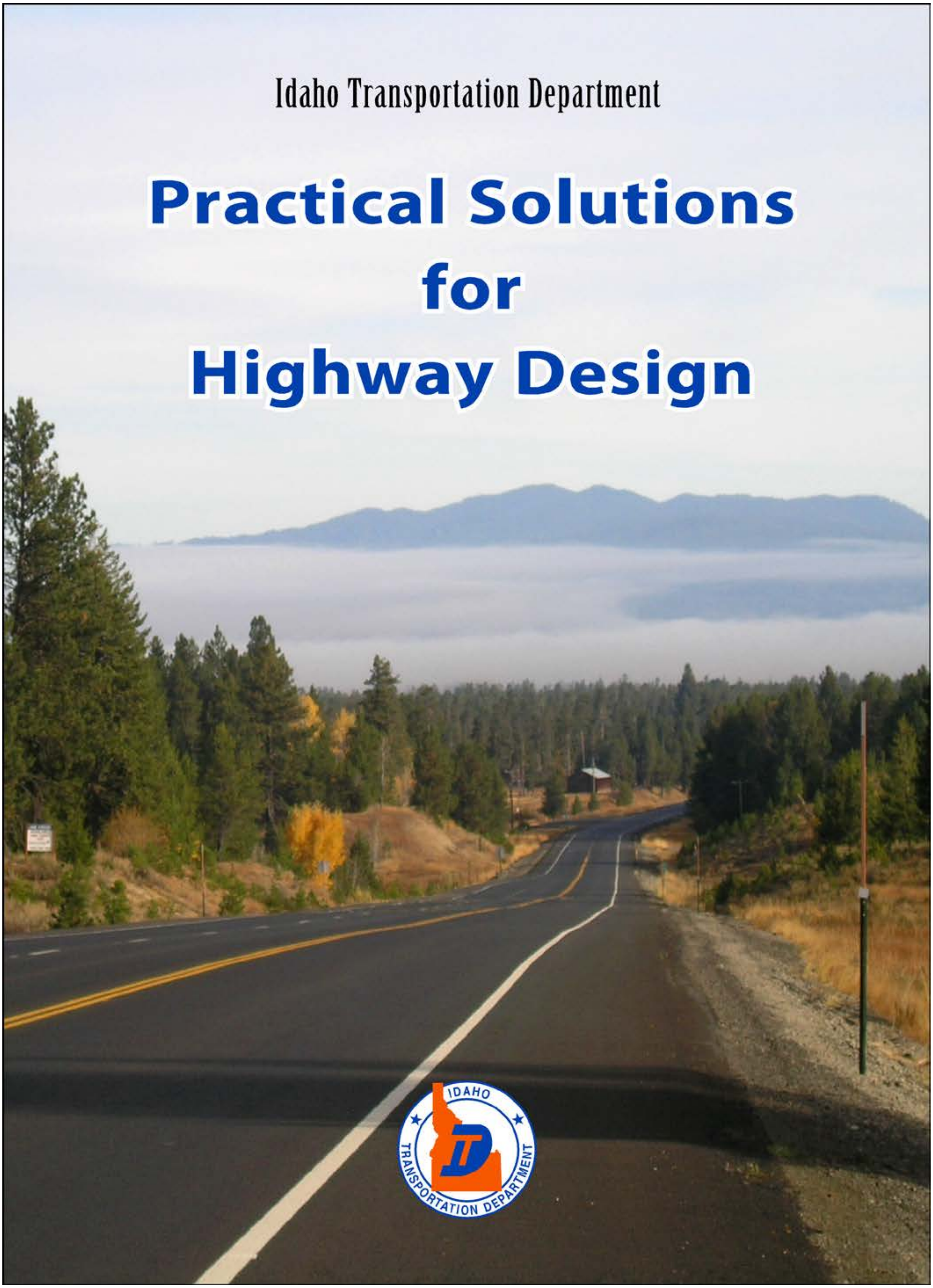
Idaho Transportation Department

Practical Solutions for Highway Design



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INTRODUCTION

Practical Design is intended to challenge traditional standards and develop safe and efficient solutions to solve today's project needs. ITD's philosophy is to build cost-effective projects to achieve a good, safe and efficient transportation system. Innovation, creativity and flexibility are necessary for us to accomplish our growing transportation challenges. Idaho's Practical Design initiatives are parallel to and mutually support our Context Sensitive Solutions approach to project development.

