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Impact of highway work zones on traffic crashes: A case study in Michigan

Qadri Hafez Shaheen

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Impact of Highway Work Zones on Traffic Crashes: A Case Study in Michigan

by

Qadri Hafez Shaheen

Thesis

Submitted to the School of Visual and Built Environment

College of Technology

Eastern Michigan University

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

Construction Management

Thesis Committee:

Suleiman Ashur, Ph.D., Chair

Kasim Korkmaz, Ph.D.

James Stein, Ph.D.

November 1, 2018

Ypsilanti, Michigan
Dedication

To my beloved wife, Abar, and my daughters, Sara, Suad and Talia …

To my density, my Dad, Dr. Hafez … To my inspiration, my Mom, Suad …

To my father and mother in law … Dr. Riyad and Suhad …

To my professors at An-Najah National University …

To my great family …
Acknowledgments

I would like to express the deepest appreciation to my committee chair, Professor Dr. Suleiman Ashur, who has the attitude and the substance of a genius: He continually and convincingly helped convert my ideas from dreams into reality. Without his guidance and persistent help, this thesis would not have been possible.

I would like to thank my committee members, Dr. Kasim Korkmaz, and Dr. James Stein, for their support and strong directions.

I would like to thank my wife, who supported me during the year and a half it took to complete this work. Without her support and patience, and the unending fortitude she embodied when she raised our children by herself more than 6,000 miles away, this dream would not have been possible.

I would like to thank the Michigan Department of Transportation, and the State Police Department for their support and information provided during my research.
Abstract

Infrastructure in the US is severely aged and outdated. This presents a seemingly paradoxical problem in the field of construction management: In order to fix and make roads and highways more safe, construction zones must become inherently less safe in the process. There is a high cost to taxpayers and drivers, as work zones experience a significant amount of crashes and fatalities each year. To mitigate some of the factors that contribute to these crashes, this paper attempts to deliver guidelines on how to update relevant crash data, identify relevant factors, and create recommendations accordingly. The research focused particularly on data from 2016 and closely observed data from the year preceding and following isolate variables affecting to work zone safety: the crash rate during construction compared to the time before construction and to the time after construction. Descriptive statistics (mean, histogram), a paired t-test, and an ANOVA test were used to test the crash rate differences. In addition, this study tested the impact of the type of work on the crash rate frequency. The study found with 95% confidence level that there is no significant difference in mean crash rates between construction time and non-construction time. Additionally, the study attempts to corroborate these data with external factors such as population and environment type and ultimately determine whether these factors are indeed significant to work zone safety. Finally, I suggest a series of recommendations to the Michigan Department of Transportation for best practices in ensuring work zone safety.
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Chapter One: Introduction

Background

Every year, the Michigan Department of Transportation spends a lot of money to maintain, rehabilitate, and construct new highways. This massive effort is expected to increase due to the deterioration of the infrastructure as stated by the American Society of Civil Engineers Infrastructure Report Card (American Society of Civil Engineers, 2018). The report states that the infrastructure in the US in general is in severe condition and needs more investment at all levels of government to avoid escalating the cost and risk over time. In particular, the highways, a major part of the infrastructure are quite aged. This need in Michigan costs each driver approximately $540 per year. The total number of Michigan licensed drivers in 2016 was 7,074,674 drivers (US Department of Transportation [USDOT] & Federal Highway Administration [FHWA], 2016). With this information, we can project the annual cost of repair for roads to be approximately 3.8 billion dollars. Moreover, 11.10% of the 11156 bridges are structurally deficient; $261,565,021 were spent on state bridge capital projects alone in 2013 and 122,286 miles of public roads, or 21%, were in poor condition (USDOT & FHWA, 2016).

Fundamental to such knowledge is the ability to relate crash data with corresponding work zones, with particular attention to data quality. The purpose of this study is to examine construction site safety by analyzing and comparing crash rates during construction work, with special attention to crash rates for the year before and crash rates for the year after on the same segment. The ultimate goal is to determine if the safety on the construction zones is
sufficient, and to create a clear correlation between the types of work being done on the highway with its respective crash rates: either an increase, decrease, or no effect.

**Problem Statement**

The need to fix, maintain, and rehabilitate highway infrastructure increased in the US and is expected to increase due to the deterioration of these facilities over the past couple years. Highway construction activities create work zones that are disruptive to regular traffic patterns and generate serious safety concerns. The main challenge to the US Departments of Transportation (USDOT) and other local and regional transportation agencies is to run the construction operations effectively while reducing impact on traffic patterns and maintain public safety for motorists and construction workers.

The 2016 Federal Highway Administration data indicates that the crashes in work zones have been increasing since 2010. The crash severities in the work zone are similar to the non-work zone crashes in property damage and injuries but with a higher frequency of fatalities in the work zone. In addition, the number of work zones crashes in 2016 resulted in 764 fatalities, which amounts to 2% of all roadway fatalities occurring in the US in the same year.

Data between the years 2003 and 2010 showed that 962 fatalities happened in roadway work zones. About 1 out of 10 fatalities were workers flagging (3.3%) or performing traffic control duties (6.3%). From 2011 to 2012, the data shows that 55% of fatalities were caused as a result of being struck by vehicles. The other major cause of worker fatalities at road construction site is by being run over or backed over by a vehicle or mobile
equipment, with an average of 46% of worker fatalities being attributed to this cause. (Federal OSHA Fatality Investigations, 2012).

It is expected under the new administration to have more money allocated to support highway projects. Therefore, there is a need to do the following:

1) Update the information on crash data and worker injuries and fatalities at work zones.
2) Identify factors contributing to crashes at work zones and compare it to the factors that have been identified in research.
3) Develop recommendations to improve safety at work zones for both motorists and workers.

**Research Questions**

Safety improvement is affecting the main function of highways in work zones. As discussed by scholars over a decades, “Work zone safety is affected by a large variety of risk factors and many of them are not fully understood” (Li & Bai, 2009).

This study will focus on highway segments that have been lightly researched during the 2016 year. This study will additionally compare the frequency levels of crashes, to the year before (2015) and the year after (2017). The main questions that this research will attempt to answer are as follows:

1. What is the impact of work type on crash rate in Michigan?
2. Do highway work zones increase or decrease the crash rate in Michigan?
3. What other factors and variables exist on the crash rate in Michigan?
Chapter Two: Literature Review

The road and highway construction industry experienced a host of issues over the last five years, which were mainly budgetary constraints and weak investments in transport infrastructure: “Over 128 billion dollars in revenue had been invested in 2017 with an annual growth of 3.5%” (IBIS World, 2018).

Table 1 observes 16 peer-reviewed articles in the area of highway construction zones, and demonstrates the methodology, the variables, and data analysis for each article, in addition to the location. In Michigan, none of the research was focused on crashes in the construction zone. Despite that fact, the construction work in highway areas have been increasing dramatically since 2015. Therefore, a deep study on Michigan highways is important.
### Table 1

**Summary of Sixteen Peer-Reviewed Articles**

<table>
<thead>
<tr>
<th>Research</th>
<th>Method</th>
<th>Variables</th>
<th>Data Analysis</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigman, Agent, (1988)</td>
<td>Case Study</td>
<td>Congestion</td>
<td>Examination</td>
<td>KY</td>
</tr>
<tr>
<td>Leotsarakos, Christos, (1988)</td>
<td>Case Study</td>
<td>Traffic Volume</td>
<td>Examination (Before And During)</td>
<td>CA &amp; GA</td>
</tr>
</tbody>
</table>
| Hall, Lorenz, (1989)          | Case Study   | • Light Conditions  
• Roadway Grade Vs. Time  
• Time Of Day Versus Period  
• Weather Condition  
• Road Surface Condition  
• Manner Of Collision  
• Principal Contributing Factor  
• Vehicle Type | Cross Tabulation                              | NM                                               |
| Shyam, Andrzej, (2002)        | Observational| Congestion                                                                                                                                     | Ditto                                             | IN    |
| Yong, Yingfeng, (2006)        | Observational| Different Variables                                                                                                                               | Frequency & Chi-Square                           | KS    |
| Yingfeng, Yong, (2007)        | Case Study   | Characteristics Of Fatal And Injury Accidents                                                                                                  | Ditto                                             | KS    |
| Yingfeng, Yong, (2007)        | Observational| • Driver At Fault  
• Time  
• Crash Environment Conditions  
• Road Conditions  
• Crash Scene Information | Frequency Analysis                             | KS    |
<table>
<thead>
<tr>
<th>Research</th>
<th>Method</th>
<th>Variables</th>
<th>Data Analysis</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yingfeng, Yong, (2009)</td>
<td>Observational</td>
<td>• Age&lt;br&gt;• Gender&lt;br&gt;• Time Of Day&lt;br&gt;• Day Of Week&lt;br&gt;• Light Condition&lt;br&gt;• Weather Condition&lt;br&gt;• Road Surface Condition&lt;br&gt;• Road Class&lt;br&gt;• Road Character&lt;br&gt;• Number Of Lanes&lt;br&gt;• Speed Limit&lt;br&gt;• Crash Location&lt;br&gt;• Surface Type&lt;br&gt;• Road Special Feature&lt;br&gt;• Area Information&lt;br&gt;• Vehicle Body Type&lt;br&gt;• Number Of Vehicles&lt;br&gt;• Driver Error&lt;br&gt;• Statistical&lt;br&gt;• Empirical</td>
<td></td>
<td>KS</td>
</tr>
<tr>
<td>Ozgur, Kaan, Hong, (2014)</td>
<td>Case Study</td>
<td>Congestion</td>
<td>Descriptive Analysis Crash Frequency Models</td>
<td>NJ</td>
</tr>
</tbody>
</table>
Table 1 continued

<table>
<thead>
<tr>
<th>Research</th>
<th>Method</th>
<th>Variables</th>
<th>Data Analysis</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osama, Tanay, (2017)</td>
<td>Experimental</td>
<td>Speed (Sign) Independent Causes</td>
<td>The Statistical Difference Determines The Effectiveness Of VSL System</td>
<td>AK</td>
</tr>
<tr>
<td>Eduardo, Robert, Bayliss, (2017)</td>
<td>Observational</td>
<td>Cannabis and Marijuana</td>
<td>Logistic Regression</td>
<td>CA</td>
</tr>
<tr>
<td>Allison, Kristina, Allan, Brian, (2017)</td>
<td>Observational</td>
<td>Driver Age</td>
<td>Descriptive Analyses</td>
<td>NJ</td>
</tr>
<tr>
<td>Qing, Feng, Sheila, Bruce, (2017)</td>
<td>Observational</td>
<td>Novice Drivers</td>
<td>Recurrent-Event Change-Point Models, Simulation Study</td>
<td>USA</td>
</tr>
</tbody>
</table>
Case Studies

A case study examines the characteristics of a particular entity, phenomenon, or person by selecting a unit of analysis. It is used for describing or answering questions about specific topics or contexts. In addition, it captures the perspectives of a participant group toward events, beliefs, or practices.

The cases can be identified and classified into different categories: critical, extreme, exemplifying, and longitudinal cases. The following studies can be classified as case study research. The summary and their findings and recommendations are as follows:

Li and Bai (2009) used a screening process to identify the risk factors of the research findings, by using a logistic regression and frequency analysis techniques. A wide range of crash variables examined Kansas work zone crashes.

Jin and Saito (2009) found that “the transition area upstream of the activity area was more crash prone than the activity area itself, regardless of the types of main traffic control devices used in the activity areas of the work zones.”

Jin, Saito and Eggett (2008) worked on crash characteristics between construction time and non-construction time. They focused in their study on the state of Utah to study the mean crash rate. They used a statistical comparisons and concluded that there was no statistical difference in Utah’s case. Recent studies include studies on Chicago area expressway system during 1980’s in which they found out that “crash rates were increased 88% in long term work zones and 69% in short term work zones” (Jin, Saito & Eggett, 2008). Similarly, studies were carried out in various other locations such as New Mexico, New
York, and North Carolina, where the rate of incidents were higher during construction period. This is the major reason why the research in Utah was carried out.

The methodology used by Utah Department of Transportation was straightforward. They considered 528 construction projects within Utah with various crash records, but while taking many factors into account such as improper and inaccurate crash records, 202 were shortlisted for the research in which 45 were rural interstate, 65 were rural non-interstate, 26 in urban interstate, and 66 urban non-interstate highways. The research was made specific to crashes during construction time, avoiding biased outcomes as much as possible. Statistical analysis tools such as SPSS is used to analyze the projects; other analysis representation such as mean, standard deviation, confidential interval, and histograms were used. Tests such as a paired t-test, ANOVA, and Tukey’s test were conducted considering the highway class and crash severity levels such as “no injury (NI), possible injury (PI), bruises and abrasion (BA), and broken bones and bleeding blood (BBBB)” (Jin et al., 2008). This study particularly emphasized crash rates by highway class which were significantly different between construction and non-construction time unlike other studies which were not specific about the type of highways, crash levels, and work zones.

Shaik, Bernhardt, and Virkler (2000) have found that “the white lane drop arrows and the CB wizard alert system were able to decrease the percentage of vehicles remaining in the closed lane, the mean speed, and the speed variance.” The authors tested the three different traffic control devices in Missouri. They tested the effectiveness of the traffic devices on interstate highway work zones to examine the difference in reducing the speed and the variation in the speed, and the impact on improving the merging flow.
Hall and Lorenz (1989) conducted a study on crashes on state highways work zone. Their focus of the study was rural highways, and the study lasted from 2000 to 2003. Their approach was to identify constructions zones and crashes that occurred in these zones during the three-year period. The research approach was to compare the crash data at the construction zones to data collected in previous year at the same segment and during the same time. They reported that “in comparison with the prior year, crash experience increased by 26%” (Hall & Lorenz, 1989) during construction.

**Observational Research**

Observational research can be used in a qualitative study. Major methodologies are to use entry data, contact potential research parities, and capture all relevant data. The following studies can be classified as observational research. The summary and their findings and recommendations are as follows:

Duddu, Penmetsa, and Pulugurtha (2018) emphasize the accidents involved in relationship to the drivers being at fault or not at fault. The data were obtained by highway safety information from North Carolina. The study was carried out for the year 2009 to 2014. The main idea of the research was to find out the effect of the independent variables on both at-fault and not-at-fault drivers, injuries.

Cheng, Gill, Dasu, and Jia (2018) carried out on a pedestrian and bicyclist crash data across 58 different counties of California for two different mode of users to evaluate user involved crashes. The paper was all about comparison of different models and finding which
one is superior. This study gives a broader idea on what model to choose and how would it be beneficial based on different parameters incorporated into different models.

Regev, Rolison, and Moutari (2018) focuses on the effect of different parameters for causing a crash. The methodology is simple and straightforward. The study compares two different methods of conventional crash rates and newly adjusted crash risk while accessing all the parameters like driver age, gender, time of the day, and risk of crash involvement and crash fatality. Basically, the study applied a new approach to model crash risks based on exposure metric that bears a linear relation with crashes.

