Shoulder Width and Guardrail for Bridge Designers

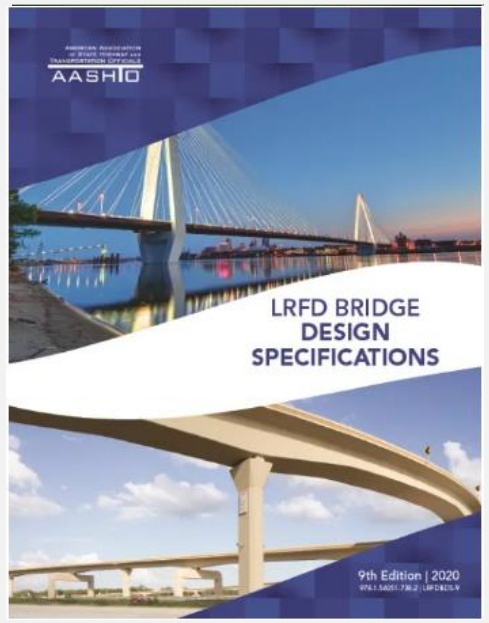
ELIZABETH MOUSER, PE

INDOT STANDARDS ENGINEER

AASHTO GREEN BOOK AND RDG

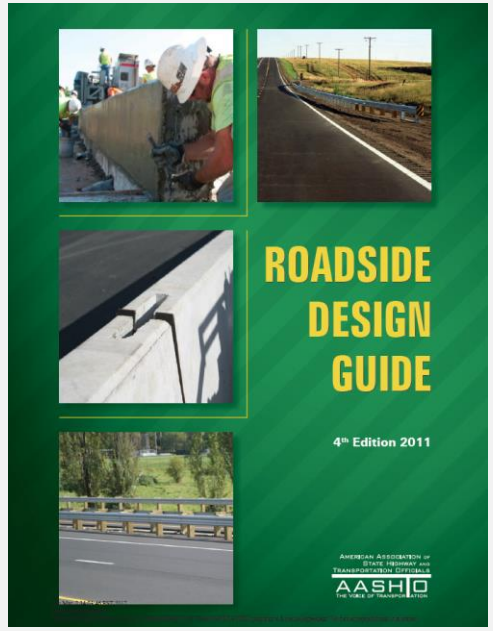
Green Book*

- General design and cross section guidance
- Specific design and cross section guidance by functional classification
- Specific *bridge* geometry (roadway width and vertical clearance) and design loading information by functional classification



Roadside Design Guide**

- Roadside safety – general, urban or restricted areas, low-volume roadways
- Clear zone
- Design options for reducing roadside obstacles
- Guardrail length of need calculations
- Roadside and median barriers - guardrail, bridge rail, transitions, end treatments, work zone barriers



*Green Book 1.1 - 7th edition introduces new definitions of project types—new construction, reconstruction, and projects on existing roads—and explains how design flexibility is provided for each project type as part of the project development process.

** RDG 1.5 - mostly applicable to new construction or major reconstruction projects. These projects often offer the greatest opportunity for implementing many of the roadside safety enhancements presented. For 3R projects, it will be generally necessary to selectively incorporate roadside safety guidelines only at locations where the greatest safety benefit can be realized.

