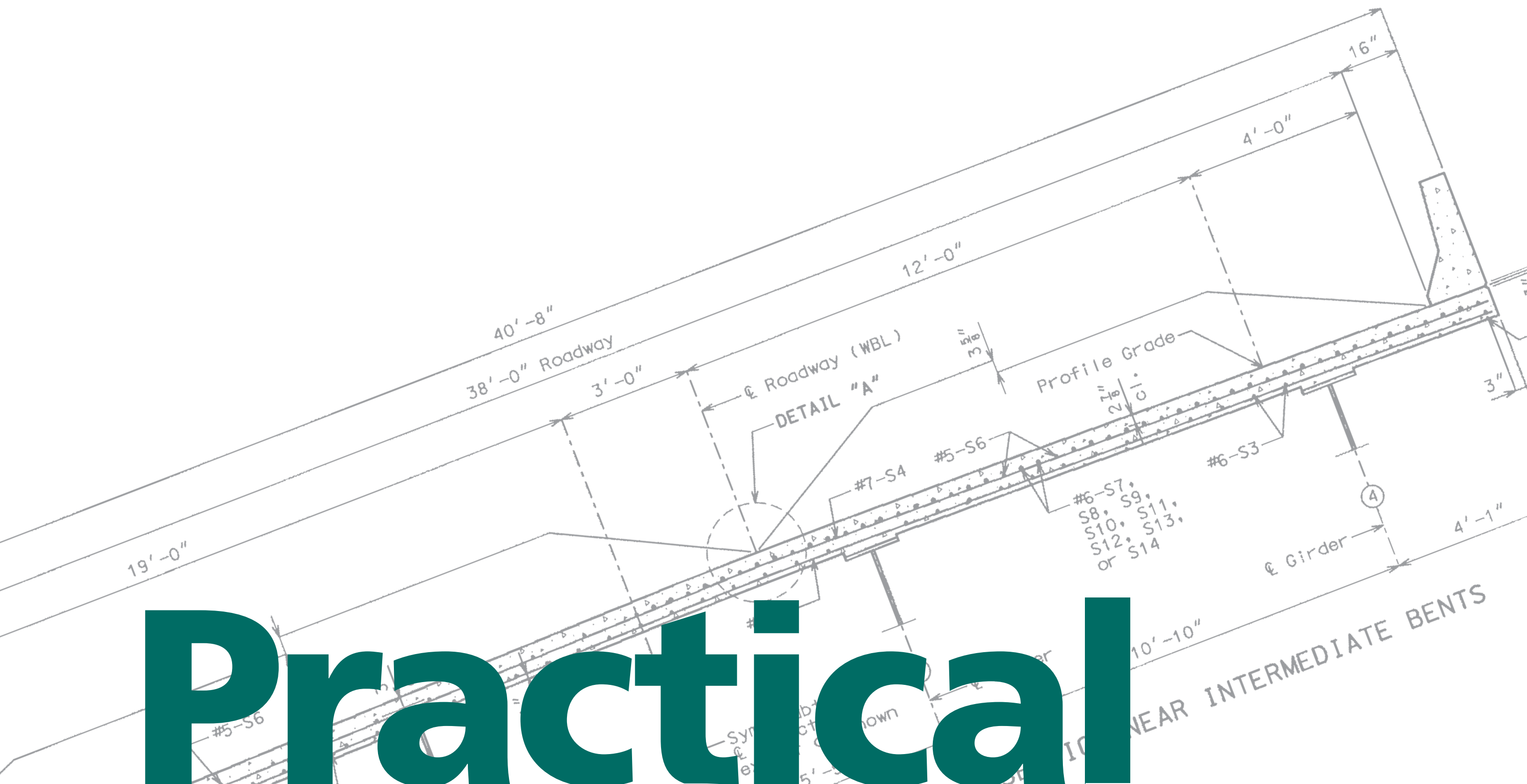
Implementation

Meeting Our Customers' Needs



Practical Design

Missouri Department of Transportation

Contents

Introduction

Practical Design challenges traditional standards to develop efficient solutions to solve today's project needs. MoDOT's goal of Practical Design is to build "good" projects, not "great" projects, to achieve a great system. Innovation and creativity are necessary for us to accomplish Practical Design. This document was prepared to effectively begin implementing Practical Design. It is purposely written to allow flexibility for project specific locations.

To accomplish Practical Design, we must properly define the scope by focusing on achieving the project purpose and need while considering the surroundings of each project. We must be sensitive to where the project is located, whether it is an interstate or a letter route. The surrounding context helps determine the design criteria. Our goal is to get the best value for the least cost. Life cycle costs must be considered. It is not our goal to shift the burden to maintenance.

Early in 2005, MoDOT began implementing Practical Design. The first step was developing best practices. These examples were intended to encourage our staff to "think outside the box" as they designed future improvement projects to provide the best value for the taxpayers.

The next step in implementing Practical Design is adopting new policies in areas most affecting our improvement costs. These areas are known as "cost drivers". Reducing costs in these key areas, while still serving motorists' needs, will enable us to construct more projects, thus better serving the taxpayer.

MoDOT senior managers developed these new policies in Oct. 2005. They represent a significant change in MoDOT direction. Each of these new policies is to be used immediately. Each policy supersedes the current direction contained in the Project Development Manual (PDM). However, information contained in the PDM not affected by these policies will continue to be used in the development of improvement projects.

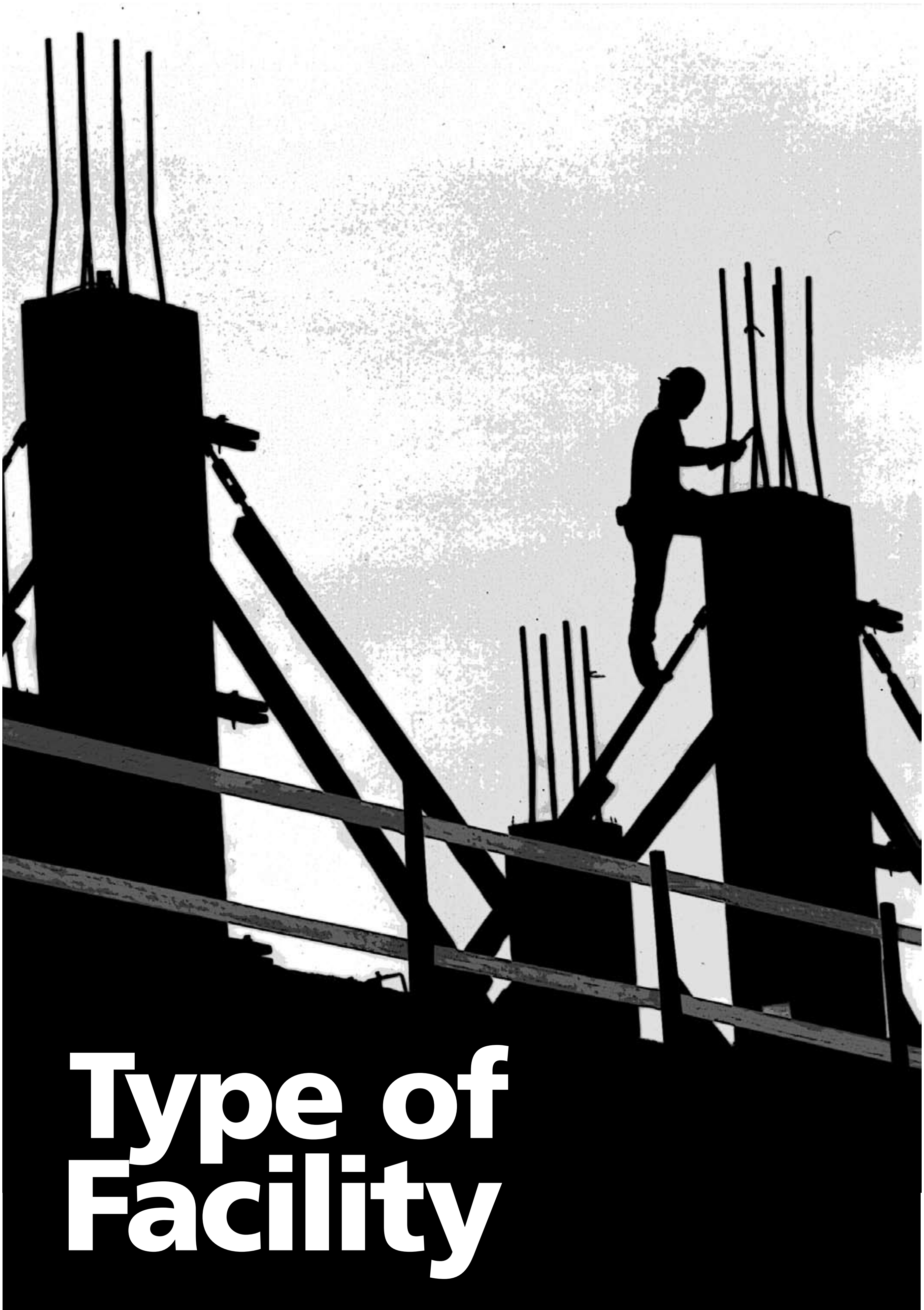
These policies will form the foundation of a new guidance document that will go into effect in the near future. This guidance document, in electronic format, will describe engineering policies throughout MoDOT. It will be the "one-stop shop" for design, right of way, bridge, construction, traffic, and maintenance activities. It will represent completion of the next step in our Practical Design effort.

These new policies will guide the project decisions we all must make. We must build the most efficient solution to the transportation need we have identified so we can spread our money to more projects across the state. We will follow three groundrules:

- Safety will not be compromised. Every project we do will make the facility safer after its completion.
- We will collaborate on the solution.
- The design speed will equal the posted speed. For example, we will not design a road for 70 mph when it will be posted 60 mph.

Practical Design has two main categories of roads. Major roads include the functional classification of principal arterial and above. These roads consist of approximately 5,400 miles of our 32,000 mile system and carry 76% of the traffic. Minor roads include the functional classification of minor arterial and below.

The Practical Design method, practiced by all areas of MoDOT, will allow us to deliver safer roadways, of great value, in a faster manner. It will take time to fully change our processes. It will take time to fully change the way we think about how our projects serve the motorist. We have already made GREAT progress!



Type of Facility

Facility Selection

Primary Guidance

- For both major and minor routes, the type of facility will be based upon the desired level of service (LOS) given the 20-year traffic projection of the corridor. More specifically:
  Peak Hour LOS
  - Rural – D
  - Urban – E

Off-Peak LOS
  - Rural - C
  - Urban - D
- Irrespective of LOS, Planning Division will continue to identify the general types of facilities for statewide system continuity.
- The facility must represent the appropriate balance between access and mobility for its intended purpose.
- When the desired LOS requires a four-lane facility, it will be designed as an expressway unless freeway is mandated.
- Two-way left-turn lanes (TWLTL) are permissible where practical.
- Passing lanes may be used in areas where poor LOS is a result of inability to pass safely.