Cheng, Parker, Ran, and Noyce (2017) worked on reviewing the data quality for GIS-based Crash and Work Zone Data Integration. Their study reviewed the overall accuracy and completeness of a previously developed crash and developed an integration algorithm for work zone data. By examining the randomly selected crashes through the original crash report and the work zone records, the results confirmed the overall accuracy of the GIS-based integration algorithm. The work zone records and crash data were pulled from two systems: the Wisconsin Lane Closure System and Wisconsin MV4000 crash database. Both systems are available through the W is Trans-Portal, a comprehensive transportation data warehouse at the 20 Wisconsin Traffic Operations and Safety (TOPS) Laboratory at the University of Wisconsin-Madison. This study examined 320 crashes and their related LCS records. The investigation confirmed the overall accuracy of the algorithm when retrieving work zone records for work zone crashes, and no evidence in the crash reports were found to suggest that the matching results were incorrect. Study duration was based on daily/nightly time: operation on a daily/nightly basis, specified by the start/end times each day within the
start/end date range. Weekly time was operation on a weekly basis, specified by start/end weekday and time. Continuous time was continuous operation within the start/end date/time range, but less than two weeks. Long-term time was continuous operation longer than two weeks. The data integration and system interoperability, and data quality control across different data sets are usually not an easy task; the capability to integrate and cross reference different data sets, such as work zones and crashes, is essential to the task. There are around 20% of studied work zone crashes as noted in the police crash report whose corresponding work zone records cannot be found.

Applying this integration method to all the crashes regardless of whether a crash is flagged on the police report as work zone related or not, the algorithm identifies two approximately 3% non-work zone crashes (according to the police report) that occurred in a work zone. Their findings were that the total number of crashes happened on interstate or US highway in Wisconsin from 2009 to 2013 is 238,584. Among them, there are 85,542 crashes flagged as “construction zone” crashes according to the crash report.

The integration algorithm was able to retrieve corresponding LCS records for 4,341 crashes among those construction zone crashes. That makes the matching rate as 78.3%. On the other hand, the matching algorithm found that there are 7,733 non-construction zone crashes that occurred within a work zone during its scheduled period, which is about 3.24% of all the non-construction zone crashes.

The study failed to show evidence in the crash reports suggesting that it is not a work-zone-related crash. However, 27 crash reports (22.5%) do not explicitly mention whether the work zones were directly related to the crashes in the narratives of the crash report.
In summation, the manual inspection verified the accuracy of the matching set. The study found cases in which the crash reports do not provide explicit information about the work zones, or the construction zone flag is likely to be wrong. Therefore, there would be a room for improvement in terms of providing better information for work zone crash data collection. This study can provide empirical data support for developing guidance related to training and work zone data collection with respect to the new Wisconsin crash report, which will provide better adherence to the national Model Minimum Uniform Crash Criteria Guideline (MMUCC) standards for crash data collection. The current version of the MMUCC (4th Edition) includes an expanded section on work zone crash data collection. The matching algorithm was not able to find the corresponding work zone records for a small portion of the confirmed work zone crashes (work zone factors explicitly included in the crash report). The future work to be considered is in finding the causes and improving the algorithm. The data integration algorithm shows a satisfying accuracy in the matching set, which could serve as a core module in the future automatic system to support real-time and proactive work zone planning and operations applications. One example is the real-time monitoring and notification of crashes in major work zones. It is desirable to monitor the safety level of work zones during their life cycle to provide more time for measure implantation to eliminate potential safety hazards as quickly as possible. Such a proactive approach can save more lives and reduce the crash loss than the traditional way, which analyzes the crashes occurred in the work zone long after the work zone finished.

Islam and Brown (2017) performed a specific analysis on the motorcycle crashes in Alabama. They compared the injury level on rural and urban analysis. The results of the study clearly indicated similarities and differences between the factors influencing the injury
severities resulting from rural and urban motorcycle at-fault accidents. Some variables were found to be significant only in one model (rural or urban) but not in the other one, while some variables were found significant in both models.

Bai, Finger, and Li (2010) examined work zones on two-lane rural highways in Kansas. Therein, they determined that “two-lane highways are particularly hazardous and cause a significant safety concern due to the disruption of regular traffic flow.”

A study by Bai (2006) focused on Kansas State highways. They applied two analysis methods: descriptive and regression analysis. A 157 fatal crashes were part of the research in the year between 1992 and 2004. Their primary findings concluded that providing safety in work zones while keeping maximum utilization of highways has become one of the overwhelming challenges in accordance with the problem statement of this research.
Chapter Three: Data Collection

Highway Construction Site Safety

Safety first, is a common adage that is often mentioned in any type of work involving physical labor. In construction, safety is one of the biggest influencers of success due to economic and human costs incurred by a lack thereof. Therefore, different types of safety requirements ought to be adhered to when it comes to construction activities.

In highway construction zones, the safety requirements are more complicated due to the type of work and the traffic volume that needs to be controlled. The federal highway administration has set up a manual for traffic control devices (MUTCD). The MUTCD has specific details on how to implement the safety requirements on highway construction zones. Figure 1 shows different types of tapers and buffer spaces along a construction site. Before any construction, a traffic engineer has to prepare a traffic control plan based on the manual, and pursue approval on the drawing from the related highway agencies. They must meticulously plan months ahead and put control devices on the road, all the while ensuring that vehicles and travelers are aware of the coming works.

An advanced warning signs have to be installed on both directions of the road. The road classification and the speed limit are the main factors on the required distance ahead of the work.
Data Reduction

The Michigan Department of Transportation (MDOT, 2016) identified 132 road construction projects in 2016. Nine projects conducted in the Upper Peninsula, and 123 in the Lower Peninsula. More records were collected of correlated crashes to some of these construction projects. The following measures were taken to reduce the data of the select projects for the study:

1. Projects without length of work.
2. Projects with unclear location and time work.
3. Projects that spanned into 2017 or spanned from 2015.
4. Projects of less than 1 month period.
5. Projects worked on undefined interchanges, and roundabouts.
6. Projects that were only bridge repair, or replace bridges.
7. Projects that did not have crash data.

Using the process discussed above, 56 project sites ultimately concluded for analysis. Thirty projects on rural areas, whereas 26 projects in urban areas.

Michigan's population concentrated in southeast Michigan with approximately 40% of Michigan’s population. In the Upper Peninsula, only 3.4% of Michigan's population is concentrated in that part (Messina, Shortridge, Groop, Varnakovida, & Finn 2006). The map in Figure 2 shows the population distribution between the urban and rural areas in Michigan.
Procedures of Data Collection

Data description. In this section, the procedure to select the construction sites and collect crash data before, during, and after the construction project is implemented. Using the same procedure described in the previous section, the data were collected for each segment for 3 different years: the study year, 2016; and the year before; and the year after. Eventually, a complete set of data was collected for site over three years, to apply the same conditions of on the studied segments and to have the same weather conditions and traffic volume characteristics.

The data were then described and briefly summarized in order to be analyzed in the next section. Every year, MDOT prepare a construction map of the location for the intended construction projects on the highways. See Appendix A for construction maps, 2015 through 2018. Figure 3, gives a snapshot of 2018 map.

The maps provided by MDOT were used to determine the time and location of these construction zones for different years. The state police department, and on most of the crash reports, has the nearest coordinates for the crash location. The crash report information is used for analysis on Michigan Crash Facts website. Note the website capture in Figure 4.
As a result, several crashes that occurred within a determined construction zone have been analyzed and studied. The main variables based on this methodology will be the time of the crash and the location, specifically whether it happened before the construction time, within the construction period or after. The percentage of crashes were determined and compared accordingly to figure out the disturbance of the percentage of the crashes. Thus, the aim is to find if the crash rate has been changed as a result of the construction.

Data Source. The area of study for this research focuses on Michigan highways. Therefore, the data source for the study area retrieved from the Michigan Traffic Crash Facts (MTCF) website. The data present and are available to capture and use for all users through data query tool. Figure 5 shows the website and the built environment for querying the data.
Then, the query had been built based on two major factors: period and geographic location based on the road segment.

\textbf{Figure 5}. Data query tool. Reprinted from Michigan Traffic Crash Facts. Retrieved October 10, 2018, from https://www.michigantrafficcrashfacts.org/.

The data that can be captured have the ability to be filtered based on the required information. For research purposes, the available information has been captured to be part of the data base of the study.

\textbf{Highway Construction Zones Data Information}. Michigan Department of Transportation (MDOT), for ease planning and safety measures on roads, publishes annual maps for Michigan roads and highways showing the construction zone and the expected time of work. Therefore, the 2018 construction map downloaded online from the MDOT website.
Figure 6 illustrates the way of gathering the construction map. Although, the previous construction zones maps have been requested and collected by the communicating MDOT agency via the provided email, the agency had sent the 2015, 2016, and 2017 maps that show approximately the construction zones during the past three years.

![Figure 6. Michigan highway construction maps. Adapted from the Michigan Department of Transportation. (2018). Retrieved October 10, 2018, from https://www.michigan.gov/mdot/0,4616,7-151--462226--,00.html.](image)

**Construction Zone Selection.** Different types of construction are expected every year in different areas based on the transportation assets management plan that has been prepared by the state for all the highways (information confirmed during Spring Transportation Assets Management Conference in Traverse City, MI, on May 2018).
Capturing the Data from MTCF. By applying the two choose features for digitizing the data, a polygon area drawn over the road segment gives the accessibility to capture all crashes that happened within the construction zone. The probability of having an error data for crashes that happened nearby or on a different road is minimum comparing to other methods of collection. Figure 7 illustrates the steps of digitizing the road segment using the polygon area tool.

![Figure 7. Digitizing the road segment of M10. Reprinted from Michigan Traffic Crash Facts. Retrieved October 10, 2018, from https://www.michigantrafficcrashfacts.org/.

The amount of data that has been captured can be significantly noticed once the area of selection is closed, identified and then applied on the selected segment. Figure 8 observes the first glance after digitizing the road segment for 2015 crash data. By returning to the previous page and choosing different time frame for 2015 and 2016, the data can be captured by just applying the selection on the road segment without digitizing the road again. By

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digitizing the road again, the same random error of accuracy is applied for the all years, based on the applied area.


Finally, by returning to the query tool, view list icon is the next step to go through and observe the captured data. The type of data and the required information can be determined in this level, and then the available information about the crashes that happened within the selected zone will pop up. The copy icon on the left side will apply to the shown data in the same page. Then, the copied cells are pasted on a spreadsheet to be ready for future analysis. The same step by copying and pasting the data for the next pages has been applied and distributed per year on difference sheets on one excel file. Figure 9 shows the final step of copying the data from the source. Appendix B is a sample of the extracted crash data.

Date Clustering for Construction and Non-Construction Times. As a procedure to eliminate crashes data from non-construction time was performed, the crashes which occurred on the same road segment were grouped by month. Table 2 shows an example of the data group. For the resurfacing of 13.6 miles on M-49 from July to Sept 2016, the work starts from state line to US-12. The total number of crashes on that segment on 2016 was 44, and the total number of crashes appeared during the construction time was six.
Table 2

Count of Crashes on Rural Non Interstate Highway (Site 71)

<table>
<thead>
<tr>
<th>Month</th>
<th>Number of Crashes in 2016</th>
<th>During Construction Time</th>
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</thead>
<tbody>
<tr>
<td>January</td>
<td>2</td>
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</tr>
<tr>
<td>February</td>
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<td>November</td>
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</tr>
<tr>
<td>December</td>
<td>8</td>
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</tbody>
</table>

Identifying the Average Annual Daily Traffic for Each Segment

The average annual daily traffic (AADT) for Michigan roads and highways is measured and calculated by the Michigan Department of Transportation. By identifying the location on from MDOT website in Figure 10, the AADT is concluded and noted for the study areas.
Figure 10. Average annual daily traffic source. Reprinted from the Michigan Department of Transportation. Retrieved October 10, 2018, from https://www.michigan.gov/mdot/0,4616,7-151-11151-22141--,00.html.

The AADT is available through the website for three years. 2017, 2016, and 2015. By identifying the year from the Layers icon and zooming to the required location, the value of the AADT at some point will be shown if the road segment has more than one value; if so, the proportion of the road is calculated accordingly. See Figure 11 for more details.
Calculations of Crash Rate

Crash rates are used to normalize the data of crashes over the road segments. The volume of traffic on road segments is used in order to fulfil the number of crashes percentage in reference to the volume. In this study, the crash rate was calculated in reference to the AADT on 56 selected projects.

According to MDOT (2018), “The Annual Average Daily Traffic (AADT) is the estimated mean daily traffic volume.” The length of each project was measured by locating the project ends and the project starts during the data processing procedure.
Crash rates of the 56 projects were analyzed using Excel as a tool for statistical analysis. A descriptive statistical analysis, a paired t-test, was performed based on different variables: the highway class, and the construction type of work. Based on Jin et al.’s (2008) study, “Highway classes were composed of Rural Interstate (RI) highways, Rural Non-Interstate (RNI) highways, Urban Interstate (UI) highways, and Urban Non-Interstate (UNI) highways”. The type of work consisted of 16 categories based on MDOT construction map. The following list illustrates the types of construction works conducted across Michigan highways:

1. Repair Bridge  
2. Repave  
3. Reconstruction Retaining  
4. Pave  
5. Replace Pave  
6. Utilities  
7. Widen  
8. Concrete Joint Resealing  
9. Chip Seal  
10. Construct  
11. Repair  
12. Patch Pavement/Concrete  
13. Reconstruct/Replace Bridge  
14. Mill and resurface  
15. Reconstruct  
16. Resurface

More than 35% of the projects were resurfacing of the asphalt, whereas 17% were reconstruction. Therefore, more than 50% of the projects consist of those type of work.

The results were determined by comparing the mean of the 2015 crash rates and the mean of the 2016 crash rate, and the mean of the crash rate of the 2015 with the mean of the crash rate of the 2017.
The crash rate was calculated by applying the total number of the highway crashes in the study period in Equation 1. The equation was adjusted and derived, as in Equation 2, to be appropriate with the limited time of construction work. The original equation is based on years, while all the sites are per days (USDOT, 2018).

\[
R = \frac{C \times 100,000,000}{V \times 365 \times N \times L}
\]  \hspace{1cm} (1) *

Where,

\( R \) = Roadway Departure crash rate for the road segment expressed as crashes per 100 million vehicle-miles of travel.

\( C \) = Total number of roadway departure crashes in the study period.

\( V \) = Traffic volumes using Average Annual Daily Traffic (AADT) volumes.

\( N \) = Number of years of data.

\( L \) = Length of the roadway segment in miles.

* (MDOT, 2018)

The adjusted equation for this research were as follows:

\[
R = \frac{C \times 100,000,000}{V_i \times D \times L}
\]  \hspace{1cm} (2) **

Where,

\( R \) = Roadway Departure crash rate for the road segment expressed as crashes per 100 million vehicle-miles of travel.

\( C \) = Total number of roadway departure crashes in the study period.

