NURail Research Project:
Highway-Rail Grade Crossing Surface Material Performance

Final Report

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Michigan Department of Transportation
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16. Abstract:
Highway-Railroad grade crossings are an integral part of the transportation system, allowing the two modes to operate in the same areas. Performance of the surface material at grade crossings has been an ongoing issue. This study reviewed the literature available on grade crossing surface materials and the crossing records available from MDOT in an attempt to determine which surface materials perform best for given traffic levels and site conditions. The study team found that the data currently available was not adequate to perform credible analysis of the situation, and recommended additions to the grade crossing data collected by MDOT, and a reporting method for that data. The team also made recommendations on a method to improve the rating system used by MDOT inspectors for crossing surface condition.

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EXECUTIVE SUMMARY

The Efficiency through Engineering and Construction (ETEC) team chosen for this project was tasked with looking at highway-rail grade crossings (grade crossings) across the State of Michigan, with four main objectives:

1. Compare the performance of four groups of grade crossing surface materials
2. Review the current surface condition of existing grade crossings
3. Develop a recommendation for the "best" surface material to use for grade crossings
4. Prepare a recommendation for an improved method for rating surface condition during grade crossing inspections.

The team started with collecting grade crossing data from MDOT and other sources, and conducting a literature review. The literature review focused on previous work on grade crossing surface evaluation, and quickly found that there was little available research on this topic. Review of readily available crossing data from MDOT also revealed a lack of historical information to use in comparing crossing performance.

During the summer of 2013 the team embarked on a program to gather information on the current condition of grade crossings in the State. A list of crossings was made from the data set provided by MDOT, which included over 3000 crossings. The team narrowed that list down to 107 crossings with at least 25 crossings of each of four surface types: asphalt, concrete panel, sectional timber, and rubber panel. Inspection visits, with and without MDOT inspectors, were made during the summer, and gave a first-hand look at current conditions of Michigan's crossings, as well as an overview of the current condition rating process. The most recent inspection rating for each of the crossings was used to create a "snapshot" of the current rating for each surface type.

The team requested additional data on the 107 crossings now included in the study in order to tackle the performance question. MDOT provided additional historical data on the study crossings near the end of the summer, including condition ratings from some inspections as far back as 1994. The data was divided up among the team and the analysis began. Graphs were created that looked at the rating of each crossing over time. Analysis of these crossings showed that many crossings performed well over time. However, not enough data is present to develop performance curves from the existing information alone.

Following the summer's work, the team was able to develop a recommendation for data collection that would allow MDOT to complete the research originally envisioned in this project. The Highway-Rail Crossing History Data (HIRCH) Sheet is a tool that could be used to consolidate existing crossing data, and to record ongoing data on the condition and repair/maintenance history of crossings. The HIRCH Sheet could be used to capture the parameters of selected crossings, which may lead to more direct correlations between Highway-Rail Crossing properties and the performance of the surface material used. The data collection process is proposed to extend indefinitely,

but initial performance results could be available after collection of data through one complete rehabilitation cycle.

The team was also tasked with developing guidelines for crossing surface evaluation. The biggest area that needed to be improved with MDOT's current grading system was the qualification of each number within the rating system. The system in place now does not define criteria for the numeric ratings. A new grading scale was modeled after the Pavement Surface Evaluation and Rating (PASER) system. The PASER system was developed by the University of Wisconsin Transportation Information Center to provide a simple, efficient, and consistent method for evaluating road condition. Each number within the rating system will have qualifications that will correspond with the distresses associated with the specific crossing material. Examples demonstrating the rating system are included in the document.

INTRODUCTION

Shipment by train is an integral part of our economy, both at a national and state level. It assists in propelling our economic output as a nation, taking goods from afar and bringing them to our local towns or cities. As with any component of infrastructure it is important that this mode of transportation survives and excels. This is important from an economic and from a sustainability point of view.

Highway-Rail Grade Crossings (Figure 1) are a vital part of the transportation network, allowing train traffic to cross highways. Without these crossings trains would have no cost effective routes to deliver the massive tonnage of freight they carry. Another alternative to a Highway-Rail grade crossing is a grade separation, with either the highway going over or under a railroad. However, grade separations are expensive, and often exceed DOT budget limitations.

Grade crossings are a common theme throughout the United States highway network, in the State of Michigan alone there are over 4000 documented crossings. These crossings must be maintained and provide a safe environment for all motorist and rail workers using them. Many high-volume crossings see upwards of 60,000 vehicles per day, and/or 60-80 trains. This highlights the need to provide a quality structural design and maintain high safety standards. Federal Highway Administration (FHWA) standards define the required safety devices at a grade crossing, but the structure of the crossing, and the choice of surface material, is normally left to the railroad company owning the rail line.

Figure 1 - Typical Railroad Grade Crossing

A typical railroad crossing is made up of several components. Starting from the bottom:

- The subgrade, the native material the rail line and highway are built on.

- Sub-ballast a free draining granular material placed on top of the sub-grade. Sometimes a geotextile fabric or a paving layer is included between the subgrade and the sub-ballast layer.
- Ballast, this is composed of rougher and larger size particles, typically 1-2 inches in diameter, and is intended to support and surround ties. This layer also provides voids for proper drainage.
- The rail ties or sleepers, the rail, and connecting hardware. The top layer includes the crossing surface material. The crossing surface can be made of different materials, but this project focusses on four: asphalt, concrete, rubber, and timber. It often sits directly atop the crossties and ballast but may include spacers. Examples of the various materials can be seen in Figure 2 through Figure 5. A flange way clearance is maintained on the inside of each rail through the crossing. Other composite materials have been developed but were not considered in this project.

Figure 2 - Asphalt Crossing Surface

Figure 3 - Concrete Crossing Surface

Figure 4 - Rubber Crossing Surface

Figure 5 - Timber Crossing Surface

The railroad crossing also has highway approaches. An approach is where the highway gradually transitions to improve ride quality over the crossing itself. The highway profile is the elevation and orientation of the roadway. Width of the highway depends on the number of lanes; the recommended cross section for a 2-lane arterial in Michigan is 12 meters wide, which includes two 3.6 m travel lanes, and 2.4 m wide shoulders (1 m paved)[4]. Highway dimensions are specified by the highway authority. Highway surfaces are generally composed of hot asphalt mix (HMA), but also may be constructed using portland cement concrete.

Many crossings are equipped with active warning devices such as flashing lights, bells, and crossing gates. A number of warning devices can be seen in Figure 6. The traffic control devices are selected for each crossing by the governing highway authority. The Federal Highway Administration (FHWA) Manual on Uniform Traffic Control Devices (MUTCD) specifies the standard configuration of warning devices, pavement markings, advanced warning signs and other signs and traffic control devices for both simple and complex situations. The number of tracks is often shown on the traffic control devices at the crossing.

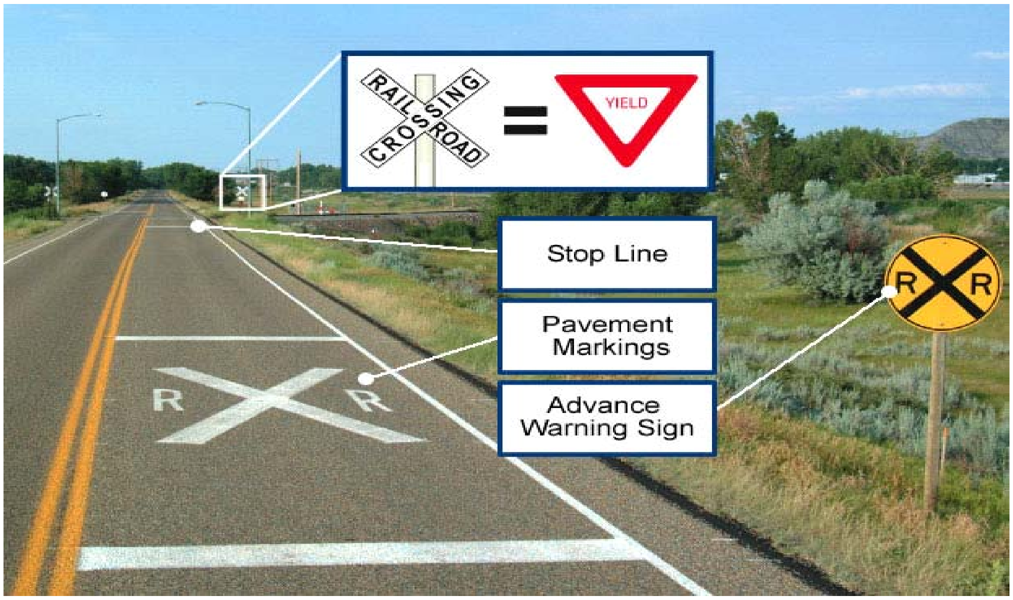


Figure 6 - Rail Crossing Warning Devices

Railroad crossings can be a difficult piece of infrastructure to maintain, because shutting a crossing down impacts both rail traffic on the track and highway vehicle traffic movement through the crossing. It can be very expensive to replace a crossing, but may be necessary in order to maintain safety and quality of travel utilizing either mode of transportation. It is important to note that the one reason many crossings deteriorate rather quickly, is because of the difference in the design and construction of highways, versus rail lines. Vertical deflections are different due to the wheel and axle loading differences between highway vehicles and railroad locomotives and cars. [1]So as the conflicting designs intersect, it can lead to a quick deterioration of the rail crossing components, which increases need for rehabilitation and costs.

Figure 7 shows a cross section of the grade crossing structure, but does not include the highway approaches. In the case of a highway crossing, the approaches should gradually slope up to match the elevation of the rail crossing.

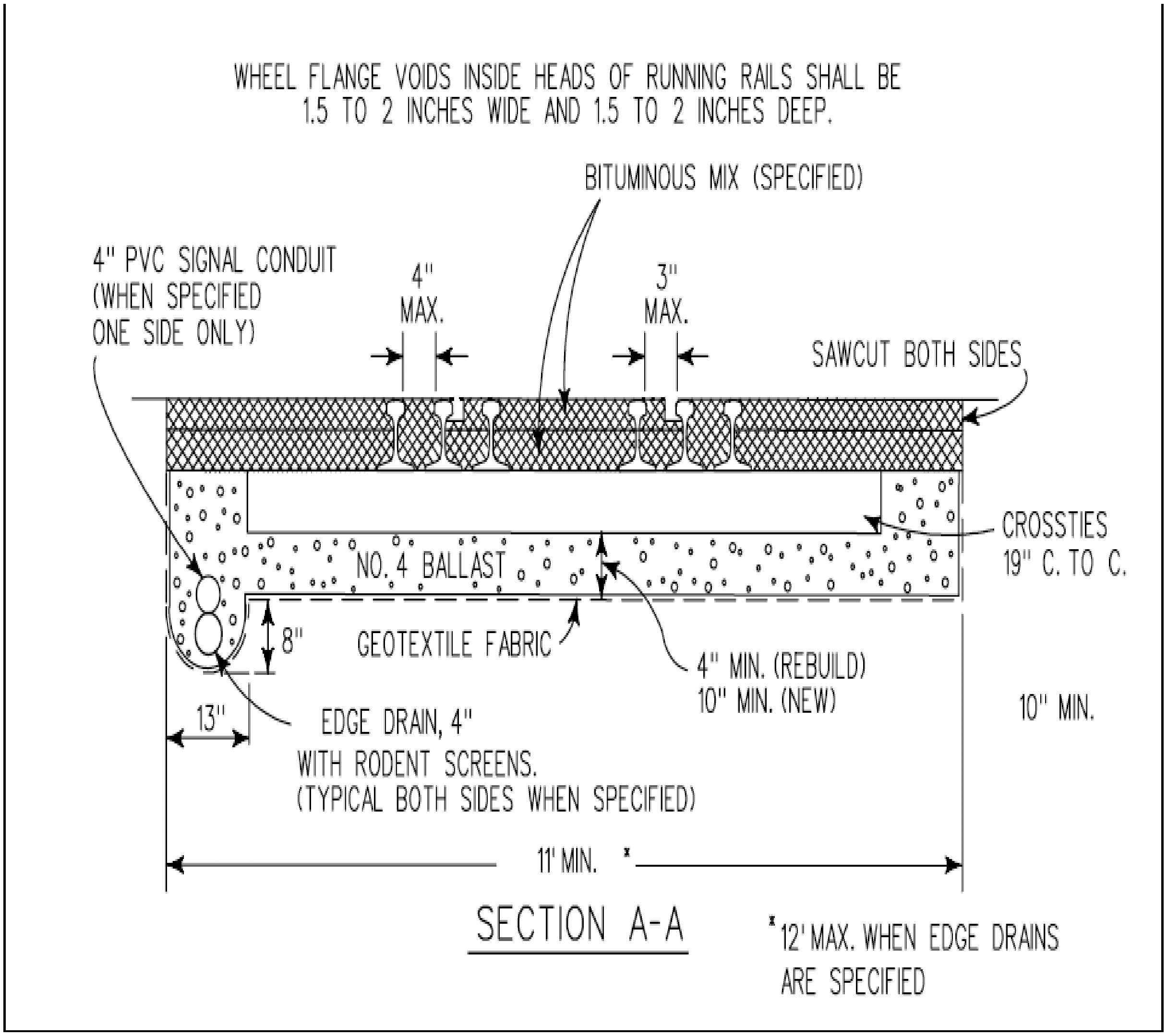


Figure 7 – Typical Highway Grade Crossing Cross Section

Original Scope of Work

The ETEC team started the project in January of 2013. The original scope of work for the project included:

- Data collection of statewide crossings data (inventory, condition, subgrade). MDOT will provide the team with available data on public crossings, such as train and roadway volume data, location and material data and information on surface improvements, etc. Additional potential data sources include:
    - Various Railroad Companies
    - Michigan Local Technical Assistance Program (LTAP)
    - Federal Railroad Administration (FRA)
- If sufficient data is available, use maintenance and condition assessments to develop deterioration estimates and comparative analysis between construction and maintenance costs, ADT and surface type.
- Field visits to crossing locations to review current conditions.
    - The crossing selected for inspection and analysis will be determined during 2013 spring semester
- Based on data and analysis, provide recommendations on what type of crossing surface would be best for certain conditions.
- Potentially develop guidelines and recommendations for crossing surface condition evaluations to MDOT.
- Disseminating the project outcomes to National University Rail Center (NURail) and other stakeholders in the form of posters and reports.

The team soon realized that there would not be enough information to complete all of the tasks as initially planned. In particular, there was not enough data to develop deterioration estimates, and there was little to no information on construction and maintenance costs. As a result it would not be possible to provide recommendations on the "best" surface material to use in given crossing conditions.

The scope of work was revised in September of 2013 to recognize the changed conditions. Table 1 outlines the original scope tasks, where revisions were required, and what would be required in the revised scope. The final scope is shown after the table.

Table 1 – Original and Revised Scope of Work

Task in Original Scope	Complete vs Revised	Details	How it Transitioned into Revised Scope
Gather crossing data from MDOT and other sources	Completed	Information was gathered from LTAP and other resources	No change
Develop deterioration estimates and data analysis	Revised	Maintenance and condition assessments not sufficient to develop trends	Determine additional data required for analysis.
Field visits to assess current crossing conditions	Completed	Field visits were completed over the summer. Refer to sections 2.2.5 and 2.2.6	No change
Provide recommendations on crossing surface selection	Revised	Data from MDOT and other sources is not sufficient for analysis	Recommendations could not be provided based on literature review and survey data with DOT's and Railroads.
Develop guidelines for crossing surface evaluations	To be completed	Recommendations will be made for crossing surface evaluation program	No Change
Disseminate the project outcomes	To be Completed	Once the remaining tasks are completed and the final report completed this will be accomplished	No Change

Revised scope of work:

- Statewide crossings data collection (inventory, condition, subgrade).
- Analyze existing MDOT crossing data to determine if data is adequate to develop deterioration estimates and perform comparative analysis between construction and maintenance costs, ADT and surface type. Determine additional data required for complete analysis.
- Field visits to crossing locations to review current conditions by inspection and analysis of 105 crossings and provide results of the inspection and analysis.
- Provide recommendations for crossing construction materials based on literature review and discussions with railroad and DOT personnel from Michigan and other states.
- Recommend Modifications to the current MDOT Highway-Rail Crossing evaluation process to provide a more systematic approach with more descriptive criteria and a data collection system to better evaluate deterioration of At Grade Highway-Rail Crossing surface material.
- Disseminate the project outcomes to National University Rail Center (NURail) and other stakeholders in the form of posters and reports.

Literature Review

The team reviewed a total of nine different documents, looking for background information related to the performance of surface materials in grade crossings.

University of Kentucky Report

The University of Kentucky's Dr. Jerry Rose, published a report titled "University of Kentucky Transportation Center, Research Report KTC-09-06/FR136-04-3F, *Highway-railway at-grade crossing structures: Long-term settlement measurements and assessments.*"[(1)] The report detailed the effect of an asphalt underlayment as a means to support, and reduce deterioration of a rail crossing structure. In this report the University of Kentucky (UK) did not focus on the surface material performance specifically.

The research conducted by Dr. Jerry Rose and his students was focused on the sub-grade of the rail crossing structure. The report suggests that the use of an asphalt underlayment will prolong the life and reduce maintenance costs to the rail crossing structure. The reasoning was that a saturated sub-grade can be detrimental to any crossing structure and the asphalt underlayment helps provide a waterproofing barrier above the sub-grade, which helps reduce the deformation of the sub-grade. The UK research team monitored 24 crossings and concluded that an asphalt underlayment can improve the lifespan of the crossing, and maintain a high-level of quality, even when subject to heavy-truck traffic.

The report did state that there was no observed correlation between crossing surface material type and the performance of the crossing structure; all materials performed well using the asphalt underlayment method. Figure 8 shows a table of asphalt underlayment vs. no underlayment and the settlement measured from the report.

It is important to note that the UK report highlighted the significance of a sound, stable, sub-grade. It appears that the sub surface structure may ultimately determine the quality and lifespan of Highway-Rail Grade Crossing.

Figure 2.1f US 60 (Stanley) crossing with underlayment.

TABLE 2.2.1a Average Approach/Crossing Settlements for Cincinnati Subdivision Crossings

Crossing	Average Approach Settlement	Average Crossing Settlement	Months in Service
Cincinnati Subdivision with No Asphalt Underlayment			
Dam	1.65 in.	1.25 in.	33
Fish Camp	1.46 in.	1.49 in.	33
Flag Spring	1.50 in.	1.28 in.	33
Union Street	1.40 in.	1.13 in.	33
AVERAGE (No Underlayment)	1.50 in.	1.29 in.	33
Cincinnati Subdivision with Asphalt Underlayment			
Rt. 8 Concord	1.28 in.	0.31 in.	40
South Portsmouth	1.65 in.	0.56 in.	42
South Shore	1.23 in.	0.20 in.	42
Vanceburg-Main Street	1.96 in.	1.04 in.	43
AVERAGE (With Underlayment)	1.53 in.	0.53 in.	42

1.0 in. = 25.4 mm

12

Figure 8 – Comparison of settlement with/without asphalt underlayment, from UK report

University of Wisconsin Report

The University of Wisconsin's C. Allen Wortley developed, "Highway-Rail Grade Crossing Safety Course"[(2)] a new course in order to teach the basic principles of highway-rail crossing safety and apply them to new and existing projects. The focus of this course was not simply on safety. Thomas Zeinz, goes into detail about grade crossing surface design and construction. From an educational standpoint this information was vital. This report provided excellent background information on grade crossings, but it did not delve into any more detail about the surface materials of that structure.

MDOT Standard Specifications

The MDOT rail specifications referenced the standard drawings package, and specify the construction of bituminous grade crossings as shown in the detail in Figure 9. The Specifications state that if other materials or methods are to be used, then plans are to be drawn up by the contractor in charge of the construction and must be accepted by the MDOT engineers. The railroad specifications provided a wealth of information on the general construction of railroad crossings which proved useful in understanding how the state designs these crossings, particularly the bituminous grade crossings specified. Since other surface materials were not included, crossings designs with those materials could not be reviewed.