Discussion

The type of facility chosen must fulfill only the purpose and need of the corridor, no more and no less. The purpose and need of a highway corridor involves more than traffic volume alone. The desired operational level of service (LOS) of the highway is the factor that contributes the most weight and is to be used when selecting the facility type.

Level of Service (LOS)

The six LOS grades are defined as:

- A - free flow
- B - reasonably free flow
- C - stable flow
- D - approaching unstable flow
- E - unstable flow
- F - forced or breakdown flow

The specific LOS of a facility is sometimes identified only after a subjective process, using traffic modeling software. In general, however, it is adequate for all routes in rural locations to accommodate the 20-year peak hour traffic at a LOS of D and off-peak traffic at a LOS of C. Similarly, it is adequate for all roads in urban or suburban locations to accommodate the 20-year peak hour traffic at a LOS of E, off-peak traffic at a LOS of D.

Given these LOS targets, the designer will use the formulas given in the AASHTO Highway Capacity Manual, Highway Capacity Software or other traffic modeling software to determine the appropriate facility type.

System Continuity

Some highway corridors in the state have a desired facility type for the entire corridor that has already been established by MoDOT's Planning Division. This has been done to establish general system continuity within the state. For this reason, projects that lie within such corridors should conform to the established facility type, regardless of localized LOS computation.

Access vs. Mobility

In general, highways serve two purposes: providing mobility and access. All highway corridors require some aspect of both access and mobility, although the relationship between the two is indirectly proportional. As the level of mobility of a facility increases, it's ability to provide access decreases and vice versa. Great care must be taken to strike an operational balance between the two, based on the project purpose and need. Nationwide, a great deal of research has been done in the area of access management. MoDOT's Access Management Guidelines (AMG) were developed by tailoring this policy to the specific needs of Missouri's highway system. The AMG must be used to provide the proper level of balance for individual projects.

Expressway vs. Freeway

In most cases, an expressway should be designed wherever the designers' calculations determine the need for a four-lane facility. Expressways are inherently safer than "head-to-head" facilities while allowing higher levels of access than freeways. The costs associated with expressways are also much lower given the lower number of interchanges required.

Exceptions to this policy should be considered where safety and operational characteristics of the project dictate the need for a freeway. Freeway is mandated for the Interstate System.

Two Way Left Turn Lanes

In the past, two way left turn lanes (TWLTL) have been viewed as operationally deficient. Within the context of a practical solution, however, this arrangement may provide legitimate access on projects and may be considered in certain locations.

Passing Lanes

At times, a poor LOS can be attributed to a lack of passing opportunities and vehicle's time spent following slower vehicles. In these situations, the highway's performance can be greatly increased by providing dedicated passing opportunities. While there are many ways to accomplish this, the improvement is generically referred to as a "passing lane". The improvement can be as simple as the addition of a climbing lane on a steep grade or as complex as a 2+1 roadway that provides a continuous third lane to offer alternating passing opportunity to either direction of travel.

MoDOT has recently commissioned a study of passing lanes and has received the final report that will be published as engineering policy in the near future. In the interim, policy guidance on this issue will be furnished by request.

At-Grade Intersections

Primary Guidance

- Signalized intersections can be considered for expressways that pass through communities.
- In rural areas, a designer is not to consider including a signalized intersection for expressways, although one may be installed at an existing intersection with Traffic's recommendation.
- The minimum distance between intersections along MoDOT roads is determined by whether the road is a major or minor road and whether the road is urban or rural. Refer to the Access Management Guidelines for desirable spacing between at-grade intersections.

Discussion

Signalized Intersections

Since bypasses are not selected for every town, signalized intersections can be considered for expressways that pass through communities. In rural areas, signalized intersections on expressways are strongly discouraged. Signals introduce a change in traffic speed that does not meet driver expectations. A designer is not to consider including a signalized intersection for expressways, although one may be installed at an existing intersection with Traffic's recommendation. Some operational issues may arise so that a signalized intersection may be installed prior to the construction of an interchange.

Distances Between Intersections

The minimum distance between public road intersections along MoDOT roads is determined by whether the road is a major or minor road and whether the road is urban or rural. It is important to maintain adequate spacing between public road intersections along roads that are primarily intended to serve through traffic. Major roads (that is, principle arterials, since interstates and other freeways do not have intersections) are mainly intended to serve through traffic and therefore have the largest spacing. Minor roads provide some service to through traffic but also provide direct access to property so the intersections can be placed more closely.

A traffic analysis is to be performed if guidance from Access Management Guidelines is not selected for intersection spacing.

Interchanges

Primary Guidance

- An interchange is to be considered when it is warranted by the 20-year design traffic projection or safety concerns.
- The desired spacing between interchanges is two miles in current and projected urban areas and five miles in rural areas.

Discussion

Interchange design and spacing

The selection of an appropriate interchange design is influenced by such factors as highway classification, composition of traffic, design speed, economics, terrain, available right-of-way and degree of access control. Also, a traffic analysis is to be performed if guidance from Access Management Guidelines is not selected for interchange spacing.

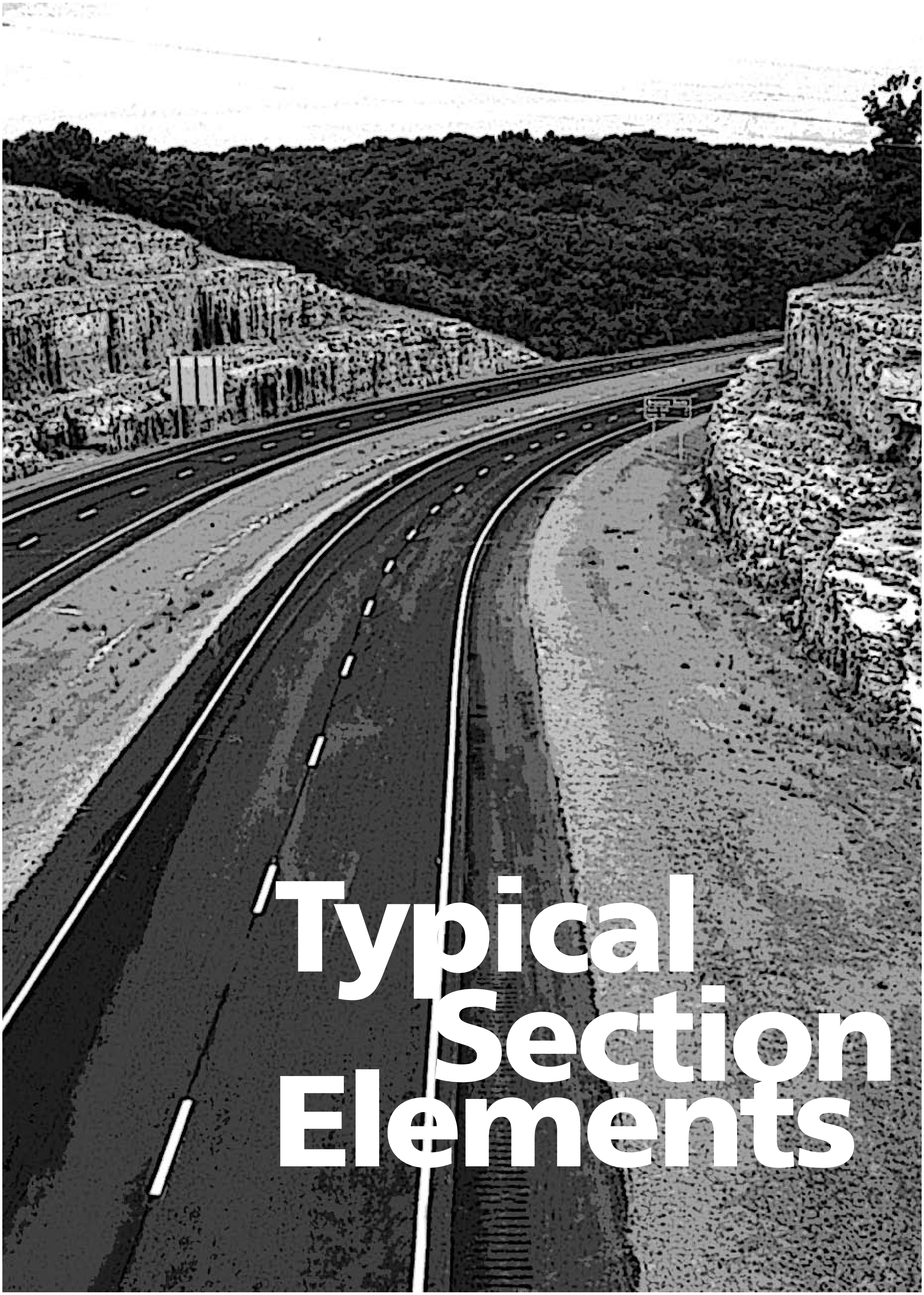
Warrants for Interchanges

An interchange's high construction cost limits its use to those cases where the expenditure is justified. The following three warrants are to be considered when determining whether an interchange is justified at a particular site:

1. Design designation. Once the choice has been made to develop a route as a freeway, it must be determined whether each intersecting highway will be terminated, rerouted or provided with an interchange.

2. Traffic volume. Interchanges are considered where conflicting high traffic volumes exceed those that can be handled efficiently and safely with at-grade intersections or by controlling the ingress and egress to the main highway. An interchange is also to be considered when the LOS of the 20-year design traffic projection warrants it. Even on facilities with partial control of access, the elimination of random signalization contributes greatly to improvement of free-flow characteristics. Approximate traffic capacities for at-grade intersections without signals are given in the PDM's Table 4-05.2. Similar data for traffic capacities of signalized intersections are given in Chapter VIII of the PDM. These traffic capacities are only a guide, since local conditions will sometimes affect the capacity and dictate the need for and design of an interchange. A traffic analysis must be performed with traffic modeling software to select the proper design.

3. Safety improvement. Some at-grade intersections have a disproportionate rate of fatal crashes. If inexpensive methods of eliminating crashes are likely to be impractical or ineffective, an interchange may be warranted.



Typical Section Elements

Lane Width

Primary Guidance

- Lanes on both rural and urban major roadways are to be 12 ft. wide.
- Lanes on rural and urban minor roadways are to be 10 to 12 ft. wide, based on the volume of traffic and the context of surrounding roadway.
- Auxiliary lanes at interchanges facilitate traffic movements. These lanes are to be as wide as the through-traffic lanes.
- Lane widths on very low volume local and collector roads and streets that carry less than 400 vehicles per day are to be based on the guidance contained in the AASHTO document *Guidelines for the Geometric Design of Very Low Volume Local Roads.*

Discussion

The lane width of a roadway greatly influences the safety and comfort of driving. The extra cost of providing a full 12 ft. lane on higher volume roadways is offset by the reduced costs of shoulder surface maintenance due to lessened wheel concentrations at the edge of pavement. The 12 ft. lane also provides desirable clearances between larger commercial vehicles traveling in opposite directions on two-lane, two-way rural roadways when high traffic volumes are expected. The same holds true when high percentages of commercial vehicles are expected.