To accomplish Practical Design, we must properly define the project 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 and implement standards that are appropriate to the context of the surroundings. Our goal is to get the best value for the least cost. Life cycle costs must be considered without shifting the burden to maintenance.

Safety will not be compromised. Every project will make the facility safer after its completion.

ITD has applied the principles of practical solutions for years and in many cases uses practical solution principles on a routine basis. Formalizing this process will help bring uniformity to Idaho highway engineering designs. This guide does not supersede nor replace ITD's Design Manual, section manuals or administrative policy or change the need for documentation of design criteria or properly documented design exceptions. It is to be used as a companion document during the planning and design process.

Primary Guidance

The type of facility chosen must fulfill the purpose and need of the corridor and involves more than traffic volume alone.

The design speed will be the posted speed or as appropriate for the context and intent of the project.

Some congestion is not bad. A moderate amount of congestion promotes more efficient use of the facility by promoting carpooling and/or more use of alternate transportation.

It is adequate for all

routes in rural locations to accommodate the 20-year peak hour traffic at a Level of Service of D and off-peak traffic at a Level of Service of C. Similarly, it is adequate for all roads in urban or suburban locations to accommodate the 20-year peak hour traffic at a Level of Service of E, off-peak traffic at a Level of Service of D.

The facility must represent the appropriate balance between access and mobility for its intended purpose. When the desired level of service requires a four-lane facility, it will be designed as an expressway unless a freeway is mandated.

Design Discussion

Expressways are inherently safer than “head-to-head” facilities while allowing higher levels of access than freeways. Exceptions to this should be considered where safety and operational characteristics of the project dictate the need for a freeway. Expressways are rural or urban arterial roadways with controlled access. They are intended to provide a high level of safety and efficiency in the movement of a significant volume of traffic at high speed. Control of access refers to the regulation of public access rights to and from properties abutting the roadway. With controlled access, preference is given to through traffic while ingress and egress to adjoining properties is only permitted at specific locations such as public roadways. This access is normally provided through the use of at-grade crossings. In certain situations, access to adjoining properties can be provided through the use of frontage or backage roads or by restricting movements to a specific entrance (i.e., right-in and right-out).

Passing lanes may be used in areas where poor level of service is a result of inability to pass safely.

At times, a poor level of service can be attributed to a lack of passing opportunities and vehicle 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 opportunities to either direction of travel or a four-lane passing section.

System continuity along highway corridors is desirable and facility types for corridors may already have been established in corridor plans. Projects that lie within such corridors should conform to the established facility type.

TRANSPORTATION PLANNING

Transportation planning is a vital part in the development of projects. Decisions made in the planning stage will influence the final outcome of the project cost and functionality of the system in the future. Planning provides the engineer direction and establishes project scope. If a project is planned and scoped with a practical solution as a goal, criteria can be set to allow for a more economical design. Careful thought should be given to items that will have a large impact on the overall cost, design, safety and function of the project.

Sensitivity to the elements that have the largest impact on a project must be weighed against the overall objective of the project.

Practical Design is most efficient if it is considered during the planning stage. Use of management systems, such as maintenance management, pavement management and safety systems should be utilized to select the proper scope of work. Use of the Transition Plan and the location of the project should also be considered.

2.1 Design Criteria

2.1.1 Design Speed

The design speed will be the posted speed for existing facilities, or as appropriate for the context and intent of the project. The design speed of the facility will not only influence the operation of the facility, but impact the physical features of the facility. Design speed should fit the intent of the facility, surroundings and terrain and there should be continuity from one segment to another. Change in design speed may be acceptable when the terrain changes.

