



Florida Department of
TRANSPORTATION

**NCHRP
Report 783**



FHWA/FDOT

Controlling Elements for Geometric Design



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Florida Department of
TRANSPORTATION

NCHRP
Report 783

Creating Flexibility in Highway Geometric Design





① Main Takeaways...

- ① No Design Criteria has changed**
- ① Documentation Reduced**
- ① Only 10 High Speed Controlling Criteria**
- ① Only 2 Low Speed Controlling Criteria**
- ① Documentation Requirements**
- ① FDOT Design Bulletin coming soon!**



1 Presentation Agenda

1 NCHRP 783 Highlights

1 FHWA Memorandum

1 High Speed Controlling Elements

1 Low Speed Controlling Elements

1 Documentation Requirements

 **WHO?**



FDOT Engineers and
Designers
“Howard Wolowitz”



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1 NCHRP 783 Purpose

 NCHRP 17-53 Project

 1985 > 30 yrs.

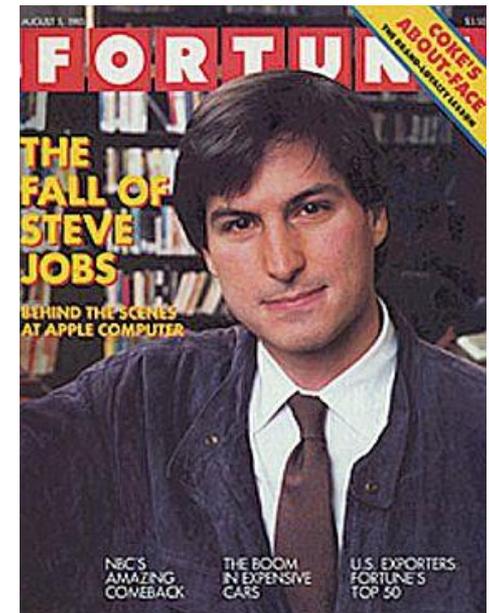
 2016 “Fresh Look”

 Latest research & experience
(2010 HCM, 2011 HSM)

 Safety & Operations Impacts

 Performance vs Standards
based design

 Flexibility in Highway Design





① NCHRP 783

① High Speed = Design Speeds greater than or equal to 50mph

① Low Speed = Design Speeds less than 50mph.

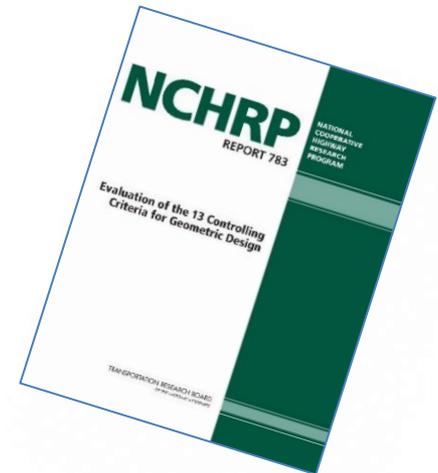
NCHRP 783

Did NOT Address:

Intersections
Roadside design
Access Mgmt
RRR Projects

Did Address:

New construction
Reconstruction



URBAN & RURAL ROADWAY TYPES

How to Influence Flexibility in Design

-  Modified criteria (add, drop, combine)
-  Design Exception process
-  Context-sensitive, performance-based design versus standards-based design

Original	Proposed Names
Design Speed	Design Speed
Lane Width	Lane Width
Shoulder Width	Shoulder Width
Bridge Width	Bridge Width
Structural Capacity	Structural Capacity
Horizontal Alignment	Horizontal Curve Radius
Vertical Alignment	Sag Vertical Curve Length
Grade	Grade
Stopping Sight Distance	Stopping Sight Distance
Cross Slope	Cross Slope
Superelevation	Superelevation
Vertical Clearance	Vertical Clearance
Horizontal Clearance	Lateral Offset

priorities based on sensitivity analysis...



Priority Rank	Roadway Type		
	Rural 2-lane Highways	Rural Multilane Highways	Rural Freeways
TRAFFIC SAFETY			
1	Shoulder width	Shoulder width	Shoulder width
2	Lane width	Lane width	Lane width
3	Grade	SSD w/hidden curve, intersection, or driveway	Horizontal curve radius
4	Horizontal curve radius	Superelevation	SSD w/hidden curve or ramp junction
5	Superelevation	Grade	Superelevation
6	SSD w/hidden curve, intersection, or driveway	Horizontal curve radius	Grade
7	Bridge Width	Bridge Width	Bridge Width
8	Cross Slope	Cross Slope	Cross Slope
9	Sag vertical curve length	Sag vertical curve length	Sag vertical curve length
10	SSD w/no hidden features	SSD w/no hidden features	SSD w/no hidden features
11	Lateral offset	Lateral offset	Lateral offset

priorities based on sensitivity analysis...



