Roadside Barriers - MASH Implementation Update & Design Lessons Learned

Richard Stepp and Derwood Sheppard
Roadside Barriers - Lessons Learned

1. GUARDRAIL
   Standard Plans, Index 536-001

2. CONCRETE BARRIER
   Standard Plans, Index 521-001

3. PIER PROTECTION BARRIER
   Standard Plans, Index 521-002
Design is generally governed by:

1. FDOT Design Manual (FDM)
https://www.fdot.gov/roadway/fdm/default.shtm

Roadway Design

Chapter 215
Roadside Safety
Roadside Barriers - Lessons Learned

Design is generally governed by:

2. FDOT Standard Plans
https://www.fdot.gov/design/standardplans/

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### 3. Standard Plans Instructions

[https://www.fdot.gov/design/standardplans/](https://www.fdot.gov/design/standardplans/)

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Design is generally governed by:

4. Standard Specifications

https://www.fdot.gov/programmanagement/implemented/specbooks/default.shtm
Grading: Any issues here?...

Answer...

YES!

- Front slope looks too steep
- Slope break likely too close to post

Photo Credit: Bill Fitzgerald, PE
KLS Engineering, LLC
Grading: ‘Standard Post’ Requirements

- Front slope must be 1:2 or flatter
- Slope break must be 2 feet behind post

Unless??...

TYPICAL GRADING & PAVT. PLACEMENT DETAIL
Grading: ‘Deep Post’ Requirements

- If ‘Deep Post’ is called for, slope break may be located at Center Line of post.

- **STILL**, Front slope must be 1:2 or flatter.

Note: Unique Pay Item 536-7-1
Shoulder Widens: Any issue here?

Answer... **YES!**

- “Taper Rate” requirement is violated
- Per Standard Plans Instructions (SPI), Part I:
  - Design Speed $\leq$ 45 mph requires 1:10 Max.
  - Design Speed $>$ 45 mph requires 1:15 Max.
Single Face to Double Face: Any Issue?

Answer...

YES!

- “Trailing Anchorage” Standard is not used here (not detailed this way)

Index 536-001 does not show this as a Trailing Anchorage scenario, and the details are not compatible or required.
Single Face to Double Face: Solution

Call for a Standard “Flared End Unit” (included with General Guardrail Pay Item).

*No “Trailing Anchorage”*

*Just call out Begin and End of guardrail types (on face closest to traveled way)*

More guidance provided in next year’s eBook!
CRT System (Radial): Any issue here?

(Controlled Release Terminal)

Answer...
YES!

First Issue:
Obstruction is in the “Clear Area Limit” per Standard Plans.

Begin GR. Begin CRT
Sta. 100+00 128.5’ RT
CRT System (Radial):

First Issue:
Obstruction is in the “Clear Area Limit” per Standard Plans.

Photo Credit:
Bill Fitzgerald, PE
KLS Engineering, LLC
CRT System (Radial): From Standard Plans...

- “Clear Area” Required (15’x30’)
- “Clear Area” is free of obstructions and has 1:2 Slope Max
CRT System (Radial): Any other issue here?

CRT
R=16'

End Treatment
Per Standard Plans

(12’-6” Shown)

Requires 25-foot linear End Treatment

Begin GR.
Begin CRT
Sta. 100+00
128.5’ RT

CRT System (Radial): Any other issue here?
CRT System (Radial): Per Standard Plans...

- **25-foot linear** End Treatment required

- If this is not possible due limited space, use a ‘variation’ for General Radial Guardrail (Not CRT) (No breakaway posts)

Begin GR. Begin CRT
Sta. 100+00
141' RT

CRT
R=16'

\[\frac{+16.00}{100'} RT\]
Pipe Rail Callouts: Any issue here?

Answer... YES!

Pipe Rail must terminate outside of End Treatments per SPI Part E and Standard Plans

Solution:
Rigid Barrier Connections, End Shielding:
Rigid Barrier Connection: Any Issue Here

Answer... YES!

≈13 foot overlap with barrier is no longer Standard!

(Overlap now only 7¼” Since FY2017-18 Standards, for new, single-faced guardrail)
Rigid Barrier Connection:

≈13 foot overlap with barrier is no longer Standard!

(Overlap now only 7¼” Since FY2017-18 Standards, for new, single-faced guardrail)
Rigid Barrier Connection:

Solution:

≈13 foot overlap with barrier is no longer Standard!

(Overlap now only 7½” Since FY2017-18 Standards, for new, single-faced guardrail)
Rigid Barrier Connection: Any issue here

Answer...

YES!

