Tools for the Planning and Design of Pedestrian Crossing Enhancements

Source: Google Maps

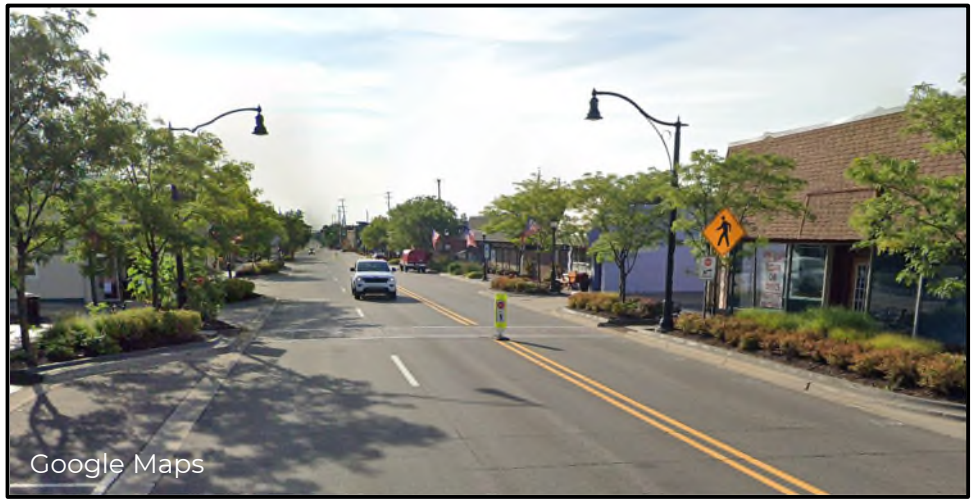
MDOT
Michigan Department of Transportation

September 2022

Overview

Toward Zero Deaths®
National Strategy on Highway Safety

As a part of MDOT's mission to provide ***"the highest quality integrated transportation services for economic benefit and improved quality of life"***, the department is working to create better, safer roadways for all users. The design and planning of roadways which supports the safety and mobility of non-motorized road users represents a key opportunity towards achieving the state's ultimate ***Towards Zero Death*** vision. While pedestrians must regularly cross the state's highway network in order to reach their destination, it is important to recognize such pedestrian crossing movements can represent a considerable safety risk [1]. These risks may be mitigated by the application of appropriate engineering treatments to enhance the level of awareness of pedestrians by motorists.



Pedestrians must cross Michigan's highway network at both controlled and uncontrolled locations. Uncontrolled pedestrian crossings "occur where sidewalks or designated walkways intersect a roadway at a location where no traffic control (i.e. traffic signal or STOP sign) is present" [2]. Uncontrolled crossings occur at both intersections and non-intersection locations (also referred to as "midblock") [2]. FHWA's *Achieving Multimodal Networks* notes the underlying principle that regardless of their location, pedestrian crossings should always "provide a safe and comfortable locations to cross the street" [3].

Midblock crossings are intended to "provide convenient locations for pedestrians to cross" roadways where the nearest controlled intersection crossings require "substantial out-of-direction travel" [4]. Given that pedestrians will often take the most direct and convenient path to their destination when intersections are spaced relatively far apart, such midblock crossings represent an important component of a transportation system which protects pedestrians and encourages walking [4]. However, the decision to install marked crosswalks, including enhanced crossing treatments, represents a complex decision-making process which should incorporate a broad range of engineering factors. The MMUTCD states that "crosswalk lines should not be used indiscriminately" and includes guidance to perform an engineering study before installing a marked crossing at an uncontrolled location [5].

This document, based on **FHWA's STEP Studio**, is intended provide an overview of the planning and design process for implementing pedestrian crossing enhancements in Michigan, including both national and state-specific resources. The document is structured in four sections (shown right) which include information specific to distinct steps of the planning and design process. It should be noted that while this tool does not directly describe pedestrian crossing requirements per the Americans with Disabilities Act (ADA), any potential improvements must meet these requirements [6].

1. Site Identification
2. Site Analysis
3. Treatment Selection
4. Design and Planning Resources

Structure

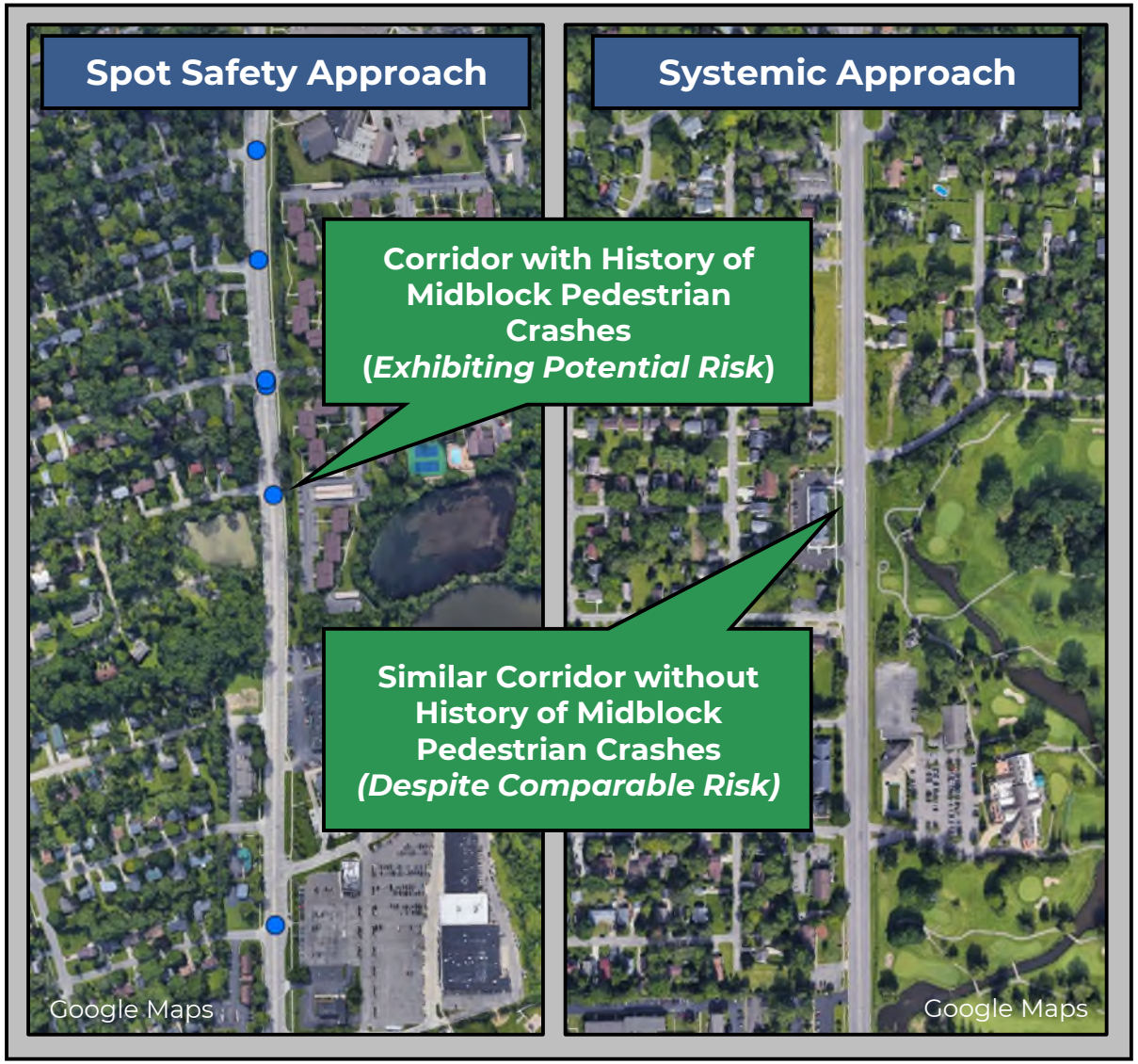
1	Site Identification	Pedestrian Crossing Risk Analysis	State and Local Safety Plans	Gather Stakeholder and Public Input
2	Site Analysis	Collect Site-Specific Characteristics	Conduct Detailed Crash Analysis	Road Safety Audits
3	Treatment Selection	Elements of Pedestrian Crossings	Michigan's Standard Crossing Treatments	Criteria for Selecting Crossing Treatments
4	Design and Planning Resources	Funding Sources	Michigan-Specific Resources	National Resources

