GEOMETRIC DESIGN GUIDELINES
FOR
FEDERAL/STATE FUNDED
LOCAL AGENCY PROJECTS

INCLUDING GUIDELINES FOR:

New Construction/Reconstruction
Resurfacing, Restoration, and Rehabilitation (3R)*
Preventive Maintenance
and
Design Exceptions

Approved : _____
Engineer of Design
Michigan Department of Transportation

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(Date)

*This section applies only to roadways not on the National Highway System (NHS)

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GENERAL

GENERAL

This manual provides information and guidelines on which to base the design of federal and state funded local agency road and bridge projects administered through Local Agency Programs of the Michigan Department of Transportation (MDOT). The guidelines allow some latitude from the road and bridge geometrics required by the American Association of State Highway and Transportation Officials (AASHTO), depending upon the type of project work.

A project may be designed based upon one of two different guidelines: 1) The AASHTO current edition of *A Policy on Geometric Design of Highways and Streets*, or applicable MDOT guidelines for new construction/reconstruction, or 2) this document, *Geometric Design Guidelines for Federal/State Funded Local Agency Projects*. The latter includes guidelines for New Construction/Reconstruction; Resurfacing, Restoration and Rehabilitation (3R); Preventive Maintenance; and Design Exceptions.

The guidance supplied by *A Policy on Geometric Design of Highways and Streets* is based on established practices supplemented by recent and continuing research. The intent of this publication is to provide a reference manual for assisting in the design of roads and bridges. As stated in the foreword to *A Policy on Geometric Design of Highways and Streets:*

> "The intent of this policy is to provide guidance to the designer by referencing a recommended range of values for critical dimensions. Sufficient flexibility is permitted to encourage independent designs tailored to particular situations. Minimum values are either given or implied by the lower value in a given range of values. The larger values within the ranges will normally be used where the social, economic, and environmental (S.E.E.) impacts are not critical."

Also, the foreword of the policy contains guidance for the design of 3R projects, specifically referring to TRB Special Report 214, *Designing Safer Roads: Practices for Resurfacing, Restoration, and Rehabilitation, 1987.* This is the basis of the 3R guidelines in this document.

Design of projects on roads, streets, and bridges under local jurisdiction which are listed on the National Highway System (NHS), shall be in accordance with applicable AASHTO guidelines and MDOT Non-Freeway NHS 3R guidelines.

The following is a chronology of events that allowed the development and implementation of this manual:

> Until 1976, federal highway funds could only be used for the construction of new highways or complete reconstruction of existing systems. The 1976 Federal-Aid Highway Act broadened the term "construction" to include "resurfacing, restoration, and rehabilitation (3R)." The intent of this legislation was to permit the use of federal funds to extend the service life of the existing highway system without the excessive costs associated with major reconstruction and, at the same time, to give adequate consideration to safety.

At that time, each state was given the authority by the Federal Highway Administration (FHWA) to publish and issue a policy and guide for the design of 3R projects. On August 11, 1978, MDOT distributed FHWA approved "3R" guidelines to be used for local agency roads on what was then termed the Federal Aid Secondary System (now generally referred to as major collectors or above). These policies and guidelines were prepared and approved on the basis that extensive consideration be given to safety concerns.

In response to a provision in the Surface Transportation Assistance Act of 1982, the Secretary of Transportation, acting through the FHWA, requested the National Academy of Sciences to study the safety cost-effectiveness of highway geometric design standards and recommend standards for 3R projects on existing federal-aid highways, other than freeways. After extensive study by an expert staff involving several states, including Michigan, the academy published *Special Report 214, Designing Safer Roads*. This report was added, as a guide and reference, to the list of publications for application on federal-aid projects in Part 625 of Title 23, Code of Federal Regulations, in May of 1988.

With the issuance of Report 214, MDOT opted to edit and revise the 1978 guidelines for local agency 3R projects. The department, in cooperation with FHWA and three county highway engineers, formed a committee to review and issue revised guidelines applicable to 3R projects on what was then the Federal Aid Secondary System. These guidelines were issued in February, 1990.

The Intermodal Surface Transportation Act of 1991 (ISTEA) mandates that all non-NHS projects be constructed in accordance with standards established by the state. In 1993, the State Transportation Commission approved using the 3R guidelines for non-NHS routes. These guidelines required using AASHTO's *A Policy on Geometric Design of Highways and Streets* for new and major reconstruction projects which do not meet the criteria for "3R" work.

