



TRANSPORTATION SYMPOSIUM

2019

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

Roadside Barriers - Lessons Learned

Design is generally governed by:

1. FDOT Design Manual (FDM)

<https://www.fdot.gov/roadway/fdm/default.shtm>



Roadway Design

Roadway Design / Roadway Criteria / FDOT Design Manual

FDOT Design Manual

Chapter	Bulletin	Webinar	Description
215			Roadside Safety



Roadside Barriers - Lessons Learned

Design is generally governed by:

2. FDOT Standard Plans

<https://www.fdot.gov/design/standardplans/>



Standard Plans for Road Construction

Standard Plans Index	Interim Revision or Errata	Index Title	Design Standards Index	Standard Plans Instructions	Design Tools	Contact
		Guardrail				
536-001	Errata	Guardrail	400	SPI	XLS	Roadway
536-002		Guardrail Transitions and Connections for Existing Bridges	402	SPI		

Roadside Barriers - Lessons Learned

Design is generally governed by:

3. Standard Plans Instructions

<https://www.fdot.gov/design/standardplans/>



Standard Plans for Road Construction

Standard Plans Index	Interim Revision or Errata	Index Title	Design Standards Index	Standard Plans Instructions	Design Tools	Contact
		Guardrail				
536-001	Errata	Guardrail	400	SPI	XLS	Roadway
536-002		Guardrail Transitions and Connections for Existing Bridges	402	SPI		

Roadside Barriers - Lessons Learned

Design is generally governed by:

4. Standard Specifications

<https://www.fdot.gov/programmanagement/implemented/specbooks/default.shtm>

Program Management

Program Management/Specifications

Standard Specifications Library



Grading: Any issues here?...



Answer...

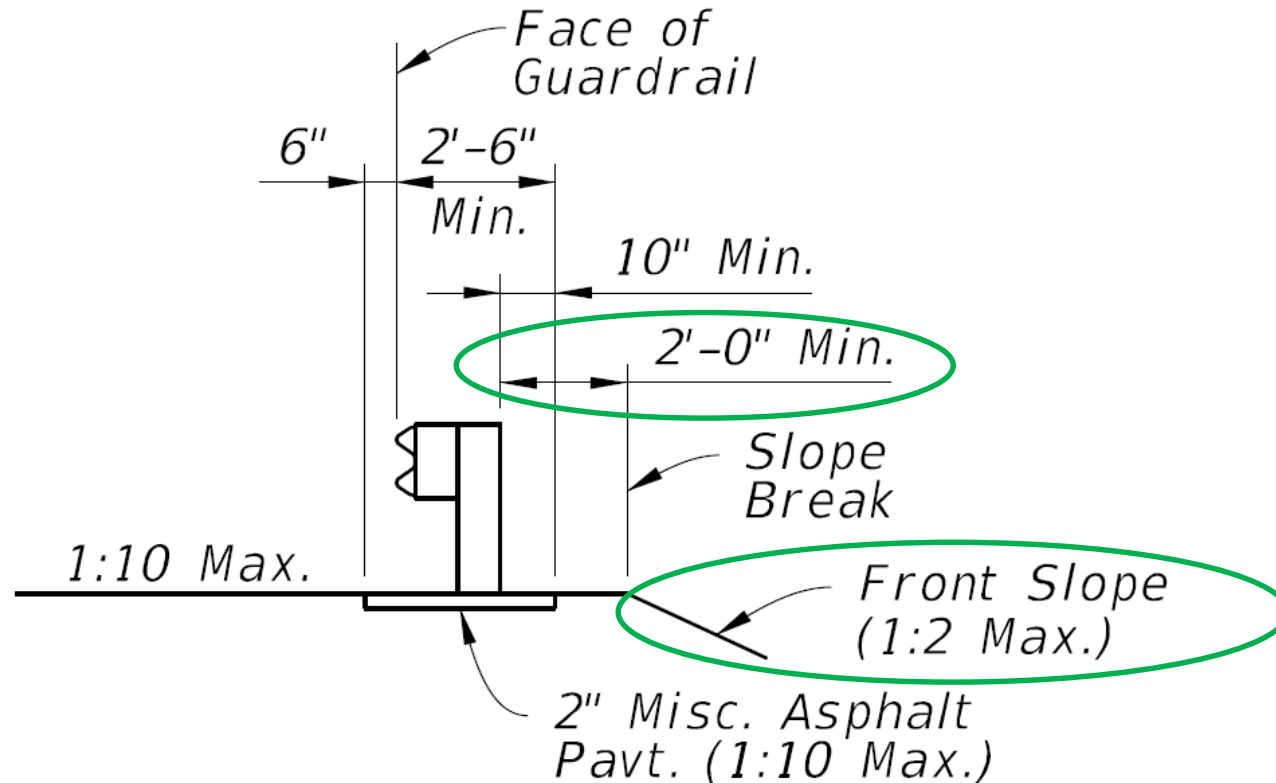
YES!



Photo Credit: Bill Fitzgerald, PE
KLS Engineering, LLC

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

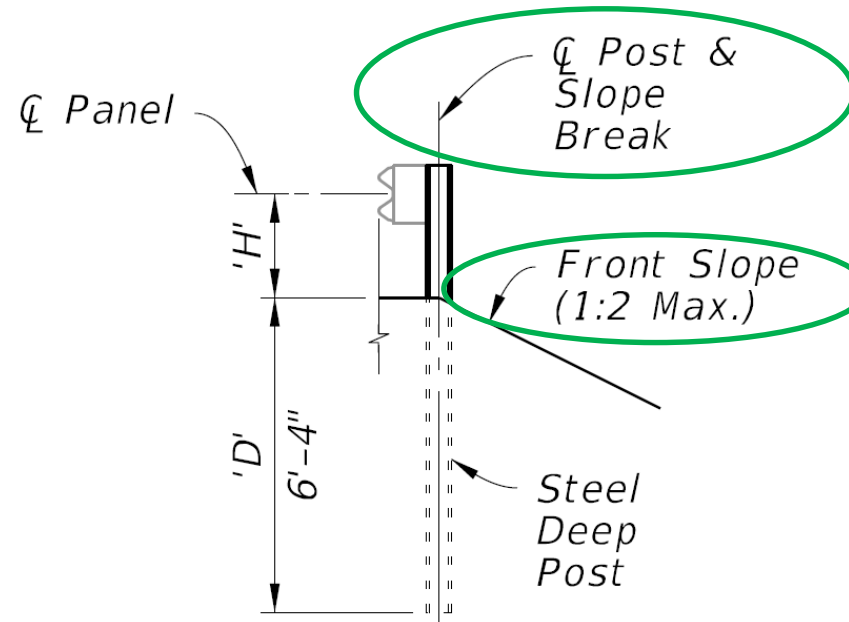
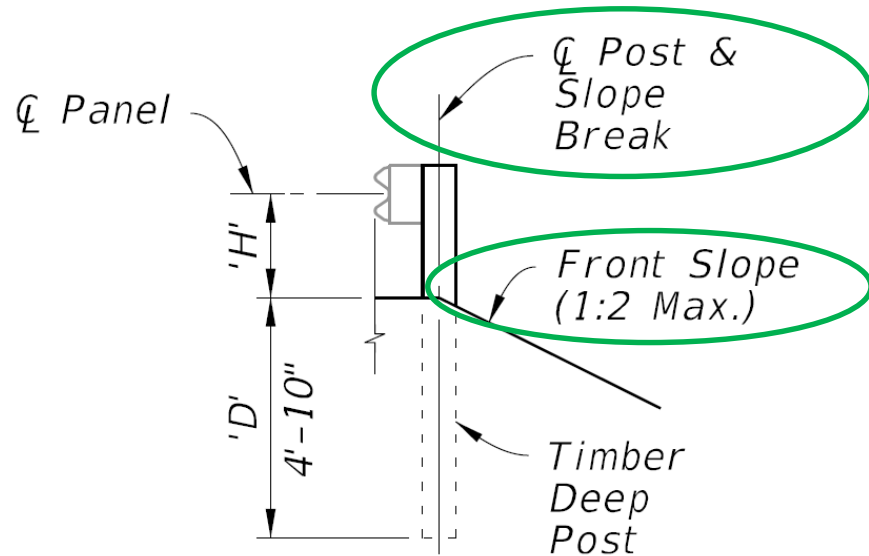
Grading: 'Standard Post' Requirements



**TYPICAL GRADING &
PAVT. PLACEMENT DETAIL**

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

Grading: 'Deep Post' Requirements



- If **'Deep Post'** is called for, slope break may be located at Center Line of post

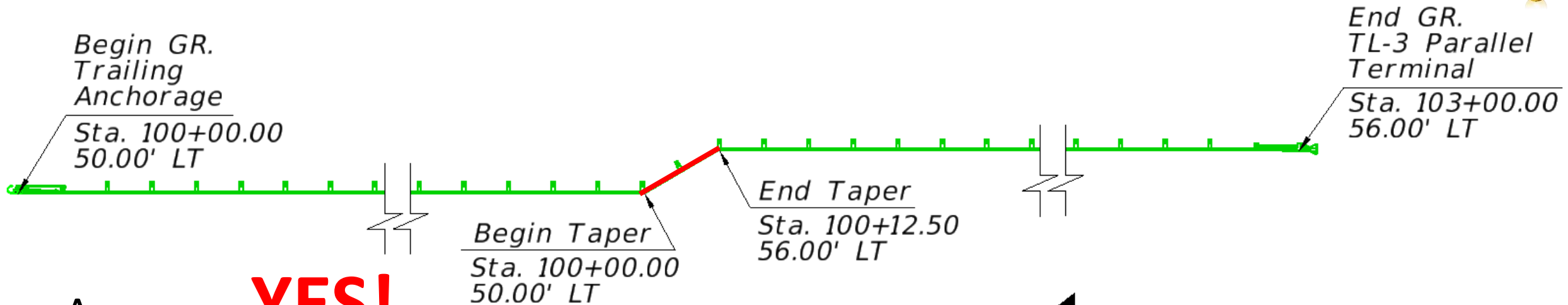
- STILL*, Front slope must be 1:2 or flatter

SLOPE BREAK CONDITION
TIMBER DEEP POST

SLOPE BREAK CONDITION
STEEL DEEP POST

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 $>$ 45mph requires 1:15 Max.

Single Face to Double Face: Any Issue?



End Single
Faced GR.

Answer...

YES!

Begin Double
Faced GR.
~~Trailing~~
~~Anchorage~~

- “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

✓ End Single Faced GR.
Begin Double Faced GR.

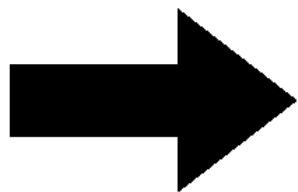
Flared End Unit ✓

- No “Trailing Anchorage”
- Just call out Begin and End of guardrail types (on face closest to traveled way)

Call for a Standard “Flared End Unit”
(included with General Guardrail Pay Item).
More guidance provided in next year’s eBook!

CRT System (Radial): Any issue here?

(Controlled Release Terminal)



+16.00
100' RT

CRT
R=16'

Begin GR.
Begin CRT

Sta. 100+00
128.5' RT

Mast Arm
Support

Answer...

YES!

First Issue:

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

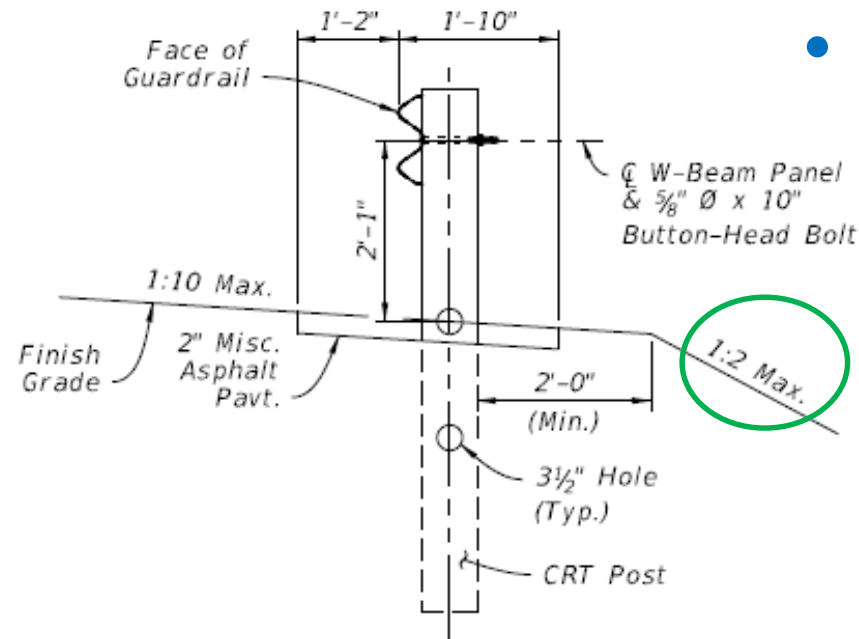
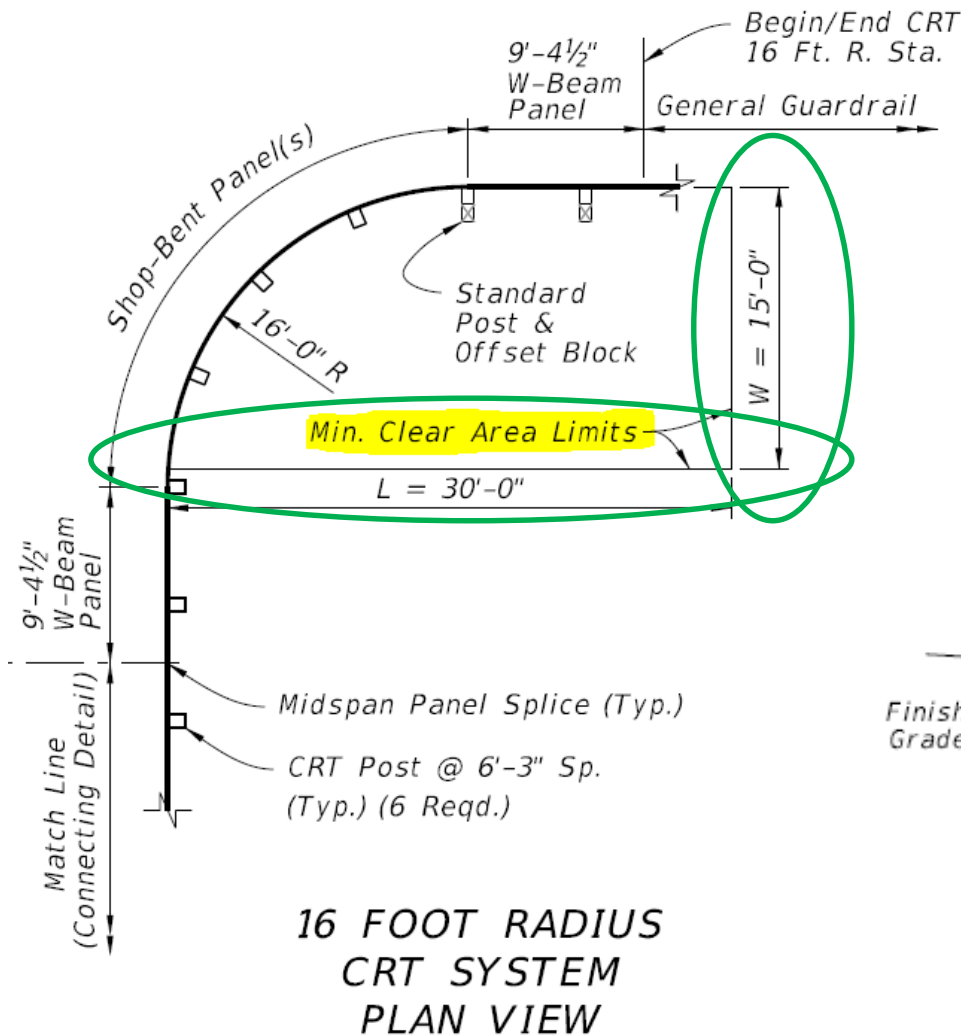
CRT System (Radial):



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

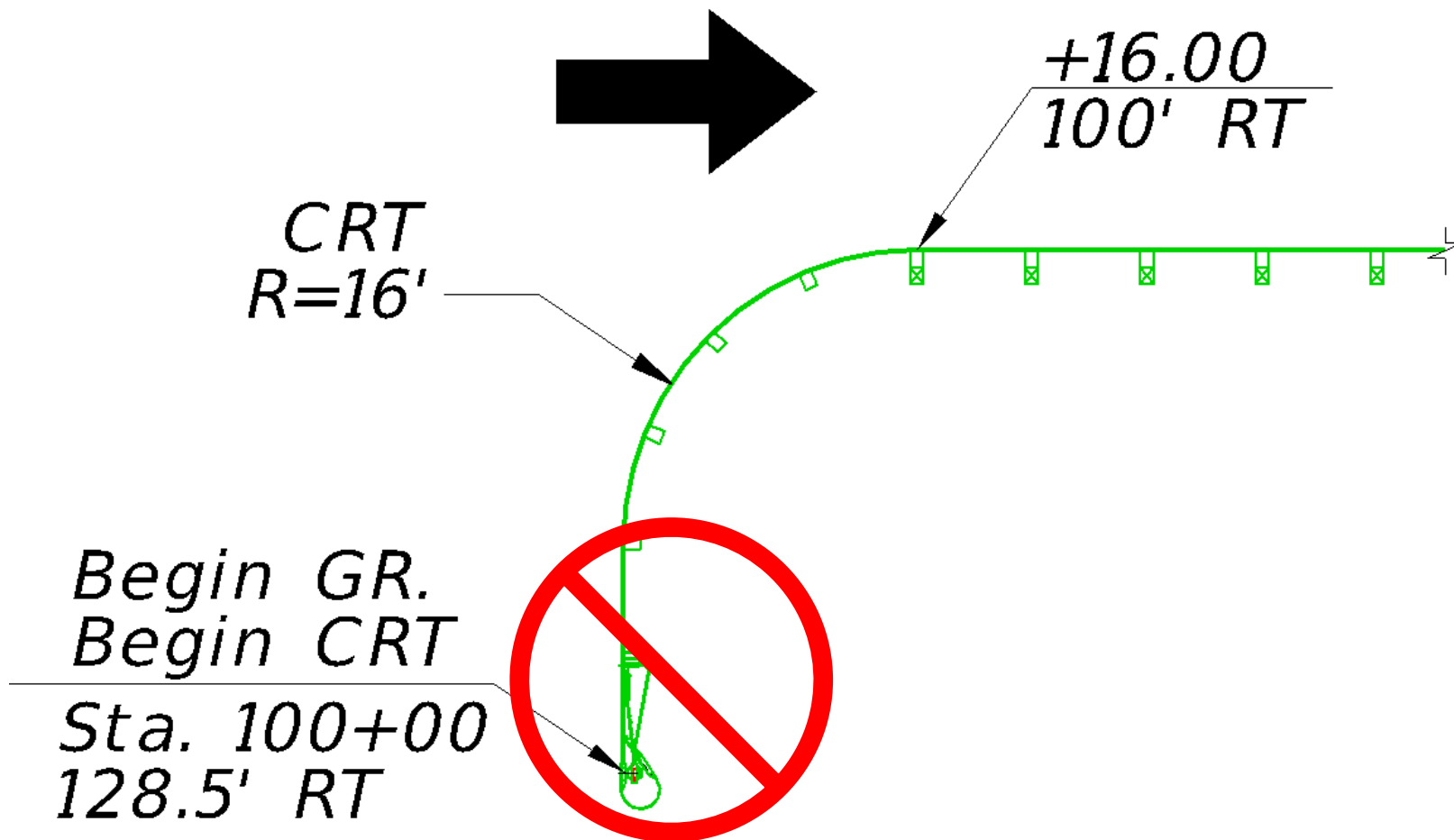
Photo Credit:
Bill Fitzgerald, PE
KLS Engineering, LLC

CRT System (Radial): From Standard Plans...