SHOULDER TERMINOLOGY

- Graded, usable, effective usable, paved

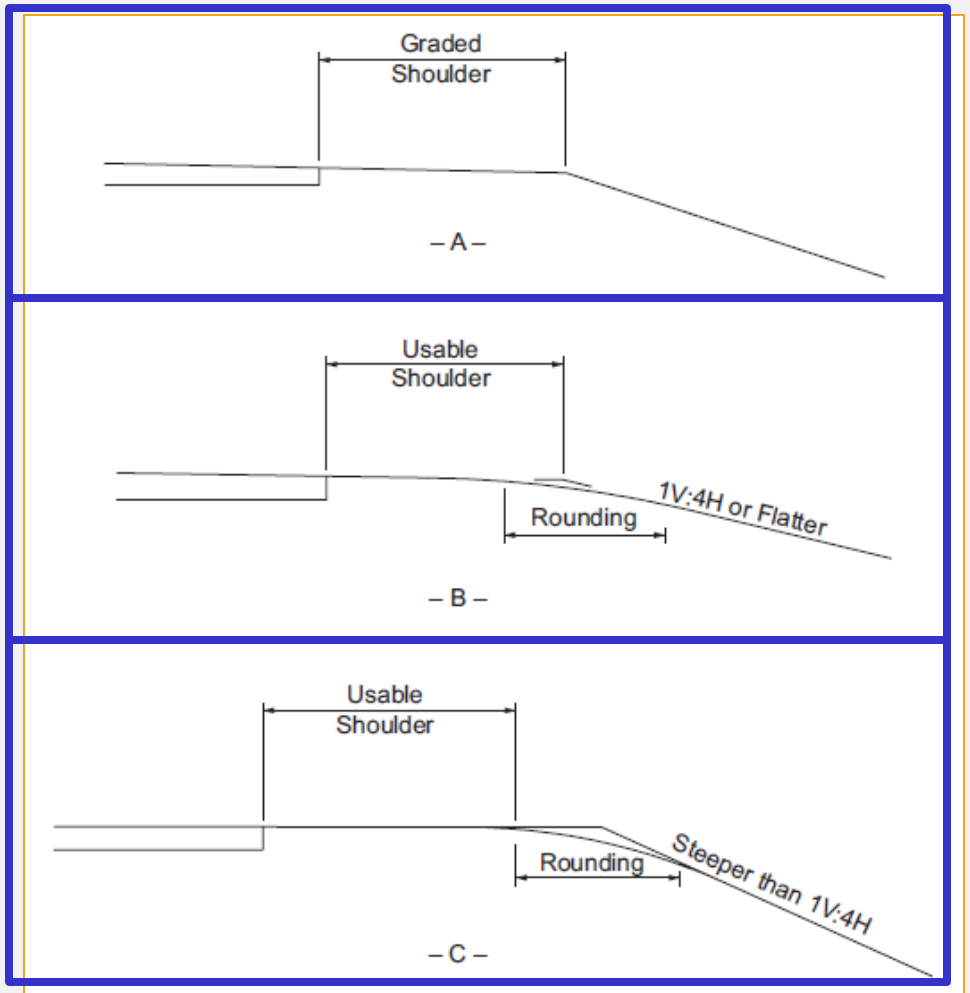
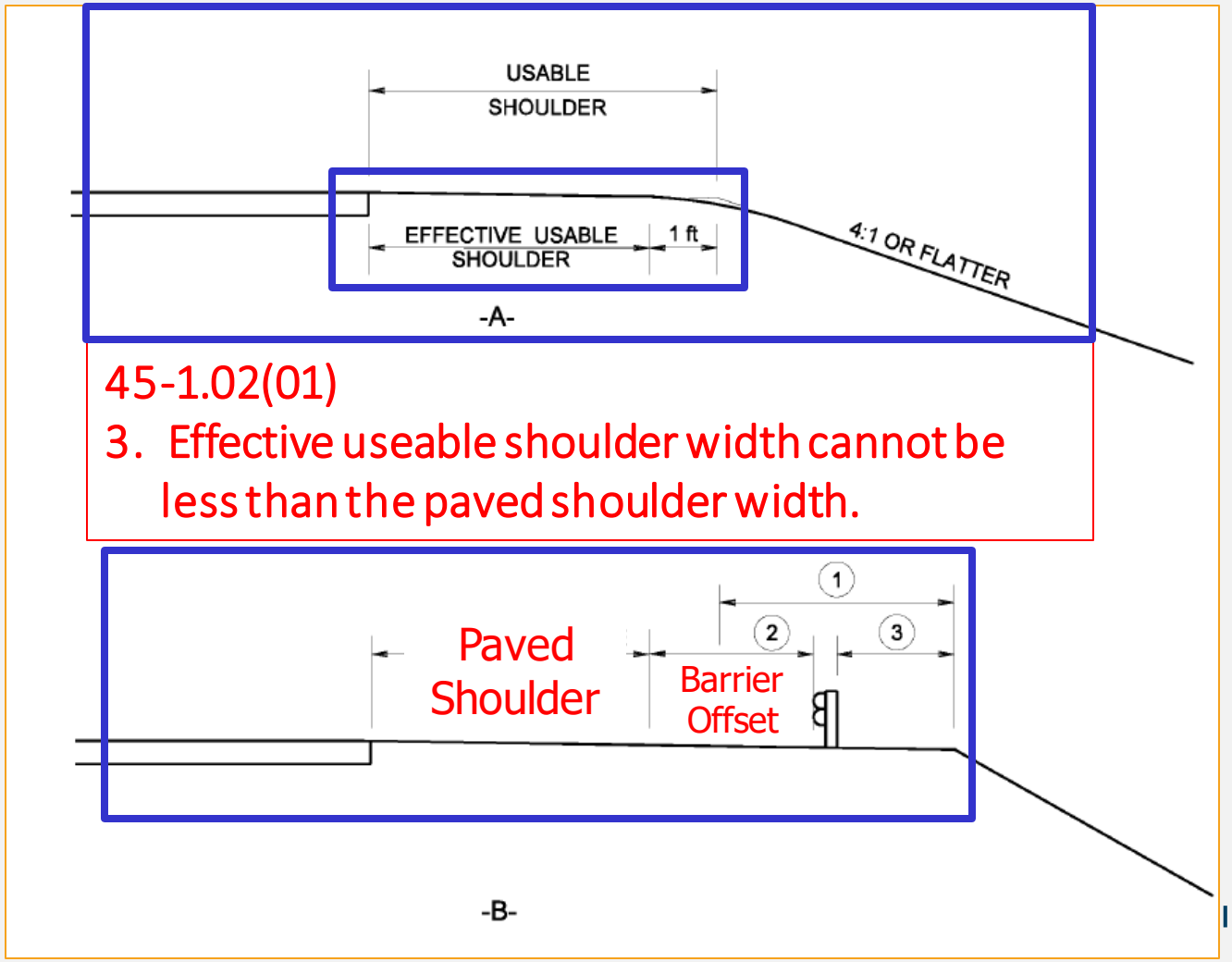