Lane widths also affect the roadways level of service. Narrow lanes force drivers to operate

their vehicles laterally closer to each other than they would normally desire. Restricted clearances have the same affect.

Further information on the effect of lane width on capacity and level of service can be found in the Highway Capacity Manual (HCM). In addition to the capacity effect, the resultant erratic operation has an undesirable effect on driver comfort and crash rates.

Although 12 ft. lane widths are desirable on both rural and urban roadways, there are circumstances where more narrow lane widths can be used. In urban areas where pedestrian crossings, right of way, or existing development become stringent controls, the use of 10 or 11 ft. lanes is acceptable. In rural areas with low traffic volumes, the use of 10 ft. lanes is acceptable.

Shoulder Width

Primary Guidance

- Never eliminate shoulders altogether. Motorists expect them.
- Shoulders on major roadways (both rural and urban) are to be 4 to 10 ft. wide based on the volume of traffic, the percentage of trucks and context of the surrounding road.
- Shoulders on rural minor roadways are to be 2 to 4 ft. wide.
- Shoulders will not be provided on urban roadways with no access control if ample turning opportunities exist for a vehicle to leave the roadway.
- An earthen shoulder will be provided behind a mountable curb.
- Rumble strips are to be provided on major and minor roadways with paved shoulders at least 2 ft. wide (see Rumble Strip guidance for further information).

Discussion

A shoulder is the portion of the roadway contiguous to the traveled way that accommodates stopped vehicles, emergency use, and provides lateral support of the subbase, base and pavement. Shoulders may be paved (with concrete or asphalt) or unpaved (with aggregate or soil).

Desirably, a vehicle stopped on the shoulder should clear the edge of the traveled way by at least 1 ft., and preferably by 2 ft. This preference has led to the preferred use of a 10 ft. shoulder on major roadways. A shoulder at least 2 ft. wide is encouraged on minor roadways.

On urban roadways, the shoulder is located inside a curb. Surfaced areas behind curbs located on urban roadways may be perceived as a sidewalk and thus subject to ADA requirements. Therefore, a surfaced area is not to be provided behind a mountable curb.

When roadside barriers, walls, or other vertical elements are present, the shoulder that is provided should be wide enough to ensure the vertical element is offset 2 ft. from the edge of the useable shoulder. This is also true when guardrail is placed along the roadway.

Regardless of the width, a shoulder functions best when it is continuous. The full benefits of a shoulder are not realized unless it provides a driver with refuge at any point along the traveled way. A continuous shoulder provides a sense of security so all drivers making emergency stops will leave the traveled way. Although continuous shoulders are preferred, narrow shoulders and intermittent shoulders are still superior to no shoulders at all.

Rural major Routes

For rural Major routes, rehabilitation projects should provide a minimum 4 ft. shoulder. Always consider the context of the surrounding route. New construction projects should provide 10 ft. shoulders.

Rural Minor Routes

The shoulder on rural minor roadways serves as structural support for the pavement and as additional width for the traveled way. This permits drivers meeting or passing other vehicles to drive on the edge of the roadway without leaving the surfaced area. Roads with a narrow traveled way, narrow shoulders and significant traffic tend to provide a poor level of service, have a higher crash rate, and need frequent and costly maintenance.

For rural Minor routes, rehabilitation projects should provide a minimum 2 ft. shoulder. Always consider the context of the surrounding route. New construction projects should provide 4 ft. shoulders.

Median Width

Primary Guidance

A wide separation between traffic moving in opposing directions is safer and more comfortable for the motorist than head-to-head traffic in close proximity. While this works well in rural areas, it may be necessary in densely developed areas with expensive right of way to provide a narrower median with a positive barrier. Therefore, the following items are important:

- The preferred typical section for expressway and freeway facilities will include a depressed median 60 ft. wide, measured from edge of traveled way to edge of traveled way. A median of this width satisfies clear zone concepts.
- A narrower median with a positive barrier can be used on expressways and freeways if the decision is based upon an economic analysis. This situation is most likely to occur when the cost of right of way adjoining the improvement is expensive or when its vertical alignment causes high fills or deep cuts.

Discussion

While MoDOT prefers to use the 60 ft. depressed median on rural and urban expressways and freeways, the cost to do so may become excessive. When this occurs, alternative designs for the improvement are to be considered. These alternatives must reflect the principles of clear zone design. Positive median barriers are not always required; however, when they are needed MoDOT uses three basic types. They are concrete barrier, guardrail and guard cable.

Concrete barrier and guardrail are best when used on flush medians narrower than 36 ft. Guard cable is effective when used in medians 36 ft. and wider and in locations with cross-median accident history.

When a median narrower than 60 ft. is provided on an expressway located on a major route, the turning movement requirements of the design vehicle must be considered. In addition, the length of storage area necessary to accommodate the design vehicle within the median must be determined to maximize safe operation of the improvement.

A closed median with raised curbs can be an effective design when used on a minor roadway in urban areas. The width of the median in these situations is a function of the turning movements of the design vehicle.

Inslope Grade

Primary Guidance

- The preliminary geotechnical report contains grading recommendations including the slope ratio that is not to be exceeded.
- The AASHTO Roadside Design Guide may be consulted to select the proper combination of inslope ratio and clear zone concept.
- Use of guardrail is preferable to a 1V:6H/1V:3H ("barnroof") design when addressing economic concerns (e.g. to balance earthwork quantities or to decrease the amount of R/W).

Discussion

Preliminary Planning

Consult with the district geologist to obtain the preliminary geotechnical report sufficiently early in the project development process so that slope ratios can be established in the preliminary plan phase. Also refer to the Roadside Ditches guidance in this document since it also impacts the foreslope.

Clear Zone

The roadway inslope would typically vary from 1V:6H to 1V:2H depending upon the application of clear zone concepts and the soil report. The clear zone is the roadside border area immediately adjacent to the traveled way. This border area is provided as a safe area for errant vehicles to regain control. It is desirable to provide clear zone on all facilities with posted speed 45 mph or greater. The application of clear zone would depend on many things including posted speed, roadway functional classification, accident history and cost comparison between clear zone and guardrail. Additional information concerning clear zone concepts can be found in Chapter 3 of the AASHTO Roadside Design Guide.

Fill Slopes

The slope ratio given in the preliminary geotechnical report is a maximum and is not to be exceeded. As a rule of thumb, to satisfy clear zone requirements and to economize grading, fills 20 ft. high and lower can utilize a 1V:4H slope. Fills greater than 20 ft. will have a "barnroof" design (typically a combination of a 1V:6H with as steep a slope as permitted by the preliminary geotechnical report.

Backslope Grade

Primary Guidance

- The preliminary geotechnical report contains grading recommendations including the slope ratio that is not to be exceeded.
- When good quality rock is present, and grading recommendations included benching, utilize a 1:1 backslope from the back of the ditch to establish the theoretical slope limit used to determine the R/W line.

Discussion

Consult with the district geologist to obtain the preliminary geotechnical report sufficiently early in the project development process so that the slope ratios can be established in the preliminary plan phase. The slope ratio given in the preliminary geotechnical report is a maximum and is not to be exceeded. Also, refer to the Roadside Ditches guidance in this document since it also impacts the backslope.

Rock Cuts

The maximum backslope allowed is included in the preliminary geotechnical report. Rock bench details are included in the preliminary geotechnical report and are typically set at 30 ft. vertical with 15 ft. horizontal benches. When good quality rock is present, it is recommended to consider using a 1:1 backslope from the back of the ditch to establish the theoretical slope limit. This slope limit can then be utilized to determine the location of the R/W line. If there is a significant amount of soil above the rock, then the soil cut slope recommended in the preliminary geotechnical report must be used to establish the theoretical slope limit.

Special Conditions

Often the preliminary geotechnical report will reveal the presence of different materials or conditions such as shale, sandstone, pinnacle rock, etc. This may necessitate site specific requirements for the backslope.

Roadside Ditches

Primary Guidance

- Roadside ditches are to be of sufficient depth to insure drainage from the design storm event and prevent seepage under the pavement through a permeable base.
- When pavement edge drains are necessary, the roadside ditch must be of sufficient depth to permit location of the drain above the water surface elevation during the pavement drainage design event.
- Flat bottom or V-ditches are to be selected for use based on hydraulic capacity and the inslope and backslope requirements necessitated by clear zone principles and/or soil conditions.
- The ditch will be designed to meet the criteria set forth in the Roadway Overtopping Criteria section.
- Necessary erosion control methods will be used in areas as determined by the district to reduce or withstand the flow velocity.

Discussion

Ditch Slopes

The primary purpose for the roadside ditch is the control of surface drainage from the pavement and surrounding area. An open-channel ditch, cut into the natural terrain along the roadside, is the most economical method to produce a drainage channel. The most desirable channel, from the standpoint of hydraulic efficiency, is one with steep sides. However, limitations on soil stability and roadside safety (clear zone principles) require flatter slopes. The effect of slope combinations on the safety of a vehicle traversing them is an important consideration. Slope combinations for channels can be selected to produce a cross-section that can be safely traversed by an errant vehicle. Additionally, the cost of right of way needs to be considered when selecting combinations of slopes for the roadside.

The depth of the roadside channel must be sufficient to remove surface water without saturation of the subgrade including the pavement base. The depth of water that can be tolerated in the channel particularly on flat channel slopes, depends on the soil characteristics. In regions with severe winter climates, channel sideslopes of 1V:5H or 1V:6H are preferable to reduce snow drifts.