Pedestrian Crossing Risk Analysis

In order to maximize the cost-effectiveness of the safety funding available to implement pedestrian crossing enhancements, it is necessary to prioritize locations along the highway network which pose potentially increased relative risks to crossing pedestrians. There are several data-driven approaches which can be employed to screen the highway network in order to identify and prioritize sites. This includes both **spot safety** and **systemic safety** approaches to assessing pedestrian crossing risks (*visualized right*).

Traditional **spot safety** analysis methods represent a reactive approach which involves mapping historical crash data (typically three to five years) to visually identify locations or corridors which have experienced a cluster of pedestrian-involved collisions. **Systemic safety** analysis methods represent a proactive approach to identifying pedestrian crash risk based upon the roadway characteristics of specific locations or corridors (as opposed to crash history). Given the rare and random nature of pedestrian-involved collisions, many roadways may present considerable crossing-related safety risk without exhibiting a history of such crashes. The systemic approach relies on an aggregated analysis of pedestrian-involved crash data to identify roadways with characteristics which are associated with increased relative pedestrian crash risk.

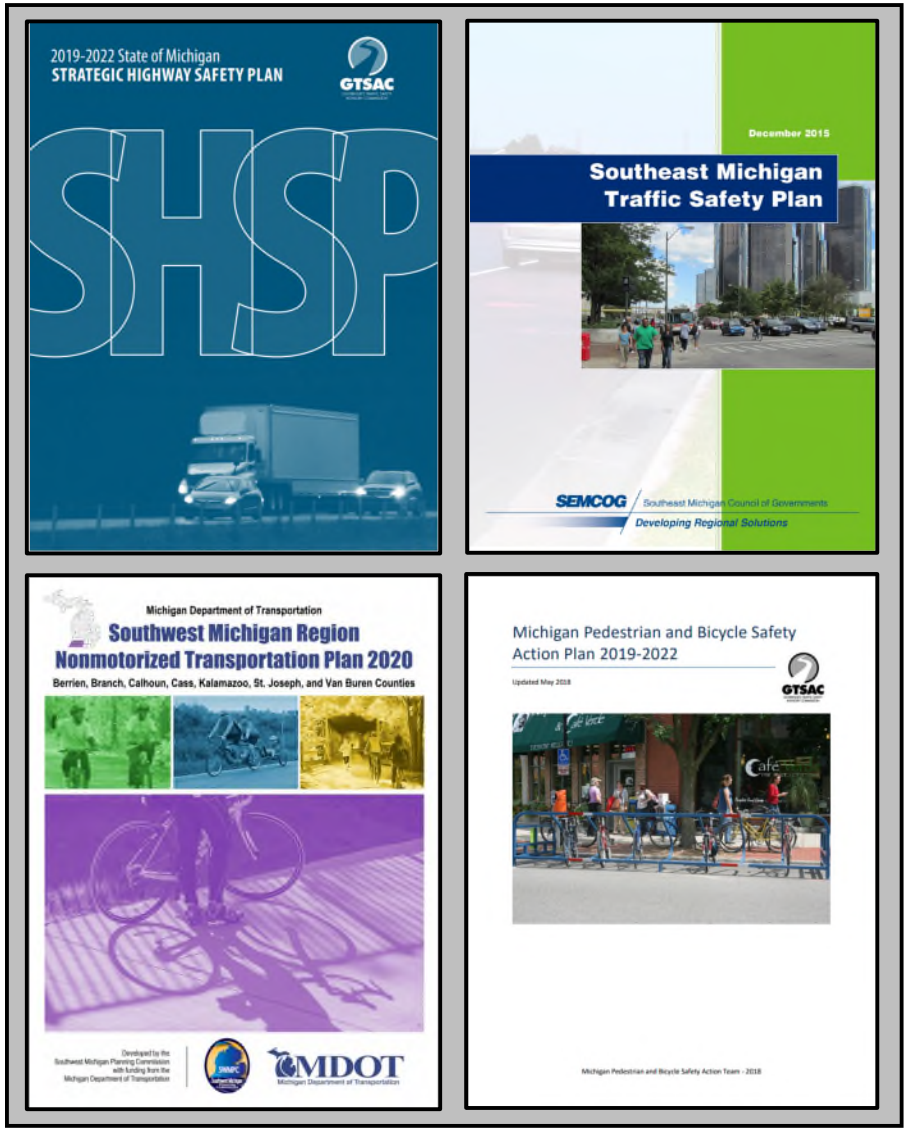
Historical traffic crash data in Michigan can be obtained from the **Michigan Office of Highway Safety Planning's *Michigan Traffic Crash Facts* website** [7] or **Michigan Technological University's *Roadsoft* tool** [8]. Additional information specific to identifying potential locations using the spot safety approach can be found in **FHWA's *Guidebook on Identification of High Pedestrian Crash Locations*** [9]. Additional information specific to identifying potential locations using the systemic safety approach can be found in **NCHRP Research Report 893: *Systemic Pedestrian Safety Analysis*** [10].