- “Clear Area” Required (15’x30’)
- “Clear Area” is free of obstructions and has 1:2 Slope Max

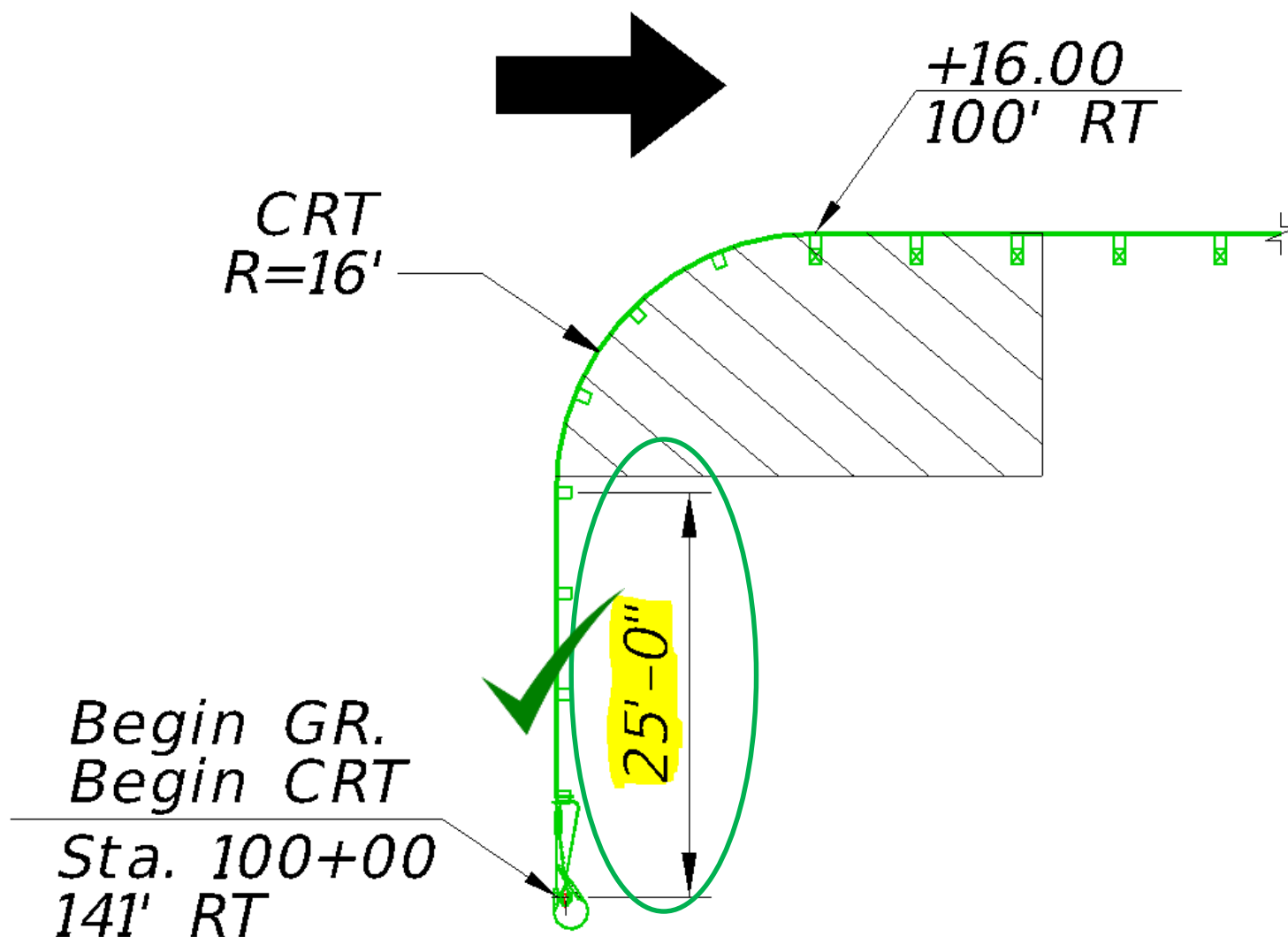
CRT System (Radial): Any other issue here?



Requires 25-foot linear End Treatment Per Standard Plans

(12'-6" Shown)

CRT System (Radial): Per Standard Plans...



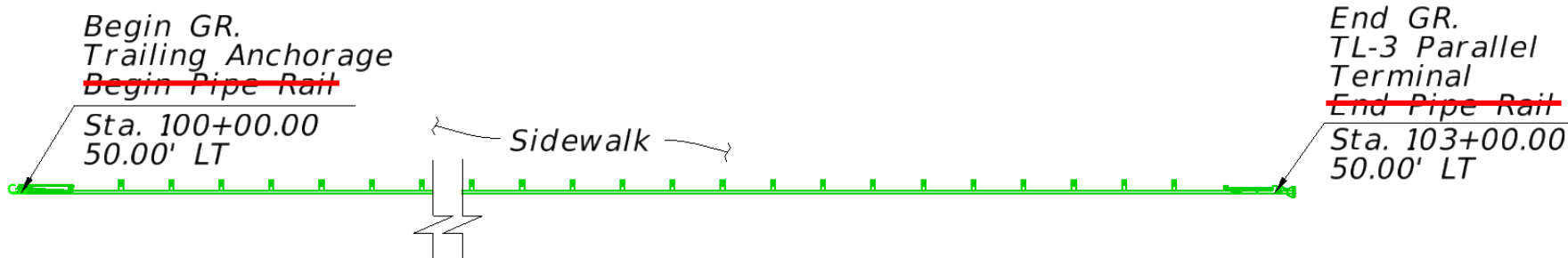
- 25-foot linear End Treatment required
- If this is not possible due limited space, use a 'variation' for General Radial Guardrail (Not CRT) (No breakaway posts)

Pipe Rail Callouts: Any issue here?

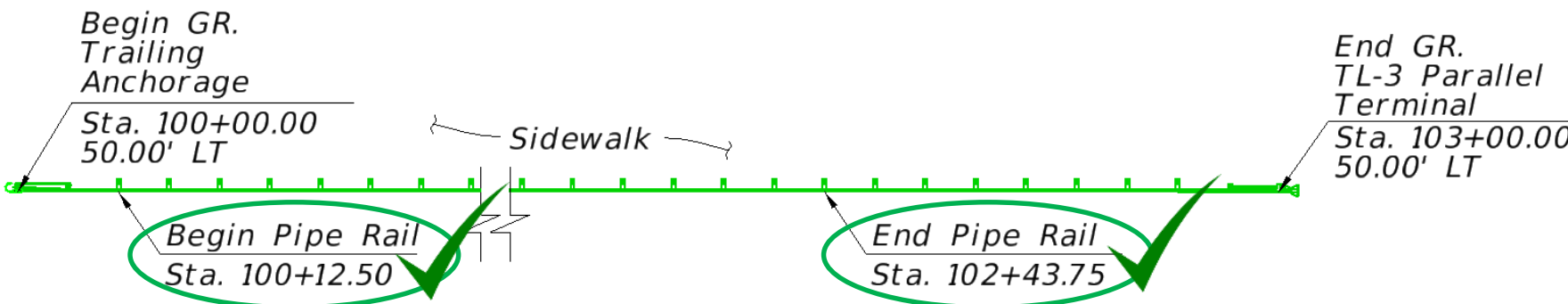


Answer... **YES!**

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



Solution:

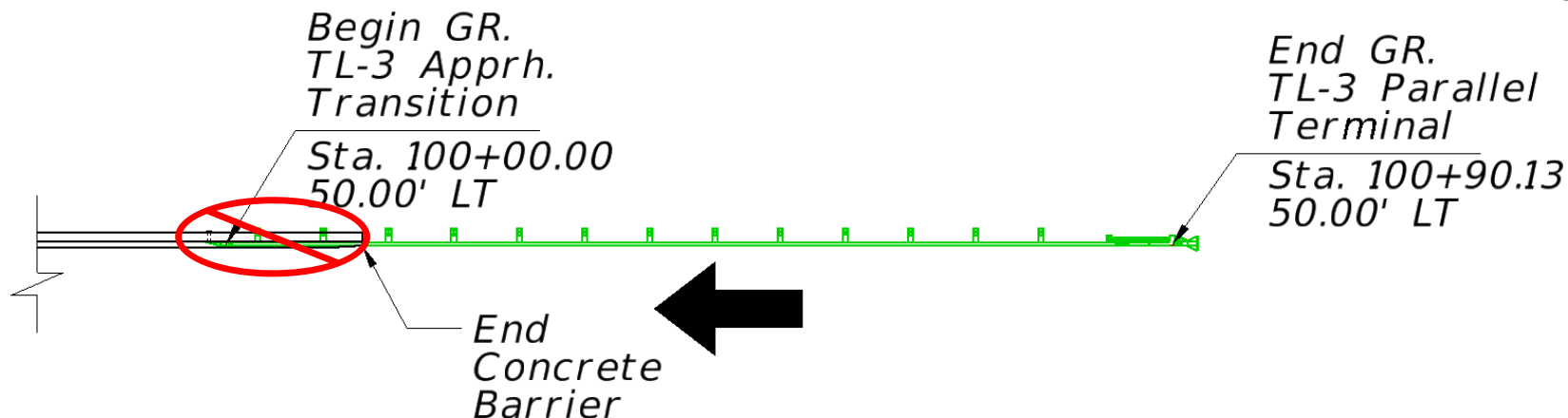


Rigid Barrier Connections, End Shielding:



Rigid Barrier Connection: Any Issue Here ?

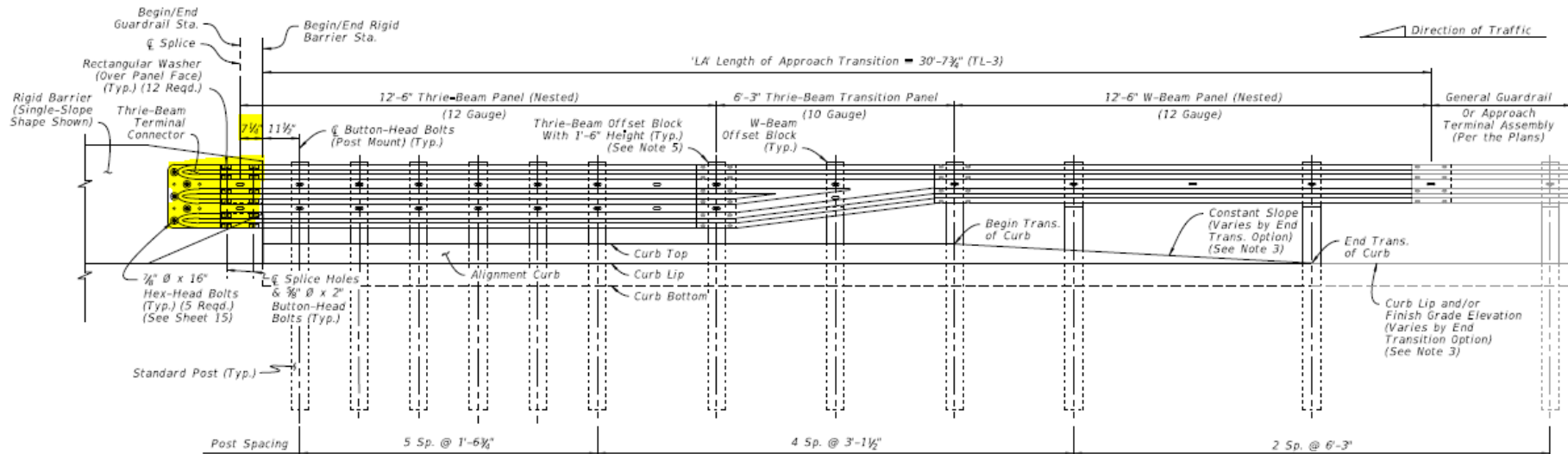
Answer... **YES!**



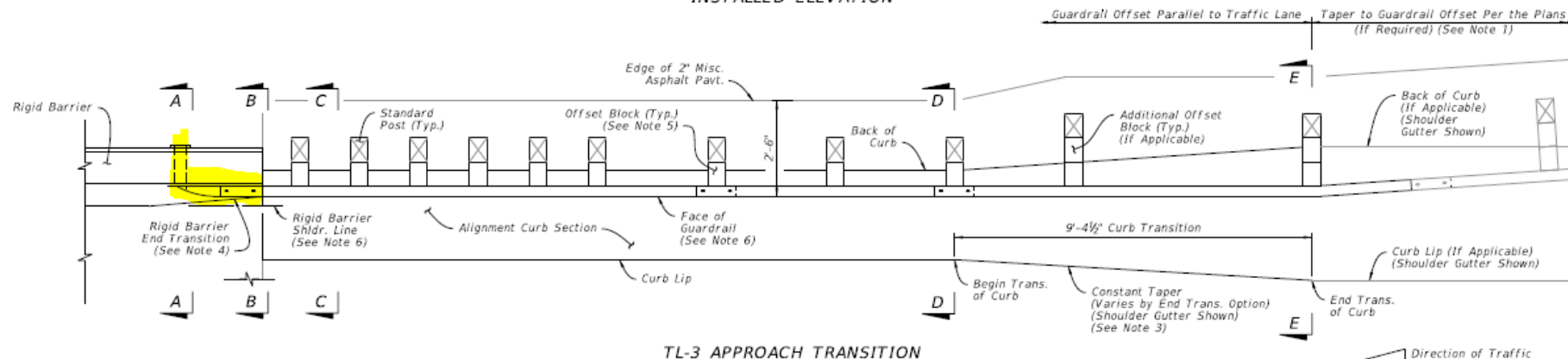
≈13 foot overlap with barrier is no longer Standard!

(Overlap now only 7¼" Since FY2017-18 Standards, for new, single-faced guardrail)

Rigid Barrier Connection:



TL-3 APPROACH TRANSITION
INSTALLED ELEVATION

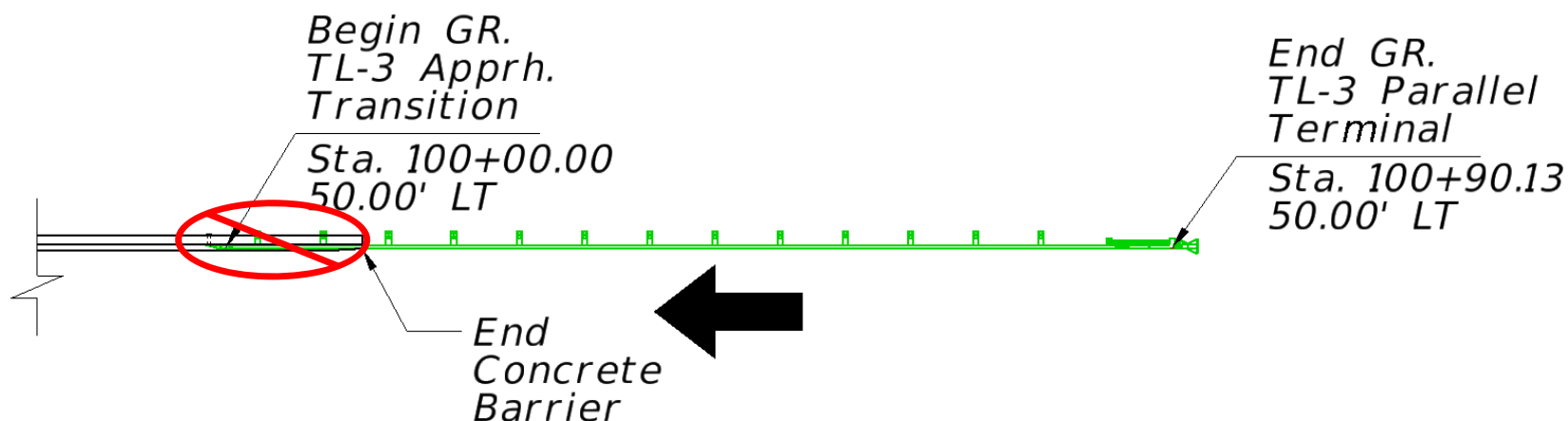


TL-3 APPROACH TRANSITION
INSTALLED PLAN

≈13 foot overlap with barrier is no longer Standard!