2.1.2 Interchanges / At-Grade Intersections

Interchanges can be very costly and should be used only when warranted. Right of way costs in urban areas will add to the overall cost of the interchange.

Roundabouts may be an alternative to signalization, but normally will take up more surface area.

Intersections on collectors and arterials are usually at grade. Factors such as level of service, accident history, traffic volume, grade and sight distance influence what attributes will impact design for an intersection (stop signs, signals, left and right turn lanes, round-abouts, etc.).

2.1.3 Two Way Left Turn Lanes (TWLTL)

TWLTL have been shown to be effective in reducing left turn and rear end accident rates in many applications. In urban and suburban applications, the reduction may be as much as 35%. The accident reduction in rural applications is not as dramatic, but if properly used at higher crash locations the TWLTL can have a large effect.

Two-way left-turn lanes do not function well once certain traffic volumes or recommended driveway spacing limits have been exceeded. In areas of high traffic volumes (i.e., AADT greater than 28,000) raised medians are at least 25 percent safer than multilane undivided sections and 15 percent safer than TWLTL. Two-way left-turn lanes should only be considered in places where commercial driveways make up a substantial portion of total driveways, overall driveway density is managed and where the percentage of vehicles turning left at peak hours is at least 20 percent.

Two-way left-turn lane configurations should not be used in areas that are expected to remain rural in the foreseeable future or on roadways with posted speeds in excess of 45 mph.

2.1.4 Passing Lanes

When passing opportunities become limited or nonexistent, passing lanes should be considered depending on the traffic volume. Passing lanes may also act as an interim solution to adding additional lanes along an entire route or segment of highway. Design speed and sight distance must be considered when evaluating passing lanes.

The speed benefits of passing lanes continue for approximately two miles downstream of the passing lane. Passing lanes typically reduce the percent time spent following by 58 to 62 percent, depending on traffic volume, within the passing lane itself. Passing lane percent time spent following benefits can continue up to 13 miles downstream of the passing lane.

Passing lanes are also used to improve safety on two-lane highways. Safety evaluations have shown that passing lanes and short four-lane sections reduce accident rates below the levels found on conventional two-lane highways. Installation of passing lanes can reduce accident rates by up to 25 percent. To maximize the traffic operational efficiency of a passing lane in level or rolling terrain, its length can vary from a minimum of 0.5 miles to a maximum of 2 miles.

ROADWAY DESIGN ELEMENTS

The design elements of the roadway will define the physical features of the final constructed road. Once the design speed and location of the roadway have been established, then the remainder of the design elements and physical features can be set.

3.1 Lane Width

Primary Guidance

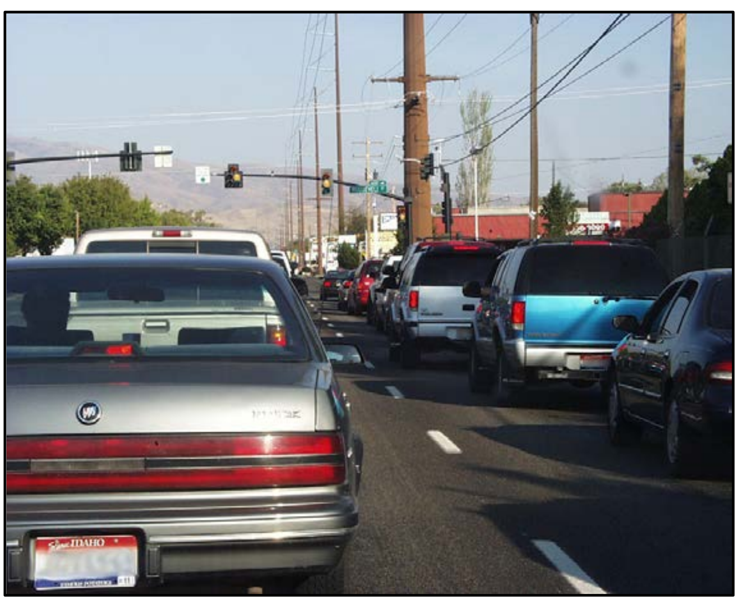
Interstate and National Highway System Routes: AASHTO Green Book, Chapter 4.

