

Bridge Rehabilitation Frequently Asked Questions

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September 17, 2013



What's new?

Proposed IDM Chapter is still Pending

Includes: 2R(Minor)/3R(Major)

Many clarifications presented here



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What's new?

Bridge Asset Management Engineers

- New Position
- Programming/Scoping
- Attending Field Checks



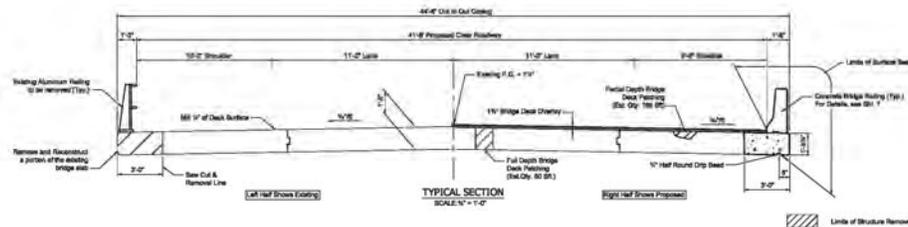
Bridge and Culvert Preservation Initiative

- Collaborating with BAM Engineers on a development process



Rehab Terminology

**“Existing Bridge to Remain in Place”
is DECK to remain in place**



Geometry Requirements – Chapter 55

Minimum Horizontal Curve [55-4.03(01)]

- No crash history
- CEDS > 15 mph below design speed
- AADT < 750

Crest Vertical Curve [55-4.04(03)]

- No crash history
- Doesn't hide a hazard
- CEDS > 20 mph below design speed
- AADT < 1500



What is CEDS?

Calculated Existing Design Speed

At what speed does the element meet the design criteria?

Design Speed (mph)	Brake Reaction Time (s)	Brake Reaction Dist. (ft)	Braking Distance (ft)	Minimum Calculated SSD (ft)	Rounded SSD for Design (ft)
15	2.5	55.1	21.6	76.7	80
20	2.5	73.5	38.4	111.9	115
25	2.5	91.9	60.0	151.9	155
30	2.5	110.3	86.4	196.7	200
35	2.5	128.6	117.6	246.2	250
40	2.5	147.0	153.6	300.6	305
45	2.5	165.4	194.4	359.8	360
50	2.5	183.8	240.0	423.8	425
55	2.5	202.1	290.3	492.4	495
60	2.5	220.5	345.5	566.0	570
65	2.5	238.9	405.5	644.4	645
70	2.5	257.3	470.3	727.6	730

STOPPING SIGHT DISTANCE FOR PASSENGER CAR

Figure 42-1A



Reference: IDM 55-4.03

Geometry Requirements – Chapter 55

Sag Vertical Curve

No crash history

Meets comfort criteria in Fig. 55-4A

Design Speed (mph)	Calculated <i>K</i> Value ($K = V^2/46.5$)	<i>K</i> Value Rounded For Design
20	8.6	9
25	13.4	14
30	19.4	20
35	26.3	27
45	43.5	44
50	53.8	54
55	65.1	66
60	77.4	78
70	105.4	106
75	121.0	122

$$L = \frac{AV^2}{46.5} = KA$$

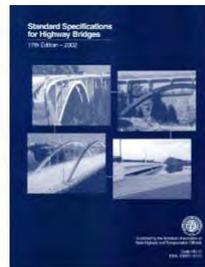
Where:

- L* = Length of vertical curve, ft.
- A* = Algebraic difference between grades, %
- K* = Horizontal distance required to effect a 1% change in gradient
- V* = Design speed, mph

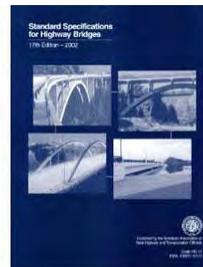


What Loads and Codes?

Design code used for existing structure should be used for rehabilitation design



Existing Design



Rehabilitation Design

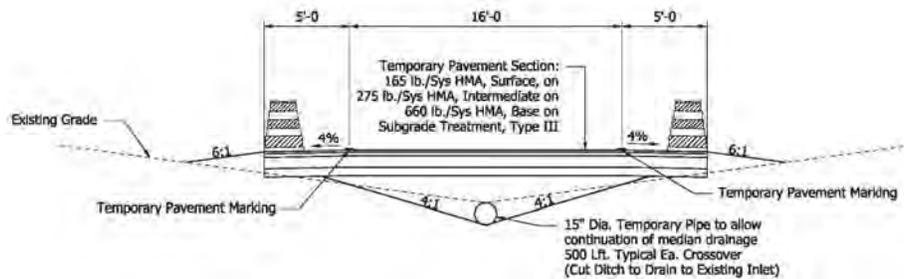


Reference: IDM 72-4.02

Pavement Considerations

Pavement designs are now required

- HMA Wedge is exempt
- Contact the Pavement Design Section early!
Possibly use existing geotech data*