Priority Rank	Roadway Type		
	Rural 2-lane Highways	Rural Multilane Highways	Rural Freeways
TRAFFIC OPERATIONS			
1	Shoulder width	Lane width	Lane width
2	Lane width	Shoulder width	Shoulder width
3	Horizontal curve radius	Horizontal curve radius	Horizontal curve radius
4	Grade	Grade	Grade
5	Bridge width	Bridge width	Bridge width
6	Superelevation	Superelevation	Superelevation
7	SSD w/hidden curve, intersection, or driveway	SSD w/hidden curve, intersection, or driveway	SSD w/hidden curve or ramp junction
8	SSD w/no hidden features	SSD w/no hidden features	SSD w/no hidden features
9	Sag vertical curve length	Sag vertical curve length	Sag vertical curve length
10	Cross slope	Cross slope	Cross slope
11	Lateral offset	Lateral offset	Lateral offset



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<http://www.fhwa.dot.gov/programadmin/standards.cfm>



U.S. Department
of Transportation
**Federal Highway
Administration**

Memorandum

Subject: **INFORMATION:** Revisions to the Controlling
Criteria for Design and Documentation for
Design Exceptions

Date: May 5, 2016

In Reply Refer To:
HIPA-20

From: Robert B. Mooney 
Acting Director, Office of Program Administration

To: Director of Field Services
Division Administrators
Director of Technical Services
Federal Lands Highway Division Engineers

This memorandum supersedes prior guidance regarding the controlling criteria for design, first established in 1985. For projects on the National Highway System (NHS), a design exception is required to justify not meeting any of the controlling criteria. The revisions below are effective immediately. Divisions should work with their State Transportation Agency (STA) to update Standard Operating Procedures, existing guidance and manuals.



① FHWA Memo: May 5, 2016

① Supersedes guidance from 1985

① 10 Controlling Criteria: High Speed

① 2 Controlling Criteria: Low Speed

① FHWA Required Documentation

① Direction to States

① Discussion of comments received



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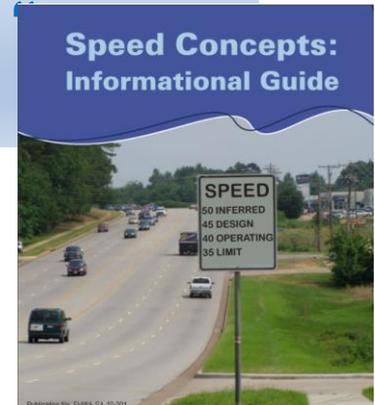
It's the ...
Real McCoy



Elijah McCoy, (1843 - 1929) INVENTOR OF THE AUTOMATIC LUBRICATING SYSTEM LISED ON TRAINS AND CARS TODAY... WITH OVER 50 PATENTS TO HIS CREDIT. People knew that when it is made based on his standards ... It is REAL quality... The BEST.

1 DESIGN SPEED

“Design speed is a selected speed used to determine the various geometric features of the roadway.”



Unique Among the 13 Controlling Criteria

 No direct effect on design of roadway

 Design control \neq Design criteria

1 DESIGN SPEED

LOW SPEED

HIGH SPEED

Of the 10 controlling criteria,
only design loading structural capacity
and design speed
apply to all NHS facility types.



1 LANE WIDTH

“Lane width determines the area where a vehicle can maneuver laterally without encroaching into the path of another vehicle or onto the shoulder.”



Formal Design Exceptions Required

 All travel lanes

 Including auxiliary lanes, ramps, etc.

1 LANE WIDTH

LOW SPEED

Urban/Suburban:

 Study found there were no effects on traffic speed or safety from before/after studies for lane widths between 10 ft and 12 ft.

HIGH SPEED

Rural:

 Prepare Design Exceptions for LW < 11 ft (CMF = 1.05 for 11 FT)

 Known safety & operational effects in HCM and HSM.

