INFRAME

INFRASTRUCTURE MANAGEMENT AND ENGINEERING

RESULTS OF PAVEMENT CONDITION 2019 SURVEY

FINAL REPORT

Submitted to:

City of Cincinnati

Department of Transportation & Engineering

By

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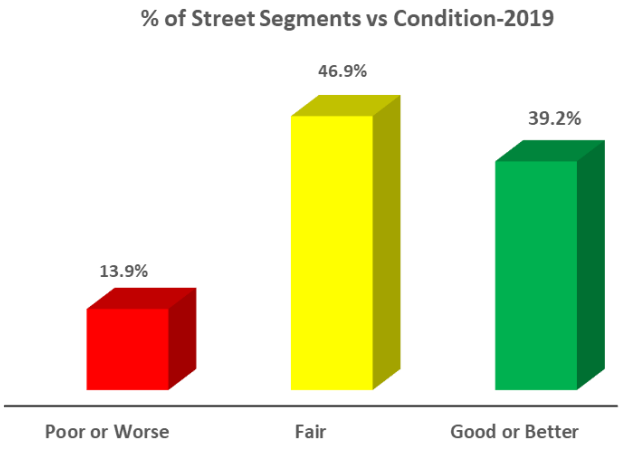

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RESULTS OF 2019 PAVEMENT CONDITION SURVEY

FINAL REPORT

1. PROJECT SUMMARY / SCOPE OF SERVICE PERFORMED

1.1 Project Summary

In its efforts to efficiently utilize the allocated funds and better manage the street pavement network, the City of Cincinnati has long been using systematic procedures that would ultimately result in cost-effective pavement management system. One of the important tasks of this process is to survey the entire pavement street network and record the condition of each pavement segment. The city has reportedly over 2,900 miles of pavements divided into more than 16,000 segments. The detailed pavement condition data collected is used to better determine which streets warrant specific types of maintenance activity. What was once a visually determined categorization method of deciding whether a pavement was Excellent, Good, Fair, or Poor has developed into a rational system using MicroPAVER, a tool widely adopted by several government agencies to manage their street pavements. By utilizing this application, the City has been able to assign a Pavement Condition Index - PCI - to every segment of every street in the City. PCI's are determined by surveying the severity and extent of a pavement's distresses such as cracking, rutting, potholes, patching etc. It ranges from 100 for a newly paved street down to 0 for a totally failed pavement.

In 2015, the City of Cincinnati selected INFRAME to collect pavement condition data using an ***automated*** process. Automated survey procedures collect high resolution images of pavement condition aided by lasers, digitize the entire pavement surface, provide a thorough documentation of the street network, stamp each image with GPS coordinates for easy integration with GIS, and allow computation of pavement condition indicators using a large volume of data. INFRAME measured distresses continuously along a street, providing reliable and consistent data to determine the PCI's of every street segment maintained by the City of Cincinnati. INFRAME was retained to collect data in 2016 through 2019. The current report relates to the pavement condition data collection and processing effort in 2019.

1.2 Scope of Services

In order to collect, process, and present the data in a usable form, a Scope of Services was established to guide INFRAME to meet the City's objectives. Some of those services included:

1. Compile information from files provided by the City to develop a list of the street blocks/segments to be surveyed;
2. Conduct automated pavement condition surveys on every street pavement in the City;
3. Process pavement condition data in accordance with ASTM D-6433 using the MicroPAVER 7.0 computer application;
4. Generate Pavement Condition Index (PCI) for each block/segment;
5. Verify and validate the field data and processed data using statistical quality control procedures;
6. Update pavement performance prediction models with PCI as the dependent variable;
7. Discuss with the city engineering staff various budget scenarios for budget analysis;
8. Develop optimal repair program scenarios for Cincinnati's street network;
9. Establish a pavement management system using MicroPAVER 7.0;
10. Deliver data, results and pavement management program to the city;
11. Provide client training.

2. AUTOMATED DATA COLLECTION - HOW THE PAVEMENT INFORMATION IS GATHERED

INFRAME uses its Pavement Condition Evaluator (PaCE) vehicle for pavement data collection. PaCE has four high resolution line scan cameras, four high powered lasers, high definition camcorder, GPS and Distance Measuring Instrument. This vehicle scans full lane width of pavements and captures distresses such as cracking, raveling, pothole, rutting etc. A high-definition camcorder onboard the vehicle is used for Pavement Right-of-Way (ROW) image acquisition. A GPS unit provides highly accurate geo-reference for all images. The PaCE vehicle will enable the engineers to conduct a full lane width distress survey at speeds of up to 60 mph. The system is extremely versatile and delivers data in multiple formats as desired by users. In summary, INFRAME's pavement condition services will result in the following:

- Use of advance technologies for data collection that will result in consistent, quality and accurate pavement condition data;
- Pavement condition fully documented and made available for verification by the City at any time;

- GPS-tagged digital images that allow accurate referencing of location for survey during subsequent years;

Figures 1 to 3 show a view of the PaCE vehicle and its components.

Figure 1 Pavement Condition Evaluator, PaCE

Figure 2 Data collection interface and High-definition Camera for ROW images

Figure 3 Computer control, laser chassis and GPS receiver

Figure 4 shows typical Right-of-Way (ROW) image collected by the system while collecting the pavement condition data.

Figure 4 ROW Image Acquisition

Such images are acquired continuously while the PaCE vehicle is driven over the street pavements. Figure 5 illustrates sequences of images acquired. These images are saved onto a hard drive for processing at a later stage.

Figure 5 Sequences of ROW Images

In addition, PaCE also acquires downward images for a close look at the pavement condition as illustrated in Figure 6.