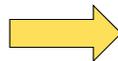


* If geotech not required for other aspects of the project

Pavement Considerations

Changes in the 402 items

- No more HMA, type A, B, C, D
- Still have HMA, Wedge and Level
- Still have HMA, Temporary Pavement



401.09

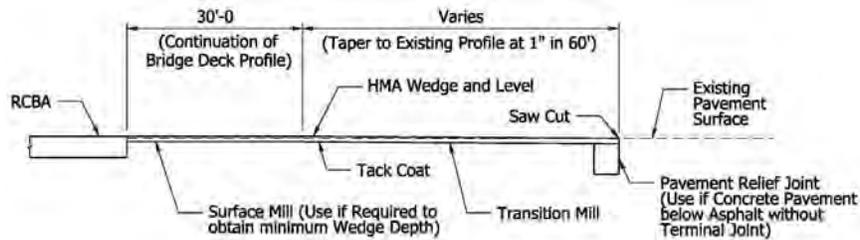
“Acceptance of mixtures...will be based on a type D certification in accordance with 402.09 for dense graded mixtures with original contract pay item quantities less than 300 t.”



Wedge and Level Detail

Proposed deck higher than existing

- Minimum wedge material thickness 1.5"
- Minimum grader taper 1" in 60'



30' Resurface when no elevation change

- Mill 1.5", place 1.5"



Replacing Bridge Joints

Eliminate when possible

- Semi-integral end bents
- Design beams continuous



Replacing Bridge Joints

Expansion Joint Sealing System (XJS)

- Replaces most BS Joints
- Check opening width with specifications
- No new BS Joints*



Replacing Bridge Joints

SS & Modular Joints are replaced in kind

- Limited success replacing seals
- Deck removal required
- Cost more than just the joint pay item



Policy on Seismic Retrofit

Proposed IDM Chapter 412

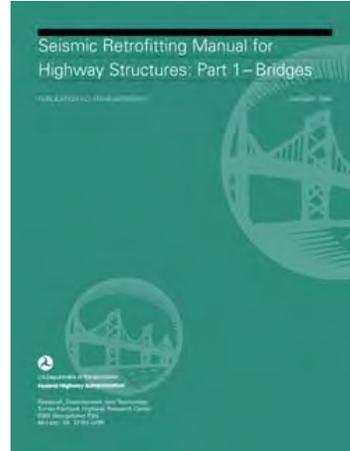
"The need for additional seismic retrofit measures will be discussed at the field check."

Considerations:

Location & Importance of Structure

Type & Magnitude of Project

Check Support Length



<http://www.in.gov/dot/div/contracts/training/2010/SeismicRetrofit/Intro.pdf>

Design Exception Justification

What makes a good design exception??



Design Exception Justification

Discuss risk associated with subject item...

- How has element impacted crash history?
- How was severity of crashes affected?



Can these be quantified?!

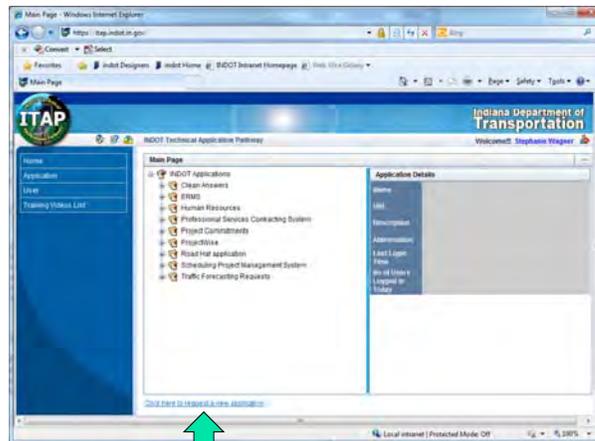


Design Exception Justification

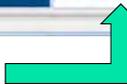
Good Resource

HAT
Hazard Analysis Tool

<https://itap.indot.in.gov/>



Request a new application



Design Exception Justification

Input:
Crash Data from District

Don't filter crashes!