Guardrail system is... not long enough

Minimum Length is **Length of Approach Transition Connection ‘LA’**

plus **Length of End Treatment ‘LE’**
Rigid Barrier End Shielding: Min Length, **TL-2**

- **‘LA’**, 21.3’
- **‘LE’**, 40.6’

= **62’**
Rigid Barrier End Shielding: Min Length, **TL-2**

```
‘LA’, 21.3’
+ ‘LE’, 40.6’
= 62’
```
Rigid Barrier End Shielding: Min Length, **TL-3**

- **'LA'**, 30.6’
- **'LE'**, 53.1’

= 84’
Rigid Barrier End Shielding: Min Length, **TL-3**

‘LA’, 30.6’

+ ‘LE’, 53.1’

= 84’

NOTE: If these lengths are not possible due to limited space, consider the use of a Crash Cushion or a project-specific ‘variation’ to fit the best barrier system possible.

*Contact Central Office for assistance.*
Approach Terminals
Approach Terminals: Any issues here?

Answer...

1. Flared terminals not permitted per RDB 18-02

2. Curbed conditions require parallel Approach Terminals per Standard Plans & SPI Part C

3. Approach Terminals require ‘Type E’ Curb
Approach Terminals:

From Standard Plans...

1. Flared terminals not permitted per RDB 18-02

2. Curbed conditions require **parallel** Approach Terminals per Standard Plans & SPI Part C

3. Approach Terminals require ‘Type E’ Curb
Approach Terminals: Solution

1. Flared terminals not permitted per RDB 18-02

2. Curbed conditions require parallel Approach Terminals per Standard Plans

3. Approach Terminals require ‘Type E’ Curb
**Approach Terminals: Any issues here?**

**Answer...**

**YES!**

**First issue...**

Front slope break should be **6 feet** behind guardrail face at post 1 per the Standards (1:10 Max.)

**Second issue...**

Misc Asphalt should extend 10 feet upstream of post 1 per Standards.
Approach Terminals:

From Standard Plans...

First issue...
Front slope break should be **6 feet** behind guardrail face at post 1 per the Standards (1:10 Min.)

Second issue...
Misc Asphalt should extend 10 feet upstream of post 1 per Standards
Approach Terminals:

Example of Poor Slope Break Location (and steep slope not shielded!)

First issue...
Front slope break should be **6 feet** behind guardrail face at post 1 per the Standards (1:10 Min.)

Second issue...
Misc Asphalt should extend 10 feet upstream of post 1 per Standards

Photo Credit: Bill Fitzgerald, PE
Approach Terminals:

First issue... Front slope break should be 6 feet behind guardrail face at post 1 per the Standards (1:10 Min.)

Second issue... Misc Asphalt should extend 10 feet upstream of post 1 per Standards

Example of Poor Grading (The reason for Misc. Asphalt requirement!)

Photo Credit: Bill Fitzgerald, PE
Approach Terminals: Solution

Corrected...

First issue...
Front slope break should be **6 feet** behind guardrail face at post 1 per the Standards (1:10 Min.)

Second issue...
Misc Asphalt should extend 10 feet upstream of post 1 per Standards
Approach Terminals: Any issues here?

Answer... YES! Wrong.

First issue...
Trees are within the Approach Terminal’s clear area in the Standard Plans (where a clear, 1:10 slope required)

Second issue...
Tree violates barrier setback per FDM Table 215.4.2
Approach Terminals: Any issues here?

Answer... YES! Wrong.

First issue...
Trees are within the Approach Terminal’s clear area in the Standard Plans (where a clear, 1:10 slope required)

Second issue...
Tree violates barrier setback per FDM Table 215.4.2
Approach Terminals:

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Trees are within the Approach Terminal’s clear area in the Standard Plans (where a clear, 1:10 slope required)

https://www.youtube.com/watch?v=h7tct7Oo9-8&feature=youtu.be
https://www.youtube.com/watch?v=OsKlfatcjog&feature=youtu.be

CREDIT: VIRGINIA DOT – SKT Crash Test Published October 2016
Approach Terminals:

First issue...
Trees are within the Approach Terminal’s clear area in the Standard Plans (where a clear, 1:10 slope required)

https://www.youtube.com/watch?v=74lmLTY-PhU&feature=youtu.be

CREDIT: VIRGINIA DOT – SKT Crash Test Published October 2016
Approach Terminals:

From Standard Plans...

First issue...
Trees are within the Approach Terminal’s clear area in the Standard Plans (where a clear, 1:10 slope required)
Second issue...
Tree violates barrier setback per FDM Table 215.4.2
From FDM...