The standard lane width is 12 feet. Any deviation from this must be requested through a Design Exception Request.

Arterial and Collector Routes: Design Manual A.15.04, AASHTO Green Book, Chapters 4 and 5. Very Low Volume Road Widths (ADT< 400) can be based on AASHTO Guidelines for Geometric Design of Very Low Volume Local Roads.

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

Design Discussion



The overall lane width of a roadway influences the safety and comfort of the driver as well as the overall performance of a roadway. The 12 ft. lane provides desirable clearances between larger commercial vehicles traveling in opposite directions.

Narrow lanes force drivers to operate their vehicles laterally closer to each other than they would normally desire. Restricted clearances have the same effect. Further information on the effect of lane width on capacity and level of service can be found in the Highway Capacity Manual (HCM).

3.2Shoulder Width

Primary Guidance

- 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.

Design 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).

It is desirable that a vehicle stopped on the shoulder should clear the edge of the traveled way by at least 1 ft. and preferably by 2 ft.

A shoulder at least 2 ft. wide is encouraged on minor roadways.

When roadside barriers, walls or other vertical elements are present, the shoulder should be wide enough to ensure the vertical element is offset 2 ft. from the edge of the useable shoulder. 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.

- For rural major routes, rehabilitation projects should provide a minimum 4 ft. shoulder. Always consider the context of the surrounding route.

- 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.

- The width of the shoulder on the interstate has very little flexibility. On all other routes, the engineer has flexibility to select a shoulder width that best suits the needs of the facility. The width of the shoulder influences the motorists' comfort when driving the route and the purpose of that shoulder must consider potential uses such as safety for stalled vehicles, emergency vehicles, pedestrians, bikes, snow storage and maintenance. Shoulder width is more beneficial at higher traffic volumes than at lower ones.

- Shoulders provide more safety effect for sharp horizontal curves and roads with substantial grades than level and straight roads.

- Roads with paved shoulders have fewer accidents than similar roads with unsurfaced shoulders.

Roadway and shoulder widths are controlling criteria and any deviation from the Design Manual must be documented and may require a design exception.

3.3Horizontal & Vertical Alignments

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. On non-NHS projects, curves with safe speed design of 15 mph below the design speed may be designed under constraining conditions such as mountainous terrain or to avoid costly damage to right of way, if the curve is properly signed and documented.

Design Discussion

Horizontal alignments should be a balance between practical economics, design safety and continuous driver operations. This can be achieved by the selection of an appropriate design speed. The operational characteristics of a roadway are directly affected by the horizontal alignment. 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 Green Book). The Green Book 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.

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).

Design Discussion

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, level of service and other safety factors in order to properly anticipate the posted speed. Highways will be designed according to their anticipated posted speed.

