Chapter 14
Design Process

14.1 General Discussion

This chapter covers the design phase of projects on non-NHS routes, Federal Highway Administration (FHWA) funded projects, and discusses a delegation of authority by the FHWA to MDT Highways in administration of FHWA funds.

The next five chapters relating to the design phase of Federal-aid projects include General; Design Standards; Preliminary Field Review and Scope of Work Approval; Plans, Specifications, and Estimates; and Advertising and Award Procedures.

The approving agency identified for the various phases of work is illustrated in the following matrix.

Action	Agency
a. PE Fund Auth. and Modification.	FHWA
b. Exceptions to Design Standards	State/ FHWA
c. Preliminary Design Approval (Preliminary Field Review, Scope of Work)	Local Agency/State
d. Experimental Work Plans	FHWA
e. PS&E Approval	FHWA/State
f. Proprietary item, sole source (public interest finding, certification)	FHWA/State
g. Concurrence in Award	State
h. State Forces Work	Local Agency /State

In addition to the Department's geometric design standards, design criteria can vary based on the proposed type of roadway treatment (e.g. new construction, resurfacing, rehabilitation). Local agencies should determine which criteria apply before beginning design. The guidelines for various types of projects are given later in this chapter.

It is strongly encouraged that value engineering be used, as needed, throughout project development, construction, operation, and maintenance. Value engineering analysis should be performed on projects where its application has a high potential for public benefit such as on high cost and complex projects. The need for value engineering should be determined on a project-by-project basis (see Chapter 15).

14.2 New Construction/Reconstruction Projects (refer to Chapter 15 of this manual and Chapter 12 of the MDT Road Design Manual for design criteria)

New construction and reconstruction projects are typically designed to meet the design standards for the functional class of the roadway. Reconstruction may include significant changes in cross-section or shifts in both vertical and horizontal alignment as well as the replacement of the existing surfacing. If 25 percent or more of the project length involves vertical or horizontal alignment changes, the project will be considered reconstruction. Reconstruction may require acquisition of additional right-of-way, and may include all items of work usually associated with new construction, including items a. through o. below.

a. Pavement Type Determination. The determination of pavement type is of major importance in the

development of plans for any project involving improvement to the road surfacing. The local agency should contact the MDT Surfacing Design Unit through the LAG Certification Liaison to obtain the most current surfacing design guidelines.

The local agency should have on file documentation of factors considered in determining that the pavement to be used has been carefully selected in terms of engineering, economics, and current design criteria. The pavement analysis should identify the design life, lifecycle costs, and impacts of the various alternatives on the total project.

b. Structural Design. Design procedures must conform to accepted engineering practices approved by a registered professional engineer. The recommended process is outlined in the MDT *Structures Manual.*

c. Roadway Geometrics. Design(s) must be based upon accepted engineering practices and the requirements listed in the MDT Road Design Manual.

d. Construction Specifications. For all Federal-Aid projects, the local agency will construct and administer the project in conformance with Montana Public Works Standard Specifications or MDT *Standard Specifications for Road and Bridge Construction*, or a combination of the two (as outlined in Section 16.5). Where the two sets of specifications are in conflict, the local agency will contact the LAG Certification Liaison to determine which specification will govern.

e. Traffic Control. All traffic control devices must conform to the MUTCD, as adopted by the Transportation Commission

f. Clear Zone. The clear zone is the roadside border area starting at the edge of the traveled lane that is available for safe use by errant vehicles. The clear zone distance tables in the MDT *Road Design Manual* should be used to determine clear zone distances at specific locations.

g. Geometric Cross-Section. It is desirable that all new construction in urban areas provide embankment slopes and ditch in-slopes of 4:1 or flatter. Embankment slopes of 3: 1 or steeper may be used when achieving flatter slopes has demonstrated to be impractical. For construction in rural and transitional areas use the slope tables in Chapter 12 of the MDT Road Design Manual. A design exception request must be submitted to use slopes that do not meet these design criteria.

h. Vertical Clearance. Vertical clearance above the paved roadway surface must be a minimum of 16.5 feet for structures. Vertical clearance of structures above the walkway surface must be a minimum of 8 feet. Overhead utilities must provide a minimum vertical clearance of 21 feet above the paved roadway surface. Sign bridges must provide a minimum vertical clearance of 17 feet from the bottom of the lowest sign.

i. Bridge Approach Rail. Approach guardrail is required at all bridge ends and must be made structurally continuous with the bridge railing. A guardrail layout has also been developed for use when an intersecting roadway or private approach exists within the limit of the bridge approach guardrail. See the MDT *Detailed Drawings* for all necessary guardrail details.

j. Bridge Guardrail. Only bridge rail designs that have been successfully crash tested (or their equivalents) will be used on federally funded new construction or reconstruction projects. The MDT *Structures Manual* contains guidelines and performance levels for bridge rail.

k. Illumination.
    1. Consider roadway illumination for high activity pedestrian areas (bus stops, crosswalks, etc.).