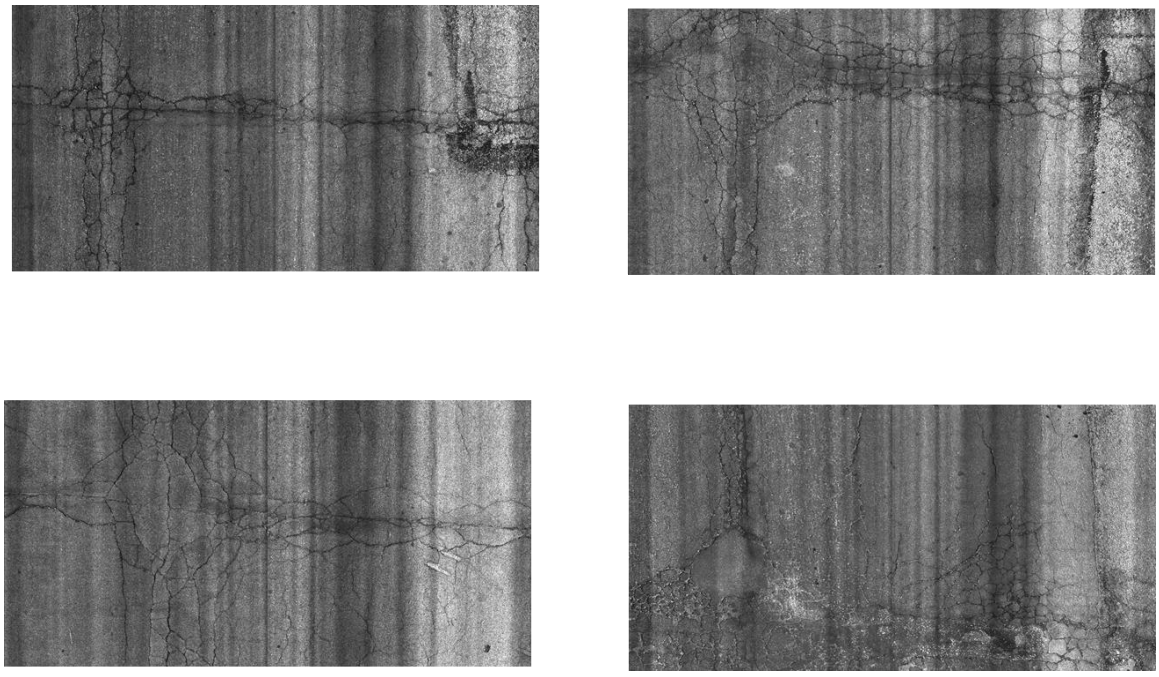


Figure 6 Downward Images

It should be recognized that each of these images (ROW and downward images as well) are stamped with GPS coordinates. As a result, we will be able to reference to these locations at any time.

Pavement images are processed to determine the severity and extent of distresses that may be exhibited by a roadway. The distress data recorded, in accordance with ASTM D-6433, is then entered into MicroPAVER software which enables computation of PCI for pavement street segment. The type of distresses to be processed depends on the type of pavement such as asphalt surface or concrete surface. The table below illustrates a list of distresses that relate to each pavement type.

Each image is tagged by the on-board GPS system to allow pinpoint accuracy in determining specifically where each photo was taken. When tied into the City's Pavement Management System, users are able to not only see the pavement condition data for a particular street, but also to see photos showing the pavement, curbs, sidewalks, and curb control signage. These images not only provide additional tools for City staff to manage maintenance needs, but

can also be used to supplement reports to City Administration, City Council, and Community Representatives to help explain how decisions are made regarding the Street Rehabilitation Program.

Distresses for Asphalt Surfaced Pavements	**Distresses for Concrete Surfaced Pavements**
Alligator or fatigue cracking	Blowup/buckling
Bleeding	Corner breaks
Block cracking	Divided slab
Bumps and sags	Durability cracking
Corrugation	Faulting
Depression	Joint seal damage
Edge cracking	Lane shoulder drop-off
Joint reflection cracking	Linear cracking
Lane/shoulder drop-off	Patching
Longitudinal cracking	Polished aggregate
Patching	Popouts
Polished aggregate	Pumping
Potholes	Punchout
Railroad crossing	Railroad crossing
Rutting	Scaling
Shoving	Shrinkage cracking
Slippage cracking	Spalling, corner
Swell	Spalling, joint
Raveling	
Weathering	

3. PCI - PAVEMENT CONDITION INDEX, WHAT THE NUMBERS REALLY MEAN

From a strictly numerical perspective, the 0-100 range of PCI's generated by MicroPAVER allows Engineers to very accurately compare the pavements of every street segment in the City, both allowing them to determine which streets need no attention now, and which ones should be

considered by any number of different approaches of reconstruction, rehabilitation, repair, or pavement preservation operations. But it is also useful to represent those numbers in a form that the general public can get an idea about the condition of the street on which they live. That is why the PCI numbers are sometimes displayed in certain ranges that the layman can find informative. The general categories that tie PCI's to a specific condition range, as proposed by the Department of Transportation Engineering (DOTE) are shown below:

Condition Category	From	To
Good or Better	100	68
Fair	67	50
Poor or Worse	49	0

The three PCI condition categories are for use with the Office of Performance and Data Analytics CAP Map for displaying data to the public. DOTE will use a seven PCI condition category, described in the Appendix, to evaluate and select streets for future street rehabilitation and preventive maintenance work.

4. HOW CINCINNATI'S STREET NETWORK MEASURES UP

Now that the data has been collected and processed, we are able to provide condition information that provides a "condition snapshot" of Cincinnati's street network.

Figure 7 shows number of street segments in each pavement condition from poor to excellent; Figure 8 shows the same information as percentage of total number of street segments. These graphs help the city administrators to quickly grasp the general health of city's street network. Figure 9 shows a comparison between 2018 and 2019 data.