Output:
Index of Crash Frequency

$I_{CF} < 0$
Fewer Crashes than Expected

$I_{CF} > 0$
More Crashes than Expected

$I_{CF} > 2$
High Crash Location

Index of Crash Frequency and Cost - Form F1		Form 1 2 3 4 5
INPUT		
Road Facility Type	Rural two-lane segment	Calculate
Annual Average Daily Traffic (veh/day)	1300	New
Segment length (mi)	5	Save
First Year with Crash Data (yyyy)	2010	SaveAs
Last Year with Crash Data (yyyy)	2012	Reports
		Exit
		Help
		Guidelines
		Equations
OUTPUT		
Number of Crashes (crash/period)	0	
Fatal and Incapacitating Injury Crashes	0	
Non-Incapacitating and Possible Injury Crashes	1	
Property Damage Only Crashes		
Route or Road Type	Rural two-lane segment	
Average Crash Costs (\$)	451200	
Fatal and Incapacitating Injury Crashes	34000	
Non-Incapacitating and Possible Injury Crashes	5100	
Property Damage Only Crashes	2009	
Crash Cost Year (yyyy)		
Expected Crash Frequency (crash/year)	0.011	Location
Fatal and Incapacitating Injury Crashes	0.05	GIS
Non-Incapacitating and Possible Injury Crashes	0.20	Post
Property Damage Only Crashes	0.26	Analyst
All Crashes	0.17	Date
Index of Crash Frequency	-0.66	Select a date
Index of Crash Cost		Comments
		Settings: Indiana state settings

<https://itap.indot.in.gov/>

Design Exception Justification

- How does deficient feature compare with the rest of corridor?



<https://itap.indot.in.gov/>

Design Exception Justification

Another use for Computed Existing Design Speed!

At what speed does the element meet the design criteria?

Is this similar to the rest of the corridor?

Design Speed (mph)	Brake Reaction Time (s)	Brake Reaction Dist. (ft)	Braking Distance (ft)	Minimum Calculated SSD (ft)	Rounded SSD for Design (ft)
15	2.5	55.1	21.6	76.7	80
20	2.5	73.5	38.4	111.9	115
25	2.5	91.9	60.0	151.9	155
30	2.5	110.3	86.4	196.7	200
35	2.5	128.6	117.6	246.2	250
40	2.5	147.0	153.6	300.6	305
45	2.5	165.4	194.4	359.8	360
50	2.5	183.8	240.0	423.8	425
55	2.5	202.1	290.3	492.4	495
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65	2.5	238.9	405.5	644.4	645
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Figure 42-1A



Reference: IDM 55-4.03

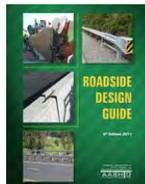
Design Exception Justification

Other Resources

Free webinars thru



www.nhi.fhwa.dot.gov



Roadside Design Guide

Module 7: Bridge Railing



Highway Safety Manual

Chapters 5 & 6: Diagnosis and Countermeasure Selection



Crashworthiness of Existing Bridge Rails

How to know: Compare to FHWA's list of crash tested bridge rails

http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/bridgerailings/

Bridge Railings

Bridge railings, although technically classified as longitudinal barriers, are listed separately here because they have been previously tested under criteria different from roadside barriers and have not generally been accepted for use on the NHS on an individual basis.

Since August 28, 1986, the FHWA has required that bridge railings used on Federal-aid projects meet full-scale crash-test criteria and has provided listings of those railings meeting these requirements. A May 30, 1997 memorandum [PDF, 28 KB] consolidated earlier listings and established tentative equivalency ratings that relate previous testing to NCHRP Report 350 test levels.

Appendix B5 [PDF, 103 KB] is a combined and sorted listing of the bridge railings included as attachments to FHWA's May 30, 1997 memorandum. Appendix B6 [PDF, 121 KB] identifies the crash test reports for each railing that is referenced in Appendix B5. Appendix B7 contains drawings or sketches of the railings included in Appendix B5 as well as subsequent acceptance letters which were issued. Each of the latter drawings is linked to the appropriate acceptance letter.

Appendix B7:

- W-Beam Bridge Rail [PDF, 468 KB]
- Three-Beam Bridge Rail [PDF, 750 KB]
- Metal Tube Bridge Rails [PDF, 1.74 MB]
- Vertical Concrete Parapet (Open or Closed) / General [PDF, 1.08 MB]
- New Jersey Barrier [PDF, 251 KB]
- New Jersey Barrier w/Rail or Rail Wall Type [PDF, 372 KB]
- F-Shape Concrete Barrier / Single Slope [PDF, 161 KB]
- Timber Bridge Rail [PDF, 427 KB]

In addition to these group listings, the FHWA now issues separate acceptance letters for each bridge rail that has been tested to NCHRP Report 350 evaluation criteria and submitted for FHWA review. The design for which individual acceptance letters have been written but are not included in any group listings may be found under Longitudinal Barriers as acceptance letters B-42A, B-53, B-65, and B-68. Some of the accepted bridge rail designs are also shown in the 1995 AASHTO/AQC-ARTBA Guide to Standardized Highway Barrier Hardware, under the SB-Series drawings.