\( V_i \) = Traffic volumes using Average Annual Daily Traffic (AADT) volumes. (i: a = after, b = before, c = during)

\( D \) = Construction time in days.
\[ L = \text{Length of the roadway segment in miles.} \]

** Adjusted from Original equation

Table 3 observes the crash rate calculations per segment over the three years. Column 1 classify the highway class. Column 2 mentions the highway number according to MDOT classification. Column 3 identifies the site index number in MDOT construction maps. Column 4 shows the type of work on each segment. Column 5 shows the length in miles. Columns 6, 7, and 8 show the construction period. Columns 9, 10, and 11 show the number of crashes on each construction site over the three years. Columns 12, 13, and 14 illustrate the AADT per site for each year. Columns 15, 16, and 17 have the calculated crash rates for each year using Equation 2.
### Table 3

**Crash Rate Calculations**

<table>
<thead>
<tr>
<th>Class</th>
<th>Road</th>
<th>Type of Work</th>
<th>Length, (Miles)</th>
<th>Days of Work</th>
<th>Total Number of Crashes</th>
<th>Traffic Volume</th>
<th>Crashes Rates, equation 2</th>
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</thead>
<tbody>
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<td>RI</td>
<td>I-94</td>
<td>Resurface</td>
<td>7.4</td>
<td>244</td>
<td>35, 67, 56</td>
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<td>I-94</td>
<td>Resurface</td>
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<td>UI</td>
<td>I-94</td>
<td>Patch</td>
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<tr>
<td>UI</td>
<td>I-75</td>
<td>Reconstruct</td>
<td>3.8</td>
<td>214</td>
<td>37, 31, 23</td>
<td>51900, 58800, 58806</td>
<td>0.88, 0.65, 0.48</td>
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<td>I-75</td>
<td>Repair Pavement</td>
<td>13.3</td>
<td>183</td>
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<td>I-96</td>
<td>Repair Pavement</td>
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<td>Repair Bridges</td>
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### Table 3 continued

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<th>Days of Work</th>
<th>Total Number of Crashes</th>
<th>Traffic Volume</th>
<th>Crashes Rates, equation 2</th>
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<th>Days of Work</th>
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Chapter Four: Statistical Analysis

Summary of Statistical Methods

Table 3 presents a summary of statistical methods by construction site crash rates. The analysis of the data based on the methodology used by (Jin, Saito & Eggett, 2008).

Frequency Analysis

Multiple sites have been visualized by comparing the number of crashes. Random sites were selected for comparing to see the differences in some major crash criteria. Table 4 illustrates the location’s criteria and description.

Table 4  
Frequency Analysis Sites Information

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<thead>
<tr>
<th>Highway Classification</th>
<th>Road Number</th>
<th>Site Index</th>
<th>Type of Work</th>
<th>Length of Segment (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RNI</td>
<td>US-23</td>
<td>81</td>
<td>Repair Pavement</td>
<td>8.1</td>
</tr>
<tr>
<td>UI</td>
<td>I-75</td>
<td>84</td>
<td>Reconstruct</td>
<td>5.0</td>
</tr>
<tr>
<td>RNI</td>
<td>M-24</td>
<td>87</td>
<td>Resurface</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Locations 81, 84, and 87 were analyzed to understand the data and to identify the crash rate factors. Figure 12 shows the three different sites locations in Michigan.
Figure 12. Key map for Michigan highway construction projects. Reprinted from 2016 *Paving the Way: Road Repair Projects*, by the Michigan Department of Transportation.

Aerial images are shown below for the selected roads, to give an indication about the selected roads. In Figure 13 on US-23, the two-way, two-lane separated road was repaired in 2016 for 8.1 miles.

One lane closed in each direction, barriers and different kind of safety rules have been used on site during the four months of work.
As shown in Figure 14 on I-75, the two-way, three-lane separated highway was patched in 2016 for 2.4 miles. Nighttime and weekend work has single lane closures for three months of work.

As shown in Figure 15 on M-24, two-way, two-lane separated highway was resurfaced in 2016 for 5.2 miles. Most of the work was done overnight, with lane shifts and flag control for three months.
The bar charts in Figures 16 through 25 illustrate the data for the three different construction sites. The data were analyzed and compared in months, in days and in hours to see and understand the peak values and the factors for the crashes and their respective frequencies.

From the bar charts in Figures 14 through 23, the information suggests that the crash rate or number has more than one variable and cannot be considered in one time of the day or a month. Although the number of crashes has changed over the years, the crash rate value based on AADT was considered correct and applicable in Michigan’s case.
Figure 16. Crash data frequency in months over three years for construction site 81

Figure 17. Crash data frequency in days over three years for construction site 81
Figure 18. Crash data frequency in hours over three years for construction site 81

Figure 19. Crash data frequency in months over three years for construction site 84
Figure 20. Crash data frequency in days over three years for construction site 84

Figure 21. Crash data frequency in hours over three years for construction site 84
Figure 22. Crash data frequency in months over three years for construction site 87

Figure 23. Crash data frequency in days over three years for construction site 87
Figure 24. Crash data frequency in hours over three years for construction site 87

Figure 25. Crash data frequency analysis for the three construction sites
Paired T-Test

The t-test is one type of statistical methods: “It is used to determine whether there is a significant difference between the means of two groups. With all inferential statistics, we assume the dependent variable fits a normal distribution” (University of Connecticut website, t-test). According to Jin et al. (2008), “This concept applies to the analysis of crash rates on highway sections where construction projects took place and the effect of construction projects on crash rates for the same highway sections.”

The null hypothesis (H₀) proposed that the crash rate for the year before construction, and the year during construction are the same. The alternative hypothesis (Hₐ) proposed the opposite of the H₀, or that the crash rates are not the same. Variable 1 is the crash rate for the year before, and Variable 2 is the crash rate for the year during or the year after.

**Interstate urban and rural.** The following t-test results were concluded for interstate highways, regardless of the population classification, and for different type of works. Table 5 (A, B, and C) illustrates the crash rate for Interstate highways and the t-test results.
### Table 5 (A)

**Interstate highway crash rates results and t-test analysis**

<table>
<thead>
<tr>
<th>Highway Class</th>
<th>Interstate Highways</th>
<th>Construction Site Index</th>
<th>Type of Work</th>
<th>Length of , L, (Miles)</th>
<th>Crashes per Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2015 R&lt;sub&gt;b&lt;/sub&gt;</td>
</tr>
<tr>
<td>RI</td>
<td>I-94</td>
<td>47</td>
<td>Resurface</td>
<td>7.4</td>
<td>0.46</td>
</tr>
<tr>
<td>UI</td>
<td>I-94</td>
<td>56</td>
<td>Resurface</td>
<td>8.1</td>
<td>0.98</td>
</tr>
<tr>
<td>UI</td>
<td>I-94</td>
<td>83</td>
<td>Patch</td>
<td>2.4</td>
<td>2.44</td>
</tr>
<tr>
<td>UI</td>
<td>I-75</td>
<td>94</td>
<td>Reconstruct</td>
<td>3.8</td>
<td>0.88</td>
</tr>
<tr>
<td>UI</td>
<td>I-75</td>
<td>92</td>
<td>Repair Pavement</td>
<td>13.3</td>
<td>0.04</td>
</tr>
<tr>
<td>UI</td>
<td>I-96</td>
<td>80</td>
<td>Repair Pavement</td>
<td>4.0</td>
<td>1.19</td>
</tr>
<tr>
<td>UI</td>
<td>I-94</td>
<td>70</td>
<td>Repair Bridges</td>
<td>14.3</td>
<td>1.06</td>
</tr>
<tr>
<td>UI</td>
<td>I-94</td>
<td>56</td>
<td>Resurface</td>
<td>8.1</td>
<td>2.20</td>
</tr>
<tr>
<td>UI</td>
<td>I-75</td>
<td>84</td>
<td>Reconstruct</td>
<td>5.0</td>
<td>1.42</td>
</tr>
<tr>
<td>UI</td>
<td>I-94</td>
<td>118</td>
<td>Resurface</td>
<td>5.6</td>
<td>0.88</td>
</tr>
<tr>
<td>RI</td>
<td>I-94</td>
<td>61</td>
<td>Repair Concrete</td>
<td>3.1</td>
<td>1.96</td>
</tr>
<tr>
<td>UI</td>
<td>I-75</td>
<td>102</td>
<td>Resurface</td>
<td>5.0</td>
<td>1.67</td>
</tr>
</tbody>
</table>

**Note:**
- RI: Rural Interstate
- UI: Urban Interstate
- RNI: Rural Non Interstate
- UNI: Urban Non Interstate
- Crash Rate, Equation (2)
Table 5 (B)

*T-Test Results for Urban Interstate and Rural Interstate, Before and During*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.26</td>
<td>1.54</td>
</tr>
<tr>
<td>Variance</td>
<td>0.50</td>
<td>1.73</td>
</tr>
<tr>
<td>Observations</td>
<td>12.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>11.00</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>-1.03</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>1.80</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>2.20</td>
<td></td>
</tr>
</tbody>
</table>

Table 5 (C)

*T-Test Results for Urban Interstate and Rural Interstate, Before and After*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.26</td>
<td>1.05</td>
</tr>
<tr>
<td>Variance</td>
<td>0.50</td>
<td>0.52</td>
</tr>
<tr>
<td>Observations</td>
<td>12.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>11.00</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>1.84</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>1.80</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>2.20</td>
<td></td>
</tr>
</tbody>
</table>
Urban roads and highways. The following t-test results are concluded for urban road and interstate highways, regardless what the population classification, and for different type of works. Table 6 (A and B) illustrates the crash rates and the t-test results.

Table 6 (A)

*T-Test Results for Urban Roads, Before and During*

<table>
<thead>
<tr>
<th></th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.39</td>
<td>2.31</td>
</tr>
<tr>
<td>Variance</td>
<td>5.75</td>
<td>4.29</td>
</tr>
<tr>
<td>Observations</td>
<td>18.00</td>
<td>18.00</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>17.00</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>1.74</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.67</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>2.11</td>
<td></td>
</tr>
</tbody>
</table>

Table 6 (B)

*T-Test Results for Urban Roads, Before and After*

<table>
<thead>
<tr>
<th></th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.39</td>
<td>2.51</td>
</tr>
<tr>
<td>Variance</td>
<td>5.75</td>
<td>9.86</td>
</tr>
<tr>
<td>Observations</td>
<td>18.00</td>
<td>18.00</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>0.98</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>17.00</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>-0.55</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>1.74</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>2.11</td>
<td></td>
</tr>
</tbody>
</table>
Urban roads and highways, resurface type of work. The following t-test results were concluded for urban roads and interstate highways, focusing on resurfacing type of work. Table 7 (A and B) illustrates the crash rates and the t-test results.

Table 7 (A)

*T-Test Results for Urban Roads, Resurfacing, Before and During*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.75</td>
<td>2.63</td>
</tr>
<tr>
<td>Variance</td>
<td>5.95</td>
<td>4.63</td>
</tr>
<tr>
<td>Observations</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>9.00</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>2.26</td>
<td></td>
</tr>
</tbody>
</table>

Table 7 (B)

*T-Test Results for Urban Roads, Resurfacing, Before and After*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.75</td>
<td>2.84</td>
</tr>
<tr>
<td>Variance</td>
<td>5.95</td>
<td>8.89</td>
</tr>
<tr>
<td>Observations</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>0.98</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>9.00</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>-0.35</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>2.26</td>
<td></td>
</tr>
</tbody>
</table>
Rural roads and highways, resurface type of work. The following t-test results were concluded for rural roads and interstate highways, focusing on resurfacing type of work. Table 8 (A and B) illustrates the crash rates and the t-test results.

Table 8 (A)

*T-Test Results for Rural Roads, Resurfacing, Before and During*

<table>
<thead>
<tr>
<th></th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>4.26</td>
<td>2.55</td>
</tr>
<tr>
<td><strong>Variance</strong></td>
<td>34.49</td>
<td>8.72</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
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<td>10.00</td>
</tr>
<tr>
<td><strong>Pearson</strong></td>
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</tr>
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<td><strong>Hypothesized Mean Difference</strong></td>
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</tr>
<tr>
<td><strong>df</strong></td>
<td>9.00</td>
<td></td>
</tr>
<tr>
<td><strong>t Stat</strong></td>
<td>1.26</td>
<td></td>
</tr>
<tr>
<td><strong>P(T&lt;=t) one-tail</strong></td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td><strong>t Critical one-tail</strong></td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td><strong>P(T&lt;=t) two-tail</strong></td>
<td>0.24</td>
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</tr>
<tr>
<td><strong>t Critical two-tail</strong></td>
<td>2.26</td>
<td></td>
</tr>
</tbody>
</table>

Table 8 (B)

*T-Test Results for Rural Roads, Resurfacing, Before and After*

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<thead>
<tr>
<th></th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
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<td><strong>Mean</strong></td>
<td>4.26</td>
<td>3.50</td>
</tr>
<tr>
<td><strong>Variance</strong></td>
<td>34.49</td>
<td>16.48</td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td><strong>Pearson</strong></td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td><strong>Hypothesized Mean Difference</strong></td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td><strong>df</strong></td>
<td>9.00</td>
<td></td>
</tr>
<tr>
<td><strong>t Stat</strong></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td><strong>P(T&lt;=t) one-tail</strong></td>
<td>0.17</td>
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</tr>
<tr>
<td><strong>t Critical one-tail</strong></td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td><strong>P(T&lt;=t) two-tail</strong></td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td><strong>t Critical two-tail</strong></td>
<td>2.26</td>
<td></td>
</tr>
</tbody>
</table>
Rural roads and highways, reconstruct type of work. The following t-test results were concluded for rural roads and interstate highways, focusing on reconstruct type of work. Table 9 (A and B) illustrates the crash rates and the t-test results.

Table 9 (A)

T-Test Results for Rural Roads, Reconstructing, Before and During

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
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<td>3.00</td>
</tr>
<tr>
<td>Variance</td>
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<td>3.23</td>
</tr>
<tr>
<td>Observations</td>
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<td>7.00</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
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<td></td>
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<td>df</td>
<td>6.00</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>-1.13</td>
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</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
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</tr>
<tr>
<td>t Critical one-tail</td>
<td>1.94</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>2.45</td>
<td></td>
</tr>
</tbody>
</table>

Table 9 (B)

T-Test Results for Rural Roads, Reconstructing, Before and After

<table>
<thead>
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<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
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<tr>
<td>Variance</td>
<td>2.01</td>
<td>2.70</td>
</tr>
<tr>
<td>Observations</td>
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<td>7.00</td>
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<tr>
<td>Pearson Correlation</td>
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<tr>
<td>Hypothesized Mean Difference</td>
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</tr>
<tr>
<td>df</td>
<td>6.00</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>1.94</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>2.45</td>
<td></td>
</tr>
</tbody>
</table>
Urban roads and highways, reconstruct type of work. The following t-test results were concluded for urban roads and interstate highways, focusing on reconstruct type of work. Table 10 (A and B) illustrates the crash rates and the t-test results.