Pavement condition degrades each year. However, the extent of degradation varies based on several factors such as current condition, traffic level, maintenance history etc. The current condition of all street pavements in the city is expressed in terms of network area-weighted average. In 2015 and 2016, the network area-weighted average PCI was 69; the network area-weighted average in both 2017 and 2018 was 70. In 2019, the network area-weighted average is 68. The City's Rehabilitation and Preventive Maintenance Program's judicious use of their

allocated resources is the primary reason the network average PCI remains in the good or better range.

Figure 9 shows a comparison between 2018 and 2019 data. It should be noted that the number of street segments used for the comparison in these charts dropped from 16,107 in 2018 to 16,004 since 103 segments were not accessible in the current study, but this has no impact on the overall percentages for each condition range.

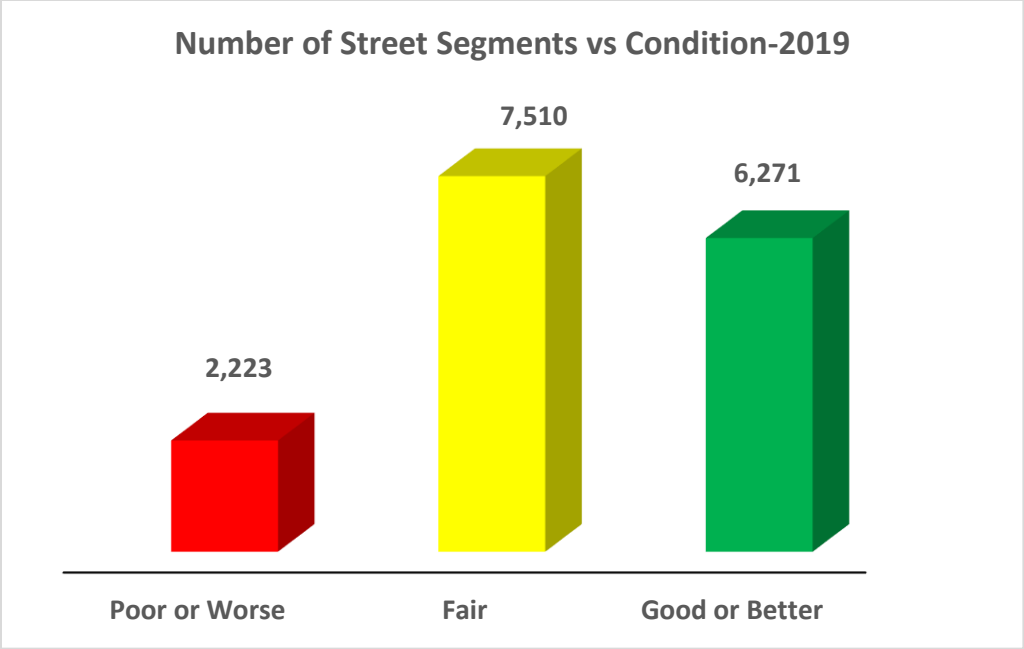


Figure 7 Number of Cincinnati's Street Segments in Various Condition Categories

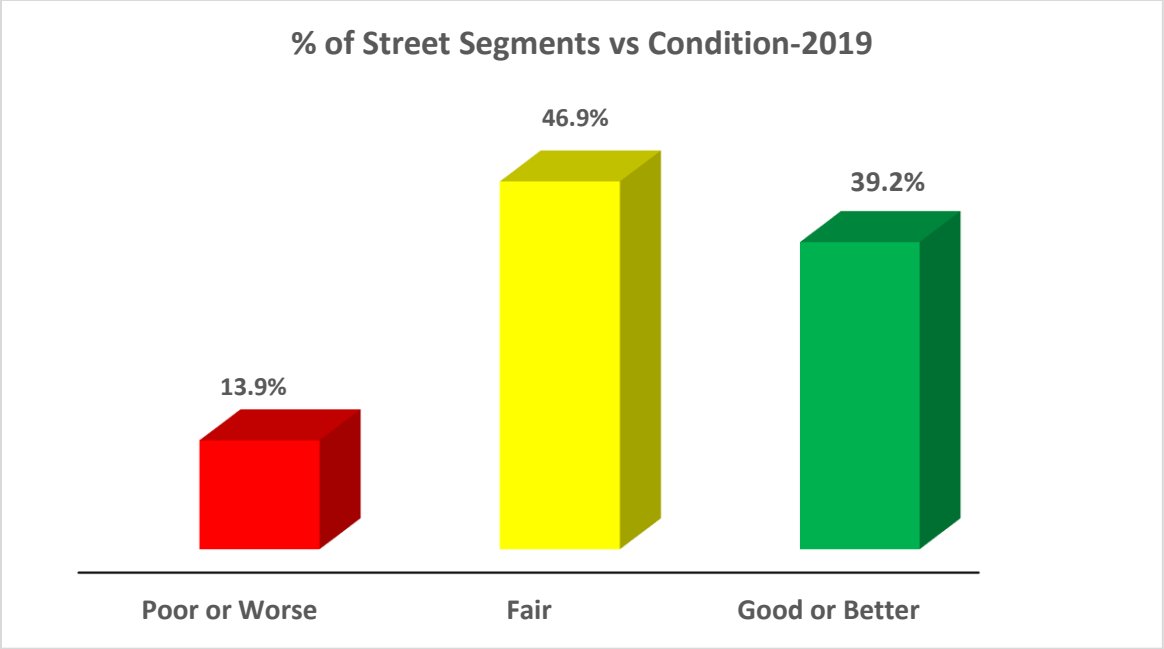


Figure 8 Percentage Street Pavements in Various Condition Categories

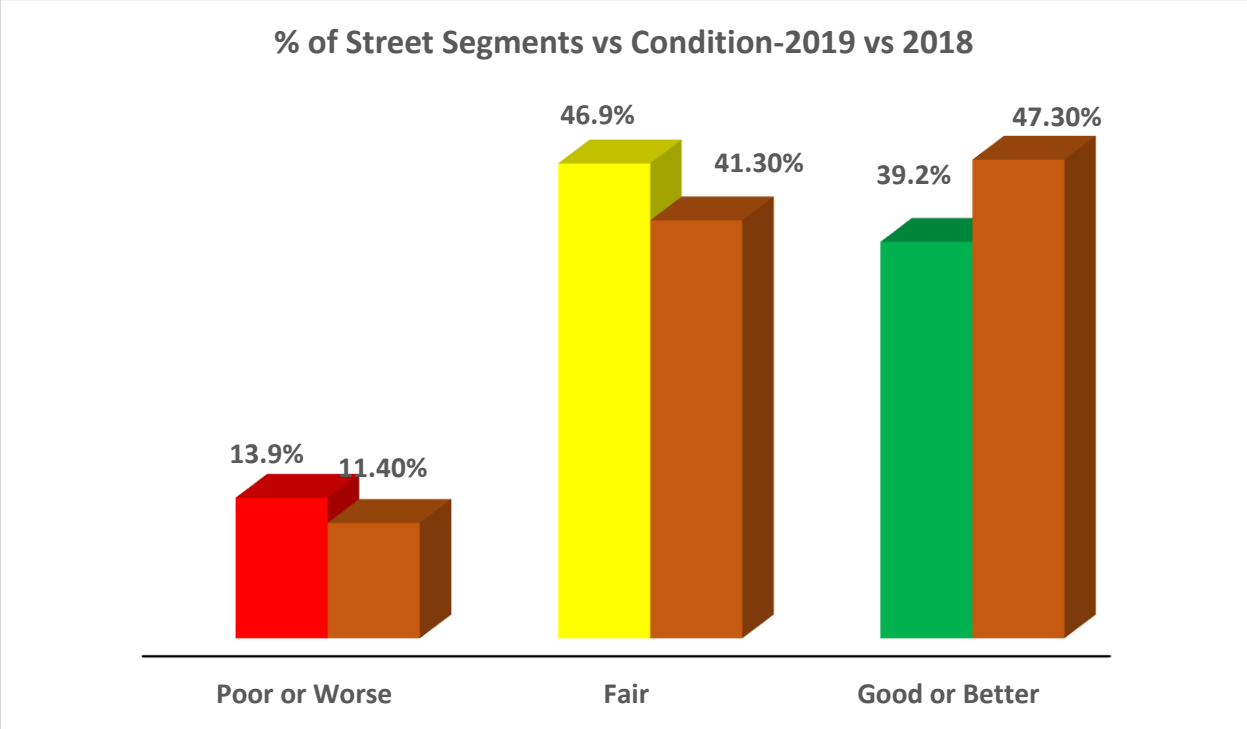


Figure 9 Comparing Pavement Condition in 2018 and 2019

Figures 10 and 11 provide condition distribution information with respect to the area of pavement.