To minimize duplicate crash testing, the FHWA may allow the use of bridge rail designs that are similar to a crash tested design based on an analytic comparison using the methodology outlined in Section 13 of the AASHTO LRFD Bridge Specifications. FHWA policy and an example comparison prepared by the Colorado Department of Transportation are contained in a May 16, 2000 memorandum [PDF, 3.64 MB] signed by Mr. Fredrick G. Wright, Jr.

- Barrier Terminals and Crash Cushions
- Longitudinal Barriers

Crashworthiness of Existing Bridge Rails

Step 1. Geometry

**Grade 60 Reinforcing Steel
4000 psi Concrete**

**Grade 60 Reinforcing Steel
4000 psi Concrete**

**Grade 40 Reinforcing Steel
3600 psi Concrete**

**Bridge Railing, Type FC
(INDOT Current TL-4)**

1989 F-Shape Bridge Railing

**32-in F-Shape Bridge Railing
(Comparison TL-4 Railing)**

Demonstrate ability to redirect errant vehicles

Crashworthiness of Existing Bridge Rails

Step 2. Structural Capacity

Nominal Railing Resistance to Transverse Load

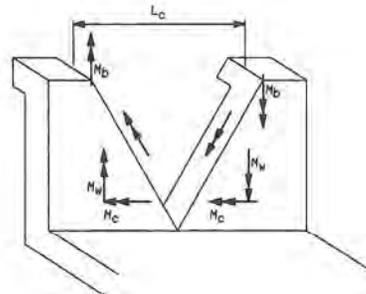
$$R_w := \left(\frac{2}{2L_c - L_t} \right) \left(8M_b + 8M_w + \frac{M_c \cdot L_c^2}{H} \right)$$

LRFD Eq. A13.3.1-1

Critical Wall Length

$$L_c := \frac{L_t}{2} + \sqrt{\left(\frac{L_t}{2} \right)^2 + \frac{8H(M_b + M_w)}{M_c}}$$

LRFD Eq. A13.3.1-2



LRFD CA13.3.1-1



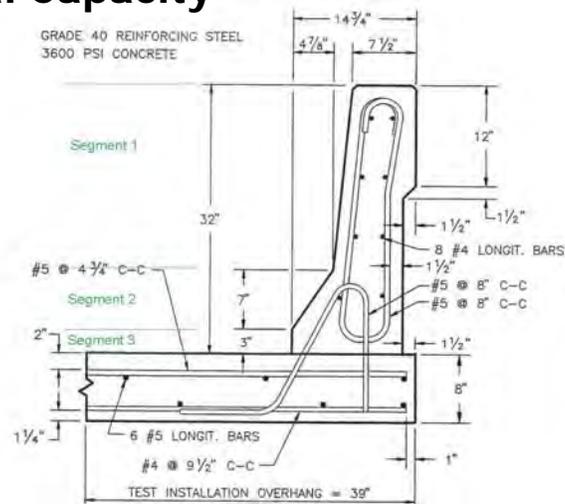
Demonstrate adequate railing resistance

Reference: LRFD Section 13

Crashworthiness of Existing Bridge Rails

Step 2. Structural Capacity

- Divide Rail into Segments
- Calculate Moment Resistance for each Segment and each Direction (Mc & Mw)
- Weighted Average for Total Mc



Reference: 32-in (813-mm) F-shape bridge railing (from FHWA site)



Crashworthiness of Existing Bridge Rails

Step 2. Structural Capacity

- Compare resistance with crash tested rail
- Compare to design forces in table

Table A13.2-1—Design Forces for Traffic Railings

Design Forces and Designations	Railing Test Levels					
	TL-1	TL-2	TL-3	TL-4	TL-5	TL-6
F_t Transverse (kips)	13.5	27.0	54.0	54.0	124.0	175.0
F_l Longitudinal (kips)	4.5	9.0	18.0	18.0	41.0	58.0
F_v Vertical (kips) Down	4.5	4.5	4.5	18.0	80.0	80.0
L_x and L_y (ft)	4.0	4.0	4.0	3.5	8.0	8.0
L_z (ft)	18.0	18.0	18.0	18.0	40.0	40.0
H_x (min) (in.)	18.0	20.0	24.0	32.0	42.0	56.0
Minimum H Height of Rail (in.)	27.0	27.0	27.0	32.0	42.0	90.0



Crashworthiness of Existing Bridge Rails

Step 3. Apply for Design Exception (FOR NOW...)

Working with FHWA on:

State-wide approval for some old standard rails

Clarifying the 2R project approval process