Table 215.4.2 Minimum Barrier Setback (Measured from the face of the barrier)

<table>
<thead>
<tr>
<th>Barrier Type</th>
<th>Setback Distance</th>
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<tr>
<td>Flexible Barrier</td>
<td></td>
</tr>
<tr>
<td>High Tension Cable Barrier (HTCB)</td>
<td>12 feet, 0 inches</td>
</tr>
<tr>
<td>Semi-Rigid Barrier</td>
<td></td>
</tr>
<tr>
<td>W-Beam with Post Spacing @ 6 feet, 3 inches (TL-3)</td>
<td>5 feet, 0 inches</td>
</tr>
<tr>
<td>W-Beam with Post Spacing @ 12 feet, 6 inches (TL-2)</td>
<td>5 feet, 0 inches</td>
</tr>
<tr>
<td>W-Beam with Post Spacing @ 3 feet, 1.5 inches (½ Spacing)</td>
<td>3 feet, 10 inches</td>
</tr>
<tr>
<td>W-Beam with Post Spacing @ 1 foot, 6.75 inches (¼ Spacing)</td>
<td>3 feet, 2 inches</td>
</tr>
</tbody>
</table>

Second issue...
Tree violates barrier setback per FDM Table 215.4.2
Approach Terminals: Any issue here?

Answer... YES! Wrong.

First issue...
Perpendicular guardrail is not proven crashworthy:
- No end treatments
- Violates “taper rate” requirements of SPI, Part I (big time).
- Requires shielding if within Clear Zone
Approach Terminals: Any issue here?

Second issue...
Perpendicular guardrail within the Approach Terminal’s clear area in the Standard Plans (where a clear, 1:10 slope required)
Approach Terminals: Any issue here?

Third issue...
Perpendicular guardrail violates barrier setback per FDM Table 215.4.2
Approach Terminals: Solution 1

REMOVE the perpendicular Guardrail!

Or...
1. Extend Guardrail to meet **Length of Need** per SPI Part B (Excel ‘Design Tool’), which is Roadside Design Guide Eq. 5-3

2. Meet minimum barrier setback per FDM Table 215.4.2 (5 feet for general guardrail)
Approach Terminals: Final Case Study!

Assumptions:
- Design Speed: 50 mph
- Piers designed to withstand 600 kip impact load per FDM215.4.5.4 (Pier Protection Barrier not Required)
Approach Terminals: Any issue here?

Answer... YES!

First issue...
Piers NOT shielded!

“Length of Need” NOT met per SPI, Part B
(Excel Design Tool)
Approach Terminals: Any issue here?

Answer... YES!

First issue...
Piers NOT shielded

“Length of Need” NOT met per SPI, Part B (Excel Design Tool)

Piers are behind the “gating” (break-away) portion of Approach Terminal
Approach Terminals: Any issue here?

Second issue... Flared Terminal usage on hold per RDB18-02

Regardless... “Taper Rate” too steep here at Approach Terminal (about 1:3 shown)

Guardrail requires 1:15 Max Taper Rate per SPI, Part I
Approach Terminals: Any issue here?

Third issue... “Barrier Setback” requirement likely not satisfied

per FDM Table 215.4.2 (5 feet or greater)...

TL-3 Flared Terminal

Trailing Anchorage

Edge of Pavt.

Bridge Pier (Typ.)

SETBACK DISTANCE

8" Nom.

8" Nom.
Approach Terminals: Any issue here?

Fourth issue... “Trailing Anchorage” not properly extended downstream of hazard

25-foot Requirement, SPI C.1 & ‘LON’ Design Tool (Excel)...

Edge of Pavt.

Bridge Pier (Typ.)

TL-3 Flared Terminal

Trailing Anchorage
Approach Terminals: Any issue here?

From ‘Length of Need’ Excel Sheet...

Fourth issue...
“Trailing Anchorage” not properly extended downstream of hazard

25-foot Requirement, SPI C.1 & ‘LON’ Design Tool (Excel)...)
Approach Terminals: Solution 1

‘Crash Cushion’
- “System Width” – ‘Wide’ per SPI 544-001, Part C
- “Length Restriction” - per SPI 544-001, Part F
- Contact Central Office for guidance!

Note: Define Crash Cushion with provided CADD cell...
“Summary of Permanent Crash Cushions Table”
Approach Terminals: Solution 1

‘Crash Cushion’

- Guardrail “reduced post spacing” to reduce required hazard setback per FDM Table 215.4.2.
- Again, contact Central Office for guidance for such limited space.
Approach Terminals: Solution 2

‘Concrete Barrier’ & ‘Crash Cushion’

- Requires project-specific design
- Contact Central Office for guidance for such limited space
Questions?

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