Figure 4-4. Graded and Usable Shoulders

AASHTO Green Book

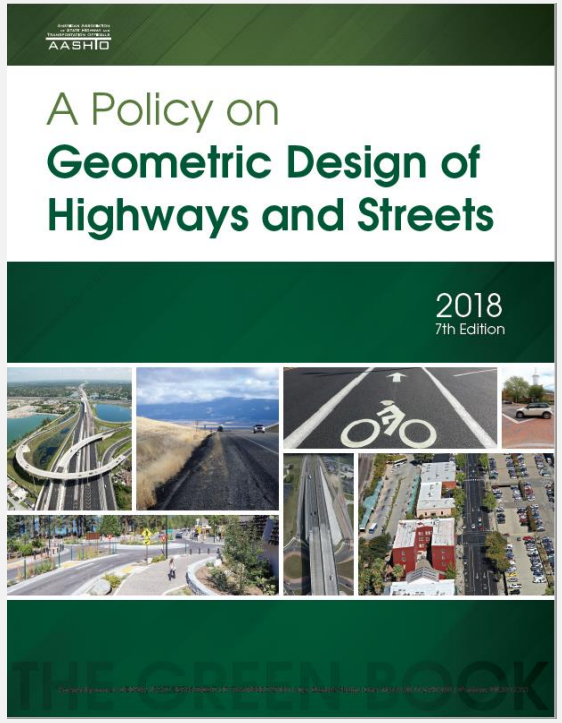


IDM Fig. 45-1A

AASHTO ON SHOULDERS

[Green Book] Cross Section Elements – Shoulder Width

- Shoulders on structures should normally have the same width as usable shoulders on the approach roadways.
- Desirably, a vehicle stopped on the shoulder should clear the edge of the traveled way by at least 1 ft, and preferably by 2 ft.
- (2011) On low-volume roads, roadside barriers may be placed at the outer edge of the shoulder… a minimum clearance of 4 ft should be provided from the traveled way to the barrier.



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AASHTO ON LATERAL OFFSET

- [Green Book] Each functional classification has a section on **Lateral offset**
  - The full approach width (traveled way, shoulders, bicycle facilities, and sidewalks) should be carried along the roadway and across bridges and overpasses where practical.
  - (2018) On facilities without a curb and with shoulder widths less than 4 ft, a minimum lateral offset of 4 ft from the edge of the traveled way is desirable and a lateral offset of 1.5 ft should be provided, where practical.

- [Roadside Design Guide]
  - A desirable feature of a bridge structure is a full, continuous shoulder so that a uniform clearance to roadside elements is maintained
  - As long as the barrier is located beyond the perceived shoulder of a roadway, it will have minimum impact on driver speed or lane position.

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AASHTO ON STRUCTURES

- Each functional classification has a section on **Structures**
  - Dimensional design (lane, shoulder, VC) and design loading of new and reconstructed bridges
  - Structural capacity and minimum width of bridges to remain in place (removed in 2018).

6.2.3 Structures - Vertical Clearance (2011)

Vertical clearance at underpasses should be at least 14 ft over the entire roadway width, with an additional allowance for future resurfacing. The vertical clearance to sign supports and to bicycle and pedestrian overpasses should be at least 15 feet*.

Table 6-6. Minimum Roadway Widths and Design Loadings for New and Reconstructed Bridges(2011)

U.S. Customary		
Design Volume (veh/day)	Minimum Clear Road-way Width for Bridges[a]	Design Load-ing Structural Capacity
400 and under	Traveled way + 2 ft (each side)	HL 93
400 to 1500	Traveled way + 3 ft (each side)	HL 93
1500 to 2000	Traveled way + 4 ft (each side)[b]	HL 93
over 2000	Approach road-way (width)[b]	HL 93

a Where the approach roadway width (traveled way plus shoulders) is surfaced, that surface width should be carried across the structures.

b For bridges in excess of 100 ft in length, the minimum width of traveled plus 3ft on each side is acceptable.