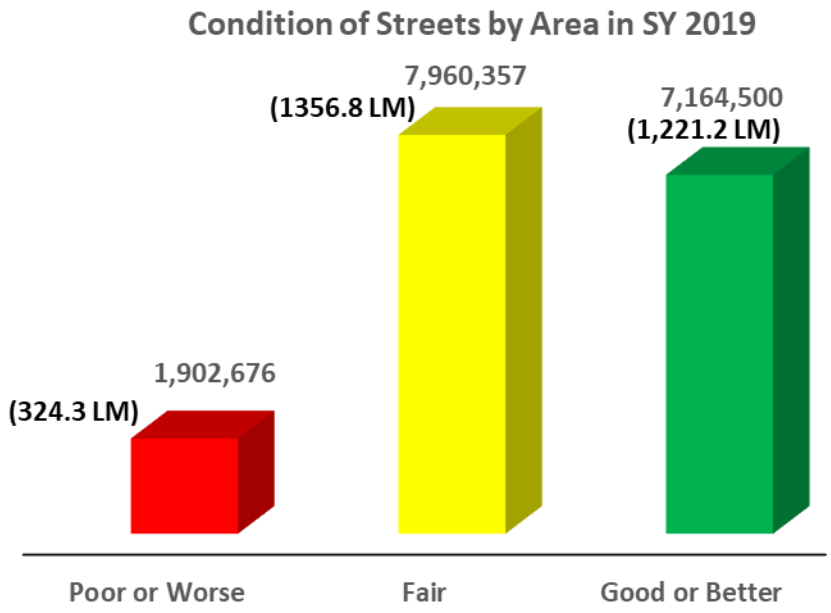


Figure 10 Condition Distribution by Pavement Area

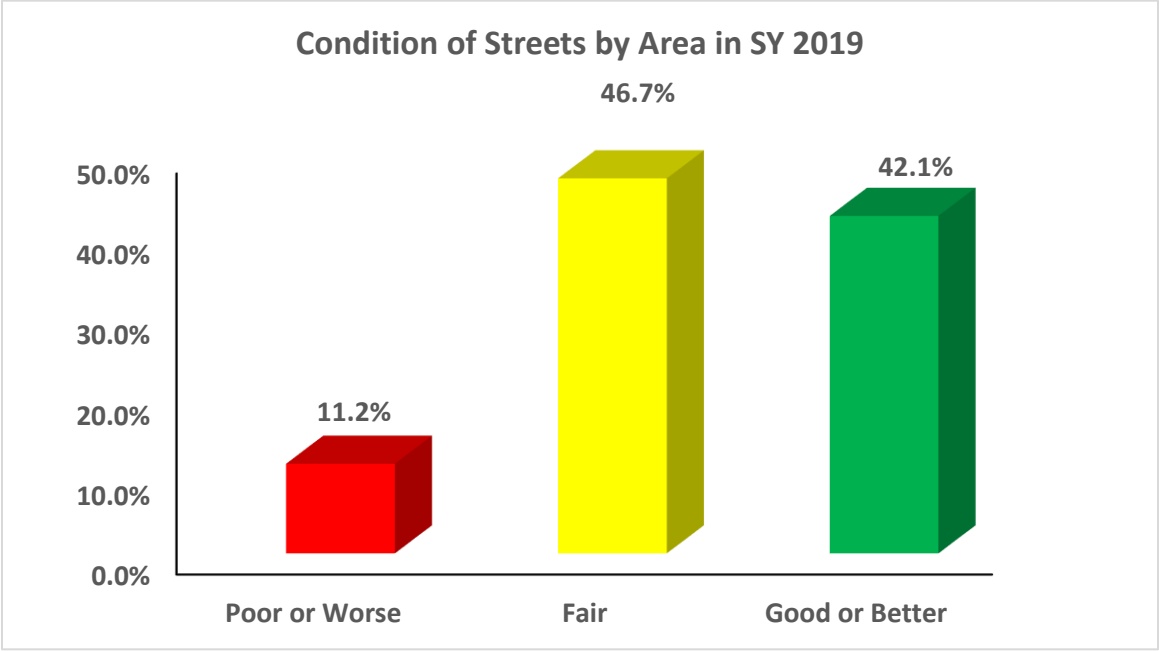


Figure 11 Condition Distribution by Percent Pavement Area

5. PAVEMENT CONDITION IN VARIOUS NEIGHBORHOODS

Figure 12 shows average pavement condition in terms of average PCI in each of the neighborhood.

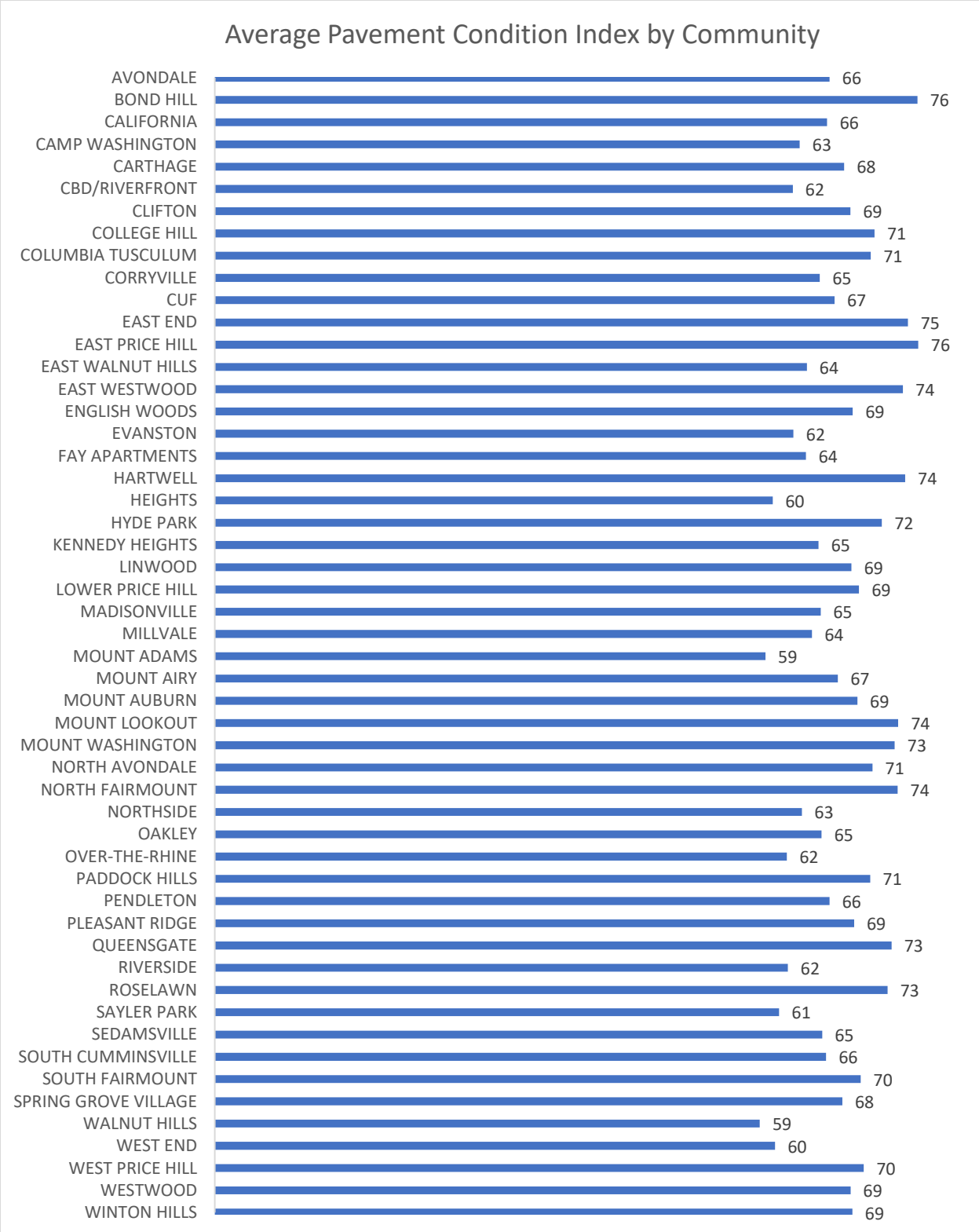


Figure 12 Average Condition of Street Network in each Neighborhood

6. ROAD VIEWER APPLICATION

The automated pavement data collection technology resulted in accumulation of over 200,000 ROW digital images and nearly 900,000 digital downward images. These images together displayed a complete and continuous coverage of Cincinnati's street network condition. To take advantage of this imagery data, an application called Road Viewer was developed. The application primarily integrates city's GIS shape file with the images and allows the users to virtually drive through city streets. Figure 13 shows Road Viewer's features and functionalities. To begin with, the application loads the GIS shape file as a layer on the Google map. Clicking on any street segment will populate the corresponding ROW images. The user can click on 'Forward' or 'Backward' commands which will display successive images and enables to navigate through the street. Users can also navigate to a street by entering the street name in the Branch Name dropdown search option. The right panel displays PCI, IRI and summary of distresses for the selected street segment – data valuable for pavement condition assessment and management. The GIS shape file can be color coded with respect to PCI categories to visually represent the condition of the city's street network. Images from successive years can similarly be used. In doing so, the application can be utilized to track changes in condition of each street segment and/or the entire network through the years.

