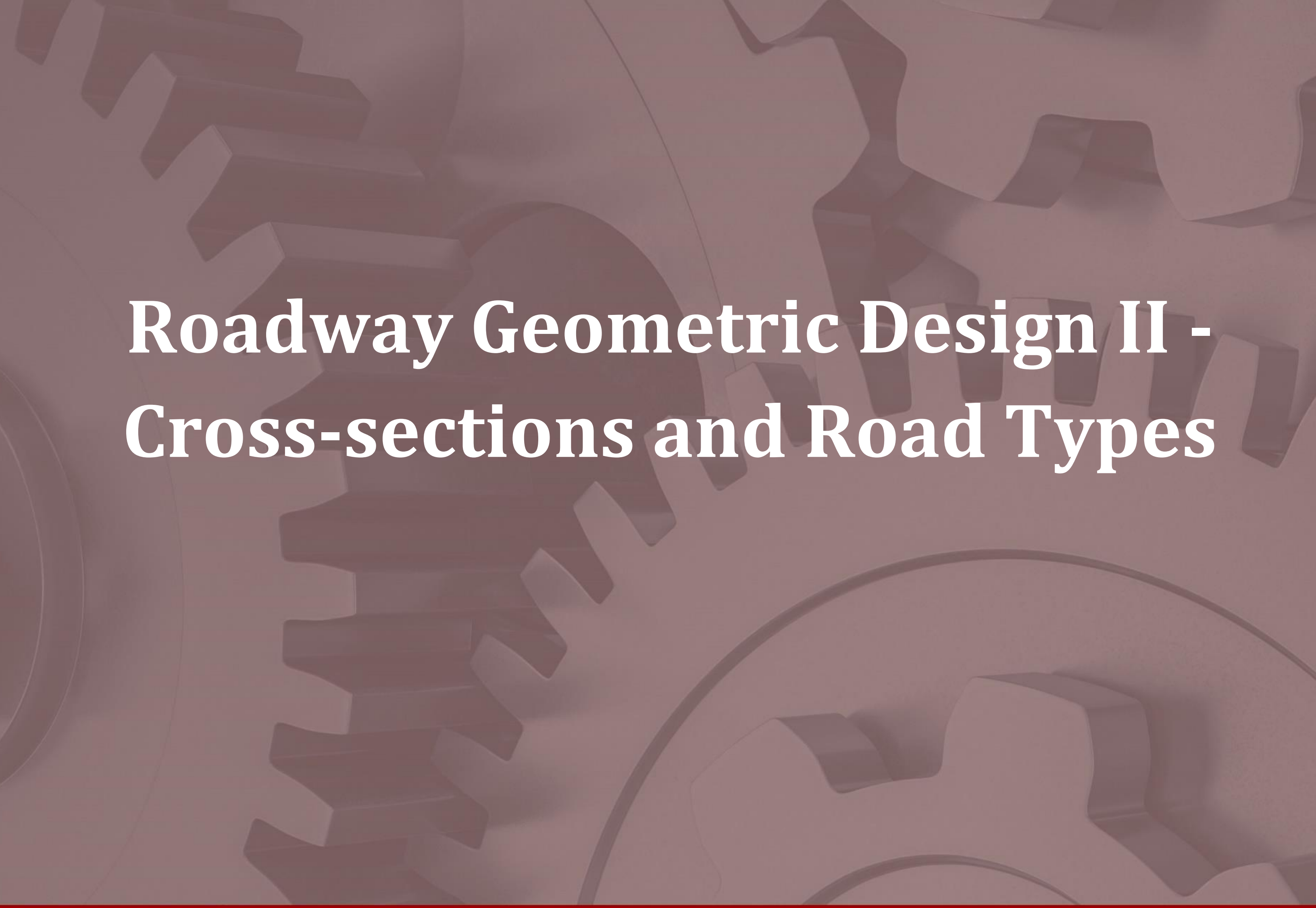


Roadway Geometric Design II - Cross-sections and Road Types

An Online Continuing Education Course for Engineers

Course Number: T-4020

Credit: 4 Hours / 4 PDH / 4 CPD

Roadway Geometric Design II

Cross-sections & Road Types

Gregory J. Taylor P.E.

INTRODUCTION

This course is the **second** in a series of three volumes that summarizes and highlights the geometric design process for modern roads and highways. Subjects covered include: *cross-section elements (lane widths, shoulders, roadside design, medians, drainage channels); 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 guidelines for roadway cross-sections 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. Much 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 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.