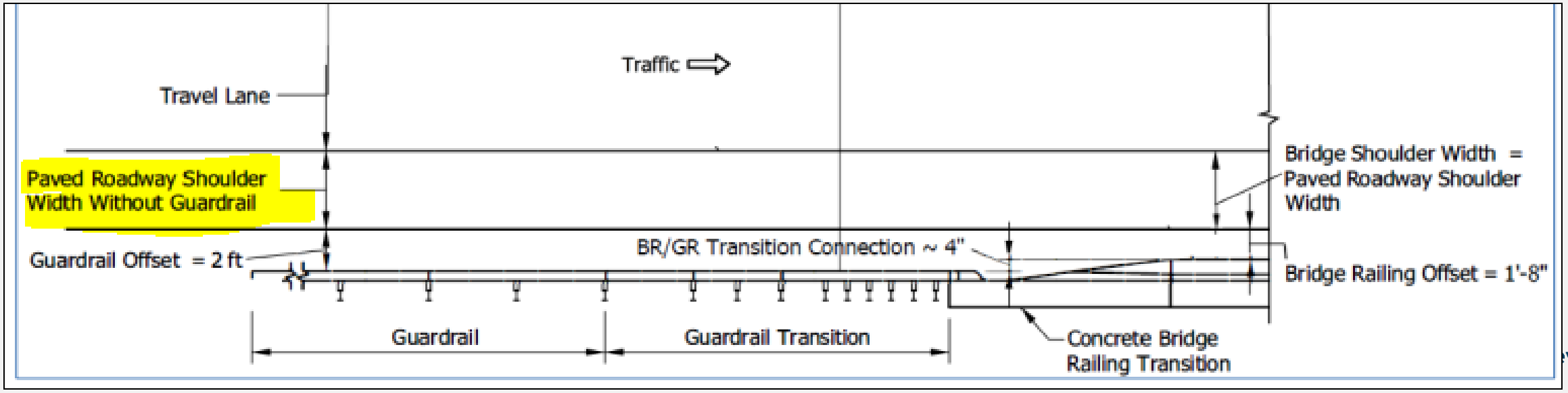
Table 6-7. Structural Capacities and Minimum Roadway Width for Bridges to Remain in Place (2011)

U.S. Customary		
Design Volume (veh/day)	Design Load-ing Structural Capacity	Minimum Clear Roadway Width (ft)[a]
under 400	HS 15	22
400 to 1500	HS 15	22
1500 to 2000	HS 15	24
over 2000	HS 15	28

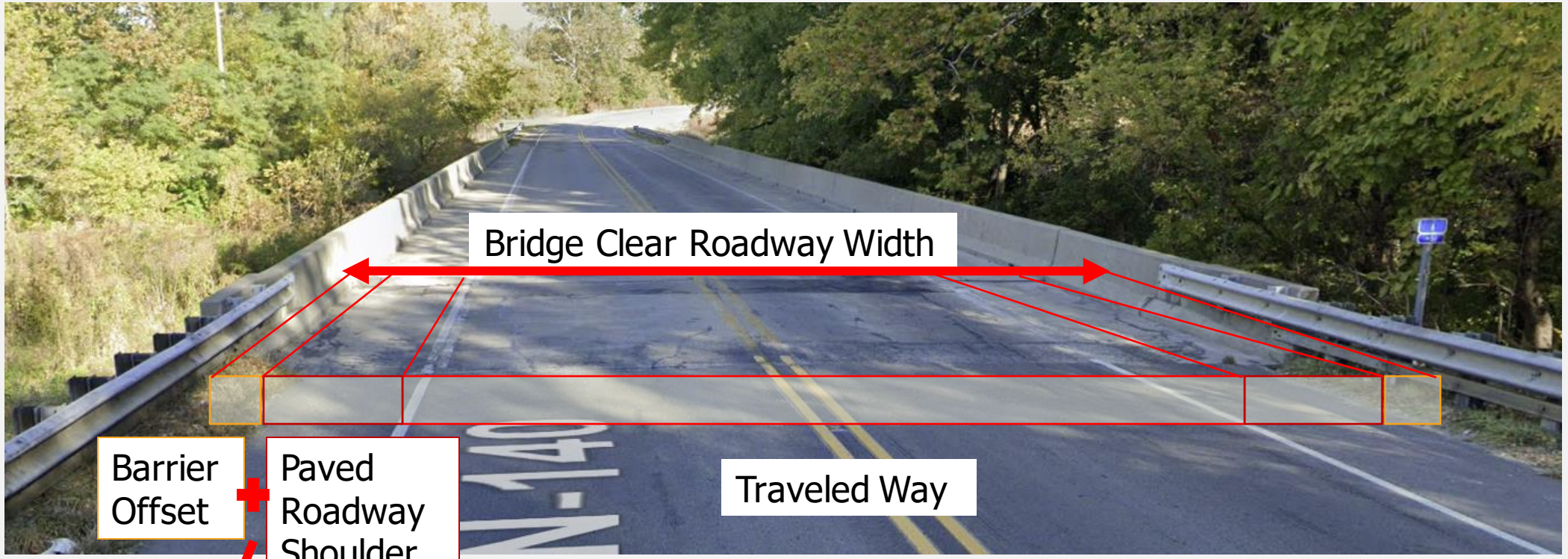
a Clear width between curbs or railings, whichever is less, should be equal to or greater than the width of the approach traveled way, wherever practical.