1 SHOULDER WIDTH

“Shoulder width affects both capacity and safety on roadways. A wide shoulder increases capacity by reducing lateral friction between traffic and roadside objects and thereby increasing driver comfort.”



1 SHOULDER WIDTH

Reduces Likelihood of Crashes

-  Provides for emergency stopping
-  Allows for errant driver recovery
-  Provides space for evasive maneuvers
-  Space for enforcement activities
-  Space for bicyclists and pedestrians in rural areas.

1 SHOULDER WIDTH

LOW SPEED

Urban/Suburban:

 Do not retain.

HIGH SPEED

Rural:

 Retain

 Greatest impact on crashes/operations of all 13 elements.

 HSM CMFs available for most facilities

1 BRIDGE WIDTH

“Bridge width is the total width of all lanes and shoulders on a bridge, measured between the points on the bridge rail, curb, or other vertical element that projects farthest onto the roadway.”



1 BRIDGE WIDTH

Concerns Associated with Narrow Bridges

-  “Short” bridges – a discontinuity that may affect driver behavior/lane position
-  “Long” bridges – inadequate space for storage, enforcement, & maintenance

1 BRIDGE WIDTH

LOW SPEED

Urban/Suburban:

 Do not retain.

HIGH SPEED

Rural:

 Do not retain.

 BW = Approach roadway width.

 Ops/Safety Effects: Similar to narrow-shoulder roadways

No evidence of increased crash frequency/severity.

1 STRUCTURAL CAPACITY

“Structural capacity has no effect on traffic operations, and its effect on safety is related only to the probability of a structural failure, not to the likelihood of traffic crashes.”

Not Reviewed Here and Not Addressed in this Research



1 STRUCTURAL CAPACITY

LOW SPEED

HIGH SPEED

Of the 10 controlling criteria,
only design loading structural capacity
and design speed
apply to all NHS facility types.

1 HORIZONTAL ALIGNMENT

“Horizontal alignment addresses only horizontal curves, not tangent sections, and the horizontal alignment criterion addresses only curve radius.”



1 HORIZONTAL ALIGNMENT

Elements Not Requiring a Formal Exception:

-  Horizontal curve length
-  Length of tangent preceding a horizontal curve

1 HORIZONTAL ALIGNMENT

LOW SPEED

Urban/Suburban:

 Do not retain.

HIGH SPEED

Rural:

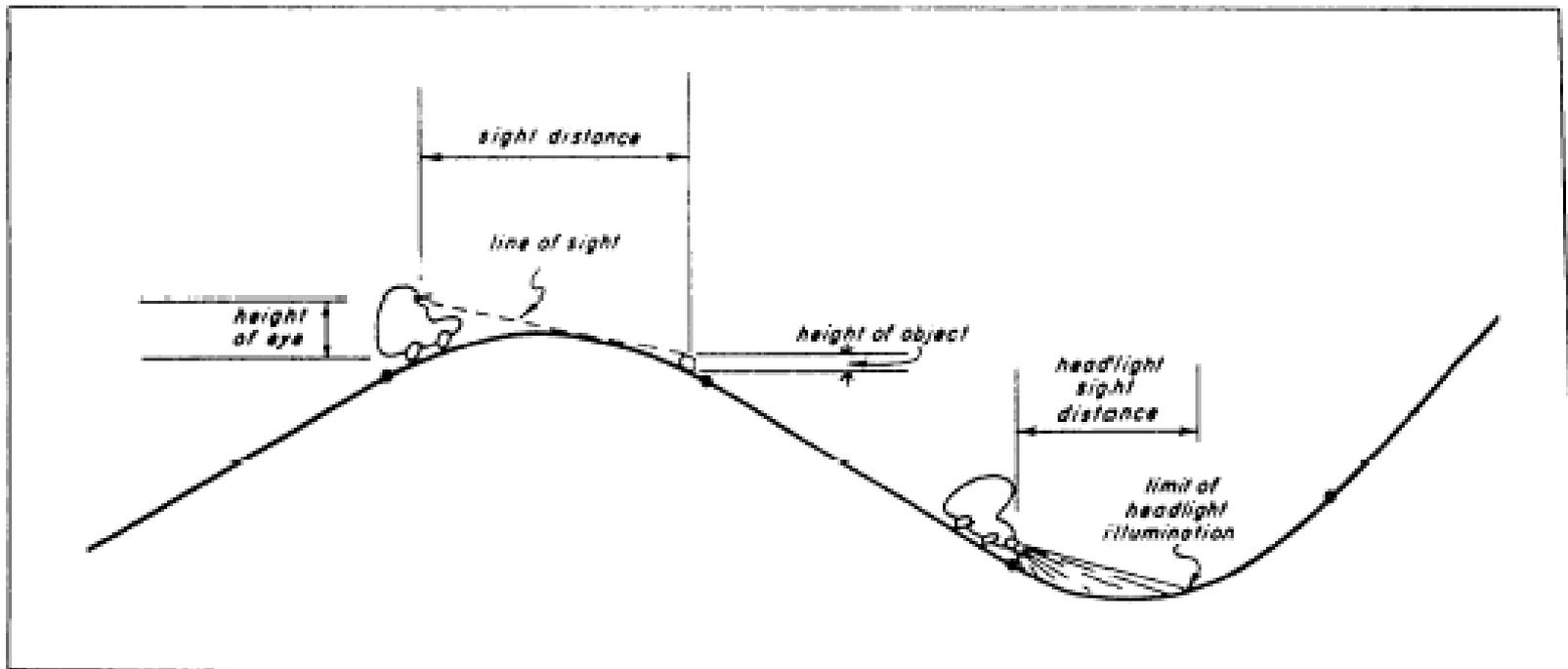
 Retain.

