Guardrail
Traffic Barrier Terminals
Energy Attenuator

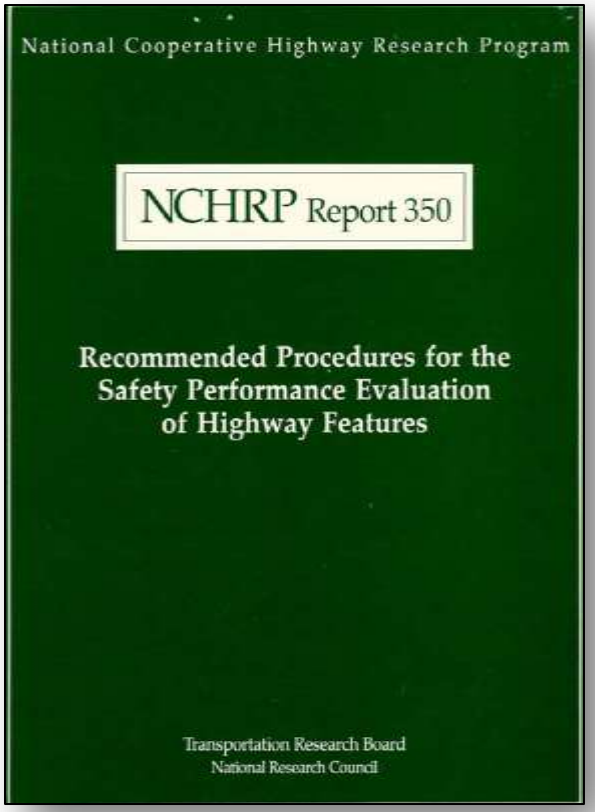
Tracy Borchardt

April 2013

National Cooperative Highway Research Program (NCHRP) 350

NCHRP Report 350, released in 1993, was formally adopted by FHWA for the NHS.

This was the first time that FHWA adopted these Procedures.



Illinois Tollway

Test Level For Roadside Barriers

NCHRP 350 Test Level For Barriers	Largest Vehicle Mass	Large Vehicle Impact Speed	Impact Angle for Barriers
TL-1	4400 lb.	31 mph	25 deg.
TL-2	4400 lb.	43 mph	25 deg.
TL-3	**4400 lb.**	**62 mph**	**25 deg.**
TL-4	17,650 lb	50 mph	15 deg.
TL-5 & TL-6	79,400 lb	50 mph	15 deg.

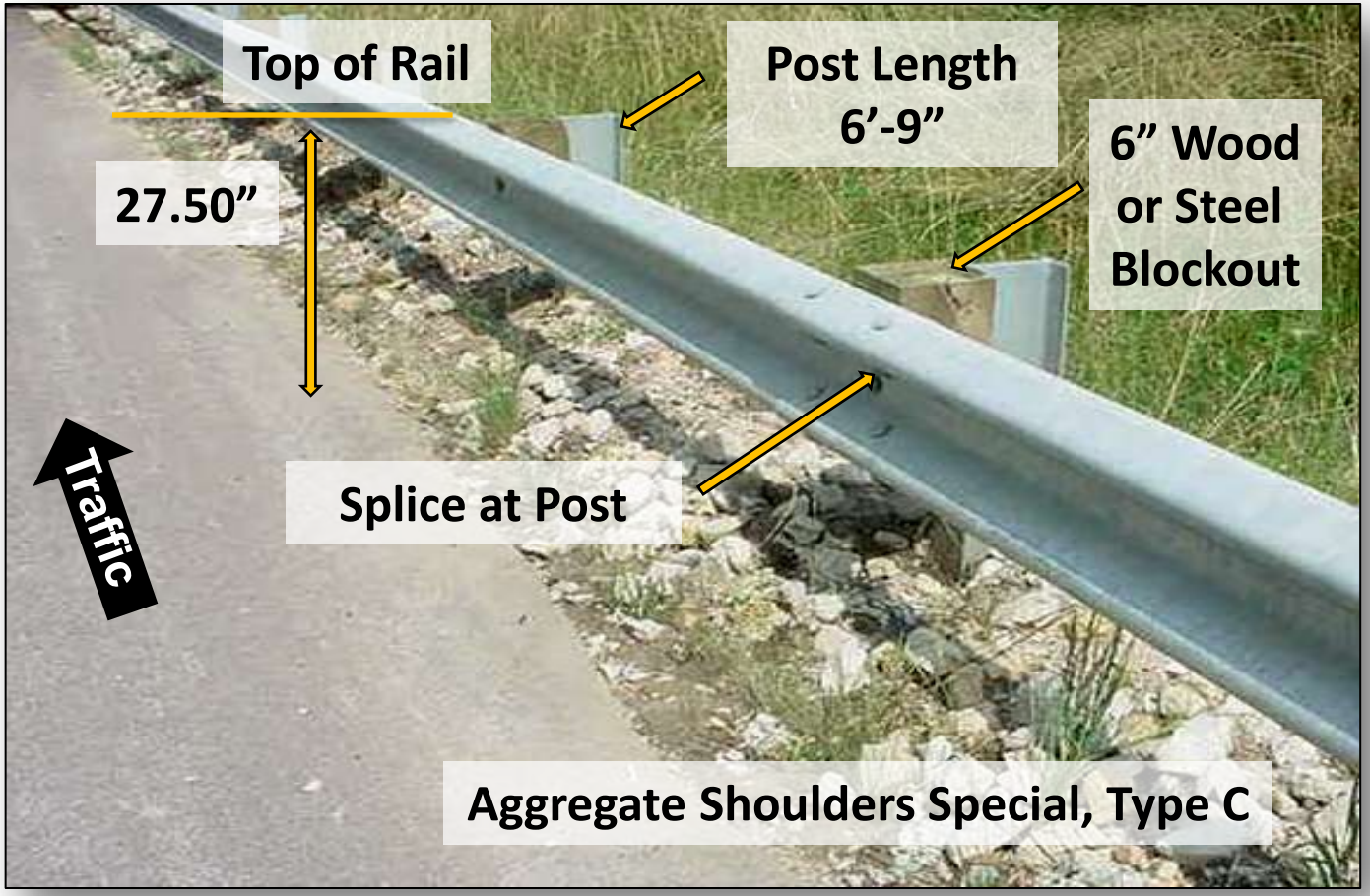
NCHRP 350, TL 3 Small Car

NCHRP 350, TL 3 Pickup Truck

Note deflection and rail separation from posts.