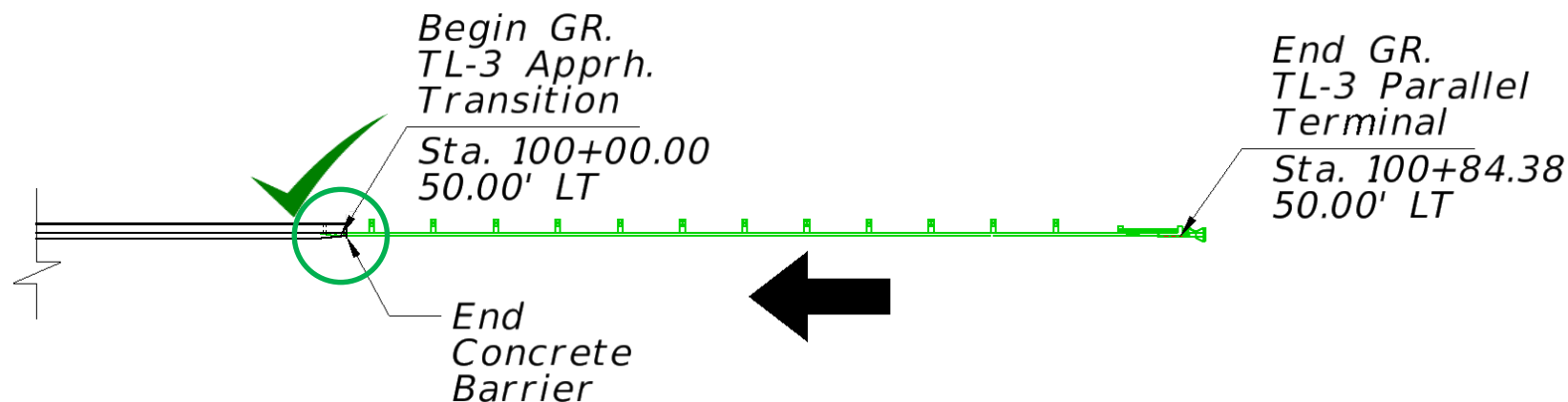
(Overlap now only 7 1/4" Since FY2017-18 Standards, for new, single-faced guardrail)

Rigid Barrier Connection:



≈13 foot overlap with barrier is no longer Standard!

Solution:



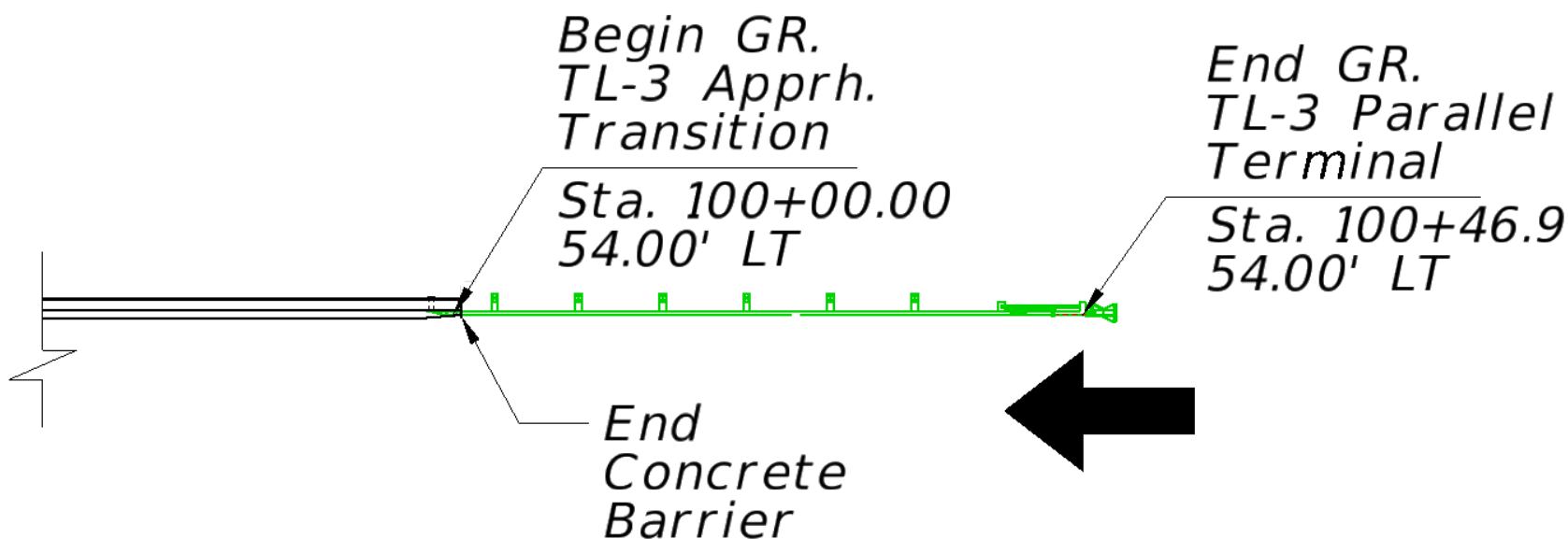
(Overlap now only 7¼" Since FY2017-18 Standards, for new, single-faced guardrail)

Rigid Barrier Connection: Any issue here ?

Answer...

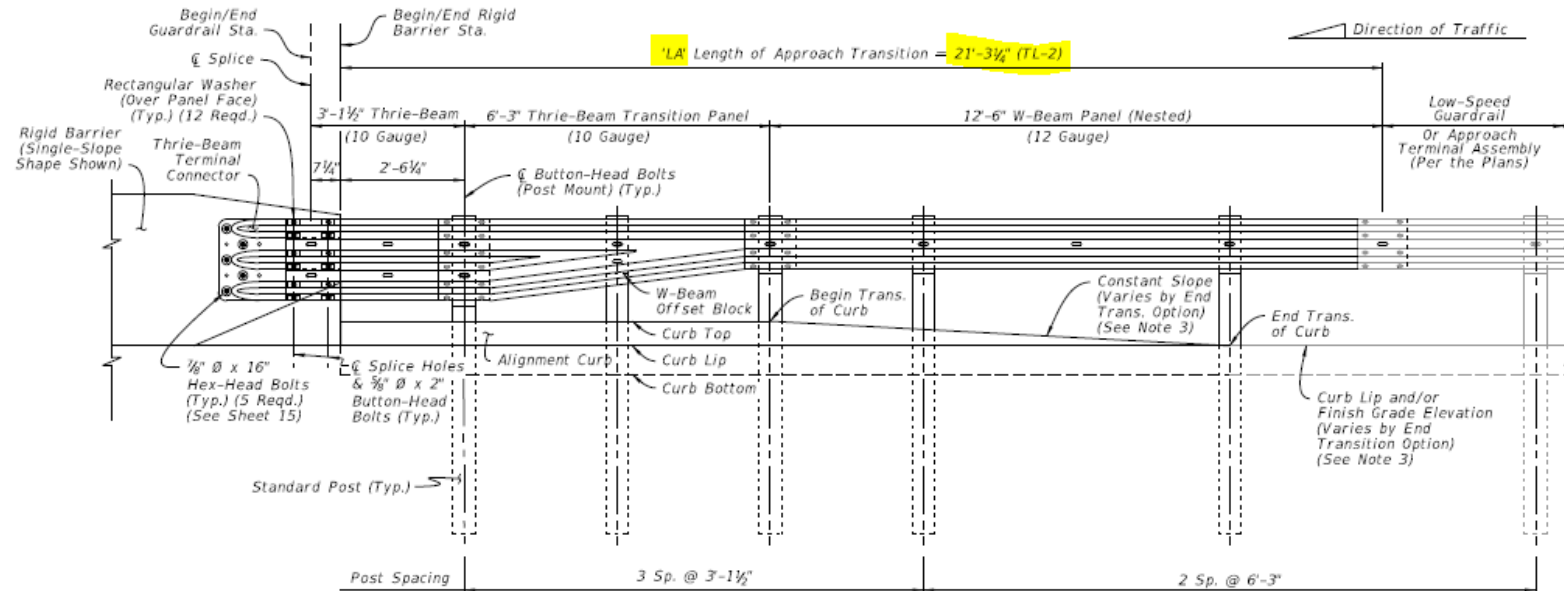
YES!

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



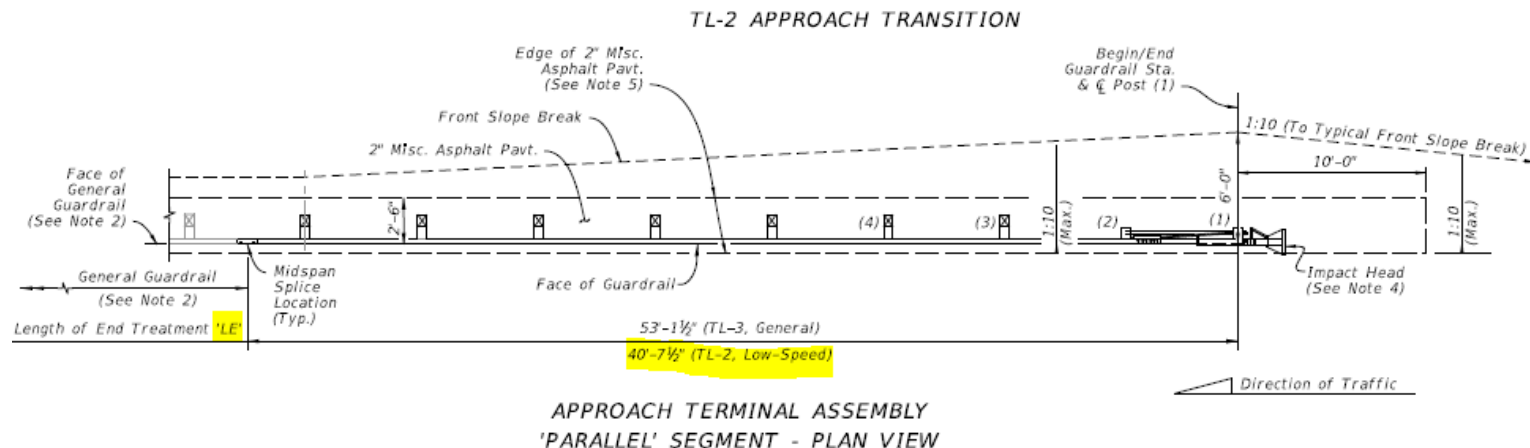
'LA', 21.3'

+

'LE', 40.6'

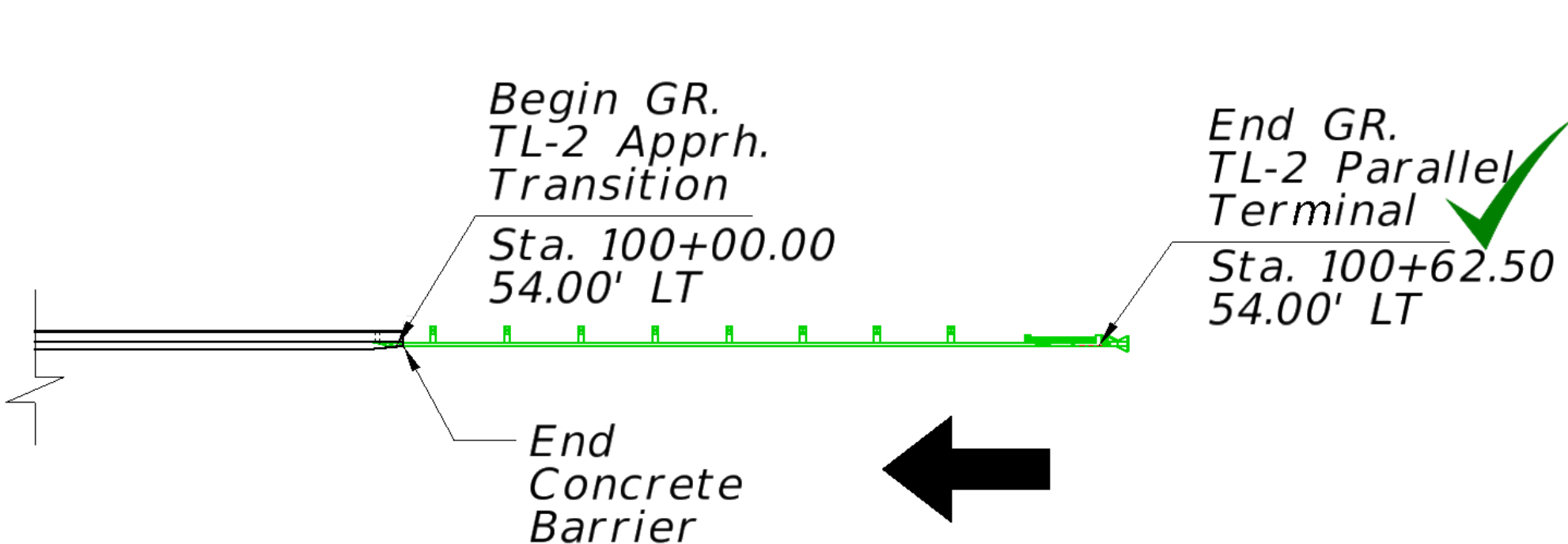
=

62'



APPROACH TERMINAL ASSEMBLY
'PARALLEL' SEGMENT - PLAN VIEW

Rigid Barrier End Shielding: Min Length, TL-2



'LA', 21.3'

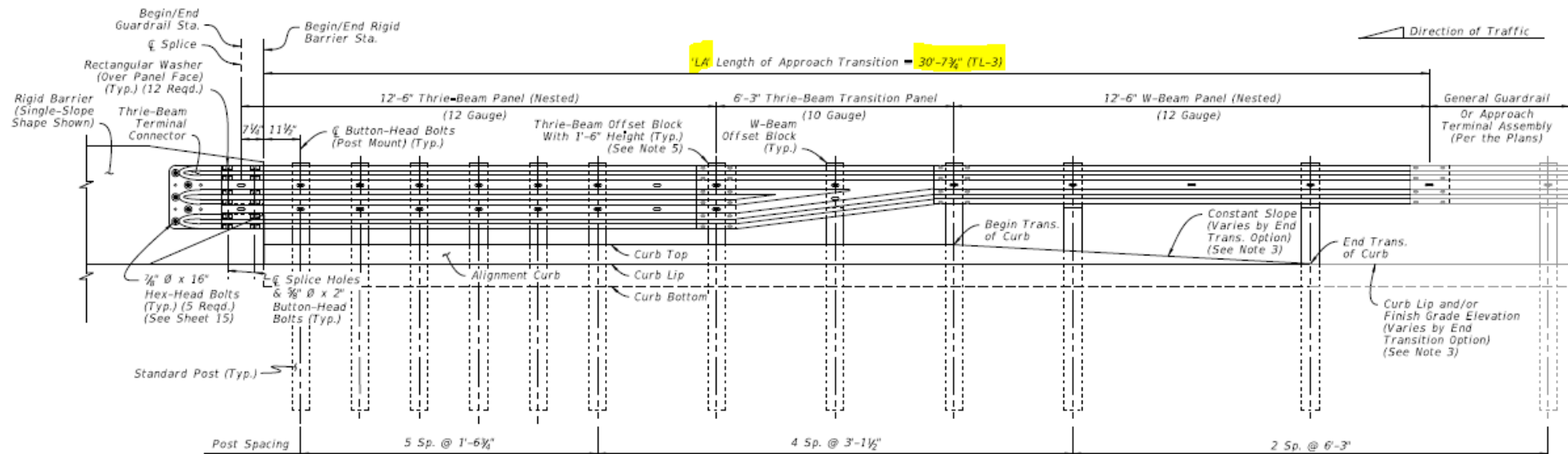
+

'LE', 40.6'

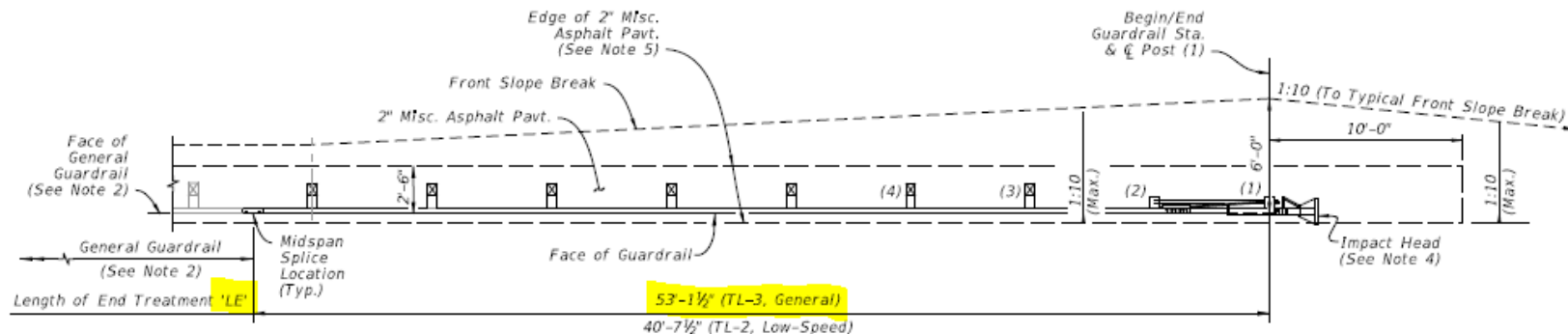
=

62'