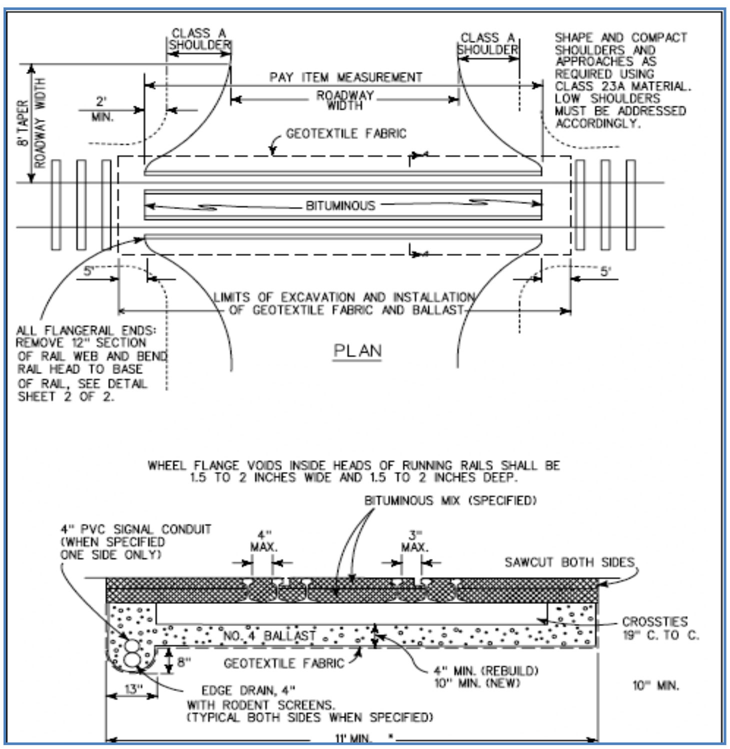


Figure 9 - MDOT Standard Crossing Detail

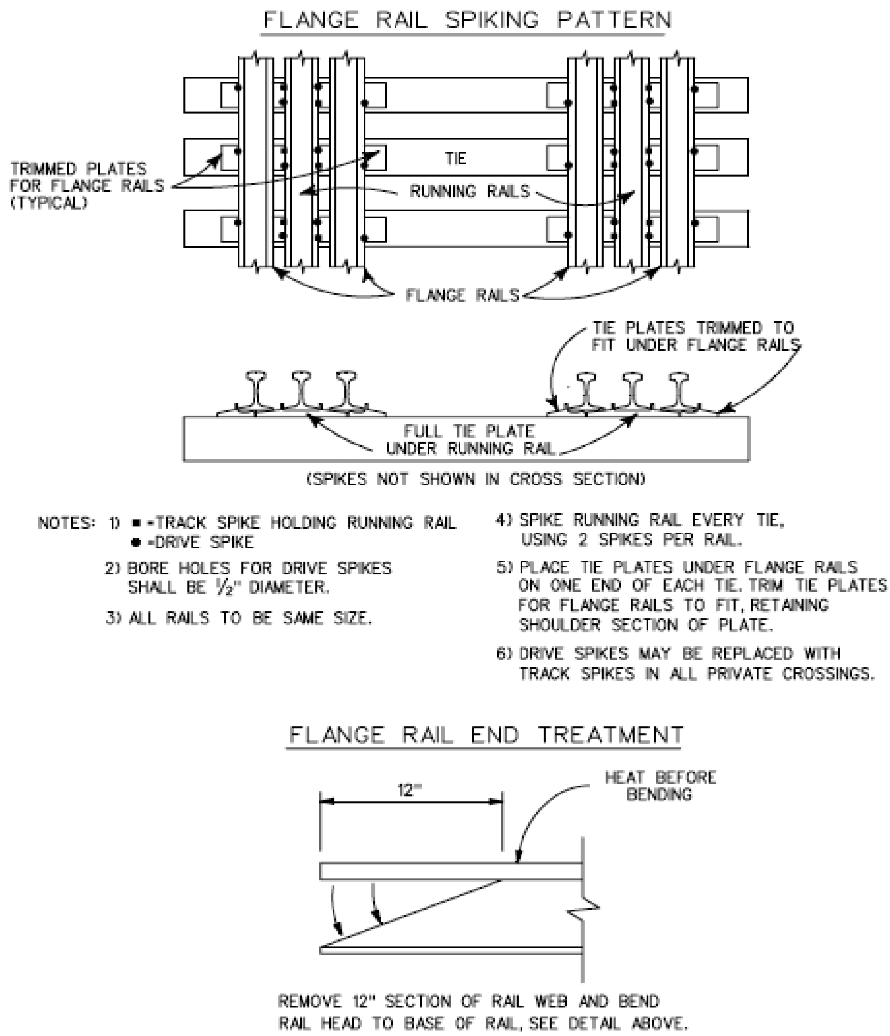


Figure 10 - MDOT Standard Crossing Detail

Synthesis of Highway Practices 250 (Highway-Rail Grade Crossing Surfaces)

Synthesis of Highway Practice 250 (Highway-Rail Grade Crossing Surfaces[6] is meant to be used as a resource for the selection of surface material, maintenance of the surface, and administration of surface improvement plans.

The report made it clear a number of times that there is almost no guidance or regulation in the selection or design of surface materials. Other aspects, such as traffic management and crossing safety are extensively covered by the Federal Highway Administration (FHWA), the American Railway Engineering and Maintenance-of-Way Association (AREMA), and the American Association of State Highway and Transportation Officials (AASHTO).

The distinction between two different types of surfaces was also made, the first being monolithic. Monolithic surfaces are formed at the crossing in one complete structure. These surfaces can't be removed without being destroyed in the process. Some examples include asphalt, poured in place concrete, and cast in place rubber. The other type of surface is sectional. One of the main advantages to this type of surface is that any of the individual panels that make up the surface can be removed and reinstalled. This allows for much easier access to the railway for maintenance. Some examples of this type of surface include treated timber, and panels made from reinforced concrete, steel, high-density polyethylene, and rubber.

Based on the FHWA's Railroad-Highway Grade Crossing handbook there are ten categories of crossing surfaces: sectional timber, wood plank, asphalt, concrete slab, rubber, metal sections, other metal, gravel, and other.

As mentioned earlier there are no national guidelines for selection of crossing materials. The trend is to use timber, wood, or gravel for crossings with an AADT of 100 or less. Rubber and concrete are saved for crossings with an AADT closer to the 10,000 region. The Railway Progress Institute has put forth some very broad guidelines for choosing a specific surface type:

- Surface material withstands the environment.
- No full rigidity in the crossing structure when completed.
- Simple adaption for all rail sizes, for both tangent and curved trackage.
- Independent or specified tie spacing, adaptable to any type of tie spacing.
- Simple flange way maintenance.
- No-skid and anti-hydroplaning surface.
- Adaption to existing roadway profile.
- Simple and fast installation procedures; interchangeable and easy to relocate sections of panels.
- Insulating qualities in signal and communication territory.
- Adaptability to skewed crossings.

Later on in the report the author goes into a life-cycle economic approach to surface selection. He describes the difficulty in determining the service life of a surface since there is no widely accepted definition of surface failure. He refers heavily to the work of D.R. Burns [7] (reviewed later in this section) stating that Burns provides guidelines for estimating surface life based on a number of variables. He even developed a chart that shows the least likely cost material to use based on highway and rail traffic. The author then explicitly states that the work of Burns is highly theoretical and up to the time of this report has not actually been tested.

There were some interesting insights into the specific incompatibilities between rail and highway design. For example, rail structure is designed to allow water to flow freely through the ballast to drainage structures below. It also is designed to allow some vertical deflection in the rail surface. Both of these design qualities are at direct conflict with highway design. It is meant to limit vertical deflections and to also be impervious to water. It relies on a crown in the road surface so water can flow off to the side. Even the crown of the road is at odds with rail lines which tend to be very flat over the distance of the crossing.

Problems with the slope of the approaches can also occur. Since the grades of the two surfaces must be level, the road must be brought to level with the crossing. In an attempt to save money the road may have a severe slope leading to the crossing. This slope can cause increased wear on the crossing surface.

The report also went into detail on the factors affecting the life span of a surface, noting that effective drainage is the most important factor. Next comes traffic loads, this also seems to be the main source of information when selecting a surface type as well. Even more important than the overall traffic count is the percent of it that represents trucks. Due to their weight and how it is distributed, trucks place more load on surfaces than cars do. It also describes how multiple tracks in a single crossing can increase loads. Other factors that come into play are track superelevation, the angle of the crossing, high highway speeds, site preparation, installation methods, and track maintenance neglect. Despite all these factors that affect the lifespan, studies performed by the FHWA found that most problems with the surface relate to the site preparation and the installation of the surface.

Grade Crossings: How to Choose a Cost-Effective Surface

Grade Crossings: How to Choose a Cost-effective Surface(7) by D.R. Burns . The article is about how to choose a cost effective grade crossing surface, which is similar to a number of our objectives. The article covers variables affecting the life span of a surface as well as methods they used to determine surface life. It wraps up with analysis of costs involved in construction and maintenance of crossings.

The section on determining surface life was the main interest of this article. Using data points from the Highway-Railroad Grade Crossing Material Selection Handbook the author was able to develop a graph showing service life compared to something he calls car equivalency count (CEC). The CEC is determined by multiplying the number of trucks by 100 and then adding that to the number of cars. This is done because trucks wear road components significantly more than cars. Figure 11 shows the average service life of crossing materials, according to Burns. It should be noted that this graph is based on limited rail traffic.

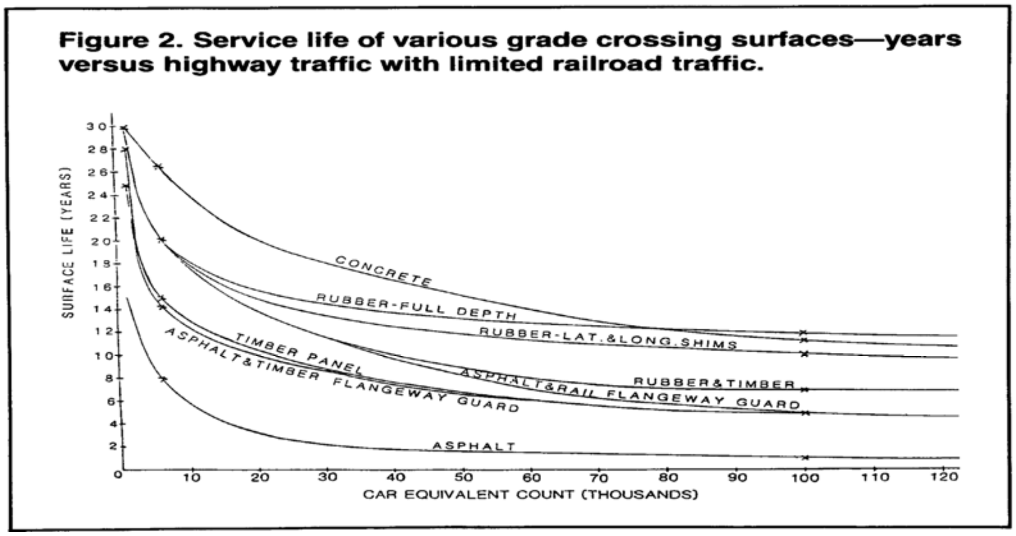


Figure 11 – Service life of crossing surface materials, Burns[7].

Based on the service life graph, Burns developed a service life table, shown in Figure 12.

Table 3. Life of grade crossing surfaces for various highway traffic levels—negligible railroad traffic

CEC/LANE	ASPHALT	ASPHALT & TIMBER (1)	ASPHALT & RAIL (1, 2)	TIMBER PANELS	RUBBER & TIMBER	RUBBER LONG. SHIM	RUBBER LAT. SHIM	RUBBER FULL DEPTH	CONCRETE (
1000	15.0	25.0	30.0	28.0	30.0	28.0	28.0	30.0	30.0
5000	6.5	12.5	18.1	13.0	18.1	18.5	18.5	18.6	24.0
10000	4.8	10.4	15.4	10.9	15.4	16.4	16.4	16.7	20.2
25000	2.5	7.6	10.8	8.1	11.3	13.5	13.5	14.7	16.4
50000	1.3	6.2	7.4	6.6	8.9	11.6	11.6	13.5	14.1
75000	1.1	5.7	5.8	5.8	7.7	10.7	10.7	12.5	12.5
100000	1.0	5.0	5.0	5.0	7.0	10.0	10.0	12.0	11.0

(1) During the service life, it is expected that the asphalt in this crossing will be resurfaced at least once.

(2) Rail, as the primary component of the crossing, will last a long time; but, with significant highway traffic the rail fastenings will become loose and necessitate the early replacement of the ties. To allow for this fact the life of the crossing surface has been reduced at high road-traffic densities.

(3) Shimmed and full-depth surfaces are assumed equal with respect to service life.

Figure 12 – Service life of crossing surface materials

Finally, the author created a graph (Figure 13) that shows the effect of rail traffic on surface life. He determined this by looking at the dominant failure mechanisms inherent in each type of surface and correlating it to information in the same Material Selection Handbook.

Figure 3. The percentage loss of road surface as a result of rail traffic (slope of graph is the rail traffic adjustment factor).

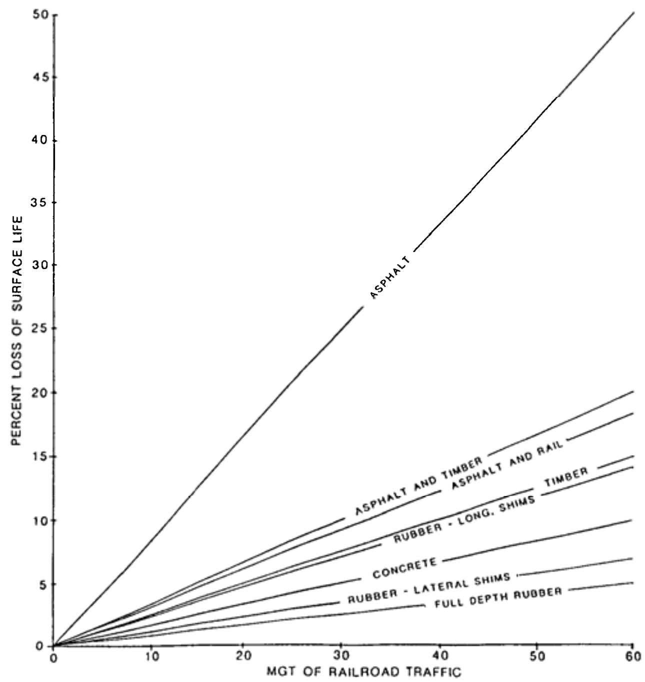


Figure 13 – Crossing Surface Life Expectancy Correlated to Rail Traffic Volume

All the above information was put together based on information on the "typical" crossing in the United States and therefore may not account for various local factors such as the freeze thaw cycle. Despite the limitations this information seems to answer some of the biggest problems presented. A simple look at the table can show which type of crossing should last the longest for any given traffic levels. Then percent loss due to rail traffic can also be determined.

The author then transitions to the topic of installation and maintenance cost. He explains the various costs with each type of crossing and even gives specific examples.

At the end of the article, recommendations are made for various conditions. These are based on the previously designed charts and costs associated with the surfaces. For low CEC and below 7 MGT asphalt is the most cost effective choice. For rail traffic over 20 MGT an easily removable surface works best. For anything less than 20 MGT and traffic over 35,000 CEC per lane timber, asphalt and timber and various other types of high level surfaces are recommended.

Additional Literature Reviewed

Several additional documents were reviewed, but the team found little of value for this effort. They are listed below, along with a brief description. While the research included may be correct, it was not applicable to this project.

The first two sources are from the Kentucky Transportation Center and initially seemed to be very promising. “Highway- Railway At-Grade Crossing Structures: Trackbed and Surface Pressure Measurements and Assessments”. This report reviewed techniques for installing instrumentation within the actual crossing structure for the measurement of pressure. The main goal of this report was to develop a non-invasive method to determine loads within the crossing structure. Therefore, it emphasizes proper methods for the installation of the instrumentation, how to properly collect the data, and how to analyze the results. Although the report is about at-grade crossings, it has little to do with the surface material.

The idea of finding a method for rating the roughness of a grade crossing that is not subjective would transform the maintenance of these crossings. This would allow the owners of these crossings to know exactly how rough each crossing was at the time of the measurement. This would not only make it easier to determine the life of a certain material but it would also make it easier for the owner to determine when to replace crossings.

That is exactly what the authors of the “Highway-Railway At-Grade Crossing Structures: Rideability Measurements and Assessments” set out to find. Unfortunately they had little success. They attempted to correlate methods used to determine the roughness of paved roads with condition of grade crossings. These methods included the use of laser based inertial profilers, and face rolling dipsticks. Data was collected and roughness indexes were made and compared to rideability ratings made by a control group. The final results found neither of these instruments could provide data that matched well with people’s perception of crossing roughness. These instruments are intended for use over large longitudinal distances, and do not scale well to the width of a crossing.

Other sources included two from the Transportation Research Record titled “Monitoring and Evaluation of High-Type Railroad Crossing Surfaces” by Dean A. Maurer, and “Procedure for a Priority Ranking System for Rail-Highway Grade Crossings” by Timothy Ryan and John Erdman.

The paper by Maurer summarizes a number of high-type crossings that were installed in Pennsylvania in 1983. In the summary brief design and construction problems are detailed. The author then determines that detailed construction guidelines are required for the use of any crossing surface and that improper installation was often the cause of problems. This paper was very general and provided superficial summaries on a few different high-type surfaces. It did not compare various surfaces and only determined how they might be installed better in the future.

The paper by Ryan and Erdman focused on vehicle safety, and only looked at three factors in determining this priority ranking system. These three factors were safety, vehicular delay, and emergency access problem potential. The paper did not discuss effects of surface condition on safety.

The final report is “Evaluation of Experimental Railroad-Highway Grade Crossings in Louisiana”. It evaluated twenty-three crossings with experimental surface materials, the majority of which were rubber. While it found there was a range of performance, the small sample size, and the fact that it was dominated by one type of material limit the usefulness of the findings.

Literature Review Summary

Although the literature review provided no concrete answers, it did point out some general trends that seem to be effective in the preservation of surface crossings. The factor most often brought up being adequate drainage. The analysis also further indicated the level of difficulty the team faced when answering the questions presented. This was clearly seen when the team found here was a wealth of information on the safety of railroad grade crossings but very little when it came to surface selection.

As stated in Synthesis of Highway Practice 250 there is almost no guidance in the selection of a surface material. It also stated that there is no universally accepted definition for surface failure. This variability in construction makes data analysis difficult due to the inability to control for a large number of variables.

The literature review did not only provide bad news, it also pointed out a few areas of interest in surface life, such as drainage and the application of an asphalt underlayment. The first was stated as the most important factor in the previously mentioned synthesis report. Asphalt underlayment may provide a mechanism for improving the performance of all grade crossing surfaces.