State and Local Safety Plans

MDOT, regional planning organizations, local highway agencies, and other stakeholders have previously partnered to develop a series of safety plans intended to help guide future investment in Michigan's transportation network. These plans can provide a valuable resource in identifying both countermeasure strategies as well as potential locations for improvement.

Name of Plan	Description
2022 State of Michigan Strategic Highway Safety Plan [11]	Statewide plan to coordinate efforts towards Michigan's long-term Towards Zero Death vision. Pedestrian and bicycle safety is a focus within the plan, including the strategy to "promote the use of best practices when designing and operating facilities".
Regional Traffic Safety Plans	Regional planning organizations partnered with MDOT in order to develop traffic safety plans intended to guide While each region has taken a unique approach to their plan, they generally include a benchmark of current safety performance, completed and planned projects, and potential strategies for improvement.
Regional Non-Motorized Investment Plans	Each region within Michigan has developed a plan intended to help coordinate future investment in the non-motorized transportation system. While each region has taken a unique approach to their plan, they generally include a benchmark of current safety performance, completed and planned projects, and potential strategies for improvement.
Michigan Pedestrian and Bicycle Safety Action Plan 2019-2022 [12]	The plan is a living document developed by the *Pedestrian and Bicycle Safety Action Team* which represents a compilation of the activities and initiatives to address pedestrian and bicycle safety in Michigan.

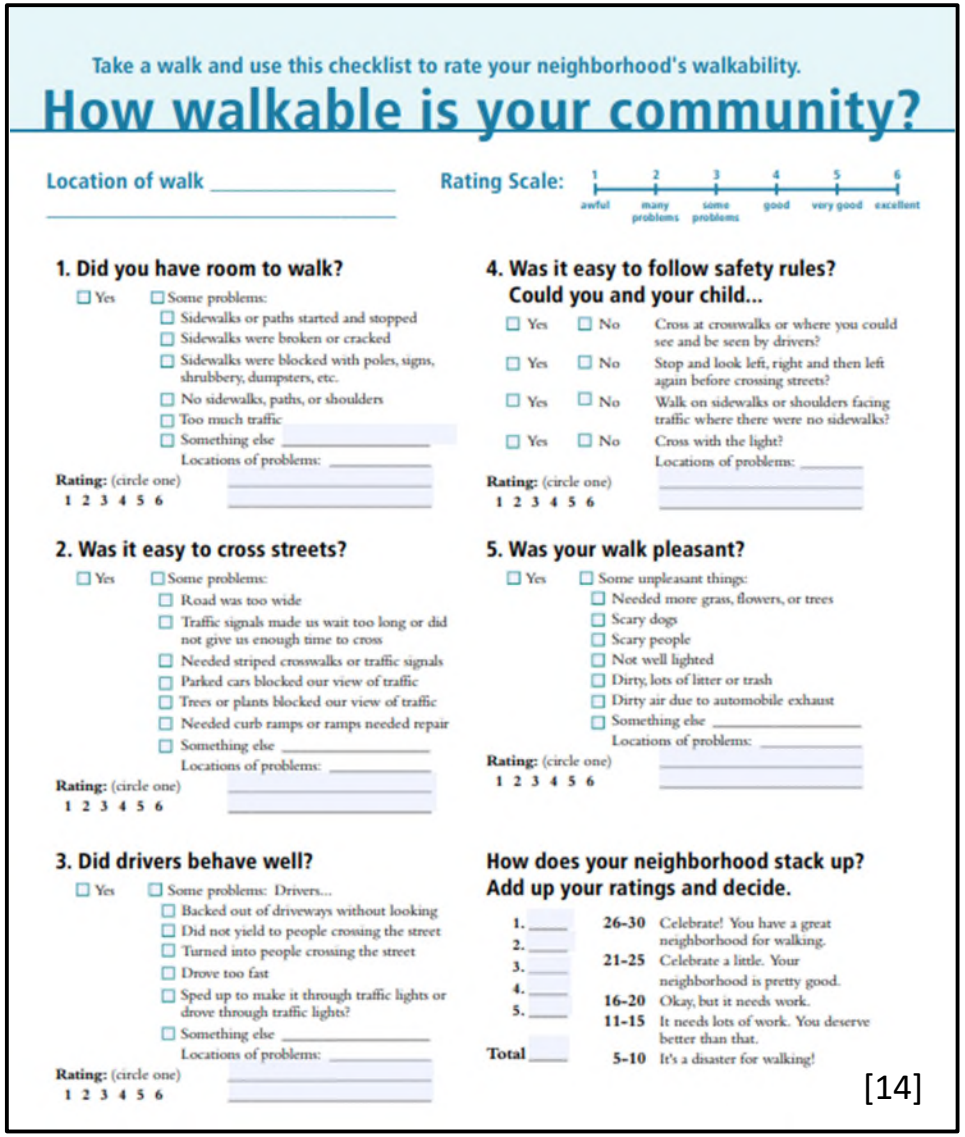


Gather Stakeholder and Public Input

Stakeholder and public input is a key component of developing successful transportation safety improvements [13]. This input is particularly important when identifying and prioritizing sites for potential crossing enhancements given the limited availability of pedestrian demand data as well as the rare and random nature of pedestrian-involved collisions. While MDOT and local agencies have processes in place for receiving and responding to input from the public, proactively seeking input specific to pedestrian safety represents a considerable opportunity as a part of identifying sites for potential crossing enhancements.

Walkability audits [14] represent one potential method of engaging stakeholders and raising general awareness related to pedestrian safety. Community leaders can engage residents within specific neighborhoods to conduct an audit using a checklist (*shown right*) to assess the street network within a local area. The results of the audit can be used to identify locations with the potential for improvement.

For more information on engaging the public in transportation decision-making refer to ***FHWA's Public Involvement Techniques for Transportation Decisionmaking*** [15]. Additionally, the FHWA provides guidance for the use of **virtual public involvement tools** which can help to increase meaningful public involvement in planning and project development [16]. MDOT also **maintains guidance** for virtual public involvement in public involvement procedures [17].



Take a walk and use this checklist to rate your neighborhood's walkability.

How walkable is your community?