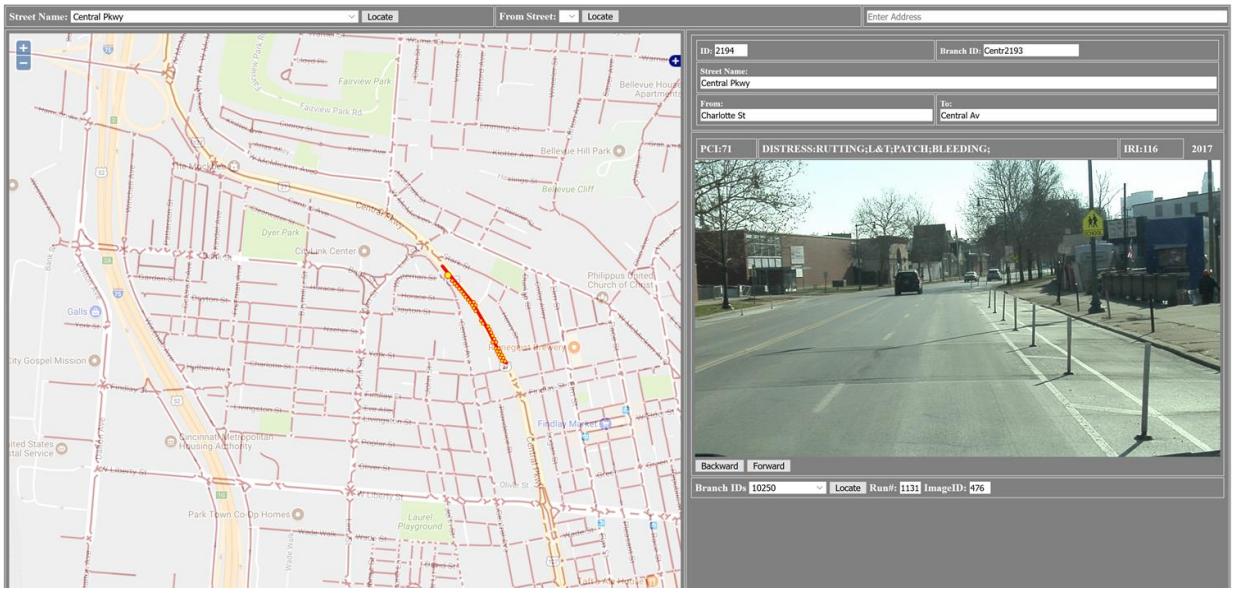


Figure 13 Snapshot of Road Viewer Application

7. PCI TREND

Until the end of 2014, the City was using a "manual" data collection system, which tended to provide more subjective results. The automated data collection process began in 2015. The automated system results in collection of a large amount of data which also provides more consistent, reliable results. So, the 2015 PCI of 69 simply reflects an adjustment to the PCI's reported previously - not an increase of four points in the span of only one year - and provides a good benchmark for comparisons to the average PCI's measured in the future years. Since the first year of automated data collection, the average PCI for the City's street network has held steady or increased slightly, showing that the increased funding for Street Rehabilitation and Preventive Maintenance has indeed been beneficial to the network's overall condition.