METHODOLOGY

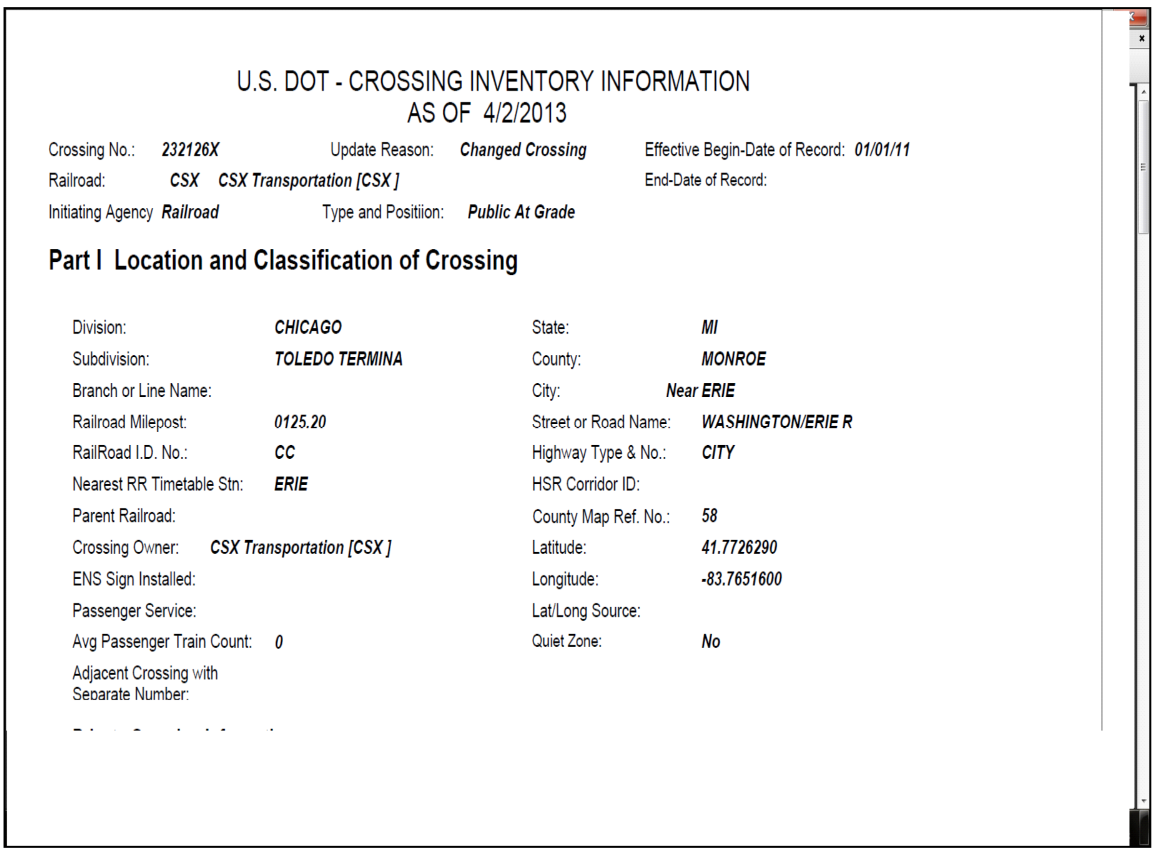
The ETEC team approached the study using four phases: Collect Data, Conduct Site Visits, Analyze Data, and Report Results

Collect Data

The team collected useful data from several sources, primarily the FRA and MDOT crossing databases, and crossing history data provided by MDOT. The team also interviewed MDOT inspectors, employees of other DOT's, and employees of railroads.

Federal Railroad Administration (FRA) Database

The FRA provided one of the most valuable resources to the project. The crossing inventory number used in the database run by the FRA is also the number used to identify the crossing in the field. This number can be used in the database to generate a report and even a map. If there is more than one report for a given crossing, a complete history of the reports contained can be downloaded as well.



U.S. DOT - CROSSING INVENTORY INFORMATION
AS OF 4/2/2013

Crossing No.: *232126X* Update Reason: *Changed Crossing* Effective Begin-Date of Record: *01/01/11*
Railroad: *CSX CSX Transportation [CSX]* End-Date of Record:
Initiating Agency *Railroad* Type and Positiion: *Public At Grade*

Part I Location and Classification of Crossing

Division:	*CHICAGO*	State:	*MI*
Subdivision:	*TOLEDO TERMINA*	County:	*MONROE*
Branch or Line Name:		City:	*Near ERIE*
Railroad Milepost:	*0125.20*	Street or Road Name:	*WASHINGTON/ERIE R*
RailRoad I.D. No.:	*CC*	Highway Type & No.:	*CITY*
Nearest RR Timetable Stn:	*ERIE*	HSR Corridor ID:	
Parent Railroad:		County Map Ref. No.:	*58*
Crossing Owner:	*CSX Transportation [CSX]*	Latitude:	*41.7726290*
ENS Sign Installed:		Longitude:	*-83.7651600*
Passenger Service:		Lat/Long Source:	
Avg Passenger Train Count:	*0*	Quiet Zone:	*No*
Adjacent Crossing with Separate Number:			

Figure 14 - Part 1, FRA Crossing Report, Location and Classification

There are five parts to the report. Figure 14 - Figure 17 display the four parts with information pertinent to the project. Part one shows the general crossing information. The location including longitude and latitude are provided and the crossing owner is noted. Part two has track and train information including train count per day and speed. Part four gives the surface type, number of traffic lanes, and other information of that nature. Finally, part 5 deals with the functional classification of the road as well as highway traffic information.

Part II Railroad Information

Number of Daily Train Movements:		Less Than One Movement Per Day:	*No*
Total Trains: *17*	Total Switching: *0*	Day Thru:	*10*
Typical Speed Range Over Crossing: From	*40* to *45* mph	Maximum Time Table Speed:	*45*
Type and Number of Tracks:	Main: *2* Other *0*	Specify:	
Does Another RR Operate a Separate Track at Crossing?	*No*		
Does Another RR Operate Over Your Track at Crossing?	*No*		

Figure 15 - Part II, FRA Crossing Report, Railroad Information

Part IV: Physical Characteristics

Type of Development:	*Commercial*	Smallest Crossing Angle:	*60 to 90 Degrees*
Number of Traffic Lanes Crossing Railroad:	*2*	Are Truck Pullout Lanes Present?	*No*
Is Highway Paved?	*Yes*		
Crossing Surface:	*Asphalt*	If Other:	
Nearby Intersecting Highway?	*Less than 75 feet*	Is it Signalized?	
Does Track Run Down a Street?	*No*	Is Crossing Illuminated?	
Is Commercial Power Available?	*Yes*		

Figure 16 - Part IV, FRA Crossing Report, Physical Characteristics

Part V: Highway Information

Highway System:	*Other FA Highway - Not NHS*	Functional Classification of Road at Crossing:	*Rural Minor Collector*
Is Crossing on State Highway System:	*No*		
Annual Average Daily Traffic (AADT):	*002040*	AADT Year:	*2008*
Estimated Percent Trucks:	*06*	Avg. No of School Buses per Day:	*14*
Posted Highway Speed:	*35*		

Figure 17 - Part V, FRA Crossing Report, Highway Information

MDOT Data Base

The data that MDOT provided to the team is the same data provided to the FRA for their database. This data was broken up into two spreadsheets, a rehabilitation sheet, and the Onsite data set. Both of the spreadsheets included some of the same information such as; FRA inventory number; who owns the crossing; and the location of the crossing such as city, township, and road. Other information differed between the two.

The rehabilitation data spreadsheet had 97 grade crossings on it, although some of the crossings were recorded multiple times due to the changing ownership of the line. The information included in this data is: the rehabilitation actions needed and the dates of the rehabilitation. This information is very pertinent to this project because it shows the times that each crossing was rebuilt and helps determine how well the surface material performs. However, the team did not find some historic data, such as when the crossing was first built or a history of rehabilitation dates. **Error! Reference source not found.**, illustrates the information included in this spreadsheet.

1	FRA NINUM	ROAD NAME	COUNTY	CITY	ROAD AUTHORITY	ORDERED ACTION	ORDERED ITEM	RESPONSIBLE PARTY	GENERAL COMMENTS
2	536176T	EAST MORRELL STREET	JACKSON	JACKSON	JACKSON, CITY OF	REBUILD	CROSSING CONDITIO	NORFOLK SOUTHERN CORPORATION	Railroad to rebuild crossing.
3	258238W	MEANWELL ROAD	MONROE	CROSSING NOT IN CI	MONROE COUNTY ROAD COMMISSION	REBUILD	CROSSING CONDITIO	GRAND TRUNK WESTERN RAILROAD COMPANY	Railroad to rebuild the crossing.
4	477459C	RIDGEVILLE ROAD	LENAWEE	CROSSING NOT IN CI	LENAWEE COUNTY ROAD COMMISSION	REBUILD	CROSSING CONDITIO	NORFOLK SOUTHERN CORPORATION	NS to rebuild the crossing surface (pumpi
5	283546S	MAIN STREET	CALHOUN	BATTLE CREEK	BATTLE CREEK, CITY OF	REBUILD	CROSSING CONDITIO	GRAND TRUNK WESTERN RAILROAD COMPANY	Rebuild & raise both tracks as agreed upo
6	258267G	TEAL ROAD	MONROE	CROSSING NOT IN CI	MONROE COUNTY ROAD COMMISSION	REBUILD	CROSSING CONDITIO	INDIANA & OHIO RAILWAY	Railroad to rebuild crossing surface.
7	P000042	PROPOSED COOPERATIVE CENTER D	NEWAYGO	NEWAYGO	NEWAYGO, CITY OF	INSTALL	CROSSING	MARQUETTE RAIL, LLC	Railroad install a crossing surface to acco
8	282918D	HALSTEAD ROAD	OAKLAND	CROSSING NOT IN CI	OAKLAND COUNTY ROAD COMMISSION	REBUILD	CROSSING CONDITIO	MICHIGAN AIR-LINE RAILWAY COMPANY	RR to rebuild crossing surface due to its p
9	282925N	LADD ROAD	OAKLAND	WALLED LAKE	WALLED LAKE, CITY OF	REBUILD	CROSSING CONDITIO	MICHIGAN AIR-LINE RAILWAY COMPANY	RR to rebuild the crossing surface due to
10	509064X	LABERDEE ROAD	LENAWEE	CROSSING NOT IN CI	LENAWEE COUNTY ROAD COMMISSION	REBUILD CROSSING SURFACE	CROSSING SURFACE	SOUTHERN MICHIGAN RAILROAD SOCIETY, INC	Railroad to rebuild crossing surface.
11	508904B	SILBERHORN HWY	LENAWEE	CROSSING NOT IN CI	LENAWEE COUNTY ROAD COMMISSION	REBUILD	CROSSING SURFACE	ADRIAN & BLISSFIELD RAILROAD COMPANY	Rebuild crossing surface when the roadw
12	285200W	GRATIOT AVENUE/M-3 SB	MACOMB	MOUNT CLEMENS	MDOT - METRO REGION	INSTALL NEW CROSSING SURF	CROSSING SURFACE	MICHIGAN TRANSIT MUSEUM	Install new crossing surface in conjunctio
13	388484P	M-69	DICKINSON	CROSSING NOT IN CI	MDOT - SUPERIOR REGION	REBUILD AND EXTEND	CROSSING CONDITIO	ESCANABA & LAKE SUPERIOR RAILROAD COM	Rebuild and extend crossing to fit the new
14	867548W	NORTH STONEY CREEK ROAD	MONROE	CROSSING NOT IN CI	MONROE COUNTY ROAD COMMISSION	EXTEND CROSSING SURFACE	CROSSING SURFACE	GRAND TRUNK WESTERN RAILROAD COMPANY	GTW extend crossing surface on both sic
15	P000039	RUSCHE DRIVE EXTENSION	KENT	CROSSING NOT IN CI	KENT COUNTY ROAD COMMISSION	INSTALL	CROSSING	MARQUETTE RAIL, LLC	Install a 40' crossing surface.
16	P000043	PROPOSED CHAMPION BIKE PATH	MARQUETTE	CHAMPION	MICHIGAN DEPARTMENT OF TRANSPORTAT	INSTALL	CROSSING	WISCONSIN CENTRAL LTD	Railroad to install a 10' crossing to accom
17	511390B	MCCOY ROAD	OTSEGO	CROSSING NOT IN CI	OTSEGO COUNTY ROAD COMMISSION	REBUILD AND EXTEND	CROSSING SURFACE	LAKE STATE RAILWAY COMPANY	Rebuild & extend crossing surface to mee
18	696807G	US-41/M-28	MARQUETTE	CROSSING NOT IN CI	MDOT - SUPERIOR REGION	REBUILD AND EXTEND CROSSI	CROSSING CONDITIO	WISCONSIN CENTRAL LTD	Rebuild crossing and extend to meet star
19	P000048	PROPOSED BAW BEESE TRAIL	HILLSDALE	HILLSDALE	HILLSDALE, CITY OF	INSTALL	CROSSING SURFACE	INDIANA NORTHEASTERN RAILROAD	Railroad and City to work together to get c
20	232455W	JANES STREET	SAGINAW	SAGINAW	SAGINAW, CITY OF	REBUILD	CROSSING CONDITIO	LAKE STATE RAILWAY COMPANY	Railroad to rebuild the main-line crossing
21	258287T	SOUTH COUNTY LINE RD	LENAWEE	CROSSING NOT IN CI	LENAWEE COUNTY ROAD COMMISSION	REBUILD	CROSSING CONDITIO	INDIANA & OHIO RAILWAY	Railroad to rebuild crossing surface which
22	284650P	LEGION STREET	SHIAWASSEE	CROSSING NOT IN CI	SHIAWASSEE COUNTY ROAD COMMISSION	RAILROAD TO REBUILD	CROSSING SURFACE	HURON AND EASTERN RAILWAY COMPANY	Rebuild crossing to create a smooth cros
23	234647V	LAKEWOOD BOULEVARD	OTTAWA	CROSSING NOT IN CI	OTTAWA COUNTY ROAD COMMISSION	REBUILD	CROSSING CONDITIO	CSX TRANSPORTATION, INCORPORATED	Railroad to rebuild both crossings.
24	284323E	BALDWIN AVENUE	OAKLAND	PONTIAC	PONTIAC, CITY OF	REBUILD	CROSSING CONDITIO	GRAND TRUNK WESTERN RAILROAD COMPANY	Railroad to rebuild the crossing surface th
25	234391U	M-52/M-43	INGHAM	CROSSING NOT IN CI	MDOT LANSING TSC OFFICE	REBUILD AND EXTEND	CROSSING SURFACE	CSX TRANSPORTATION, INCORPORATED	Rebuild the crossing surface and extend
26	511703N	LUNA PIER ROAD	MONROE	CROSSING NOT IN CI	MONROE COUNTY ROAD COMMISSION	REBUILD	CROSSING CONDITIO	GRAND TRUNK WESTERN RAILROAD COMPANY	CN to rebuild the crossing surface due to
27	511703N	LUNA PIER ROAD	MONROE	CROSSING NOT IN CI	MONROE COUNTY ROAD COMMISSION	REBUILD	CROSSING CONDITIO	NORFOLK SOUTHERN CORPORATION	NS to rebuild the crossing surface for the
28	511703N	LUNA PIER ROAD	MONROE	CROSSING NOT IN CI	MONROE COUNTY ROAD COMMISSION	REBUILD	CROSSING CONDITIO	GRAND TRUNK WESTERN RAILROAD COMPANY	GTW to rebuild the crossing due to aspha
29	P000050	MEYER DRIVE	GRAND TRAVERS	CROSSING NOT IN CI	GRAND TRAVERSE COUNTY ROAD COMMIS	INSTALL	CROSSING	GREAT LAKES CENTRAL RAILROAD	Railroad to install a 40' crossing consistin
30	512208D	DEMILLE STREET	LAPEER	LAPEER	LAPEER, CITY OF	REBUILD	CROSSING CONDITIO	LAPEER INDUSTRIAL RAILROAD	Railroad to rebuild the crossing surface w
31	509934W	US-12/CHICAGO ROAD	BRANCH	CROSSING NOT IN CI	MDOT MARSHALL TSC OFFICE	REBUILD	CROSSING CONDITIO	INDIANA NORTHEASTERN RAILROAD	Railroad to rebuild crossing surface.
32	282922T	WELCH ROAD	OAKLAND	CROSSING NOT IN CI	ROAD COMMISSION FOR OAKLAND COUNTY	REBUILD	CROSSING CONDITIO	MICHIGAN AIR-LINE RAILWAY COMPANY	Railroad to rebuild existing crossing surfa
33	545724C	W. SUPERIOR STREET/135TH STREET	ALLEGAN	WAYLAND	WAYLAND, CITY OF	REBUILD	CROSSING	GRAND ELK RAILROAD, L.L.C.	Railroad to rebuild and extend crossing to
34	283598J	SHEPHERD STREET	EATON	CHARLOTTE	CHARLOTTE, CITY OF	REBUILD	GENERAL CROSSING	GRAND TRUNK WESTERN RAILROAD COMPANY	Railroad to rebuild crossing surface.
35	232848E	WOODSIDE AVENUE	BAY	ESSEXVILLE	ESSEXVILLE, CITY OF	INSTALL	CROSSING SURFACE	LAKE STATE RAILWAY COMPANY	Railroad to install two new crossing surfac

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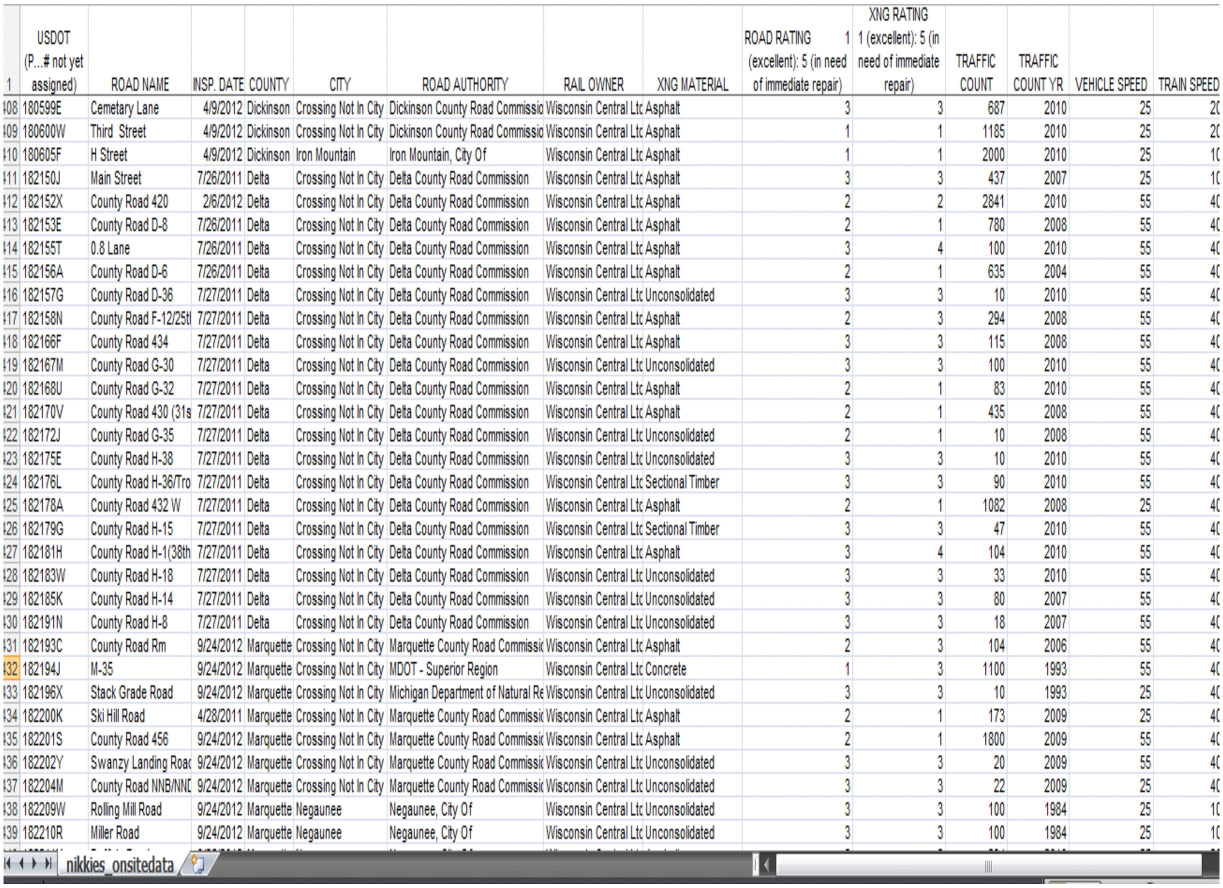
Figure 18 – Example of Crossing Rehabilitation Spreadsheet by MDOT

The Onsite spreadsheet had basic information on the crossing, including the crossing surface material rating along with other parameters that are important in determining how well the material performs. However, the rehabilitation dates that were included in the rehabilitation spreadsheet are missing. The fields this sheet included are shown in Figure 19 including the extra data that the team found useful to the project goals: the rating of the crossing surface, and train and vehicle speed.