Location of walk _____

Rating Scale: 1 awful, 2 many problems, 3 some problems, 4 good, 5 very good, 6 excellent

1. Did you have room to walk?
- ☐ Yes
- ☐ Some problems:
  - ☐ Sidewalks or paths started and stopped
  - ☐ Sidewalks were broken or cracked
  - ☐ Sidewalks were blocked with poles, signs, shrubbery, dumpsters, etc.
  - ☐ No sidewalks, paths, or shoulders
  - ☐ Too much traffic
  - ☐ Something else _____
  - Locations of problems: _____

Rating: (circle one) 1 2 3 4 5 6

2. Was it easy to cross streets?
- ☐ Yes
- ☐ Some problems:
  - ☐ Road was too wide
  - ☐ Traffic signals made us wait too long or did not give us enough time to cross
  - ☐ Needed striped crosswalks or traffic signals
  - ☐ Parked cars blocked our view of traffic
  - ☐ Trees or plants blocked our view of traffic
  - ☐ Needed curb ramps or ramps needed repair
  - ☐ Something else _____
  - Locations of problems: _____

Rating: (circle one) 1 2 3 4 5 6

3. Did drivers behave well?
- ☐ Yes
- ☐ Some problems: Drivers...
  - ☐ Backed out of driveways without looking
  - ☐ Did not yield to people crossing the street
  - ☐ Turned into people crossing the street
  - ☐ Drove too fast
  - ☐ Sped up to make it through traffic lights or drove through traffic lights?
  - ☐ Something else _____
  - Locations of problems: _____

Rating: (circle one) 1 2 3 4 5 6

4. Was it easy to follow safety rules? Could you and your child...
- ☐ Yes ☐ No Cross at crosswalks or where you could see and be seen by drivers?
- ☐ Yes ☐ No Stop and look left, right and then left again before crossing streets?
- ☐ Yes ☐ No Walk on sidewalks or shoulders facing traffic where there were no sidewalks?
- ☐ Yes ☐ No Cross with the light?

Locations of problems: _____

Rating: (circle one) 1 2 3 4 5 6

5. Was your walk pleasant?
- ☐ Yes
- ☐ Some unpleasant things:
  - ☐ Needed more grass, flowers, or trees
  - ☐ Scary dogs
  - ☐ Scary people
  - ☐ Not well lighted
  - ☐ Dirty, lots of litter or trash
  - ☐ Dirty air due to automobile exhaust
  - ☐ Something else _____
  - Locations of problems: _____

Rating: (circle one) 1 2 3 4 5 6

How does your neighborhood stack up? Add up your ratings and decide.

1. ____
2. ____
3. ____
4. ____
5. ____

Total ____

26-30	Celebrate! You have a great neighborhood for walking.
21-25	Celebrate a little. Your neighborhood is pretty good.
16-20	Okay, but it needs work.
11-15	It needs lots of work. You deserve better than that.
5-10	It's a disaster for walking!

[14]

Collect Site-Specific Characteristics

The planning and design of pedestrian crossing enhancements represents a complex decision-making process which should incorporate a broad range of engineering factors. Site-specific characteristics which can be collected to conduct a more detailed evaluation of sites identified via the network screening process outlined in **Section 1** are summarized in the table below. See ***Guidance for Installation of Pedestrian Crosswalks on Michigan State Trunkline Highways*** [18] for more detailed information related to collecting site-specific characteristics.

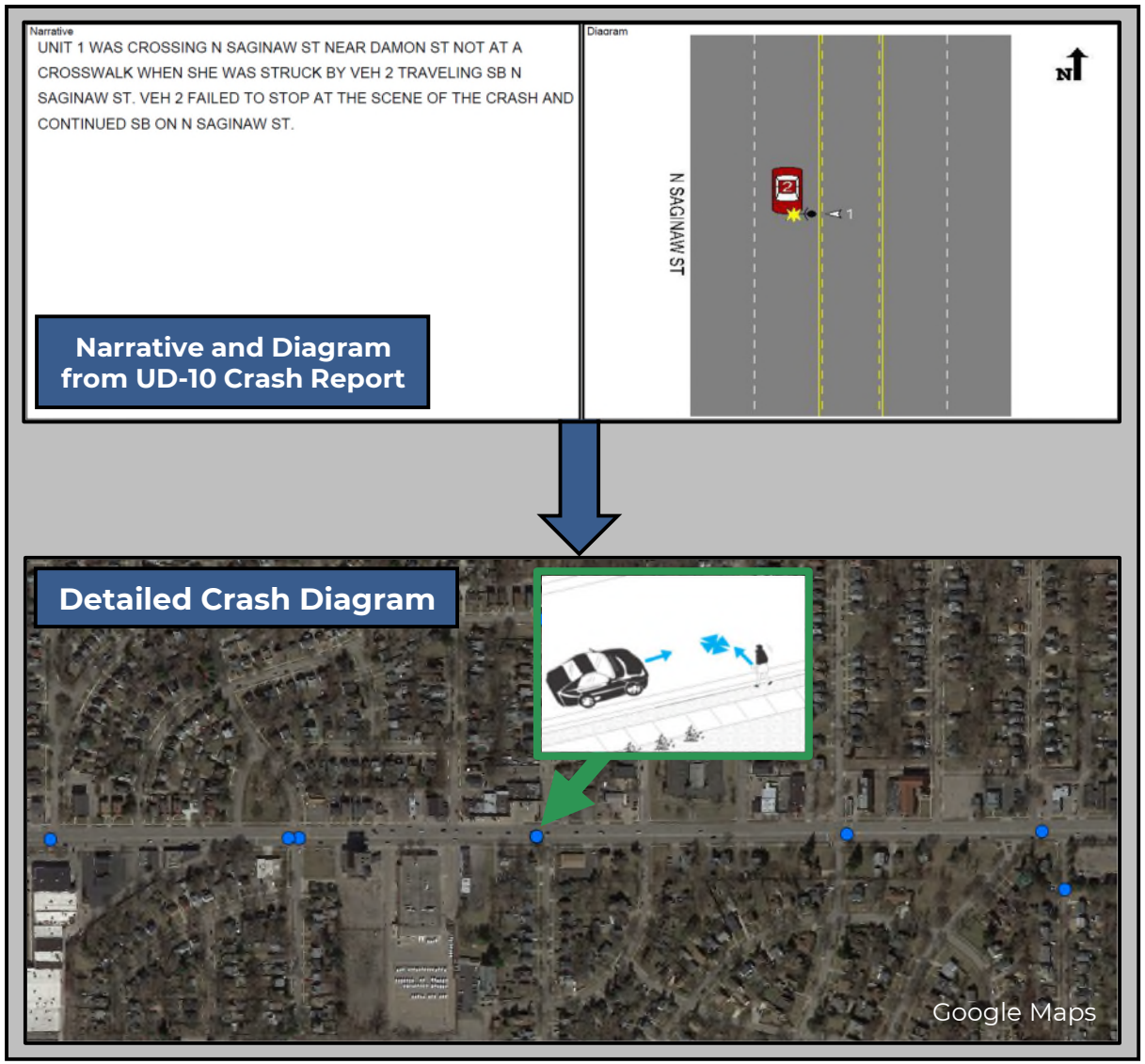
Characteristic	Description
Non-Motorized Demand and Behavior Information	Pedestrian and bicycle count data can be collected or may be available from local agencies. For example, SEMCOG maintains **a map of pedestrian and bicycle count data** for locations within Southeast Michigan. Additionally, pedestrian crossing behavior can be observed which may help to identify preferred crossing routes or other site-specific circumstances. Typical characteristics of pedestrians present in the local area (such as children, the elderly, or disabled persons) can also be identified.
Distance to the Nearest Controlled Crossing	The distance to the nearest controlled pedestrian crossing can be obtained by reviewing satellite imagery or as a part of a site visit. This includes marked crosswalks at intersections where through vehicle movements are controlled by traffic control devices (such as a traffic signal, STOP or YIELD signs, or an existing beacon).
Existing Surrounding Non-Motorized Facilities	The presence of existing non-motorized facilities can be collected by visiting the site or reviewing satellite imagery. This could include sidewalk coverage, existing marked crossings, adjacent trails or shared-use paths, bicycle lanes, or other facilities which are specific to non-motorized road users. Connectivity with the surrounding non-motorized transportation network is a key consideration for the planning and design of future crossing enhancements.
Historical Traffic Crash Data	Historical traffic crash data involving non-motorized road users can be obtained from either the **Michigan Office of Highway Safety Planning's *Michigan Traffic Crash Facts* website** [7] or **Michigan Technological University's *Roadsoft* tool** [8].
Vehicular Speed Data	Vehicular speed data to collect could include the posted speed limit of the roadway, observed operating speeds (such as the mean or 85th percentile) of vehicles traveling along the roadway, as well as the design speed of the roadway. It should be noted that the posted speed limit represents a direct input into the treatment selection process outlined in **Section 3**.
Vehicle Traffic Characteristics	The annual average daily traffic (AADT) volume for the roadway can be collected from statewide or local agency resources where available. For example, MDOT maintains a robust **traffic monitoring program** and local agencies may maintain their own resources (such as **SEMCOG's *Traffic Volume Map***). The percentage of trucks can often be obtained from historical traffic count data. There may also be circumstances which require hourly count data is required to conduct traffic studies to determine if minimum warrants are met for specific treatments. Site-specific driver behavior observed in the field may also provide insight when designing future crossing enhancements.
Roadway Cross-Section	The cross-section of the existing roadway, including the total crossing distance, can be obtained by reviewing satellite imagery, design documents, or collected as a part of a site visit. This includes the number of through lanes, the number of exclusive turn lanes, existing medians, shoulders, or other design features such as curb extensions or on-street parking. It should be noted that the number of through lanes represents a direct input into the treatment selection process outlined in **Section 3**.

