Roadway Cross-Sections

An Online Continuing Education Course for Engineers

Course Number: T-4017

Credit: 4 Hours / 4 PDH / 4 CPD

Roadway Cross-Sections

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Introduction

The AASHTO "Green Book" defines a **roadway cross-section** as *"a vertical section of the ground and roadway at right angles to the centerline of the roadway, including all elements of a highway or street from right-of-way line"*. Along with the vertical alignment (grades and vertical curves) and horizontal alignment (tangents and curves), the roadway cross-section (lanes and shoulders, curbs, medians, roadside slopes and ditches, sidewalks) helps to present a three-dimensional roadway model. Its ultimate goal is to provide a safe, smooth-flowing facility that is crash-free.

This course focuses on the geometric design of cross-sections for modern roads and highways. Its contents are intended to serve as guidance and not as an absolute standard or rule.

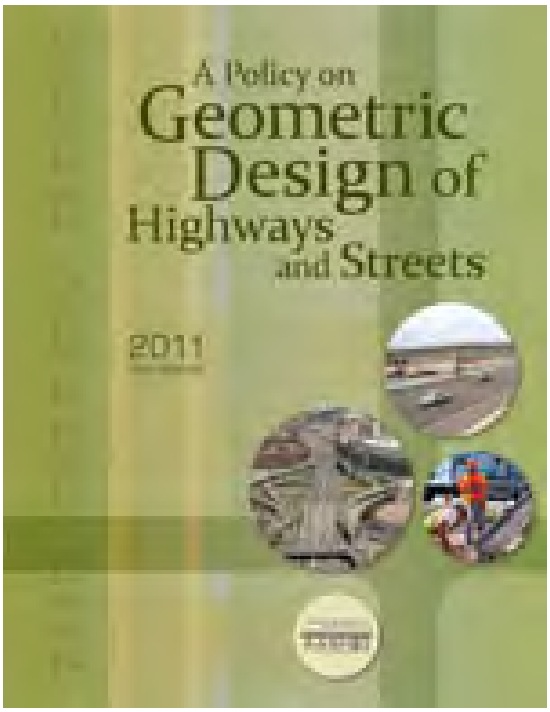
Upon course completion, you should be familiar with the general design concepts for roadway cross-sections. The course objective is to give engineers and designers an in-depth look at the principles to be considered when selecting and designing a roadway.

Subjects covered include:

- Design guidelines
- Traveled way
- Lane width
- Shoulders
- Rumble strips
- Roadside design
- Curbs
- Drainage channels & sideslopes
- Traffic barriers
- Medians
- Frontage roads
- Outer separations
- Noise control
- Roadside control
- Tunnels
- Pedestrian facilities
- Bicycle facilities

- Bus turnouts
- On-street parking

A Policy on Geometric Design of Highways and Streets (also known as the "Green Book") published by the *American Association of State Highway and Transportation Officials (AASHTO)* is considered to be the primary guidance for U.S. roadway design. For this course, **Chapter 4 - Cross-Section Elements** will be used exclusively for fundamental roadway geometric design principles.



Background

Roadway geometric design consists of the following fundamental three-dimensional features:

> **Vertical alignment -** grades and vertical curves ("profile")
> **Horizontal alignment -** tangents and horizontal curves ("centerline")
> **Cross section -** lanes and shoulders, curbs, medians, roadside slopes and ditches, sidewalks

Combined, these elements contribute to the roadway's operational quality and safety by striving to provide a smooth-flowing, crash-free facility.

Roadway geometric design will always be a dynamic process with a multitude of considerations, such as:

- *driver age and abilities*
- *vehicle fleet variety and types*
- *construction costs*
- *maintenance requirements*
- *environmental sensitivity*
- *land use*
- *aesthetics*
- and most importantly, *societal values.*

Engineers must understand how all of the roadway elements contribute to overall safety and operation. Applying design standards and criteria to 'solve' a problem is not enough.

The fundamental objective of good geometric design will remain as it has always been – *to produce a roadway that is safe, efficient, reasonably economic and sensitive to conflicting concerns.*

Design Guidelines

In today's world, designers need to understand how all elements of the roadway affect its safety and operation – *horizontal and vertical alignment, cross section, intersections, and interchanges.* Each location presents its own unique set of design challenges.

A designer's ability to make reasonable, cost-effective, and site-specific choices will be dependent on their understanding of the functional rationale behind their design guidelines. Design criteria reflect the research and experience which consider local site conditions, needs of space, and other transportation factors. Their use provides a measure of consistency and quality for roads designed by different individuals.

Design Criteria

- Safety
- Operational quality
- Cost-effectiveness
- Maintenance needs

Roadways are designed in conjunction with design guidelines and standards that take into account speed, vehicle type, road grade (slope), view obstructions, and stopping distance. Using these guidelines along with good engineering judgment will help produce a comfortable, safe, and aesthetically pleasing roadway.