In late 1996, a task force was formed to review the existing Michigan Guidelines for Local Agency Projects. The mission of the task force is to ensure that Michigan guidelines are consistent with safe, cost-effective design of federal and state funded local agency road and bridge projects, while allowing local agencies maximum flexibility in extending the service life of their existing roadway system with available funding.

It must be understood that these guidelines provide minimum criteria. Wherever it is cost effective, values greater than these must be given serious consideration. The 3R program is to provide a design life of seven (7) to twenty (20) years. The preventive maintenance program is to provide a design life of five (5) to seven (7) years, until a more permanent improvement can be constructed.

The passage of ISTEA allowed federal aid to be used in certain maintenance type work. This Act is the basis for preventive maintenance type projects on local agency roads.

NEW CONSTRUCTION / RECONSTRUCTION

NEW CONSTRUCTION / RECONSTRUCTION

The design of any federal or state funded new construction or reconstruction project on a road or bridge under local jurisdiction shall, at a minimum, be designed using AASHTO guidelines.

Projects that are mainly comprised of the following types of work are considered new construction or reconstruction:

- Complete removal and replacement of pavement.
- Major alignment improvements.
- Adding lanes for through traffic.
- New roadways, new bridges, or bridge replacements.
- Widening or lengthening existing bridges.
- Complete bridge deck or superstructure replacement.
- Reconstruction of the roadway pavement, including more than fifty (50) percent of the subbase or subgrade, exclusive of such work as rubblizing and crushing and shaping.
- On aggregate surface roadways, reconstruction is defined as involving more than fifty (50) percent of the subbase.

The above list is not all inclusive, but is intended to give typical examples of new construction or reconstruction work.

Bridge widths:

- For new construction or reconstruction, bridges should be designed to the minimum clear roadway width recommended by AASHTO in *A Policy on Geometric Design of Highways and Streets.* Bridge widths in excess of minimum AASHTO guidelines must be justified.
- Bridges designed to a width less than the minimum recommended by AASHTO will require a design exception. However, in no case may the approach roadway width used to determine the clear bridge width, be less than the corresponding lane/shoulder widths in the Local Agency Projects 3R guidelines.
- The “traveled way” in the AASHTO bridge width tables refers to the minimum width of traveled way (i.e., total lane width) for new or reconstructed roadways, as shown in the appropriate AASHTO table. Approach roadway width is the width of traveled way plus graded shoulders, also as shown in AASHTO.

New construction or reconstruction for road or bridge projects on the National Highway System (NHS) must be designed, at a minimum, to applicable AASHTO guidelines.

The design speed selected for new construction or reconstruction projects shall be in accordance with the following criteria:

- The recommended design speed is 10 km/h over the posted or regulatory speed.
- The minimum design speed without a design exception is the posted or regulatory speed, or 90 km/h if the road is not posted.
- The minimum design speed considered for a design exception is 50 km/h. However, a design speed of 40 km/h is acceptable where the road is posted for 40 km/h (25 mph) and does not require a design exception.

NON-NHS

RESURFACING, RESTORATION AND REHABILITATION (3R)

INDEX

Non-NHS
Resurfacing, Restoration, and Rehabilitation (3R)

APPLICATION OF THE 3R GUIDELINES

These guidelines for Resurfacing, Restoration, and Rehabilitation (3R) are applicable to federal or state funded projects on roads and bridges under local agency jurisdiction which are not on the National Highway System (NHS) in Michigan. For features not addressed in these 3R guidelines, the requirements of AASHTO's current guide entitled, *A Policy on Geometric Design of Highways and Streets*, or applicable Michigan Department of Transportation guidelines, will govern.

The design policies and criteria described in this section are intended for projects that are to restore resurface and/or rehabilitate existing facilities within the general constraints of existing alignment and right-of-way. Examples of this type of work include, but are not limited to, the following:

1. Resurfacing, milling or profiling.
2. Lane and/or shoulder widening with no increase in number of through lanes.
3. Roadway aggregate base correction.
4. Minor alignment improvements.
5. Bridge deck overlay and/or minor widening (with no increase in the number of through lanes).
6. Roadside safety improvements.
7. Signing, pavement marking, and traffic signals.
8. Intersection and railroad crossing upgrades.
9. Bridge painting, joint replacements, pin and hanger replacements, and railing replacement.
10. Pavement joint repair.
11. Crushing and shaping and resurfacing.
12. Rubblizing and resurfacing.
13. Passing relief lanes.
14. Reconstruction of the roadway pavement, including less that fifty (50) percent of the subbase or subgrade