Table 10 (A)

*T-Test Results for Urban Roads, Reconstructing, Before and During*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.34</td>
<td>2.60</td>
</tr>
<tr>
<td>Variance</td>
<td>14.44</td>
<td>10.12</td>
</tr>
<tr>
<td>Observations</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
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<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>2.92</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>4.30</td>
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</tbody>
</table>

Table 10 (B)

*T-Test Results for Urban Roads, Reconstructing, Before and After*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable 1</th>
<th>Variable 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.34</td>
<td>3.86</td>
</tr>
<tr>
<td>Variance</td>
<td>14.44</td>
<td>33.57</td>
</tr>
<tr>
<td>Observations</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean Difference</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>-0.45</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>2.92</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>4.30</td>
<td></td>
</tr>
</tbody>
</table>
ANOVA Test Results

An ANOVA test is a way to find out if survey or experiment results are significant (https://www.statisticshowto.datasciencecentral.com/). In this research analysis, R software was used to analyze the crash rate. Group 1 was the crash data for the year before construction. Group 2 was the crash rate data for the year of construction. Group 3 was for the year after construction.

In the ANOVA test, the null hypothesis proposed that the means of Group 1, Group 2, and Group 3 crash rates are equal. The alternative hypothesis proposed that the mean is not equal. Table 11 (A and B) observes the ANOVA results for interstate highway crash rates and for urban road crash rates, respectively. Appendix C contains the calculations and the data exported from R software.
Table 11 (A)

ANOVA Summary Results for Interstate Highways

<table>
<thead>
<tr>
<th>Group1</th>
<th>Group2</th>
<th>Group3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min.</td>
<td>0.04</td>
<td>Min.</td>
</tr>
<tr>
<td>1st Qu.</td>
<td>0.88</td>
<td>1st Qu.</td>
</tr>
<tr>
<td>Median</td>
<td>1.06</td>
<td>Median</td>
</tr>
<tr>
<td>Mean</td>
<td>1.23</td>
<td>Mean</td>
</tr>
<tr>
<td>3rd Qu.</td>
<td>1.67</td>
<td>3rd Qu.</td>
</tr>
</tbody>
</table>

|          | df | Sum Sq | Mean Sq | F value | Pr (>|F|) |
|----------|----|--------|---------|---------|----------|
| ind      | 2  | 0.90   | 0.45    | 0.55    | 0.58     |
| Residuals| 48 | 39.27  | 0.82    |         |          |

Table 11 (B)

ANOVA Summary Results for Urban Roads

<table>
<thead>
<tr>
<th>Group1</th>
<th>Group2</th>
<th>Group3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min.</td>
<td>0.04</td>
<td>Min.</td>
</tr>
<tr>
<td>1st Qu.</td>
<td>0.92</td>
<td>1st Qu.</td>
</tr>
<tr>
<td>Median</td>
<td>1.42</td>
<td>Median</td>
</tr>
<tr>
<td>Mean</td>
<td>2.24</td>
<td>Mean</td>
</tr>
<tr>
<td>3rd Qu.</td>
<td>2.44</td>
<td>3rd Qu.</td>
</tr>
</tbody>
</table>

|          | df | Sum Sq | Mean Sq | F value | Pr (>|F|) |
|----------|----|--------|---------|---------|----------|
| ind      | 2  | 0.6    | 0.30    | 0.06    | 0.95     |
| Residuals| 72 | 384.4  | 5.34    |         |          |
Chapter Five: Conclusions, Recommendations, and Future Work

Conclusions

Highway construction is implemented under the watchful eye of federal highway commissions. A high number of research reported the crash frequency in construction zones is more than the crash rate in non-work zones. Previous studies reported that there is no significant difference between the crash rate at the same section of the road before and during the construction time. However, that study did not observe if the crash rates on road class were significantly different. Moreover, it did not mention or measure the difference in crash rate after construction, to examine the new roads conditions. This study focused on the mean crash rates between construction time and the year before and the year after.

The paired $t$-test of crash rates between construction time and non-construction time (before and after) showed that there is no difference statistically between the mean crash rates on urban and rural areas. Based on the results of the paired $t$-test, the test was not able to find at the 95% confidence level that the crash rates during construction time were higher than the crash rates during non-construction time for the year before. Similar conclusions were drawn in between the non-construction time for the year before construction and the year after construction. Thus, one-way ANOVA was performed to further compare the different between the three groups (before, during, and after the construction).

The previous results implied that the inclination of higher crash rates during construction time addressed by previous work zone traffic crash studies do not apply to
Michigan’s crash records. It is important to mention that the crash severity has not been analyzed in this study due the lack of crash severity in the available data.

**Recommendations**

This study recommends that MDOT increase the enforcement of the MUTCD guidelines. Moreover, Michigan State Police should continue to adhere to the safety requirements on the road.

In addition, it is recommended that the crash reports include the crash severity, and the type of construction on the road if related, and should mention that if there were any injuries and death to the laborer. Finally, it is recommended that MDOT works on reporting accurate construction information and provides this information and data to research agencies.

**Future Work**

More research is required in this area. To find the severity level of crashes in construction zones and to find the major factors of the severity level. The findings of this research conclude that the difference in crashes, before, during, and after construction work is no longer significant. However, the crash severity was not part of this research.
References


Appendix C: Crash Rate Calculations. (n.d.). Retrieved from https://safety.fhwa.dot.gov/local_rural/training/fhwasa1109/app_c.cfm


*Journal of Transportation Engineering, 135*(10), 694-701.


https://www.michigantrafficcrashfacts.org/


Zhao, M., & Garber, N. J. (2001). *Crash characteristics at work zones* (No. UVA/29472/CE01/100). Pennsylvania Transportation Institute, Pennsylvania State University.
APPENDICES
Appendix A: Michigan Construction Maps
1. **M-28: June-Aug**
   Replace bridge over Jackson Creek. Closed and detoured.

2. **M-64: May-Sept**
   Apply epoxy overlay and replace joints on Ontonagon River Bridge. 1 alternating lane open with traffic signals.

3. **US-41: June-Aug**
   Mill and resurface 7 miles from Old US-41 to county line. Traffic shifts, 1 alternating lane open under flag control.

   Resurface 11.3 miles of US-41 from M-28 to Mead Rd and US-141 from county line north 4.5 miles. 1 alternating lane open under flag control.

   Reconstruct intersection. 1 lane open in each direction, short-term US-141 detour.

6. **M-95: May-Aug**
   Reconstruct 9.5 miles from Channing to county line. 1 lane open in each direction during non-work hours. 1 alternating lane open under flag control during work hours.

7. **US-41/M-28: June-Sept**
   Mill and resurface 1.5 miles from Water St to Malton Rd and 3 miles from Second St to west of Westwood Dr. 1 lane open in each direction.

   Second year of 2-year project. Replace US-2 bridge over Escanaba River. 1 lane open in each direction, 1 daytime detour.

9. **US-2: June-Sept**
   Reconstruct 5.5 miles westbound lanes from Gladstone to Rapid River. 1 lane open in each direction on eastbound side.

10. **US-2: May-Aug**
    Repair steel, paint and replace joints on Cut River Bridge. Closed and detoured.

11. **M-28: May-Nov**
    Reconstruct 0.4 miles and reconstruct ramp terminals at I-75 interchange. 1 alternating lane open with traffic signal.

12. **I-75 BS: May-Nov**
    First year of 2-year project. Reconstruct 2.2 miles from 3 Mile Rd ramp to 10th Ave, construct roundabout at Mackinac Trail intersection, 1 lane open in each direction or 1 alternating lane open. Minor overnight detours.

Go to the Mi Drive website for up-to-date traffic information: www.michigan.gov/drive
Go to the Mi Drive website for up-to-date traffic information:
www.michigan.gov/drive

Map current as of February 2018.

See pages 6 and 7 for Metropolitan Detroit and Grand Rapids road repair repair projects.
<table>
<thead>
<tr>
<th>Project Number</th>
<th>Dates</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>US-31: June-July</td>
<td>Resurface 4 miles from south of East Levering Rd to south of Munger Rd. 1 lane open under flag control.</td>
</tr>
<tr>
<td>14</td>
<td>I-75: Apr-Aug</td>
<td>Resurface 12.5 miles from I-75 BL to Sturgeon Valley Rd and from M-68 to North Central State Trail.</td>
</tr>
<tr>
<td>15</td>
<td>M-72: Apr-Nov</td>
<td>Reconstruct and resurface 7.7 miles from Baggs Rd to Kalkaska Rd. Traffic shifts, 1 lane open under flag control.</td>
</tr>
<tr>
<td>16</td>
<td>M-37: Aug</td>
<td>Resurface 2 miles from Vance Rd to north of Chums Corner. Traffic shifts and night work.</td>
</tr>
<tr>
<td>17</td>
<td>US-31: Mar-May</td>
<td>Stabilize roadway at Bear Lake. 1 lane open with temporary traffic signal.</td>
</tr>
<tr>
<td>20</td>
<td>I-75: July-Oct</td>
<td>Resurface 12.7 miles from Maple Valley Rd to north of M-18/I-75 BL. 1-lane and shoulder closures.</td>
</tr>
<tr>
<td>21</td>
<td>I-75: May-July</td>
<td>Diamond grind 4.1 miles northbound lanes from Ski Park Rd to county line. Lane closures with traffic shifts.</td>
</tr>
<tr>
<td>22</td>
<td>M-55/M-33: June-Aug</td>
<td>M-55: resurface 7.9 miles from east of M-33 to Beach Rd. M-33: resurface 1.9 miles from north of Rose City to north of Oyster Rd. 1 lane open under flag control.</td>
</tr>
<tr>
<td>23</td>
<td>US-23: Apr-Oct</td>
<td>Reconstruct 5.7 miles from north of Tawas Beach Rd to south of Kirkland Dr. 1 lane open under flag control.</td>
</tr>
<tr>
<td>24</td>
<td>US-10: Apr-May</td>
<td>Resurface and upgrade sidewalks 0.9 miles from Rowe St to Jackson St. Daytime work, 1 lane open in each direction.</td>
</tr>
<tr>
<td>26</td>
<td>US-10: May-July</td>
<td>Resurface 8.6 miles from Custer east village limit to county line. Daytime work only, 1 lane open under flag control.</td>
</tr>
<tr>
<td>27</td>
<td>M-37: Sept-Oct</td>
<td>Resurface 6.4 miles from 7 Mile Rd to county line. Daytime work only, 1 alternating lane open under flag control.</td>
</tr>
<tr>
<td>28</td>
<td>M-37: June-July</td>
<td>Chip seal 12.5 miles from 44th St to 7 Mile Rd. Daytime work only, 1 alternating lane open under flag control.</td>
</tr>
<tr>
<td>29</td>
<td>M-37: Apr-June</td>
<td>Resurface 0.9 miles from 3rd St to US-10. Daytime work only, 1 alternating lane open under flag control.</td>
</tr>
<tr>
<td>30</td>
<td>US-10 BR (Chestnut St): June-Aug</td>
<td>Resurface 1 mile from Church St to US-10. Traffic shifts, detours and 1 alternating lane open under flag control.</td>
</tr>
<tr>
<td>31</td>
<td>M-66: May-June</td>
<td>Chip seal 15.1 miles from county line to M-115. Daytime work only, 1 alternating lane open under flag control.</td>
</tr>
<tr>
<td>32</td>
<td>US-10: Oct</td>
<td>Resurface 3.3 miles from M-66 to county line. Daytime work only, 1 alternating lane open under flag control.</td>
</tr>
<tr>
<td>33</td>
<td>M-20: Sept-Oct</td>
<td>Improve bridge over Muskegon River. Traffic shifts with 1 alternating lane open under signal control.</td>
</tr>
<tr>
<td>34</td>
<td>US-31: Sept-Nov</td>
<td>Resurface 3.7 miles from Pentwater River north branch to county line. Daytime work only, 1 lane open in each direction.</td>
</tr>
<tr>
<td>35</td>
<td>US-31 BR (Monroe St/6th St): Sept-Oct</td>
<td>Resurface 2.9 miles from US-31 to Wythe St. Daytime work, 1 alternating lane open under flag control.</td>
</tr>
<tr>
<td>36</td>
<td>US-31: May-Oct</td>
<td>Resurface 5 miles from Shelby Rd to Polk Rd. 1 lane open in each direction, intermittent ramp closures.</td>
</tr>
<tr>
<td>37</td>
<td>M-20: July-Aug</td>
<td>Replace culvert over Gillon Lake Drain. Closed and detoured.</td>
</tr>
<tr>
<td>38</td>
<td>US-31: June-Nov</td>
<td>Improve bridge over Muskegon River. Daytime work only, lane closures. 2 lanes open Memorial Day - Labor Day.</td>
</tr>
<tr>
<td>39</td>
<td>M-37: June-Aug</td>
<td>Reconstruct 0.4 miles and improve drainage from Lee St to State St. 1 southbound lane open, northbound lanes closed and detoured.</td>
</tr>
<tr>
<td>40</td>
<td>M-37: Sept-Oct</td>
<td>Resurface 5 miles from State Rd to M-82. Daytime work only, 1 alternating lane open under flag control.</td>
</tr>
<tr>
<td>42</td>
<td>M-46: Sept-Oct</td>
<td>Resurface 5 miles from M-91 to Miles Rd. Daytime work only, 1 alternating lane open under flag control.</td>
</tr>
<tr>
<td>43</td>
<td>US-131: Mar-June</td>
<td>Improve bridge over Cedar Springs Ave. Daytime work only, 1 lane open in each direction. Cedar Springs Rd: 2-way traffic with temporary signals.</td>
</tr>
<tr>
<td>45</td>
<td>M-45 (Lake Michigan Dr): Apr-June</td>
<td>Resurface 4.7 miles from US-31 to M-231. Daytime work only, 1 alternating lane open under flag control.</td>
</tr>
<tr>
<td>46</td>
<td>I-196 BL: July-Oct</td>
<td>Resurface 4.7 miles from US-31 to M-231. Daytime work only, 1 alternating lane open under flag control.</td>
</tr>
</tbody>
</table>

See pages 6 and 7 for Metropolitan Detroit and Grand Rapids road repair projects.
47  US-31: Apr-June
Construct indirect left-turn lanes at Barry St. Daytime work, 1 lane open in each direction.

48  M-40: May-July
Resurface 0.4 miles and realign 64th Ave intersection. Daytime work, 1-lane closures. 64th St closed and detoured during portions of project.

49  M-40: Mar-Nov
Resurface 8.3 miles from 124th Ave to 136th Ave, plus widen from 2 to 3 lanes in front of elementary school. Daytime work only, 1 alternating lane open under flag control.

50  M-89: May-Aug
Replace bridge over Kalamazoo River. Daytime work only, 2-way traffic maintained at all times with temporary signals.

51  US-131: Sept-Oct
Repair concrete joints 1.7 miles from south of 102nd Ave to Grand Elk Railroad. Weekday work only, 1 lane open in each direction. Ramp closures at M-89 on weekends.

52  M-37: May-June
Chip seal 5.5 miles from county line to Groat Rd. Daytime work only, 1 alternating lane open under flag control.

53  M-66: Sept
Resurface 4.8 miles from Cox Rd to Assyria Rd. Daytime work only, 1 alternating lane open under flag control.

54  M-66: Aug
Resurface 4.5 miles from Nashville north village limit to Coats Grove Rd. Daytime work only, 1 alternating lane open under flag control.

