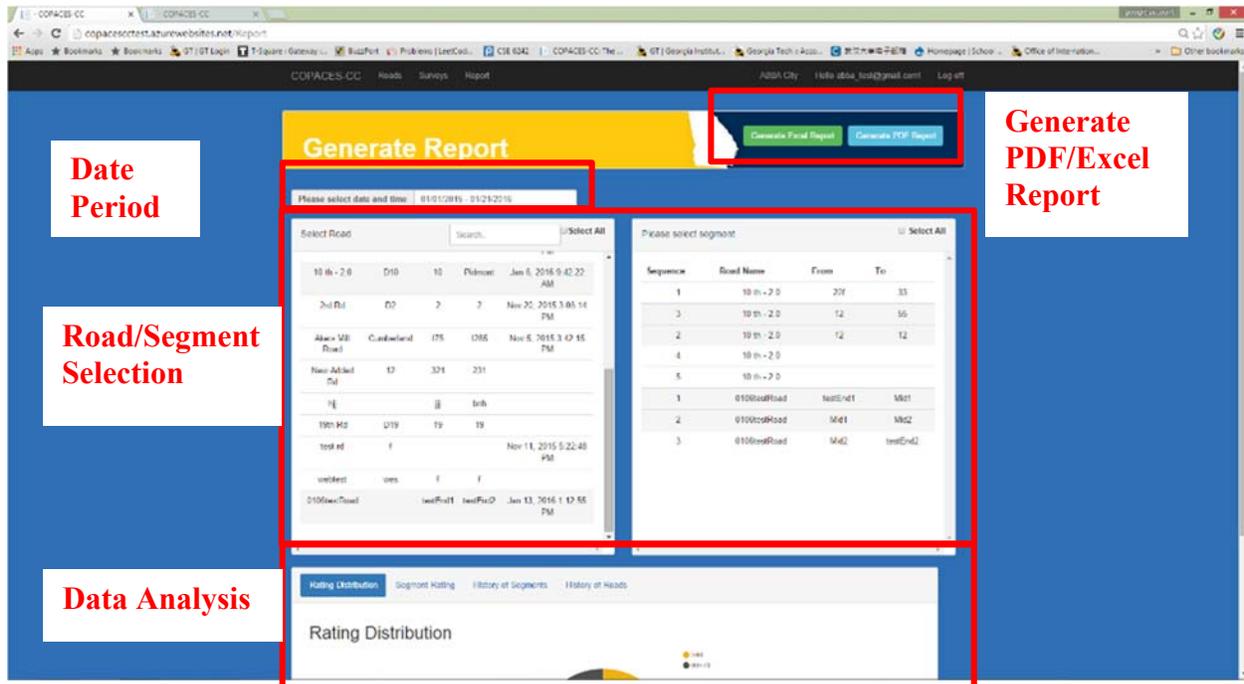


Figure 39: COPACES Website — Generate Report

6.1 Selecting Road/Segment

Select the desired date period; follow the same instruction as in 3.0. The default date is the same as the date you have selected on the Dashboard page.

Scroll down the list or use the search function. A dark background indicates the road/segment is selected. Click on the roads you are interested in. The segments of selected roads will show on the right side as filtered segments, **which haven't been selected yet**. Select the segment you are interested in to make its background grey. Analysis of selected roads and segments will show below.

Un-selecting any segment will change its state to un-selected, but it is still listed there as long as its road is still selected. Un-selecting a road will change the road state to un-selected and remove

the segment from the list, while the "all the segment selection state" remains the same. That is to say, if a segment is selected, un-selecting its road will make the road un-selected and the segment will disappear, but the segment is still selected. **So, make sure to un-select the segments before un-selecting its road.**

In the road list, using the **Select All roads** function will change all roads into the selected state and list all segments. You may need to **Select All segments** if you want to include the segments, or just click the ones you are interested in. The **Cancel the Select All Segments** button will change all segments to un-selected, but they are still listed there. The **Cancel the Select All roads** button will change all roads into the un-selected state, and change all segments into the un-selected state, removing the segments from the list. **It is still recommended that you cancel the Select All Segments before canceling the Select All roads if you want to clear all the selected ones.**

Tip: if you found some exceptions in the chart, it may be because you didn't un-select the segments before un-selecting the road. **In this case, you may want to use Cancel Selecting All Segments and then Cancel Selecting All roads to reset.**

6.2 Rate Distribution

Similar to the distribution chart on the dashboard page, this rating distribution gives a detailed classification. Also, instead of distribution of the whole set of surveys, users can define the road and segment dataset themselves by selecting targeted roads/segments (Figure 40).