    2. Consider low energy consumption designs.

l. Pedestrian Facilities. In urban areas, sidewalks are desirable on both sides of the street per the MDT Geometric Design Standards for Urban and Developed Areas.

m. Bicycle Facilities. On streets and roads intended to accommodate designated bicycle routes, the current AASHTO Guide for Development of Bicycle Facilities and the *MDT Road Design Manual* chapter 18 on bicycle facilities should be used as a design guideline.

n. Sidewalk Curb Ramps. ADA accessible ramps must be included in all walkways and/or curb construction. The ramps must meet the design requirements of the Americans with Disabilities Act and the Public Right-of-Way Accessibility Guidelines (PROWAG).

o. Drainage and Hydraulic Design. Refer to MDT *Hydraulics Manual* and local agency requirements.

14.3 Pavement Preservation and Rehabilitation Projects

As noted in Section 13.1 different design criteria can be applied based on the proposed type of roadway treatment. The treatments include pavement preservation and major and minor rehabilitation. The features of the roadway must still be assessed against the geometric design standards in Chapter 15. However, certain deviations from these standards are acceptable depending on the type of surface treatment.

Rehabilitation is a strategy to extend the useful life of a highway through pavement structure improvement, safety enhancement and operational improvement without necessarily improving geometrics. Engineering judgment is applied on individual rehabilitation projects to achieve appropriate levels of safety and operational characteristics.

Pavement preservation consists of various surface treatments that are limited to the existing plant mix. Projects may include safety enhancements but the existing geometric features will be used without modification.

Americans with Disabilities Act

Curb ramps must be installed along sections that have existing curb, gutter, and sidewalk for projects involving more extensive work than seal and cover (milling and filling, plant mix overlays, etc.). The condition of the sidewalks along the project should also be evaluated to determine if repairs are needed to eliminate obstacles to disabled people.

14.3.1 Pavement Preservation

The intent of these projects is to extend the useful life of the pavement based on observed pavement distress as opposed to scheduled maintenance. The existing pavement structure should be adequate and exhibit minimal distress. Projects on roadways that have had some type of rehabilitation in the past 20 years are the most appropriate candidates. Others will be evaluated on a case-by-case basis.

Pavement preservation treatments include the following:

Plant mix overlays $\leq$ 0.20’	Crack Seals
Mill and Fill $\leq$ 0.20’	Micro Surfacing
Seal and Cover	Rut Fill

Plant mix leveling quantities should not exceed 25% of the plant mix overlay quantity

Roadway Width. The width of the roadway is only a consideration for projects that will receive a plant mix overlay. The width for curbed sections should correspond to Urban Standards. For shouldered sections the minimum width should be the width in the Urban Standards or 28' whichever is less. The surfacing inslopes should be no steeper than 4:1.

Safety. An accident review should be conducted for projects involving plant mix overlays or mill and fills to determine if there are any accident clusters or accident rates that are higher than the statewide average. Any trends or clusters that have cost effective treatments should be addressed as part of the project.

Guardrail. Upgrading of substandard guardrail should be considered on overlay projects. The guardrail needs should be reviewed on a project-by-project basis to determine what upgrades will be included in the project. Decisions must be documented. The following deficiencies require upgrading:

- Blunt ends
- 12' post spacing
- Unconnected or no bridge approach rail

The following deficiencies should be considered for upgrading but are not mandatory:

- Incorrect rail height (Unless the height to the centerline of the bolt < 20")
- No rail at locations that meet warrants
- Inadequate length of need

Clear Zone. The clear zone should be checked to determine if any substantial hazards exists that can be removed or shielded with the project. Decisions should be documented.

14.3.2 Minor Rehabilitation

The intent of these projects is to rehabilitate the existing pavement surface through an engineered approach including appropriate subsurface analysis, observed pavement distress and a consideration of in-place materials. All work is usually accomplished within the existing R/W.

Minor rehabilitation is limited to engineered milling and plant mix overlays. Milling should be $\leq$ 0.20' and should not expose base gravel.

Roadway Width. The width for curbed sections should correspond to Urban Standards. For shouldered sections the minimum width should be the width in the Urban Standards or 28' whichever is less. The surfacing inslopes should be no steeper than 4:1. Minor shoulder work may be necessary to meet these criteria.

Safety. Traffic and accident data must be collected and an accident review should be conducted for the projects to determine if there are any accident clusters or accident rates that are higher than the statewide average. Any trends or clusters that have cost effective treatments should be addressed as part of the project. The inclusion of other safety features such as mailbox turnouts, approach slope flattening and upgraded signing should also be considered. See sample safety checklist in Appendix 14.5.1.