55  M-37: June-July
Resurface 2.7 miles from Heath Rd to Golden Ln. Daytime work only, 1 alternating lane open under flag control.

56  M-91: July-Aug
Resurface 2.3 miles from Snows Lake Rd to Sunnyside Ct. Daytime work only, 1 alternating lane open under flag control.

57  M-66: July-Sept
Resurface 1.2 miles from Walnut St to Cedar St. Daytime work only, 1 alternating lane open under flag control.

58  M-66: May-Aug
Resurface 2.6 miles from Frey Dr to Capital Ave/Division St. Convert from 4 to 3 lanes. 1 lane open in each direction.

59  I-194: June-Sept

60  M-96: May-June
Construct right-turn lane at G Ave. 1 lane open under flag control.

61  M-96: Apr-May
Construct left-turn lane at 33rd St. Lane shifts.

62  US-131 BR (Westnedge Ave/ Park St): Apr-Sept
Upgrade sidewalk ramps, resurface 2.5 miles from I-94 BL (West Michigan Ave) to Hopkins St. Lane closures and traffic shifts.

63  M-43: Aug-Oct
Resurface 5 miles from county line to US-131. 1-lane closures.

64  I-94: Aug-Nov
Repair 9th St bridge over I-94. I-94: nighttime lane closures. 9th St: lane closures and traffic shifts. 9th St ramp to westbound I-94 detoured.

65  M-40: Aug-Oct
Resurface 1 mile from south to north Gobles city limits. 1-lane closures.

66  I-94: Mar-Sept
Repave and reconstruct 5.8 miles eastbound lanes from 56th St to M-51. Shoulder/lane closures with traffic shifts.

67  US-31: Apr-June
Seal cracks and joints 8.6 miles southbound lanes from Napier Ave to M-139. 1-lane closures.

68  I-94: Mar-Sept

69  I-94: Sept-Nov
Resurface 3.2 miles from M-239 to Kruger Rd. 1- and 2-lane closures.

70  US-12: May-July
Repair bridge over Galien River. Temporary traffic signal.

71  US-12: July-Oct
Upgrade sidewalk ramps, resurface 0.9 miles from west Edwardsburg village limit to east of M-62. 1 lane open under flag control. Detour in Aug.

72  M-62: Apr-May
Resurface 9.5 miles from north of US-12 to north of Hilton St. 1 lane open under flag control.

73  M-40: Aug-Sept
Improve drainage, resurface 0.1 mile from Prang St to Bair Lake Rd. Detour.

74  M-216: July-Aug
Resurface 10.2 miles from M-40 to US-131. 1 lane open under flag control.

75  M-66: May-Nov
Repair bridges over St. Joseph River and Prairie River. 1 lane open with temporary traffic signals.

76  US-12: May-July
Resurface 5.9 miles from Franks Ave to St. Joseph Rd. 1 lane open under flag control.

77  US-12: May-July
Resurface 9.9 miles from Bronson to Coldwater, remove Indiana Northeastern Railroad bridge west of Coldwater. Closed during bridge removal, traffic detoured on Snow Prairie Rd and M-86. 1 lane open under flag control during resurfacing.

78  I-69 BL: Aug-Oct
Resurface 3.5 miles from Fenn Rd to Clay St, convert from 4 to 3 lanes. 4-lane section: 1 lane open in each direction. 2-lane section: 1 lane open under flag control.

79  I-69: June-Aug
Repair 7 miles north from state line. 1 lane open in each direction.

80  M-60: Aug-Sept
Resurface 8.5 miles between Homer and Tekonsha. 1 lane open under flag control.

See pages 6 and 7 for Metropolitan Detroit and Grand Rapids road repair projects.
81 I-94: May-Oct
Resurface 5.4 miles westbound lanes from 17 1/2 Mile Rd to 21 1/2 Mile Rd. 2 lanes open in each direction during daytime. 1 lane open in each direction overnight.

82 M-99: May-July

83 M-79: Aug-Nov
Resurface 13 miles between M-66 and High St. 1 lane open under flag control.

84 Old US-27: June-Sept
Resurface 1.5 miles between Northcrest Dr and Clark Rd, install a center turn lane at Stoll Rd. 1 lane open in each direction.

85 US-127: June-July
Install 3.1 miles of median cable barrier and guardrail between I-496 and county line. Shoulder closures.

86 I-69 BL (Saginaw Hwy): May-Sept
Resurface 2 miles between Coolidge Rd and Hagadorn Rd, plus ADA upgrades. At least 1 lane open in each direction.

87 Michigan Ave: June-Aug
Repair bridge over the Grand River. Detour posted. 1 direction detoured at a time.

88 I-96: Apr-Nov
Resurface 14 miles between M-52 and M-59, install median cable barrier. 1 lane closed at night. Ramp closures. 1 lane closed 1 direction at a time over 4 weekends (by early July).

89 US-23: May-Sept
Resurface 1 mile between Crouse Rd and Clyde Rd. 1 lane closed in each direction at night.

90 M-99: July-Aug
Chip seal 8 miles from I-94 to Willow St. 1 lane open with flag control.

91 M-52: July-Aug
Resurface 3.9 miles from M-106 to county line. 1 lane open with flag control.

92 M-60: May-June
Resurface 3.4 miles from I-94 to Renfrew Dr. 1 lane open in each direction.

93 M-50/US-127 BR: Apr-June
Repair pavement 1.6 miles from Washington Ave to South St. 1 lane open in each direction.

94 I-94/M-106: June 2018-Dec 2019
I-94: repair pavement between M-60 and Sargent Rd; replace bridges at Cooper St and over the Grand River. 2 lanes open in each direction during daytime. 1 lane closed at off-peak times. M-106: resurface from Porter St to Ganson St. Flag control.

95 US-12: Apr-Oct
Resurface 27.2 miles between US-127 and Quincy (excluding Jonesville). 1 lane open under flag control.

96 M-49/M-99: June-Aug
Repair various railroad crossings. Short-term detours and lane closures.

97 M-156: May-June
Resurface 4.7 miles from Park Dr to Brown Rd. Lane closures with flag control.

98 US-23: May-Sept
Resurface 5.7 miles between Milan and Bemis Rd. 1 lane closed in each direction at night.

99 US-23: May-Sept
Repair pavement 3.7 miles between Ida Center Rd and School St. 1 lane closed in each direction at night.

100 I-69: July-Sept
Resurface 3.8 miles from Taylor Rd to Range Rd. Traffic shift with lane closures.

101 M-25: Apr-June
Replace bridge beam at Howe Drain. Traffic detoured starting early May followed by lane shifts.

See pages 6 and 7 for Metropolitan Detroit and Grand Rapids road repair projects.
I-75 BL (Perry St): Apr-Oct
Repair concrete and resurface 5 miles from M-1 (Woodward Ave) to Harmon Rd. 1 lane open in each direction.

M-59: Aug 2018-2019
Install intelligent transportation system equipment from Paddock St to M-53. Lane closures.

M-59 (Hall Rd): Mar-Sept
Reconstruct 1.2 miles, add left-turn lane and repair bridges from just west of Garfield Rd to just east of Romeo Plank Rd. Lane closures nights and weekends. 3 lanes open at peak times.

US-24 (Telegraph Rd): Aug-Oct
Construct 6 pedestrian refuge islands between James K Blvd and M-59 (Huron St). 1 lane closed in each direction.

I-75: July 2018-2020
Reconstruct and widen 9 miles from north of 13 Mile Rd to Coolidge Hwy. 2 lanes open in each direction via traffic shift.

M-5: Jan-Aug
Construct pedestrian bridge over M-5 between Maple Rd and Pontiac Trail. Nightly lane closures. Closed 2 weekends 1 direction at a time.

I-696: Apr-Nov
Major repair 17.5 miles from I-75 to I-275. Open daytime, 1 lane open weeknights, segments closed over 10 weekends.

I-696: Apr-Nov
Reconstruct 8.3 miles from I-94 to I-75. Westbound lanes closed with eastbound lanes open via traffic shift.

M-1: Mar-Aug
Repair concrete 2.5 miles from 14 Mile Rd to Big Beaver Rd. 1 lane closed at all times, 2 lanes closed nightly. 3 lanes closed over 4 weekends.

M-3: Aug-Oct
Construct median pedestrian island at 9 Mile Rd. Lane closures with 2 lanes open in each direction.

US-24: Apr-July
Mill and resurface from I-96 to Grand River Ave. 1 lane closed. 2 lanes closed middays and nights. 3 lanes closed for 3 weekends.

M-39: July-Nov
Mill and resurface from M-153 to McNichols Rd. 2 lanes closed in each direction nights and 4 weekends. 1 lane and ramps closed nights and weekends.

M-153: July-Sept
Mill and resurface from Lotz Rd to Wayne Rd. Lane closures.

M-153: Apr-June
Mill and resurface 1.8 miles from Fairwood Dr to Vernon Rd. 2 lanes closed middays and nights.

I-96: May-July

M-8: Jan-Sept
Upgrade traffic signals and pedestrian crossings from I-96 to M-10. 1 lane closed middays.

I-94: Jan-Nov

I-94: May 2018-Nov 2019

Grand Ave: Jan-Nov
Repair Douglas MacArthur Bridge. 1 lane closed spring and fall, plus summer weekdays. 2 lanes open each direction summer weekends.

I-75: Mar-Aug
Repair bridges at 14th St, Trumbull Ave, M-3, I-375, Warren Ave, and I-94. Daily and nightly lane closures, nightly and weekend ramp closures.

I-75: 2017-Nov 2018
Concrete and sewer work between Clark Ave and Springwells St. 1 southbound lane open, intermittent northbound lane closures.

I-75: 2017-Dec 2018
Bridge work 17 miles between Springwells St and Gibraltar Rd, including Rouge River, Goddard Rd, Northline Rd, Allen Rd, and Eureka Rd. Southbound lanes closed from Springwells St to US-24 connector. Northbound lanes closed nightly and weekends, at least 2 lanes open during peak periods. 1 northbound lane closed from Sibley Rd to Northline Rd.
133 US-131: Aug

134 I-96: Mar-Oct

135 I-196: Jan 2017-Nov 2019

136 I-96: July 2018-Nov 2019
Construct new eastbound bridge over westbound I-196. Lane and shoulder closures on I-96 and I-196.

137 M-44 (East Beltline Ave): Sept-Nov
Extend northbound dual left-turn lanes at Leonard St. Nighttime work only, 1 lane closed.

138 US-131: Jan-May
Improve bridge over Plaster Creek. Northbound and southbound lanes closed and detoured for 1 weekend each.

139 I-196 BS (Chicago Dr): Sept-Oct
Reconstruct CSX Railroad crossing. 1 lane open in each direction.

140 M-11 (28th St): Sept-Oct
Improve bridge over CSX Railroad and Chicago Dr. Daytime work, 1 lane closed.

141 I-196: Aug-Oct
Construct temporary median crossovers from 32nd Ave to county line. Daytime work, 1 lane open in each direction.

142 M-6: Sept-Dec
Install freeway lighting at Kalamazoo Ave interchange. Daytime work only, lane and shoulder closures.

143 M-37: Sept-Nov
Repair concrete joints 2.2 miles from Patterson Ave to 44th St. 1 lane open in each direction.

Go to the Mi Drive website for up-to-date traffic information: www.michigan.gov/drive
1. **US-41: May-July**
   Reconstruct Front St from Portage Lake Lift Bridge to Reservation St. 1 lane open in each direction.

2. **US-2: May-Sept**
   Resurface 5.2 miles from Oss Rd to US-141 in Crystal Falls. 1 alternating lane open under flag control.

3. **US-2/M-95: May-Sept**
   Reconstruct US-2/M-95 intersection. 1 lane open in each direction with intermittent flag control.


5. **US-41: May-Sept**
   Resurface 1 mile from Iroquois Dr to west of Teal Lake Ave, with drainage improvements, curb and gutter. 1 lane open in each direction.

6. **M-553: Apr-Oct**
   Reconstruct 1 mile and realign curves north of County Rd 480 to Marquette Mountain Ski Hill. 1 alternating lane open under flag control.

7. **US-41: May-Oct**
   Construct 2 roundabouts at Grove St and Hospital Access Dr. 1 lane open in each direction with local road detour.

8. **M-94: Mar-July**
   Construct new bridge over Chocolay River, west of US-41. Detour.


10. **M-123: June-Sept**
    Construct concrete culvert over Black Creek. 1 alternating lane open with temporary traffic signal.

11. **US-2: July-Nov**
    Repair structural steel and replace joints on Cut River Bridge. 1 alternating lane open with a temporary traffic signal during joint replacement. Detour for structural steel repairs.

12. **I-75 BL: May-Nov**
    Reconstruct 1 mile from Grondin Rd to Mackinac Trail in St. Ignace. 1 lane open in each direction during non-working hours. 1 alternating lane open under flag control during working hours.
2017 PAVING THE WAY
Road Repair Projects

Go to the Mi Drive website for up-to-date traffic information and to download the free Mi Drive app: www.michigan.gov/drive

Map current as of February 2017.
13 **US-23: June-Aug**
Resurface 10.6 miles from Little Black River to Mill Creek Discovery Park. 1 lane open under flag control.

14 **US-23: Jan-May**
Repair bridge over Cheboygan River. Single-lane closures.

15 **US-31: Apr-Oct**
Reconstruct 4 miles from Douglas Lake Rd to E Levering Rd. Detour and flag control.

16 **US-31: Jan-May**
Repair bridge over Pine River in Charlevoix. Traffic shifts; detour on 12 consecutive nights.

17 **US-131: Sept-Nov**
Resurface 4.2 miles from Bear River Rd to Lears Rd. 1 lane open under flag control.

18 **M-32/I-75 BL: July-Sept**
Resurface 1.8 miles from Wisconsin St to Hayes Rd and M-32 to Grandview Blvd in Gaylord. Lane closures with traffic shifts.

19 **US-23: Apr-June**
Resurface 2 miles from Island Dr to Thunder Bay Ave in Alpena. Lane closures with traffic shifts.

20 **M-22: May-Aug**
Repair pavement and resurface 12.7 miles between Glen Arbor and Leland. 1 lane open under flag control.

21 **M-22: Sept-Nov**
Repair concrete joints 8.8 miles near Sutons Bay. 1 lane open under flag control.

22 **US-31: Feb-June**
Resurface Murchie Bridge deck in Traverse City. Lane closures with traffic shifts.

23 **US-31: Sept-Nov**
Resurface 2.1 miles from 3 Mile Rd to Garfield Ave. Lane closures with traffic shifts.

24 **M-72: May-Aug**
Resurface 16.9 miles between Kalkaska and Grayling. 1 lane open under flag control.

25 **M-72: Aug-Sept**
Resurface 11.8 miles from Industrial Dr to Keystone Landing Rd and east of Stephan Bridge Rd to M-18. 1 lane open under flag control.

26 **Old US-131: Apr-Oct**
Reconstruct 5.8 miles between Cadillac and Manton. Detour.

27 **I-75: Mar-Nov**
Reconstruct 6.5 miles from south Ogemaw County line to Cook Rd. Lane closures; Cook Rd ramp nighttime closures.