GUARDRAIL

Galvanized Steel Plate Beam Guardrail
Previous Standard – No Gutter

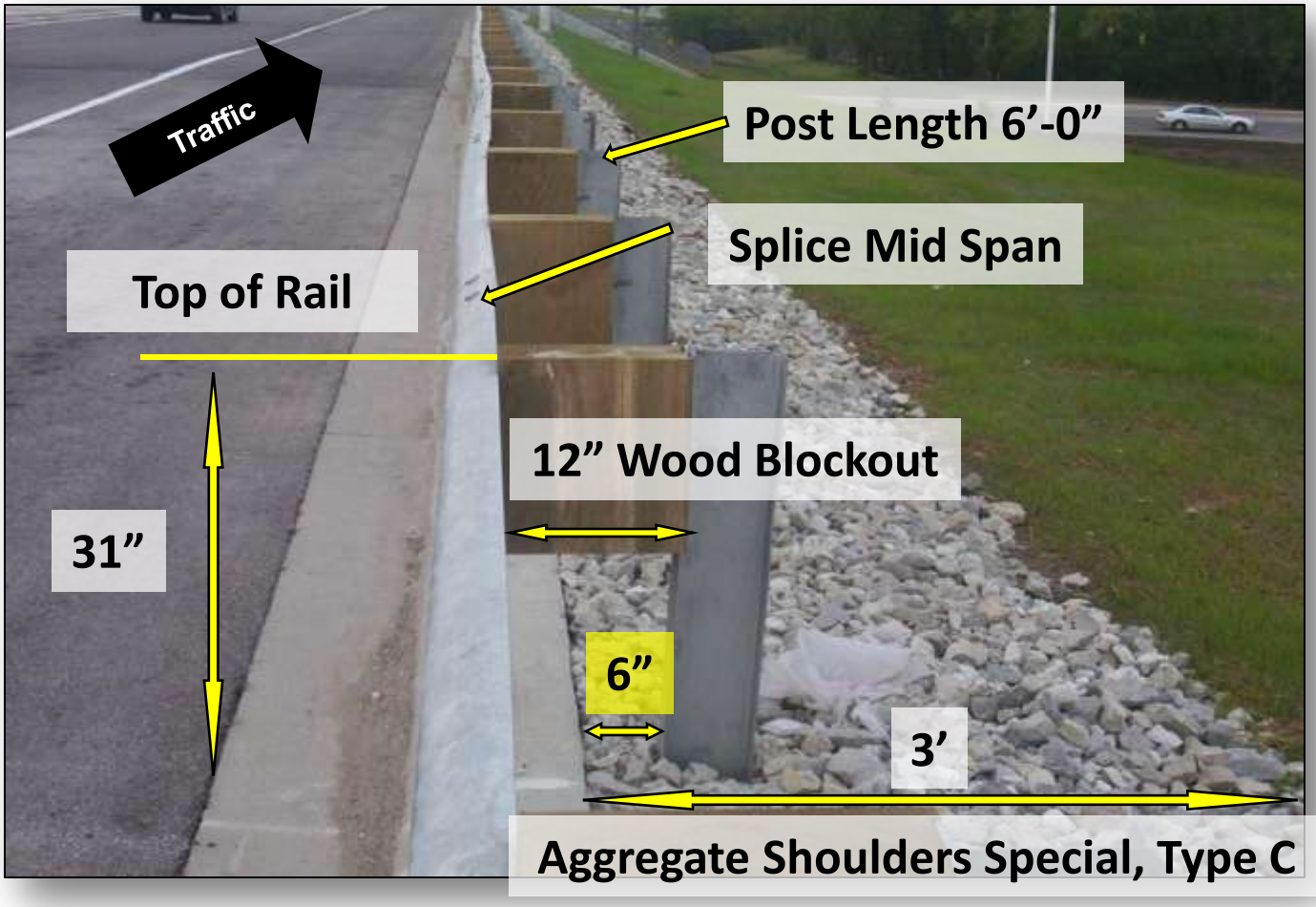


Guardrail Height

An installation too low may allow a larger vehicle to climb or override the barrier.

Standard C1:
Galvanized Steel Plate Beam Guardrail

Midwest Guardrail System with Gutter



Tollway Detail

Illinois Tollway

Connecting to Existing Guardrail

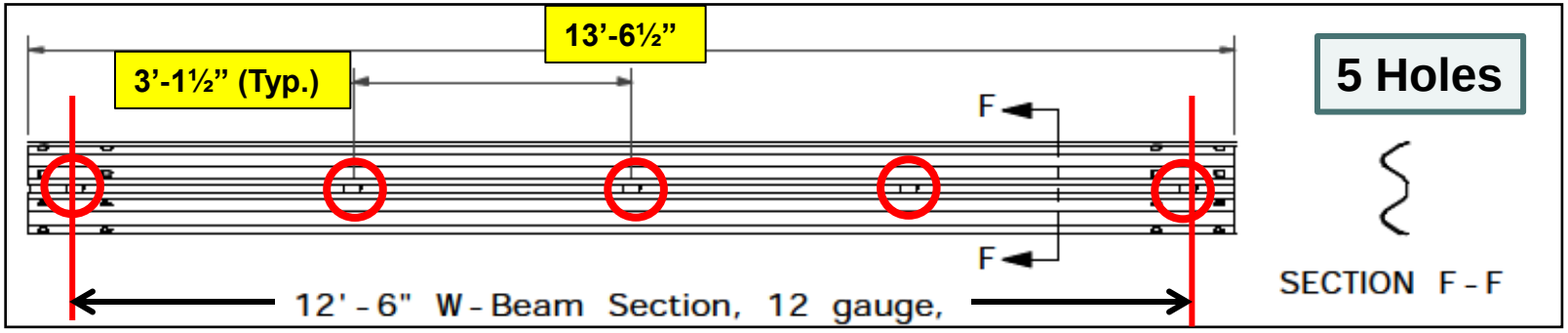
Increasing Guardrail Height

- **This work shall consist of the complete removal and re-erection of existing steel plate beam guardrail and traffic barrier terminals.**

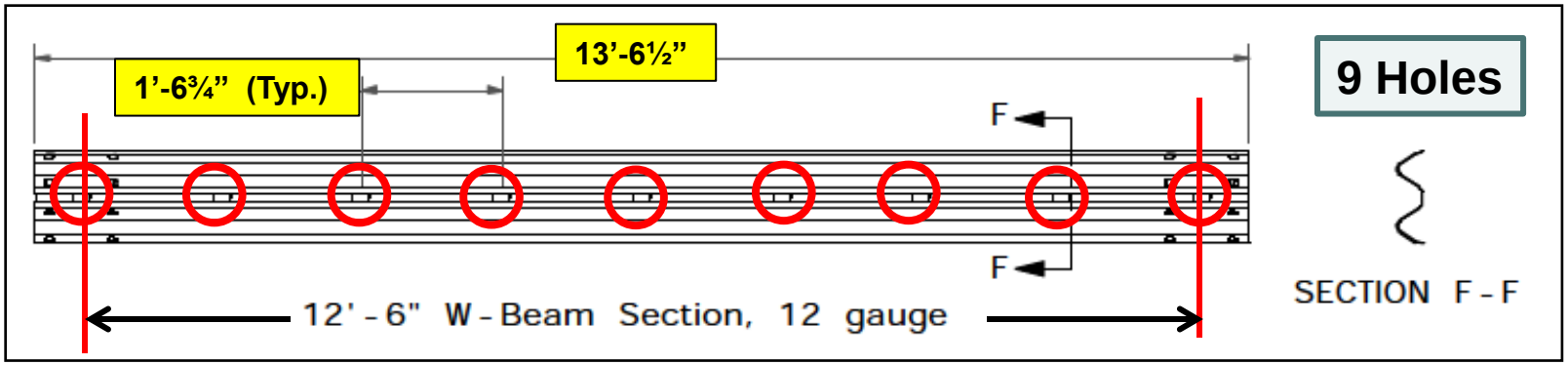
Guardrail – 3 Types

Guardrail System	Post Spacing
MGS- 31” Type A	6’- 3”
MGS- 31” Type B ½-Post Spacing	3’- 1 ½”
MGS- 31” Type C ¼-Post Spacing	1’-6 ¾”

