Roadway Geometric Design 3

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INTRODUCTION

This course is the **third** in a series of five volumes that summarizes and highlights the geometric design process for modern roads and highways. Subjects covered include: *traffic barriers; local roads; collector roads; rural and urban arterials;* and *freeways.* The contents of this document are intended to serve as guidance and not as an absolute standard or rule.

When you complete this course, you should be familiar with the general design guidelines for roadways and different road types. The course objective is to give engineers and designers an in-depth look at the principles to be considered when selecting and designing roads.

The *American Association of State Highway and Transportation Officials (AASHTO)* publishes and approves information on geometric roadway design for use by individual state transportation agencies. The majority of today's geometric design research is sponsored and directed by AASHTO and the Federal Highway Administration (FHWA) through the National Cooperative Highway Research Program (NCHRP).

For this course, AASHTO's **A Policy on Geometric Design of Highways and Streets** (also known as the "Green Book") will be used primarily for fundamental geometric design principles. This text is considered to be the primary guidance for U.S. roadway geometric design.

This document is intended to explain some principles of good roadway design and show the potential trade-offs that the designer may have to face in a variety of situations, including cost of construction, maintenance requirements, compatibility with adjacent land uses, operational and safety impacts, environmental sensitivity, and compatibility with infrastructure needs.

The practice of geometric design will always be a dynamic process with a multitude of considerations: driver age and abilities; vehicle fleet variety and types; construction costs; maintenance requirements; environmental sensitivity; land use; aesthetics; and most importantly, societal values. Despite this dynamic character, the primary objective of good design will remain as it has always been – to provide a safe, efficient and cost-effective roadway that addresses conflicting needs or concerns.

TRAFFIC BARRIERS

Traffic barriers (*guardrails, concrete barriers, and attenuation devices*) are used to keep vehicles on the road and prevent them from colliding with dangerous objects. Determining their need (including location and type) are critical factors in roadway design. The “clear zone” distance should be considered when determining the need for roadside protection.

Barriers should only be used where the crash severity is less with the barrier than a collision with the hazard behind it. The barriers themselves may be an object that can be struck with a significant crash severity and require continual maintenance.

The potential danger that a roadside hazard might have to roadway users should be assessed based on *size, shape, rigidity, and distance from the traveled way*.

Common Traffic Barrier Locations

Bridge ends

Near steep roadway slopes

Drainage facilities with steep drops

Signs/poles or other roadside hazards

Longitudinal barriers are used along roadsides and medians to redirect errant vehicles. These are subdivided into types (*flexible, semirigid, or rigid*) based on the amount of deflection that occurs upon impact by a vehicle.

Flexible barriers deflect considerably when struck by dissipating energy through tension in longitudinal members, deformation of posts/rail elements and vehicle bodywork, and friction between vehicle and barrier. Flexible barriers are meant to contain and not redirect vehicles. These systems also need more lateral clearance from fixed objects due to the resulting deflection from vehicle impact.

For **semi-rigid barriers,** impact energy is dissipated through deformation of the rails, posts, soil and bodywork, plus rail/vehicle friction. Longitudinal members spread the impact force over a number of posts – posts near the impact area are designed to break or tear away. Semirigid systems maintain controlled deflection limits and redirect errant vehicles.

Rigid systems are typically made of reinforced concrete with negligible deflection when struck by a vehicle. Impact energy is dissipated through vehicle deformation and redirection. The shape of the barrier is designed to redirect vehicles into a path parallel to the rigid barrier. These are most appropriate for locations with shallow impact angles or where deflection cannot be tolerated (work zones, hazards, etc.). Rigid barriers typically require very minimal maintenance.

Roadside Obstacles Options

- Remove or redesign the obstacle
- Relocate the obstacle
- Reduce impact severity with appropriate devices
- Redirect vehicles by shielding the obstacle
- Delineate the obstacle
- Take no action

Roadside Barriers

Roadside barriers are longitudinal systems designed to protect vehicles from roadside obstacles or hazards (steep slopes, fixed objects, sensitive areas, pedestrians, bicycles, etc.) on either side of the roadway. These barriers should be installed beyond the edge of the roadway's shoulder in order to use full shoulder width. Any fill needs to be wide enough to provide adequate lateral support for the barrier. Exposed barrier ends should be properly treated to prevent the creation of a dangerous roadside hazard. Typical treatments include: *buried ends; earth mounds; flared ends; crash cushions; and crash-tested terminals.*