28 **M-115: Sept-Oct**
Improve intersection at 20 Mile Rd. Lane closures under flag control.

29 **M-20: June**
Resurface 0.6 miles from Winter St east to Greenback St. Lane closures.

30 **M-20: July-Aug**
Chip seal 20.5 miles from 144th Ave east to Winter St, and from Greenback St east to M-37. Daytime lane closures under flag control.

31 **US-131: Mar-Aug**
Reconstruct 3.5 miles from M-46 north to Montcalm/Mecosta county line. Lane closures.

32 **US-31: Sept-Oct**
Resurface 11.3 miles from C&O Railroad north to Fruitvale Rd. Lane closures.

33 **US-31 BR (Colby St/Thompson St): Apr-June**
Resurface and reconstruct 1.2 miles from White River bridge to east of Hall St. Lane closures with a detour.

34 **M-120: June-Aug**
Construct center left-turn lane and resurface 0.7 miles from Whitehall Rd to Mid-Michigan Railroad. Lane closures, westbound M-120 detoured.

35 **US-131: Sept**
Resurface 4.2 miles from Kent/Montcalm county line north to Cannonsville Rd. Lane closures.

36 **M-46: June**
Chip seal 9 miles from Neff Rd to Montcalm/Gratiot county line. Lane closures under flag control.

37 **M-37: Aug-Nov**
Resurface 10.1 miles from Sparta Ave north to M-37/M-46 roundabout. Lane closures under flag control.

38 **US-131: Apr-Nov**
Improve bridges at M-46 and over White Creek Ave, reconstruct 3.6 miles from 14 Mile Rd to White Creek Ave. Lane closures with a traffic shift.

39 **M-44 (Belding Rd): Mar-Sept**
Reconstruct 1.2 miles from Wolverine Blvd to Blakely Dr, add 1.3-mile center left-turn lane from Blakely Dr to Myers Lake Ave. Lane closures under flag control, detour.

40 **I-96: July-Aug**
Resurface 4.3 miles from 112th Ave to 68th Ave. Weekday lane closures.

41 **US-31: Sept-Oct**
Construct indirect left-turn lanes at Bingham St. Weekday lane closures.

42 **US-131: June-Aug**
Improve bridge at 84th St. Lane closures.

43 **M-37 (Middleville Rd): June-July**
Resurface 1.7 miles from Timber Creek Dr to south Middleville village limit. Lane closures under flag control.

44 **I-96: May**
Improve bridge at Peake Rd. Lane closures, traffic shift. Peake Rd detoured.

45 **M-66: May-June**
Resurface 4.3 miles from Calhoun/Barry county line north to Cox Rd. Lane closures under flag control.

46 **Blue Star Hwy: April-June**
Reconstruct bridge over Black River in South Haven. Closed and detoured.

47 **I-196 BL: May-June**
Repave and widen intersection at Blue Star Hwy in South Haven. 1 lane open.

48 **I-196: Apr-May**
Repave 2.5 miles southbound lanes from Van Buren Trail south. 1 lane open during day.

49 **M-140: July-Aug**
Repair concrete between Watervliet and South Haven. Northbound lanes closed and detoured. 1 southbound lane open.

50 **I-94: Mar-Aug**
Resurface 3.8 miles eastbound lanes from Hennesey Rd to east of Van Buren County line in Watervliet. 1 lane open at all times, 2 lanes open at peak times.

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See pages 5 and 6 for Metropolitan Detroit and Grand Rapids road repair projects.

Michigan’s Lower Peninsula
51  I-94: Mar-Sept  
Repave 7 miles eastbound lanes from Bridgman Exit 16 to Red Arrow Hwy Exit 23 in Stevensville. 2 lanes open during day, 1 lane open at night.

52  M-139/M-63: June-Aug  
Repave M-139 in Niles and M-63 in St. Joseph. 1 lane open under flag control in each area.

53  M-51: May-Aug  
Repave from Dowagiac to Decatur. 1 lane open under flag control.

54  M-40: Apr-May  
Repave 4 miles from Gobles to Allegan County line. 1 lane open under flag control.

55  I-94: May-Aug  
Reconstruct westbound bridge over east branch of Paw Paw River in Paw Paw. 2 lanes open in each direction.

56  US-12: Apr-Aug  
Replace culvert over Deer Creek in Three Oaks, 1 alternating lane open with temporary traffic signal.

57  M-66: May-July  
Resurface 7.5 miles from Lafayette St to M-86 (Centreville Rd) near Sturgis. 1 lane open under flag control.

58  M-43 (W Main St): May-Nov  
Repave 4.7 miles from US-131 to Pitcher St in Kalamazoo. 1 lane open. September: Closures and detours for railroad crossing replacement.

59  I-94 BL (E Michigan Ave): Apr-May  
Install traffic signal at Harrison St in Kalamazoo. 1 lane open in each direction.

60  M-96 (King Hwy): May-July  
Repave 2.5 miles from Kalamazoo River to Michigan Ave in Comstock. 1 lane open under flag control.

61  M-96 (Augusta Dr): June-Sept  
Resurface 7.9 miles between Augusta and Galesburg. 1 lane open under flag control.

62  I-94: Apr-June  
Repave 7.4 miles eastbound lanes from east of Sprinkle Rd Exit 80 to 40th St Exit 88 in Kalamazoo. 1 lane open at night, 2 lanes open during the day.

63  M-66: Aug-Nov  
Repave 2.7 miles from Glen Cross Rd to D Dr S in Battle Creek. 1 lane open under flag control.

64  M-66: May-July  
Repair and resurface 3.9 miles from S Dr S to L Dr S. 1 lane open under flag control.

65  M-60 (Mendon Rd): July-Nov  
Resurface 8.6 miles from Hacker Rd to 8 Mile Rd. 1 lane open under flag control.

66  M-99 (S Superior St): Apr-Nov  
Reconstruct 0.4 miles from Ash St to Vine St in Albion. Closed and detoured.

67  M-21: May-Sept  
Resurface 13.7 miles from Ionia County line to St. Johns. 1 lane open under flag control.

68  US-127: May-Sept  
Resurface 17.2 miles from Henry Rd to M-36. 1 lane open in each direction.

69  I-94: May-Aug  
Patch concrete 7.4 miles from west of Michigan Ave to M-60. 1 lane closed 10am Mondays-2pm Thursdays.

70  I-94 BL/M-50 (Michigan Ave): Apr-Nov  
Reconstruct 1.2 miles from Brown St to Louis Glick Hwy/Washington Ave split, upgrade for 2-way traffic from split to Cooper St in downtown Jackson. 1 lane open in each direction, westbound detour.

71  M-50: Apr-Oct  
Resurface 6 miles from US-127 to Napoleon Rd. Flag control. All lanes open during race weekends at MIS.

72  M-52: Apr-July  
Add center left-turn lane at Siena Heights Dr in Adrian. 1 lane open in each direction.

73  M-52: July-Sept  
Install roundabout at Church St/State St in Adrian. 1 lane open in each direction, southbound detour.

74  US-23: Nov 2016-Dec 2017  
Upgrade shoulders, replace and repair bridges, extend ramps, and resurface 10.5 miles from M-14 to Silver Lake Rd. 2 lanes open in each direction during peak times. Short-term ramp and bridge detours.

75  US-23: May-Oct  
Resurface 6.9 miles from the Macon River to Plank Rd. 1 lane open in each direction.

76  I-75: May-Oct  
Patch concrete 11 miles from state line to Laplace Rd. Daytime single-lane closures; nighttime and weekend double-lane closures.

77  I-69: Aug-Oct  
Reconstruct 3 miles from east of Ballenger Hwy to west of Fenton Rd, including ramps. Remove pedestrian bridge. Traffic shifts and lane closures.

78  M-24: May-Aug  
Resurface 1.6 miles from Nepessing St to north of Davis Lake Rd. Traffic shifts and lane closures.

79  I-75: Apr-Sept  
Repair and resurface 13 miles from I-475 to Birch Run Creek. Traffic shift with lane closures.

80  M-15: July-Nov  
Resurface and patch concrete 6 miles from M-46 to south of Vassar, widen to construct center left-turn lane from north of city limit to Cottrell Rd. Traffic shift with lane closures.

81  M-142: Mar-Aug  
Repair and resurface 6.2 miles from M-19 to Johnston Rd. 1 alternating lane open with traffic shifts.

82  I-75/I-675: Apr-Nov  
Reconstruct 1 mile of I-75 and I-675 at north junction. Lane closures and traffic shifts.

83  US-10/M-25: June-Aug  
Resurface 12.6 miles of US-10/M-25 from Bay/Midland county line to west of Bay City. Traffic shifts and lane closures.

84  I-75: Apr-Oct  
Repair and resurface 1.9 miles from Cottage Grove Rd to East Anderson Rd. Shoulder/lane closures and traffic shifts.

85  US-127: Mar-Aug  
Resurface 2.8 miles from Van Buren Rd to Begole Rd. Traffic shift with lane closures.

86  US-127 BR: May-July  
Construct roundabout at North Mission Rd in Mt. Pleasant. Detours, shoulder/lane closures and traffic shifts.

See pages 5 and 6 for Metropolitan Detroit and Grand Rapids road repair projects.
M-59 (Highland Rd): June-Oct
Repair 1.8 miles from Pontiac Lake Rd to Airport Rd. Night and weekend lane closures.

I-75: May-Sept
Reconstruct 3.1 miles from Coolidge Hwy to South Blvd, including Square Lake Rd interchange. 2 lanes open in each direction with temporary crossovers. Ramp closures within interchange, including Adams Rd.

Old M-59 (Auburn Rd): Apr-Oct
Widen 1 mile from Crooks Rd to Livernois Rd, add right-turn lanes at other intersections between Livernois Rd and Dequindre Rd. Auburn Rd: 1 direction maintained between Crooks Rd and Livernois Rd on other segments via traffic shifts and staging.

M-59 (Hall Rd): Mar 2017-Oct 2018
Reconstruct 3.8 miles, add left-turn lane and repair bridges from M-53 to just east of Romeo Plank Rd. Lane closures for day and night work. 3 lanes open during daytime work, 2 lanes open during nighttime work.

I-94: May-June
Resurface 6.1 miles from South River Rd to 23 Mile Rd. Lane closures for night work.

M-5: May-June
Repair 3.1 miles from 12 Mile Rd to Pontiac Trail. Closed 1 direction at a time.

I-696: Feb-Oct
Upgrade freeway signs 20.2 miles from I-275 to Dequindre Rd. Intermittent single-lane closures, multiple lane closures possible during off-peak hours. 1-week eastbound lane closure over Pebble Creek.

Old I-96 (Grand River Ave): Apr-Oct
Resurface 4.5 miles from M-5 to Purdue St; 1-way traffic between Shiawassee St and Farmington Rd. Night and weekend lane closures, intermittent short-term road closures and detours.

M-102 (8 Mile Rd): May-Nov
Repair bridge and substructure over I-75. Lane closures.

M-3 (Gratiot Ave): May-Aug
Resurface 3 miles, improve drainage and upgrade sidewalk ramps from 8 Mile Rd to 11 Mile Rd. Lane closures for night work; daytime intermittent lane closures.

M-8: Apr-July
Repair Charest St bridge over M-8. M-8: 1 lane closed daily.

M-10: Apr-July
Repair Calvert Ave bridge over M-10. M-10: 1 lane closed daily.

I-75: Apr-Nov
Resurface 1.4 miles northbound lanes between Canfield St and Piquette St. Nighttime and weekend lane closures. 1 lane open up to 4 weekends. Northbound ramp to I-94 closed 1 weekend.

M-10: Apr-Oct

I-75/M-10: Apr-Oct
Replace I-75 bridge deck and repair substructure over M-10, including ramps. I-75: closed for 3 weeks. M-10: lane and shoulder closures.

M-85: Apr-Oct
Resurface bridge over M-10. 1 lane open in each direction.

I-75: Aug-Oct
Replace 2 miles of concrete on southbound lanes from Clark Ave to Springwells St.

I-75: Feb 2017-Dec 2018
Replace and repair concrete 17 miles from Springwells St to Gibraltar Rd. Includes replacing concrete on Rouge River bridge, replacing bridges over Goddard Rd, and repairs to West Rd and Gibraltar Rd bridges. Southbound lanes: closed from Springwells St to Northline Rd. Northbound lanes: lane closures.

Old M-14 (Plymouth Rd): Apr-Sept
Resurface 4.8 miles from Farmington Rd to US-24 (Telegraph Rd). Intermittent lane closures. 1 lane open in each direction.

I-94: Apr-June
Replace concrete 1 mile on eastbound collector-distributor lanes from Merriman Rd to Middle Belt Rd. Closed. Access to Detroit Metro Airport maintained at all times.

M-85: Apr-June
Replace southbound bridge over Marsh Creek, near Vreeland Rd. 1 lane open at all times.
**Map current as of February 2017.**

**US-131: June-Sept**
Upgrade lighting from M-11 (28th St) to I-96. Off-peak lane closures.

**I-196: Jan 2017-Oct 2019**
Widen westbound bridge over the Grand River near US-131. Lane and ramp closures.

**M-44 (East Beltline Ave): Sept-Nov**
Resurface 2.8 miles from I-96 to 3 Mile Rd. Nightly lane closures.

**M-21 (Fulton St): July-Sept**
Repair concrete joints from M-37 (East Beltline Ave) to I-96. Lane closures with a detour.

**M-6: June-Nov**
Repair and rebuild 3 miles from Jackson St east to Wilson Ave. Closed and detoured.

**US-131: May-Aug**
Concrete joint work 11.7 miles from 76th St to 44th St, and from North Park St to 10 Mile Rd. Nightly lane closures.
1. **US-2: June-Aug**
   Resurface 4 miles between Ironwood and Bessemer. Lane closures.

2. **M-28: June-Sept**
   Bridge work over Presque Isle River. 1 alternating lane open with a temporary traffic signal.

3. **US-41 (Front, Reservation and Quincy St): Apr 2016-July 2017**
   Reconstruct US-41 from Portage Lake Lift Bridge to M-203. Traffic detoured to Hancock St with local access on Quincy St and Reservation St. Front St: 1 lane open in each direction.

4. **US-2: May-Sept**
   Resurface 3.1 miles between Bates-Amasa Rd and East Emily Lake Rd. 1 alternating lane open under flag control.

5. **US-41/M-28: Apr-Oct**
   Construct roundabout at US-41/M-28 and Second St intersection, resurface US-41/M-28 from Second St to Malton Rd, and reconstruct Second St and Third St. US-41: 1 lane open in each direction. Local streets: posted detours.

6. **M-553: June-Aug**
   Resurface from M-35 to CR 480. 1 alternating lane open under flag control.

7. **US-2: May-June**
   Resurface 10.1 miles from Dickinson County line to US-41. 1 alternating lane open under flag control.

8. **M-123: May-Nov**
   Resurface 3.7 miles, repair joints, install new curb and gutter from M-28 to Railroad St. M-123: 1 alternating lane open under flag control from M-28 to Hamilton Lake Rd and from Ave C to Truman Blvd. 1 lane open in each direction throughout rest of the project.