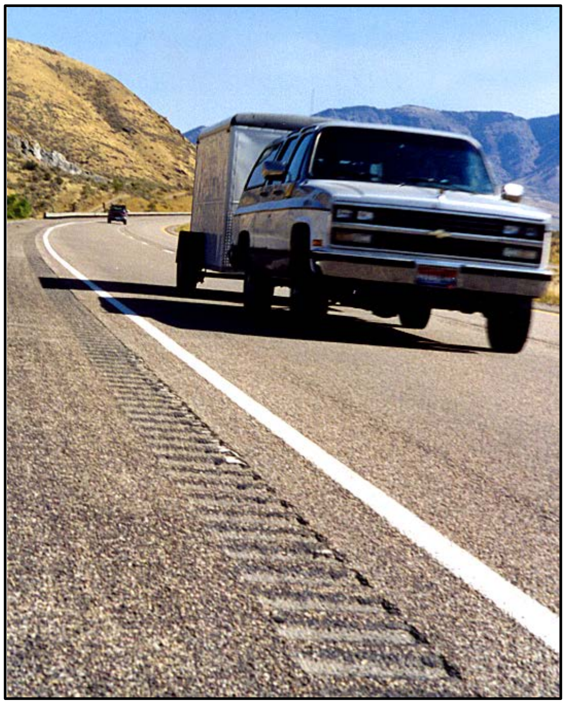
Once the anticipated posted speed is identified, the road's vertical alignment can be selected. The AASHTO publication A *Policy on Geometric Design of Highways and Streets* (the Green Book) can be used as guidance to determine maximum vertical grades. When terrain or some other factor causes the maximum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

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.

Horizontal and vertical curves are controlling criteria and deviations from the Design Manual must be documented and may require a design exception.

3.4Roadside Design Elements

Roadside Safety - Rumble Strips



A cost effective safety improvement to all roadways is the use of shoulder rumble strips. A rumble strip is a longitudinal design feature installed on a paved shoulder near the travel way. The design and installation of rumble strips is important to ensure the desired overall effectiveness is met. Research has shown that shoulder rumble strips are an effective countermeasure to reduce run off the road crashes. On rural roads, run off the road accidents account for a large number of accidents and fatalities. Studies suggest that rumble strips can largely reduce rural crashes caused due to driver fatigue, drowsiness and inattentive driving.

Primary Guidance

- Rumble strips are to be provided on roadways with paved shoulders at least

1) 4 ft. wide.

- Edge line rumble strips may be used on minor roadways as a specific safe countermeasure with a paved shoulder.
- Where several sections of edge line rumble strips are installed in close proximity, continuity should be maintained.
- Centerline rumble strips should be used on roadways with a significant head-on accident history. Where several sections of centerline rumble strips are installed in close proximity, continuity should be maintained.
- Rumble stripes (rumble under edge line markings) may be used where shoulder width will not accommodate ITD’s standard rumble strip.
- Rumble strips should not be in or near urban areas.

Design Discussion

Edge line rumble strips are used to enhance safety on every shoulder at least 4 ft. wide, unless the shoulder has a curbed section or is intended to be used as a future travel lane. In urban areas, edge line rumble strips should be omitted where noise is a concern.

Rumble strips on a centerline have been shown to reduce head-on crashes by alerting drivers that they are leaving their lane of travel. 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 inches to accommodate the width of the rumble strip. The centerline pavement marking material is sprayed over the rumble strip.

Roadside Safety – 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 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.

Design 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 method 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 3 of the AASHTO Roadside Design Guide gives the proper geometric standards for use of clear zone. 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 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.

3.5Pavement Structure

Paved Shoulders

Primary Guidance

- On major roads, the entire shoulder width should be paved.
- On minor roads, the shoulder may be aggregate stabilized except where maintenance or safety concerns (e.g., edge drop-off, high run off road occurrence) justify a paved shoulder.
- Shoulders on urban roadways with access control (major or minor) are to be paved.

Design 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 part of the pavement design configuration. Where a paved shoulder is provided, the full thickness of the travel way pavement is extended laterally a minimum 2 ft. outside the travel way and a reduced ballast section used for the remainder. Ramp shoulders should be consistent with the mainline.

Pavement

Primary Guidance

- Spot improvements such as pavement replacement less than 0.5 miles in length adjacent to bridge replacements, notch widening for minor shoulder improvements, widening for turning lanes with a turning movement that has less than 1,000 vehicles per day or for short realignments, patching and soft spot repair, a pavement thickness determination by the Materials Section is not required. The new pavement thickness is to be equivalent to the existing pavement.

- For improvements greater than 0.5 miles in length or widening for turning lanes with a turning movement with more than 1,000 vehicles per day, the Materials Section will make a pavement thickness determination.