Collect Site-Specific Characteristics (Cont.)

Characteristic	Description
Adjacent Intersection Characteristics	The characteristics of intersections which are adjacent to the proposed crossing can be collected as a part of a site visit. This includes the type of intersection (i.e. signalized, stop-controlled, or a roundabout), marking crossing presence, signal phasing (such as the presence of a leading pedestrian interval) or other signal timing information, as well as adjacent queue lengths which could impact the potential crossing.
Parking Characteristics	The presence of on-street parking can be obtained by reviewing satellite imagery or as a part of a site visit. The site-specific parking characteristics can also be obtained by observing behavior in the field which could potentially impact the design of future pedestrian crossings.
Existing Traffic Control Devices	The presence of existing traffic control devices (such as signs, pavement markings, or electronic devices) along the roadway can be obtained as a part of a site visit.
Existing Pedestrian Design Features	The presence of existing pedestrian design features (such as curb extensions or refuge islands) can be obtained as a part of a site visit.
Lighting	The presence of existing lighting along the roadway (including both vehicle-focused and pedestrian-focused) lighting can be obtained as a part of a site visit.
Surrounding Land Use	The surrounding land use around the roadway and the potential crossing can be obtained by reviewing satellite imagery as well as during a site visit. Specifically, the presence of schools, residential developments, senior care facilities, or certain businesses represent important pedestrian destinations which result in adjacent crossing demand. This general context of the roadway (urban, suburban, rural) also always an important role in the context sensitive solution and complete street/multimodal approaches employed by MDOT.
Adjacent Transit Stops	The presence of adjacent transit stops is an important consideration when locating potential crossing enhancements. The location of adjacent transit stops can be obtained as a part of a site visit or reviewing routes from the relevant transit authority.
Available Right-of-Way	The available right-of-way impacts the potential design options and can be obtained as a part of reviewing design documents or a site visit. MDOT also maintains **right-of-way maps** which are available as a reference but should be verified by other sources.
Sight Distance Considerations	Ensuring that stopping sight distance is available is a key consideration for potential new marked pedestrian crossings. The sight distance at proposed crossings can be collected on all vehicular approaches as a part of a site visit. See ***MDOT's Road Design Manual*** [20] or ***Sight Distance Guidelines*** [21] for more information.

Conduct Detailed Crash Analysis

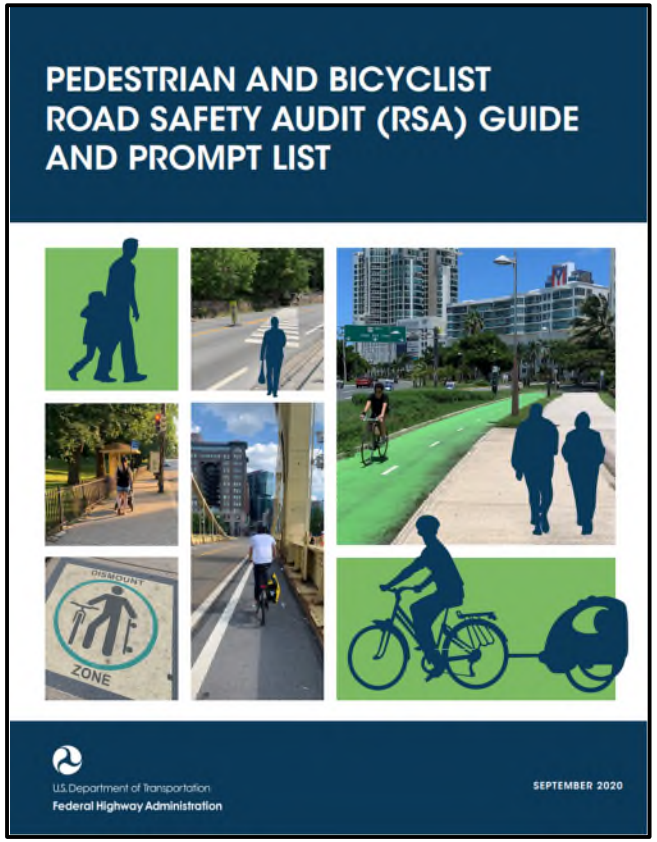
As a part of a site-specific analysis, it can be helpful to conduct a more detailed crash analysis beyond the network screening process outlined in **Section 1** to identify potential safety concerns present along the corridor of interest. This process involves obtaining the **Michigan UD-10 Crash Report Forms** associated with crashes occurring along the corridor. The narrative and diagram included within each report can be reviewed to determine the precise location and circumstances of the collision. This process can include categorizing crashes into groups in order to determine potential trends. The University of North Carolina Highway Safety Research Center has previously developed the ***Pedestrian and Bicycle Crash Analysis Tool*** [22] which includes 12 crash type groups specific to pedestrian-involved crashes which can be applied to this process. **FHWA's PEDSAFE Pedestrian Safety Guide and Countermeasure Selection System** [23] provides detailed guidance related to the causes and potential countermeasures for each crash type. A detailed crash diagram can be developed from this process (*shown right*) which can help to visualize potential patterns.