Median Barriers

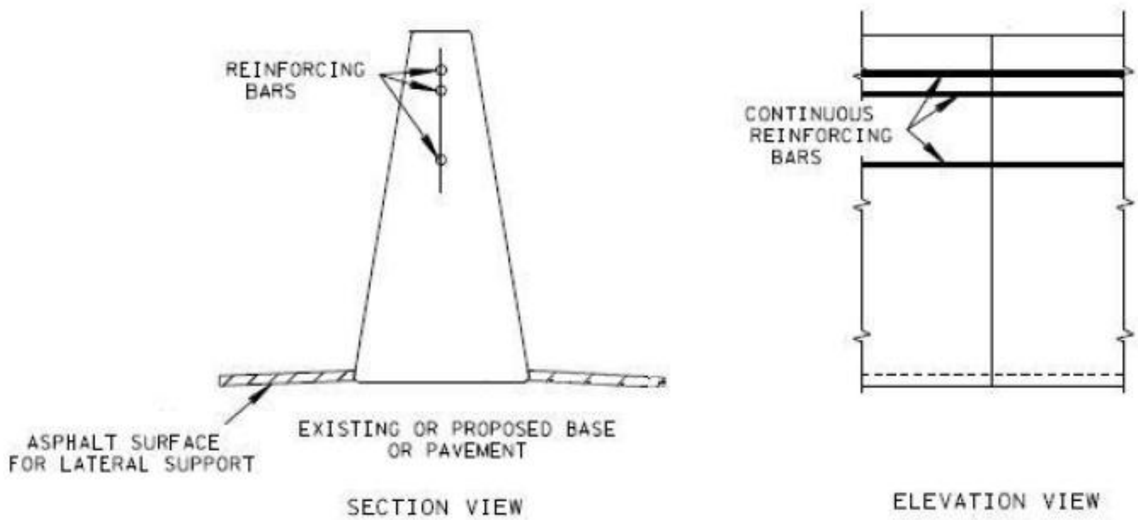
Median barriers are another type of longitudinal system used to prevent vehicles from crossing the median and crashing head-on into oncoming traffic. For roadways with low traffic volumes or wide medians, the likelihood of errant vehicles crossing the median and hitting an opposing vehicle is relatively low. In this case, median barriers are typically used at locations with a history of collisions or new roads where high crash rates are expected.

Cross-median crashes are typically reduced by median barriers – however, total crash frequency usually increases due to the decreased space available for return-to-the-road maneuvers.

Median Barrier Considerations

- Alignment
- Crash history
- Median openings
- Sight distance
- Design speed
- Traffic volume
- Median width

The potential impact of median barriers on horizontal curve sight distance should also be considered during the selection and design of the median barrier.



Typical Concrete Barrier Wall

Unlike roadside systems, median barriers are designed to be struck from either side. Types of these barriers include: *doublefaced steel W-beam on strong posts; box-beam on weak posts; concrete barriers; and cable barrier on light steel posts.* Each type has its own unique performance characteristics and applicability, depending on the design circumstances. It is crucial to tailor the dynamic lateral deflection to the location – **maximum deflection should be less than one-half the median width.** This should prevent travel into opposing traffic, and redirect the errant vehicle in the same direction as flowing traffic.

Bridge Railings

Bridge railings are used to restrain and redirect errant vehicles and prevent them from crashing off the structure onto whatever is below. These longitudinal traffic barriers differ from other types by being a structural extension of the bridge as opposed to having a foundation in/on soil. Typical bridge rails are either multi-rail tubular steel or concrete barriers that are higher than roadside barriers to prevent users from vaulting over the rail and off the bridge.

Bridge railings can be extended with roadside barriers and crashworthy terminals for approaches to a bridge. Any end treatments should help reduce crash severity but not impede pedestrian usage for bridges with walkways.

Crash Cushions

The main function of crash cushions is to bring errant vehicles to a safe stop after head-on collisions or redirect vehicles away from a hazard. These may be used to shield rigid objects, roadside and median barrier terminals.

Typical Crash Cushion Applications

- End of bridge rails
- Bridge piers
- Overhead sign supports
- Abutments
- Retaining wall ends

Locations for curb cushions require a level area without curbs or other hazards/obstacles.

The *AASHTO Roadside Design Guide* contains warrants and design guidelines for determining the need, selection and design for barriers.

MEDIANS

Roadway medians separate opposing lanes of traffic and are suitable for multilane arterials. This area is located between the edges of opposing traveled ways (including any left shoulders). Median width and design characteristics are among the most important safety features of high-speed highways in both urban and rural areas.

Principal Median Functions

- Separate opposing traffic
- Provide clear recovery area (errant vehicles)
- Provide emergency stopping areas
- Allow space for speed changes
- Provide storage for left-turns and U-turns
- Lessen headlight glare
- Provide space for future widths

Medians need to be highly visible regardless of time of day and should contrast with the traveled way to ensure maximum efficiency. Benefits of medians include: providing an open green space; offering a pedestrian refuge area; and controlling intersection traffic conflicts.

Median widths are dependent on the roadway type and location. Any proposed median widths should be evaluated for potential barrier needs. Ideally, median widths (typically 4 to 80 feet) should be sufficient so that no barrier is needed, when practical. The wider medians are safer but more costly - requiring more right-of-way, construction, and maintenance. These costs often limit median widths – costs increase as median widths increase.