 Rename to
Horizontal Curve
Radius.

 New CMFs
developed to
evaluate curves
as function of
length & radius.

1 VERTICAL ALIGNMENT

“Vertical alignment generally consists of two elements: grades and vertical curves. Both of these elements are considered in the controlling criteria.”



VERTICAL ALIGNMENT

“Vertical alignment generally consists of two elements: grades and vertical curves. Both of these elements are considered in the controlling criteria.”

If Retained, Rename “Sag Vertical Curve Length”

 Crest curves are addressed through Stopping Sight Distance evaluations

1 VERTICAL ALIGNMENT

LOW SPEED

Urban/Suburban:

 Do not retain.

HIGH SPEED

Rural:

 Do not retain.

GRADE

“Grade is the rate of change of vertical elevation along a roadway. The controlling criterion for grade includes both maximum and minimum grades.”

New CMF for Grades Developed

$$ CMF = 1.0 + 0.016G$$

GRADE

LOW SPEED

Urban/Suburban:

 Do not retain.

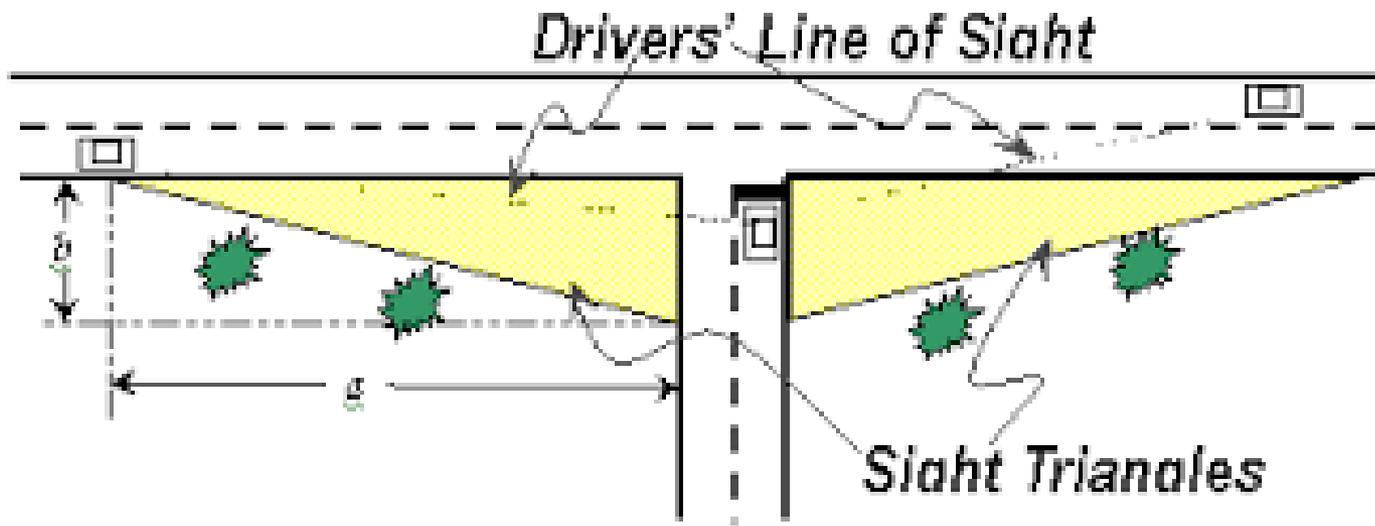
HIGH SPEED

Rural:

 Retain.