1	USDOT (P...# not yet assigned)	ROAD NAME	INSP. DATE	COUNTY	CITY	ROAD AUTHORITY	RAIL OWNER	XNG MATERIAL	ROAD RATING 1 (excellent): 5 (in need of immediate repair)	XNG RATING 1 (excellent): 5 (in need of immediate repair)	TRAFFIC COUNT	TRAFFIC COUNT YR	VEHICLE SPEED	TRAIN SPEED
408	180599E	Cemetary Lane	4/9/2012	Dickinson	Crossing Not In City	Dickinson County Road Commissio	Wisconsin Central Ltc	Asphalt	3	3	687	2010	25	20
409	180600W	Third Street	4/9/2012	Dickinson	Crossing Not In City	Dickinson County Road Commissio	Wisconsin Central Ltc	Asphalt	1	1	1185	2010	25	20
410	180605F	H Street	4/9/2012	Dickinson	Iron Mountain	Iron Mountain, City Of	Wisconsin Central Ltc	Asphalt	1	1	2000	2010	25	10
411	182150J	Main Street	7/26/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Asphalt	3	3	437	2007	25	10
412	182152X	County Road 420	2/6/2012	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Asphalt	2	2	2841	2010	55	40
413	182153E	County Road D-8	7/26/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Asphalt	2	1	780	2008	55	40
414	182155T	0.8 Lane	7/26/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Asphalt	3	4	100	2010	55	40
415	182156A	County Road D-6	7/26/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Asphalt	2	1	635	2004	55	40
416	182157G	County Road D-36	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Unconsolidated	3	3	10	2010	55	40
417	182158N	County Road F-12/25tl	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Asphalt	2	3	294	2008	55	40
418	182166F	County Road 434	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Asphalt	3	3	115	2008	55	40
419	182167M	County Road G-30	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Unconsolidated	3	3	100	2010	55	40
420	182168U	County Road G-32	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Asphalt	2	1	83	2010	55	40
421	182170V	County Road 430 (31s	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Asphalt	2	1	435	2008	55	40
422	182172J	County Road G-35	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Unconsolidated	2	1	10	2008	55	40
423	182175E	County Road H-38	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Unconsolidated	3	3	10	2010	55	40
424	182176L	County Road H-36/Tro	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Sectional Timber	3	3	90	2010	55	40
425	182178A	County Road 432 W	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Asphalt	2	1	1082	2008	25	40
426	182179G	County Road H-15	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Sectional Timber	3	3	47	2010	55	40
427	182181H	County Road H-1(38th	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Asphalt	3	4	104	2010	55	40
428	182183W	County Road H-18	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Unconsolidated	3	3	33	2010	55	40
429	182185K	County Road H-14	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Unconsolidated	3	3	80	2007	55	40
430	182191N	County Road H-8	7/27/2011	Delta	Crossing Not In City	Delta County Road Commission	Wisconsin Central Ltc	Unconsolidated	3	3	18	2007	55	40
431	182193C	County Road Rm	9/24/2012	Marquette	Crossing Not In City	Marquette County Road Commissic	Wisconsin Central Ltc	Asphalt	2	3	104	2006	55	40
432	182194J	M-35	9/24/2012	Marquette	Crossing Not In City	MDOT - Superior Region	Wisconsin Central Ltc	Concrete	1	3	1100	1993	55	40
433	182196X	Stack Grade Road	9/24/2012	Marquette	Crossing Not In City	Michigan Department of Natural Re	Wisconsin Central Ltc	Unconsolidated	3	3	10	1993	25	40
434	182200K	Ski Hill Road	4/28/2011	Marquette	Crossing Not In City	Marquette County Road Commissic	Wisconsin Central Ltc	Asphalt	2	1	173	2009	25	40
435	182201S	County Road 456	9/24/2012	Marquette	Crossing Not In City	Marquette County Road Commissic	Wisconsin Central Ltc	Asphalt	2	1	1800	2009	55	40
436	182202Y	Swanzy Landing Roac	9/24/2012	Marquette	Crossing Not In City	Marquette County Road Commissic	Wisconsin Central Ltc	Unconsolidated	3	3	20	2009	55	40
437	182204M	County Road NNB/NNI	9/24/2012	Marquette	Crossing Not In City	Marquette County Road Commissic	Wisconsin Central Ltc	Unconsolidated	3	3	22	2009	25	40
438	182209W	Rolling Mill Road	9/24/2012	Marquette	Negaunee	Negaunee, City Of	Wisconsin Central Ltc	Unconsolidated	3	3	100	1984	25	10
439	182210R	Miller Road	9/24/2012	Marquette	Negaunee	Negaunee, City Of	Wisconsin Central Ltc	Unconsolidated	3	3	100	1984	25	10

Figure 19 - Onsite Data Base

Combined Data Sets

With the two separate spreadsheets it was difficult to correlate the information to assess the surface conditions and how well each one would last. The team chose to combine the rehabilitation data with the Onsite data to make a combined spreadsheet that included all the pertinent information from both. The Onsite spreadsheet had over 4000 crossings each with different crossing surface materials and no general order. To address this, the team arranged the crossings into four separate sections: asphalt, concrete, timber, and rubber. After that the new spreadsheet contained the rehabilitation dates, separate tabs for each material type, along with all the other data needed. The result was a combined spreadsheet that was easier to understand and use in correlating the data. Figure 20 shows the new spreadsheet with the addition of rehabilitation dates and with separate tabs for each crossing surface.

1	USDOT (P...# not yet assigned)	Rehabilitation Date	ROAD NAME	INSP. DATE	COUNTY	RAIL OWNER	# LANES	XNG MATERIAL	XNG RATING 1 (excellent): 5 (in need of immediate repair)	TRAFFIC COUNT	TRAFFIC COUNT YR	VEHICLE SPEED	TRAIN SPEED
2	000153D		Monroe Street/M-50	1/31/2011	Monroe	Ann Arbor Railroad	2	Concrete	3	7832	1993	40	25
3	180433A		13th Street @ 18th Avenue	7/31/2012	Menominee	Wisconsin Central Ltd	4	Concrete	2	6000	2010	25	25
4	180527B		Maple Street	8/2/2012	Menominee	Wisconsin Central Ltd	2	Concrete	2	564	2009	25	40
5	180547M		County Road 535/D Road	7/25/2011	Delta	Wisconsin Central Ltd	2	Concrete	2	841	2008	25	40
6	180548U		M-69	7/25/2011	Delta	Wisconsin Central Ltd	2	Concrete	2	2010	1993	55	40
7	182194J		M-35	9/24/2012	Marquette	Wisconsin Central Ltd	2	Concrete	3	1100	1993	55	40
8	232231Y		Seven Mile Road	12/12/2011	Wayne	CSX Transportation, Inc	4	Concrete	1	16446	2009	35	50
9	232241E		Gen-mar Drive	10/31/2012	Oakland	CSX Transportation, Inc	2	Concrete	3	867	2009	30	10
10	232250D		Beck Road	10/31/2012	Oakland	CSX Transportation, Inc	3	Concrete	1	13000	2010	40	50
11	232252S		S Wixom Road	11/1/2012	Oakland	CSX Transportation, Inc	5	Concrete	2	32640	2011	45	10
12	232256U		Wixom Road	11/1/2012	Oakland	CSX Transportation, Inc	9	Concrete	1	17190	2011	25	40
13	232334Y		Grange Hall Road	12/6/2007	Oakland	CSX Transportation, Inc	3	Concrete	1	11180	2010	55	25
14	232821V		Vet Memorial Pk/M-13	12/10/2010	Saginaw	Lake State Railway Company	4	Concrete	1	4300	2010	55	20
15	232845J		Center Avenue/M-25	1/23/2012	Bay	Lake State Railway Company	5	Concrete	3	20000	2009	35	10
16	232958P		Towerline Road	12/10/2010	Saginaw	Huron and Eastern Railway Compan	2	Concrete	1	1010	2010	55	25
17	232966G		Vassar Road/M-15	12/22/2010	Saginaw	Huron and Eastern Railway Compan	2	Concrete	1	4500	2006	55	25
18	232973S		Saginaw Street/M-81	3/6/2012	Tuscola	Huron and Eastern Railway Compan	2	Concrete	1	6900	1993	35	10
19	233017X		Beech Street/M-138	3/7/2012	Tuscola	Huron and Eastern Railway Compan	2	Concrete	3	2000	1993	35	10
20	233068H		Union Street	10/1/2012	Huron	Huron and Eastern Railway Compan	2	Concrete	1	1353	2009	25	10
21	233070J		Unionville Road/M-25	10/1/2012	Huron	Huron and Eastern Railway Compan	2	Concrete	2	2100	1993	55	25
22	233112T		East Huron Ave/M-142	10/2/2012	Huron	Huron and Eastern Railway Compan	3	Concrete	1	12000	1993	30	10
23	233468B		M-15/Goodrich Street	3/12/2012	Tuscola	Huron and Eastern Railway Compan	3	Concrete	2	8700	1993	40	25
24	233498T		M-24/Ohmer Road	3/14/2012	Tuscola	Huron and Eastern Railway Compan	2	Concrete	1	4400	1993	55	25
25	234292W		Inkster Road	3/14/2012	Wayne	CSX Transportation, Inc	5	Concrete	1	23856	2009	40	45
26	234296Y		Stark Road	3/14/2012	Wayne	CSX Transportation, Inc	4	Concrete	1	11793	2010	40	45

Asphalt / Concrete / Rubber / Sectional Timber

Ready — Average: 8.654929577 Count: 286 Sum: 1229 90%

Figure 20 - Combined Spreadsheet

Some problems appeared with the data after the combination of the spreadsheets; missing rehabilitation dates and missing historic dates for some records, and no history of surface material ratings in general.

MDOT Crossing History

Near the end of the summer MDOT provided a set of crossing history data. Files dating back to the 1990s are common. There are a few scattered documents that are older still. Although there are some records that describe repair work done to a crossing, most files are simply a compilation of crossing inspection data.

One of the primary challenges with the history data is that the 1-5 rating scale seems to have only been implemented since 2002. Before that crossings were rated as good, good/fair, fair, fair/poor, and poor. In order to use previous review forms, the old rating system was converted to the current scale through the following method. A rating of good was deemed the same as a 2, fair turned into a 3, and poor became a 4. If there was a comment about immediate repair following the word poor it became a 5.

The other main challenge stemmed from a lack of information regarding crossing repairs. Often the rating would change from a 5 to a 2 within a few years. A logical assumption would be that these crossings underwent repairs sometime between these two reports, despite the fact that there was often nothing in the history to indicate such work. On the rare occasion that a repair was noted the team assigned a rating of 2 to the crossing at the date of the repair.

MDOT Railroad Crossing Inspector Field Visit

During the Spring Break of 2013 several students from our team made a visit to Jackson, MI to ride with two MDOT inspectors for a day. During the trip students were able to pick the brains of the inspectors to get a better idea of what goes into the evaluating process of railroad crossings.

The MDOT inspectors try to make it a point to inspect the crossings every 18 - 24 months. Whenever the inspectors head out into the field for inspections they always keep their eyes open for problems. Each inspector carries a laptop, in which they fill out the crossing inspection data base. Photos are taken at each crossing

 Crossing rated 1	 Crossing rated 2
 Crossing rated 3	 Crossing rated 4
 Crossing rated 5	 Crossing rated 5

Figure 21 - Examples of Crossing Condition Rating

for documentation as seen in figure 20. These photos document the conditions of the crossings, highlighting what needs to be corrected or what can stay the same. Among this information is a grade for the overall performance of the crossing. The grading scale is 1-5 with 1 being the best and 5 being the worst and in need of immediate repair. According to the inspectors, crossings do not stay at a classification of 1 for long. Shortly after the track is opened to traffic wear and tear begin to take effect thus lowering the grade of the crossing. A crossing with a grade of two or three is acceptable and is safe for public use. When a grade of 4 is given to a crossing, recommendations are made to the owner of the track for improvements. A grade of 5 requires immediate action to return the rating to an acceptable grade of 1, 2 or 3. In these cases MDOT will issue a repair order to the railroad responsible for the crossing.

Figure 21 shows different grade crossings that each are rated 1 - 5. The explanation of how each figure received their rating from a MDOT inspector is as followed:

- Rated 1 - This crossing was just installed last year and is in very good condition.
- Rated 2 - This crossing is only a couple years old and is just starting to show wear.
- Rated 3 - This crossing was previously written up for a poor crossing surface. The railroad has repaired the asphalt and it is now rated 3.
- Rated 4 -This crossing looks really bad in the picture, but the ride quality is not as bad as the appearance. I wrote a deficiency for the RR to rebuild this crossing.
- Rated 5 - This crossing was written up to rebuild because of how its deterioration.

These crossings and the ratings where provided to the team by James Goff, an MDOT rail inspector.

Creating a List of Railroad Crossings for Inspection

In order to carry out the task of inspecting the crossings over the summer of 2013, the team developed a list of crossings to use as the crossing selection for this project. This list was taken directly from the MDOT crossing inventory data base. On the list are crossings of all four different surface material types: asphalt, concrete, timber, and rubber. Two variables were focused on for the selection of crossings- train speed and vehicle speed. From there, roughly 25 crossings of each surface type were selected, for a total of 107 crossings.

The team visited 10-15 Highway-Grade Crossings per day. The crossings are localized mainly in the lower peninsula of Michigan. Visits were conducted throughout the summer starting in June 2013. This same list was also sent to MDOT in order to acquire historical data on these crossings.

Survey Questionnaire

A short survey was created and distributed to select DOTs in an attempt to gain a better understanding of what other DOTs do with their grade crossing surfaces. It was also an attempt to figure out which DOTs had people that were willing to talk with the team about the project. This survey consisted of 9 very general questions that were intended to get a broad sense of how rail-grade crossings were handled in that particular state. The survey questions can be seen in Appendix A.

The team decided to send this survey to states that faced similar weather conditions to what is experienced in Michigan. This decision was made for two reasons. First, it allowed for a method to select a handful of states instead of picking at random. It also ensured that any state that responded would likely have the same problems and possibly solutions to those problems. In the end the survey was sent to 9 different states including Wisconsin, Minnesota, New Hampshire, Vermont, New York, and Pennsylvania.

Of the nine states that surveyed, only three responded. States that responded include Pennsylvania, New Hampshire, and Wisconsin. Of the three states, none had specific guidelines for choosing a surface crossing. Despite this, those interviewed did have preferences for high and low density traffic areas. All three respondents preferred asphalt crossings for low density road traffic crossings. The response for high volume traffic flow was not as unanimous. The three types that were given were asphalt, concrete panels, and concrete pavement.

Wisconsin was the only state that responded without a system for rating grade crossings, and all three keep some sort of history of inspections. The information that these states retain is likely different than what MDOT maintains. Unfortunately, ongoing attempts to contact the respondents about this information have proven ineffective.

FINDINGS

Analysis of MDOT Crossing History

Once the combined spreadsheet was created and the problems addressed, it made it possible to develop graphs of the crossing data showing a relationship between the surface material and the crossing surface rating. Figure 22 shows a set of graphs that were created from the current data correlating the surface material type against the grade it received along with how many crossings of the type received the grade. This gives a snapshot of crossing conditions in Michigan during the study. The average condition rating for rubber crossings was 2.6, for timber it was 2.4, for asphalt it was 2.3, and for concrete the average rating was 1.7.

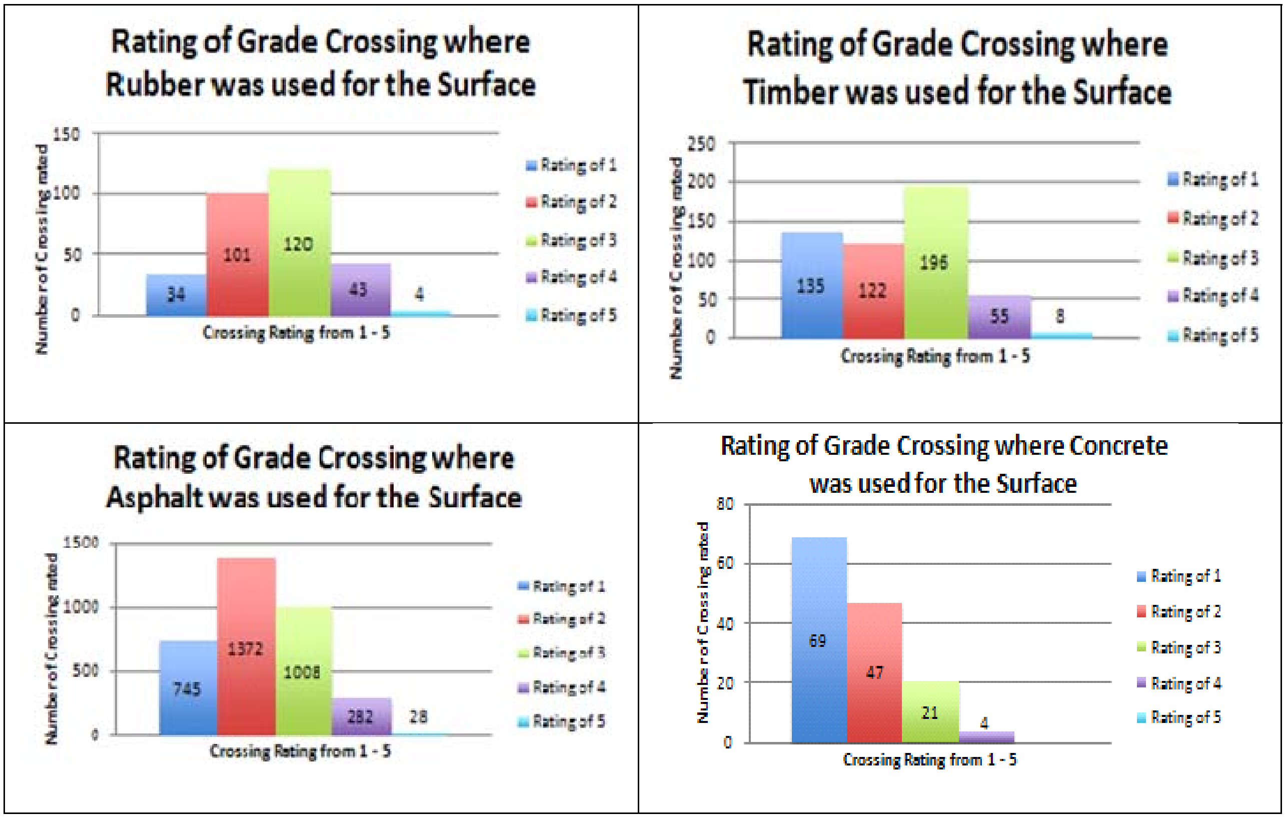


Figure 22 - Snapshot of crossing condition during study period

The MDOT history files were examined manually, and a spreadsheet was developed including the following data fields (where data was available): Date of inspection; Crossing surface material; ADT; % Trucks (in ADT); Surface rating; and train speed. The crossings were divided into four categories of Concrete, Asphalt, Timber, and Rubber. A graph of inspection year vs rating was created for each crossing in the history provided. To avoid scaling issues, the year was graphed horizontally, with each graph showing the same range, from 1994 to 2013, to cover all the data included in the history. The graphs included a vertical scale of 1-5, with integer values only, to correspond to the possible rating values. A visual inspection of the resulting graphs was conducted, with following results:

General observations:

- very few historical records included a complete crossing life cycle from one reconstruction to the next
- Although graphs show changes in ratings, there is no causal data to go with the records, so the reasons for the changes cannot be reliably determined
- It appears that a rating change of one point in either direction for a single rating period may have no real significance. With no rating criteria two different inspectors could rate the same crossing differently on the same day.