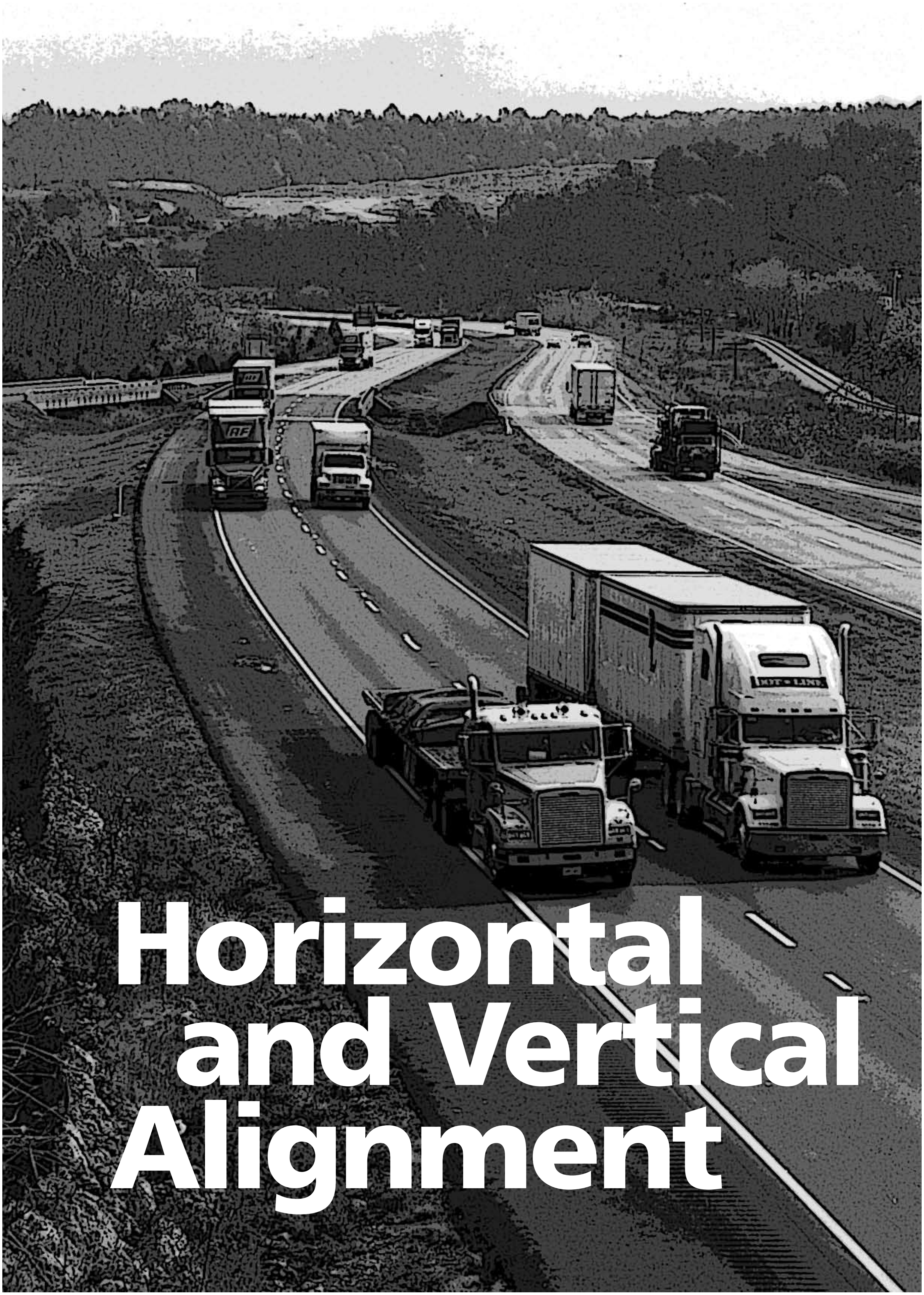
Ditch Grades

The minimum desirable grade for a roadside channel is based on the drainage velocities needed to avoid sedimentation. The maximum desirable grade for roadside channels is based on a tolerable velocity for vegetation and shear on soil types. The channel grade does not have to follow the grade of the adjacent roadbed, particularly if the roadbed is flat. Not only can the depth and width of the channel be varied to meet different quantities of runoff, slopes of channel, types of lining, and the distance between discharge points, but the lateral distance between the channel and the edge of traveled way can also be varied. Care should be taken to avoid abrupt changes in the roadway section that produces a discontinuity of the roadside environment and violates driver expectancy. Care should also be taken to avoid major breaks in channel grade that could cause unnecessary scour or silt deposition.

Construction and Maintenance Operations

Maintenance and construction core team members will provide input on the ditch cross section, e.g., an 8 ft. flat bottom ditch may be desirable for maintenance equipment to remove fallen rock.

Horizontal and Vertical Alignment



Horizontal Alignment

Primary Guidance

- Horizontal alignments are to be coordinated with anticipated posted speeds.
- Chapter 3 of the AASHTO publication A Policy on Geometric Design of Highways and Streets (the Green Book) will be used as guidance to determine maximum horizontal alignments.
- A relatively sharp curve may be designed if the curve is properly signed.

Discussion

The operational characteristics of a roadway are directly affected by the horizontal alignment. The designer is to consider the road's terrain, traffic volume, expected capacity and LOS and other safety factors in order to properly anticipate the posted speed. Highways will be designed according to their anticipated posted speed as opposed to an arbitrary design speed.

Once the anticipated posted speed is identified, the road's horizontal alignment can be selected. All horizontal curve data is now defined by radius. The basic design criteria for horizontal curvature are based upon the information from Chapter 3 of the AASHTO publication *A Policy on Geometric Design of Highways and Streets* (the Greenbook). The Greenbook will also be used as guidance to determine other horizontal alignments.

Terrain, traffic volume and the anticipated posted speed must be considered when establishing a roadway's minimum horizontal curvature.

A sharper curve may be designed if the curve is properly signed. Proper signage is required to inform the driver.

Vertical Alignment

Primary Guidance

- Vertical alignments are to be coordinated with anticipated posted speeds.
- The AASHTO publication A Policy on Geometric Design of Highways and Streets (the Green Book) can be used as guidance to determine maximum vertical grades.
- Every effort should be made during the design of a project to insure the quantities of fill and excavation are balanced (i.e., the excavation plus swell volume equals the fill plus shrinkage volume).

Discussion

Rural Major Roads

The operational characteristics of a roadway are directly affected by the length and steepness of the vertical alignment. The designer is to consider the road's terrain, traffic volume, expected capacity and LOS and other safety factors in order to properly anticipate the posted speed. Highways will be designed according to their anticipated posted speed as opposed to an arbitrary design speed.

Once the anticipated posted speed is identified, the road's vertical alignment can be selected. The AASHTO publication *A Policy on Geometric Design of Highways and Streets* (the Green Book) can be used as guidance to determine maximum vertical grades.

When terrain or some other factor causes the maximum grade to be impractical for a roadway segment, a grade in excess of those indicated in the Green Book can be incorporated into the design and the posted speed for that roadway decreased.

Urban Major Roads

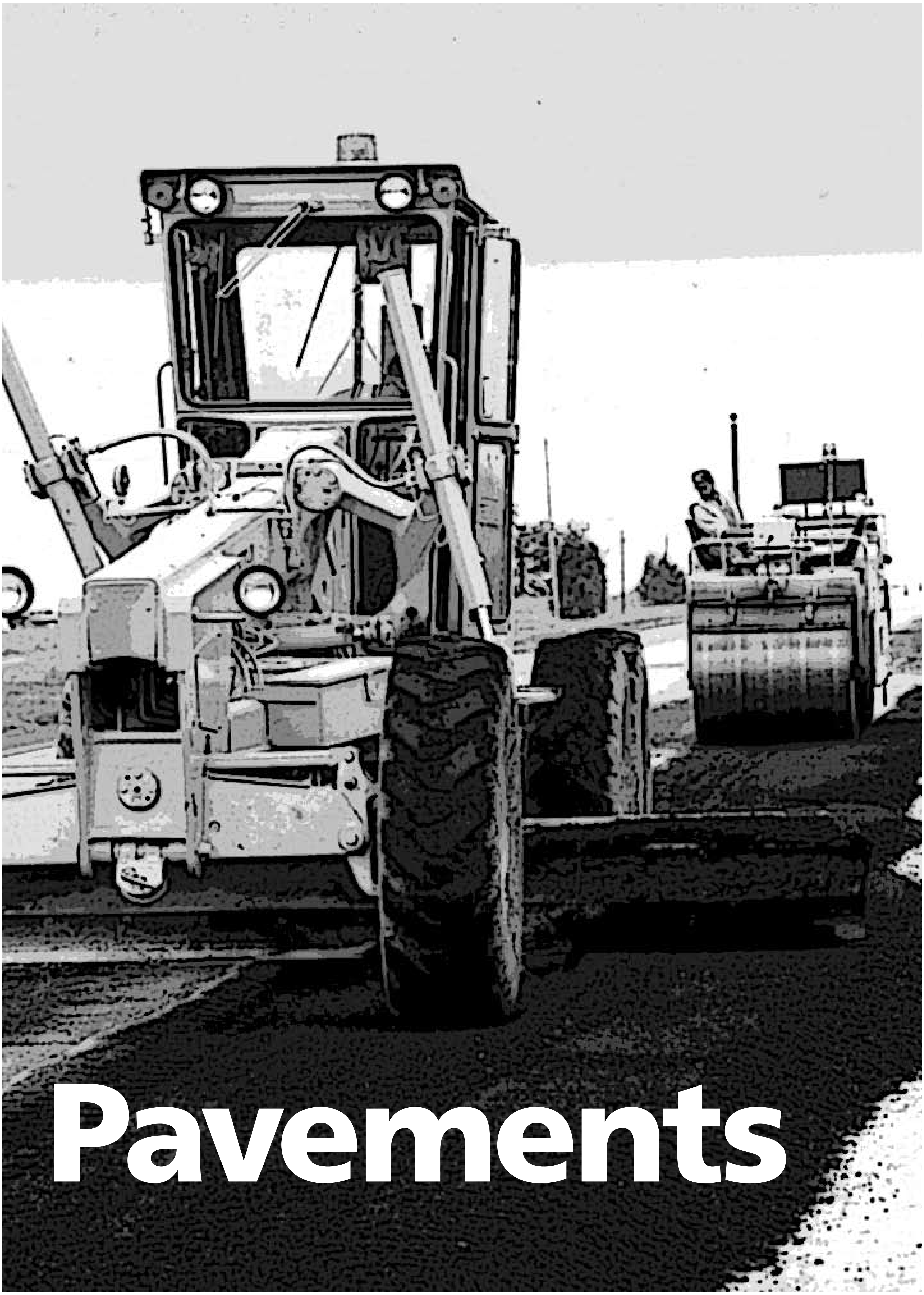
The operational characteristics of a roadway are directly affected by the length and steepness of the vertical alignment, but in urban projects extensive steep terrain would not be typically encountered. While no maximum grade for urban roads is specified, the Green Book's table "Recommended Maximum % Grades for Rural Major Roads" can be consulted to determine an urban major road's grade.

Minor Roads

Terrain, traffic volume and the anticipated posted speed are to be considered when selecting a roadway's maximum vertical grade.

Stopping Sight Distance

The minimum stopping sight distances and "K" factors for various anticipated posted speeds are given in the Green Book. These controls are based on a 3.5 ft. height of eye and a 2 ft. height of object. The "K" factors are approximate only and are used as a guide in determining the length of vertical curve. The stopping sight distance, as determined by formula, is used as the final control. Where practicable, vertical curves at least 300 ft. in length are used.



Pavements

Paved Shoulders

Primary Guidance

- On major roads the entire shoulder width should be paved.
- On minor roads the shoulder should be aggregate stabilized except where maintenance or safety concerns (e.g., edge drop off, high runoff road occurrence) justify a paved shoulder.
- Shoulders on urban roadways with access control (major or minor) are to be paved.
- In no case will a paved or aggregate surface be used directly behind a mountable curb along the outer edge of a roadway. A curb and gutter will only be used with an anticipated posted speed less than 50 mph.