Rigid Barrier End Shielding: Min Length, TL-3



TL-3 APPROACH TRANSITION
INSTALLED ELEVATION

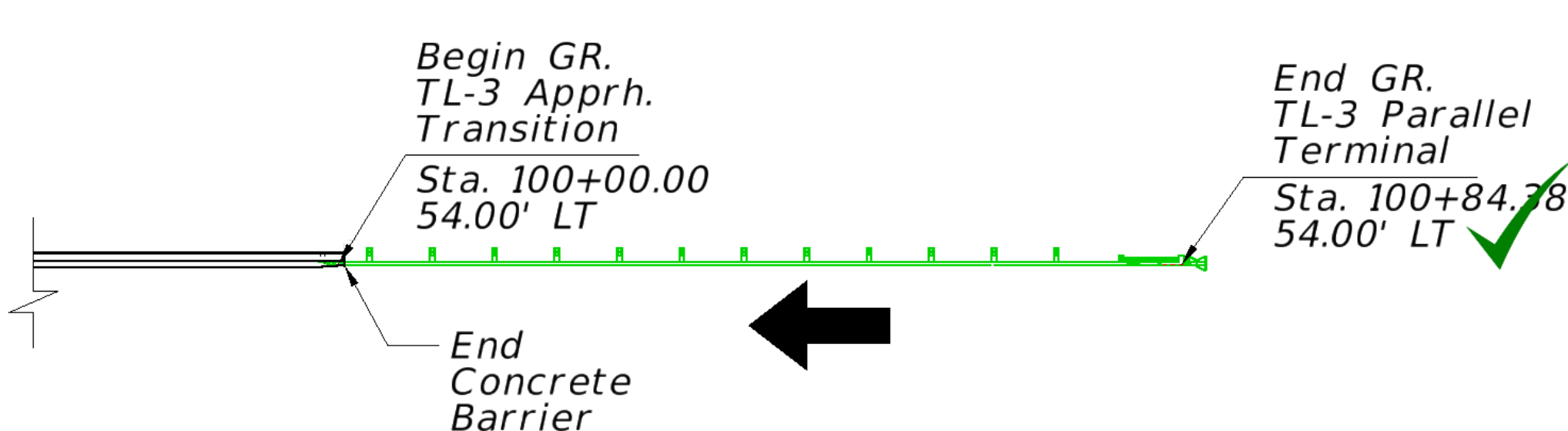


APPROACH TERMINAL ASSEMBLY
'PARALLEL' SEGMENT - PLAN VIEW

$$\begin{aligned} & \text{'LA', 30.6'} \\ & + \\ & \text{'LE', 53.1'} \\ & = \end{aligned}$$

84'

Rigid Barrier End Shielding: Min Length, TL-3



$$\begin{aligned}
 &\text{'LA', 30.6'} \\
 &+ \\
 &\text{'LE', 53.1'} \\
 &= \\
 &\mathbf{84'}
 \end{aligned}$$

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

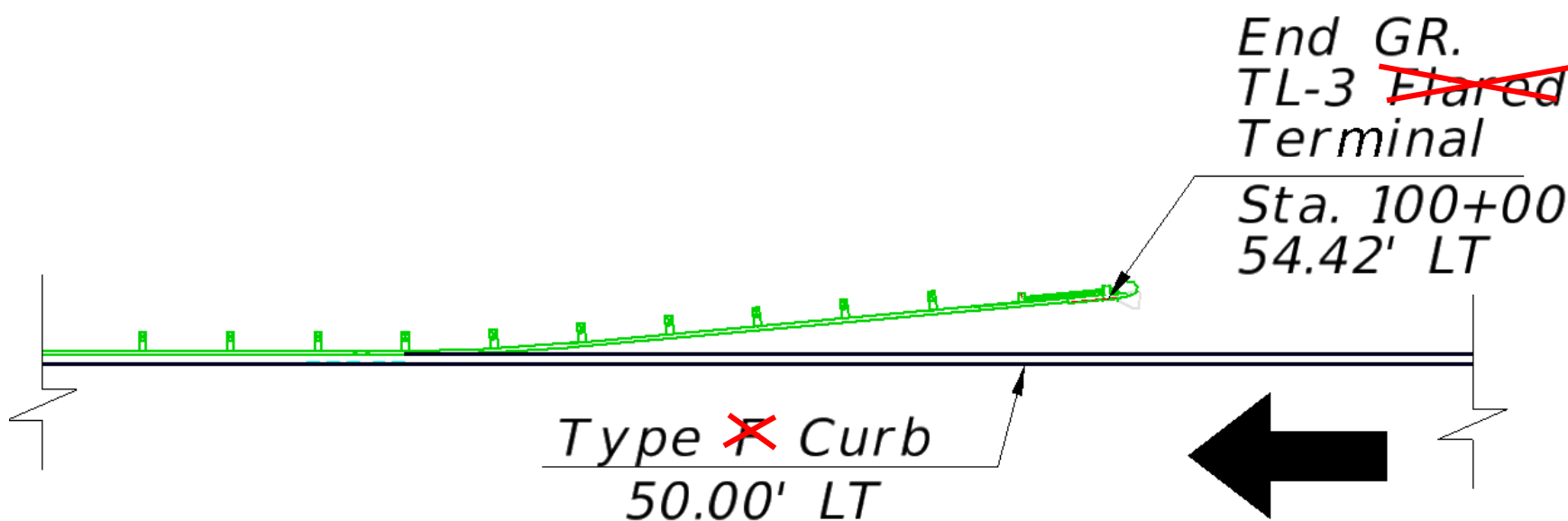


Approach Terminals: Any issues here?



Answer...

YES!



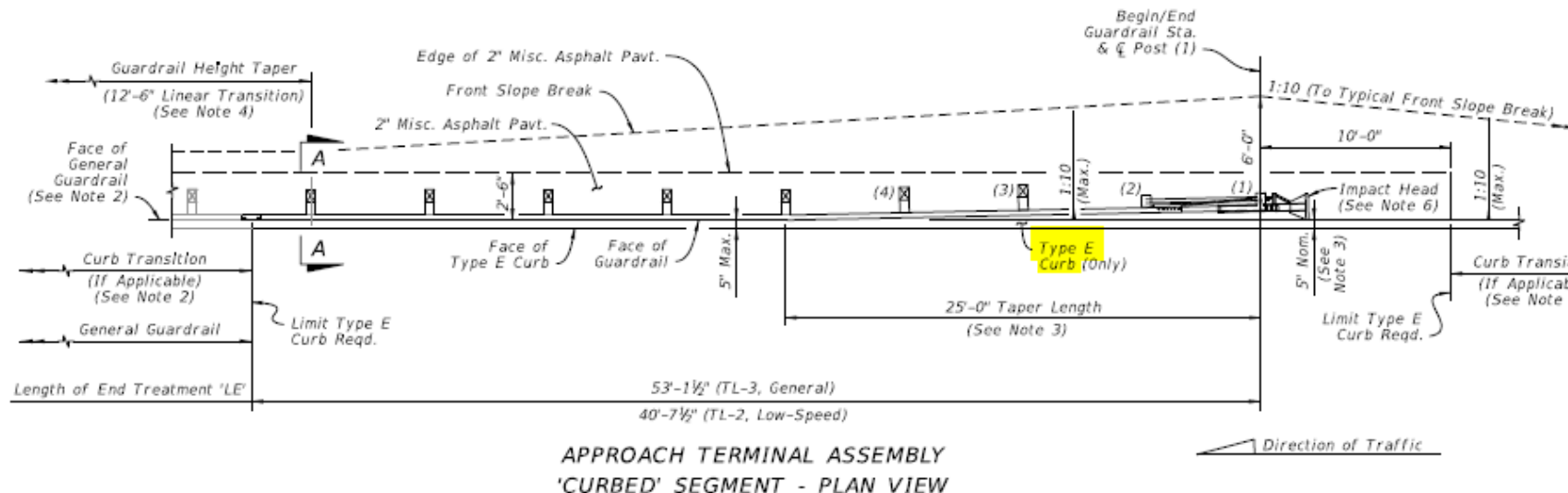
1. Flared terminals not permitted per RDB 18-02

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...

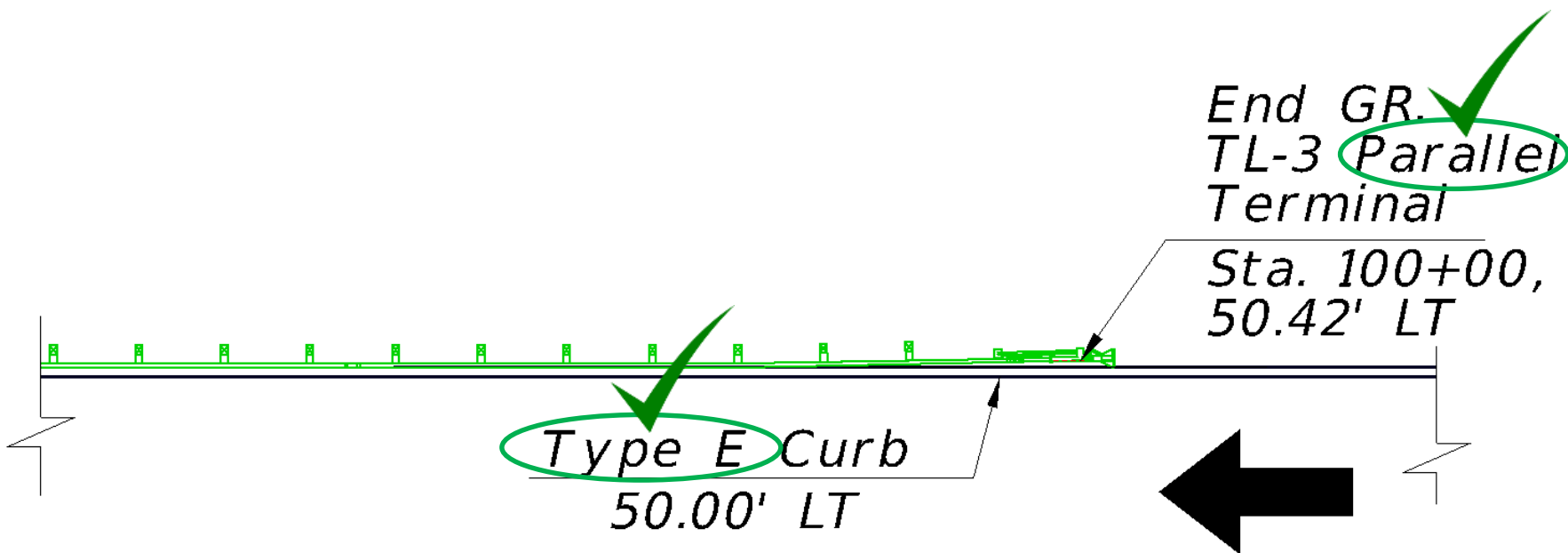


1. Flared terminals not permitted per RDB 18-02

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

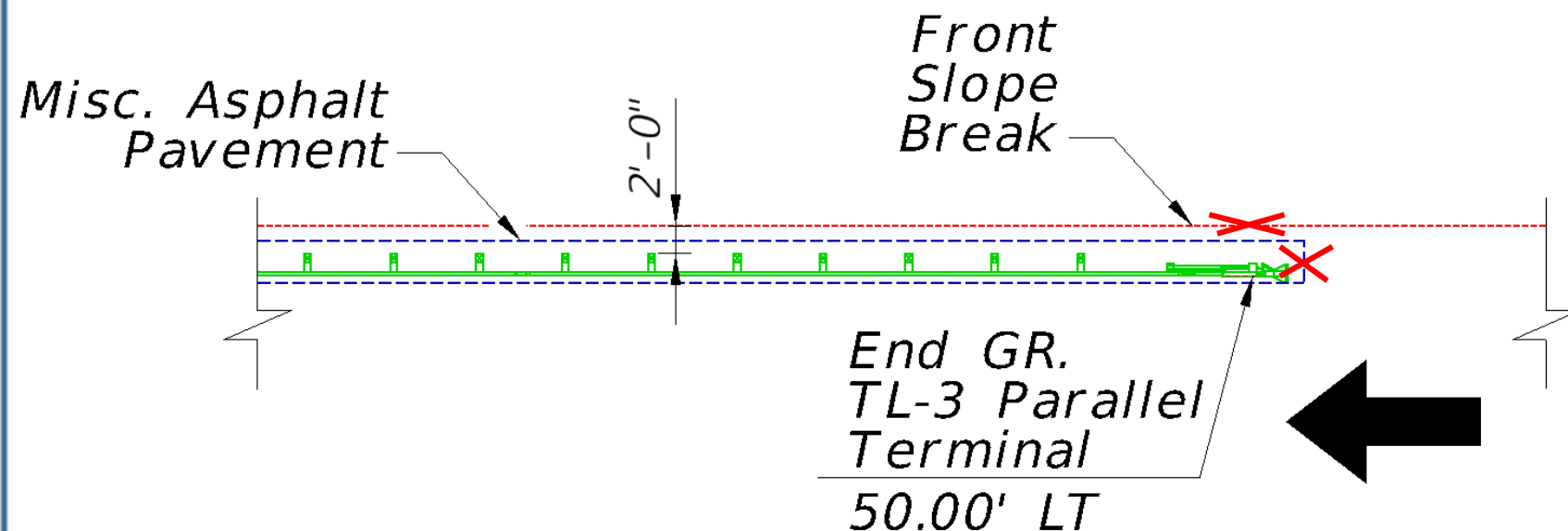
2. Curbed conditions require parallel Approach Terminals per Standard Plans

3. Approach Terminals require 'Type E' Curb

Approach Terminals: Any issues here?



Answer... **YES!**



First issue...

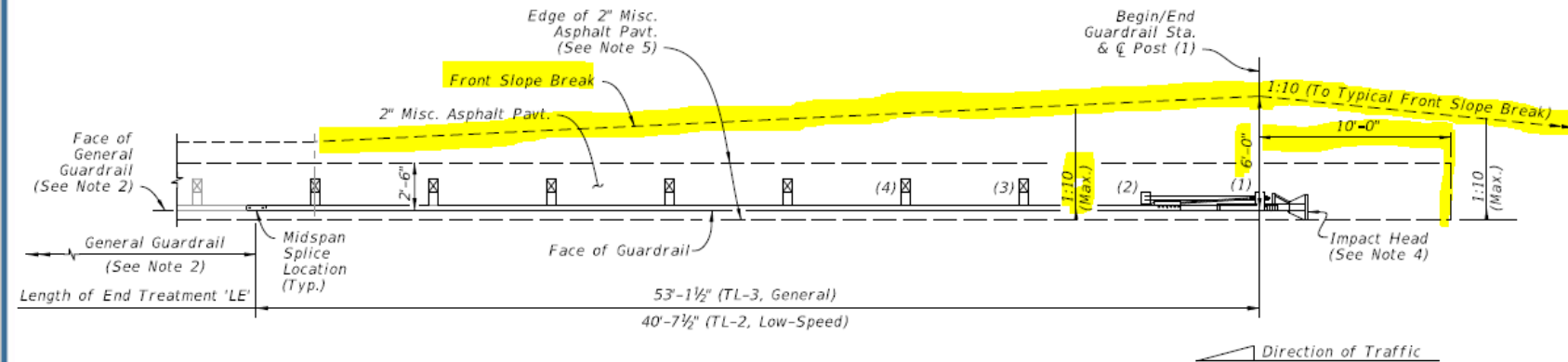
Front slope break should be **6 feet** behind guardrail face at post 1 per the Standards (1:10 Max.)

Second issue...

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

Approach Terminals:

From Standard Plans...



APPROACH TERMINAL ASSEMBLY
'PARALLEL' SEGMENT - PLAN VIEW

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

Approach Terminals:



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

First issue...

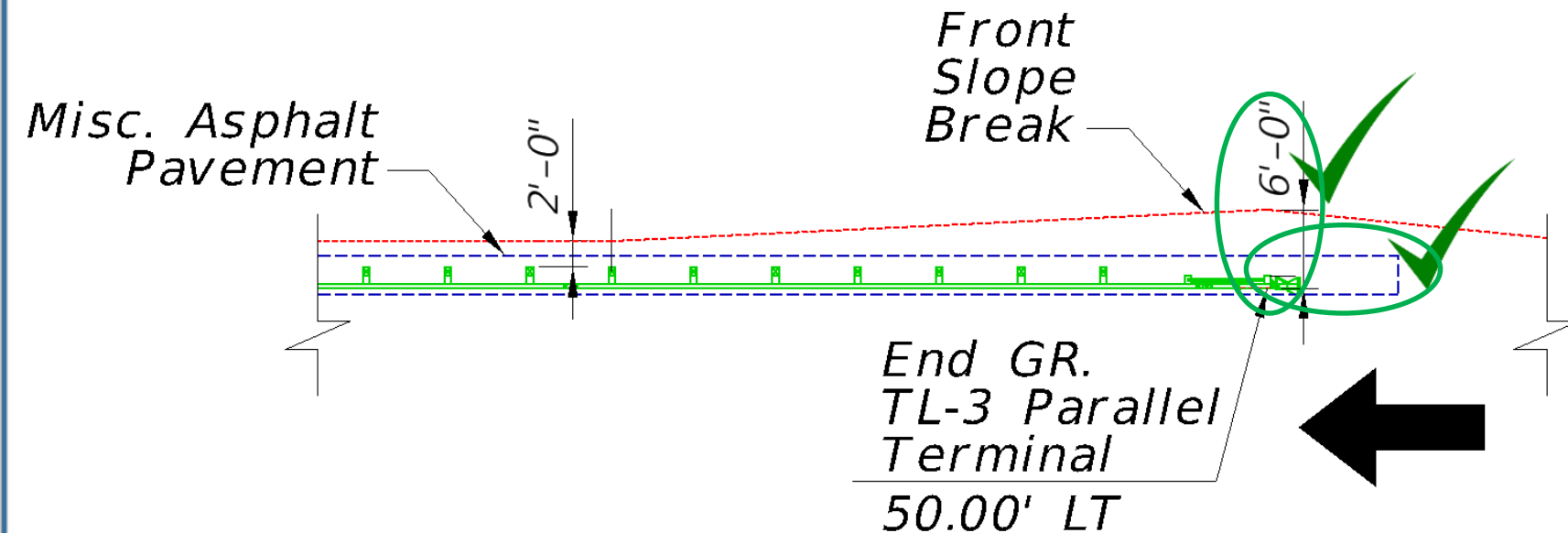
Front slope break should be **6 feet** behind guardrail face at post 1 per the Standards (1:10 Min.)

Second issue...

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

Approach Terminals: Solution

Corrected...



First issue...