Concrete Crossings – 30 Crossing records (some crossings were upgraded during the period included in the history, and the surface material change. Five records covered only one inspection, another four covered three years of inspection or less)

- Performance of the crossings in this group were remarkably consistent.
    - 14 of the records of more than three years, and all ten with less than three years of ratings, had absolutely no change in the in the rating during the history period.
    - 4 records showed a change in rating of only one point in the history available (interestingly, 2 showed increases of one point)
    - 2 records had changes of more than one point
    - Concrete ratings decreased by 0.01 points per year on the average

Asphalt Crossings – 20 Crossing records

- Performance of these crossings was erratic
    - 4 crossings showed a change of 1 point or less during the history period available
    - 10 crossings had very erratic histories, with swings of more than two points up and down, often in consecutive ratings periods.
    - 6 crossings had decreases, followed by increases and then a stable period, or gradual decreases in rating.
    - 2 crossings had material changes in the history, one from asphalt to concrete, the other from asphalt to rubber, then to concrete.
    - The rating for these crossings decreased by 0.03 points per year, however it was impossible to include a slope for the most erratic crossings

Rubber Crossings – 17 Crossing records

- Performance of these crossings was fairly stable
    - 12 crossings had changes of 1 point or less, although several of these bounced up or down by a point over consecutive inspections
    - 2 crossings had significant drops, followed by a jump and a stable period.
    - 2 crossings showed gradual decline over the rating period
    - The average decrease in rating was 0.03 points per year

Timber Crossings – 20 crossing records, one crossing had a reconstruction part way through the history

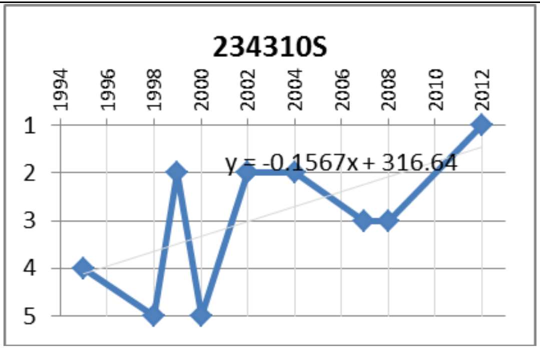
- Performance of these crossings was also fairly stable, similar to that of the Rubber crossings
    - 6 crossings had changes of less than one point, although they may have bounced up or down
    - 9 crossings showed steady decline, however some drops might have been more than one point at a time.

- 3 crossings had erotic behavior, swings of more than two points both up and down.
- 3 crossings did not have enough history to evaluate.
- Timber crossings decreased by an average of 0.16 points per year

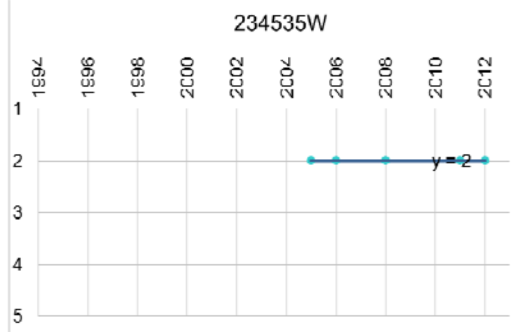
An example of the data and graph for Asphalt Crossing 234310S is shown in Table 2 and Figure 22 shows examples of the four different crossing materials included in the study. The complete data set and graphs are in Appendix D rating spreadsheets

Table 2 – Asphalt Crossing data, for crossing 234310S

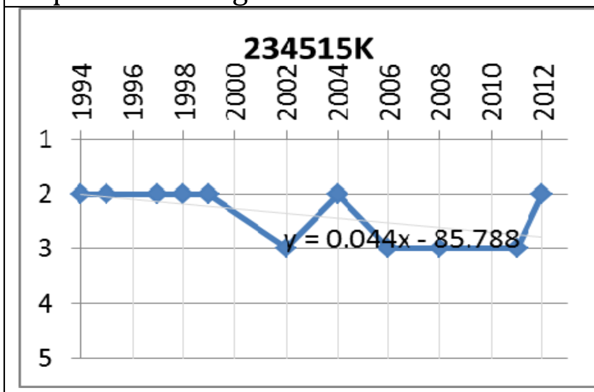
234310S					
date	type	adt	Year	rating	speed
6/12/1995	sectional timber	10491	1995	4	45
3/27/1998	asphalt	10491	1998	5	45
7/29/1999	asphalt	repair	1999	2	45
4/20/2000	asphalt	10491	2000	5	45
1/28/2002	asphalt	10491	2002	2	45
5/14/2002	asphalt	10491	2002	2	45
12/8/2004	asphalt	10491	2004	2	45
3/7/2007	asphalt	10491	2007	3	45
9/8/2008	asphalt	10491	2008	3	45
1/4/2012	asphalt	29343	2012	1	45



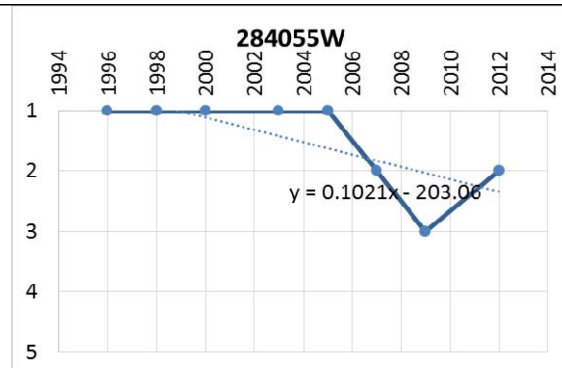
Asphalt Crossing 234310S



Concrete Crossing 234535W



Rubber Crossing 234515K



Timber Crossing 284055W

Figure 23 - Examples of Crossing Rating Graphs

Questionnaire Responses

A questionnaire was sent out to CN, CSX, Wisconsin Southern, and the Iowa DOT to further help clarify any questions regarding record keeping, maintenance cycles, and preferred highway-grade crossing surface materials.

Iowa Department of Transportation (IowaDOT)

The team talked with Travis Tinken of the Iowa Department of Transportation (IowaDOT), and found a considerable difference with MDOT's grading process and data collection for individual highway grade crossings.

A large volume of information is collected for each crossing when a reconstruction takes place (see Appendix C). IowaDOT breaks down each material that makes up the crossing. Ballast size and type, tie quality, rail weight, sub-drainage type, crossing dimensions, and compaction methods. Without a doubt, there are many advantages in having such a system in place including better cost forecasting and improved crossing performance data over an extended period of time.

To supplement each crossing's data history, we were also given individual crossing reports for a large part of Iowa. Each crossing has an exact location given along with eleven different sets of criteria (see Appendix C). The most notable data columns, however, involved driver behavior. By measuring such events as vehicle speed reduction and vehicle swerving (to avoid a raised rail or pot hole, for example), DOT officials can more accurately determine which crossings are unsafe (but never reported). Combining this with the standard means of measuring a highway-grade crossing, such as approach profile and surface deformation, will make future highway-grade crossing improvements much more streamlined.

A second interview with Mr. Tinken revealed the results of an asphalt underlayment system. In the discussion, Mr. Tinken strongly stressed that the subgrade is the number one issue, and *not* the surface material. The IowaDOT design for an asphalt underlayment consists of an asphalt hardpan, poured, rolled, and compacted to a minimum depth of 8''. In other words, it is as if there is a newly paved street running right under the crossing. This is the crucial component to the crossing that has many benefits.

For one, by having a strong, smooth, and crowned surface, water can freely drain *away* from the center of the crossing and ties into drainage pipes on both sides, virtually eliminating pooling water and rot that otherwise would compromise the strength of the crossing.

Secondly, the asphalt underlayment, while still fresh, acts as a locking mechanism for the ballast spread and compacted on top. With each new compaction, the bottom layer of ballast becomes more and more implanted into the asphalt layer. This stabilizes the foundation, forming and interconnecting the bond between the ballast. Vibrations and movement of the crossing are therefore reduced considerably.

Lastly, the problem of mud seeping up through the soil is entirely eliminated. The utilization of an asphalt underlayment acts as a shield against soil particles building up from below the crossing. By removing this build-up, water can remain to flow freely down to the asphalt layer where it will then flow off to the sides, away from the crossing.

The cost savings seen from these crossing improvements have been very good. A crossing whose operational life was once 1-3 years has now jumped to 12-15 years (and that is a double mainline crossing). Furthermore, roaming tie gangs, who would originally perform work on a particular crossing, can now skip over them and continue down the mainline. This completely eliminates the need for a delay, road closure, and additional man power to rehab the crossing, saving a lot of time and money in the process.

On a further note, however, Mr. Tinken made it especially clear that consistency *must* be maintained for this to work. Not only is it consistency in design, but also consistency in a grading scale and consistency in who is *performing* that grading. Mr Tinken recommended a single individual be assigned to all inspection duties.

Wisconsin Southern Railroad

The team obtained a response from Brent Marsh of the Wisconsin Southern Railroad (WSOR) in November of 2013. In his response (see Appendix B) he clarified many details as to how records are kept, when crossings are rehabilitated, and how different crossings deteriorate over time. The team was surprised to see that rubber and composite are two of the lower performing crossings (see crossings 5 and 6 under the answer for Question 4). Additionally, it was interesting to note that prior to 2012, WSOR did not keep records on all crossings (see answer to Question 3). They now report, through their foreman on a daily basis, general crossing information. Regardless, it appears that any sort of record keeping on crossing rehabilitation projects is in its beginning stages. With similar climates, WSOR shares a lot of the same environmental conditions as MDOT, and this will be very useful in determining what surface crossing material is best.

Canadian National Railway

Jim Gasiecki of CN Railway also responded to the survey. In his answers he described the many traits that break down a crossing including drainage, geometry, and any electrical current running through the rail (see Appendix B, CN Response). Interestingly enough, crossing materials vary from railroad to railroad. As was suggested in another response by Brent Marsh of the Wisconsin Southern Railroad, rubber and composite crossings have proven unsatisfactory and have led to a complete avoidance of them. However, CN maintains full depth timber crossings wherever possible, but may choose to *upgrade* to a composite or rubber crossing.

CSX Transportation

In a response by Amanda DeCesare of CSX Transportation (see Appendix B, CSX Response), information was given on how CSX participates in cost sharing programs with local road authorities in a particular area. Sometimes, the road authority will pay for the labor and materials or just the materials only. Furthermore, she suggested that we contact the Transportation Technology Center (TTCI) out of Pueblo, Colorado as they have been conducting research on grade crossing materials in the past.

MDOT Highway-Rail Crossing History Data Sheet

Additional information is required for a comprehensive analysis of the Highway-Rail Crossing surface. To achieve this analysis, the team developed the Highway-Rail Crossing History Data (HIRCH) Sheet. The purpose of the HIRCH Sheet is to capture the parameters of selected crossings, which may lead to more direct correlations between Highway-Rail Crossing properties and the performance of the surface material used.

Many of the items to be recorded on the HIRCH Sheet can be collected from existing reports and databases. Much of the information only needs to be collected once, or after a significant construction event. If an inspection report is not submitted for a particular crossing in a given year, a visual inspection should be done by the researching party. To complete the HIRCH Sheet, a more detailed review of surface and drainage conditions for a crossing will be required. If this cannot be done during a routine inspection, an annual surface material and drainage inspection should be accomplished by research team.

The data collection process should continue until a given crossing is closed or replaced by a grade separated crossing. Initial analysis may begin after a complete rehabilitation cycle has been completed. The data collection may be done by intern students, MDOT appointed employees, or as an ongoing university research project. The HIRCH Sheet should be updated and filed by the researching group or by MDOT if a researching group is not selected on an annual basis. The additional information included on the proposed HIRCH Sheet is of great importance for completing the research, integrating the data shown into the MDOT database would speed data entry and retrieval. Instructions and recommendations for using the HIRCH Sheet are included. The HIRCH sheet is intended to be easily understood and completed.

The parameters of the HIRCH Sheet build on the current information already collected by MDOT. Along with the AADT, Average Train Tonnage per Day, and the current data supplied by MDOT inspection reports, additional data items were selected. The new data includes subbase composition, drainage system, soil type, soil moisture content, average yearly rainfall, average yearly snowfall, more detailed rehabilitation notes, along with the dates of all the reported data. These parameters may provide additional insight into how a crossing structure performs. With additional data, and the dates of the rehabilitations, multiple correlations can be made with the data over time. This data can be used to relate the impact of each parameter on the surface performance, and possibly provide a prediction of the best performing surface material, and other factors that affect the crossing structure integrity the most. Figure 24, shows an overall view of the proposed HIRCH sheet, detailed discussion of each section follows.

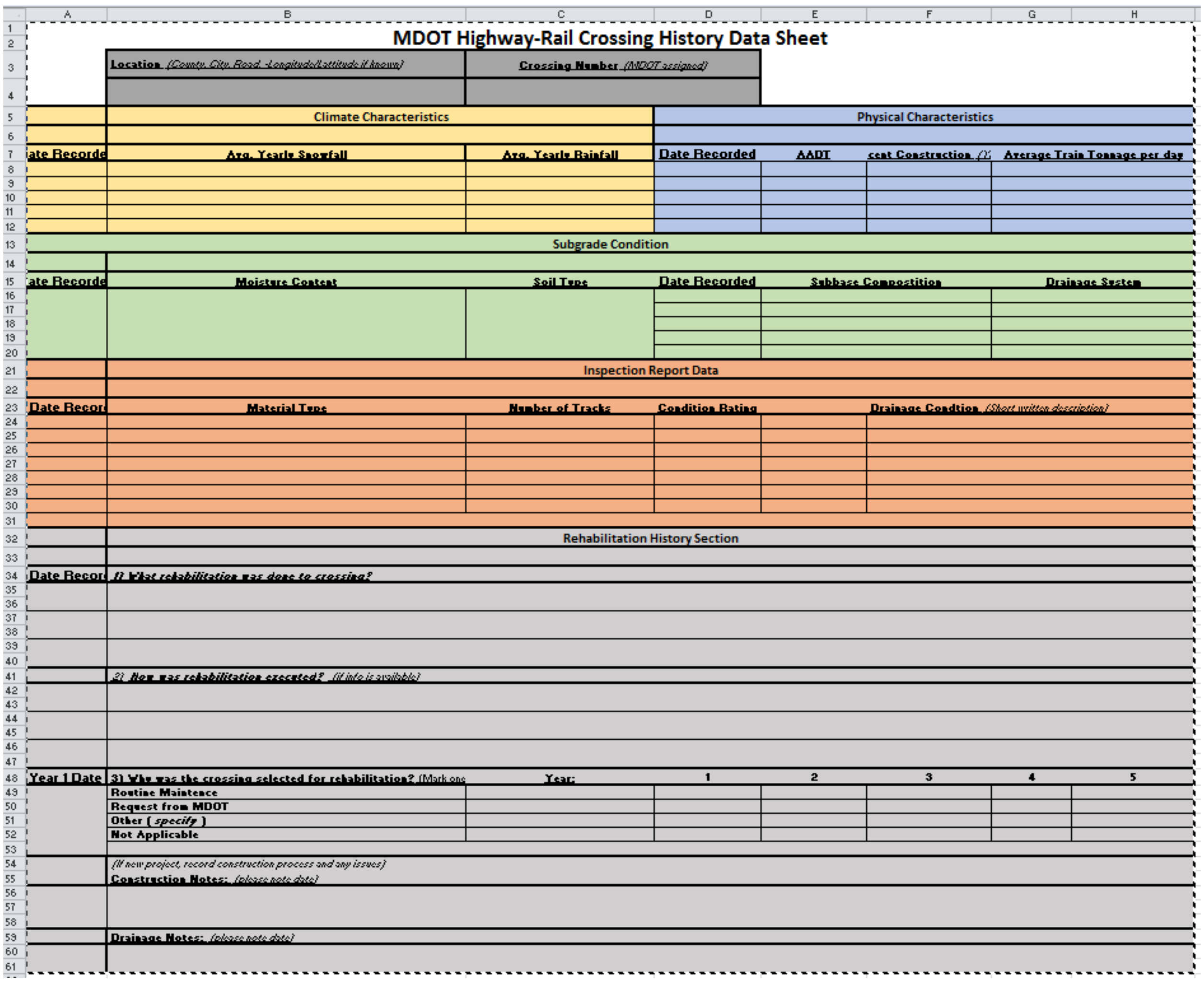


Figure 24 - HIRCH Data Sheet

The additional data collection needs vary between parameters. Each section represents an aspect of the crossing, with the different items falling under each section, along with dates for each item. The discussion below outlines how the HIRCH sheet would be completed and used. Cell and column sizes have been adjusted to improve clarity and understanding.

Table 3, shows the general conditions for the crossing, including location, and crossing number, along with physical conditions from MDOT data sources (AADT is available from the highway planners, recent construction should be noted on the inspection. The research team may need to establish a relationship with railroad personnel to check the train traffic figures. Climate conditions are shown here, too, and would only be recorded once (assuming global warming doesn't significantly change climate!) Climate data can be easily obtained on-line for most locations using weatherchannel.com or weatherunderground.com.

Table 3 - HIRCH General Conditions

MDOT Highway-Rail Crossing History Data Sheet						
	Location *(County, City, Road, -Longitude/Latitude if known)*	**Crossing Number** *(MDOT assigned)*				
	Climate Characteristics		**Physical Characteristics**			
Date Recorded	**Avg. Yearly Snowfall**	**Avg. Yearly Rainfall**	**Date Recorded**	**AADT**	**Recent Construction** *(Y/N)*	**Average Train Tonnage per day**

Table 4 includes the Subgrade Condition Section; this will provide the moisture content, soil type, subbase composition, and drainage system. This data is important for understanding the foundation on which the crossing structure is placed. Understanding the forces involved, the settlement of the soil, and the amount of water located around the structure will provide valuable insight. Many structures perform poorly with a saturated subgrade, and deterioration will quicken. The drainage system is especially important because of its role in providing a dry subgrade, based upon the climate characteristics it may be determined if the drainage system is suitable. This data would be collected during reconstruction events or by a soils investigation if an MDOT survey team is in the area.

Table 4 - HIRCH Subgrade Condition

Subgrade Condition					
Date Recorded	**Moisture Content**	**Soil Type**	**Date Recorded**	**Subbase Composition**	**Drainage System**

Table 5 shows the information pulled directly from the MDOT Inspection Reports, the only item not located on the Inspection Reports is the Drainage Condition. The most recent Inspection Reports supplied with the MDOT Crossing Histories, did not have drainage as an item to be evaluated, this should be added to the Inspection Reports, or the research team should make field visits to record the information on an annual basis

Table 5 - HIRCH Inspection Report Data

	Inspection Report Data				
Date Recorded	Material Type	Number of Tracks	Condition Rating		Drainage Condition *(Short written description)*

Table 6 is the Rehabilitation History Section. This section is much different than the other sections, and provides data of the rehabilitation of crossings, which previously was not well documented. Along with the dates of the rehabilitations done, are descriptors of what took place, how it was done, and why it was done. Many times a crossing is selected for rehabilitation simply because it is on the railroads track maintenance list. To properly tamp the ballast, the surface must be removed. This makes it difficult to determine structural performance. Construction Notes have been added to help identify any problem areas during the Construction or Rehabilitation process, details of the process will provide valuable information on how to improve the effectiveness of the design. Drainage notes were added to provide a place to add more detail from the Inspection Report Data Section. Drainage is critical for any structure, and its importance on the performance the crossing structure cannot be overstated. Overall, this section will provide information that will help in the accuracy of any future analysis effort.

Table 6 - Rehabilitation History Section

	Rehabilitation History Section
Date Recorded	*1) What rehabilitation was done to crossing?*

	Rehabilitation History Section						
	*2) **How was rehabilitation executed?** (if info is available)*						
Year 1 Date	**3) Why was the crossing selected for rehabilitation?** (Mark one for each year)	**Yea r:**	**1**	**2**	**3**	**4**	**5**
	Routine Maintenance						
	Request from MDOT						
	Other (*specify*)						
	Not Applicable						
	(If new project, record construction process and any issues) **Construction Notes:** *(please note date)*						
	Drainage Notes: *(please note date)*						

Crossing Surface Rating

Under the scope of work the team was tasked with developing guidelines for crossing surface rating. Michigan's Department of Transportation has a grading scale in place now that is designed to evaluate the surface conditions of railroad crossings throughout the state. The grading scale is 1-5 with 1 being the best and 5 being the worst; a 5 indicates the crossing is in need of immediate repair. According to the inspectors, crossings do not usually stay long at a rating of one. Shortly after the crossing is opened to traffic, wear and tear begins to take effect thus lowering the rating of the crossing. A crossing with a rating of two or three is acceptable and is safe for public use. When a rating of 4 is given to a crossing, recommendations are made to the owner of the track for improvements. A rating of 5 means that a crossing needs immediate attention in order to bring the track back to an acceptable condition, and results in a repair order from MDOT to the Railroad.

The biggest area that needed to be improved with MDOT’s current grading system was the qualification of each number within the rating system. The system in place now does not define criteria for the numeric ratings. It is difficult to share information across mediums if there is no system in place that defines each number in the system. This can make it difficult to train new inspectors and limits analysis that can be accomplished with the ratings.