STOPPING SIGHT DISTANCE

“Stopping sight distance is the distance required for a driver to perceive or recognize a need to stop, react to that perception, and then decelerate to a stop.”





STOPPING SIGHT DISTANCE

“Stopping sight distance is the distance required for a driver to perceive or recognize a need to stop, react to that perception, and then decelerate to a stop.”

Sight Distance Needs are Based On:



Design speed



Grade Adjustments for downhill/uphill



STOPPING SIGHT DISTANCE

LOW SPEED

HIGH SPEED

Only evaluate for safety and operation
in the presence of:
Horizontal Curves
Intersections
Driveways.

Not retained

Retained

Better design guidance is needed.

CROSS SLOPE

“The controlling criterion for cross slope addresses the transverse slope of the pavement surface on tangent sections or on horizontal curves where superelevation is not used.”



... **1 CROSS SLOPE**

LOW SPEED

HIGH SPEED

Retain as a controlling criterion due to negative consequences of poor drainage.

Not retained

Retained

NCHRP 03-105: Shoulder Breakover Research Planned

1 SUPERELEVATION

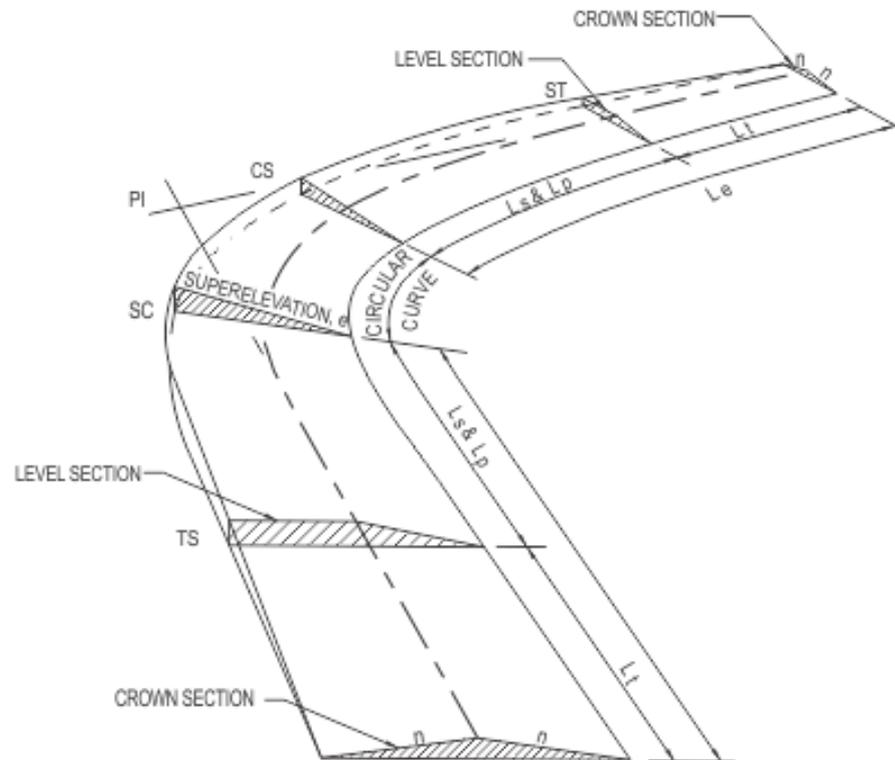
“Superelevation is the rotation of the pavement on the approach to and through a horizontal curve intended to assist the driver by counteracting the lateral acceleration produced by tracking the curve;



1 SUPERELEVATION

No quantifiable effects on traffic operations.

Minor variations from AASHTO unlikely to have much effect on traffic operations





SUPERELEVATION RATE

LOW SPEED

Urban/Suburban:

 Do not retain.

HIGH SPEED

Rural:

 Retain.

Rural: Retain as long as Hz. Curve Radius is retained



VERTICAL CLEARANCE

“Vertical clearance values for the various highway functional classifications provide at least a 1-foot differential between the maximum legal vehicle height and the ~~roadway~~ structure, with additional allowances for future resurfacing.”