9. **US-2: June-Nov**
   Mill and resurface 4.4 miles from I-75 to Martin Lake Rd. US-2: 1 lane open in each direction, except near Martin Lake Rd (1 alternating lane open under flag control).
Go to the Mi Drive website for up-to-date traffic information and to download the free Mi Drive app: www.michigan.gov/drive

Map current as of March 4, 2016.
Replace Little Black River bridge. 1 lane open under temporary traffic signal.

Resurface 7.2 miles from south of Milton Rd to south of Douglas Lake Rd. Lane closures with flag control and traffic shifts.

12. M-33: Feb-Sept

13. US-23: May-June
Chip seal 11.6 miles from Ocqueoc Rd north to Presque Isle County line. 1 lane open under flag control.

Reconstruct 6.4 miles from M-32 to south of Boyne Falls. 1 lane open under flag control.

15. I-75: Sept-Oct
Resurface 4.5 miles (northbound) and 2.9 miles (southbound) from south of Charles Brink Rd to M-32. 1 lane open in each direction.

Resurface 8.1 miles from Alpena/Alocona county line north to Cranberry Creek. 1 lane open under flag control.

17. M-115: Mar-Sept
Reconstruct 6.4 miles from Frankfort to US-31. 1 lane open under flag control.

18. M-72/I-75 BL: Mar-July
Repair M-72/I-75 BL AuSable River bridge. Passenger vehicle detour on city streets; commercial vehicle detour on I-75.

19. M-113: May-Sept
Reconstruct 5.1 miles from north of M-186 to US-131. 1 lane open under flag control.

Resurface 5.6 miles from south of M-42 interchange to north of Old 131 crossover. 1 lane open in each direction.

Reconstruct 1.4 miles from south of Jennings Rd to north of 1st St. 1 lane open under flag control.

22. M-55/I-75 BL: July-Oct
Reconstruct 1 mile from Gray Rd to Green Rd. Lane closures with traffic shifts and 1-way detour.

23. M-66: June
Resurface 5.7 miles from just north of M-115 to 21 Mile Rd. Traffic shifts and single-lane closures under flag control.

24. US-10: July-Aug
Resurface 5.8 miles from 180th Ave to Patterson Ave. Traffic shifts and single-lane closures under flag control.

25. US-131 BR (Northland Dr): July-Aug
Resurface 3.5 miles from M-20 (Maple St) to 19 Mile Rd. Single-lane closures under flag control.

Resurface 2 miles from 17 Mile Rd to 19 Mile Rd. Traffic shifts and single-lane closures under flag control.

27. US-131: Apr-Aug
Reconstruct 7.4 miles of northbound lanes from 6 Mile Rd to 13 Mile Rd. Lane closures 7 a.m. Sundays to noon Fridays.

28. US-31: Apr-Sept
Resurface 5.5 miles from Fruitvale Rd to Winston Rd. Single-lane closures. All lanes open on weekends starting July 1.

29. M-82: July-Aug
Chip seal 15 miles from M-37 to US-131. 1 alternating lane under flag control.

Resurface 2.3 miles from US-131 to Federal Rd, construct a center-left turn lane from US-131 to Edgar Rd. Traffic shift with lane closures.

31. US-131: July-Aug
Resurface 5 miles from White Creek Ave to Kent/Montcalm county line. Off-peak lane closures.

32. US-131: Sept-Nov
Construct temporary median crossovers and widen shoulders from 10 Mile Rd to M-46 (17 Mile Rd) for upcoming reconstruction. Lane closures.

33. M-37 (Alpine Ave): Aug-Oct
Resurface 6.5 miles from Alpenhorn Dr to Sparta Ave. Lane closures.

34. US-31: Mar-June

35. I-96: July-Aug
Repair eastbound bridge over Crockery Creek tributary. Single-lane closures.

36. US-31: Mar-Nov
Reconstruct 4 miles from 8th St to Quincy St and add a through-lane in each direction from Lakewood Blvd to Quincy St. Traffic maintained via crossovers.

37. I-96: Sept-Oct

38. M-21 (Fulton St): Apr-June
Resurface 2.3 miles from Valley Vista Dr to Kent/onia county line, construct right-turn lane at Hudson St. Single-lane closures under flag control.

39. I-96: June-Aug

40. M-66: Sept-Oct
Resurface 4.5 miles from Portland Rd to Sprague Rd. Single-lane closures under flag control.

41. M-43: June
Resurface 8 miles from Usborne Rd to M-66. Single-lane closures under flag control.

42. I-196/US-31: July-Oct
Repair bridges over Old Allegan Rd. 1 lane open in each direction on I-196/US-31; 1 alternating lane on Old Allegan Rd.
M-89: May-July
Resurface 2.2 miles from Kalamazoo St to 12th St. Lane closures.

US-131: Apr-July
Reconstruct 0.8 miles from 106th Ave to 110th Ave, repair bridges over Gun River. 1 lane open in each direction.

M-140: Mar-June
Resurface 7.2 miles from Watervliet to CR 378 (32nd Ave). 1 lane of alternating traffic under flag control.

M-63: June
Concrete joint resealing 1.1 miles from St. Joseph River to Higman Park Rd. 1 lane open in each direction. Short-duration closure of ramp to Whitmore Dr.

I-94: Mar-Oct
Resurface 7.4 miles from Red Arrow Hwy to Puetz Rd, repair bridges over Lost Dunes Dr and Puetz Rd. 2 lanes open in each direction during peak hours, minimum 1 lane open all other times. Ramp closures with posted detours. Puetz Rd: closed with posted detour. Lost Dunes Dr: 1 lane of alternating traffic.

US-31: Apr-Nov
Bridge painting over St. Joseph River. 1 lane open in each direction.

US-12: June-July
Chip seal 12 miles from Galien River to Dayton Rd. 1 lane of alternating traffic under flag control.

M-51: July-Aug
Resurface 5.7 miles from Decatur to I-94. 1 lane of alternating traffic under flag control.

I-94: Aug-Sept
Repair pavement 2.9 miles from MM 58 to 61. Nighttime single-lane closures.

I-94: May-July
Replace bridge over east branch of Paw Paw River. 2 lanes open in each direction during peak hours, minimum 1 lane open all other times.

M-40/M-43: June-Aug
Resurface 4.6 miles of M-40 from Paw Paw to M-43, and 5.2 miles of M-43 from M-40 to Kalamazoo County line. 1 lane of alternating traffic under flag control. Resurface carpool lot at M-40/M-43; closed.

US-12: May-Sept
Construct roundabout at Five Points Hwy, Old M-205 and US-12; includes drainage work. US-12: 1 lane open in each direction. Five Points Hwy and Old M-205: posted detours.

US-131: Mar-Aug
Resurface 6.6 miles from U Ave to I-94. 1 lane open in each direction. Work at night and on weekends. Ramp closures at Centre Ave, I-94, and Shaver Rd with posted detours. Centre Ave and 12th St open.

I-94: Sept-Oct
Resurface 8.1 miles from ML Ave to Michigan Ave. 2 lanes open in each direction during peak hours, 1 lane open in each direction all other times.

I-94: Mar-Sept
Reconstruct interchange and replace bridges at 40th St; some night work. 2 lanes open in each direction during peak hours, 1 lane open in each direction all other times. Ramp closures with posted detours. 40th St and Michigan Ave open, except during short-duration posted detours.

M-86: July-Nov
Replace bridge over Prairie River. Detour on Shimmel Rd, Featherston Rd and M-66.

US-12: July-Oct
Replace bridge east of the city of Bronson. Detour: M-66 in Sturgis and M-86 in Coldwater.

I-94 BL (Dickman Rd): June-July
Widen roadway for turn lane at Riverside Dr; includes drainage work. I-94 BL: 1 lane closed in each direction. Local road closures with posted detour.

M-49: July-Sept
Resurface 18.6 miles from state line to US-12. 1 lane open under flag control.

M-99: June-July
Resurface 13.6 miles from state line to just north of M-34. 1 lane open under flag control.
73 I-94: June-Sept

74 M-50/US-127 BR (West Ave): Apr-Sept
Reconstruct from Michigan Ave to Wildwood Ave (July-Sept) and from Ganson St to North St (Apr-June). Closed and detoured.

75 M-50 (Brooklyn Rd): May
Resurface 1.2 miles from Napoleon Rd to Stoney Lake Drain. 1 lane open under flag control.

76 M-52: July-Aug
Resurface 4 miles between Morton Rd and M-36. 1 lane open under flag control.

77 I-96: Apr-June
Patch concrete, repair shoulders and ramps 6.5 miles between M-52 and Fowlerville Rd. 1 lane open in each direction during off-peak hours and during 4 summer weekends. Ramp closures with a detour.


79 M-52: June-Nov

80 M-14: Mar-Aug
Repair pavement and bridges between I-94 and US-23/M-14 interchange. M-14 closed between Miller Rd and US-23 BR (Main St). M-14 access to US-23 BR (Main St) maintained, along with access to Miller Rd/Maple Rd interchange.

81 US-23: June-Sept
Repair pavement 8.1 miles between Ida Center and Macon Creek. 1 lane closed in each direction.

82 US-12: Apr-Nov
Reconstruct in Saline. 1 westbound lane open; eastbound detoured between Monroe St and Maple Rd.

83 I-94: May-Aug
Patch pavement 2.4 miles between east junction of US-12 to Rawsonville Rd. Nighttime and weekend single-lane closures.

84 I-75: May 2015-Sept 2016
Reconstruct southbound lanes between I-275 and Dixie Hwy. 2 lanes open in each direction on northbound side using median crossovers.

85 I-69: Apr-Aug

86 M-25: Aug-Nov
Reconstruct bridge over Mill Creek. Traffic detoured.

87 M-24: Aug-Oct
Resurface 5.2 miles from Davison Lake Rd to Pratt Rd; lane shifts and flag control. Most work overnight.

88 I-69: Mar-Oct
Repair 14 bridges; lane closures, traffic shifts, and detours.

89 M-54: May-June
Mill and resurface 2.2 miles from I-69 to Leith St. 1 lane open in each direction using lane shifts.

90 I-475: Apr-July
Repair 2 bridges over Atherton Rd, repair concrete 1.2 miles from Bristol Rd to Atherton Rd. Lane closures and detours.

91 I-75: July-Oct
Construct a roundabout at Bristol Rd. Resurface and repair ramps between Torrey Rd and Van Slyke Rd. Temporary ramp closures. Bristol Rd: at least 1 lane open in each direction with lane shifts and temporary signals.

92 I-75: Apr-Oct
Repair 13.3 miles of southbound lanes from Birch Run Creek to I-475. Days: 2 lanes open with traffic shifts. Nights: potential for only 1 lane open.

93 I-75: Apr-May
Resurface approach and bridge deck on southbound bridge over CSX RR. Shoulder and double-lane closures. Work to be completed prior to Memorial Day.

94 I-75: Apr-Nov
Reconstruct and widen 3.8 miles of northbound lanes from Dixie Hwy to Hess Ave. Maintain at least 3 lanes in peak direction, 2 lanes in non-peak direction.

95 M-57: Feb-Nov
Reconstruct bridge over Shiawassee River; 1 lane of alternating traffic with temporary signals. Replace culvert at Deer Creek; traffic detoured.

96 I-75: July-Nov
Remove Crane Rd bridge. Prep work to reconstruct 1.7 miles from I-675 to Crane Rd in 2017.

97 US-23: Mar-July
Repair bridge over AuGres River. 1 lane of alternating traffic under temporary signals.

98 I-75: July-Nov
Mill and resurface 6.4 miles from Bay/Arenac county line to Lincoln Rd. Weekdays: 1 lane open in each direction using lane shifts. Weekends: 2 lanes open in peak direction.

99 M-18: Apr-Nov
Mill and resurface 5.8 miles from US-10 to Coolidge Rd, including pavement joint repairs. Southbound traffic detoured.

100 US-127: Mar-Nov
Resurface 5.5 miles from Washington Rd to Van Buren Rd. 1 lane open in each direction with traffic shifts.

101 US-10: May-Aug
Reconstruct bridge over Chippewa Creek. 1 lane of alternating traffic under temporary signals.
102 I-75: Apr-Sept
Resurface 5 miles between Giddings Rd and Clintonville Rd. Nightly double-lane closures; 4 weekends of double-lane closures for concrete patching.

103 M-24: Mar-Nov

104 M-150: June-Sept
Reconstruct intersection at Avon Rd. M-150: 1 lane open in each direction. Avon Rd: eastbound lanes closed at M-150 during first stage, then westbound lanes during second stage.

105 I-75: June 2016-Nov 2017
Reconstruct and widen 3 miles from north of Coolidge Rd to South Blvd. Reconstruct Squirrel Rd, Adams Rd, Square Lake Rd, and I-75 BL/Square Lake Rd bridges. 2 lanes open in each direction. Ramp closures at Adams Rd, Square Lake Rd, and M-59 interchanges.

106 M-97: May-June
Resurface between 16 Mile Rd (Metro Pkwy) and M-59 (Hall Rd). Night work and daytime shoulder work.

107 I-696: Spring-Fall
Install fiber cable along 20 miles between I-275 and M-10, and I-75 and I-94. Shoulder, lane and ramp closures middays and weekends.

108 I-696: Apr-Nov
Repair drainage system on plaza near Greenfield Rd over I-696. Plaza, Church St and park: closed. I-696: single-lane closures between Church St and Lincoln St middays and weekends, intermittent ramp closures.

109 I-75: July-Aug
Apply high-friction surface treatment on northbound lanes at Gardenia Ave. 2 weekends of double-lane closures.

110 I-96/L-275/I-696/M-5: Mar-Nov

111 I-75: Apr-Sept
Repave 1 mile between 7 Mile Rd and 8 Mile Rd. Night work; multiple lane and ramp closures.

112 M-10: Apr-June
Reconstruct retaining wall between Meyers St and McNichols Rd. Southbound right lane and service drive closed.

113 Evergreen Rd: Apr-Oct
Resurface 1 mile, including bridge over I-96. 1 lane open in each direction; closed over I-96 for 1 weekend near project completion.

114 M-39: May-Sept
Repair 5 miles between south of I-94 and south of M-153 (Ford Rd). Multiple lane and ramp closures during nights and weekends.

115 I-94: Mar-Nov

116 M-1: Jan-Nov
Reconstruct 3 miles between Adams Rd and Bethune Rd for M-1 RAIL. 1 lane open in each direction.

117 M-3 (Gratiot Ave): Apr-July
Resurface intersection at Randolph Ave during weekends with detours.

118 I-94: Mar-Nov
Resurface 5.6 miles of I-94 between Wayne Rd and Beech Daly Rd. Multiple lane and ramp closures during night and weekends.

119 M-85: Mar-Sept
Replace bridges over Marsh Creek, near Vreeland Rd, and Frank and Poet Drain. 1 lane open in each direction, traffic shifts.