3.6 Structures

Primary Guidance

Bridge width equaling full roadbed width is desirable.

Design Discussion

Bridge width will vary based on project scope, context of surrounding road, type of road, ADT 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. Interstate structures will be built to AASHTO standards for shoulder width and barriers. For major highways, the bridge width should equal the roadway width. Additional width may be warranted depending on use and ADT. Safety studies have shown that bridges should be a minimum of 24 ft. wide.

The desirable width of bridges on major roads includes the traveled lanes and shoulders. The minimum width of bridges for major roads is 28 ft. There could be situations where an existing bridge may be rehabilitated and used in place even though it may not be the desirable width.

The desirable minimum width of bridges on minor roads includes the traveled lanes and

2 ft. shoulders. For routes with 10 ft. lanes, the bridge width to strive for is 24 ft. and for routes with 12 ft. lanes, the desirable width is 28 ft.

3.7 Bicycle and Pedestrian Facilities

Accommodations for bicycles and pedestrians may be required and lane width adjustments may be warranted. When pedestrians use the right of way, the Americans with Disabilities Act (ADA) requirements apply. Consult the ITD Bicycle Guide Manual and the ITD Design Manual for Pedestrian Requirements.

Bicycle Facilities

Primary Guidance

ITD values the needs of all customers including non-motorized travelers. The provision of bicycle facilities on improvement projects during planning and design activities may be 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.
- 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 the 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.

Design Discussion

Provision of Bicycle Facilities: 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 limits. Examples include bike lanes, wide curb lanes, paved shoulders or a shared use path separated from the travel way by a barrier curb. 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, other non-department sources or the department

itself. Enhancement funds cannot be used for maintenance of bicycle facilities. State funds will only be used for facilities located on ITD 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 ITD improvement will be replaced at ITD'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

ITD values the needs of all its customers including non-motorized travelers. The provision of pedestrian facilities on improvement projects during planning and design activities are 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 the 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).

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

- 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 should be a minimum of 5 ft. wide. 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 and the Public Rights-of-Way Access Advisory Committe*e (PROWAAC).

3.8 Property (Right of Way)

The cost of purchasing property needed on urban projects can be a substantial portion of the overall cost of the project. The cost to relocate businesses and residences can be significant on some projects. These elements must be considered when determining right of way needs for a project.

During the planning stage, there is the opportunity for cities and counties to plan for growth and transportation projects together, by requiring setbacks and property transfer when development occurs. If this is done properly, needed project right of way could be available once a transportation project is initiated.

During design, many factors impact the right of way needs. Lane width, horizontal and vertical alignment, shoulder width, cut and fill heights, retaining walls, bridges and other elements at times can be varied to influence right of way needs.

From the time a project is proposed and throughout the design process, the value of property can continue to rise. The design team and right of way agent must work closely to ensure that the right of way needs are met and that all regulations are followed. The design engineer should be precise on the amount of right of way needed, secure property as early as possible and communicate early and often with property owners.

3.9 Processed Materials

Processed materials including crushed aggregates, asphalt, cement and steel are significant cost elements on most transportation projects.

3.9.1 Aggregate

Aggregates are produced by crushing rock, cobbles, boulders and man-made materials to specific sizes (gradation). Both usable materials (within the gradation ranges) and un-usable materials (waste) are produced. Requiring narrowly defined gradations for aggregate needs can lead to the production of large quantities of waste. The engineer must evaluate the needed gradations and the ratio of the cost of material versus the thickness or amount needed to determine the most cost effective solution for each project.

A project's design may not need thick aggregate layers or narrowly graded aggregate materials beneath shoulders, gores, medians and behind guardrail. The engineer may consider less expensive, broader graded materials for some projects. These same principles apply to the design of aggregate materials used for drainage applications such as riprap, pipe bedding, backfill and drain materials.