The recommended grading scale was modeled after the Pavement Surface Evaluation and Rating (PASER) system. The PASER system was developed by the University of Wisconsin Transportation Information Center to provide a simple, efficient, and consistent method for evaluating road condition, and is used extensively for rating pavements in Michigan. The new system has been set up based on crossing type and takes into account the different types of distress that each crossing encounters. Table 7 shows the recommended criteria for rating each type of crossing.

The crossing will be rated at the highest point where ALL criteria are met, allowing for meaningful statistical analysis of the system. For example, an asphalt crossing with less than 30 feet of cracking, all cracks tight, no surface raveling, but with a couple of patches in only fair condition would be rated as a 3, even though all criteria items in the 2 range are met except for the patching. A defined numeric rating system will allow distress to be better tracked over time. Looking at crossings over time means that inspectors as well as researchers will be able to look at a crossing and know why it was repaired and possibly predict when a crossing will need to be repaired.

Table 7 - Recommendations for Crossing Rating Criteria

Asphalt
1 - Excellent
New Construction or Recent Reconstruction
No Defects
No Action Required
2 - Very Good
< 30 feet of cracking
All cracks tight (hairline)
Patches in good condition
Minor surface raveling
No holes > 2”
3 - Fair
First signs of alligator cracking, Surface

Concrete
1 - Excellent
New Construction or Recent Reconstruction
No Defects
No Action Required
2 - Very Good
Joints all in good condition
Minor Surface defects - pop outs, map cracks
Light Surface wear
3 - Fair
First signs of crack or joint faulting up to 1/4"
First signs of joint or crack spalling
Moderate to severe scaling or polishing

Depression 1/2" - 1" deep
< 50% of surface block cracking
< 30 feet of cracking
Cracks open, 1/8" or less
Severe surface raveling
Patching in fair condition
One or two holes < 6"
4 - Poor
> 25% Alligator Cracking
Surface Depression > 1" deep
Severe block cracking
30 to 60 feet of cracking
Cracks showing extensive crack erosion and/or cracks > ¼" wide
More than two holes < 6" No holes > 6"
Patches in poor condition
5 - Very Poor
> 50% Alligator cracking
Severe Rutting or Surface depression > 2"
Holes > 6"
Extensive patches in poor condition
Loss of Surface integrity
Extensive surface distress

25-50% of surface
Minor spalling from reinforcement
Multiple corner cracks
Fasteners loose, but not projecting above surface
4 - Poor
Severe cracking or joint faulting up to 1"
Many joints, transverse, meander cracks open, severely spalled
Extensive Patching in poor condition
Occasional holes
Fasteners loose, projecting < ¼" above surface
Loose panels, no vertical displacement
5 - Very Poor
Extensive and severely spalled cracks
Extensive failed patches
Joints failed
Restricted speeds
Loose panels, vertical displacements between panels, > ½"
Loose fasteners, projecting > ¼" above surface

Rubber
1 - Excellent
New Construction or Recent Reconstruction

Timber
1 - Excellent
New Construction or Recent Reconstruction

No Defects
No Action Required
2 - Very Good
All joints in good condition
Minor Surface defects
Light Surface wear
3 - Fair
Moderate to heavy surface wear
Surface depressions 1/2" - 1" deep
Loose fasteners, none projecting above surface level
Corners bending upward
Vertical displacements ½" or less
4 - Poor
Surface depressions > 1" deep
Many joints opening ½" or more
Extensive Patching in poor condition
Occasional holes > 6"
Loose panels
Loose fasteners projecting < ¼" above surface
Vertical displacements ½" to 1"
5 - Very Poor
Extensive open joints, > ½"
Extensive failed patches
Missing Panels

No Defects
No Action Required
2 - Very Good
Joints all in good condition
Minor Surface defects – cracking, splitting
Light Surface wear
First signs of crack or joint faulting up to 1/4"
3 - Fair
Signs of joint or crack faulting ¼" to ½"
Splits, Cracks up to ¼ length of timber
Loose fasteners, not projection above surface
Surface deterioration … missing chunks greater than 36 square inches
4 - Poor
Severe crack or joint faulting > 1/2" wide
Loose boards or timbers
Vertical displacement ½" to 1"
Extensive Patching in poor condition
Occasional holes or missing material 36 square inches to 100 square inches
Loose fasteners projecting < ¼" above surface
Cracks or splits ¼ to ½ length of timber
5 - Very Poor
Extensive and severe cracks > 1" wide
Extensive failed patches
Missing or Extremely loose timbers

Restricted speeds
Vertical displacements > 1”
Fasteners loose and projecting > ¼” above surface.

Restricted speeds
Loose Fasteners projecting more than ¼” above surface
Vertical displacements > 1”
Frequent holes or missing material > 100 square inches
Cracks or splits more than half length of timber.

DISCUSSION

Although limited analysis was completed with the available data, the research team does not feel that it is adequate for a firm recommendation on the best crossing material. It is apparent that construction details and subsurface conditions contribute a great deal to the performance of a crossing. Based on the limited data it seems that concrete panel crossings perform very well, with very few reconstructions required. Timber crossings and rubber crossings also perform well, but may need attention more quickly. Although some asphalt pavement crossings in the data set performed extremely well, the performance of these crossings overall seemed more erratic. However, it is important to note that the available data did not allow for any credible causal analysis of crossing failure.

In order to address that shortfall the research team developed two methods for improving the data available to MDOT for analysis of rail-highway grade crossings.

The first item compiles existing data on crossings into a single location, the HIRCH data sheet, for easier access and analysis. The sheet may require some initial research to complete, climate data and current drainage information do not seem to be available from current MDOT sources. Historical data on crossing construction details would be a nice addition, but may not be available from any source. Construction details on any new work should be collected and added on an annual basis. This may require coordination with the Railroad to document any work done. Incorporating the data collected in this effort into the MDOT data system would allow it to be retrieved and used more efficiently.

The second item is a more detailed inspection system for documenting the surface condition. Modeled after the PASER system currently in use for evaluating highway pavement conditions in Michigan, this system establishes a set of criteria that would define the rating for each inspection, and record the surface deficiencies that led to the rating. This information would allow analysis of the surface performance over time.

Completing the research originally envisioned in this project will require data collection over an extended period of time. If MDOT wishes to continue, data collection using the tools outlined here could be performed on a regular basis by MDOT personnel, interns hired by MDOT for summer work, or by establishing an ongoing contract with a university like Michigan Tech. Although not included in this effort, collecting cost information for crossing construction and maintenance activities would allow a more thorough analysis.

CONCLUSIONS

Performance of highway-rail grade crossing surface materials has not been well researched in the past. The research team conducted a literature review and came up with some interesting information, but nothing that provides a clear answer to the research question. The team inspected more than 100 crossings throughout Michigan and prepared a “snapshot” indicating the current condition of those crossings. A list of data required to complete the research envisioned in this project was developed, as well as a tool for collecting and recording that data. The team also developed a recommended crossing surface inspection protocol.

While the available data does not allow a comprehensive analysis of surface material performance, some information from the study could be useful. It appears that subsurface preparation impacts surface performance more than the surface material used. Some crossings from each of the categories investigated appeared to perform well over time, others from each category failed relatively quickly. Further investigation of the use of an asphalt underlayment, or other subsurface preparation may be warranted.

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ABBREVIATIONS AND ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AREMA	American Railway Engineering and Maintenance-of-Way Association
CEC	Car Equivalency Count
ETEC	Efficiency through Engineering and Construction
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
HIRCH	Highway-Rail Crossing History Data
HMA	Hot Asphalt Mix
IowaDOT	Iowa Department of Transportation
LTAP	Michigan Local Technical Assistance Program
MDOT	Michigan Department of Transportation
MUTCD	Manual on Uniform Traffic Control Devices
NURail	National University Rail Center
PASER	Pavement Surface Evaluation and Rating
TTCI	Transportation Technology Center
UK	University of Kentucky

Appendix A – State DOT Crossing Survey

1. Name:

2. E-mail:

3. phone:

4. What kind of rail-highway grade crossings have you installed? (select all that apply)

sectional timber
wood plank
asphalt
concrete slab
concrete pavement
rubber
metal section
other metal
unconsolidated

Other (please specify)

5. Which type of grade crossing surface material is most prevalent in your state?

sectional timber
wood plank
asphalt
concrete slab
concrete pavement
rubber

metal section
other metal
unconsolidated

Other (please specify)

6. Do you have guidelines for choosing the type of surface material to be installed in crossings?

yes
no

7. How often do you inspect highway-rail grade crossing surface material?

never
every 1-6 months
every 6 months-1 year
every 1-2 years
longer

8. Do you have a system for rating highway-rail grade crossings based on wear?

yes
no

9. Do you have a history of inspections and/or ratings for the highway-rail grade crossings in your state?

yes
no

10. Which type of surface material do you prefer for low volume traffic flow?

sectional timber
wood plank
asphalt
concrete slab
concrete pavement

rubber
metal section
other metal
unconsolidated

Other (please specify)

11. Which type of surface material do you prefer for high volume traffic flow?

sectional timber
wood plank
asphalt
concrete slab
concrete pavement
rubber
metal section
other metal
unconsolidated

Other (please specify)

12. Do you coordinate highway work with rail grade crossing work?

yes
no

APPENDIX B – STATE DOT SURVEY RESPONSES

ETEC Enterprise

Michigan Technological University

Michigan Department of Transportation Highway-Rail Crossing Improvement Project

Survey Response from Brent Marsh of Wisconsin Southern Railroad

1.) Does your company rate the condition of rail crossings? If so would you be willing to provide us with information as to how it is done?

We don't rate the condition of crossings. Often, our crossings are reconstructed through 3 major methods:

- State Projects - We select the worst ones on a subdivision (no rating system) that we will be able to reconstruct with a certain amount of funding, we always try and get the best bang for our buck with the funds available.
- Road Reconstruction – As a road is being reconstructed as part of a local or DOT project, we always try and replace or at least put new surface material on the crossing. This saves on our detour costs
- Complaints – For some crossings, we do reach the complaint stage. We are usually able to work with local authorities to participate with some of the costs to replace the crossing sooner than we had planned. For example, the road authority replaces the asphalt and sets up the detour, we do the rest.

2.) Is there a system in place that matches grade crossing material with traffic and/or tonnage quantities? If so, may you provide us with your criteria?

Our system is usually the local road authority. If they say to upgrade to the concrete panel crossing, we usually do. Afterall, they supply some of the money to do the work with how funding is setup here at the WSOR. We want them to be happy with the product we give them! They also know what to expect for truck traffic on the road.

3.) Are records kept on the work performed on individual crossings? If so, how comprehensive is it and how long is it kept?

Since I started the job in 2009, I've been keeping records of crossing work. Other crossings had some records kept prior, most did not. Since we have been bought by Watco in 2012, there are methods that they keep track of this through the daily reporting of the foreman in charge of the crew. This is mostly done to keep track of the time that crews put toward state projects, as all of this time is reimbursable. I'm sure that there is probably an internal database that they are forming to show how long it takes to replace a crossing, but I am unaware of any. My paper files in my drawer are still kept for my reference.

4.) Is there a predictable pattern of deterioration within grade crossing materials?

This really depends on the material that is used. Certain materials fare better than others in the Wisconsin environment. We have all types, but 6 basic types of crossings on our system:

- Concrete Panel – Depends on the year the panels were made and the manufacturer. Early installations of these had issues with quality control and they were not well engineered. Currently, the spec for the concrete has improved and the panels have steel angle channel at the edges to eliminate the breakage of the concrete at the panel edge. Current panels also have been properly reinforced, prior panels just had any old amount of steel put in them, if at any all… They get taken out and can be broken up at a quarry for the concrete and separate out the steel for recycling. Other uses are to put them in parking lots to park on or to use as fill in embankments.

- Timber/Asphalt – This one is hard to say it's a manufacturer's defect because it's pretty tough to screw up a timber, when they show up and are out of spec they get sent back. Asphalt is usually whatever is left in the plant when the contractor makes the call, unless it is a state job and has a spec for it. These crossings wear out when the timber wears off from the vehicles going over it and plows shaving it off, the asphalt eventually cracks if it is thin enough and then plows start to catch it. Asphalt is easy to recycle and the timbers are disposed of with old ties.

- 

- 3 Rail (Mud Rail) – This one is an inherited crossing type that we no longer install. There is a rail on the field and gage side to keep the asphalt back and also create a flangeway. The rails will cause damage to plows and they are very hard to repair when something goes wrong with them. Scrap rail is also much more valuable than is had been, so we sell it for scrap rather than stick it in 3 rail crossings anymore…

- Full Timber – Timber panels that install like a concrete panel crossing. These had been installed in years past and we have begun to install them again where they are specified. The state of Illinois has this as their standard crossing, so we install them down there rather than the timber/asphalt crossings we usually install. Disposal of the timber panels can be done with ties as well.

- Rubber Panel – In the past these were made out of recycled rubber. Now some are made of virgin rubber. We had bad experiences with them in years past and have not installed them since. They eventually would let loose and start to move around under traffic. Section crews had a very hard time keeping them secured. Also, they are quite costly to dispose of, they are worth nothing once they are used up and have to be disposed in the landfill.

- Composite / Rail Seal – These are a cheaper capital cost option, but they do not last in most cases. The composite crossing material is installed like timber / asphalt crossing and it does not withstand heavy traffic like timbers can. The rail seal is a rubber seal along the rail, claiming to keep water out of the crossing but it traps it instead. It heaves out of place and does not last.

Sorry no Pics of these, they are the most scarce of the 6 types…give me some time and I can get you one if you want.

The big thing here that I have found is that it really all depends on how the crossing is constructed. Most of the time, crossings are not given the time and material that they need. Some crossings are dug down and given a sub-ballast section, full ballast section and these are lasting much longer than those built on un-suitable soils. Another HUGE factor for crossings holding up is the proper drainage of the crossing. If the crossing holds water, it will tear itself up much quicker than one that drains freely. The expense of putting in a crossing drain system is something that should never be downplayed. No plastic pipe should be installed to drain, it should always be rigid pipe. Plastic pipe moves around in the roadbed and eventually it becomes another place for water to sit rather than drain out. We install perforated steel pipe wrapped in clear stone and geo-tex fabric. Don't forget salt gets in the crossings too, the easier it is to drain all of this out, the better!

5.) Do you typically replace grade crossing surfaces during rail surfacing or other routine track maintenance events?

Yes and no. See question 1. When we surface the track we will sometimes surface through a crossing if it needs to be tamped. Otherwise we will treat it like fixed point and surface into it and from it.

6.) Does the amount of maintenance on a particular crossing surface fluctuate depending on the aforementioned track maintenance cycles?

If I get this right, you are asking if maintaining the crossing periodically has any play in the crossing longevity…? If it is caught soon enough to be correctly repaired, otherwise we tend to let the crossing go, especially if we have already gotten a good 7-10 years out of it. We will chalk it up as a learning experience and just replace it when the time comes to do so. If we have an issue with a crossing we spent a lot of money on two years after we finished the work, we'll be out there trying to fix it so we can get our money's worth out of the investment.

7.) When given a list of crossings that need to be rehabilitated, how do you prioritize which ones to fix first?

Usually whichever ones have the most complaints or are in the worst shape considering the traffic that goes over them. If we have a crossing that sees 5000 cars a day and is in the same shape as one that sees 500, we'll be fixing the 5000 car one first.

8.) If you are updating a crossing, are you required to notify the FRA of a change in grade crossing surface materials?

I don't know. I do know that the FRA DOT crossing inventory has a place to list the crossing surface type. When it is changed, I'm guessing we are supposed to update this information on the crossing inventory. To my knowledge, it is not enforced if it is something that is supposed to happen.

http://safetydata.fra.dot.gov/officeofsafety/publicsite/crossing/xingqryloc.aspx

ETEC Enterprise - Michigan Technological University

Michigan Department of Transportation Highway-Rail Crossing Improvement Project

Survey Response from Amanda DeCesare of CSX Transportation

Crossings do get replaced as part of routine maintenance of track. We call this routine maintenance “system production” work. It is a traveling work gang that will replace miles of ties and/or rail when it becomes necessary. Generally, crossings get replaced when they are on the route of the system production team. The system production teams work different sections of track each year. The frequency of a system production team’s presence on any track is mainly governed by rail traffic- the more traffic that passes over the track, the more frequently the track will require tie and rail replacement. This will also affect the frequency of crossing surface replacements.

Other intermediate replacements occur when a road authority requests a “premium” surface such as concrete panels. Generally these premium installations are done with a cost sharing arrangement between the road authority and CSX. Sometimes the road authority pays for the entire project (labor and material), other times, and the road authority pays for the surface material only. The cost sharing arrangement depends on whether or not CSX was planning to replace the crossing- if we were planning to replace it anyway, we will usually only request the price of the premium material. If we were not planning on replacing it, the road authority would be requested to pay for labor and material.

The final type of replacement would be in a situation where the crossing material is just in bad shape, creating a poor “ride” for the public or posing a hazard for the public. There is not a schedule kept for this- rather, it is on an as-needed basis. The wear on a crossing surface has so many variables- truck traffic, weather, number of tracks, asphalt quality, etc- that no two crossings will perform exactly the same, and it is nearly impossible to “schedule” crossing maintenance.

Our Standards group recommended that you speak with TTCI. TTCI is part of the AAR and is located out in Colorado. They have a facility to test multiple types of railroad materials, including crossing surfaces. They may have more “scientific” data that could be used.
I also reached out to MDOT and spoke with Kris Foondle. He said MDOT did a project with Dr. Jerry Rose 10 years ago on some CSX track, installing crossings per Mr. Rose’s preferred method of installing asphalt underlayment under crossings. MDOT will be asking CSX for some data to compare the “Dr. Rose” crossings with “regular” CSX crossings. Perhaps some of that information will be useful to you as well.

ETEC Enterprise - Michigan Technological University

Michigan Department of Transportation Highway-Rail Crossing Improvement Project

Survey Response from Jim Gasiecki of CN Railway

1.) Does your company rate the condition of rail crossings? If so would you be willing to provide us with information as to how it is done?

We don't have a specific rating system. A Track Supervisor will go out and prioritize which crossing will be rebuilt based on the condition of the crossing for rail and vehicular traffic. Safety on both fronts is a big factor in our decision making.

2.) Is there a system in place that matches grade crossing material with traffic and/or tonnage quantities? If so, may you provide us with your criteria?

Each railroad has their crossing material of choice. Our standard is a full depth timber. On occasion we will upgrade to a composite or full depth rubber crossing material.

3.) Are records kept on the work performed on individual crossings? If so, how comprehensive is it and how long is it kept?

In the age of computers, records may be kept indefinitely. To answer the question, yes records are kept. I imagine each Supervisor does it a little different. I would keep track of the crossing rebuilds for future reference. The job I'm in now I deal with Local, State, and Federal funded projects. We archive the projects and they'll be around longer than I will.

4.) Is there a predictable pattern of deterioration within grade crossing materials?

You can always expect a crossing with high rail tonnage and heavy vehicular traffic, especially trucks, to deteriorate at a faster rate. Those are two main contributing factors. Others are rain, snow, road salt, road surface, drainage, geometry (in a curve or tangent track). Location: is the crossing at a bottom of a grade where the road drains into the track; does a crossing involve a turning lane where trucks tear the crossing material up. One factor most people don't realize is the electrical current that runs through the rail. This with water, mud, and salt accelerates the corrosive process of the rail, plates, and spikes. Once these components are compromised, the rail starts moving resulting in wide gage.

5.) Do you typically replace grade crossing surfaces during rail surfacing or other routine track maintenance events?

We try to coordinate rebuilds or removing the deck of a crossing and surface through them with production gangs such as rail gangs, tie gangs, surface units. It's efficient as far as getting work blocks and you get a quality job.