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

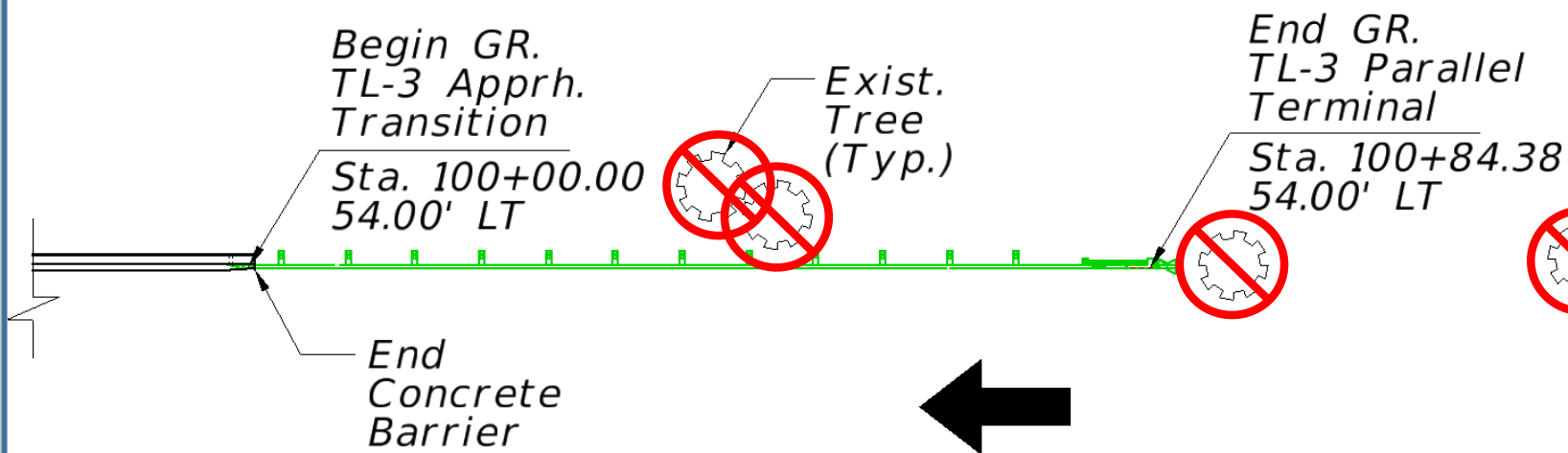
Second issue...

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...

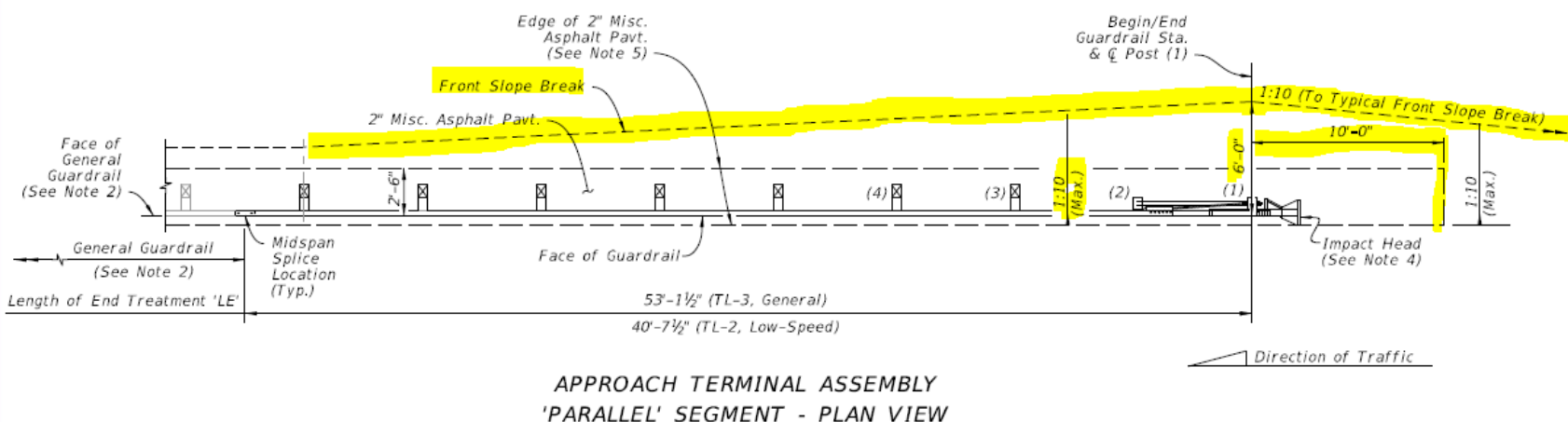
Tree violates barrier setback per FDM Table 215.4.2

Approach Terminals:

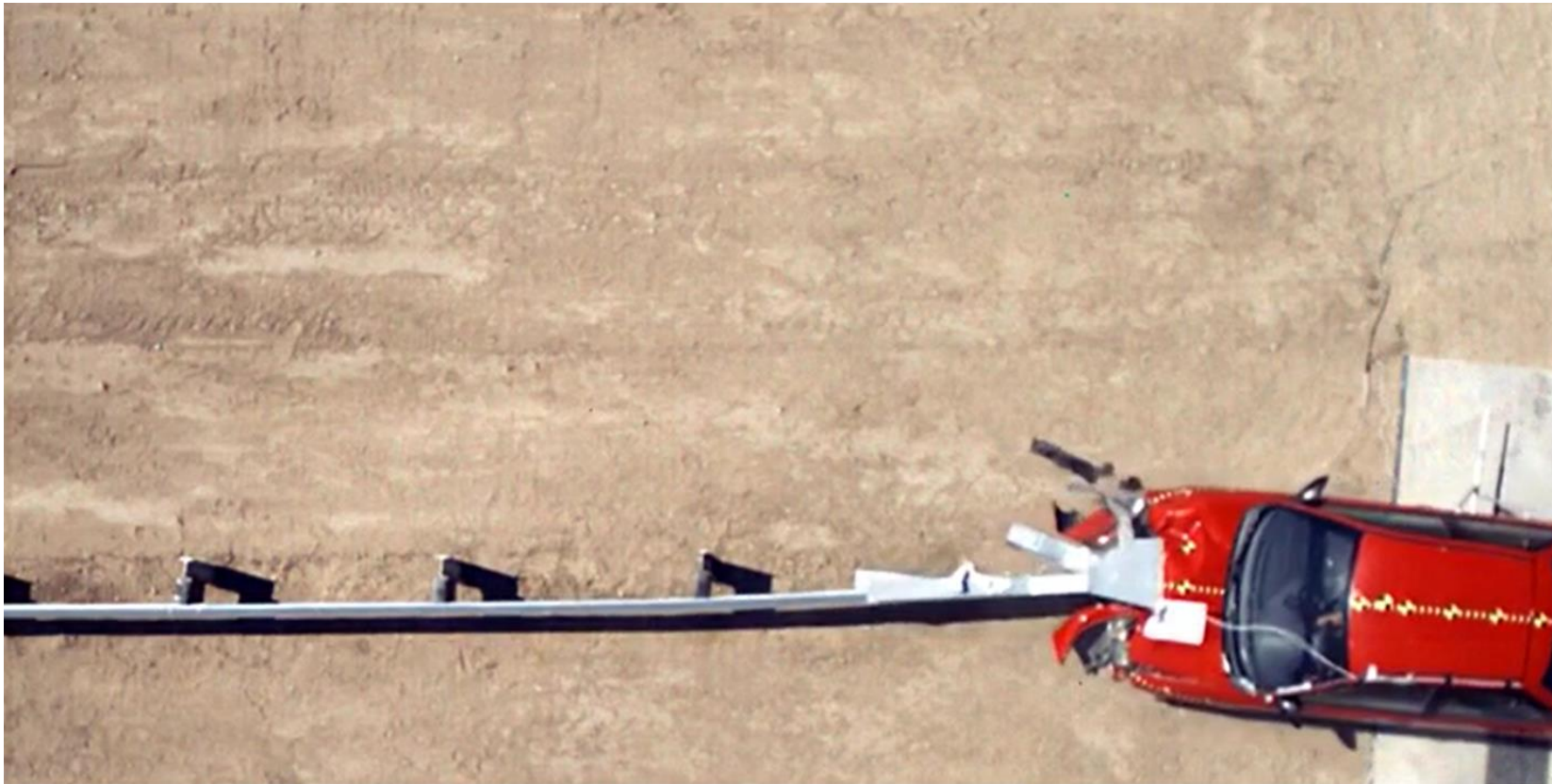
From Standard Plans...

First issue...

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



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=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=74ImLTY-PhU&feature=youtu.be>

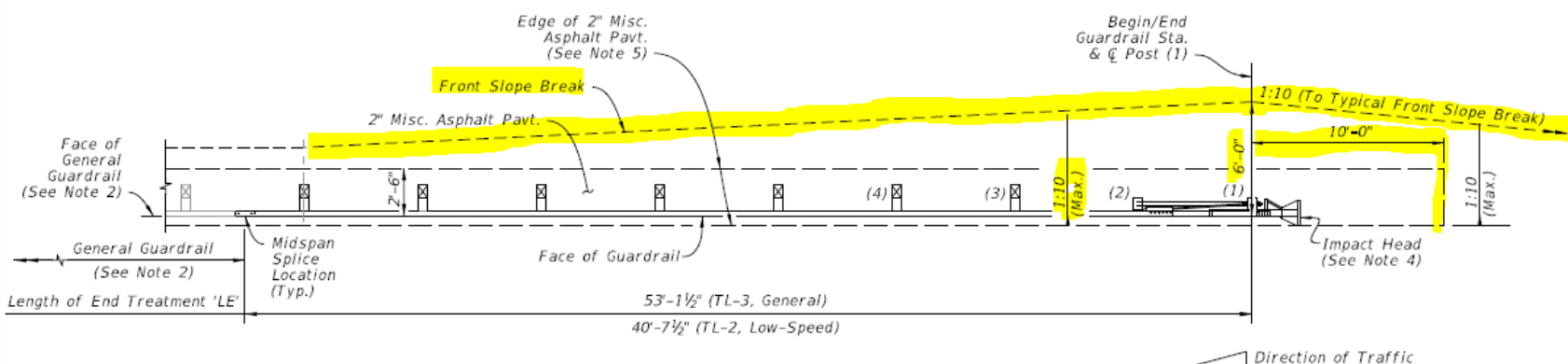
CREDIT: VIRGINIA DOT – SKT Crash Test Published October 2016

Approach Terminals:

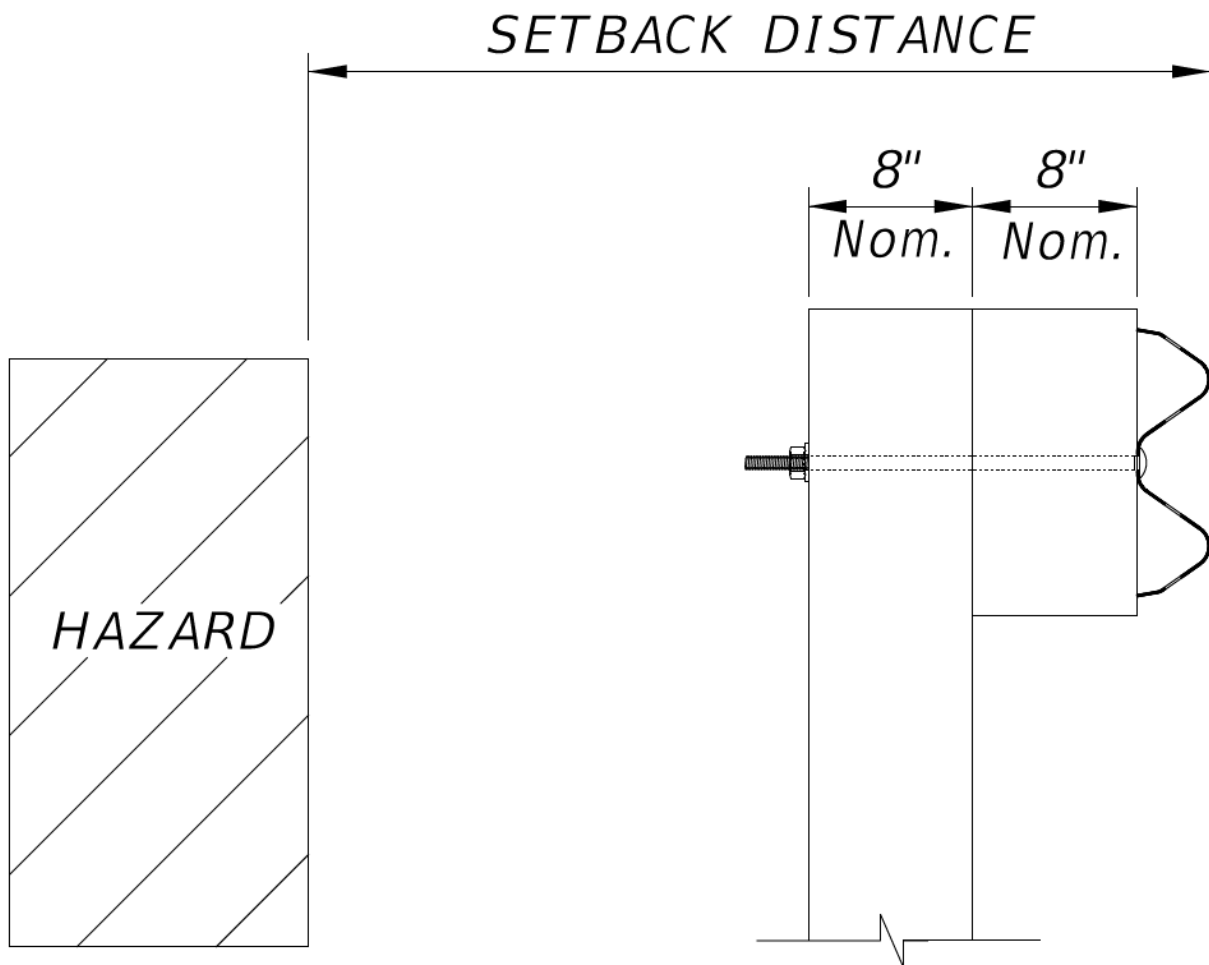
From Standard Plans...

First issue...

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



APPROACH TERMINAL ASSEMBLY
'PARALLEL' SEGMENT - PLAN VIEW



Second issue...

Tree violates barrier setback per FDM Table 215.4.2

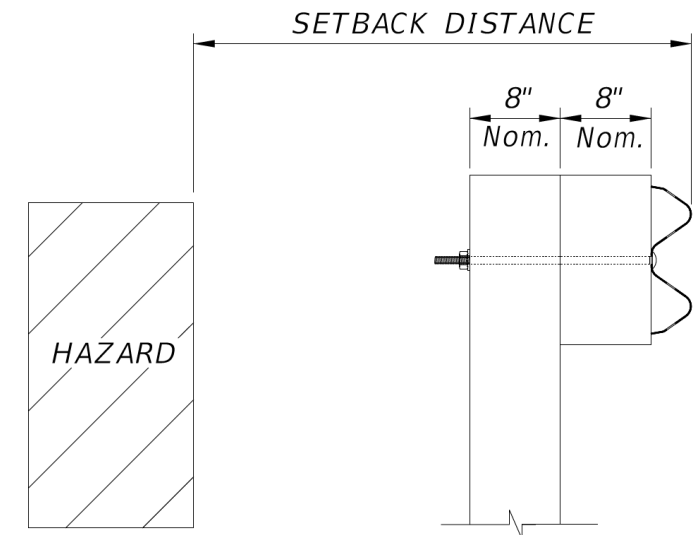
From FDM...

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

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

Second issue...

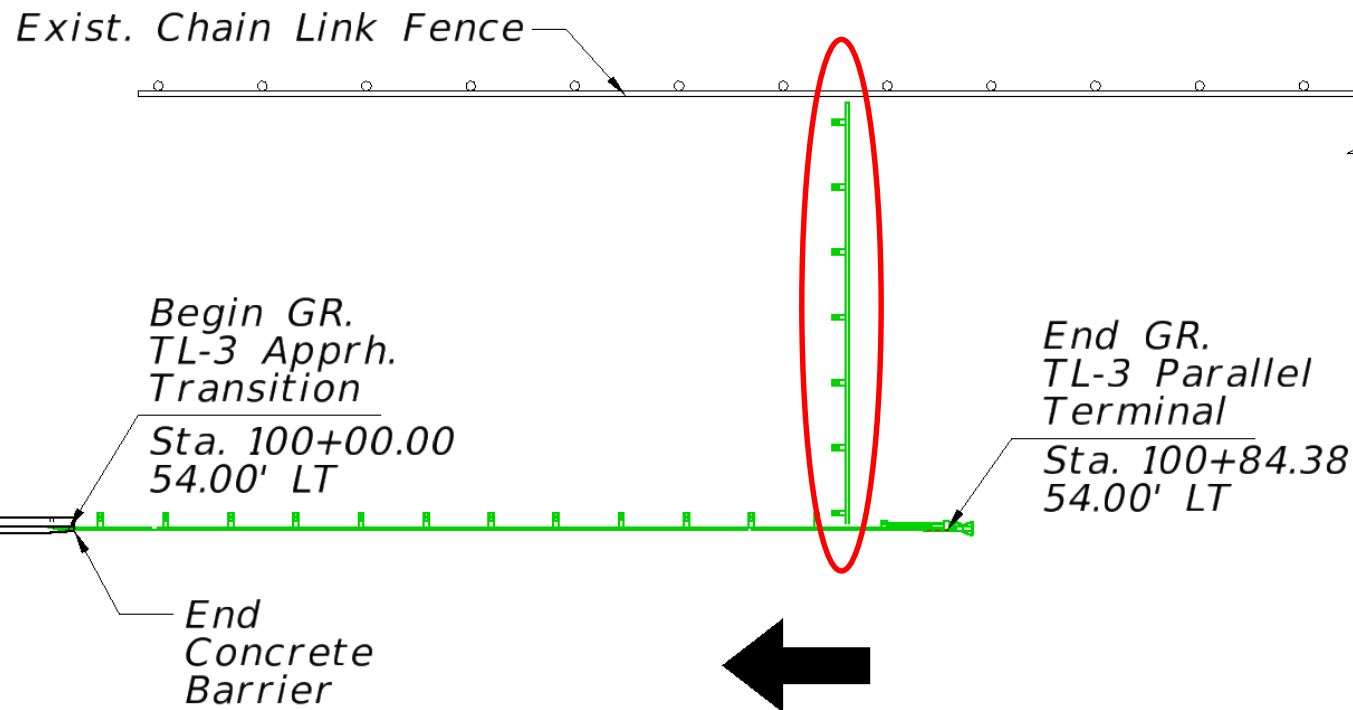
Tree violates barrier setback per FDM Table 215.4.2



Approach Terminals: Any issue here?