MGS W-Beam Rail (2 types)



Post Spacing Type A (6’-3”)and Type B (3’-1½”)



Post Spacing Type C (1’-6¾”)

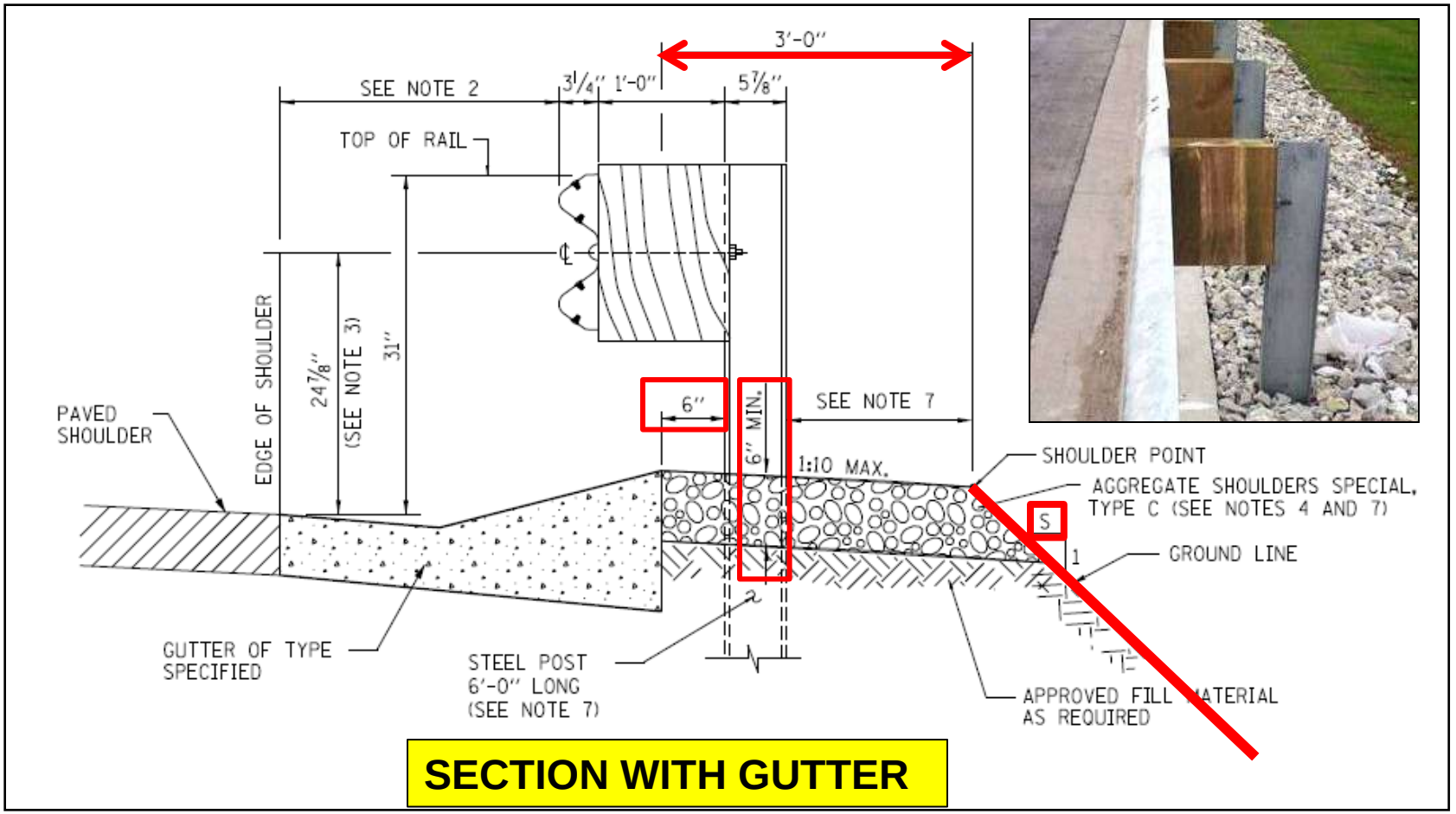
Galvanized Steel Plate Beam Guardrail

Strong Post Systems

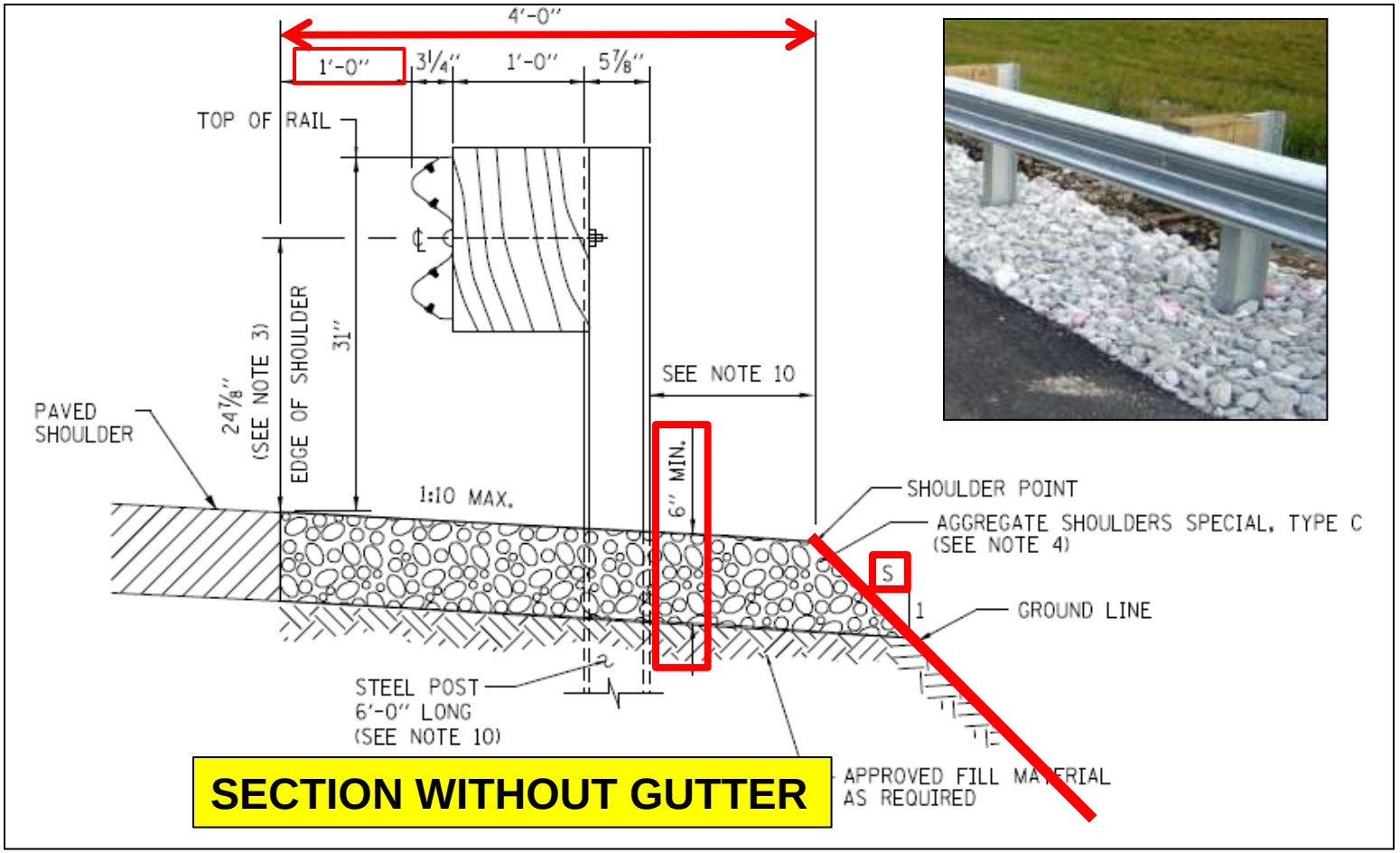
- Since there is a considerable contribution to the redirection capability of the system from the strength of the strong posts, it is necessary to develop adequate soil support for the post to prevent it from pushing backwards too easily.