Guardrail. Upgrading of substandard guardrail should be considered on overlay projects. The guardrail

needs should be reviewed on a project-by-project basis to determine what upgrades will be included in the project. Decisions must be documented. The following deficiencies require upgrading:

- Blunt ends
- 12' post spacing
- Unconnected or no bridge approach rail

The deficiencies mentioned in Section 13.31 should also be considered for upgrading but are not mandatory:

Clear Zone. The clear zone should be checked to determine if any substantial hazards exists that can be removed or shielded with the project. Decisions should be documented

Geometrics. The following applies to geometric features that will be used without modification. For vertical curves where the design speed of the curve is 20 mph less than the design speed of the project segment of the roadway and for horizontal curves where the design speed of the curve is 15 mph less than the design speed of the project segment, a design exception is required if there is an accident cluster or trend associated with the design element.

14.3.3 Major Rehabilitation

The intent of these projects is to rehabilitate the existing surfacing structure through an engineered approach including appropriate subsurface analysis, observed pavement distress and a consideration of in-place materials. The work may include modification or treatment of the existing base material. The surfacing should be engineered to provide a 20-year design life. (Section 14.1 states that surfacing must provide an 8-year structural service life.) New right-of-way and utility relocation may be required to improve geometrics, widen the roadway or enhance safety.

Roadway Width. For urban routes the roadway width should correspond to Urban Standards. For rural routes the required roadway width will be determined through MDT's Roadway Width Decision Process. Major widening may be necessary to meet these criteria. Exceptions should be documented.

Bridge. Bridge work up to and including major rehabilitation should be considered.

Safety. Traffic and accident data must be collected and an accident review should be conducted for the projects to determine if there are any accident clusters or accident rates that are higher than the statewide average. Any trends or clusters that have cost effective treatments should be addressed as part of the project. The inclusion of other safety features could include the following:

- Improving existing operational features — operational features include traffic control devices, lighting, and pedestrian accommodations that provide for the safe and efficient movement of vehicles and pedestrians.
- Reducing the potential hazard of existing roadside features - roadside features include sideslopes, mailbox turnouts, approach slopes, ditches, drainage facilities, barrier systems, sign supports, luminaries, trees, utility poles, and other features adjacent to the roadway.
- Upgrading bridge safety features - on all projects which include structures with deficient safety features, consideration must be given to correcting the deficient features. Bridge rails, approach rails, connections, and terminals are considered bridge safety features.

See sample safety checklist in Appendix 14.5.1

Guardrail. Upgrade all guardrail to current standards (NCHRP 350 requirements). A complete guardrail inventory should be performed and all deficiencies corrected including installing new rail where warranted.

Clear Zone. The clear zone should be checked to determine if any substantial hazards exists that can be removed or shielded with the project. The clear zone must be given particular attention at identified high roadside accident locations (fixed object accidents). Decisions should be documented.

Geometrics. Alignment improvements should always be considered for elements that do not meet the current geometric standards. The following applies to geometric features that will be used without modification. For vertical curves where the design speed of the curve is 20 mph less than the design speed of the project segment of the roadway and for horizontal curves where the design speed of the curve is 15 mph less than the design speed of the project segment, a design exception is required.

14.4 Design Exceptions

Requests for deviations from the design criteria in Chapter 15 of this manual and Chapter 12 of the MDT Road Design Manual will be submitted to the Consultant Design Engineer for approval or denial. The design exception request will be submitted to the FHWA for approval on projects with full federal oversight.

The CA Agency is authorized to design projects to the criteria provided in Chapter 15, following the warrants and qualifying statements given. In the event all minimum recommendations cannot be incorporated into the design, the agency must submit the design exception request for review and approval by the MDT Consultant Design Engineer or the Federal Highway Administration.

14.4.1 Documentation

A local agency must document their reasons for exceptions from these design criteria. The design exception request must include a description of the problem and its proposed solution and a vicinity map in sufficient detail to aid in evaluating the problem. The design exception request document should generally stand complete on its own, without references to other sources or documents. Appropriate quotes and excerpts should be used if necessary.

An analysis of the engineering and financial aspects of the proposal as compared to the standard and options considered must be provided. The analysis must specifically address safety issues, including accident history and projections. It must address applicable operational characteristics, including traffic speeds, traffic volumes, capacity, and route continuity. It should include financial considerations such as high construction costs, unusual or extraordinary site conditions, or environmental requirements that may impact the decision. The analysis may include a Benefit/Cost comparison, and/or Life Cycle Costing of alternatives considered. The analysis should also include any other information which may be helpful as a future reference.

The level of detail of the request should be based on the relative complexity and scope of the project and the deviation requested. Requests will be considered based on the merits presented. This analysis and design exception request must be documented and completed prior to the agency's completion of PS&E documents.