Answer... **YES! Wrong.**

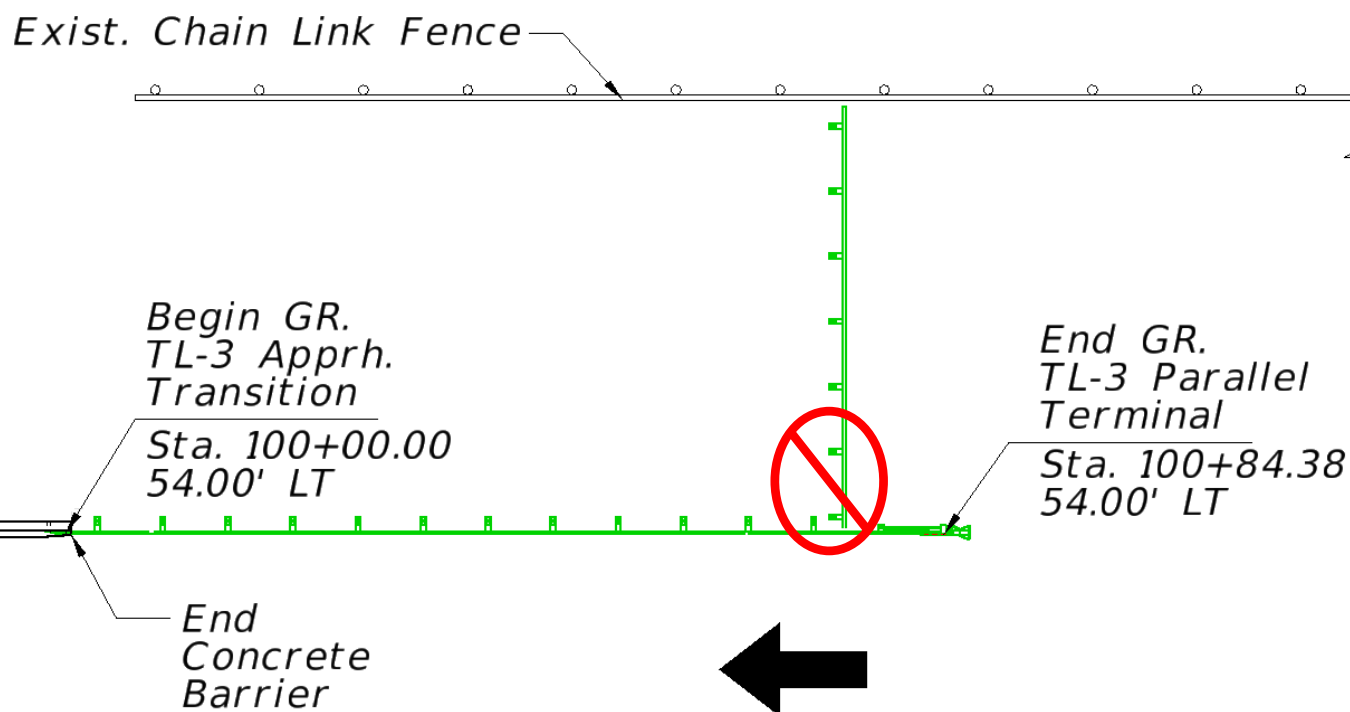


First issue...

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

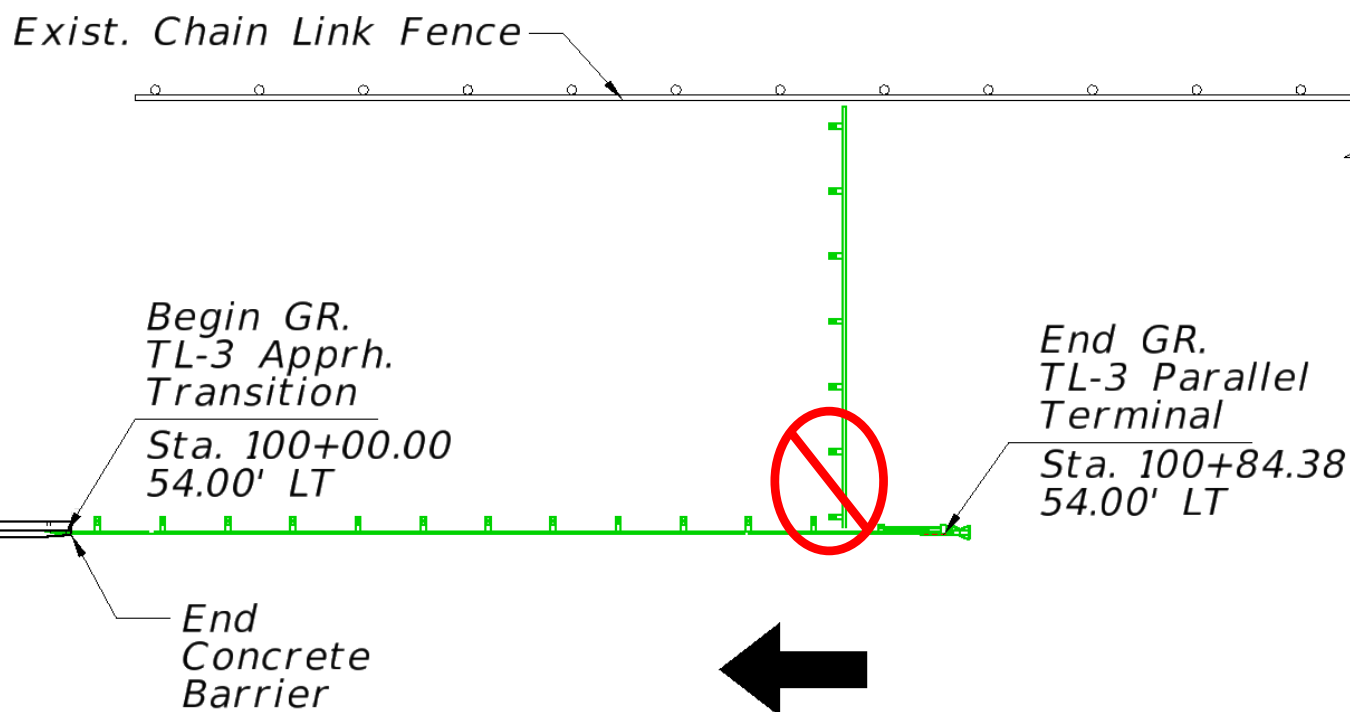
Approach Terminals: Any issue here?



Second issue...

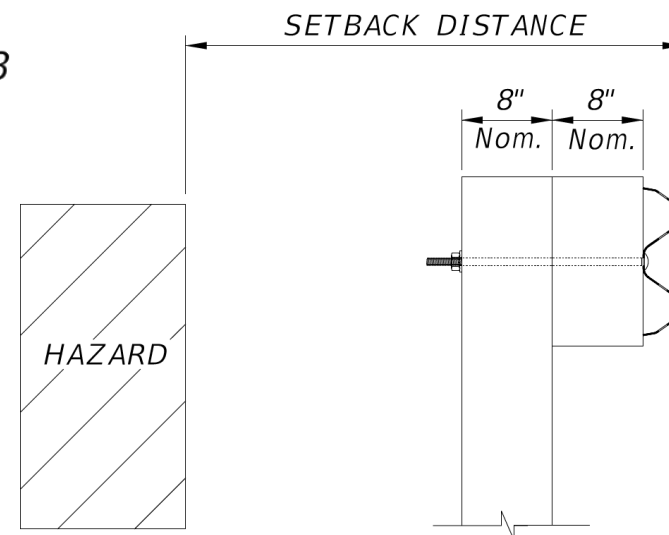
Perpendicular guardrail within the Approach Terminal's clear area in the Standard Plans (where a clear, 1:10 slope required)

Approach Terminals: Any issue here?

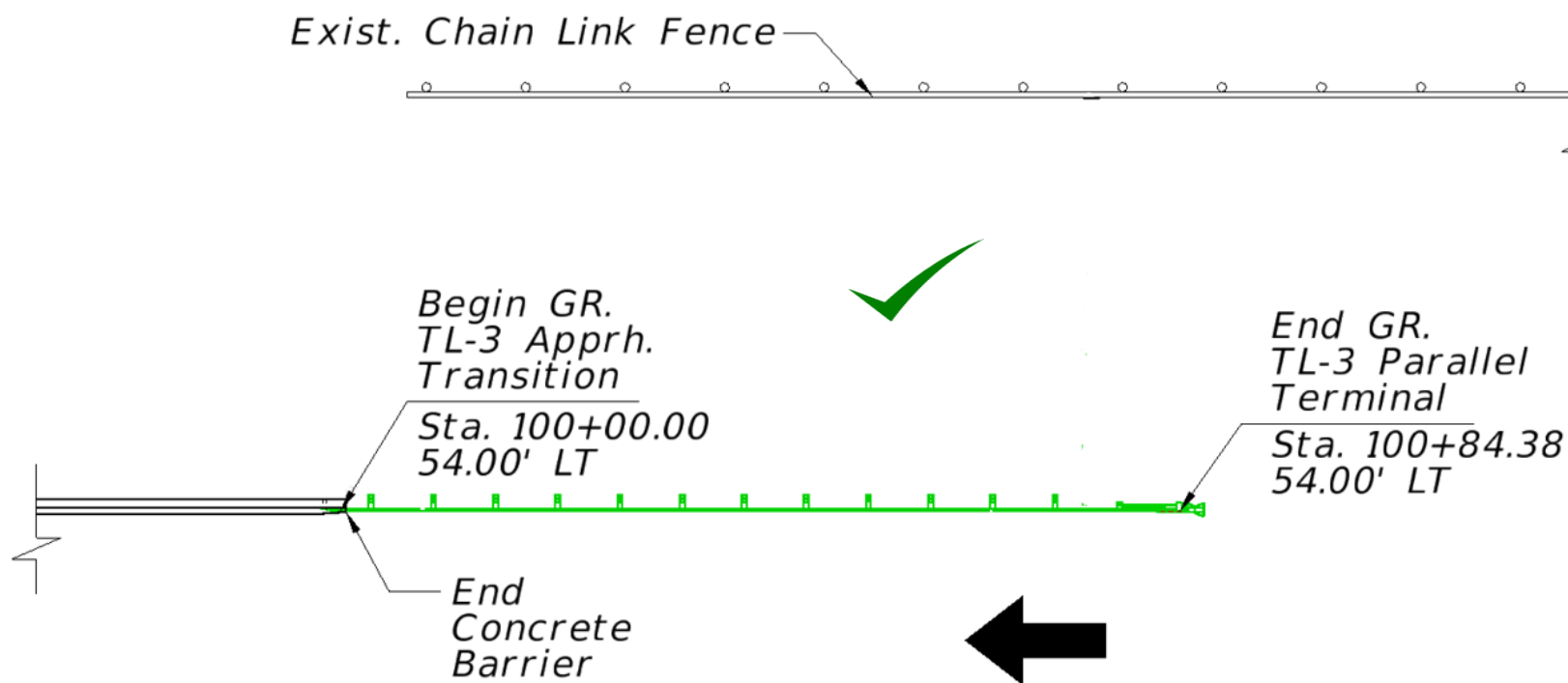


Third issue...

Perpendicular guardrail violates barrier setback per FDM Table 215.4.2



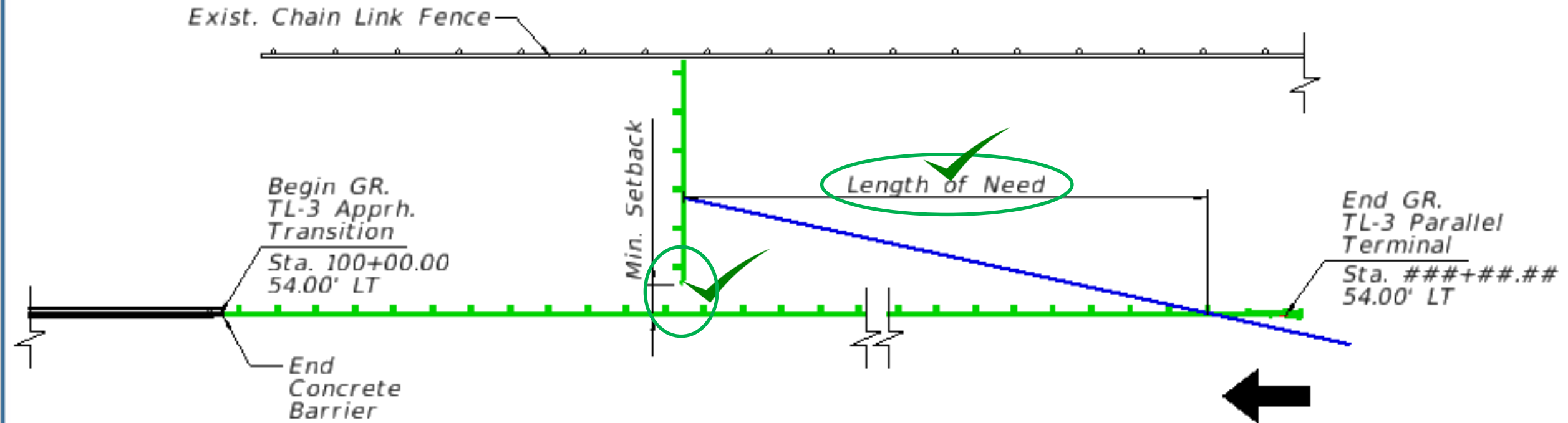
Approach Terminals: Solution 1



REMOVE the perpendicular Guardrail!

Or...

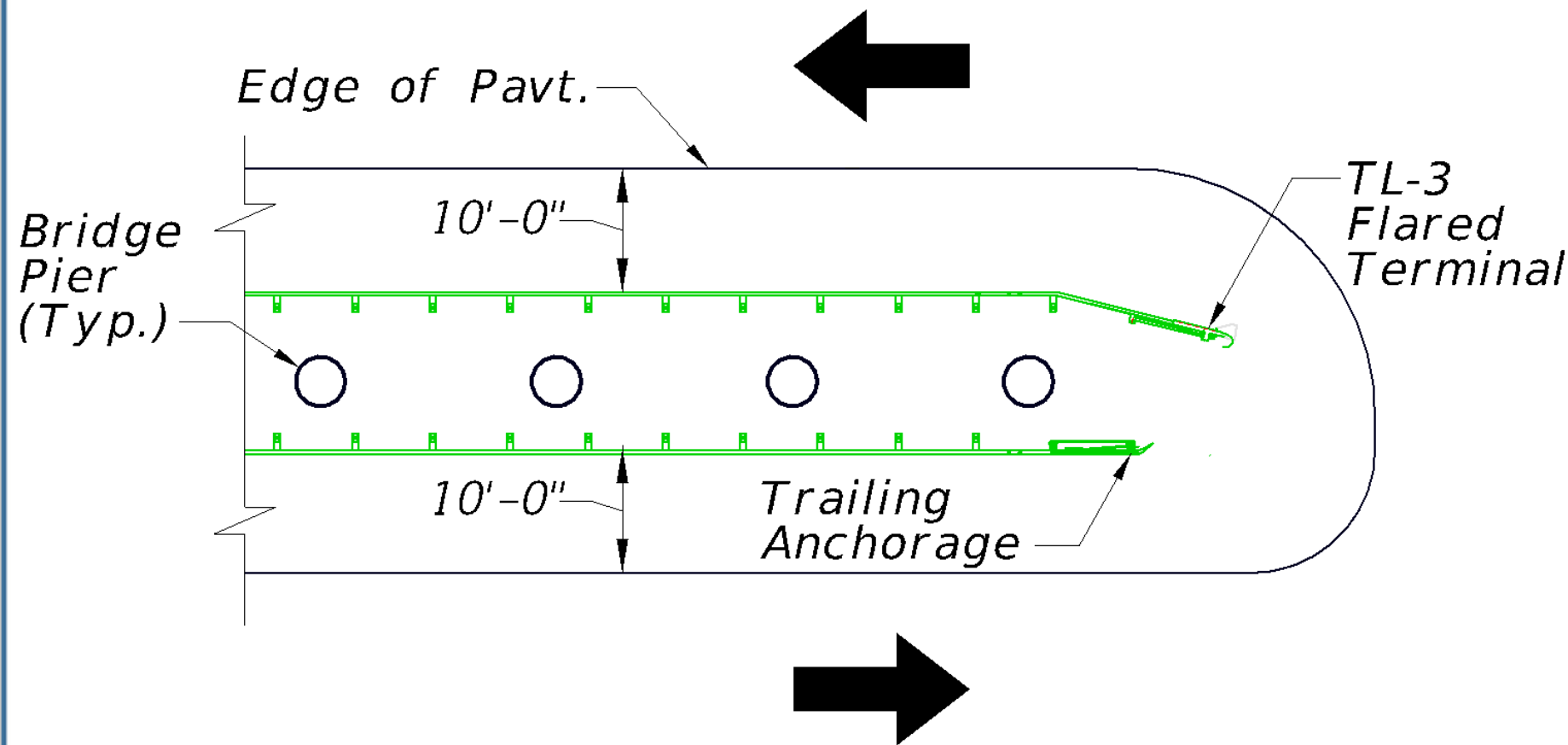
Approach Terminals: Solution 2



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?