Road Safety Audits

Road safety audits (RSAs) are a formal safety performance examination of an existing or future road or bridge project by an independent, multi-disciplinary RSA team. RSAs contribute to the MDOT's *Towards Zero Death* vision by providing an unbiased assessment of a highway location in an effort to identify potential safety issues and solutions. RSAs can be conducted at any stage of the project development process and includes eight steps (shown below). It is important to note that RSAs consider the needs of all road users, including pedestrians and bicyclists. RSA teams are generally comprised of trained MDOT employees as independent reviewers and facilitated by a contracted consultant. The audit team focuses in four specific areas, including geometry, operations, road users, and the environment.

While **MDOT's *Road Safety Audit Guidance*** [24] details the RSA process in Michigan and which identifies projects where audits should be conducted, there are also opportunities conduct RSAs specific to pedestrians and bicyclists. **FHWA's *Pedestrian and Bicyclist Road Safety Audit (RSA) Guide and Prompt List*** [25] includes information to support RSA's which are focused on pedestrians and bicyclists.



Identify Project → Select RSA Team → Conduct Start Up Meeting → Perform Field Review(s) → Conduct RSA Analysis → Present Analysis Findings → Prepare Formal Response → Incorporate Findings

Elements of Pedestrian Crossings

NCHRP Synthesis 498: *Application of Pedestrian Crossing Treatments for Streets and Highways* [26] developed a list of typical elements which comprise pedestrian crossings, including infrastructure and design features as well as traffic control devices (summarized in the table below). Effective pedestrian crossing enhancements include a combination of these elements which are selected based upon the design scenario, such as the geometric or traffic characteristics of the crossing location. More detailed information on these elements specific to designing pedestrian crossing enhancements within Michigan can be found in ***Best Design Practices for Walking and Bicycling in Michigan*** [27] as well as the **additional resources provided in Section 4**.

Infrastructure and Design Features	Traffic Control Devices
Raised Medians	High-Visibility Crosswalk Markings
Refuge Islands	Advanced Stop/Yield Signs and Bars
Raised Crosswalks	Pedestrian Signal Heads and Countdown Signals
Curb Extensions	Pedestrian Hybrid Beacons (PHBs)
Reduced Corner Radii	Rectangular Rapid-Flashing Beacons (RRFBs)
Road Diets	Overhead or Roadside Mounted Flashing Beacons
Narrow Lane Widths	Pedestrian Only Crossing Phases
Grade Separated Crossings	Leading Pedestrian Intervals (LPIs)
Corridor-Wide Speed Calming	Right-Turn on Red Restrictions
Enhanced Illumination	R1-6 Signs and Gateway Treatments
	Pedestrian Warning Signs
	Parking Restrictions
	In-Pavement Flashing Warning Lights

MDOT's Standard Crossing Treatments

MDOT's crosswalk guidance [18] includes four crossing treatment categories (labeled A through D) which are intended to represent the primary uncontrolled crossing treatments employed by the department for trunkline highways that are appropriate for commonly encountered situations. It is important to recognize that these treatments may not be comprehensive and additional applicable alternative treatments could be available depending on the situation [18]. Criteria for selecting an appropriate treatment type is provided on the following page based upon the roadway configuration at the crossing, traffic volume, and the posted speed limit. While these crossing types are summarized in the table below, see ***Guidance for Installation of Pedestrian Crosswalks on Michigan State Trunkline Highways*** [18] for more information specific to the selection of the standard crossing treatments.

Crossing Type	Description
A	• Use marked special emphasis crosswalks (See **MDOT PAVE 945 series** [28]) • Use standard pedestrian warning signs (W11-2) and consider the need for advanced warning signs • Consider the use of R1-6 in-street sign gateway treatment (See **R1-6 User Guide** [29]) • If the location is a designated school crossing, the standard school crossing signs should be used (S1-1)
B	• Use marked special emphasis crosswalks (See **MDOT PAVE 945 series** [28]) • Use standard pedestrian warning signs (W11-2) and consider the need for advanced warning signs, including potential dynamic electronic devices • Consider the use of R1-6 in-street signs, including a potential gateway treatment, in low-speed urban settings (See **R1-6 User Guide** [29]) • Consider potential geometric improvements (such as curb extensions or refuge islands) based upon the characteristics of the existing roadway • Consider RRFBs if the criteria is met from the crosswalk guidance [18], and refer to Crossing Type D • If the location is a designated school crossing, the standard school crossing signs should be (S1-1)
C	• When the posted speed limit is greater than or equal to 45 mph, determine if traffic calming measures can be installed to effectively reduce operating speeds in order to reduce the posted speed limit to 40 mph • Evaluate if a raised median could be implemented within the roadway cross-section • If these conditions can be met, refer to **Crossing Type B**. Otherwise, refer to **Crossing Type D**.
D	• Crossing three or more though lanes in a given direction along roadways with a speed limit of 40 mph or more is not suitable for an uncontrolled marked crosswalk • Consider the use of a PHB, pedestrian traffic signal, or grade-separated pedestrian crossing. Refer to the **crosswalk guidance** [18], or the **MMUTCD** [5] for criteria. • Such crossings must consider signal progression, grades, physical constraints, and other engineering-related factors.