Discussion

Paved shoulders and aggregate stabilized shoulders provide a secure surface to accommodate vehicles for emergencies and other uses. Paved shoulders are an integral part of the pavement structure and are considered as part of the pavement design configuration.

Where a paved shoulder is provided for either concrete or asphalt pavements, the full thickness of the travel way pavement is extended laterally to a longitudinal joint 2 ft. outside the travel way. The remainder of the shoulder width is paved with 5 ¾ in. of concrete or asphalt, at the contractor's option, as a Type A2 Shoulder. Where an additional lane is considered imminent, a full depth Type A paved shoulder is provided as an integral part of the pavement structure, with the width desired for future lane use. In this case the joint is placed at the edge of the travel way. Ramp shoulders should be consistent with the mainline. For ramps with integral curbs, the shoulder material and thickness will be specified in the pavement thickness determination.

For maintenance, structural or safety concerns on a minor road, the pavement structure width may be extended two additional feet. If paving the remaining width of shoulder is justified, the shoulder should consist of the Type A2 shoulder design.

Bridge Approach Slabs

Primary Guidance

- Bridge approach slabs will be used on all major road bridges. The approach slabs will only be omitted by design exception, not by a construction value engineering (VE) proposal.
- On minor roads bridge approach slabs will not be used except with a design exception.

Discussion

A bridge approach slab is used to provide a smooth and structurally sound transition from the pavement to the bridge. The area between the roadway embankment and the bridge end bent frequently receives inadequate compaction or a different degree of compaction than the roadway fill. In order to prevent pavement failure, an unacceptable differential elevation between the pavement and the bridge pavement, and excessive loading on the end bent, a bridge approach slab is constructed to span from the end bent over the roadway embankment.

Major Roads

In site specific circumstances, the project core team may decide that a bridge approach slab is not needed on a major road. In those cases, a design exception is required. When the decision is made to include a bridge approach slab in the project plans, Construction personnel will not underrun the item nor will the contractor be allowed to remove it by VE proposal.

Minor Roads

In light of their expense, bridge approach slabs on minor roads have shown less than satisfactory in-service performance. In keeping with the true purpose and need of the project, bridges on minor roads will be constructed without bridge approach slabs. In order to maintain an acceptably smooth pavement, maintenance forces may need to fill or patch pavement adjacent to the bridge end as settlements occur.

Drainage

When a bridge approach slab is included in the plans, the roadway items of curb and drain basin as shown on Standard Plan 609.40 are also specified. When the bridge approach slab is not needed, a method of moving drainage away from the bridge end will be necessary. In most cases, Type A curb and drain basin will be sufficient. The project core team is to make recommendations for handling drainage as necessary.

Pavement

Primary Guidance

- The Construction and Materials Division will determine the pavement thickness for all projects on major roads. During early scoping, pavement thicknesses for conceptual design and estimating purposes may be obtained from the ME (Mechanistic-Empirical) Design Table for Project Scoping.
- On minor roads, for spot improvements such as pavement replacement less than 0.5 miles in length adjacent to bridge replacements, widening for turning lanes for a turning movement that has less than 1000 vehicles per day or for short realignments, a pavement thickness determination by Construction and Materials is not required. The new pavement thickness is to be equivalent to the existing pavement thickness on 4 in. of aggregate base or 5 3/4 in. on 4 in. of aggregate base, whichever is greater. For these projects, the new pavement is to consist of asphalt (cold mix or hot mix) or concrete pavement, at the contractor's option. If the AADT is between 1000 and 2000, the cold mix may be elilminated. If the AADT is greater than 2000, cold mix is not allowed.
- On minor roads, for improvements greater than 0.5 miles in length or for widening for turning lanes for a turning movement with more than 1000 vehicles per day, the Construction and Materials Division will make a pavement thickness determination. During early scoping, pavement thickness for conceptual design and estimating purposes may be obtained from the ME (Mechanistic-Empirical) Design Table for Project Scoping.
- Superpave mixes are not appropriate for minor roads except for unusual circumstances with a design exception.
- Aggregate surfaces will not be used except on very low volume or dead end road applications, such as outer roads, temporary bypasses and roadways to be turned over to another agency. In these circumstances an aggregate surface may be appropriate if dust can be tolerated. For these situations a minimum 2 in. thickness of gravel, crushed stone, or chat may be used.

Discussion

Pavement Thickness Determination

Pavements are designed to provide adequate support for loads imposed by traffic, and to provide a uniformly firm, stable, smooth, all-weather surface. To achieve these objectives, the subgrade, base, underdrainage and surface are designed so that the pavement will not fail under design loads. Pavements are either flexible (asphalt) or rigid (concrete).

A pavement thickness request is submitted to the Pavement Section in the Construction and Materials Division, with a copy to the Design Division, during preliminary design. The pavement thickness determination will include the aggregate base and underdrainage design. The pavement thickness request is to include the following information:

- A description of the existing and proposed design template for the mainline, ramps and any other roadways associated with the project (appurtenances) requiring a pavement structural design
- The existing pavement structure on each end of the new pavement
- Special conditions prevalent within the project area that may affect design consideration.
- Due date the pavement thickness determination as needed to maintain the project development schedule.
- Traffic data (construction year AADT, truck percentage, truck classification distribution (if available), and annual growth rate).
- Soils survey, including data for P.I., gradation, and depth of water table.
- Location sketch and length of each new pavement to be designed, including log mile reference and exceptions

The district is to request a review of the study for project changes, including (1) delays beyond the anticipated construction, (2) traffic changes, (3) section expansion or reduction, or (4) a revised typical section or other standards revisions, etc.

Pavement Design for Scoping

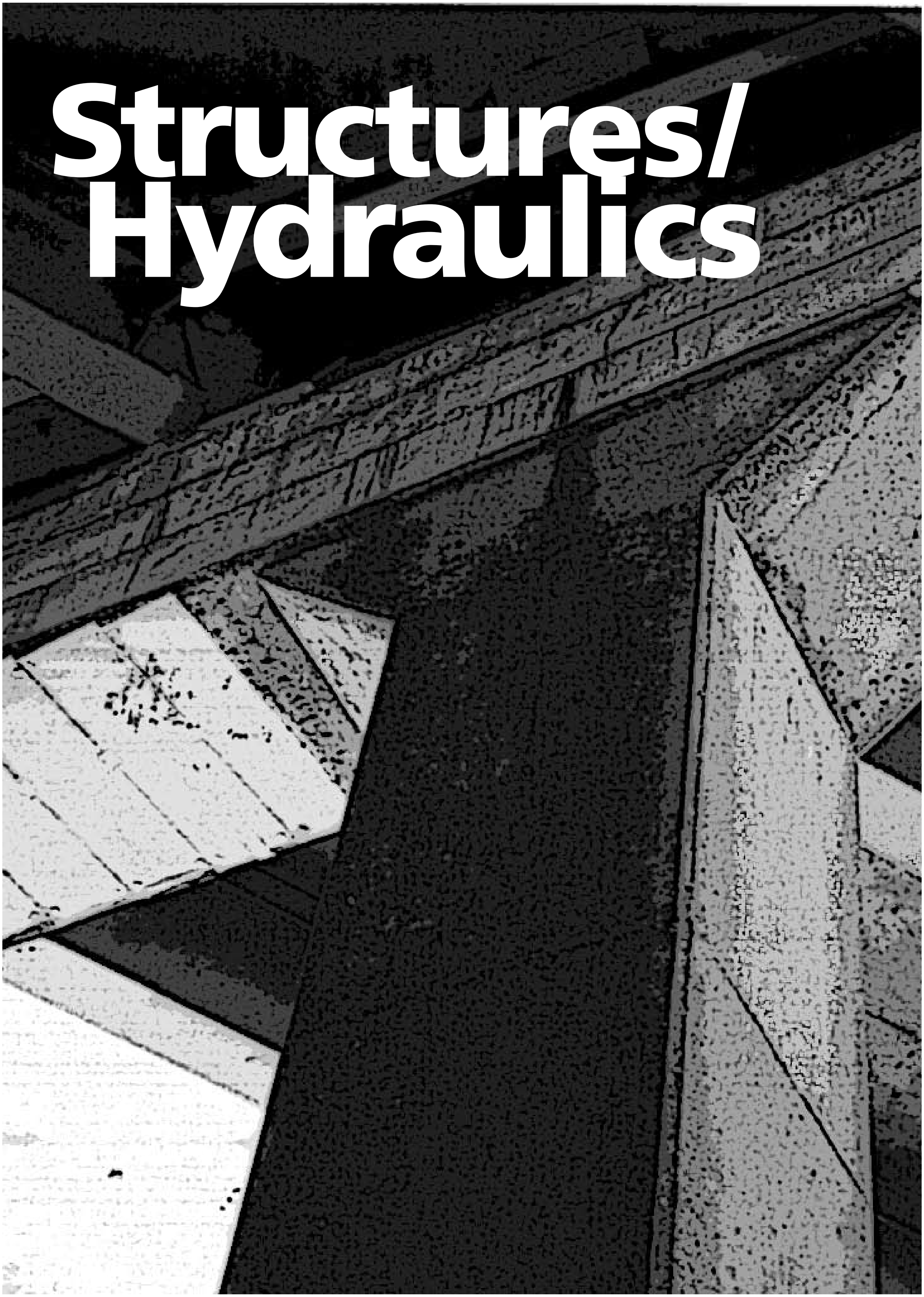
During project scoping for conceptual estimates only, a pavement thickness from the following table may be used. This table is not used for preliminary or final design.

Pavement

Approximate ME Design Table for Project Scoping

Two-Way AADTT*	Total Asphalt Thickness (in.)	Total Concrete Thickness (in.)
10 - 50	8	7
50 - 100	10	8
100 - 1000	12	9
1000 - 5000	15	10
5000 - 10,000	17	11
10,000 - 25,000	20	12

*AADTT – Annual Average Daily Truck Traffic in the Construction Year


Structures/
Hydraulics

Bridge Width

Primary Guidance

- For Major roads, bridge width equaling full roadbed width is desirable.
- For Minor roads, strive for 2’ shoulders (24 to 28 foot bridge width, depending on lane width).
- Minimum width for all bridges is 24’.
- Full shoulders are required for bridges over 1000’ long.

Discussion

Bridge width will vary based on project scope, context of surrounding road and future plans for the route. Project scope and bridge economics usually determine the treatment strategy for individual projects. Treatment strategies range from rehabilitation to rehabilitation and widening to complete replacement.Bridges over 1000’ in length require full width shoulders so that disabled vehicles can be accommodated.

Major roads

The desirable width of bridges on Major roads includes the traveled lanes and shoulders. The minimum width of bridges for Major roads is 24’, that is, there could be situations where an existing bridge may be rehabilitated and used in place even though it may not be the desirable width.