Controlling Elements Subject to Formal Design Exception

- Design Speed
- Shoulder Width
- Lane Width
- Bridge Width
- Bridge Structural Capacity (including static loading of bridge railings)
- Horizontal Alignment
- Vertical Alignment
- Stopping Sight Distance
- Grade
- Cross Slope
- Superelevation
- Vertical Clearance
- Horizontal Clearance (not including clear zone)

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<tr><td>> 2000</td><td colspan="2">1.8</td></tr>
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<tr><td>≤ 750</td><td colspan="2">3.0
(Lane width may be 2.7 m where design speed ≤ 60 km/h and ADT ≤ 250)</td></tr>
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(Lane width may be 3.0 m where design speed is ≤ 60 km/h and ADT 750-1500)

3.6 m lanes are desirable on designated truck routes or where truck traffic ≥ 10%</td></tr>
<tr><td rowspan="6">Bridges to Remain
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Bridge Width & Structural Capacity

Any existing bridge railing or proposed railing retro-fit that does not meet AASHTO static load criteria, will require a design exception. (See page C-5)</td><td>ADT</td><td>Loading</td><td>Usable Width</td></tr>
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CRASH ANALYSIS

A safety review (3 year period) shall be performed on each 3R project before starting design work. This review should include an analysis of available crash data to determine where safety enhancements are warranted.

The 3R project should incorporate features that alleviate any excessive crash patterns identified during the review. This should be considered regardless of other minimum requirements shown elsewhere in this guideline.

DESIGN TRAFFIC VOLUME (ADT)

According to Special Report 214 (recommendation 14, page 204), "The design traffic volume for a given highway feature should match the average traffic anticipated over the expected performance period of that feature." However, for 3R projects the ADT may range from the present to the anticipated design life.

DESIGN SPEED

There are two methods that can be used to select the design speed for 3R projects. These may be used alone or in combination.

- Select an overall design speed greater than or equal to the posted regulatory or prima fascia speed on the section being improved.

- Determine the 85^{th} percentile speed for the feature being designed, such as horizontal curves or vertical curves.

BRIDGES TO REMAIN

- If lane widening is planned as part of the 3R project, the usable bridge width should be compared to the approach width after widening.

- These values do not apply to bridges greater than 30 meters in length. These structures should be evaluated individually according to clear width provided, traffic volume, remaining life of the structure, pedestrian volume, snow storage, design speed, crash record, and other pertinent factors.

The designer should evaluate retention of an existing bridge if the bridge is less than 30 meters long and the usable width or structural loading of the bridge is less than shown in the table on page C-3. When evaluating the replacement or widening, consider the following:

1. Cost of replacing the existing bridge with a wider bridge designed to AASHTO guidelines for new bridges.

2. Cost of widening the existing bridge (if practical).

3. Review of available crash data.

4. Structural condition of the existing bridge.

If the guidelines for bridge width and structural capacity are not met, a design exception is required.

BRIDGE RAILINGS

Evaluation of all existing bridge railings that have not been successfully crash-tested should be made. Retro-fitting the existing bridge railing to provide additional strength and safety characteristics in lieu of replacement of the entire rail system with a crash-tested rail, may be cost effective and feasible.

However, any proposed retro-fit that does not meet AASHTO static load criteria, or proposed non-treatment of an existing rail that fails to meet this criteria, will require a design exception.

HORIZONTAL/VERTICAL ALIGNMENT AND STOPPING SIGHT DISTANCE

Horizontal Curves

Without crash concentrations that warrant revision, existing horizontal curves with a design speed 0-25 km/h less than the project design speed, may be retained without further documentation. However, the operation and safety should be improved to the extent feasible through such elements as superelevation modifications, removing crown, and removal of sight obstructions to improve stopping sight distance. When the horizontal alignment does not meet the design speed, applicable traffic control devices should be installed according to the Michigan Manual of Uniform Traffic Control Devices.

A decision not to reconstruct an existing horizontal curve where:

- the curve design speed is more than 25 km/h below the design speed, and
- the ADT is greater than 750 vehicles per day

shall be supported with a design exception.