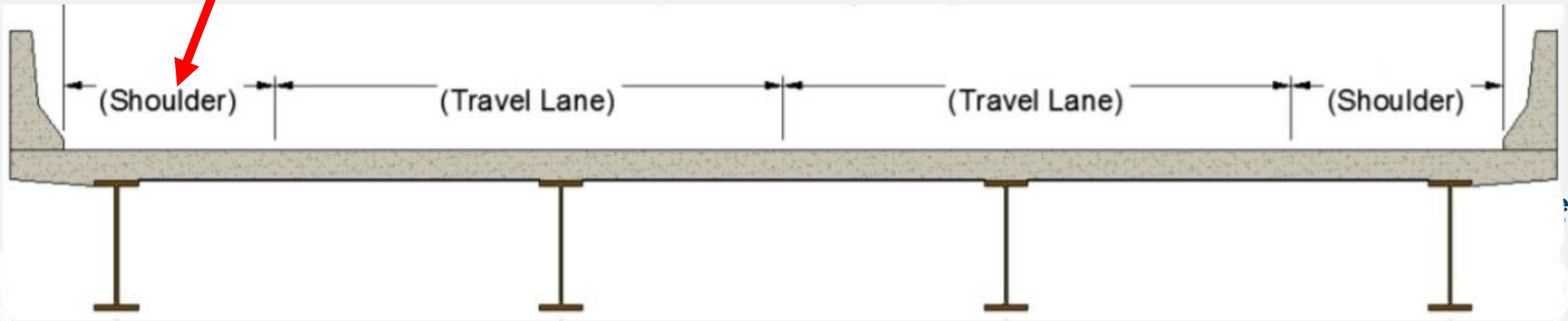
MINIMUM SHOULDER WIDTH ON BRIDGE

- The minimum shoulder width on a bridge is the minimum paved shoulder width from the geometric tables or the existing approach roadway paved shoulder width without guardrail, whichever is greater.
- Check against minimum bridge clear roadway width criteria
  - The *appropriate* width (wider or narrower) should be based on site conditions, speed, traffic, needs of the bridge as part of the transportation network and the needs of the community. Document these decisions.

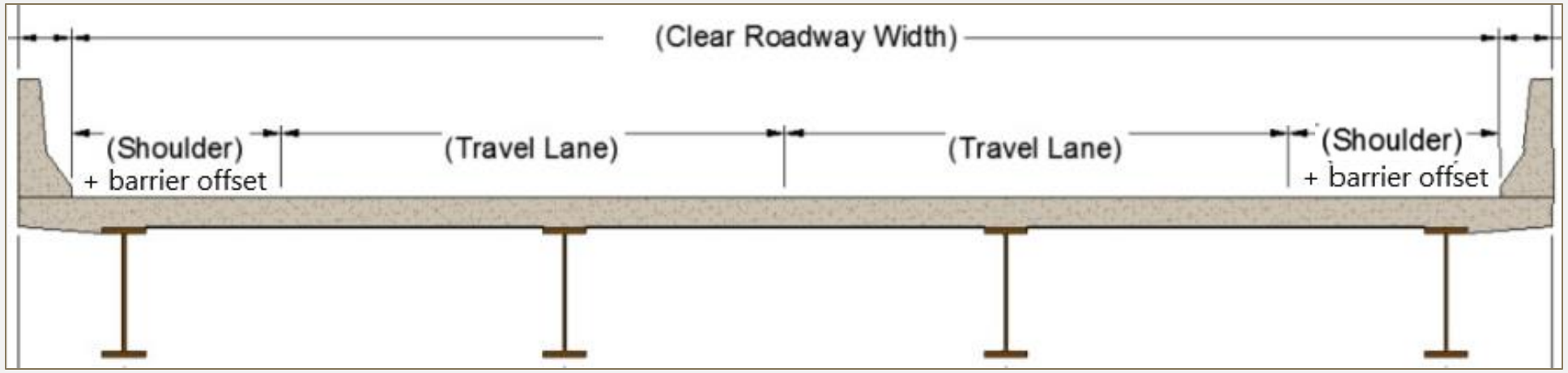


BRIDGE CLEAR ROADWAY WIDTH





BRIDGE CLEAR ROADWAY WIDTH



*Local Roads is a functional classification, not locally-owned

**Applies to LPA and State projects

- Level One Controlling Criteria → Level Two Criteria (Aug. 2020 – DM 20-13, recently incorporated into IDM Ch. 40)
  - Where the sum of the lane and shoulder widths is less than 30 ft (arterials and collectors) or 28 ft (local roads*), the greater width is the minimum criteria. **
  - The *appropriate* width (wider or narrower) should be based on site conditions, speed, traffic, needs of the bridge as part of the transportation network and the needs of the community.

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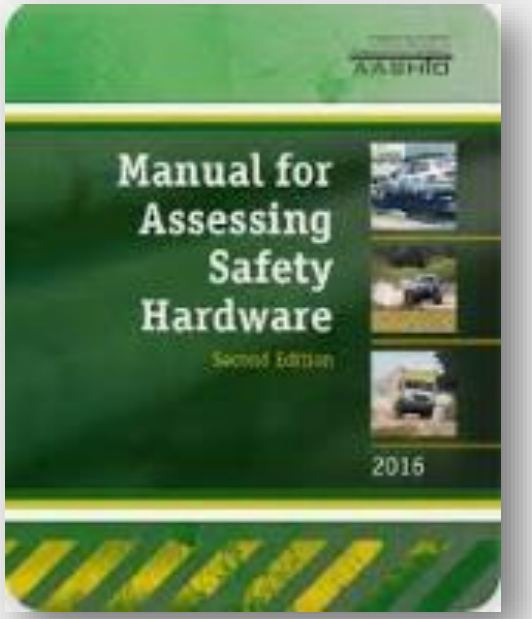
GUARDRAIL STATE OF THE UNION