14.4.2 Format

Appendix 13.52 is a Sample Design Exception Analysis Format sheet. The sample is intended to present format and items to be included in the request.

14.5 Appendices

14.5.1 Safety Checklist — A Guideline for Resurfacing and Rehabilitation Projects

14.5.2 Sample Design Exception Analysis Format

Appendix 14.5.1 Safety Checklist — A Guideline for Resurfacing and Rehabilitation Projects

Project_____
Number Title
_____
Local Agency

The proposed project should be given a roadside hazard inventory to determine if the following elements exist within the project termini and if the scope of the project includes construction, elimination, modification, or protection of these elements:

Drainage Structures
Existing:_____ Proposed:_____
Project includes mitering end sections: Yes: _____ No:_____
Comments:

Guardrail (Reviewed for Adequacy)
Comments:

Signs, Signals, and Illumination Supports
Existing:_____
Proposed:_____
Breakaway bases proposed: Yes: _____ No: _____
Comments:

Bridge Piers/Abutments
Protection Existing:_____
Protection Proposed:_____
Comments:

Clear Zone (Reviewed for Adequacy)
Roadside Obstacles:
Trees:
Utility Poles:
Ditch Cross-Sections:
Protection Proposed:
Comments:

Horizontal Alignment (Reviewed for Adequacy)
Comments:

Vertical Alignment (Reviewed for Adequacy)
Comments:

Roadway Widths (Reviewed for Adequacy)
Comments:

Sight Distance (Reviewed for Adequacy)
Comments:

Pavement Structure (Reviewed for Adequacy)
Comments:

Traffic Control Devices
Warranted:_____
Unwarranted: _____
Comments:

Side Slopes (Reviewed for Adequacy)
Comments:

Appendix 14.5.2 Sample Design Exception Analysis Format

Project Number:
Project Title:

We are providing the following guidelines and format to assist in the writing of requests for design exceptions. The format may not be appropriate for all design exceptions but will serve for the majority of requests.

Description
Provide a brief description of the features that will require an exception to approved design criteria for the route. The features will be described in more detail under the "Basis For Request".

Example
We request that you approve an exception to the design criteria for principal arterials (NHS primary) to allow the use of the following existing design features:

- Nonstandard fill slopes at four locations on the project
- A horizontal curve that does not meet the criteria for a 60 mph design speed
- A grade of 4.5%

Project Intent
Describe the project scope (reconstruction, overlay, etc.) and provide a brief summary of the work.

Specify if the project will follow the existing horizontal and vertical alignment. Note if the project will require the acquisition of new right-of-way and if the relocation of utilities is necessary.

Project Location
This section should include the following information:

- Route
- Beginning and ending reference posts
- County
- Terrain (level, rolling, mountainous)
- Predominant use of the land adjacent to the project. Include a description of the land use adjacent to the feature in question if it is different than the overall land use on the project.

Traffic and Accident Data
Provide the traffic data (current and projected volumes, design hourly volume, percent commercial truck traffic).

The accident data should include the following information:

- Number of accidents during the specified period
- Accident rate and severity rate
- Accident trends and deviations from statewide averages

- Accident clusters that may pertain to the design features in question

Design Speed

Note the design speed of the project. Discuss the posted speed limits, speed zone studies and approved speed zones if they are relevant to the issues. This discussion is particularly useful in the transition zones between rural and urban areas.

Project Design Features

Briefly describe the design features of the project and note which existing features will be used in place.

When the project involves changes to a number of existing design features, provide a comparison between the existing and the new features.

Example

The vertical alignment will provide the stopping sight distance (SSD) for a 60 mph design speed and will have a maximum grade of 3.8%. The existing vertical alignment includes 5 crests and 2 sags that do not provide the SSD for a 60 mph design speed. The existing grade exceeds 4% at 3 locations on the project.

Basis for Request

The basis for the request for a design exception should include a discussion of the following items:

- Describe the feature that requires an exception in more detail if appropriate
- Other design features associated with the site (top width, alignment, side slopes)
- Discuss the effect on the clear zone
- Accidents associated with the site
- Natural features that may limit what can practicably be constructed
- Measures that will mitigate the effect of the design feature in question (improved geometrics, use of guardrail, rumble strips, etc.)
- Environmental or cultural impacts resulting from the use of standard design criteria.
- Costs involved with constructing the feature to meet the required design criteria
- Right-of-way and utility impacts – these items typically have a cost associated with them (railroads are an exception)
- Clear Zone - clear zone impacts usually apply to changes in side slopes and potentially the outside of horizontal curves
- Driver expectancy – will this feature reasonably be anticipated by the driver

Conclusion

In general terms summarize the request, the cost savings and reduced impacts associated with the use of nonstandard features and the cumulative effect of the project on safety.