Minor Roads

The desirable minimum width of bridges on Minor roads includes the traveled lanes and 2’ shoulders. For routes with 10’ lanes, the bridge width to strive for is 24’ and for routes with 12’ lanes, the desirable width is 28’.

Bridge and Culvert Hydraulic Design

Primary Guidance

The design frequency and criteria should be selected separately for roadway overtopping, freeboard, and backwater/headwater of bridge or culvert hydraulic design after considering the specific impacts and cost/benefit issues.

- Roadway Overtopping
  - Minor Routes
    - For bridges and boxes, the water level shall be no deeper than 1 foot below the lowest shoulder point during a 25- to 50-year event. For pipes, the water level shall be no deeper than 1 foot below the lowest shoulder point during a 10- to 25-year event.
  - Major Routes
    - For bridges and boxes, the water level shall be no deeper than 1 foot below the lowest shoulder point during a 50- to 100-year event. For interstates use the 100-year event. For pipes, the water level shall be no deeper than 1 foot below the lowest shoulder point during a 25- to 50-year event. For interstates use the 50-year event.
- Freeboard for Bridges on All Routes
  For a drainage area less than 20 square miles, the bridge shall have 1 foot of freeboard during a 50-year event. For a drainage area greater than 20 square miles, the bridge shall have 2 feet of freeboard during a 50-year event.
- Backwater/Headwater for bridges, box culverts and pipes on all routes shall meet the National Flood Insurance Program requirements. The designer must consider the impacts to upstream improvements, crops and property values as well as the depth, frequency, extent and duration of the backwater impacts. The backwater must be reasonable for the full range of flows less than or equal to the design event. "Impact", is defined in terms of value and quantity of property that may be affected. Prior to selecting backwater criteria, the potential backwater impacts are evaluated:
  1) For bridges and boxes in areas with low levels of potential impact, allow from 0 to 2 feet of backwater over natural in a 100-year event. In areas with moderate to high potential impact allow 0 to 1 foot of backwater over natural in a 100-year event.
  2) For pipes with upstream impacts that may be moderate to high, analyze backwater and consider impacts from depth, extent and frequency of flooding for the range of flows.
- The Design High Water Elevation (DHW) will be based on the return period of the freeboard design.
- Design exceptions for frequency or criteria are encouraged when they are practical.
- When an existing structure that is to be replaced has provided adequate performance, a design exception to match the hydraulic performance of the existing structure is necessary and encouraged. Thorough documentation of the adequate historical performance is included with the Design Exception.

Discussion

To produce the most practical and flexible design, each hydraulic aspect and the resulting design frequencies must be considered and established based upon the relative risks and costs. The hydraulic frequency establishes a design storm and associated discharge and the criteria establish the acceptable level of performance during that storm. Instead of the simple term "design frequency", use the terms "backwater design frequency", "roadway overtopping design frequency", "freeboard design frequency", etc. The plans are to show the frequency to which each aspect of the project is designed.

Roadway Overtopping

For structural replacements, the upper end of the hydraulic frequency ranges is used for high volume routes and sites requiring only minimal roadway work. The lower end of the hydraulic frequency ranges is used for low volume routes and sites requiring extensive roadway work. For new locations, consider the expected traffic volumes and length of roadway to be constructed in selecting an overtopping design frequency. When rehabilitating an existing structure it is not required that the adjacent roadway be raised to meet the roadway overtopping standards for new roads. The replacement structure should be designed such that it does not increase the frequency of roadway overtopping. The roadway overtopping frequency is documented in the files and labeled on the plans as the "overtopping frequency". The files include a note indicating that improving the roadway overtopping frequency would have been outside the scope of the project.

Freeboard

When the drainage area produces unusually large debris, additional freeboard to protect the structure is desirable. If the drainage area produces very little debris the freeboard criteria may be reduced.

Backwater

For projects with moderate or high upstream property impacts, analyze and quantify backwater impacts so that design decisions can be made. This applies even when the District does the design. In some cases, the District may choose to document reasons why backwater impacts do not need to be estimated instead of performing the calculations. The Bridge Division will continue to assess the backwater impacts as part of most hydraulic designs performed by Bridge. Impacts to areas with no existing improvements or anticipated potential for development would be considered minimal, even for relatively large areas. Impacts to agricultural land can be considered minimal if only a small area is affected, or considered moderate to high for a large area.

Consider the extent, depth, duration and frequency of flooding when evaluating backwater impacts. The depth and frequency of flooding are the most critical, but MoDOT can be held responsible for unreasonable increases in any of these.

If it can be assumed that the road won't be raised in the foreseeable future, consider the flow over the road when sizing the structure. Otherwise, size the structure to handle the full flow so that the structure won't need to be replaced to raise the road in the future. In this case, the backwater must be specifically calculated for the event that just overtops the road in addition to the standard frequencies. This event may produce the maximum backwater impact.

Choose the upper end of the allowable backwater range only when it is appropriate and reasonable. For new structures the backwater impacts are determined cumulative with bridges left in place. When extending a culvert, a complete hydraulic analysis or documentation of why a complete analysis is not necessary is required. When the existing culvert can be shown to be adequate and impacts from the lengthening are minor, design exceptions can be sought to allow the use of reduced criteria to avoid replacing the culvert. However, a hydraulic analysis is still necessary to determine the impacts.

Seismic Design

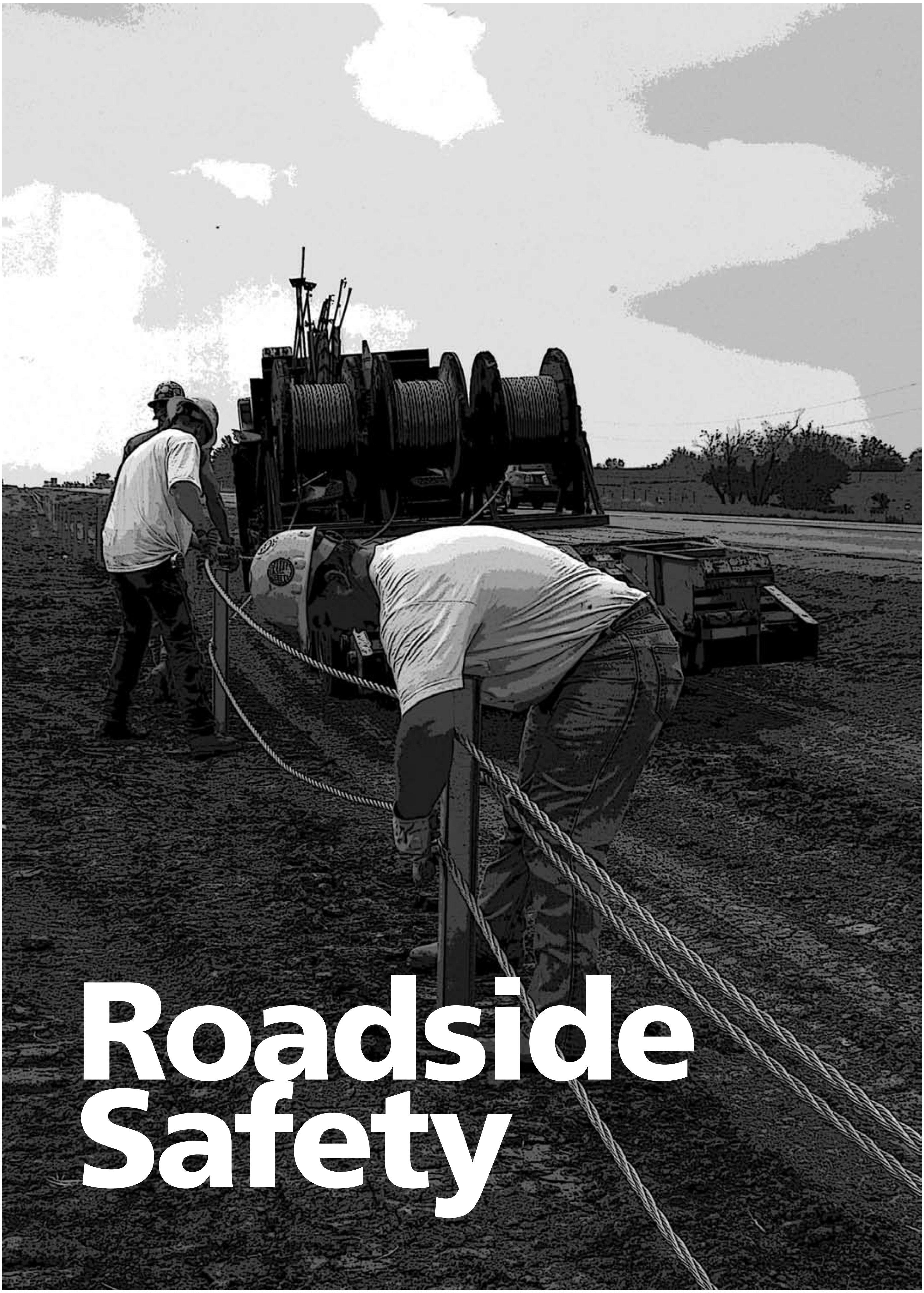
Primary Guidance

- Seismic design of bridges is guided by the AASHTO design specifications, which delineate seismic zones in Missouri.
- New bridges on major roads and Earthquake Emergency Routes are modeled (comprehensively analyzed) and designed to resist earthquakes according to Seismic Performance Categories (SPC) B, C and D.
- New bridges on minor routes in SPC B, C and D, include limited seismic details to improve their resistance to earthquakes; however, they are not modeled (comprehensively analyzed) and specifically designed to resist earthquakes.
- A decision is made on each bridge rehabilitation project as to the necessity and extent of seismic retrofitting.

Discussion

All new bridges on the state system include small details and design checks to resist earthquakes. In Seismic Performance Categories B, C and D, additional design and detailing work is needed because of the increased probability of damaging earthquakes.

When existing bridges in SPC B, C and D are identified as needing repairs or maintenance, a decision on whether to include seismic retrofitting in the scope of the project should be made based on the location of the bridge, the extent of the rehabilitation work and the expected life of the of the bridge after the work. For example, if the bridge needs painting or deck patching, no retrofitting is recommended. However, redecking or widening the bridge indicates that MoDOT is planning to keep the bridge in the state system with an expected life of at least 30 more years. In these instances, the project core team should consider cost effective methods of retrofitting the existing bridge.


Roadside
Safety

Rumble Strips

Primary Guidance

- All major roads will have edgeline rumble strips.
- All major 2-lane roads with new pavement will have centerline rumble strips.
- Edgeline rumble strips may be used on minor roadways as a specific safety countermeasure with a paved shoulder. Where several sections of edgeline rumble strips are installed in close proximity, continuity should be maintained.
- Centerline rumble strips may be used on minor roadways with a significant accident history. Where several sections of centerline rumble strips are installed in close proximity, continuity should be maintained.
- Rumble strips are omitted where the posted speed limit is less than 50 mph.