1 VERTICAL CLEARANCE

-  Apply to the entire roadway width (traveled way and shoulders)
-  No effects on operations & safety other than increased travel times for overheight trucks

1 VERTICAL CLEARANCE

LOW SPEED

Urban/Suburban:

 Do not retain.

HIGH SPEED

Rural:

 Retain.

Important: Maintain integrity for national defense!

1 LATERAL OFFSET ~~HZ. CLEARANCE~~

“Lateral offset deals with the distance from the edge of the traveled way, face of curb, shoulder, or other designated point to a vertical roadside element or obstruction.”

An operational offset; roadside elements are offset so:

-  They do not affect a driver's speed or lane position, and
-  Adequate clearance is provided for overhangs/mirrors of trucks/buses and for opening curbside doors.

1 **LATERAL OFFSET ~~HZ. CLEARANCE~~**

LOW SPEED

Urban/Suburban:

 Not Retained.

 Apply new RDG offset (Face/Curb):

- 1.5' (all locations)
- 3.0' (D/W, Inter/S)
- 6.0' (outside Hz. Curve; 8' & 12' elsewhere)

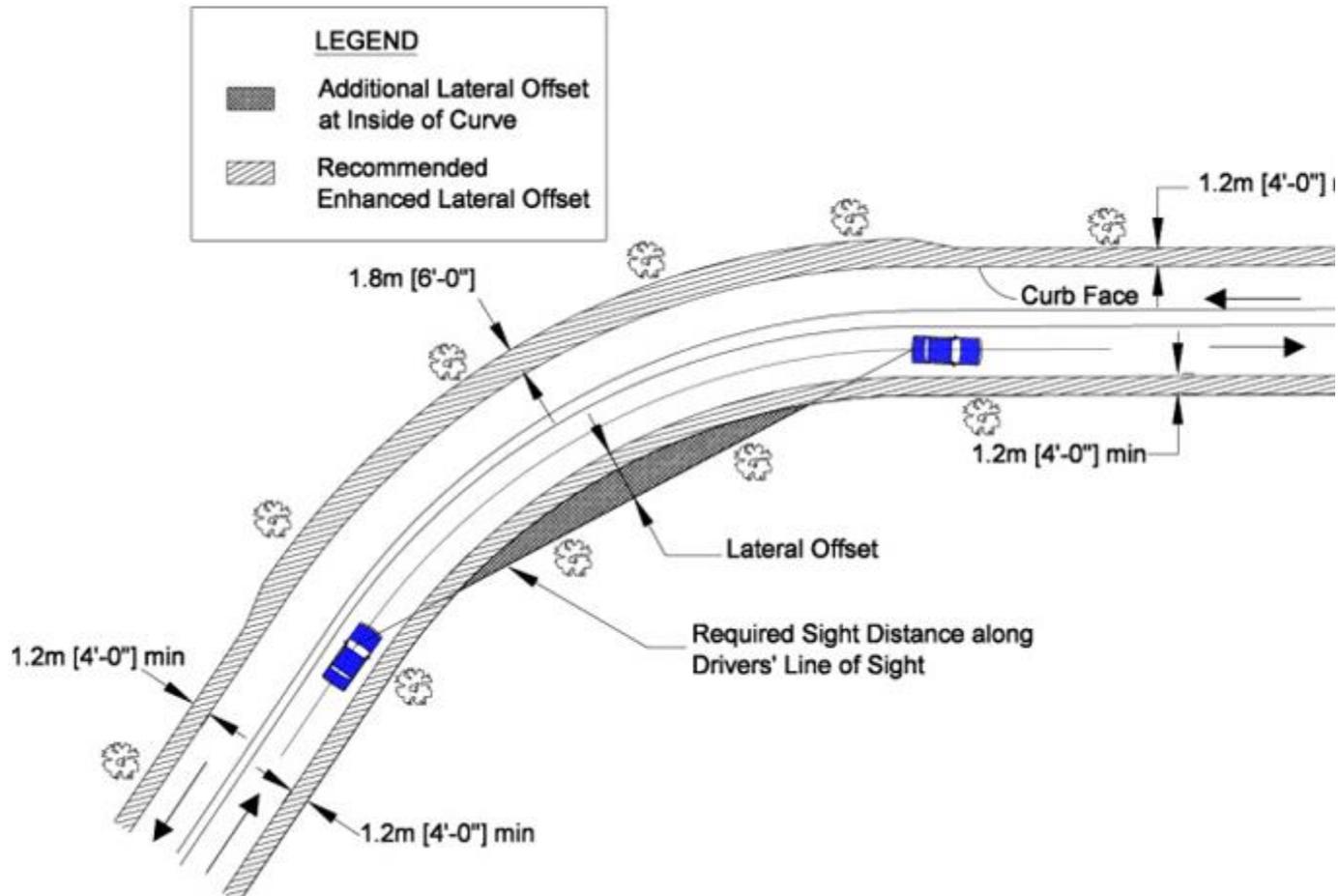
HIGH SPEED

Rural:

 Do not retain.