Go to the Mi Drive website for up-to-date traffic information and to download the free Mi Drive app: www.michigan.gov/drive
Map Explanation

- **FREeway**
- Paved (two or more lanes) and multi-lane divided
- **EATOn**
- **CounTy Line and Name**
- **AREA of CONSTRUCTION**
- **CONSTRUCTION PROJECT**
- Interstate Business Loop or Spur
- U.S. Route or B.R. (B.R. - Business Route)
- State Route or B.R. (B.R. - Business Route)

Go to the Mi Drive website for up-to-date traffic information and to download the free Mi Drive app: www.michigan.gov/drive

### Grand Rapids Area

**120 I-96: June-Sept**
Repair Cheney Ave bridge over I-96. I-96: weekend and nightly lane closures. Cheney Ave: closed and detoured.

**121 US-131: Apr-Oct**
Construct southbound weave/merge lane from Ann St to Leonard St, repair pavement from Ann St to Pearl St. Traffic shifts and lane closures. Ramps and local roads closed and detoured.

**122 US-131 BR (Leonard St): July-Sept**
Repair bridge over the Grand River. Closed and detoured.

**123 US-131 BR (Division Ave/Leonard St): Sept-Oct**

**124 US-131: July-Aug**
Construct right-turn lane on southbound off ramp to Market Ave. Ramp closed and detoured.

**125 US-131: July-Aug**

**126 US-131: June-Aug**
Repair concrete joints 2.8 miles from 28th St to Wealthy St. Multiple-lane closures.

**127 I-196: June-Sept**
Repair bridge over Butterworth St and Kent Trails. Single-lane closures.

**128 I-96: Mar-Oct**
Replace bridge and reconstruct interchange at Cascade Rd. Traffic shifts and single-lane closures.

**129 I-196: June-Sept**
Reconstruct westbound off ramp to M-11. Ramp closed and detoured.

**130 M-121 (Chicago Dr): July-Aug**
Resurface 3.6 miles from Rush Creek to Ottawa/Kent county line. Single-lane closures.

**131 US-131: July-Aug**
Repair 36th St and 54th St bridges over US-131. US-131: lane closures. 36th St and 54th St: open.

**132 M-11 (28th St): June-Sept**
Repair bridge over Plaster Creek. Off-peak lane closures.
44 M-14 BL (Stadium Dr): Apr-Sep

43 M-9: Apr-Oct
Reconstruct bridge over US-131 at Midland. Lane closures under flag control.

42 M-10: Mar-Oct
Reconstruct section of US-10 from US-10 to I-75. 1 lane maintained at all times. Nighttime lane closures.

41 M-8: Aug-Oct
Reconstruct 1.1 miles from east of I-75 to north of US-10. 1 lane maintained at all times. Nighttime lane closures.

40 M-7: Jul-Oct
Reconstruct 0.3 miles from east of US-23 to north of US-10. 1 lane maintained at all times. Nighttime lane closures.

39 M-6: May-Oct
Reconstruct 1 mile from M-50 to US-10. 1 lane maintained at all times. Nighttime lane closures.

38 M-5: Apr-Oct

37 M-4: Apr-Oct
Reconstruct bridge over US-131 at Saginaw. 1 lane maintained at all times. Nighttime lane closures.

36 M-3: Jul-Oct
Reconstruct 1 mile from east of US-23 to north of I-75. 1 lane maintained at all times. Nighttime lane closures.

35 M-2: May-Oct
Reconstruct 0.3 miles from west of I-75 to north of I-75. 1 lane maintained at all times. Nighttime lane closures.

34 M-1: Apr-Oct
Reconstruct bridge over US-131 at Macy. 1 lane maintained at all times. Nighttime lane closures.

33 M-0: Apr-Oct
Reconstruct bridge over US-131 at Coldwater. 1 lane maintained at all times. Nighttime lane closures.

32 M-21 (Fulton St): Aug-Oct
Repave northbound lanes from I-96 to I-96/US-127 BR in Battle Creek. 1 lane open in each direction. Detour for 6 weeks.

31 M-20: Mar-Oct

30 M-19: Jul-Oct
Reconstruct bridge over US-127 (BR/M-50) from US-127 to I-75. 1 lane kept open at all times. Nighttime lane closures.

29 M-18: Apr-Oct
Reconstruct 1.1 miles from east of US-23 to north of US-10. 1 lane maintained at all times. Nighttime lane closures.

28 M-17: Jul-Oct
Reconstruct 1 mile from south of US-10 to north of US-10. Lane closures under flag control.

27 M-16: Apr-Oct
Reconstruct bridge over west branch of Middle Branch River. Detour on M-61 and M-11. 1 lane open at all times.

26 M-15: Jul-Oct
Reconstruct bridge over M-54 bridge over M-54. 1 lane open at all times. Nighttime lane closures.

25 M-14: Apr-Oct
Reconstruct bridge over M-54 bridge over M-54. 1 lane open at all times. Nighttime lane closures.

24 M-13: Jul-Oct

23 M-12: Jul-Oct

22 M-11: Jul-Oct

21 M-10: Jul-Oct

20 M-9: Jul-Oct

19 M-8: Jul-Oct

18 M-7: Jul-Oct

17 M-6: Jul-Oct

16 M-5: Jul-Oct

15 M-4: Jul-Oct

14 M-3: Jul-Oct

13 M-2: Jul-Oct

12 M-1: Jul-Oct

11 M-0: Jul-Oct

10 M-9: Jul-Oct

9 M-8: Jul-Oct

8 M-7: Jul-Oct

7 M-6: Jul-Oct

6 M-5: Jul-Oct

5 M-4: Jul-Oct

4 M-3: Jul-Oct

3 M-2: Jul-Oct

2 M-1: Jul-Oct

1 M-0: Jul-Oct

0 M-9: Jul-Oct
For More Information
You can be fined $65 for not wearing your seat belt.
AND there are no apparent serious injuries (or deaths).
vehicle from the main traveled portion of the roadway
“If you can Steer it, Clear it - It’s our law!”
Drivers breaking this law face fines up to $2,750 each time, possibly losing their commercial
permitted). Drivers breaking this law face fines up to $2,750 each time, possibly losing their commercial

Federal law prohibits commercial truck and bus drivers
who use hand-held cell phones while operating a
vehicle.

State law prohibits any drivers with a Level 1 or Level 2

driver using a cell phone to:
• Report a traffic crash, medical emergency
• Report a situation in which the person believes

• Report an illegal or illegal or suspicious activity
• Obey workers directing traffic.

• Don’t tailgate.

• Slow down. Drive to road surface and
weather conditions.

• Turn on your light(s).

• Signal appropriate, perform

• Pay attention.

• Keep your eyes on the road.

• Stay alert while driving.

• Reduce your speed.

• Watch for pedestrians, bicyclists, and
animals on the road.

• Reduce your speed.

• Get a date night.

• Slow down.

To report a work zone or traffic violation,
please call 888-920-6368.

To report a traffic crash, medical emergency,
or a situation in which the person believes

• Report an illegal activity.

• Signal appropriate, perform

• Turn on your light(s).

• Slow down.

• Get a date night.

• Slow down.

• Get a date night.

• Slow down.

• Stay alert while driving.

• Turn on your light(s).

• Signal appropriate, perform

• Turn on your light(s).

• Slow down.

To report a traffic crash, medical emergency,
or a situation in which the person believes

• Report an illegal activity.

• Signal appropriate, perform

• Turn on your light(s).

• Slow down.

• Get a date night.

• Slow down.

• Get a date night.

• Slow down.

• Turn on your light(s).

• Signal appropriate, perform

• Turn on your light(s).

• Slow down.

• Get a date night.

• Slow down.

• Get a date night.

• Slow down.

• Signal appropriate, perform

• Turn on your light(s).

• Slow down.

• Get a date night.

• Slow down.

• Get a date night.

• Slow down.

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• Turn on your light(s).

• Slow down.

• Get a date night.

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• Slow down.

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• Slow down.

• Get a date night.

• Slow down.

• Signal appropriate, perform

• Turn on your light(s).

• Slow down.

• Get a date night.

• Slow down.

• Get a date night.

• Slow down.

• Signal appropriate, perform

• Turn on your light(s).

• Slow down.

• Get a date night.

• Slow down.
Appendix B: Sample of Crash Data
| Crash Instance | Highway Class | Highway Number | Number of Traffic Lanes | Location to Roadway | Roadway Area | Type of Roadway | Relation to Roadway | Area of Road at Crash | Relation to Roadway | Condition | Speed Limit | Posted Speed Limit | Traffic Control |
|----------------|---------------|---------------|------------------------|--------------------|-------------|---------------|-------------------|----------------------|-------------------|-----------|-----------|--------------|-----------------|----------------|
| 2017013590      | Michigan route | M-24\US-24\US-24BR | 0 On the shoulder | Other Non-Freeway Area - Straight roadway not related to other selections | Ice | 55 | Posted speed limit | None | | | | | |
| 2017013610      | Michigan route | M-24\US-24\US-24BR | 2 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Posted speed limit | None | | | | | |
| 2017013611      | Michigan route | M-24\US-24\US-24BR | 3 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013612      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013613      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013614      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013615      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013616      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013617      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013618      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013619      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013620      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013621      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013622      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013623      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013624      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013625      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013626      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
| 2017013627      | Michigan route | M-24\US-24\US-24BR | 4 On the road | Other Non-Freeway Area - Straight roadway not related to other selections | Dry | 55 | Not posted | None | | | | | |
Appendix C: ANOVA Test Results
Michigan Interstate Highways ANOVA Test:

```r
> Group1 <-
c(0.46,0.98,2.44,0.88,0.04,1.19,1.06,2.20,1.42,0.88,1.96,1.67,0.82,1.38,1.06,0.27,2.18)
> Group2 <-
c(0.88,0.72,3.52,0.65,0.09,1.45,1.59,1.62,0.89,1.13,4.76,1.21,0.67,1.84,1.03,0.11,2.02)
> Group3 <-
c(0.71,0.79,2.52,0.48,0.12,0.66,1.02,1.59,0.55,1.00,2.26,0.87,0.84,1.36,0.87,0.25,2.80)
>
> Combined_Groups <- data.frame(cbind(Group1, Group2, Group3))
> Combined_Groups

   Group1 Group2 Group3
1       0.46   0.88   0.71
2       0.98   0.72   0.79
3       2.44   3.52   2.52
4       0.88   0.65   0.48
5       0.04   0.09   0.12
6       1.19   1.45   0.66
7       1.06   1.59   1.02
8       2.20   1.62   1.59
9       1.42   0.89   0.55
10      0.88   1.13   1.00
11      1.96   4.76   2.26
12      1.67   1.21   0.87
13      0.82   0.67   0.84
14      1.38   1.84   1.36
15      1.06   1.03   0.87
16      0.27   0.11   0.25
17      2.18   2.02   2.80
```

```r
> summary(Combined_Groups)
```
Group1          Group2          Group3
Min.   :0.040   Min.   :0.090   Min.   :0.120
1st Qu.:0.880   1st Qu.:0.720   1st Qu.:0.660
Median :1.060   Median :1.130   Median :0.870
Mean   :1.229   Mean   :1.422   Mean   :1.099
3rd Qu.:1.670   3rd Qu.:1.620   3rd Qu.:1.360
Max.   :2.440   Max.   :4.760   Max.   :2.800

> Stacked_Groups <- stack(Combined_Groups)
> Stacked_Groups
    values   ind
 1     0.46 Group1
 2     0.98 Group1
 3     2.44 Group1
 4     0.88 Group1
 5     0.04 Group1
 6     1.19 Group1
 7     1.06 Group1
 8     2.20 Group1
 9     1.42 Group1
10     0.88 Group1
11     1.96 Group1
12     1.67 Group1
13     0.82 Group1
14     1.38 Group1
15     1.06 Group1
16     0.27 Group1
17     2.18 Group1
18     0.88 Group2
19  0.72 Group2
20  3.52 Group2
21  0.65 Group2
22  0.09 Group2
23  1.45 Group2
24  1.59 Group2
25  1.62 Group2
26  0.89 Group2
27  1.13 Group2
28  4.76 Group2
29  1.21 Group2
30  0.67 Group2
31  1.84 Group2
32  1.03 Group2
33  0.11 Group2
34  2.02 Group2
35  0.71 Group3
36  0.79 Group3
37  2.52 Group3
38  0.48 Group3
39  0.12 Group3
40  0.66 Group3
41  1.02 Group3
42  1.59 Group3
43  0.55 Group3
44  1.00 Group3
45  2.26 Group3
46  0.87 Group3
47  0.84 Group3
48  1.36 Group3
49  0.87 Group3
50  0.25 Group3
51  2.80 Group3

> Anova_Results <- aov(values ~ ind, data = Stacked_Groups)
> summary(Anova_Results)

          Df Sum Sq Mean Sq F value Pr(>F)
ind         2   0.90  0.4491  0.549  0.581
Residuals 48  39.27  0.8182

Residuals  48  39.27  0.8182
Michigan Urban Roads ANOVA Test:

> Group1 <- c(0.98,2.44,0.88,0.04,1.19,1.06,2.20,1.42,0.88,0.79,0.92,3.32,1.27,1.67,3.66,3.71,8.90,7.71,2.24, 0.82,1.38,1.68,4.34,0.27,2.18)

> Group2 <- c(0.72,3.52,0.65,0.09,1.45,1.59,1.62,0.89,1.13,0.87,1.34,4.21,1.13,1.21,4.71,2.92,7.31,6.28,3.30, 0.67,1.84,1.69,5.32,0.11,2.02)

> Group3 <- c(0.79,2.52,0.48,0.12,0.66,1.02,1.59,0.55,1.00,0.91,0.84,2.54,1.30,0.87,4.22,5.13,10.14,10.55,2.17,0.84,1.36,3.30,5.04,0.25,2.80)

> Combined_Groups <- data.frame(cbind(Group1, Group2, Group3))

> Combined_Groups

<table>
<thead>
<tr>
<th></th>
<th>Group1</th>
<th>Group2</th>
<th>Group3</th>
</tr>
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<tr>
<td>1</td>
<td>0.98</td>
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<td>0.79</td>
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<tr>
<td>2</td>
<td>2.44</td>
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<td>4.22</td>
</tr>
<tr>
<td>16</td>
<td>3.71</td>
<td>2.92</td>
<td>5.13</td>
</tr>
</tbody>
</table>
> summary(Combined_Groups)

    Group1  Group2  Group3
Min.   :0.040  Min.   :0.090  Min.   : 0.12
1st Qu.:0.920  1st Qu.:0.890  1st Qu.: 0.84
Median :1.420  Median :1.590  Median : 1.30
Mean   :2.238  Mean   :2.264  Mean   : 2.44
3rd Qu.:2.440  3rd Qu.:3.300  3rd Qu.: 2.80

> Stacked_Groups <- stack(Combined_Groups)

> Stacked_Groups

  values    ind
 1    0.98 Group1
 2    2.44 Group1
 3    0.88 Group1
 4    0.04 Group1
 5    1.19 Group1
 6    1.06 Group1
 7    2.20 Group1
<table>
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Anova_Results <- aov(values ~ ind, data = Stacked_Groups)
summary(Anova_Results)

Df Sum Sq Mean Sq F value Pr(>F)
ind 2 0.6 0.301 0.056 0.945
Residuals 72 384.4 5.340