Discussion

Edgeline Rumble Strips

Edgeline rumble strips are used to enhance safety on every shoulder at least 2 ft. wide, unless the shoulder has a curbed section or is intended to be used as a future travel lane. In urban areas, edgeline rumble strips may be omitted on major roads with a design exception (e.g., noise is a significant issue and safety is not a significant issue).

The edgeline pavement marking material is sprayed over the rumble strip, creating a "rumble stripe".

Centerline Rumble Strips

Centerline rumble strips are desired on all major 2-lane roads, and on minor roads with a cross-centerline accident history. Rumble strips on a centerline have been shown to reduce head-on crashes by alerting drivers that they are leaving their lane of travel. On roadways with a travelway width of 20 ft., centerline rumble strips become obtrusive and are not recommended.

On minor roads, a cross-centerline crash rate of at least 10 per hundred million vehicle miles traveled would justify installation of centerline rumble strips. The cross-centerline crashes should include only those crashes that a centerline rumble strip could influence (distracted drivers, sleepy drivers, etc.). A crash that qualifies as a cross-centerline crash is any crash that begins with a vehicle encroaching on the opposing lane. It does not include crashes that begin by running off the right-side of the road, then overcorrecting and crossing the centerline or an out of control vehicle crossing the centerline due to wet pavement, snow, ice or roadway alignment.

In order to maintain the integrity of the rumble strip and the pavement, the pavement material must be either concrete or the final lift of bituminous material must be least 1 3/4 in. thick, and the pavement must have a final asphalt thickness of at least 3 3/4 in. Centerline rumble strips are not to be placed on bridges or within the limits of an intersection with left turn lanes. The limits of the intersection are defined by the beginning of the tapers for the left turn lanes. Centerline rumble strips are not to be placed on any joint. Longitudinal joints shall be offset 10 in. to accommodate the width of the rumble strip. The centerline pavement marking material is sprayed over the rumble strip.

Guardrail

Primary Guidance

- The clear zone concept is the preferred method of providing roadside safety.
- If providing the proper clear zone is impractical, then shielding (concrete barrier, guardrail, or guard cable) is preferred. If shielding is also impractical, the obstacle must be delineated as a final, but least preferred, alternative.
- Shielding should be specified when the possibility of poor public perception of the clear zone exists, especially in areas of high fill.

Discussion

Roadside Safety

About one in every three fatal accidents is a result of a single vehicle leaving the road. For this reason, the roadside must be given the same level of safety scrutiny as the traveled way. National best practice indicates the concept of the forgiving roadside as the responsible approach.

In general, there are six methods of accomplishing the forgiving roadside. In order of preference, they are:

1. Remove the obstacle.
2. Redesign the obstacle so it can be safely traversed.
3. Relocate the obstacle to a point where it is less likely to be struck.
4. Reduce impact severity by using an appropriate breakaway device.
5. Shield the obstacle.
6. Delineate the obstacle

The Clear Zone Concept

In the above list, items one through four define the clear zone concept and are always the preferred methods of attaining roadside safety.

Among the advantages of the clear zone are the opportunities for an errant vehicle to correct and regain the roadway or at least come to rest with a minimal amount of damage or injury. The clear zone concept has proven to be an effective treatment for most roadside obstacles including high fill areas, adverse slopes, and fixed objects.

Chapter three of the AASHTO Roadside Design Guide gives the proper geometric standards for use of clear zone.

Shielding

In many cases, it is either impractical or impossible to use any of the first four methods of delivering the forgiving roadside. In these cases, shielding will likely be used to protect the errant vehicle. Shielding is simply the use of a barrier to physically separate the vehicle from the obstacle.

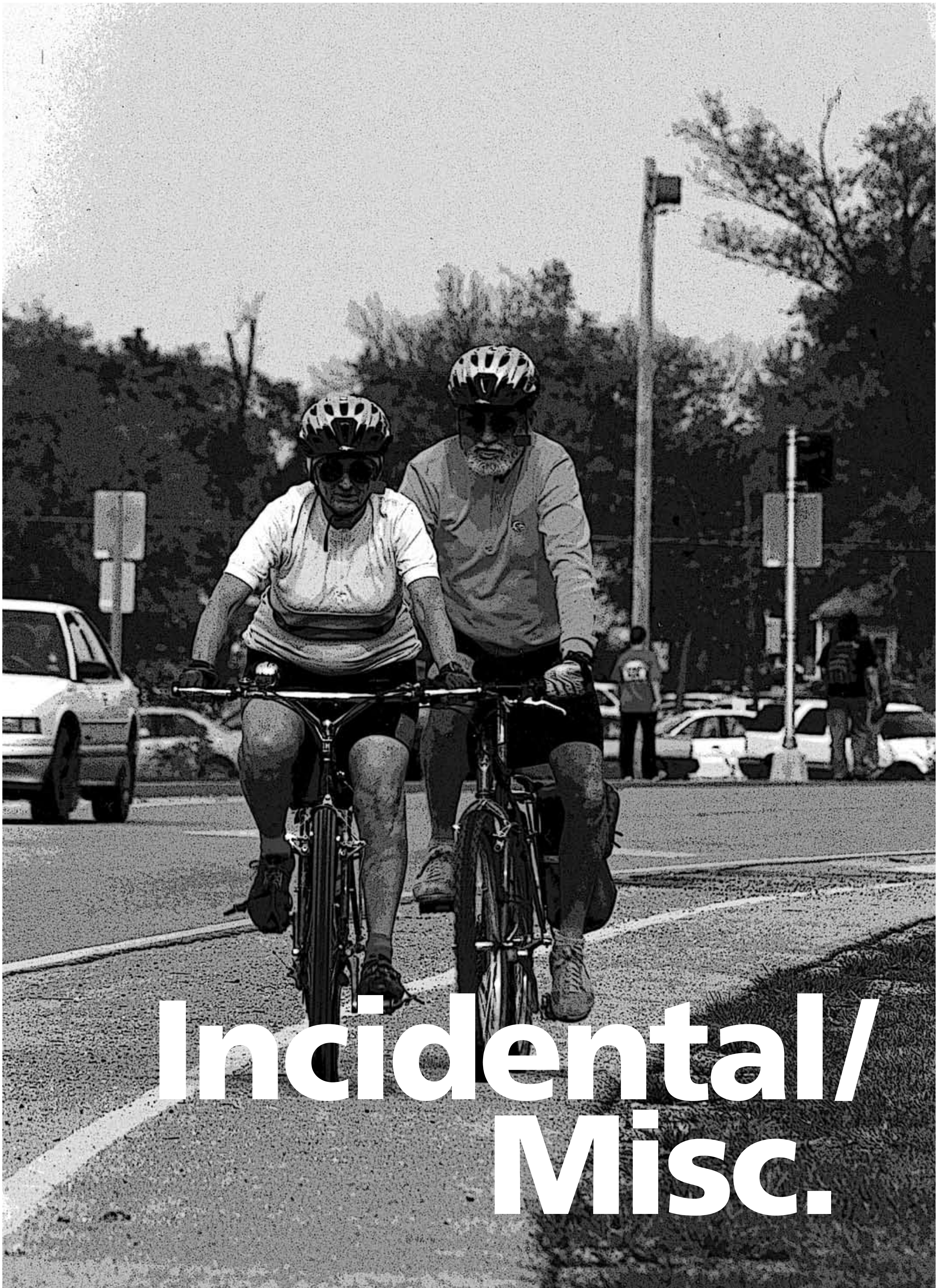
Barriers, whether they be concrete, guardrail, or guard cable are themselves, roadside obstacles. Even though they are engineered and rigorously tested to preserve the safety of vehicle occupants, all shielding systems cause damage to the vehicle and/or sustain damage themselves when struck. This is the reason their use is preferable only to obstacle delineation, which is widely considered a last resort.

In most cases, the clear zone concept is more practical than the use of a shielding barrier. There is, however, a notable exception.

Clear Zone Perception Issues

Occasionally, the public will poorly perceive the clear zone concept. In areas of very high fills, particularly those on the outside of a horizontal curve, the clear zone alone may give the impression of an unsafe situation. Even though the design may be completely safe within the guidance of the AASHTO Roadside Design Guide the public will inevitably lobby to have the area shielded, most often with guardrail.

In these cases, the best practice is to specify shielding initially. By doing so, MoDOT can avoid the needless expense of eventually using both treatments in the same location.



Incidental/ Misc.

Disposition of Routes

Primary Guidance

- A written agreement for disposition should be in place before a project is placed on the STIP.
- During project development, if a written agreement is revoked, then the project will be removed from the STIP. A written agreement must be in place before a project is advertised for letting.
- It is acceptable to negotiate small improvements to the existing route in order to make the relinquishment more attractive.

Discussion

MoDOT does not prefer to increase the roadway system's centerline mileage. Some projects such as realignments and perhaps some bypasses lend themselves well to disposing of the existing route. Often, realignment projects are replacing an existing alignment so that the existing route is no longer needed, except perhaps to provide access. Many times when a bypass is constructed, the existing route becomes a business route and actually functions more as a city street. Thus, it is not advantageous for MoDOT to include it in the statewide system. With this in mind, the disposition of the existing route is to be considered very early in the project development process. A written agreement to dispose of the existing route must be in place before the project is placed on the STIP.

Methods of Disposition

After the decision is made to not retain the existing route on MoDOT's system, three main methods of disposing the existing routes are available. Conveyance to a local public agency is a viable option when portions of the existing roadway will not be incorporated into the new facility but will need to remain in place serving public or private interests.

Some sections of the existing routes may not be needed to serve local public interests but may need to remain in place to serve local private interests. Project-specific situations like this may lead to conveying sections of the existing route to adjacent landowners.

When no other method to dispose the existing route can be found, i.e., if the local public agency and adjacent property owners are not receptive to accepting ownership of the route to be disposed, then the option of abandonment may be explored. It is not desirable to abandon a road. The Chief Counsel's Office or District Counsel must provide an opinion as to the ability of the department to successfully abandon the existing route. If this opinion suggests that MoDOT cannot successfully abandon the existing roadway and no other method of disposal can be found, then the road cannot be abandoned.

Negotiate Low Cost Improvements

It is permissible to negotiate small improvements to the existing roadway before it is disposed. For example, if the existing route is improved with a thin lift overlay or bridge rehabilitation, this may make it more acceptable to another entity.