Vertical Curves

CREST - Without crash concentration and/or other geometric features such as:

- intersections
- lane drops
- horizontal curves warranting consideration

existing vertical curves with a design speed from 0-35 km/h less than the design speed and ADT less than 1500 vehicles per day, do not require a design exception. However, designers should examine the nature of potential hazards in relation to sight distance and provide warning signs when appropriate.

A decision not to reconstruct an existing vertical curve where:

- the curve design speed is more than 35 km/h below the design speed, and
- the ADT is greater than 1500 vehicles per day

shall be supported with a design exception.

SAG - In general, all sag vertical curves may be retained unless a safety review indicates a problem with crashes.

3R SAFETY CONSIDERATIONS

The following serves as guidance for the design of roadside features. The designer should consider site specific conditions to determine if it would be cost effective to provide improvements to side slopes and/or clear zones.

SIDE SLOPES

An effort should be made to flatten the side slopes as much as cost considerations and conditions permit. Review crash history for improvement needs. Consideration should be given to the following:

- Where run-off road crashes are likely to occur (i.e., outside of sharp horizontal curves), side slopes steeper than 1:3 within existing right-of-way should be flattened as much as conditions permit.

- Retain the current rate of side slopes when widening lanes and/or shoulders, unless steeper slopes are warranted by special circumstances. This often requires new ditches, however, the fore-slopes should not be steepened beyond the existing fore-slope rate (existing rates flatter than 1:4, may be steepened to 1:4**).**

CLEAR ZONE

An effort should be made to provide a uniform clear zone (i.e., a uniform distance from the edge of pavement to the tree line, utility poles, etc.) for the project length. Consideration should be given to the following:

- Removing, relocating, and/or shielding isolated roadside obstacles on the fore-slope or roadside ditches, particularly in target areas.

- Removing, relocating and/or shielding roadside obstacles with recorded crash concentrations.

- If run-off road crashes are not concentrated in any location, but there is a significant number distributed throughout the project, consider widening the average clear zone for the length of the project.

TREE REMOVAL

Consideration should be given to removing all trees, shrubs and other obstacles within the existing right-of-way in the following circumstances:

- From the fore-slope of roadside ditches.
- On the inside of curves, as needed, to meet passing sight distance requirements.
- At intersections as necessary for sight distance requirements.
- Where there is evidence of vehicle-tree crashes, either from actual crash reports or scarring of trees.
- From the target area on the outside of sharp horizontal curves.

GUARDRAIL

An analysis (including an onsite inspection of the height, length and overall condition) should be made of all existing guardrail installations to determine if continued existence or removal is appropriate. Refer to MDOT Road Design Manual, Section 3.09.03B, "Evaluation of Guardrail and Bridge Rail," for further guidance on guardrail upgrading.

- An existing guardrail installation should be removed when:

    1. It does not meet the guidelines in the current *AASHTO Roadside Design Guide*.
    2. The cost of removing the obstacle is less than the cost of the guardrail upgrading and maintenance.

- Existing guardrail that is warranted, should be upgraded to current standards (MDOT Standard Plans or Special Details and Chapter 7 "Appurtenances" of the MDOT Road Design Manual) when the design ADT is greater than 750 and:

    1. It does not conform with the current MDOT standards. (It may be retained if it meets the current MDOT standards and has a height deficiency of not more than 25 mm).
    2. It conforms with the current MDOT standards, but is seriously damaged or deteriorated.

- The following guardrail improvements should be made on existing warranted guardrail when the ADT is less than 750, horizontal curvature is 3 degrees or less, and truck traffic is 25 percent or less:

    1. Replaced where it is seriously damaged or deteriorated.

    2. Upgraded with approved end sections.

    3. Corrected for height when deficient by more than 75 mm, except in no case shall the existing guardrail be less than 600 mm in height.

- For all projects, consideration should be given to the following:

    1. Blunt ends and turned down endings should be upgraded to meet the current MDOT standards.

    2. Unconnected guardrail to bridge rail transitions should be upgraded to meet the current MDOT standards.

INTERSECTION DESIGN

Designers should evaluate existing intersections when design traffic volumes on either roadway exceed 1,500 vehicles per day or there is evidence of crashes related to existing conditions. Such intersections should be reviewed during design and safety improvements and should be included in the project where practical and feasible. All available crash data should be utilized in the field review of the intersection.