Illinois Tollway

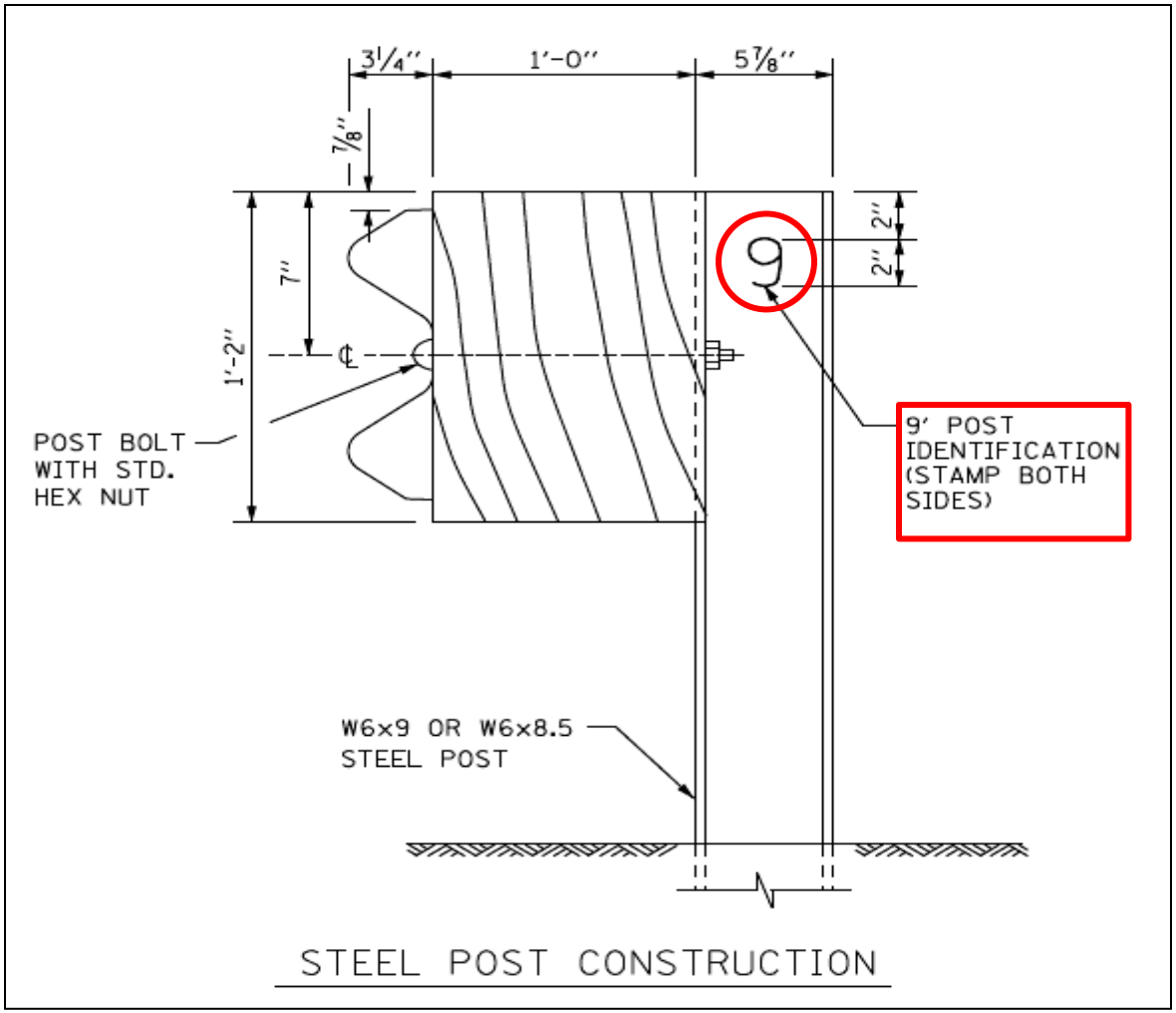
Galvanized Steel Plate Beam Guardrail



Galvanized Steel Plate Beam Guardrail



Galvanized Steel Plate Beam Guardrail



Aggregate Shoulder Material

Aggregate Shoulders Special, Type C

Aggregate Shoulders Type B

Aggregate Shoulder Material

DO NOT MOUND AGGREGATE – RESTRICTS ROADWAY DRAINAGE

Galvanized Steel Plate Beam Guardrail

Shall Not Be Bolted Down

Galvanized Steel Plate Beam Guardrail

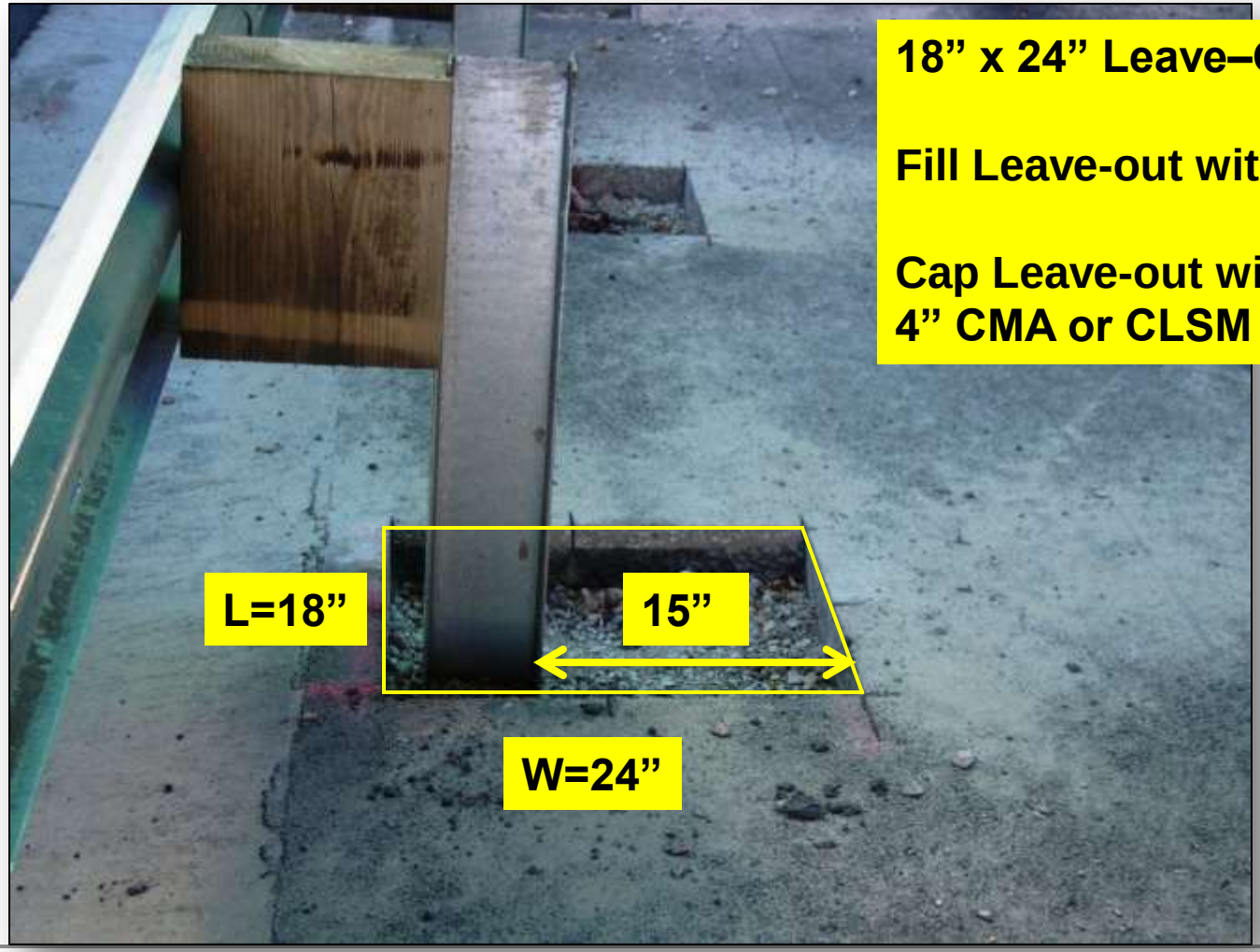
Shall Not Be Encased in Concrete