AASHTO

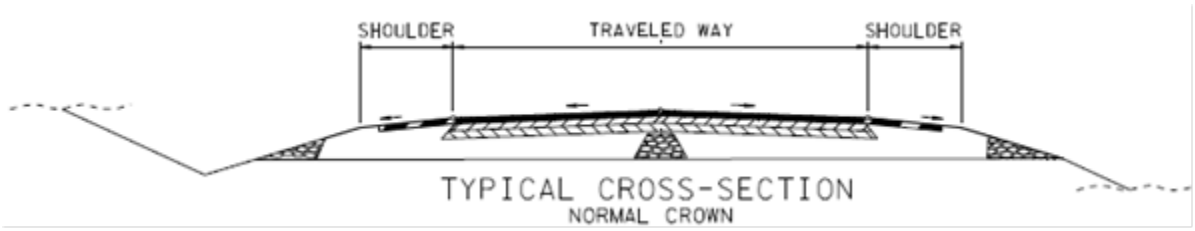
The *American Association of State Highway and Transportation Officials (AASHTO)* publishes and approves information on geometric roadway design for use by individual state transportation agencies. The majority of today's geometric design research is sponsored and directed by AASHTO and the Federal Highway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

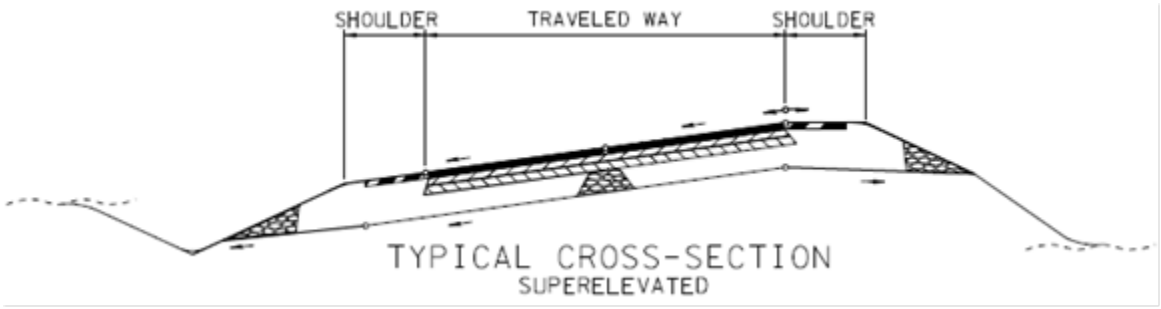
Individual transportation agencies adopt or develop their own design criteria, referencing approved AASHTO policies. Most states usually adopt major portions of the AASHTO design values or adopt the AASHTO policy completely as their design criteria.

Cross-Section

Traveled Way

AASHTO defines the roadway's traveled way as *"the portion of the roadway for the movement of vehicles, exclusive of shoulders and bicycle lanes"*. This area usually contains two or more lanes for roadway traffic.





Surface Type Criteria

Initial cost	Traffic volume & composition
Soil characteristics	Climate
Maintenance cost	Pavement performance
Availability of materials	Energy conservation
Service-life cost	

Important geometric design considerations include the effect on driver behavior, surface resiliency, drainage ability, and skid resistance. The AASHTO Mechanistic-Empirical Pavement Design Guide provides additional detailed information about the structural design of pavements.

The number of required roadway lanes is typically determined by the analysis procedures in the Highway Capacity Manual for the level of service desired.

Community input may also show that a lower level of service may be acceptable for *the situation versus the level of service* normally provided for new construction projects.

Signalized intersections are an important factor controlling the capacity of an urban roadway. While there may be more flexibility in determining their number of lanes, the need to distribute traffic safely will determine if any expansion of the approach roadway is warranted. Any additional lanes at the intersections can be tailored in a variety of configurations to serve traffic needs.

Cross Slope

Cross slopes on undivided roads have a high point (crown) in the center and slope downward toward the roadway edges. These downward slopes can be plane, rounded, or a combination of both.

Plane - *Slope break at crown line*
Uniform slope on each side

Rounded - *Parabolic cross-section*
Rounded surface at crown line
Increasing slope toward edges

The rounded section is beneficial for roadway drainage due to its steepening cross slope toward the edge of traveled way. However, disadvantages include: difficult construction; excessive outer lane cross slopes; and pavement transitions at intersection areas.

Pavement cross slopes on *divided* roadways can be unidirectional or crowned separately (i.e. undivided road). Roadways with separate crowns may be advantageous for their drainage ability but may require more drainage facilities for stormwater runoff. Unidirectional cross slopes

provide more driver comfort for lane changing and drain toward or away from the roadway median. Drainage toward the median helps free the outer lanes from surface water. Drainage away from the median minimizes drainage (savings in structures) and simplifies intersection treatment.

The rate of roadway cross slope is a crucial design element for cross-sections. For curved locations, the outside edge of the road is **superelevated** above the centerline. Since the road is banked toward the inside of the curve, gravity forces the vehicle down near the inside of the curve and provides some of the centripetal force needed to go around the curve.

Cross slopes over 2 percent are perceptible to motorists and may require a conscious effort in terms of vehicle steering. Steep cross slopes increase the chances of lateral skidding on wet or icy roadways or when making emergency stops on dry pavement.

The accepted range of cross slope for paved two-lane roadways (**normal crown**) is *1.5 to 2 percent*. Any effect on steering is barely perceptible for vehicles operating on crowned pavements. Cross slopes should not exceed 3% on tangent alignments – unless there are three or more lanes in one direction. Cross slope rates over 2 percent are unsuited for high-speed roadways (crowned in the center) due to a total rollover rate over 4 percent. Heavy vehicles with high centers of gravity would have difficulty in maintaining control when traveling at high speeds over steep slopes.

Steeper cross slopes (2.5 percent) may be used for roads su… …nse rainfall that need increased surface drainage. Reasonabl… …e to minimize ponding on flat roadway sections … …letely level sections can drain very slowly and … …-graded pavements or pavement grooving ma… …urface.

Greater cross slope rate… …urface materials, increased cross slope ra… …r absorption into the road surface.

A minimum cross slope … …r gutter sections may permit lower cross slope …

AASHTO provides tables … …termined based on design speed and curve ra… …roadway design guides and manuals.

Skid Resistance

With skidding incidents be… …ways need to have adequate skid resistance for typical braki… …maneuvers. Crashes due to skidding cannot be written off simply as *driver error* or *driving too fast for conditions.*