- MASH is the current crash testing criteria. MASH is a rewrite of NCHRP Report 350, including updated test vehicles, impact condition criteria, and evaluation criteria.
- INDOT adopted the non-proprietary Midwest Guardrail System (MGS)
  - Callout on plans as MGS W-beam, not W-beam
- All INDOT MASH-compliant guardrail and guardrail systems are in Standard Drawing series 601-MGSA.
  - Current design guidance in DM 17-10, 17-17, and 23-07
  - IDM Chapter 49 reflects the previous (strong post) w-beam guardrail systems standards.
- Other 601- series guardrail and guardrail systems considered acceptable under NCHRP 350.
- Project-specific constraints and lack of a MASH-compliant alternative may necessitate the use of a previous guardrail standard.
  - Coordinate with S&P Division
  - Document as Level Two exception



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GUARDRAIL

- Resource: Guardrail Tab on "Common Errors List" (2023 Highway Design Conference). https://www.in.gov/indot/engineering/highway-design/
- 601-MGSA series Standard Drawings = multiple systems in single series.
  - Details for MGS guardrail systems are not applicable to non-MGS systems
  - Modifications to one system are not applicable to all systems.
    - Omitted posts. For linear runs of MGS only and has other design requirements.
    - Presence of curb. If curb is not in the system detail, system should not be placed in conjunction with curb
    - Curving. Linear runs of MGS w-beam guardrail can be shop-curved*. Transitions, cable terminal anchorage, long-span should not be placed on a curve. *Shop-curved guardrail is not equivalent to curved terminal/connector system.
- MGS Height transition needed to connect to non-MGS guardrail or guardrail systems, ex. Curved Terminal/Connector guardrail

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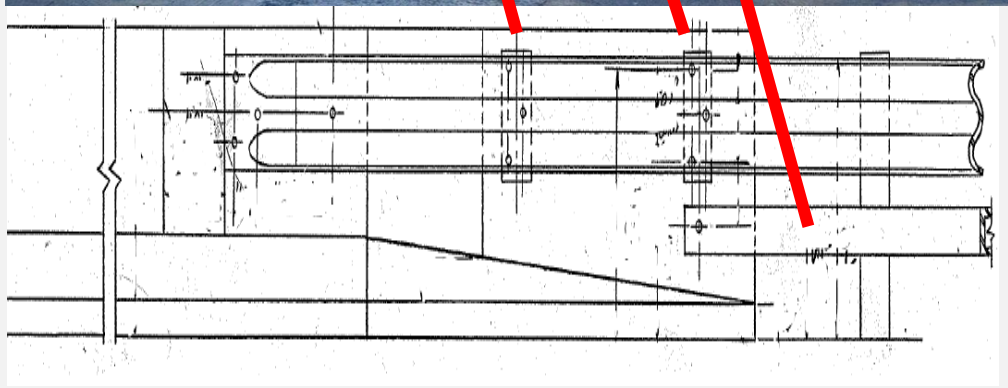
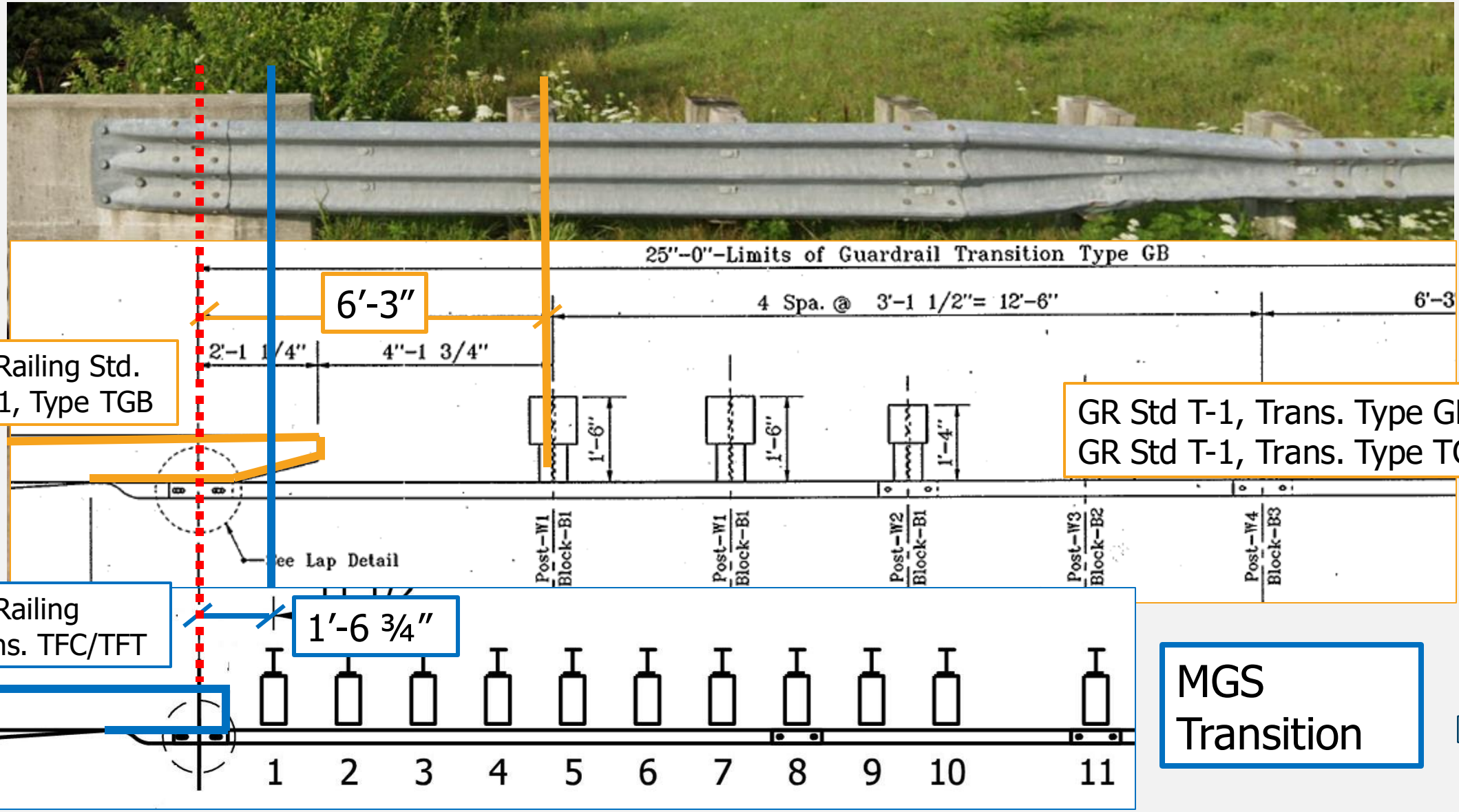
TRANSITIONS