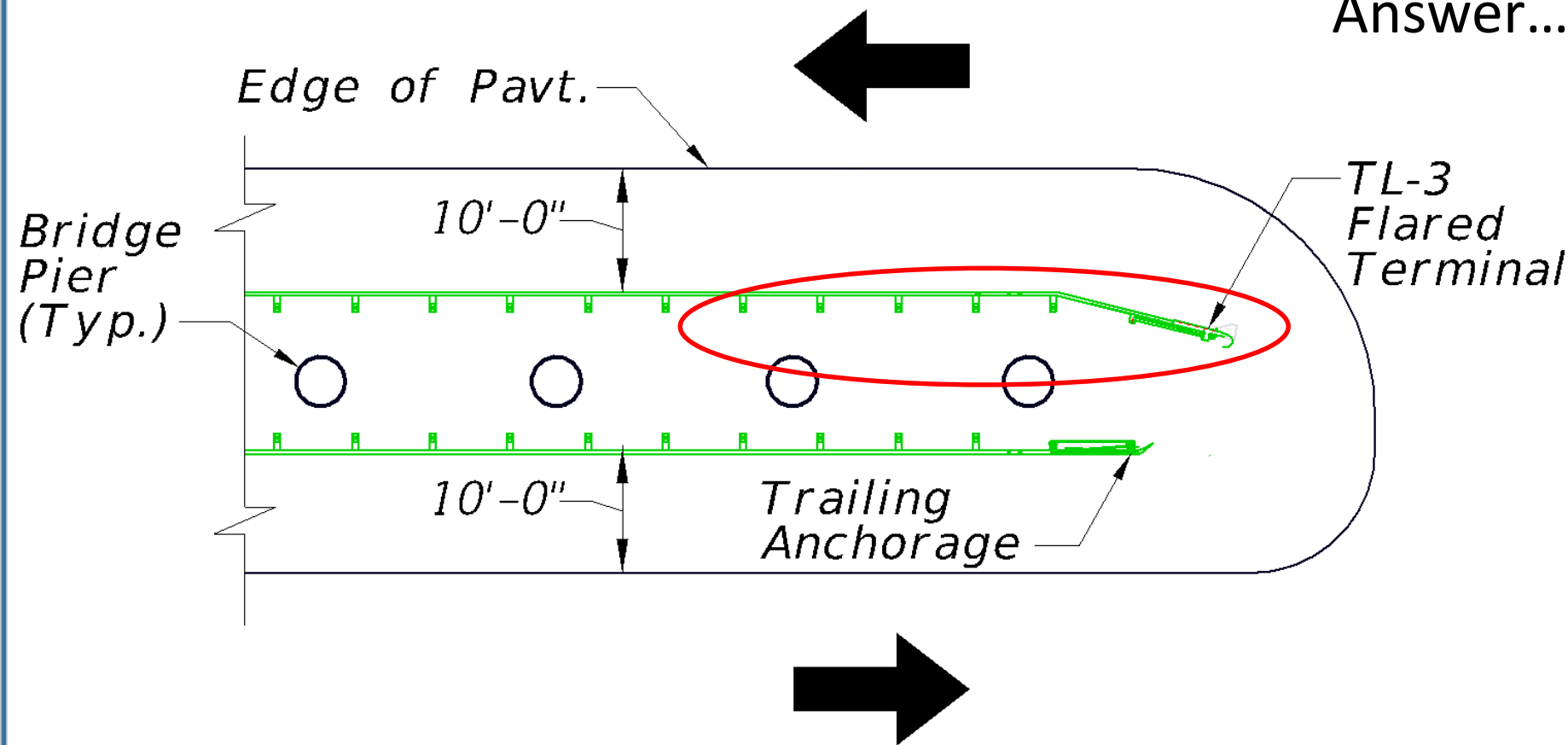


Answer... **YES!**

First issue...

Piers NOT shielded!

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



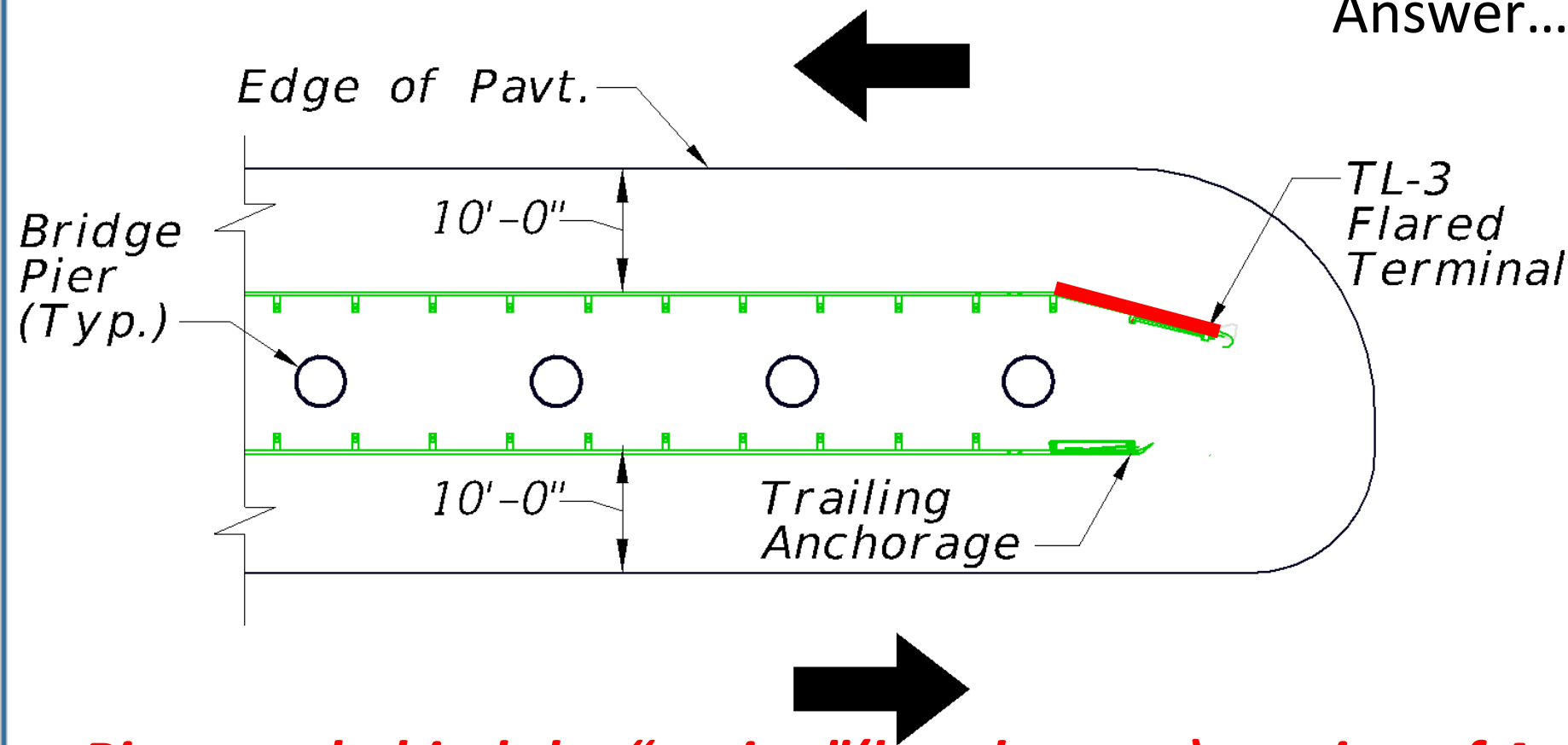
Approach Terminals: Any issue here?

Answer... **YES!**

First issue...

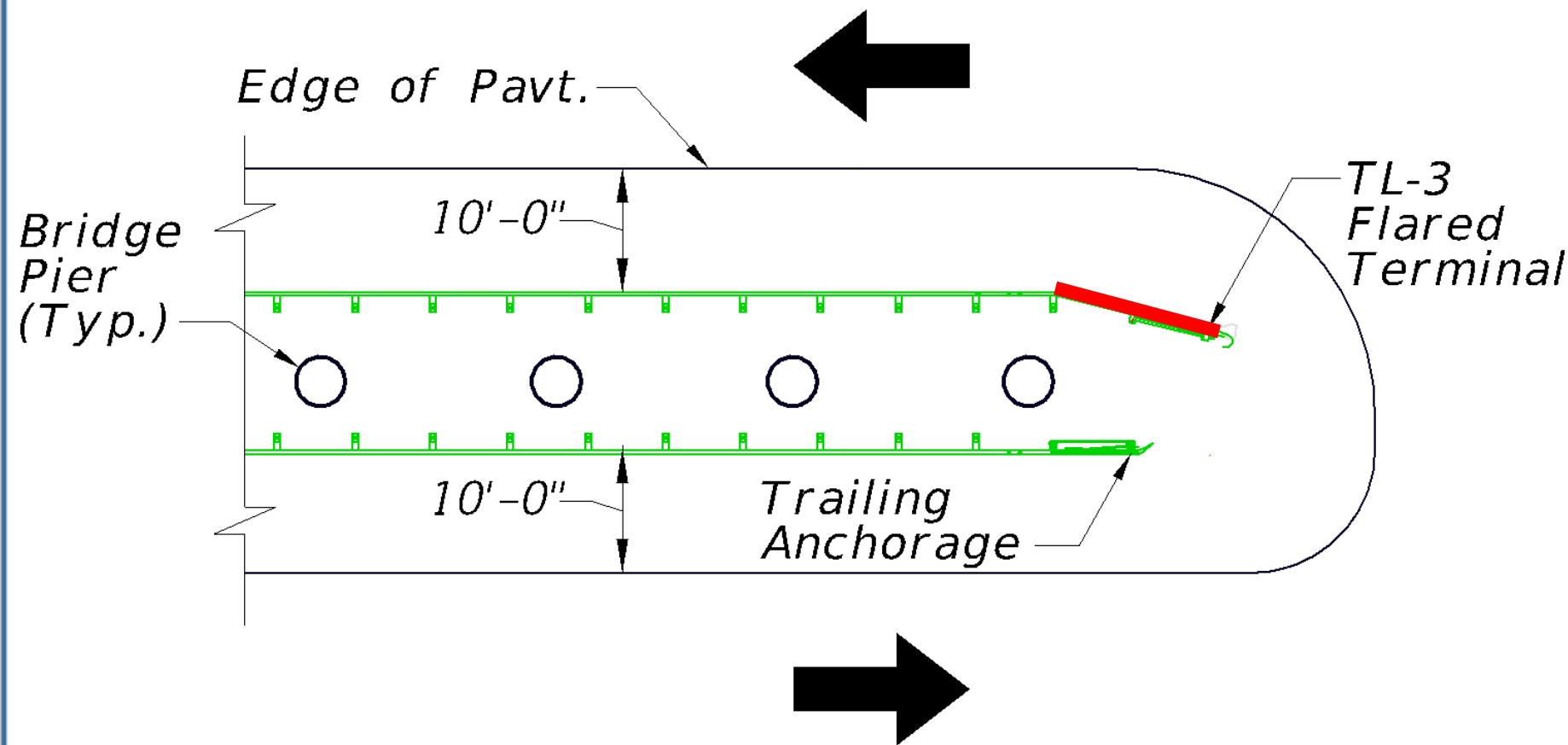
Piers NOT shielded

“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?

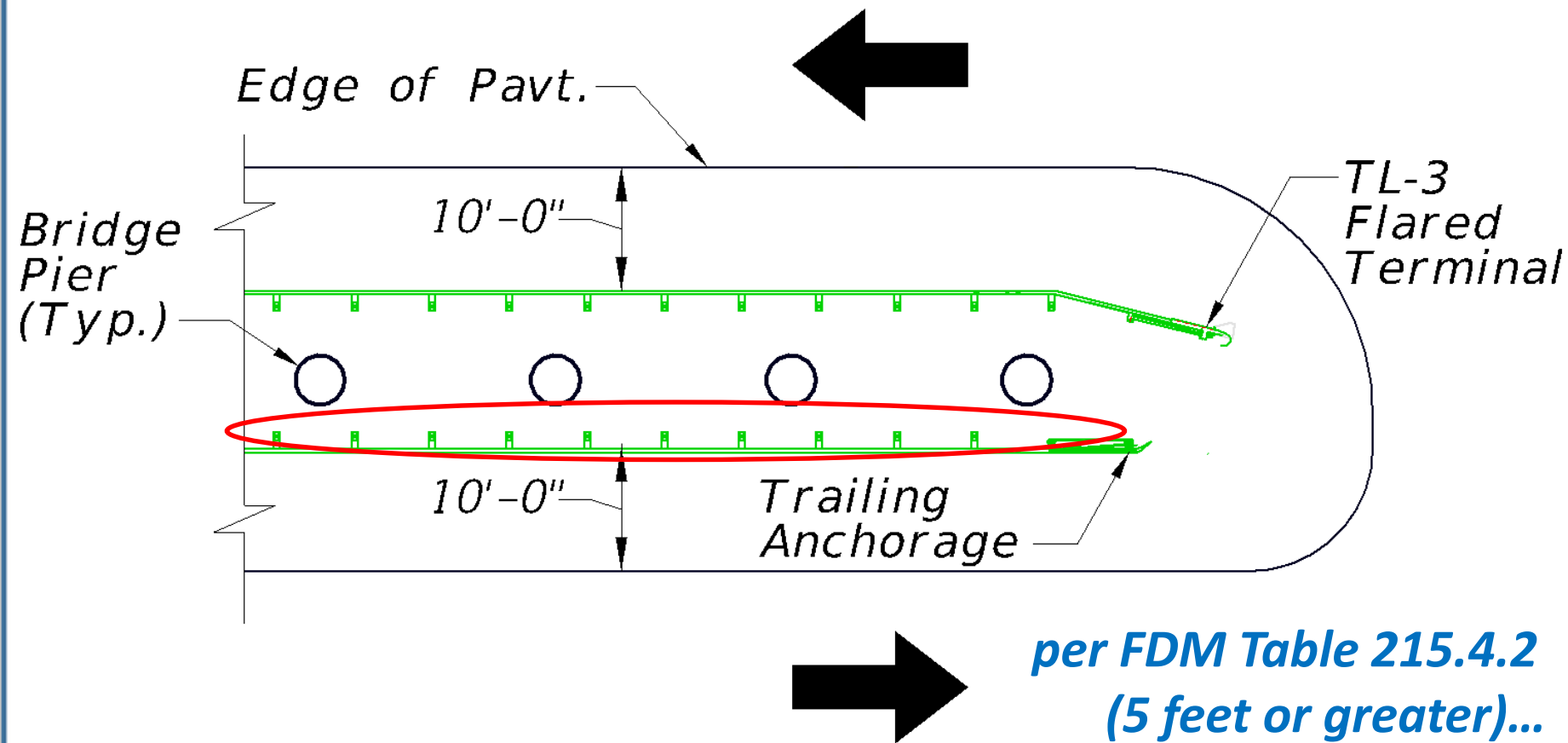


Second issue...
Flared Terminal usage on hold per RDB18-02

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

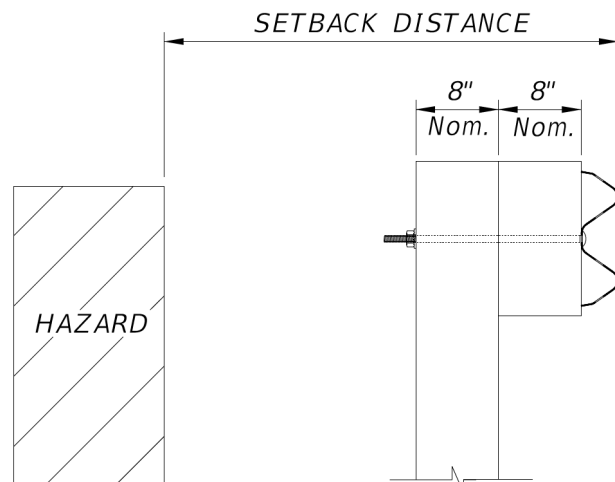
Guardrail requires 1:15 Max Taper Rate per SPI, Part I

Approach Terminals: Any issue here?

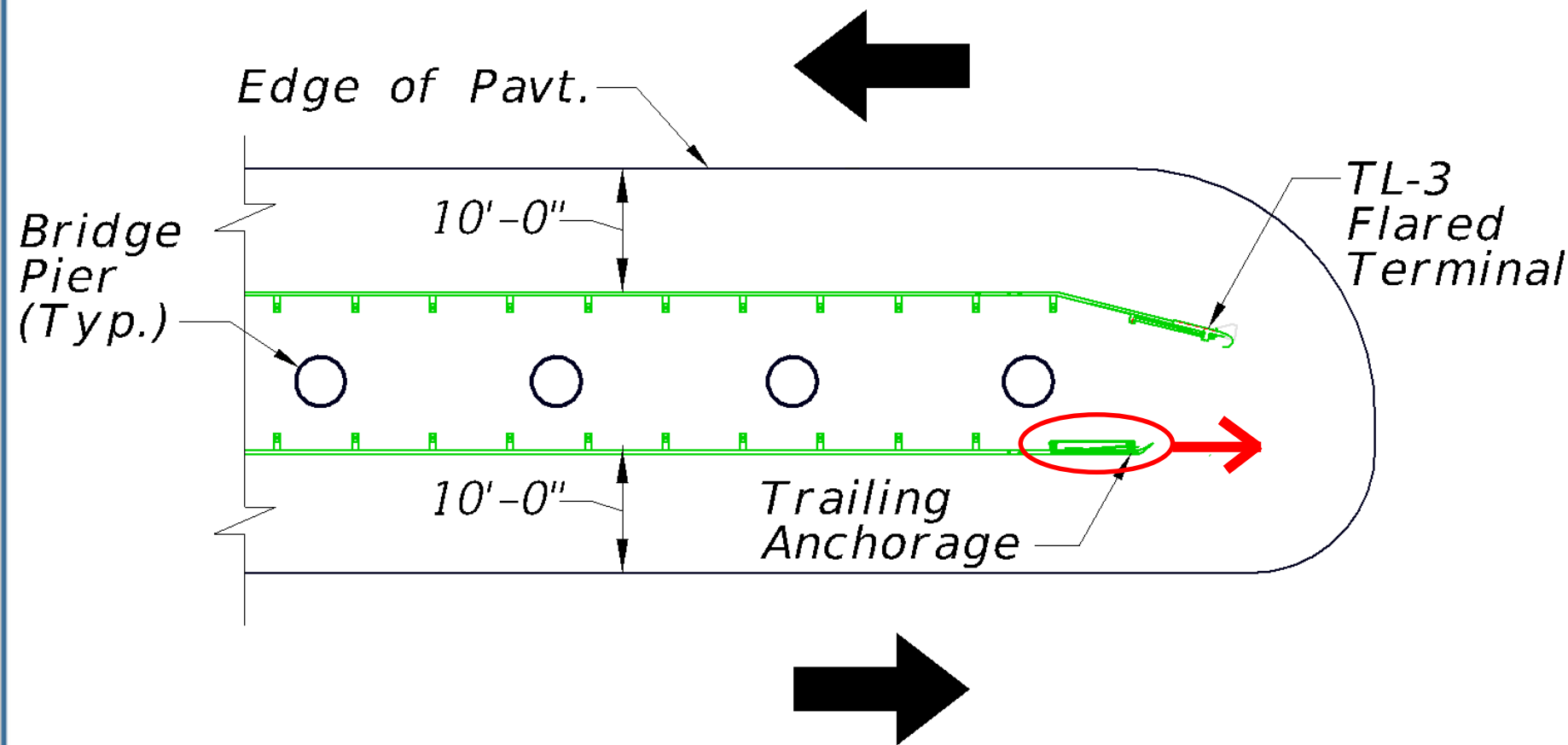


Third issue...