Bicycle Facilities

Primary Guidance

MoDOT values the needs of all customers including non-motorized travelers. The provision of bicycle facilities on improvement projects during planning, and design activities is necessary when any one or more of the following conditions exist:

- The local jurisdiction has a comprehensive bicycle policy in the area of the proposed improvement.
- There is public support through local planning organizations for the provision of bicycle facilities.
- The local jurisdiction agrees to fund the total cost of the facility (right of way and construction) plus the provision of future maintenance.
- Bicycle traffic generators are located near the proposed project (i.e. residential neighborhoods, employment centers, shopping centers, schools, parks, libraries, etc.).
- There is evidence of bicycle traffic along the proposed project or the local community supports the incorporation of facilities at this time.
- The route provides access across a natural or man-made barrier (i.e. bridges over rivers, roadways, or railroads or under access controlled facilities).

Dedicated Bicycle facilities will not be provided on interstate roadways.

Discussion

Provision of Bicycle Facilities

The design and installation of bicycle facilities is at the sole discretion of the director or the district engineer acting as the director's designee. The decision to provide or not provide bicycle facilities on any project will be documented.

Bicycle facilities should be located off right of way wherever possible. Many times bicycle traffic can be accommodated on the proposed improvement simply through the use of a paved shoulder.

In developed areas, bicycle accommodations differ according to ADT and speed limit. Examples include bikelanes, wide curb lanes, paved shoulders or a shared use path separated from the travel way by a barrier curb; mountable curbs are prohibited as a positive separation. In rural areas bicycle accommodation may include a shared traveled way on low ADT roads or a paved shoulder on roads with higher ADTs.

By state law, bicycles are allowed to operate on all state highways, except travel lanes of interstates or where specifically prohibited. Where special bicycle accommodation is not provided, bicyclists will use the travel lane. For this reason, probable use by bicyclists should be considered in determining construction details such as drain grates and expansion joints.

Funding

Costs for new bicycle facilities, including right of way, construction and maintenance may be funded by local jurisdictions, by other non-department sources, or by the department itself. Enhancement funds cannot be used for maintenance of bicycle facilities. State funds will only be used for facilities located on MoDOT right of way. Bicycle facility funding arrangements for design, construction and maintenance must be addressed with a written agreement.

Existing bicycle facilities disturbed by any MoDOT improvement will be replaced at MoDOT's expense. Normal right of way and construction costs for this restoration will be included as a project cost for the proposed improvement.

Pedestrian Facilities

Primary Guidance

MoDOT values the needs of all of its customers including non-motorized travelers.

The provision of pedestrian facilities on improvement projects during planning, and design activities is necessary when any of the following conditions exist:

- The local jurisdiction has a comprehensive pedestrian policy in the area of the proposed improvement.
- There is public support through local planning organizations for the provision of pedestrian facilities.
- Pedestrian traffic generators are located near the proposed project (i.e. residential neighborhoods, employment centers, shopping centers, schools, parks, libraries, etc.).
- There is evidence of pedestrian traffic along the proposed project or the local community supports the incorporation of facilities at this time.
- The route provides access across a natural or man-made barrier (i.e. bridges over rivers, roadways, or railroads or under access controlled facilities).
- Existing sidewalks are disturbed by construction.

When sidewalks are constructed the following items are to be considered:

- In developed areas, sidewalks are to be separated from the traveled way by a barrier curb.
- Sidewalks are not to be designated on paved shoulders located behind a mountable curb
- In rural areas where it is necessary to accommodate pedestrian movements, a paved shoulder may be used.
- Designated sidewalks or pedestrian paths must be accessible according to the Americans with Disabilities Act of 1990 (ADA).
- Sidewalks are to be a minimum of 5 ft. wide and 4 in. thick. However, if necessary, the width of the sidewalk can be reduced to 4 ft., the minimum width allowed by ADA guidelines.
- Additional guidance regarding sidewalk design can be found in the AASHTO publication Guide for the Planning, Design, and Operation of Pedestrian Facilities or the Americans with Disabilities Act Accessibility Guidelines (ADAAG) publication Part 2 Designing Sidewalks and Trails for Access.
- Technical assistance on a case-by-case basis is also available from the Missouri office of the United States Access Board or MoDOT's Bicycle and Pedestrian Program Coordinator.

Discussion

When sidewalks are constructed, a barrier curb is sufficient to separate pedestrians from vehicular traffic on low speed roadways (posted speed less than 45 mph). At higher speeds a vehicle can mount a barrier at a relatively flat impact angle. Therefore, a barrier curb will not be used to separate vehicular traffic from pedestrians on roadways with a posted speed of 45mph or greater. In the event a sidewalk adjacent to a high-speed roadway is necessary, another type of physical separation between the vehicle and the pedestrian will be required.

Embankment Protection

Primary Guidance

- Rock blanket is used under the ends of all grade separation structures, around bridge end slopes, around culverts and to protect stream banks.
- Concrete slope protection may be used for aesthetic reasons to prevent slope erosion under the ends of grade separation structures or other locations.

Discussion

On most projects, rock blanket is the economical method of protecting the embankment around grade separation structures and bridge ends. The need for rock blanket at bridge ends and at bridge box culverts is specified on the bridge field check memorandum. The need for rock blanket at other locations is determined during plan field checks. Additional information on selecting the type and location of rock blanket can be found in PDM Subsection 4-09.5. Concrete slope protection is always used as an apron adjacent to the bridge wing walls in order to move any scouring away from the walls. Therefore, when rock blanket is used under bridge ends, a sufficient quantity of concrete slope protection must be specified to provide the apron as noted on Standard Plan 609.40 and shown on Standard Plan 611.60.

In urban areas, the project core team may decide that concrete slope protection is appropriate for specific aesthetic reasons. Concrete slope protection is constructed to a 4 in. thickness, unless otherwise specified on the plans. Other types of protection such as masonry construction may also be appropriate if funded by local jurisdictions, enhancement funds, or other non-department sources.

Borrow and Excess Earthwork

Primary Guidance

- When borrow material is necessary on a project, the contractor will be required to locate a satisfactory site from which the necessary material can be obtained.
- On rare occasions (i.e. highly sensitive environmental or cultural areas) a Commission furnished borrow site may be provided. When this is done, the site is indicated on the plans and the contractor must use the site to obtain the borrow material.
- When it is necessary to dispose of excess material, the above guidance is to be used.

Discussion

Balancing Projects

Every effort should be made during the design of a project to insure the quantities of fill and excavation are balanced (i.e., the excavation plus swell volume equals the fill plus shrinkage volume). This produces an economical project. However, for many projects this cannot be accomplished. When borrow material is necessary to provide sufficient fill material to complete the project, the contractor will be required to locate a satisfactory site from which the borrow will be obtained. This borrow material will be designated on the plans, quantified and paid for as "embankment in place".

Contractor Responsibilities

Clearance letters and other evidence of coordination with the appropriate regulatory agencies to obtain the necessary permits and approvals is to be provided to the resident engineer by the contractor. The contractor will resolve any concern or violation received from regulatory agencies resulting from contractor activities, including financial reimbursement to the Commission. The contractor will also reimburse the Commission for any reduced or eliminated FHWA financial participation in the project as a result of their failure to comply with the regulations. The contractor's responsibility in this area is described in language contained in the construction contract executed with the Commission.

Disposal Sites

When excess material is available on a project, the plans may indicate suggested disposal sites. However, mandatory disposal sites should not be indicated unless their use is economically justified. The FHWA should approve use of a mandatory site based solely on environmental considerations, providing a substantial enhancement to the environment can be made without excessive cost. The use of a mandatory disposal site is rare. Usually the contractor is given the option to find an acceptable location.

Minimum Right of Way Width

Primary Guidance

- Acquire only the minimum R/W width needed to build and maintain the facility.
- Attempt to minimize breaks in R/W line.

Discussion

The minimum R/W width established for each project should be the minimum width necessary to accommodate construction and proper maintenance of the roadway without an undue number of jogs in the R/W line. The established R/W width must also be sufficient to accommodate all roadway cross-section elements and any required appurtenances necessary for an adequate facility in the design year.

Urban Right of Way

In developed areas, it may be desirable to limit R/W width. The width should not be less than that required for all the elements of the cross-section design and utilities.

Utilities

The area for the placement of utilities is six feet wide, located parallel to and immediately inside the R/W line. Since utilities are typically relocated prior to road construction, R/W width needs to ensure that the new location is beyond the slope limits of the improvement.

Easements

It is permissible to utilize easements for cut and fill slopes. Many factors are to be considered when deciding how to provide space for the facility, such as the cost of permanent R/W verses easements, project goals and scope, proper maintenance of the facility and adjacent land use.

Future Improvements

It may be practical in certain cases for R/W to be purchased at the time of the initial project to accommodate future improvements. Typically this would be in developed areas that have both high R/W costs and identified needs of improvements in the near future.

Maintenance Considerations

A Maintenance representative is to be a member of the project core team. When establishing minimum R/W widths, maintenance items to consider include:

- Signing guidelines suggest fixed signs be 6 ft. to 12 ft. from the edge of pavement.
- Currently, mowing tractors are either 6 ft. or 15 ft. wide.
- Roadside vegetation guidelines suggest mowing 30 ft. to 80 ft. beyond the edge of pavement, provided the slope is 1V:3H or flatter. This controls the brushy vegetation more effectively. If the fence lines are not placed sufficiently far from the edge of pavement, the trees eventually grow over the road, requiring expensive maintenance activities such as renting bucket trucks to trim limbs over the road.

Design Exception

Primary Guidance

- Design exceptions are encouraged wherever the potential for additional value lies outside of written engineering policy.
- Design exceptions, using the standard form, must be completed and approved for each variance, whether the change fails to attain or exceeds engineering policy.
- A slightly different production and approval process exists for each of the following project categories:
  1. Full FHWA Oversight Projects
  2. Exempt Roadway Projects
  3. Exempt Bridge Projects
  4. Consultant Designed or Cost Share Projects

Discussion

When to Complete a Design Exception

A design exception is encouraged wherever the potential for additional value lies outside of written engineering policy. They should not be considered breaches of policy as much as opportunities to add practicality to design.

Exceptions are not requests for permission; rather, they simply document deliberate variances from engineering policy. As such, it is equally important to document those variances that exceed written standards as well as those that fail to attain them. That is not to say a designer should strive to exceed policy although such a course of action is, at times, the most practical solution.

How to complete a design exception

When the need for a design exception has been identified, the appropriate person (listed below) is responsible for completing the standard design exception form. This form is used nationwide and is believed to be more effective than casual notation as official documentation. The form must include a detailed description of the rationale for the change.

After completion of the form, the order of approval by transportation officials is given below, for each project category.

Full FHWA Oversight Projects
1. District Project manager
2. State Design and/or State Bridge Engineer
3. FHWA

Exempt Roadway Projects
1. District Project Manager
2. District Engineer

Exempt Bridge Projects
1. District Project Manager
2. District Engineer
3. State Bridge Engineer

Consultant Designed or Cost Share Projects
1. Consultant or Local Public Agency
2. Appropriate project-specific path shown above

The Federal Highway Administration (FHWA) reserves the right to audit the design exceptions of any federal aid project regardless of level of oversight.