Criteria for Selecting Crossing Treatments [18]

Roadway Configuration at the Location of the Crossing Treatment	Number of Lanes Crossed to Reach Refuge	Number of Multiple Threat Lanes*	Roadway ADT and Posted Speed Limit															
			1,500 – 9,000 VPD				9,000 – 12,000 VPD				12,000 – 15,000 VPD				> 15,000 VPD			
			≤ 30 MPH	35 MPH	40 MPH	≥ 45 MPH	≤ 30 MPH	35 MPH	40 MPH	≥ 45 MPH	≤ 30 MPH	35 MPH	40 MPH	≥ 45 MPH	≤ 30 MPH	35 MPH	40 MPH	≥ 45 MPH
Two-Lane (One-Way)	2	1	A	A	A	B	A	A	B	B	A	A	B	B	A	A	B	B
Two-Lane Two-Way Undivided	2	0	A	A	A	B	A	A	B	B	A	A	B	B	A	A	B	B
Three-Lane with Refuge Island **or** Two-Lane with Raised Median	1	0	A	A	A	B	A	A	B	B	A	A	B	B	A	B	B	B
Two-Lane with Center Left-Turn Lane	3	1	A	A	B	B	A	B	B	B	A	B	B	B	A	B	B	B
Four-Lane Two-Way Undivided	4	2	A	B	B	C	A	B	C	C	A	B	C	C	B	B	C	C
Five-Lane with Refuge Island **or** Four Lane with Raised Median	2	2	A	A	B	B	A	B	B	C	A	B	C	C	B	B	C	C
Five-Lane with Center Left-Turn Lane	5	2	A	B	C	C	B	B	C	C	C	C	C	D	C	C	C	C
Six-Lane (with or without Raised Median)	3 - 6	4	A	B	D	D	B	B	D	D	D	D	D	D	D	D	D	D

**Multiple threat lanes represent travel lanes where a pedestrian crossing in front of a stopped or slowed vehicle in an adjacent travel lane could step out in front of a moving vehicle in the same direction*

Funding Sources

Source	Description
Highway Safety Improvement Program (HSIP) [30]	Core federal aid program intended to "achieve a significant reduction in traffic fatalities and serious injuries on all public roads through the implementation of infrastructure-related highway safety improvements" [30]. While there are distinct calls for projects along the state trunkline and locally-owned roadways, the implementation of crossing enhancements are eligible in both programs.
Safe Routes to School (SRTS) [31]	SRTS is "an international movement—and now a federal program—to make it safe, convenient, and fun for children, including those with disabilities, to bicycle and walk to school." The competitive program provides "Major Grants" which include up to $220,000 per school for potential infrastructure improvements. Crossing enhancements are eligible for the program, however, the cost of traffic studies to determine if minimum warrants are met for specific devices can not be funded by the grants.
Transportation Alternatives Program (TAP) [32]	TAP is "a competitive grant program for projects such as bike paths, pedestrian and bicycle safety improvements, and preservation of historic transportation facilities that enhance Michigan's intermodal transportation system and provide safe alternative transportation options". The elements of crossing enhancements summarized in Section 3 are eligible as long as they conform with the MMUTCD and AASHTO guidance.

Michigan-Specific Resources

Document	Summary of Role in Pedestrian Crossing Planning and Design
Guidance for Installation of Pedestrian Crosswalks on Michigan State Trunkline Highways [18]	Guidance document which provides a "step-by-step" procedure for identifying the appropriate location and type of pedestrian crossing on Michigan's trunkline highways.
Michigan MUTCD [5]	The "official manual for the uniform system of traffic control devices for the State of Michigan" which provides the standards for traffic control devices in the state, including devices related to pedestrian crossing treatments.
Electronic Traffic Control Device Guidelines [33]	Document which is intended to "provide guidelines and recommendations for the use and operation of electronic traffic control devices in the state of Michigan", including the use of PHBs and RRFBs.
Road Design Manual [20]	The department's road design manual includes guidance to integrate pedestrian crossings into the design process.
Pavement Marking Standards [28]	The department's pavement marking standards include details for marked crosswalks in several environments.
Traffic Signal Details [34]	The department's traffic signal special details include drawings specific to PHBs and RRFBs.
Best Design Practices for Walking and Bicycling in Michigan [27]	Toolbox of design practices which have been shown to improve safety and/or mobility for non-motorized road users.
Traffic Sign Design, Placement, and Application Guidelines [35]	Guidance document intended to "provide additional guidance to designers on the appropriate design, placement, and application" of signing, including signs related to pedestrian crossings.

National Resources

Reference	Summary
NCHRP Synthesis 498: Application of Pedestrian Crossing Treatments for Streets and Highways [26]	The synthesis document summarizes the commonly used pedestrian crossing treatments used in the United States, including policies and practices employed by highway agencies towards prioritizing treatment locations.
FHWA's Step Studio [13]	Comprehensive set of tools to identify appropriate countermeasures to improve pedestrian safety developed as a part of FHWA's Every Day Counts Round 5 (EDC-5) initiative.
FHWA's Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations [2]	Guidance document developed by the FHWA which provides information to support the installation of engineering countermeasures specific to uncontrolled pedestrian crossing locations.
AASHTO's Guide for the Planning, Design, and Operation of Pedestrian Facilities [36]	Document which provides guidance specific to the planning, design and operation of pedestrian facilities along both streets and highways.
NCHRP Research Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments [1]	Research report which quantities the safety benefits of RRFBs, PHBs, pedestrian refuge islands, and advanced YIELD or STOP markings and signs.
FHWA's Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations [37]	Research report which evaluated pedestrian crash history at uncontrolled locations with both marked and unmarked crosswalks. The document includes recommendations to improve safety at uncontrolled locations.
FHWA's Pedestrian Safety Guide and Countermeasures Selection System (PEDSAFE) [38]	Tool developed by the FHWA which provides practitioners with the latest information specific to improving safety and mobility for pedestrians.
TCRP Report 112/NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings [39]	Report which summarizes the findings of a research project intended to recommend engineering treatments for pedestrian crossings of high-volume, high-speed roadways at unsignalized intersections. The report also includes recommended modifications to the MUTCD pedestrian signal warrant.