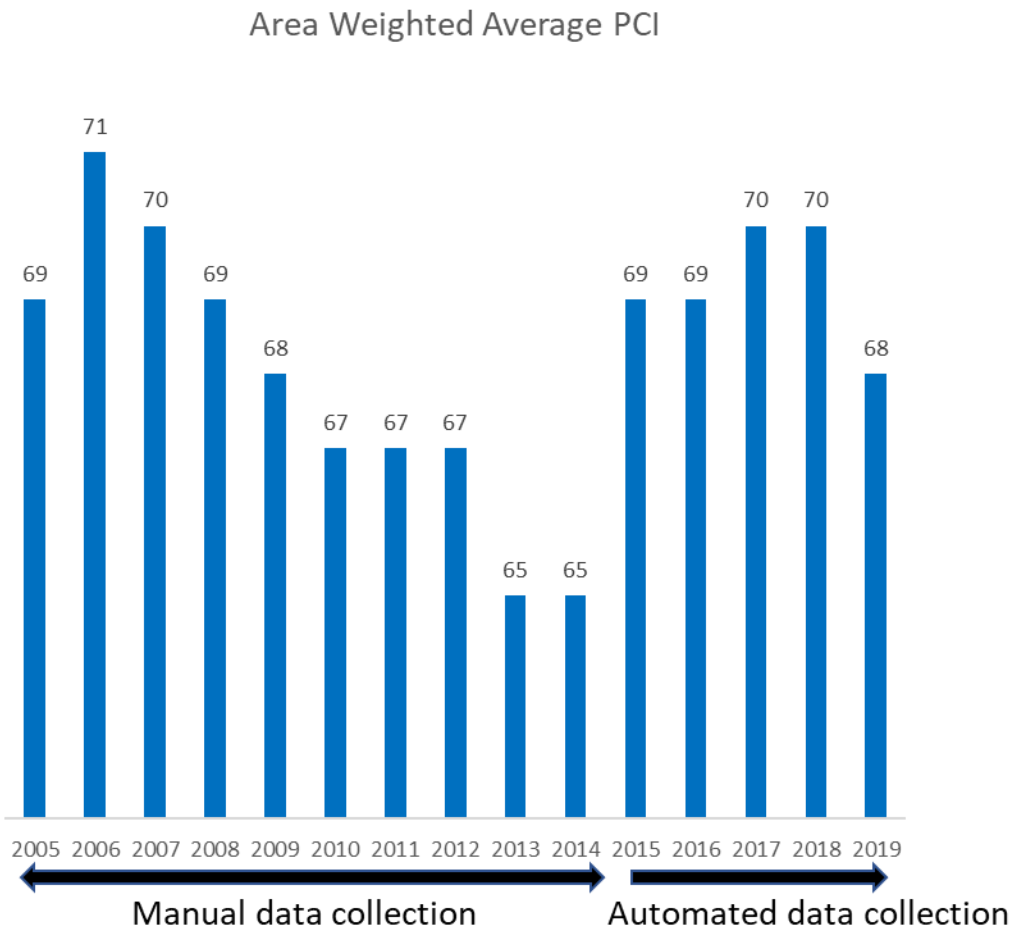


Figure 14 Cincinnati's Network PCI Average 2005 to 2019

APPENDIX

The DOTE uses seven PCI condition categories to manage pavements. The table below is list of the condition category and PCI ranges. This Appendix presents charts using seven PCI condition categories. These categories tie PCI's to a specific condition range, as proposed by Micro Paver software.

Condition Category	From	To
Excellent	100	92
Very Good	91	82
Good	81	68
Fair	67	50
Poor	49	35
Very Poor	34	20
Failed	19	0

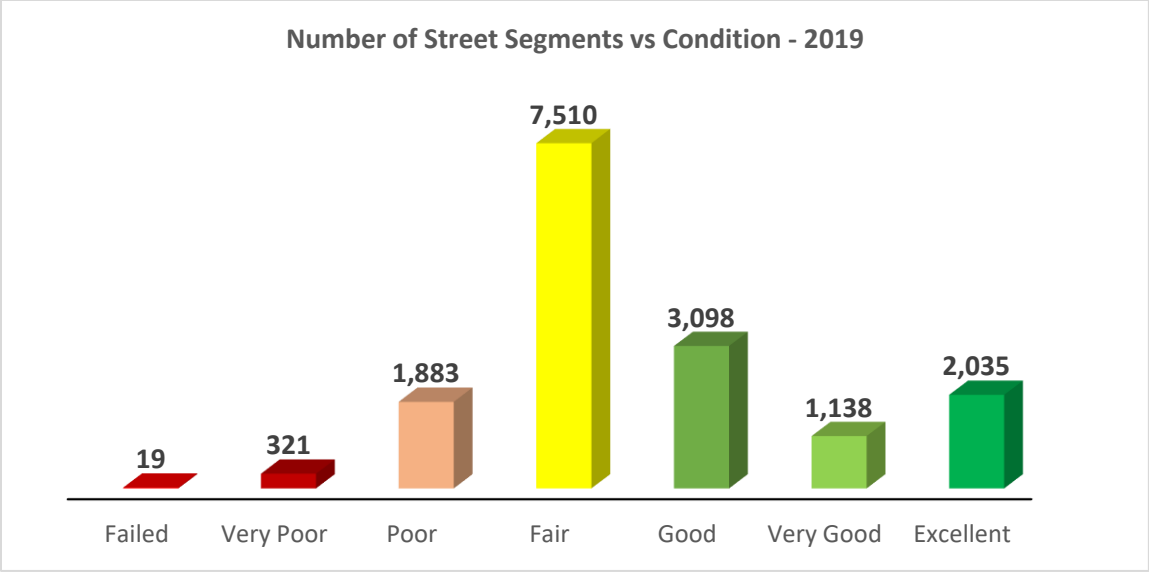


Figure A-1 Number of Cincinnati's Street Segments in Various Condition Categories