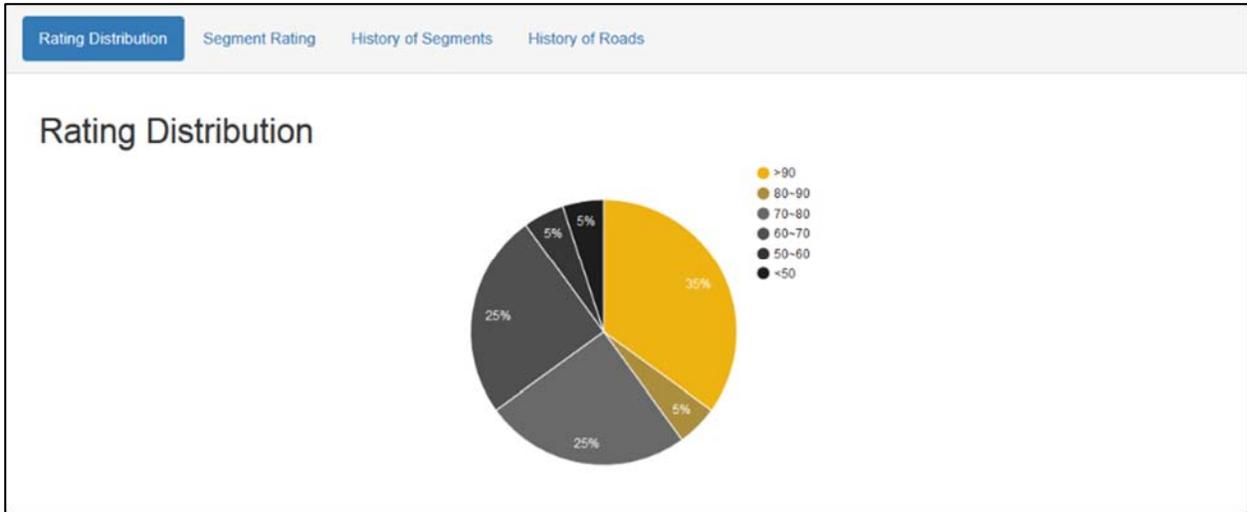


Figure 40: COPACES Website — Rating Distribution pie chart

6.3 Segment Rating

This site provides segments survey data for one specific road. All roads selected will show here, no matter whether or not its segments have been selected. Selecting just one road by clicking its name will show the segment survey data of this road (Figure 41).



Figure 41: COPACES Website — Rating of segments chart

6.4 History of Segments

This chart shows the condition of all the segments of a selected road, whether or not they have been selected, sorted by year, and represented by different color lines (or dots if only one year's condition is available). If many segments are displayed, use the triangle button to change pages if the current page can't show all the segments' names (Figure 42).