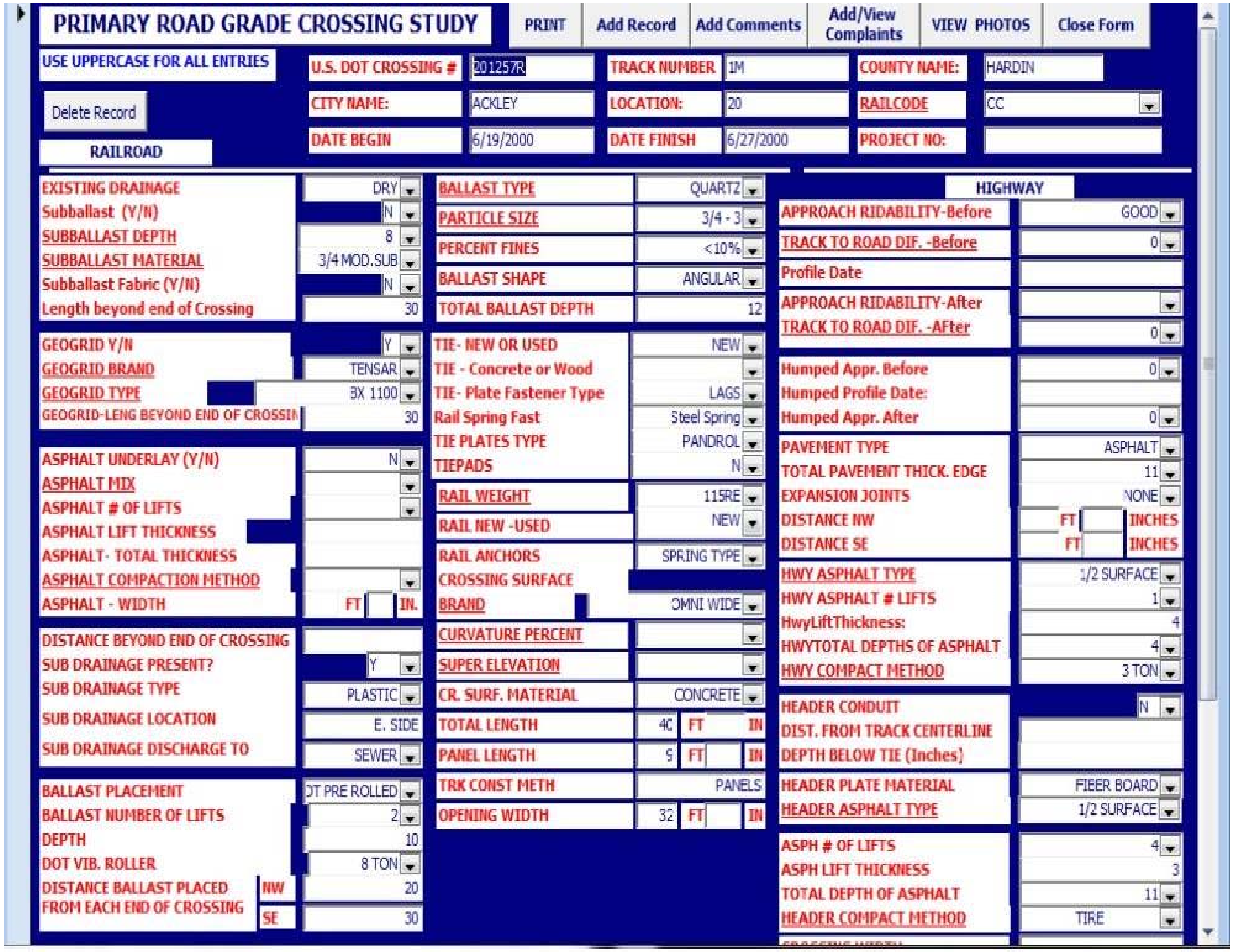
6.) Does the amount of maintenance on a particular crossing surface fluctuate depending on the aforementioned track maintenance cycles?

Yes, it does fluctuate. Heavier traveled roads on the same line will require more maintenance. Vehicle and truck traffic have a huge impact on the life of a crossing. The more traffic that drives over a crossing, the faster the crossing surface and track deteriorates.

7.) When given a list of crossings that need to be rehabilitated, how do you prioritize which ones to fix first?

If you have eight crossings to rebuild and you know they will all get done, you go with convenience and opportunity. Sometimes I would schedule crossings during the summer when it's a high impact crossing to a school. State, County, and Local road construction projects dictate when you can close a road. Even local events and holidays may play into a closure. Bottom line is the availability of equipment, men, and material. Scheduling is key. If you know for some constraint or another, you're only going to get four crossings rebuilt out of eight, you go for the worst ones first.

APPENDIX C IOWADOT GRADING SCALE AND DATA COLLECTION



PRIMARY ROAD GRADE CROSSING STUDY | PRINT | Add Record | Add Comments | Add/View Complaints | VIEW PHOTOS | Close Form

USE UPPERCASE FOR ALL ENTRIES

Delete Record

U.S. DOT CROSSING #: 201257R
TRACK NUMBER: 1M
COUNTY NAME: HARDIN
CITY NAME: ACKLEY
LOCATION: 20
RAILCODE: CC
DATE BEGIN: 6/19/2000
DATE FINISH: 6/27/2000
PROJECT NO:

RAILROAD

EXISTING DRAINAGE: DRY
Subballast (Y/N): N
SUBBALLAST DEPTH: 8
SUBBALLAST MATERIAL: 3/4 MOD.SUB
Subballast Fabric (Y/N): N
Length beyond end of Crossing: 30

GEOGRID Y/N: Y
GEOGRID BRAND: TENSAR
GEOGRID TYPE: BX 1100
GEOGRID-LENG BEYOND END OF CROSSIN: 30

ASPHALT UNDERLAY (Y/N): N
ASPHALT MIX
ASPHALT # OF LIFTS
ASPHALT LIFT THICKNESS
ASPHALT- TOTAL THICKNESS
ASPHALT COMPACTION METHOD
ASPHALT - WIDTH: FT IN.

DISTANCE BEYOND END OF CROSSING
SUB DRAINAGE PRESENT?: Y
SUB DRAINAGE TYPE: PLASTIC
SUB DRAINAGE LOCATION: E. SIDE
SUB DRAINAGE DISCHARGE TO: SEWER

BALLAST PLACEMENT: DT PRE ROLLED
BALLAST NUMBER OF LIFTS: 2
DEPTH: 10
DOT VIB. ROLLER: 8 TON
DISTANCE BALLAST PLACED FROM EACH END OF CROSSING: NW 20, SE 30

BALLAST TYPE: QUARTZ
PARTICLE SIZE: 3/4 - 3
PERCENT FINES: <10%
BALLAST SHAPE: ANGULAR
TOTAL BALLAST DEPTH: 12

TIE- NEW OR USED: NEW
TIE - Concrete or Wood
TIE- Plate Fastener Type: LAGS
Rail Spring Fast: Steel Spring
TIE PLATES TYPE: PANDROL
TIEPADS: N

RAIL WEIGHT: 115RE
RAIL NEW -USED: NEW
RAIL ANCHORS: SPRING TYPE
CROSSING SURFACE
BRAND: OMNI WIDE
CURVATURE PERCENT
SUPER ELEVATION
CR. SURF. MATERIAL: CONCRETE
TOTAL LENGTH: 40 FT IN
PANEL LENGTH: 9 FT IN
TRK CONST METH: PANELS
OPENING WIDTH: 32 FT IN

HIGHWAY

APPROACH RIDABILITY-Before: GOOD
TRACK TO ROAD DIF. -Before: 0
Profile Date
APPROACH RIDABILITY-After
TRACK TO ROAD DIF. -AFter: 0

Humped Appr. Before: 0
Humped Profile Date:
Humped Appr. After: 0

PAVEMENT TYPE: ASPHALT
TOTAL PAVEMENT THICK. EDGE: 11
EXPANSION JOINTS: NONE
DISTANCE NW: FT INCHES
DISTANCE SE: FT INCHES

HWY ASPHALT TYPE: 1/2 SURFACE
HWY ASPHALT # LIFTS: 1
HwyLiftThickness: 4
HWYTOTAL DEPTHS OF ASPHALT: 4
HWY COMPACT METHOD: 3 TON

HEADER CONDUIT: N
DIST. FROM TRACK CENTERLINE
DEPTH BELOW TIE (Inches)

HEADER PLATE MATERIAL: FIBER BOARD
HEADER ASPHALT TYPE: 1/2 SURFACE

ASPH # OF LIFTS: 4
ASPH LIFT THICKNESS: 3
TOTAL DEPTH OF ASPHALT: 11
HEADER COMPACT METHOD: TIRE

							Driver Behavior			Highway Condition					Crossing Condition		
District	County	Crossing number	Railroad	City	Highway	Street name	Vehicles reduce speed	Vehicles weaving	Ride ability (x2)	Header area	Elevation differential	Approach profile	Cross section	Approach pavement	Surface deterioration	Surface stability	Rail stability
1	POLK	193045N	UP	DES MOINES	IA 28	63RD ST	1	1	2	1	1	1	1	1	1	1	1
1	POLK	192750N	UP	DES MOINES	US 6	ECULID AVE	2	2	6	3	3	2	3	3	4	4	4
1	POLK	192845W	UP	DES MOINES	US 69	NE 14TH ST	2	2	6	3	3	3	3	4	3	3	4
1	JOHNSON	840190Y	CIC	IOWA CITY	IA 1	BURLINGTON ST	2	2	6	4	4	2	2	4	4	3	4
1	LINN	190508Y	UP	CEDAR RAPIDS	IA 922	1ST AVE & 4TH ST E	3	3	8	3	4	1	1	1	5	4	3
1	LEE	063309Y	BNSF	FORT MADISON	US 61	NR 36TH ST	2	2	4	2	2	1	1	1	2	2	1
1	MAHASKA	199578U	UP	OSKALOOSA	IA 92	A AVE WEST	1	1	4	3	2	2	3	5	2	2	2
1	MUSCATINE	606769E	IMRL	MUSCATINE	IA 92	2ND ST	1	1	1	1	1	1	1	1	1	1	1
1	MARION	063403M	BNSF	KNOXVILLE	IA 14	LINCOLN ST	4	4	8	4	5	4	3	4	5	4	3
1	MARION	063404U	BNSF	KNOXVILLE	IA 14	LINCOLN ST	4	4	8	5	5	2	2	3	4	3	5
1	POLK	192762H	UP	ANKENY	IA 160	50E NW/C 36-80-24	2	2	6	2	3	2	2	2	2	3	4
1	DES MOINES	063006P	BNSF	WEST BURLING	US 34	75E99S NW/C IA AMMO	1	1	1	1	1	1	1	1	1	1	1
1	WOODBURY	191398U	UP	SIOUX CITY	I-29	I-29 ON RAMP	1	Track moved									
1	DALLAS	192946H	UP	PERRY	IA 144	1ST ST	3	3	6	4	3	3	2	3	3	3	2
1	FRANKLIN	201919N	CC	HAMPTON	IA 3	CENTRAL AVE W	1	Crossing removed, track abandoned									
1	MUSCATINE	375954H	IMRL	MUSCATINE	IA 92	GRANDVIEW AVE.	1	1	1	1	1	1	1	1	1	1	1
1	POLK	864243N	NS	DES MOINES	IA 46	SE 30TH & CB&Q ST	1	Road vacated									
1	FLOYD	858607X	CCRY	CHARLES CITY	US 218	GRAND AVE	1	Track removed									
1	WAPELLO	375781V	IMRL	OTTUMWA	IA 23	W. SECOND ST.	1	Road vacated									
1	WARREN	602487A	UP	CARLISLE	IA 5	72E09S NW/C 10-77-23	1	Track gone									
1	DUBUQUE	306997N	CC	DYERSVILLE	IA 136	11TH ST S.E.	1	1	2	1	1	1	1	1	1	1	1
1	POLK	063402F	BNSF	DES MOINES	IA 46	S.E. 43RD	1	Road vacated									
1	POLK	904673L	NS	DES MOINES	IA.46	S.E.43RD ST	1	Road vacated									
1	BUCHANAN	307069X	CC	INDEPENDENCE	IA 150	FIFTH AVE N.E.	1	1	1	1	1	1	1	1	1	1	1
1	IOWA	376767D	CIC	AMANA	US 151	70E60S NW/C 27-81-9	1	1	1	1	1	1	1	1	1	1	1
1	OBRIEN	185863C	UP	SHELDON	US 18	PARK ST.	2	2	6	3	3	2	2	1	4	4	2
1	MARION	606549J	IAIS	PELLA	IA 163	05E40S NW/C 31-77-18	1	Track removed									
1	PALO ALTO	875831C	UP	EMMETSBURG	US 18	MAIN ST.(9TH ST)	2	2	4	3	2	2	2	2	2	1	1
1	KOSSUTH	196739C	UP	ALGONA	US 18	1-95-29(CENTRE ST)	2	2	6	3	2	1	1	2	4	4	2
1	MAHASKA	199590B	UP	OSKALOOSA	US 63	SO 17TH ST	2	2	4	3	4	1	1	1	3	2	2

APPENDIX D RATING SPREADSHEETS

Table 8 - Sectional Timber Crossing Ratings

				Timber Crossing Analysis						
258201G							258204C			
date	type	adt	rating	speed		date	type	adt	rating	speed
3/14/1995	rubber	1273	good	35		3/14/1995	Sectional timber	1082	good	35
9/18/1997	rubber	1273	good	35		9/18/1997	Sectional timber	1082	good	35
11/18/2002	rubber	1273	fair	35		5/17/2005	Sectional timber	1082	3	35
4/26/2005	rubber	1273	4	35		5/16/2007	Sectional timber	1082	3	35
5/16/2007	rubber	1273	4	35		1/24/2011	Sectional timber	1082	3	35
1/19/2011	sectional timber	1273	1	35		6/5/2013	Sectional timber	1082	3	35
6/5/2013	Sectional timber	1273	1	35						
180466M							182176L			
date	type	adt	rating	speed		date	type	adt	rating	speed
8/13/1998	Sectional timber	10	fair	55		7/24/1997	Sectional timber	10	fair	55
7/18/2001	Sectional timber	10	fair	55		10/27/1999	Sectional timber	10	good	55
7/7/2003	Sectional timber	10	good	55		8/7/2001	Sectional timber	10	fair	55
4/4/2006	Sectional timber	43	3	55		3/25/2003	Sectional timber	10	good	55
10/21/2008	Sectional timber	43	3	55		8/31/2005	Sectional timber	10	2	55
4/19/2011	Sectional timber	37	3	55		10/30/2007	Sectional timber	10	2	55
7/31/2012	Sectional timber	37	3	55		10/20/2009	Sectional timber	10	2	55

						7/27/2011	Sectional timber	90	3	55
						9/11/2013	Sectional timber	90	3	55
182179G							232474B			
date	type	adt	rating	speed		date	type	adt	rating	speed
7/24/1997	Unconsolidated	10	poor	10		11/22/2000	Sectional timber	100	fair/poor	25
10/27/1999	Sectionl timber	10	good	10		11/6/2002	Sectional timber	100	fair/poor	25
8/7/2001	Sectionl timber	10	good	10		9/16/2004	Sectional timber	100	fair/poor	25
1/25/2003	Sectionl timber	10	fair	10		7/25/2006	Sectional timber	5284	4	25
3/25/2003	Sectionl timber	10	fair	10		7/10/2008	Sectional timber	5284	4	25
8/31/2005	Sectionl timber	10	2	10		12/22/2010	Sectional timber	3768	4	25
10/30/2007	Sectionl timber	10	2	10		1/22/2013	Asphalt	4569	1	25
10/20/2009	Sectionl timber	10	2	10						
7/27/2011	Sectionl timber	47	3	55						
9/11/2013	Sectionl timber	47	3	55						
232489R							232497H			
date	type	adt	rating	speed		date	type	adt	rating	speed
12/1/2000	Sectional timber	172	good/fair	55		8/13/1997	Sectional timber	70	fair	55
10/29/2002	Sectional timber	172	fair	55		12/1/2000	Sectional timber	162	good/fair	55
7/20/2004	Sectional timber	172	fair	55		11/8/2002	Sectional timber	162	good/fair	55
5/12/2006	Sectional timber	157	2	55		7/20/2004	Sectional timber	162	fair	55
7/15/2008	Sectional timber	256	3	55		5/11/2006	Sectional timber	189	3	55
12/28/2010	Sectional timber	256	3	55		7/15/2008	Sectional timber	189	3	55
1/23/2013	Sectional timber	136	3	55		12/28/2010	Sectional timber	295	3	55
						1/23/2013	Sectional timber	367	3	55

233418X							284055W			
date	type	adt	rating	speed		date	type	adt	rating	speed
6/14/1995	Sectional timber	9450	fair	40		6/18/1998	rubber	18497	good	35
11/13/1997	Sectional timber	9450	good/fair	40		3/29/1996	rubber	18497	good	35
4/17/2000	Sectional timber	9450	fair/poor	40		6/9/2000	rubber	18497	good	35
8/21/2002	Sectional timber	9450	poor	40		2/27/2003	rubber	18497	good	35
7/12/2004	Sectional timber	9450	poor	40		2/25/2005	rubber	18497	0	35
3/23/2006	Sectional timber	10497	4	40		1/26/2007	rubber	18497	2	35
8/1/2008	Sectional timber	10019	4	40		2/9/2009	rubber	18497	3	35
11/30/2010	Sectional timber	10019	4	40		4/3/2012	Sectional timber	18497	2	35
1/16/2013	Sectional timber	10256	3	40						
284102C							284165G			
date	type	adt	rating	speed		date	type	adt	rating	speed
7/7/1997	Sectional timber	500	good	40		1/27/1997	rubber	7979	good	45
3/25/1999	Sectional timber	500	good	40		9/28/1998	rubber	7979	good	45
9/17/2002	Sectional timber	500	good	40		5/9/2001	rubber	7979	good	45
8/5/2004	Sectional timber	500	good	40		6/3/2003	rubber	7979	good	45
5/8/2006	Sectional timber	2418	2	40		7/18/2005	rubber	7979	3	45

1/16/2008	Sectional timber	2418	2	40		8/24/2007	asphalt	7979	4	45
3/29/2011	Sectional timber	3062	1	40		1/26/2010	Sectional timber	6265	1	45
						6/28/2012	Sectional timber	8385	1	45
284304A							284418M			
date	type	adt	rating	speed		date	type	adt	rating	speed
12/29/1994	Sectional timber	13250	poor	35		8/3/1995	Sectional timber	120	good	55
8/12/1997	Sectional timber	13250	good	35		11/26/1996	Sectional timber	120	good	55
1/20/1999	Sectional timber	13250	good	35		8/12/1998	Sectional timber	120	Good/Fair	55
6/1/2001	Sectional timber	13250	good	35		1/28/2000	Sectional timber	120	Good/Fair	55
9/9/2003	Sectional timber	13250	fair	35		5/20/2002	Sectional timber	120	Good/Fair	55
8/2/2005	Sectional timber	13250	3	35		3/18/2004	Sectional timber	120	good	55
12/20/2007	Sectional timber	13250	3	35		3/2/2006	Sectional timber	120	2	55
	284071F					284077W				
1/30/2013	Sectional timber	13250	1	35		6/17/2008	Sectional timber	146	3	55
						3/25/2010	Sectional timber	508	3	55
						12/21/2011	Sectional timber	508	3	55
						4/11/2012	Sectional timber	508	3	55

Table 9 - Rubber Crossing Surface Ratings

000115U						000126G				

Date	Type	ADT	Rating	Speed		Date	Type	ADT		Speed
5/5/2005	Rubber	1467	3	45		5/26/1989	Rubber Panels	3893		40
5/4/2007	Rubber	1467	3	45		2/1/1995	Rubber	3690		40
2/1/2011	Rubber	1411	3	45		10/28/1997	Rubber	3690		40
5/29/2013	Rubber	1411	3	45		1/20/2000	Rubber	3690		40
						11/6/2002	Rubber	3690		40
						5/6/2005	Rubber	3690		40
						5/4/2007	Rubber	3690		40
						2/1/2011	Rubber	3150		40
						5/29/2013	Rubber	3150		40
232403E						232472M				
Date	Type	ADT	Rating	Speed		Date	Type	ADT		Speed
12/17/1997	Sectional Timber	7383	4	35		8/4/1997	Rubber	5609		35
1/19/1999	Sectional Timber	7383	4	35		11/22/2000	Rubber	5609		35
12/13/2002	Rubber	7383	3	35		11/6/2002	Rubber	5609		35
10/19/2004	Rubber	10553	3	35		9/16/2004	Rubber	5609		35
10/9/2006	Rubber	10553	3	35		7/25/2006	Rubber	14007		35
4/22/2008	Rubber	10553	3	35		7/10/2008	Rubber	14007		35
1/27/2010	Rubber	8249	3	35		11/23/2010	Rubber	12990		35
1/20/2012	Rubber	8249	4	35		1/22/2013	Rubber	12531		35