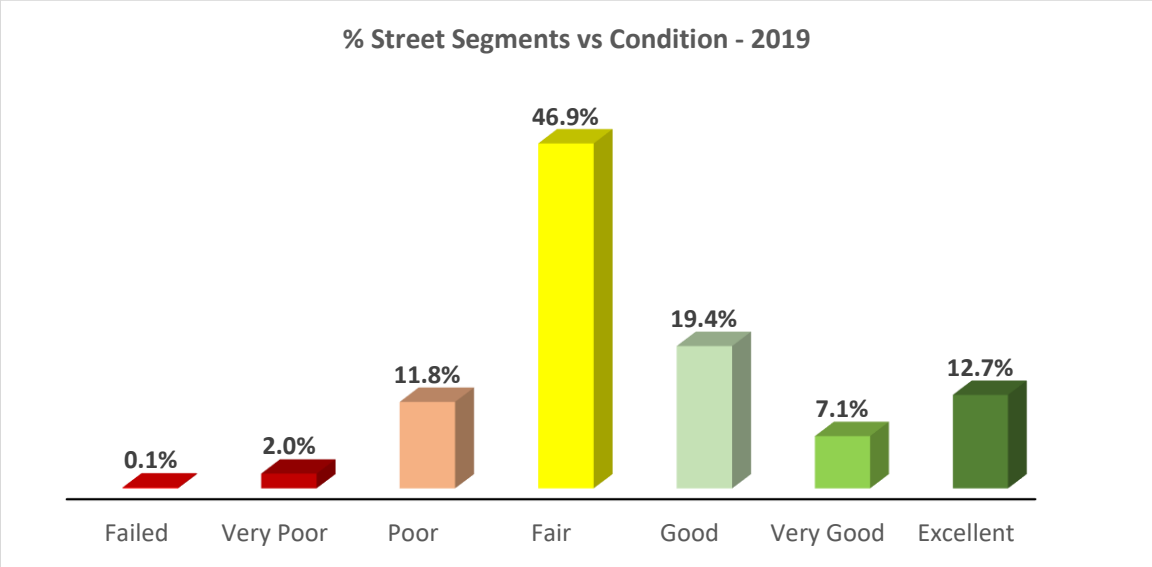


Figure A-2 Percentage Street Pavements in Various Condition Categories

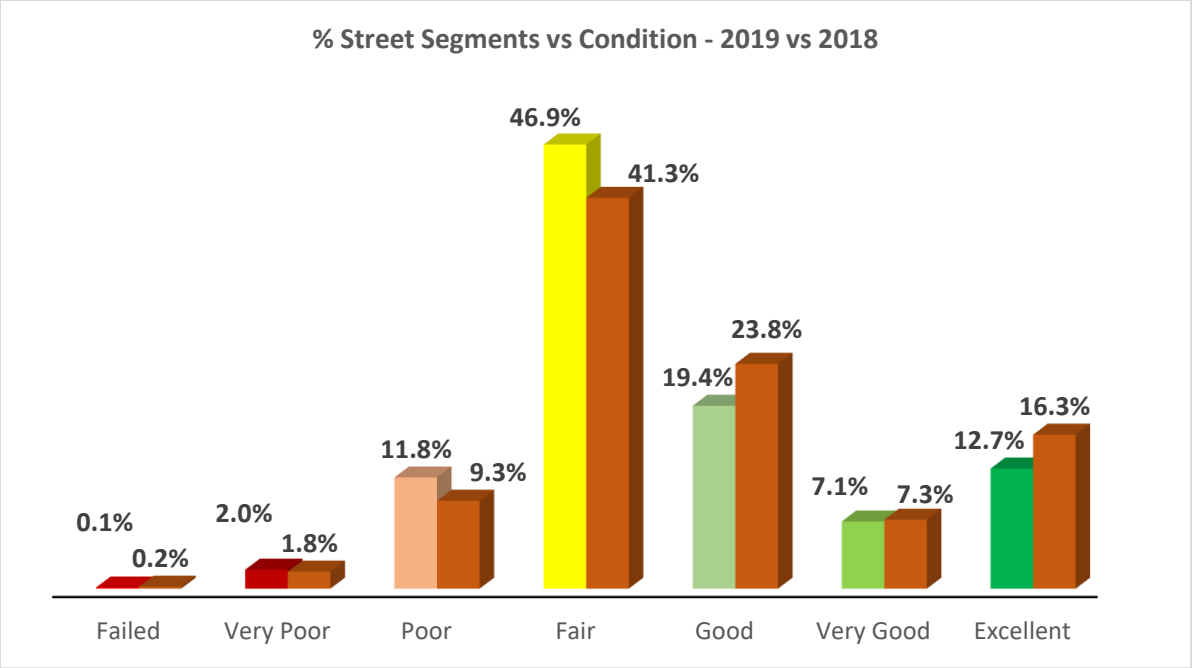
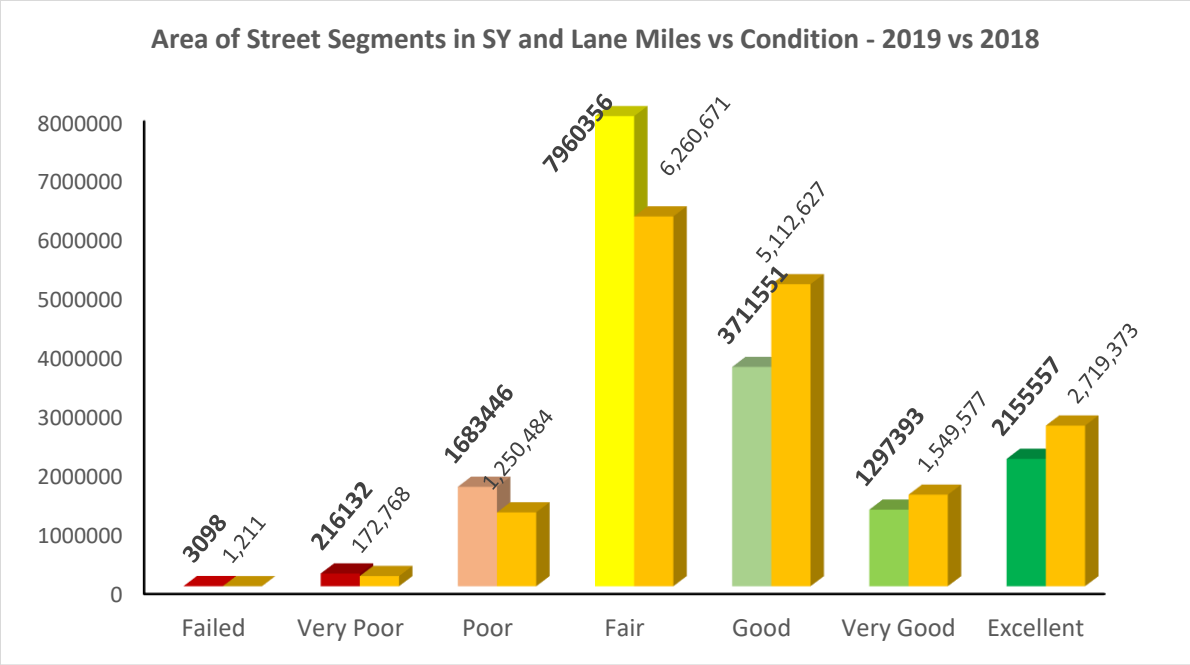


Figure A-3 Comparing Pavement Condition in 2018 and 2017



2019 LM	**0.5**	**36.8**	**286.9**	**1356.8**	**632.6**	**221.1**	**367.4**
2018 LM	**0.2**	**29.5**	**213.2**	**1067.3**	**871.6**	**264.2**	**463.6**

Figure A-4 Condition Distribution by Pavement Area and Lane Miles, 2019 vs. 2018