Galvanized Steel Plate Beam Guardrail

Shall Not Be Encased in Asphalt

Guardrail Post Leave-Outs

Guardrail Post Leave-Outs



18” x 24” Leave–Out

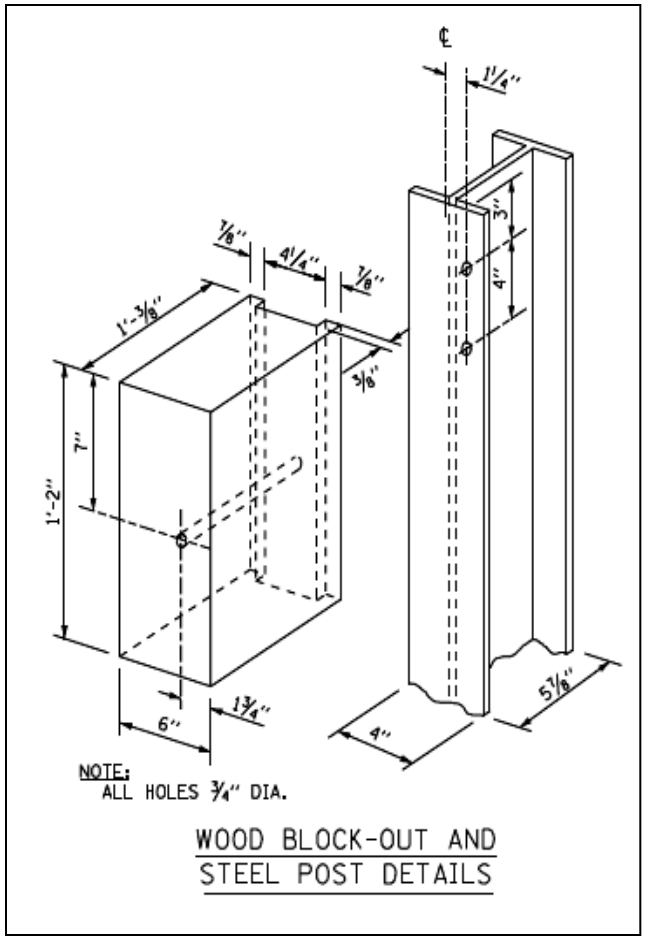
Fill Leave-out with: CA6

Cap Leave-out with:
4” CMA or CLSM

Illinois Tollway

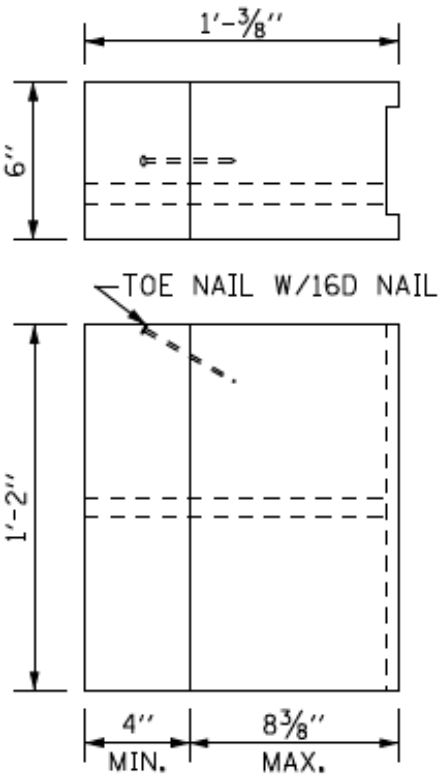
Guardrail Post Leave-outs Video

Wood Block-Out



WOOD BLOCK-OUT AND
STEEL POST DETAILS

Wood Block-Out

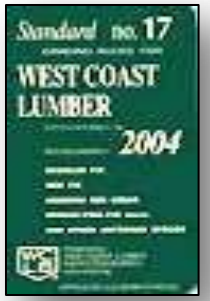


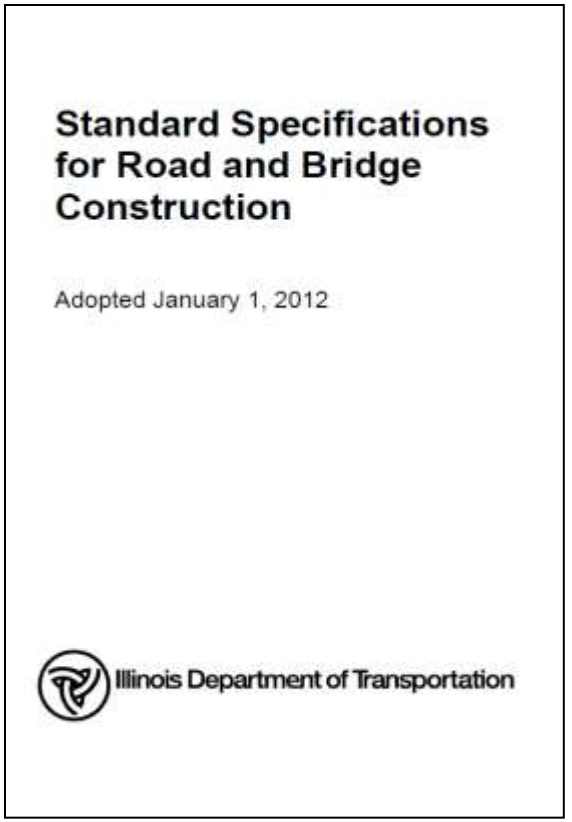
Two Piece Wood Block-Out Option