284079K						284310D				
Date	Type	ADT	Rating	Speed		Date	Type	ADT		Speed
11/17/1994	Rubber	70	2	35		12/28/1994	Asphalt	7200		25
7/9/1997	Rubber	70	2	35		8/8/1997	Rubber	7200		25
8/5/1999	Rubber	70	2	35		1/20/1999	Rubber	7200		25
9/18/2002	Rubber	70	2	35		9/9/2003	Rubber	7200		25
8/9/2004	Rubber	70	2	35		7/27/2005	Rubber	7200		25
4/18/2006	Rubber	6532	2	35		12/20/2007	Rubber	7200		25
1/17/2008	Rubber	6532	2	35		1/15/2013	Rubber	5700		35
5/11/2011	Rubber	5086	3	35						
545751Y										
Date	Type	ADT	Rating	Speed		693857A				
3/2/1994	Rubber	8501	2	35		Date	Type	ADT		Speed
2/28/1995	Rubber	32396	2	35		6/23/1994	Gravel	10		55
1/30/1997	Rubber	32396	2	35		7/24/1997	Unconsolidated	10		55
7/16/1998	Rubber	32396	2	35		10/28/1999	Unconsolidated	10		55
2/1/2000	Rubber	32396	2	35		8/15/2001	Unconsolidated	10		55
5/21/2002	Rubber	32396	2	35		3/27/2003	Asphalt	10		55
7/26/2004	Rubber	32396	2	35		10/5/2005	Asphalt	63		55
2/2/2006	Rubber	30770	3	35		10/31/2007	Asphalt	63		55
5/19/2008	Rubber	30770	3	35		10/14/2009	Asphalt	63		55

5/6/2010	Rubber	29128	4	35		7/28/2011	Rubber	64		55
2/24/2011	Rubber	41661	4	35		9/17/2013	Composite	64		55
9/5/2012	Rubber	41661	3	35						

232344E						232345L				
Date	Type	ADT	Rating	Speed		Date	Type	ADT	Rating	Speed
12/19/1997	Asphalt	9621	4	45		12/19/1997	Rubber	6902	2	35
1/29/1999	Asphalt	9621	2	45		1/27/1999	Rubber	6902	2	35
1/25/2001	Asphalt	9621	2	45		2/6/2001	Rubber	6902	2.5	35
10/5/2004	Rubber	16008	2	45		10/18/2004	Rubber	6902	2.5	35
10/31/2006	Rubber	16008	2	45		10/31/2006	Rubber	14023	2	35
4/25/2008	Rubber	16008	2	45		4/25/2008	Rubber	14023	2	35
2/3/2010	Rubber	19011	2	45		2/3/2010	Rubber	14023	4	35
1/13/2012	Rubber	19011	2	45		1/13/2012	Rubber	15573	4	35
234515K						258107T				
Date	Type	ADT	Rating	Speed		Date	Type	ADT	Rating	Speed
4/20/1994	Rubber	4319	2	55		5/14/1998	Rubber	6810	5	45
2/10/1995	Rubber	8300	2	55		1/27/2000	Rubber	6810	2	45
1/28/1997	Rubber	8300	2	55		3/24/2003	Rubber	6810	3	45
12/17/1998	Rubber	8300	2	55		2/8/2005	Rubber	6810	0	45
12/17/1999	Rubber	8300	2	55		4/9/2007	Rubber	6810	3	45

6/3/2002	Rubber	8300	3.5	55		10/21/2008	Rubber	6810	3	45
7/13/2004	Rubber	8300	2	55		1/30/2012	Rubber	7384	3	45
3/22/2006	Rubber	8300	3	55						
5/16/2008	Rubber	5966	3	55						
2/23/2011	Rubber	5966	3	55						
8/17/2012	Rubber	5966	2	55						
284320J						536523M				
Date	Type	ADT	Rating	Speed		Date	Type	ADT	Rating	Speed
12/28/1994	Rubber	6450	2	35		5/14/1996	Rubber	20051	2	35
8/7/1997	Rubber	6450	2	35		11/13/1997	Rubber	20051	2	35
1/20/1999	Rubber	6450	2	35		5/4/2001	Rubber	20051	2	35
7/19/2001	Rubber	6450	2	35		11/19/2002	Rubber	20051	2	35
9/5/2003	Rubber	6450	3	35		11/5/2004	Rubber	20051	2	35
8/2/2005	Rubber	6450	2	35		2/21/2006	Rubber	20840	2	35
12/20/2007	Rubber	10000	3	35		5/12/2008	Rubber	20840	2	35
1/21/2009	Rubber	10000	3	35		3/31/2011	Rubber	22788	2	35
1/15/2013	Sectional Timber	6000	1	35		12/20/2012	RUbber	20802	2	35
693865S						693949M				

Date	Type	ADT	Rating	Speed		Date	Type	ADT	Rating	Speed	
6/23/1994	NA	231	1	55		10/3/1994	NA	400	2	55	
7/24/1997	Asphalt	574	2	55		8/26/1997	Asphalt	600	3	55	
10/2/1999	Asphalt	574	2	55		5/11/1999	Asphalt	600	3	55	
8/15/2001	Asphalt	574	3	55		4/19/2001	Asphalt	600	2	55	
3/27/2003	Asphalt	574	3	55		11/5/2002	Asphalt	600	2	55	
10/5/2005	Asphalt	375	3	55		10/5/2004	Asphalt	600	2	55	
10/31/2007	Asphalt	375	3	55		5/23/2006	Asphalt	600	2	55	
10/14/2009	Asphalt	375	3	55		8/26/2008	Asphalt	600	2		55
7/28/2011	Rubber	141	1	55		5/23/2011	Rubber	713	1		55
9/17/2013	Composite	141	1	55							

867532A				
Date	Type	ADT	Speed	Year
12/12/1997	Rubber	NA	50	0
9/24/1999	Rubber	NA	50	2
12/6/2002	Rubber	0	40	5
4/28/2005	Rubber	0	40	8
6/6/2007	Rubber	0	40	10
2/14/2011	Rubber	8480	40	14

7/9/2013	Rubber	8480	40	16

Table 10 - Asphalt Crossing Surface Ratings

Asphalt Crossings										
000128V						000255W				
date	type	adt	rating	speed		date	type	adt	rating	speed
10/28/1997	asphalt	668	2	45		11/6/1995	asphalt	15604	2	40
11/6/2002	asphalt	424	2	45		2/9/1998	asphalt	15604	2	40
5/6/2005	asphalt	424	2	45		4/26/2002	asphalt	15604	3	40
5/3/2007	asphalt	424	2	45		2/2/2004	asphalt	15604	2	40
2/1/2011	asphalt	520	2	45		6/28/2005	asphalt	15604	2	40
5/29/2013	asphalt	520	3	45		3/20/2007	asphalt	15604	2	40
						40322	asphalt	15604	4	40
						41368	asphalt	6831	1	45
232168J						232169R				
date	type	adt	rating	speed		date	type	adt	rating	speed
6/16/1995	asphalt	3218	4	35		6/16/1995	asphalt	300	3	55
4/23/1997	asphalt	repair	2			3/25/1998	asphalt	300	3	55
3/25/1998	asphalt	3218	2	35		5/11/2000	asphalt	300	5	55
5/11/2000	asphalt	3218	5	35		5/13/2002	asphalt	300	2	55
5/13/2002	asphalt	3218	2	45		4/7/2003	asphalt	300	2	55
4/7/2003	asphalt	3218	2	35		12/1/2004	asphalt	300	2	35

38322	asphalt	3218	3	35		1/3/2007	asphalt	95	3	35
39085	asphalt	3218	4	35		7/5/2007	asphalt	95	3	35
39702	asphalt	3218	2	35		9/11/2008	asphalt	95	3	35
40883	asphalt	3765	1	35		12/6/2011	asphalt	110	1	35
232231Y						232250D				
date	type	adt	rating	speed		date	type	adt	rating	speed
6/14/1995	asphalt	13200	2	40		12/16/1994	asphalt	7000	2	35
3/12/1998	asphalt	13200	2	40		6/6/1997	asphalt	7000	5	35
4/27/2000	aasphalt	13200	2	40		7/5/2001	asphalt	7000	2	40
5/14/2002	asphalt	13200	3	40		1/29/2002	asphalt	7000	2	40
4/8/2003	asphalt	13200	2	40		8/12/2003	rubber	7000	2	40
2/7/2004	asphalt	13200	2	40		6/21/2005	rubber	7000	2	40
3/15/2007	asphalt	13200	3	40		11/27/2007	ruber	7000	2	40
9/8/2008	asphalt	13200	3	40		10/31/2012	concrete	13000	1	40
12/12/2011	concrete	16446	1	35						
233685B						234220T				
date	type	adt	rating	speed		date	type	adt	rating	speed
8/19/1999	rubber	na	2	55		6/13/1995	sectional timber	16095	5	35
11/12/2002	asphalt	na	2	40		1/18/1996	asphalt	16059	5	35
11/29/2004	asphalt	replace	1			3/30/1998	asphalt	16059	2	35

5/11/2005	asphalt	na	3	40		4/26/2000	asphalt	16059	3	35
5/7/2007	asphalt	na	3	40		5/14/2002	asphalt	16059	2	35
1/18/2011	asphalt	5990	2	40		3/20/2003	asphalt	16059	3	35
6/3/2013	asphalt	5990	4	40		3/29/2005	asphalt	16059	3	35
						3/20/2007	asphalt	16059	3	35
						3/29/2009	asphalt	16059	3	35
						5/1/2012	asphalt	17761	3	35
234310S						234312F				
date	type	adt	rating	speed		date	type	adt	rating	speed
6/12/1995	sectional timber	10491	4	45		6/12/1995	asphalt	1245	2	45
3/27/1998	asphalt	10491	5	45		3/27/1998	asphalt	1245	2	45
7/29/1999	asphalt	repair	2	45		4/20/2000	asphalt	1245	2	45
4/20/2000	asphalt	10491	5	45		5/14/2002	asphalt	1245	2	45
1/28/2002	asphalt	10491	2	45		12/7/2004	asphalt	1245	2	45
5/14/2002	asphalt	10491	2	45		3/7/2007	asphalt	1245	2	45
12/8/2004	asphalt	10491	2	45		9/8/2008	asphalt	1245	2	45
3/7/2007	asphalt	10491	3	45		12/12/2011	asphalt	5206	2	45
9/8/2008	asphalt	10491	3	45		3/26/2013	asphalt	5206	2	45
1/4/2012	asphalt	29343	1	45						

000374F						000378H				

date	type	adt	rating	speed		date	type	adt	rating	speed
9/11/1995	asphalt	10	2	55		9/11/1995	asphalt	220	2	55
12/16/1996	asphalt	10	2	55		12/16/1996	asphalt	220	2	55
9/1/1998	asphalt	10	2	55		9/1/1998	asphalt	146	2	55
2/10/2000	asphalt	10	3	55		2/10/2000	asphalt	146	3	55
7/15/2002	asphalt	10	2	55		7/18/2002	asphalt	146	2	55
2/10/2004	asphalt	10	2	55		6/8/2004	asphalt	146	2	55
3/10/2006	asphalt	10	2	55		3/10/2006	asphalt	146	1	55
5/22/2008	asphalt	40	2	55		5/22/2008	asphalt	138	1	55
5/6/2010	asphalt	26	2	55		4/14/2010	asphalt	199	1	55
4/5/2012	asphalt	26	2	55		4/4/2012	asphalt	199	1	55
232173F						232213B				
date	type	adt	rating	speed		date	type	adt	rating	speed
6/16/1995	asphalt	1769	2	35		6/14/1995	sectional timber	12937	4	35
3/25/1998	asphalt	1769	2	35		3/12/1998	sectional timber	12937	5	35
5/10/2000	asphalt	1769	2	35		5/3/2000	asphalt	12937	2	35
5/13/2002	asphalt	1769	5	35		5/8/2002	asphalt	12937	3	35
4/7/2003	asphault	1769	2	35		4/8/2003	asphalt	12937	2	35
2/1/2004	asphalt	1769	2	35		12/7/2004	asphalt	12937	3	35
3/20/2007	asphalt	1769	2	35		3/15/2007	asphalt	12937	2	35

9/11/2008	asphalt	1769	2	35		9/10/2008	asphalt	12937	2	35
2/7/2011	asphalt	4237	2	35		1/4/2012	asphalt	10179	2	35
232361V						232366E				
date	type	adt	rating	speed		date	type	adt	rating	speed
12/18/1997	ruber	14076	4	40		12/17/1997	sectional timber	15546	4	40
1/21/1999	asphalt	14076	2	40		1/19/1999	asphalt	15546	2	40
2/5/2001	asphalt	14076	2	40		2/5/2001	asphalt	15546	3	40
12/13/2002	asphalt	14076	3	40		12/13/2002	asphalt	15546	3	40
10/19/2004	asphalt	14076	4	40		10/19/2004	asphalt	15546	4	40
10/25/2006	asphalt	14076	3	40		10/9/2006	asphalt	15546	3	40
4/24/2008	asphalt	14076	3	40		4/22/2008	asphalt	15546	4	40
1/28/2010	asphalt	14076	3	40		1/27/2010	asphalt	15546	4	40
2/1/2012	asphalt	13541	3	40		11/23/2010		repair	2	40
						1/20/2012	asphalt	10118	4	40
234302A						234303G				
date	type	adt	rating	speed		date	type	adt	rating	speed
6/13/1995	asphalt	3975	5	40		6/12/1995	asphalt	8257	2	45
3/30/1998	asphalt	3975	2	40		3/30/1998	asphalt	8257	5	45
5/14/2002	asphalt	3975	4	40		5/14/2002	asphalt	8257	4	45
3/20/2003	asphalt	3975	4	40		3/20/2003	asphalt	8257	5	45

12/8/2004	asphalt	3975	2	40		5/8/2003	asphalt	rebuild	1	45
2/21/2007	asphalt	3975	2	40		12/8/2004	asphalt	8257	2	45
10/7/2008	asphalt	3975	2	40		4/25/2007	asphalt	8257	2	45
1/4/2012	asphalt	4485	2	40		10/7/2008	asphalt	8257	2	45
						1/4/2012	asphalt	11309	2	45
234318W						234319D				
date	type	adt	rating	speed		date	type	adt	rating	speed
11/9/1995	asphalt	1671	2	55		11/9/1995	asphalt	1607	2	50
2/13/1998	asphalt	1671	5	55		2/13/1998	asphalt	1607	2	50
5/2/2002	asphalt	1671	2	55		5/2/2002	asphalt	1607	2	50
1/8/2004	asphalt	1671	2	55		1/8/2004	asphalt	1607	2	50
7/12/2005	asphalt	1671	3	55		7/12/2005	asphalt	1607	2	50
3/28/2007	asphalt	2929	3	50		3/28/2007	asphalt	2021	2	50
6/1/2010	asphalt	2929	3	50		6/1/2010	asphalt	2021	2	50
3/26/2013	asphalt	2339	3	50		4/11/2013	asphalt	1297	2	50

Table 11 - Concrete Crossing Surface Ratings

Concrete Crossings								
Crossing Number	Year	Rating	Surface material		Crossing Number	Year	Rating	Surface material
232231Y	2007	3	Asphalt		234536D	2006	3	Concrete
	2008	3	Asphalt			2008	3	Concrete
	2011	1	Concrete			2011	2	Concrete

						2012	2	Concrete
Crossing Number	Year	Rating	Surface material					
234423X	2005	3	Rubber		Crossing Number	Year	Rating	Surface material
	2007	3	Rubber		234539Y	2011	2	Concrete
	2009	1	Concrete			2012	2	Concrete
	2011	1	Concrete					
					Crossing Number	Year	Rating	Surface material
Crossing Number	Year	Rating	Surface material		536528W	2006	2	Concrete
536524U	2006	2	Concrete			2008	2	Concrete
	2008	2	Concrete			2011	2	Concrete
	2011	2	Concrete			2012	2	Concrete
	2012	2	Concrete			2012	2	Concrete
Crossing Number	Year	Rating	Surface material		Crossing Number	Year	Rating	Surface material
999064A	2005	1	Concrete		232250D	2005	2	Rubber
	2006	1	Concrete			2007	2	Rubber
	2007	1	Concrete			2012	1	Concrete
	2008	1	Concrete					
	2010	1	Concrete		Crossing Number	Year	Rating	Surface material
	2012	1	Concrete		234299U	2007	3	Concrete
						2008	3	Concrete
Crossing Number	Year	Rating	Surface material			2012	3	Concrete
234296Y	2007	2	Rubber					

	2008	3	Rubber		Crossing Number	Year	Rating	Surface material
	2012	1	Concrete		234408V	2005	2	Concrete
						2007	2	Concrete
Crossing Number	Year	Rating	Surface material			2009	2	Concrete
234538S	2006	3	Concrete			2011	1	Concrete
	2008	3	Concrete					
	2011	3	Concrete		Crossing Number	Year	Rating	Surface material
	2012	3	Concrete		283638E	2005	1	Concrete
						2005	2	Concrete
Crossing Number	Year	Rating	Surface material			2007	2	Concrete
234535W	2005	2	Concrete			2009	2	Concrete
	2006	2	Concrete			2011	2	Concrete
	2008	2	Concrete					
	2011	2	Concrete		Crossing Number	Year	Rating	Surface material
	2012	2	Concrete		234407N	2005	4	Rubber
						2007	3	Rubber
Crossing Number	Year	Rating	Surface material			2009	3	Rubber
234313M	2007	4	Asphalt			2011	1	Concrete
	2008	1	Concrete					
	2011	2	Concrete		Crossing Number	Year	Rating	Surface material
	2013	2	Concrete		234314U	2007	4	Asphalt
						2008	2	Concrete
Crossing Number	Year	Rating	Surface material			2010	2	Concrete

284103J	2006	1	Concrete			2011	3	Concrete
	2008	1	Concrete					
	2011	1	Concrete		Crossing Number	Year	Rating	Surface material
					284078D	2006	4	Rubber
Crossing Number	Year	Rating	Surface material			2008	4	Rubber
235197E	2006	3	Concrete			2011	1	Concrete
	2008	1	Concrete			2011	1	Concrete
	2010	4	Concrete					
	2011	3	Concrete					
Crossing Number	Year	Rating	Surface material		Crossing Number	Year	Rating	Surface material
235677R	2005	1	Concrete		234534P	2006	3	Asphalt
	2006	3	Concrete			2008	3	Asphalt
	2008	3	Concrete			2011	1	Concrete
	2011	1	Concrete			2012	1	Concrete
	2013	1	Concrete					
					Crossing Number	Year	Rating	Surface material
Crossing Number	Year	Rating	Surface material		693952V	2006	3	Asphalt
284061A	2005	1	Concrete			2008	1	Concrete
	2006	1	Concrete			2011	1	Concrete
	2006	1	Concrete					
	2008	1	Concrete		Crossing Number	Year	Rating	Surface material
	2011	1	Concrete		284080E	2006	5	Rubber
						2008	1	Concrete

Crossing Number	Year	Rating	Surface material			2011	1	Concrete
545750S	2006	3	Concrete					
	2008	3	Concrete		Crossing Number	Year	Rating	Surface material
	2010	3	Concrete		234371H	2005	2	Concrete
	2011	3	Concrete			2007	2	Concrete
	2012	3	Concrete			2008	2	Concrete
						2009	2	Concrete
Crossing Number	Year	Rating	Surface material			2012	2	Concrete
234929W	2005	3	Asphalt					
	2007	3	Asphalt		Crossing Number	Year	Rating	Surface material
	2008	4	Asphalt		284108T	2005	1	Concrete
	2012	1	Concrete			2006	1	Concrete
						2008	1	Concrete
Crossing Number	Year	Rating	Surface material			2011	1	Concrete
234405A	2005	2	Concrete					
	2007	2	Concrete					
	2009	2	Concrete					
	2011	2	Concrete					