- Old standards for concrete and guardrail transitions were a pair
  - Designed specifically to be used together and not interchangeable with other transitions
  - Attaching "current standard" guardrail transition does not make the connection MASH compliant. Update the bridge railing transition accordingly



Bridge Standard BR5 Railing Connection

TRANSITIONS



Br. Railing Std. BR-1, Type TGB

GR Std T-1, Trans. Type GB (1991)
GR Std T-1, Trans. Type TGB (1992)

Br. Railing Trans. TFC/TFT

MGS Transition

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CULVERTS, SHIELD OR EXTEND?

- [IDM Part 3 Preface] IDM guidance is not a standard to be met regardless of impact - context matters.
  - Document decisions that deviate from IDM guidance.
- Consider the hierarchy for treating obstructions
  - Remove or make traversable
  - Relocate
  - Make breakaway
  - Shield
  - Delineate where above not practical
- Applying the hierarchy is engineering judgement, not right or wrong.

- Resource: AASHTO *Roadside Design Guide*
- Resource: IDM Ch 49 and Ch 55
- Resource: Good Decision Making, Highway Design Conference 2022 https://www.in.gov/indot/engineering/highway-design/

Span	Rise	Treatment
≤ 10 ft	All	B preferred; A acceptable
> 10 ft	< 5.5 ft	B preferred; A acceptable
> 10 ft	≥ 5.5 ft	B

A *Provide a clear zone with 6:1 slopes or flatter at least a distance L_R in advance of, and 100 ft beyond, the structure. Taper 10:1 on both sides of the structure to tie back in.*

B *Guardrail should be placed. Use treatment A if guardrail is impractical due to the close proximity of a public road approach or drive. The drive grade should be designed to be compatible with the clear-zone slope. The drive sideslope should be 10:1.*

CONSIDERATIONS FOR OBSTRUCTIONS

- In the context of 3R work, scopes are limited, more likely to have constraints from the built environment.
- AASHTO RDG guidance developed for new/reconstruction
  - Clear Zone – frame of reference only
  - Consider obstruction free zone distances (OFZ)
- Consider the existing clear zone ("effective clear zone")
  - If numerous obstacles are at an offset less than the clear zone, locating the structure at the clear zone will not significantly reduce the risk of a crash.
- Consider alignment and traffic volume
  - Is there adverse geometry?
  - Poor sight distance?
- Consider crash history. Useful tool when evaluating the likelihood of a driver leaving the roadway.
  - Is there a pattern of crashes near the culvert?
  - History of repairs from maintenance?
  - Site investigation show evidences of crashes?