Lowest in safety priority rankings.

1 LATERAL OFFSET ~~HZ. CLEARANCE~~



Lowest in safety priority rankings.

1 “New” High Speed Controlling Elements

1. Design Speed
2. Lane Width
3. Shoulder Width
4. Horizontal Curve
Radius
5. Superelevation Rate
6. Stopping Sight
Distance
7. Maximum Grade
8. Cross Slope
9. Vertical Clearance
10. Design Loading
Structural Capacity

1 “New” Low Speed Controlling Elements

1. Design Speed
2. Design Loading
Structural
Capacity



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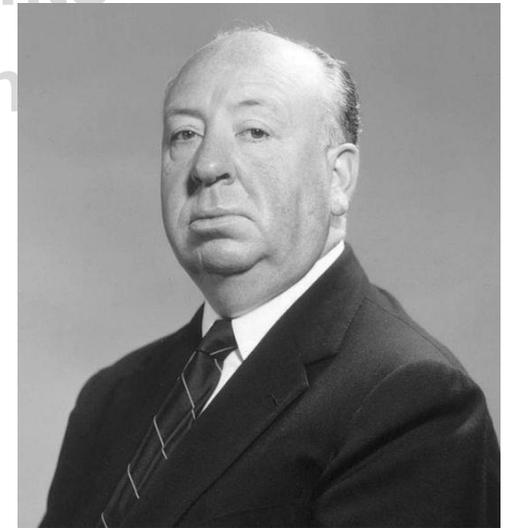
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Alfred Hitchcock



1 FHWA Documentation Requirements

“The FHWA expects documentation of Design Exceptions to include all of the following:”

 “Specific design criteria that will not be met”

 AASHTO, PPM, Interstate Requirements

 “Existing roadway characteristics”

 Typical Sections, Traffic, Lanes, Context, Etc.

 “Alternatives Considered”

 Correction, Partial correction, Etc.

1 FHWA Documentation Requirements

“The FHWA expects documentation of Design Exceptions to include all of the following:”



“Comparison of the safety and operational performance of the roadway and other impacts such as right-of-way, community, environmental, cost, and usability by all modes of transportation.”

1 FHWA Documentation Requirements

“The FHWA expects documentation of Design Exceptions to include all of the following:”



“Proposed mitigation measures”



See FHWA Mitigation Strategies for Design Exceptions publication.



“Compatibility with adjacent sections of roadway”

1 FHWA Documentation Requirements

“Design Speed and Design Loading Structural Capacity are fundamental criteria in the design of a project. Exceptions to these criteria should be extremely rare and FHWA expects the documentation to provide the following additional information:”

1 FHWA Documentation Requirements

Design Speed exceptions require:

-  Length of section with reduced design speed compared to overall length of project
-  Measures used in transitions to adjacent sections with higher or lower design or operating speeds.

1 FHWA Documentation Requirements

Design Loading Structural Capacity exceptions require:

-  Verification of safe load-carrying capacity (load rating) for all State unrestricted legal loads or routine permit loads, and in the case of bridges and tunnels on the Interstate, all Federal legal loads.



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James Doohan
"Scotty"





① Draft FDOT Bulletin

① Full implementation of FHWA Memo to State Facilities and Projects. (NHS/SHS)

① Chapter 23 changes

① Documentation and Approvals Updated

① Coming in June/July 2016

① AASHTO 2011 (Coming Later Jan 2017)





1 Main Takeaways

- 1 No Design Criteria has changed**
- 1 Documentation Reduced**
- 1 Only 10 High Speed Controlling Criteria**
- 1 Only 2 Low Speed Controlling Criteria**
- 1 Documentation Requirements**
- 1 FDOT Design Bulletin coming soon!**



1 Thank you for coming!!

1 Questions?