Wood Block Grading Rules

- Southern Pine Inspection Bureau

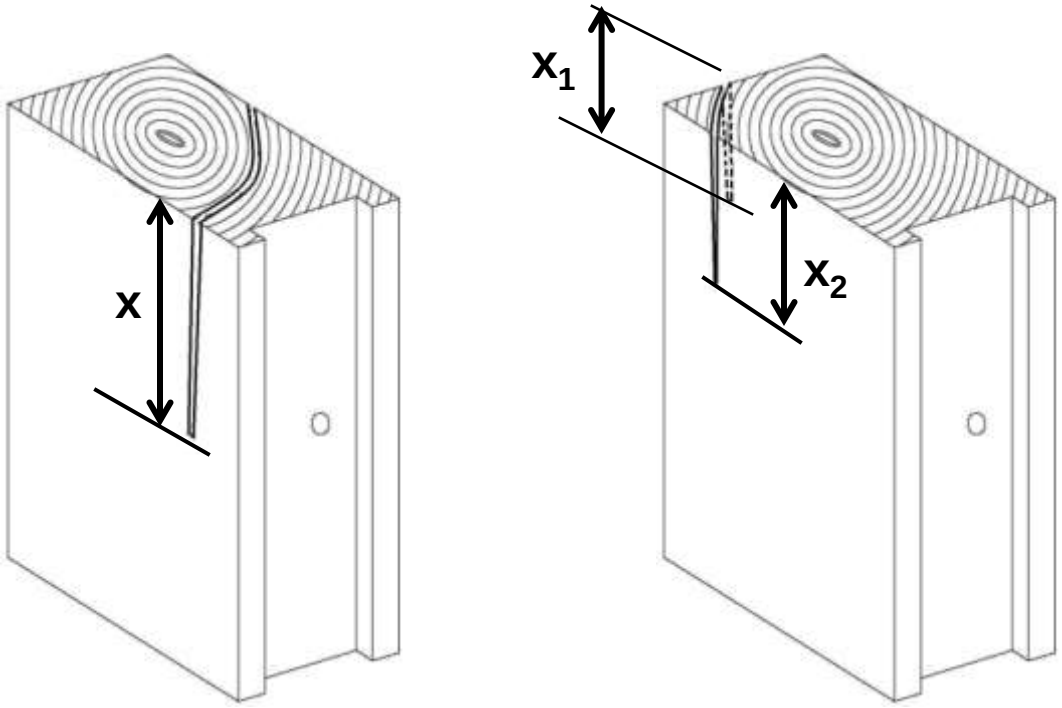
- West Coast Lumber Inspection Bureau





Illinois Tollway

Wood Block Defect-Splits



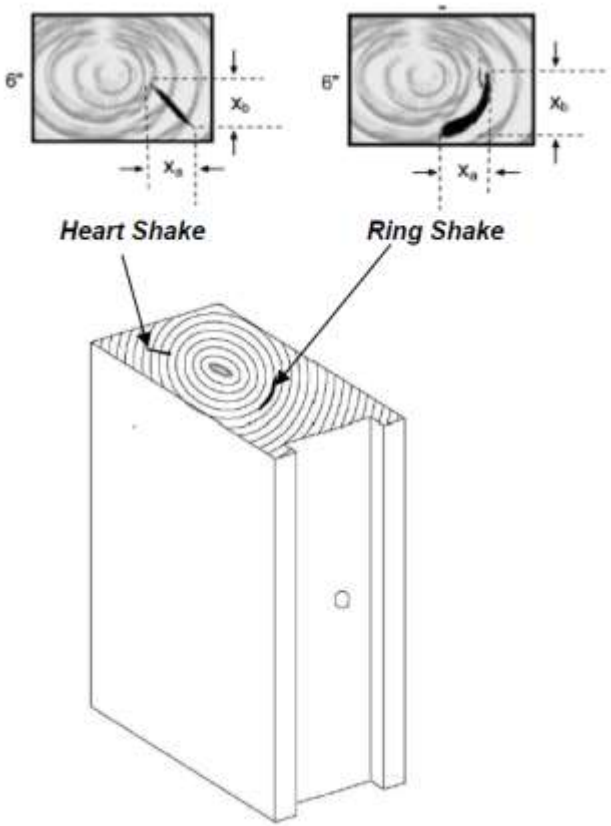
A split is a separation of the wood through the piece to the opposite surface or to an adjoining surface due to the tearing apart of wood cells.

Splits are limited to 1/6 the block length (14”) = 2¼”.

Wood Block Defect- Split

Limited to 1/6 the block length(14”) = 2¼”
This split runs entire length of wood block-out.