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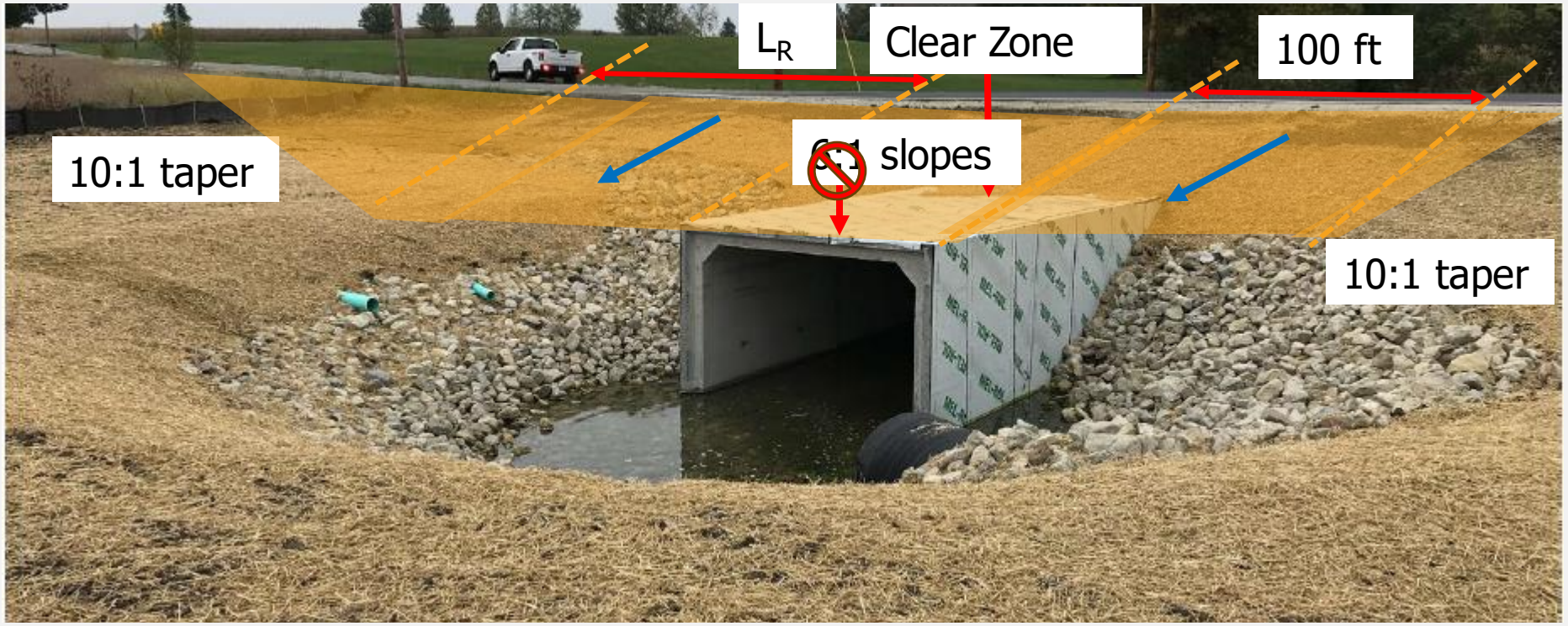
CONSIDERATIONS WHEN EXTENDING

- Clear zone and OFZ are not a magic distances where crashes will not happen.
  - Measured where structure protrudes from the slope, not where the end is located.
- When extending the culvert end, grading is key to meeting clear zone requirements and may be extensive to blend with surrounding terrain.
- Protruding ends are prone to erosion.



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CONSIDERATIONS WHEN SHIELDING

- ~~"I have to provide guardrail. The span and rise are outside of range."~~
  - Site context may make deviations appropriate. Document these decisions.
- Lack of sufficient cover and the proximity of driveways add complexity for preferred guardrail installation.
- Guardrail presents significantly more exposure (opportunity to strike)
- Cross section often needs to be widened to provide a desirable lateral offset.

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TRAVERSABLE END SECTION

- Making an obstruction traversable is preferred to relocating (per the hierarchy)
- Span and rise limitations

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INCREMENTAL IMPROVEMENT

- Consider the “effective clear zone” along the corridor
- Consider an incremental improvement in the offset rather than full OFZ or clear zone
- Headwalls and wingwalls will reduce overall structure length. Proper grading is important.

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INCREMENTAL IMPROVEMENT

- Consider the “effective clear zone” along the corridor
- Consider an incremental improvement in the offset rather than full OFZ or clear zone
- Precast tapered end sections may be practical alternative to wingwalls

Remember This

- The AASHTO Green Book and RDG are for you!
- Carry paved shoulder and guardrail offset across the bridge.
- Don’t mix and match standard drawing details.
- Older guardrail/bridge rail transitions were a pair
- Consider the hierarchy for roadside obstructions
- Applying the hierarchy is an engineering decision.
- Context matters! Let the corridor be your guide.

- AASHTO *A Policy on Geometric Design of Highways and Streets* (Green Book)
- AASHTO *Roadside Design Guide*
- *Indiana Design Manual*, Chapter 49, Roadside Safety (New Construction/Reconstruction)
- *Indiana Design Manual*, Chapter 55, Geometric Design of Existing Non-Freeways
- "Good Decision Making" - 2022 Highway Design Conference https://www.in.gov/indot/engineering/highway-design/
- "Common Errors List" (Guardrail Tab) - 2023 Highway Design Conference https://www.in.gov/indot/engineering/highway-design/

Bridge Questions?

BridgeDesignOffice@indot.in.gov

Guardrail Questions?

DesignManualInquiries@indot.in.gov

INDOT BRIDGE DESIGN CONFERENCE 2024

SHOULDER WIDTH AND GUARDRAIL FOR BRIDGE DESIGNERS