ROADWAY CROSS-SECTIONS

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, shoulders, curbs, medians, slopes, ditches, and sidewalks

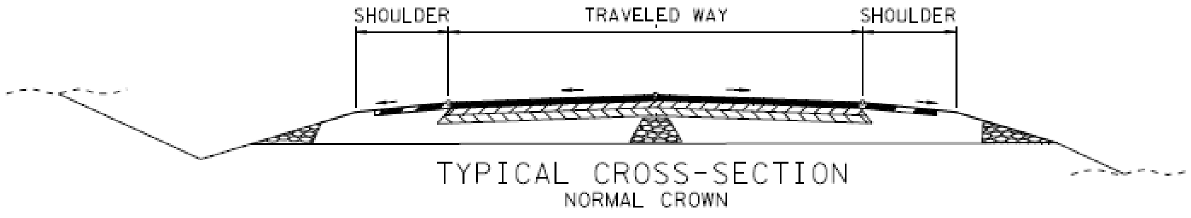
Combined, these elements contribute to the roadway's operational quality and safety by striving to provide a smooth-flowing, crash-free facility.

Roadway geometric design is 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 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.**

TRAVELED WAY

AASHTO defines the roadways 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.



(Ref: TDOT, Standard Roadway Drawings)

Surface Type Criteria

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

Important geometric design considerations include the effect on driver behavior, surface resiliency, drainage ability, and skid resistance (see *AASHTO Mechanistic-Empirical Pavement Design Guide).* The number of required roadway lanes is typically determined by the analysis procedures in the *Highway Capacity Manual* for the level of service desired. Signalized intersections are also an important factor controlling the capacity of an urban roadway.

Cross Slope

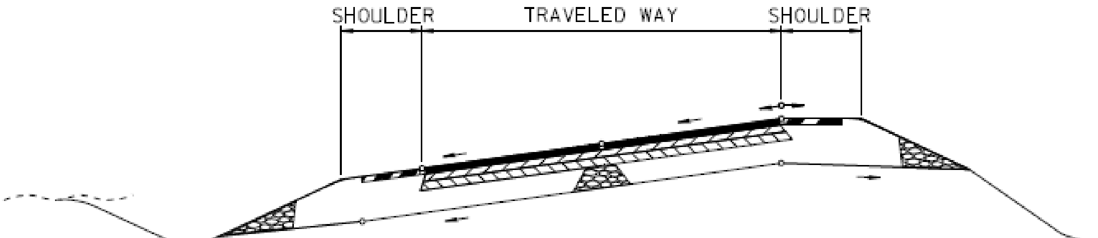
Cross slopes on **undivided** roads have a high point (crown) in the center and slope downward toward the roadway edges. These downward slopes can be plane, rounded, or a combination of both.

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.



TYPICAL CROSS-SECTION
SUPERELEVATED

(Ref: TDOT, Standard Roadway Drawings)

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 subject to intense rainfall that need increased surface drainage. Reasonably steep lateral slopes are desirable to minimize ponding on flat roadway sections due to imperfections or unequal settlement. Completely level sections can drain very slowly and create problems with hydroplaning and ice. Open-graded pavements or pavement grooving may be used to help water drain from the roadway surface.

Greater cross slope rates need to be used for unpaved roadways. Due to surface materials, increased cross slope rates on tangent sections are needed to prevent water absorption into the road surface.

A minimum cross slope of 1.5% is suggested for curbed pavements. Steeper gutter sections may permit lower cross slope rates.

AASHTO provides tables from which desired superelevation rates can be determined based on design speed and curve radius. These tables are incorporated into many state roadway design guides and manuals.

Skid Resistance

With skidding incidents being a major safety concern, roadways need to have adequate skid resistance for typical braking and steering maneuvers. Crashes due to skidding cannot be written off simply as *driver error* or *driving too fast for conditions.*

Vertical and horizontal geometric design should incorporate skid reduction measures (pavement types, textures, etc.) for all new and reconstruction roadway projects.

Causes of Poor Skid Resistance

Rutting – causes water accumulation in wheel tracks
Polishing – reduces pavement surface microtexture
Bleeding – covers pavement surface microtexture
Dirty pavements – loses skid resistance when contaminated

Skid resistance corrective actions should produce high initial durability, long term resistance (traffic, time) and minimum resistance decrease with increasing speeds.