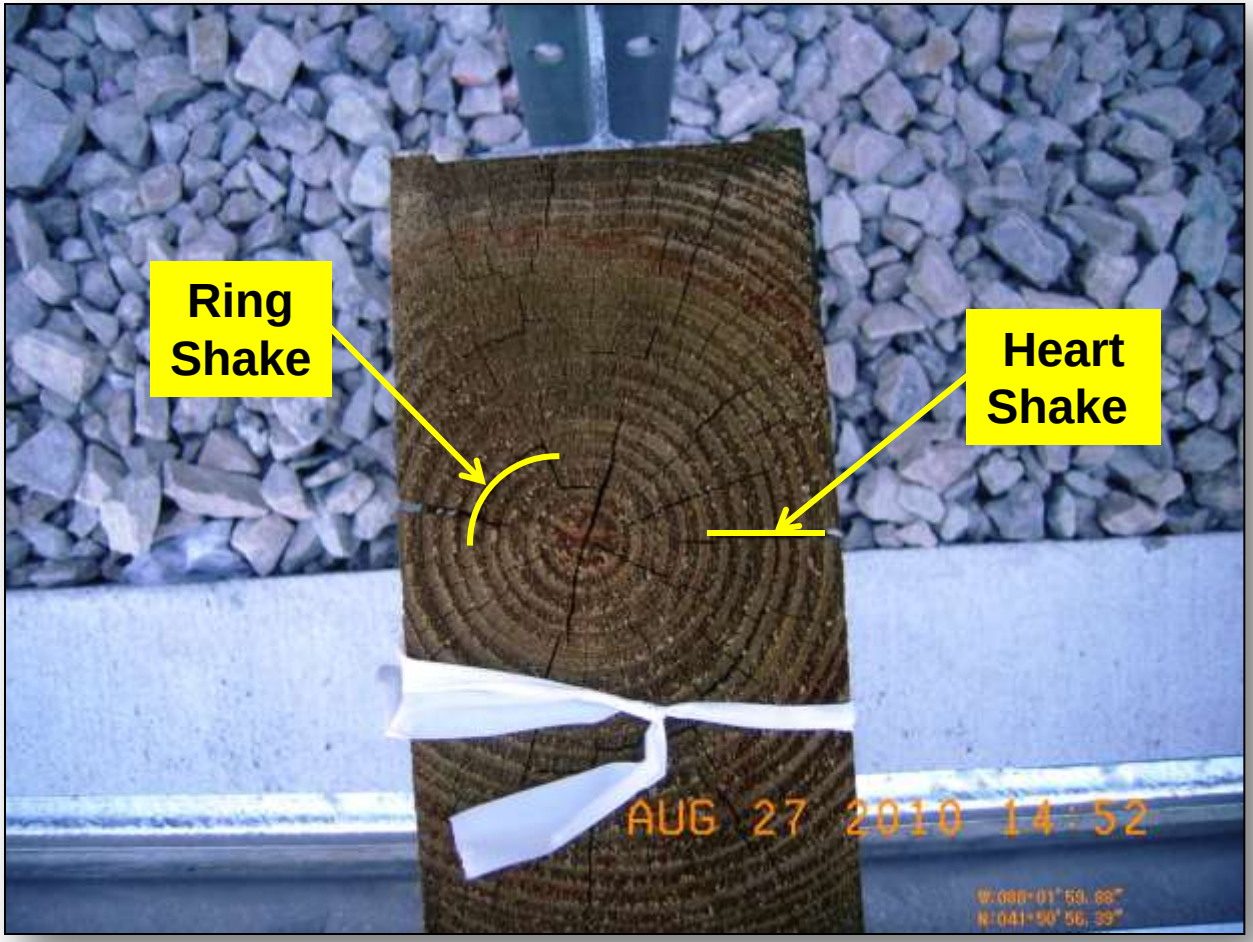
Wood Block Defect-Shakes



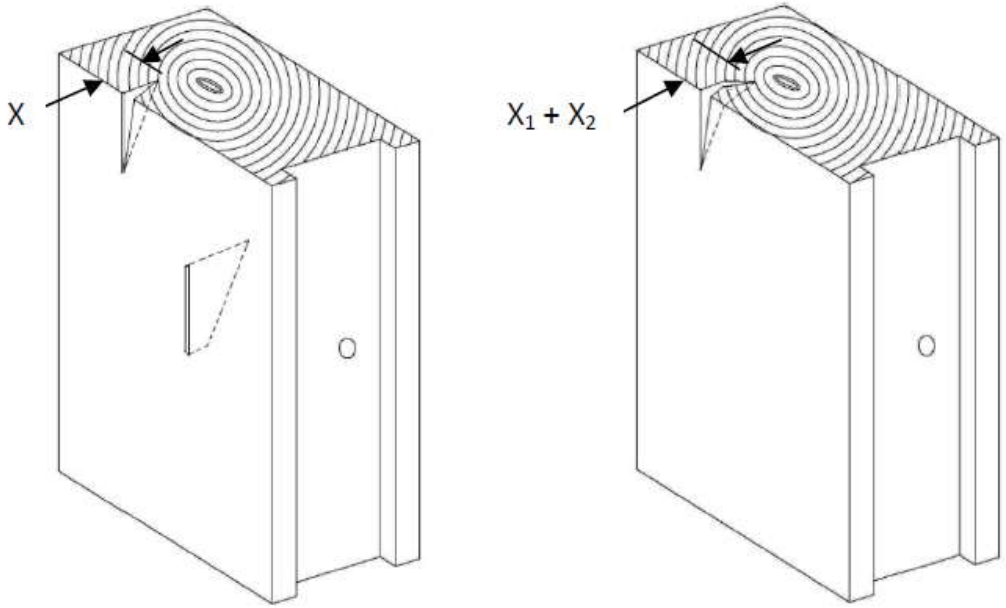
Shakes are a lengthwise separation of the wood which occurs between or through the annual rings of growth.

Shakes are limited to 1/3 the thickness (6”) on end = 2”.

Wood Block Defect-Shakes



Wood Block Defect-Checks



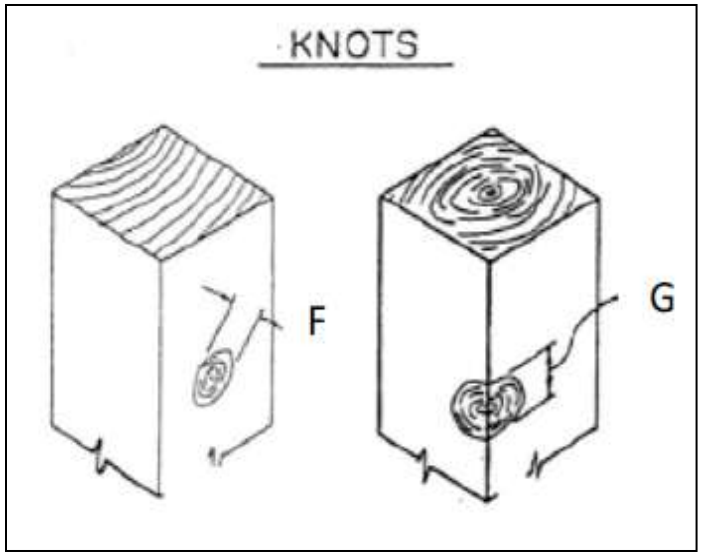
Checks are a separation of the wood normally occurring across or through the rings of annual growth and usually as a result of seasoning.

Checks are limited to the sum of ½ the thickness (6”) = 3”.

Always measure perpendicular to the face of the block if check is on the 6-inch face, not the actual length of the crack.

Wood Block Defect-Check

Wood Block Defect-Knots



Knots are a portion of branch or limb that has become incorporated in a piece of lumber. Knots shall be measured as shown in Figure.