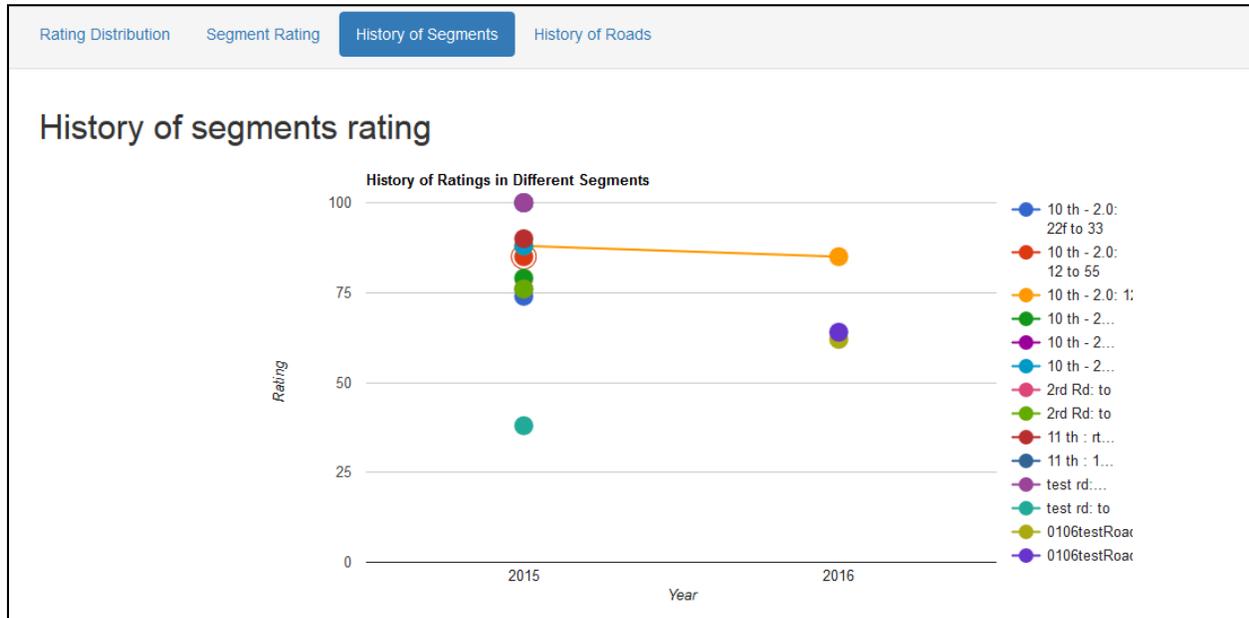


Figure 42: COPACES Website -- History of segment rating chart

6.5 History of Roads

This chart is similar to the previous one, but it is in road units, not segments. The blue line represents the simple average value, while the red one is the average value of segments in terms of segment length (Figure 43). Only survey data of selected segments will show here. You can combine any segment or road that you would like to be represented.

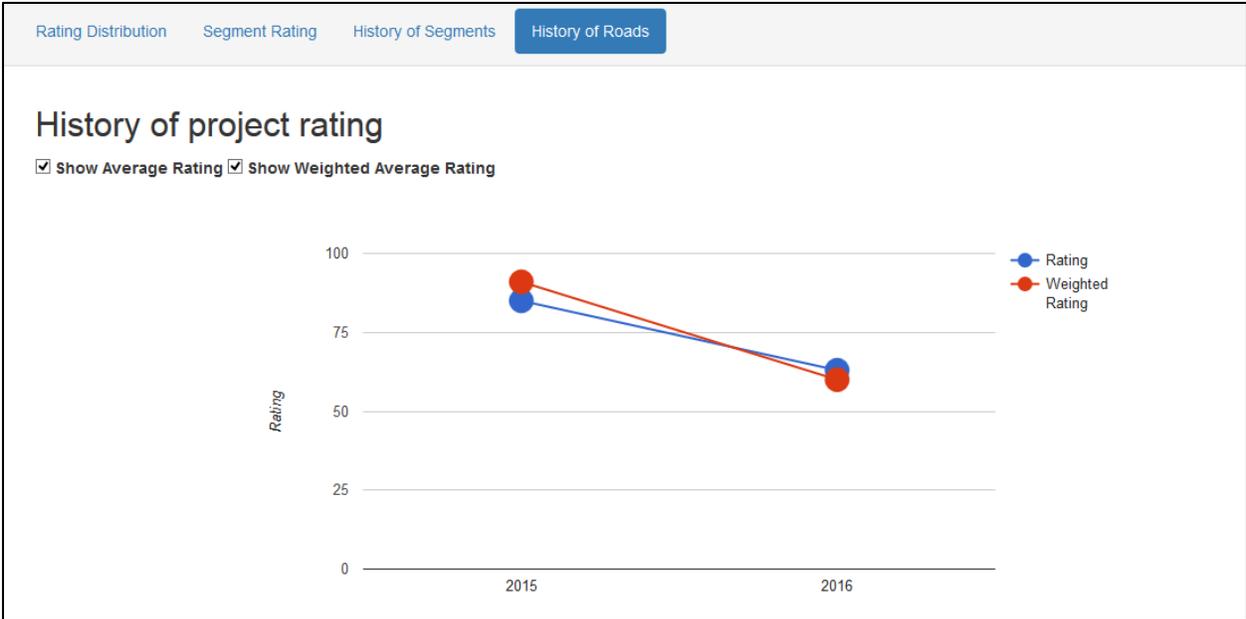


Figure 43: COPACES Website – History of project rating chart