LANE WIDTH

The selection of a roadway lane width can affect the facility's cost as well as its performance. Lane widths are influenced by: driver comfort; operational characteristics; crash probability; and level of service.

Drivers typically increase their speeds with wider traffic lanes - so it may be appropriate to use narrower lane widths that are compatible with the alignment and intended speed at locations with low design speeds and restricted alignments. Using a **typical lane width of 12 feet** reduces maintenance costs and provides adequate clearance between heavy vehicles on two-lane, two-way rural highways with high commercial vehicle traffic.

Typical Lane Widths

Range: *9 to 12 feet*
High speed, high volume highways: *12 feet (predominant)*
Urban areas with lane width controls: *11 feet*
Low-speed facilities: *10 feet (acceptable)*
Rural low-volume roads & residential areas: *9 feet (acceptable)*

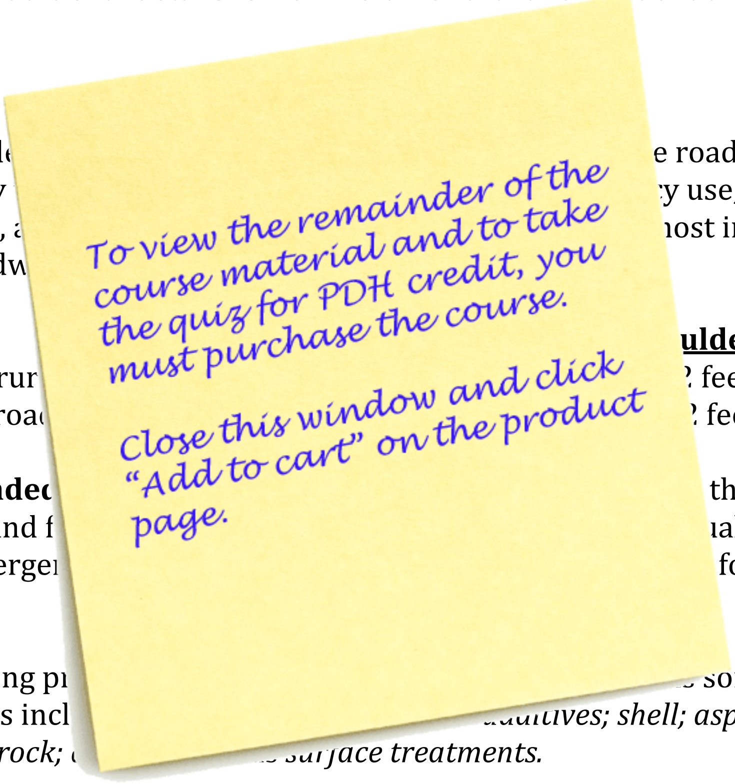
Narrow lanes and restricted clearances make vehicles operate closer laterally than normal – affecting the roadway's level of service. The capacity is impacted by the reduced effective width of the traveled way due to restricted lateral clearance. The *Highway Capacity Manual* provides further information regarding the effect of lane width on capacity and level of service.

Although the total roadway width is a critical design decision, pavement marking (stripes) determines lane widths. For locations with unequal-width lanes, outside (right) wider lanes provide more space for heavy vehicles, bicycles, and lateral clearance.

At intersections and interchanges, auxiliary lanes (10-ft minimum) should be wide enough to facilitate traffic. An optimal lane width of 10 to 16 feet is appropriate for continuous left-turn lanes.

AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads provides alternative design criteria for local roads and collectors with less than 400 vehicles per day. It may not be cost-effective to design low-volume roadway cross-sections using the same criteria for high volume roads. *NCHRP Report 362 – Roadway Widths for Low-Traffic Volume Roads* contains additional details for low-volume rural and residential roadways.

SHOULDERS


To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

Close this window and click "Add to cart" on the product page.

Roadway should   e roadway contiguous with
the traveled way   y use, and lateral support
of subbase, base, a   ost important safety
features for roadw

ulder Width

Minor rur   feet
Major roa   feet

The limits of **grade**   the intersection of the
shoulder slope and f   al shoulder for
parking and emerge   for sideslopes of
1V:4H or flatter.

Shoulder surfacing p   soil. Typical shoulder
surface materials incl   *ves; shell; asphaltic/concrete*
paving; crushed rock;   *face treatments.*