Safety measures, as discussed in the Supplemental Safety Measures herein, can be utilized to mitigate safety concerns at intersections. Warning panels should be installed where appropriate.

TRAFFIC CONTROL DEVICES

Signs, pavement markings, and traffic signal controls shall be installed in accordance with the current *Michigan Manual of Uniform Traffic Control Devices*.

SUPPLEMENTAL SAFETY MEASURES

The design of highways provides a range of supplemental measures that can be utilized alone or in combination with others to mitigate deficiencies in controlling elements to provide for safer roadways. Where reconstruction of a roadway feature, such as a horizontal curve, vertical curve, intersection or bridge, is not feasible or prudent because of economic, social or environmental concerns, alternative safety measures should be considered. Some of these are:

Geometric Concern	**Supplemental Safety Measure**
Narrow lanes and shoulders	Pavement edge lines Paved shoulders Permanent pavement markers Post delineators Warning signs
Steep side slopes; roadside obstacles	Warning signs Slope flattening Round ditches Obstacle removal Breakaway hardware Post delineators
Narrow bridge	Traffic control devices Approach guardrail Pavement markings Warning signs
Poor sight distance at hill crest	Traffic control devices Shoulder widening Driveway relocation Warning signs
Sharp horizontal curve	Traffic control devices Shoulder widening Appropriate superelevation Advisory signs Slope flattening Pavement anti-skid treatment Obstacle removal Post delineators Permanent pavement markers
Problem intersections	Traffic control devices Traffic signalization Fixed lighting Pavement anti-skid treatment Speed controls Advisory signs Rumble strips

PREVENTIVE MAINTENANCE

PREVENTIVE MAINTENANCE

Preventive maintenance projects are defined by FHWA as cost-effective projects designed to preserve the existing pavement and base, and give extended life to a roadway without undertaking reconstruction or major rehabilitation.

Preventive maintenance projects:

- do not increase lane widths.
- extend pavement life 5-7 years.
- do not exceed an application of more than 120 kilograms per square meter of bituminous material.
- have base courses in good condition.

A crash analysis is required for treatments that add thickness, such as bituminous overlays. The review will be to determine the merits of the project and that highway safety has been or will be addressed, if feasible. Where the crash analysis indicates existing problem areas directly related to the pavement surface, then the project shall be modified in accordance with 3R, AASHTO, or applicable MDOT guidelines as appropriate.

At a minimum, existing conditions along the route shall include the following:

- All guardrail must be in good condition and maintained to the original installed specifications and within +/- 75 millimeters of required height.
- Guardrail connections at bridges that are properly secured. (Turned down guardrail endings and blunt guardrail endings must be replaced with suitable endings.)

The design exception process shall not be applied to preventive maintenance projects.

It is important to note that other maintenance operations, such as crack sealing, filling of potholes, replacement of small sections of curb and gutter, drainage facility clean out, etc., are considered reactive or routine maintenance and are not eligible for federal or state aid.

DESIGN EXCEPTIONS

DESIGN EXCEPTIONS

Exceptions to particular design elements of AASHTO's, *A Policy on Geometric Design of Highways and Streets*, and Michigan's local agency 3R guidelines, may be warranted on projects at individual locations. These design exceptions shall be submitted to MDOT, Local Agency Programs by the project owner. A design exception must show the need for the exception and must demonstrate that it would not create or maintain a potential or existing crash situation.

The need for a design exception should be discussed with Local Agency Programs during the early stages of the project's development. The design exception request form should be completed and submitted to Local Agency Programs along with the project program application. **Current forms can be obtained by contacting the Local Agency Programs Unit at MDOT.**

The following information must be included in a design exception request:

1. Feature and location not meeting the minimum guideline.

2. Minimum value that will be obtained.

3. Estimated cost of meeting the guideline.

4. Environmental or physical constraints that prevent the design from meeting the guideline.

5. Past traffic crash analysis at the location that might be related to this design element. (If such crashes have occurred, further analysis will be required to show why upgrading is not cost effective.)

6. Discussion of whether some compromise design value could be used that would at least enhance the existing condition (include estimated cost of compromise solution).

The design exception process applies to the following design elements: Design speed, lane and shoulder width, bridge width, bridge structural capacity (including static loading of bridge railing), horizontal and vertical alignment, stopping sight distance, grade, cross-slope, superelevation, and horizontal and vertical clearance.

The design exception does not apply to preventive maintenance projects.