Engineers should consider gradation and quality specifications for aggregates for pavements and backfill needs during preparation of Material Phase reports to determine the most cost effective materials. Engineers should also consider materials and gradations during preparation of hydraulic reports. Engineers should consult with local and regional suppliers to the project for suitable available materials.

Special graded aggregates may give the roadway structure added strength, but the engineer must assess the cost versus the reduction in larger aggregate thickness. When making special gradations, a sizable amount of wasted material is produced that may otherwise be used in the roadway. Substitution of geotextiles or geogrids may allow the engineer to decrease the quantities of crushed aggregates where cost is high or availability of crushed aggregate is limited.

3.9.2 Asphalt

Asphalt and aggregate mixed to form asphaltic concrete (plant mix) is a major expenditure on projects requiring substantial paving. Controlling the thickness and area of flexible pavement will control costs significantly. Assessing the performance grades used, costs and local availability of various mixes will also aid in reducing flexible pavement costs. Design elements for plant mix pavement to be assessed during design include:

- Thickness of the asphalt surfacing
- Mix design
- Paving only travel areas
- Shoulders are for emergencies and can be thinner.

3.9.3 Cement

Evaluation of concrete products, rigid pavement, concrete piping, walls, barriers and bridge elements should be an integral part of design. For paving, design can consider thickness depending on the type of facility, ADT and the quality of local aggregates. For other concrete products, the engineer should weigh the strength and longevity of concrete versus other products and the type and use of the highway.

Engineers should consider subgrade strengthening in the design for rigid pavements during preparation of Material Phase Reports. Engineers should consult with regional and local suppliers near the project for suitable materials. Design engineers should assess all areas to be paved to determine if non-traffic areas can use a less costly surfacing option. Engineers also need to make an assessment of bridge materials to determine the most cost effective option for the time and location. The engineer may consider alternate bids when choices of material may not be known.

Consideration should be given to the transportation of materials to a job site. Remote sites may make transport for certain types of materials more difficult. The engineer must consider the adequacy of the transportation facilities to the project's site for the materials specified. Alternate bid allows the contractor to select the material best suited for their operation and adequacy of the transportation facilities to the project site.

3.10 Traffic Control

Traffic control during construction can be costly to both the overall project and the traveling public. The two types of costs incurred are capital costs to the project (costs for controlling traffic throughout the project and costs to perform work with public traffic mixed into contractor operations) and road user costs. Road user costs are incurred by public motorists due to delays and added miles in detours. Capital costs are real costs to the project. Road user costs will not usually impact the cost to the project, but may impact public perception toward transportation projects. The engineer must be sensitive to both when developing traffic control plans as well as when reviewing and approving contractor traffic control plans.

If the project is on a major route (interstate or high volume highway), has a long duration or causes long daily delays, the user costs can be very high and negatively impact local businesses and economies. Engineers should weigh the added cost of accelerated construction (double shifting, multiple crews, new technology and night work) versus normal construction along with other options such as temporary detours to shorten the construction time. The engineer should also avoid lane reductions for any length of time, if possible, during peak travel times in congested areas.

Removal of all traffic from a project construction zone will allow contractors to conduct work without interaction with public motorists. This option will provide the safest construction zone, however the engineer must ensure that there is no wasted time while work is being performed, as road user costs could go up due to detours and alternate routes.

When positive barriers are used to separate the traveling public and construction, costs can increase because the contractor's operations are restricted. (The Work Zone Safety and Mobility Policy gives the requirements for proper separation and protection.) Multiple movements of signing and barriers and installation of temporary pavement can add substantial costs to a project. This situation is less safe for the public and contractor employees than detours; however a full road closure is not needed. Mixing construction activities and public traffic leads to unsafe conditions and inefficient contractor operations and should be avoided.

3.11 Value Engineering

Practical Design is not intended to be used in place of Value Engineering. Value Engineering is to be considered on all projects of a complex nature with a high potential for savings.

References

Practical Solutions to Highway Design