Reference List

1. Zeeger, C., R. Srinivasan, B. Lan, D. Carter, S. Smith, C. Sundstrom, N.J. Thirsk, C. Lyon, B. Persaud, J. Zeeger, E. Ferguson, and R. Van Houton (2017). NCHRP Research Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments. National Academies of Sciences, Washington, D.C.
2. Blackburn, L., C. Zeeger, and K. Brookshire (2018). Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations. Federal Highway Administration, Washington, D.C.
3. Federal Highway Administration (2016). Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts. Washington, D.C.
4. Institute of Transportation Engineers (2010). Designing Walkable Urban Throughfares: A Context Sensitive Approach.
5. Michigan Department of Transportation (2013). Michigan Manual on Uniform Traffic Control Devices.
6. United States Department of Justice Civil Rights Division. Information and Technical Assistance on the Americans with Disabilities Act. Retrieved June 2021 from: https://www.ada.gov/
7. Michigan Office of Highway Safety Planning (2021). Michigan Traffic Crash Facts. Retrieved June 2021 from: https://www.michigantrafficcrashfacts.org/
8. Michigan Technological University. Roadsoft. Retrieved June 2021 from: https://www.roadsoft.org/
9. Fitzpatrick, K., R. Avelar, and S. Turner (2018). Guidebook on Identification of High Pedestrian Crash Locations. Federal Highway Administration, FHWA-HRT-17-106.
10. Thomas, L., L. Sandt, C. Zegeer, W. Kumfer, K. Lang, B. Lan, Z. Horowitiz, A. Butsick, J. Toole, and R.J. Schneider (2018). NCHRP Research Report 893: Systemic Pedestrian Safety Analysis. The National Academies of Sciences, Transportation Research Board.
11. Governor's Traffic Safety Commission (2019). 2019-2022 State of Michigan Strategic Highway Safety Plan.
12. Michigan Pedestrian and Bicycle Safety Action Team (2018). Michigan Pedestrian and Bicycle Safety Action Plan 2019-2022.
13. Federal Highway Administration. STEP Studio: Tools for Selecting and Implementing Countermeasures for Improving Pedestrian Crossing Safety. Retrieved June 2021 from: https://safety.fhwa.dot.gov/ped_bike/step/resources/docs/step_studio.pdf
14. National Highway Traffic Safety Administration. Walkability Checklist. Retrieved June 2021 from: https://www.nhtsa.gov/sites/nhtsa.gov/files/walkingchecklist.pdf
15. Federal Highway Administration (2015). Public Involvement Techniques for Transportation Decisionmaking – 2015 Update. Retrieved June 2021 from: https://www.fhwa.dot.gov/planning/public_involvement/publications/pi_techniques/fhwahep15044.pdf
16. Federal Highway Administration (2020). Virtual Public Involvement. Retrieved June 2021 from: https://www.fhwa.dot.gov/planning/public_involvement/vpi/
17. Michigan Department of Transportation. Inclusion of Virtual Public Involvement (VPI) in Michigan Department of Transportation's Public Involvement Procedures. Retrieved June 2021 from: https://www.michigan.gov/documents/mdot/Guidance_on_Inclusion_of_Virtual_Public_Involvement_704413_7.pdf
18. Michigan Department of Transportation (2020). Guidance for Installation of Pedestrian Crosswalks on Michigan State Trunkline Highways.
19. Michigan Department of Transportation. Traffic and Safety/Standards and Special Details – Pedestrian/Bicyclist. Retrieved June 2021 from: https://mdotjboss.state.mi.us/TSSD/getCategoryDocuments.htm?categoryPrjNumbers=1403862&category=Pedestrian/Bicyclist
20. Michigan Department of Transportation. Road Design Manual. Retrieved June 2021 from: https://mdotjboss.state.mi.us/stdplan/englishroadmanual.htm
21. Michigan Department of Transportation (2015). Sight Distance Guidelines. Retrieved June 2021 from: https://mdotjboss.state.mi.us/TSSD/getTSDocument.htm?docGuid=7608e140-5def-4ad2-90c9-40e4abb822a5&fileName=mdot_sight_distance_guidelines.pdf
22. Pedestrian and Bicycle Information Center. Pedestrian and Bicycle Crash Analysis Tool (PBCAT). Retrieved June 2021 from: https://www.pedbikeinfo.org/pbcat_us/index.cfm
23. Federal Highway Administration. PEDSAFE: Selecting Improvements for Pedestrians. Retrieved June 2021 from: http://www.pedbikesafe.org/pedsafe/guide_analysis.cfm#crashtypeanalysis
24. Michigan Department of Transportation (2019). Road Safety Audit Guidance. Retrieved June 2021 from: https://mdotjboss.state.mi.us/TSSD/getTSDocument.htm?docGuid=2b81405d-38a4-4c52-b08a-28051f01af3c&fileName=10241.pdf
25. Federal Highway Administration (2020). Pedestrian and Bicyclist Road Safety Audit (RSA) Guide and Prompt List. Retrieved June 2021 from: https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa20042.pdf
26. Thomas, L., N.J. Thirsk, C.V. Zegeer (2016). NCHRP Synthesis 498: Application of Pedestrian Crossing Treatments for Streets and Highways. The National Academies of Sciences, Transportation Research Board.
27. Michigan Department of Transportation. Best Design Practices for Walking and Bicycling in Michigan.
28. Michigan Department of Transportation. Traffic and Safety/Standards and Special Details – Pavement Markings. Retrieved June 2021 from: https://mdotjboss.state.mi.us/TSSD/getCategoryDocuments.htm?categoryPrjNumbers=1403856,1403857,1403858,1403859,1403860&category=Pavement%20Markings
29. Western Michigan University and T.Y. Lin International (2018). User Guide for R1-6 Gateway Treatment for Pedestrian Crossings. Michigan Department of Transportation.
30. Federal Highway Administration (2021). Highway Safety Improvement Program. Retrieved June 2021 from: https://safety.fhwa.dot.gov/hsip/
31. Michigan Fitness Foundation (2021). About Safe Routes to School. Retrieved June 2021 from: https://saferoutesmichigan.org/
32. Michigan Department of Transportation. Transportation Alternatives Program. Retrieved June 2021 from: https://www.michigan.gov/mdot/0,4616,7-151-9621_17216_18231---,00.html
33. Michigan Department of Transportation (2021). Electronic Traffic Control Device Guidelines.
34. Michigan Department of Transportation. Traffic and Safety/Standards and Special Details – Traffic Signals. Retrieved June 2021 from: https://mdotjboss.state.mi.us/TSSD/getCategoryDocuments.htm?categoryPrjNumbers=1403877,1403878,1403879,1403880,1403881,1403882,1403883,1403884,1403885&category=Traffic%20Signals
35. Michigan Department of Transportation (2021). Traffic Sign Design, Placement, and Application Guidelines.
36. American Association of State Highway and Transportation Officials (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.
37. C.V. Zeeger, J.R. Stewart, H.H. Huang, P.A. Lagerway, J. Feaganes, and B.J. Campbell (2005). Safety Effects of Marked versus Unmarked Crosswalks at Uncontrolled Locations: Final Report and Recommended Guidelines. Washington, D.C.
38. Federal Highway Administration. Pedestrian Safety Guide and Countermeasures Selection System (PEDSAFE). Retrieved March 2021 from: http://www.pedbikesafe.org/pedsafe/
39. Fitzpatrick, K., S. Turner, M. Brewer, P. Carlson, B. Ullman, N. Trout, E.S. Park, J. Whitacre, N. Lalani, and D. Lord (2006). TCRP Report 112/NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings. National Academies of Sciences, Washington, D.C.