“Barrier Setback” requirement likely not satisfied



Approach Terminals: Any issue here?



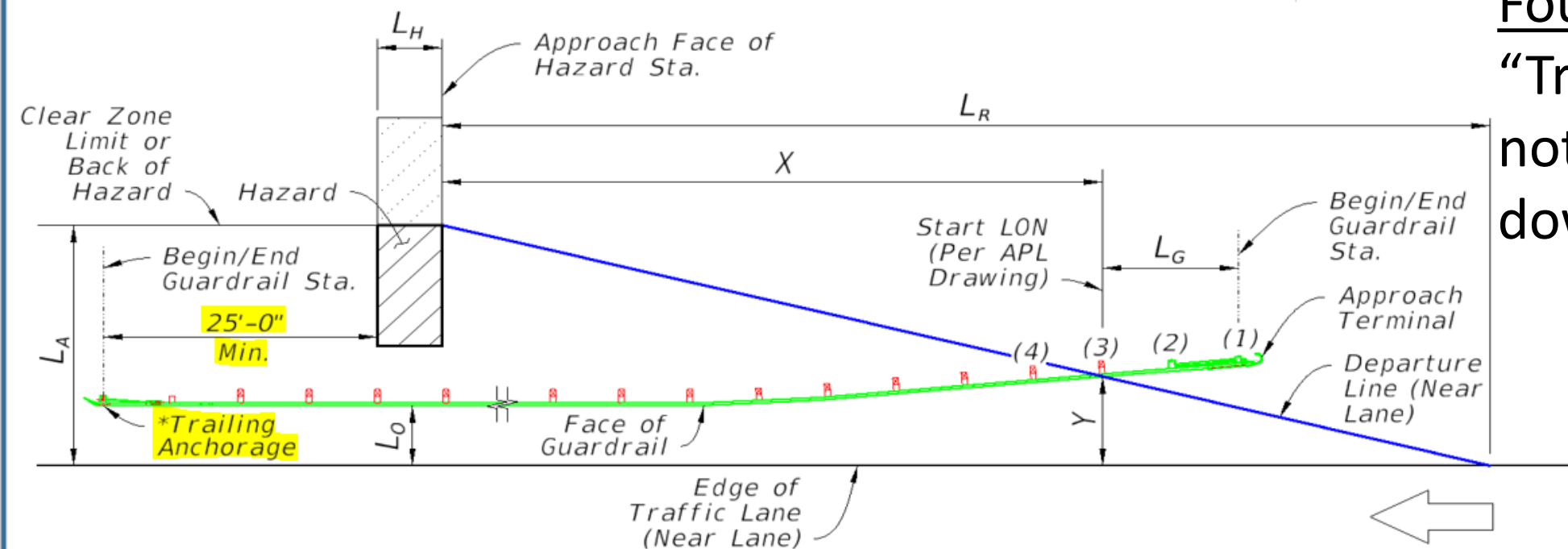
Fourth issue...

“Trailing Anchorage”
not properly extended
downstream of hazard

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

Approach Terminals: Any issue here?

From 'Length of Need' Excel Sheet...

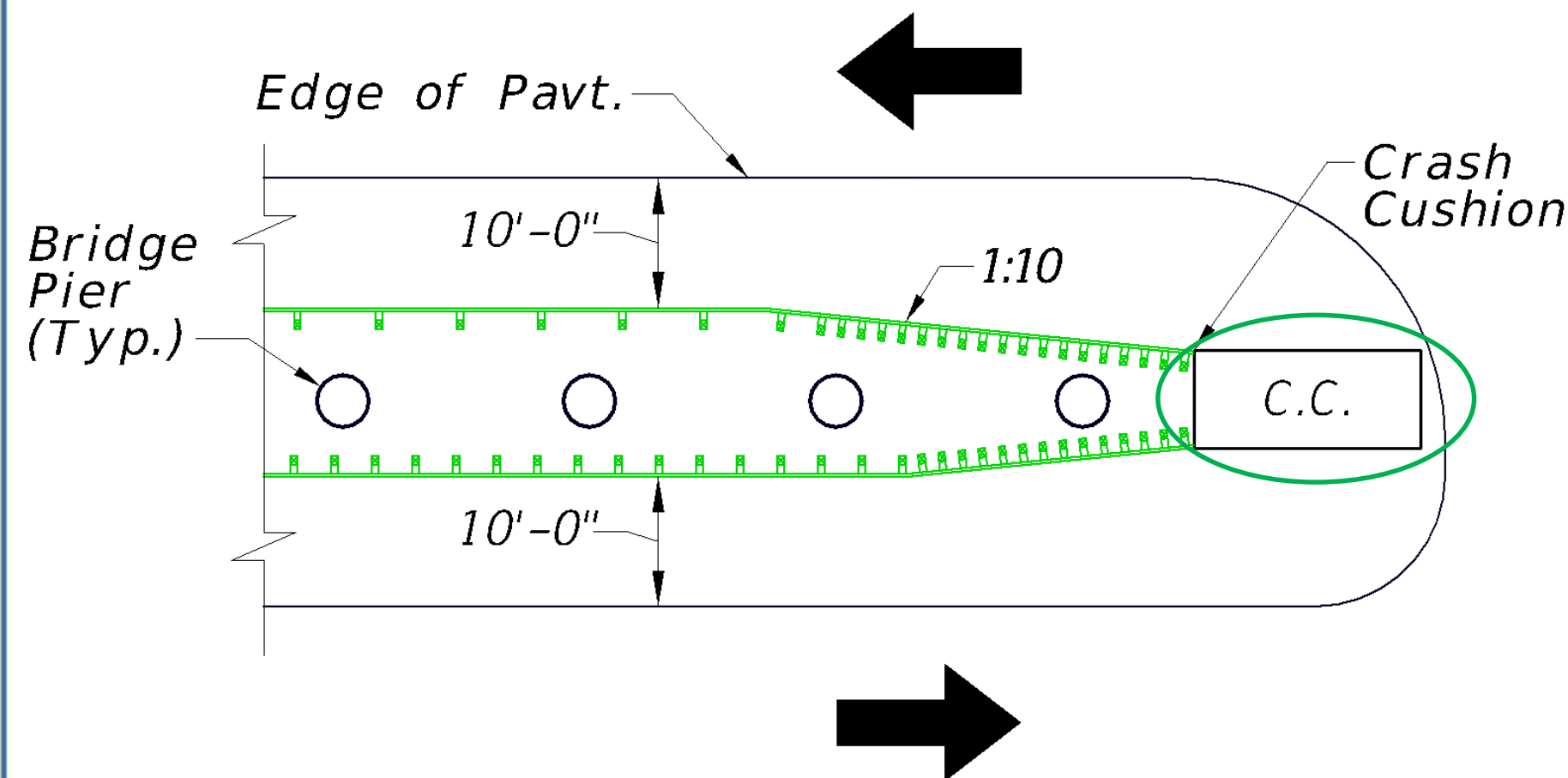


Fourth issue...

“Trailing Anchorage”
not properly extended
downstream of hazard

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

Approach Terminals: Solution 1

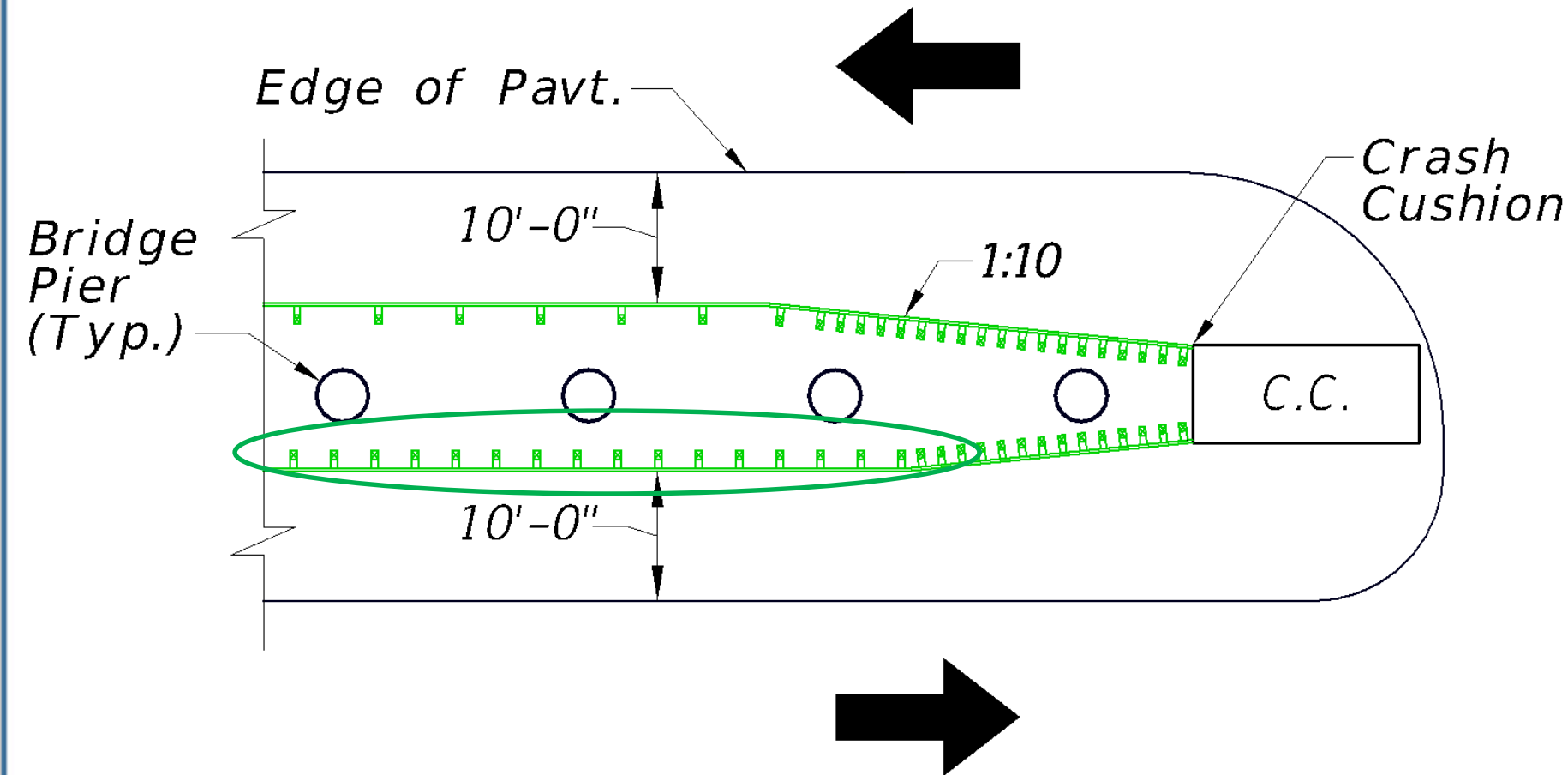


'Crash Cushion'

- "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"

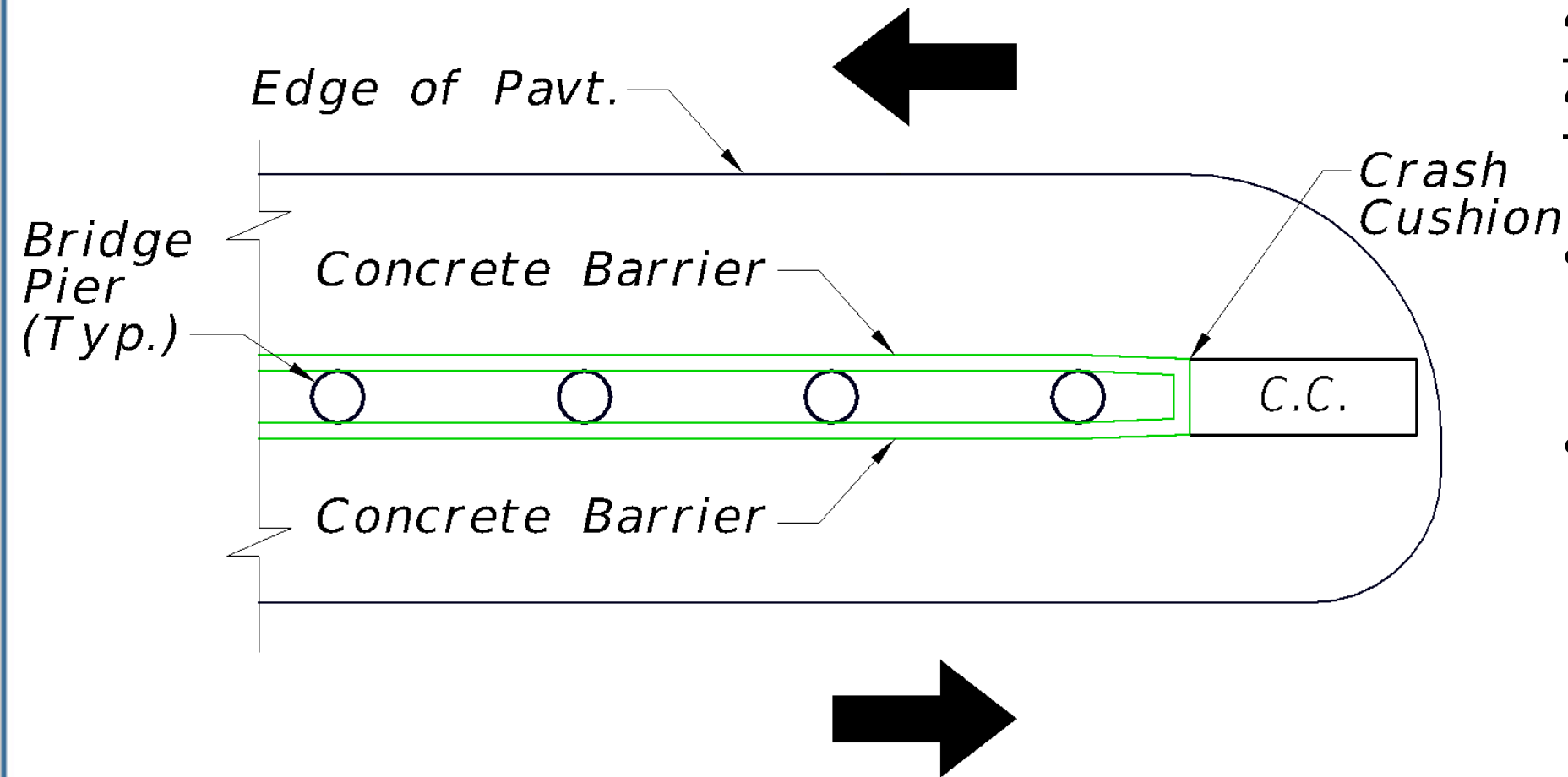
Approach Terminals: Solution 1



'Crash Cushion'

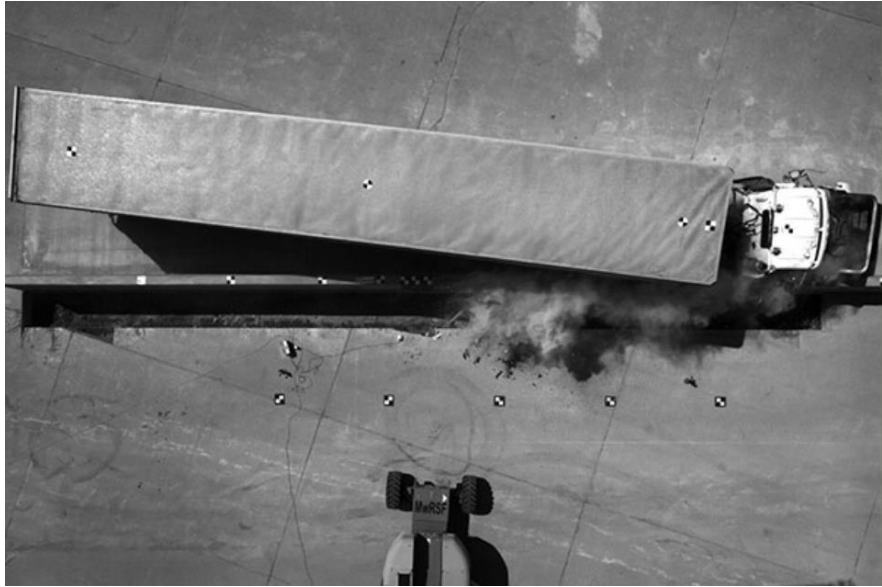
- Guardrail “reduced post spacing” to reduce required hazard setback per FDM Table 215.4.2.
- Again, *contact Central Office for guidance for such limited space*

Approach Terminals: Solution 2



'Concrete Barrier' & 'Crash Cushion'

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



Questions?



Richard Stepp, P.E.
Standard Plans Engineer
Central Office, Roadway Design
(850) 414-4313
richard.stepp@dot.state.fl.us