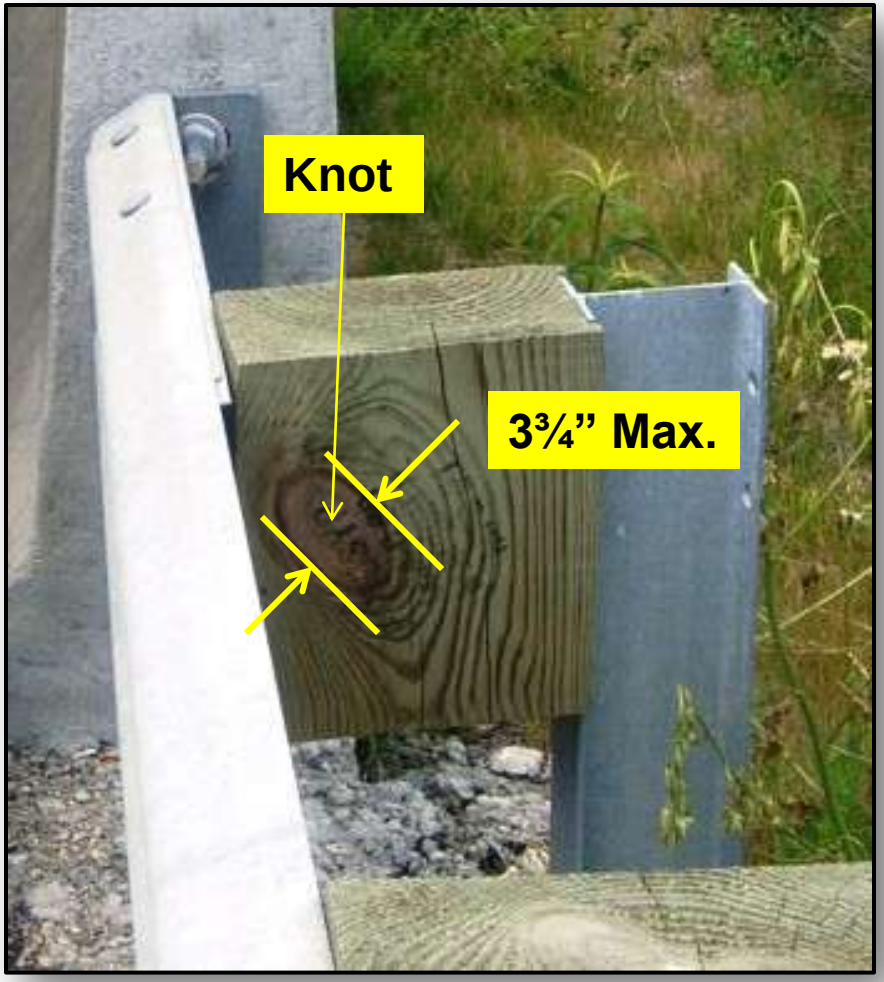
F- Measure least dimension.

G-Measure along corner or measure size most nearly representing diameter of branch causing the knot.

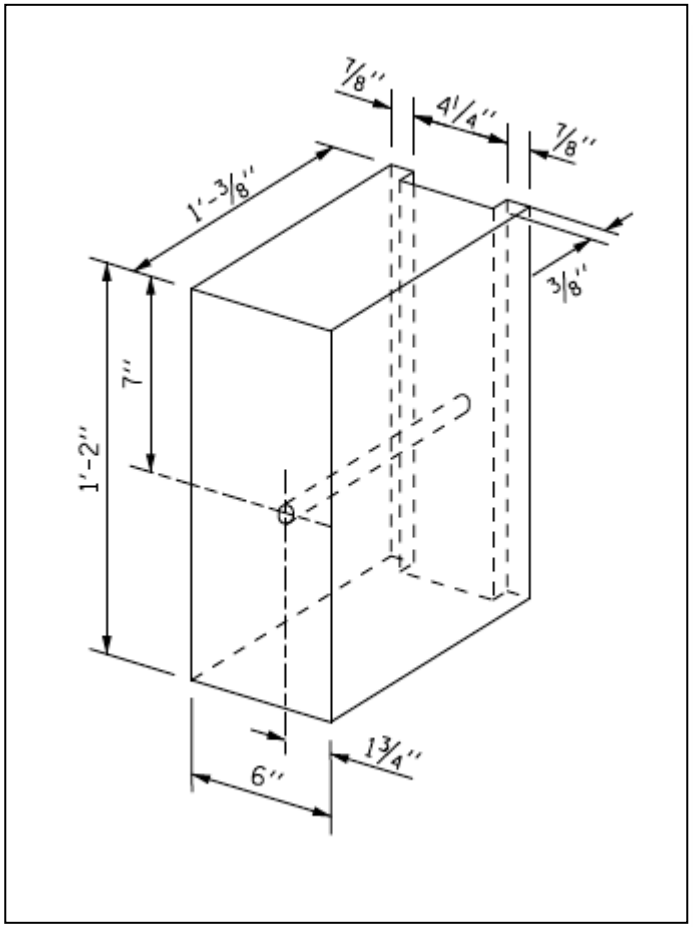
The sum of the sizes of all knots in any 6” length of piece must not exceed twice the size of the largest knot permitted.

Nominal Width	Approximate Knot Size
6”	1-7/8”
12”	3-3/4”

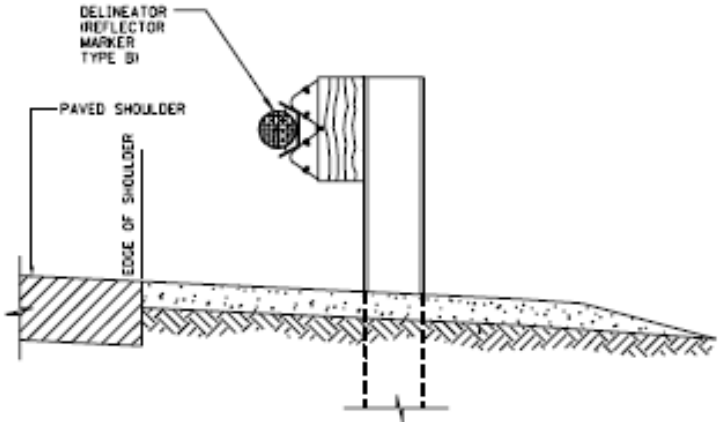
Wood Block Defect-Knots



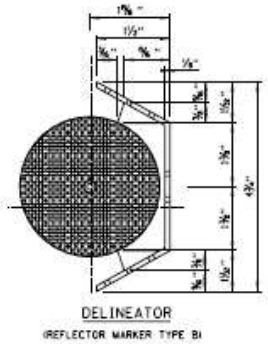
Wood Block Defect-Routed Edge



Standard D4: Delineators



Reflector Marker Type B



D4-Delineators

Revised Permanent Delineation Spacing

		MAINLINE		RAMP	
		TANGENT	CURVE	TANGENT	CURVE
*	GUARDRAIL	100′	100′	100′	TABLE A
*	CONCRETE BARRIER (DOUBLE FACE)	100′	100′	100′	TABLE A
*	CONCRETE BARRIER (SINGLE FACE)	100′	100′	100′	TABLE A
	SHOULDER NARROWING	3 @ 15′	3 @ 15′	3 @ 15′	3 @ 15′
	BRIDGE APPROACHES	3 @ 15′	3 @ 15′	3 @ 15′	3 @ 15′
*	BRIDGE PARAPET	50′	50′	50′	50′
*	NOISE ABATEMENT WALL (CRASH WORTHY)	100′	100′	100′	TABLE A
	POST MOUNTED DELINEATOR	200′	200′	200′	TABLE A
	POST MOUNTED DELINEATOR (RAMP TAPERS AND TANGENTS)	100′	100′	NA	NA

D4-Delineators

New Temporary Delineation Spacing

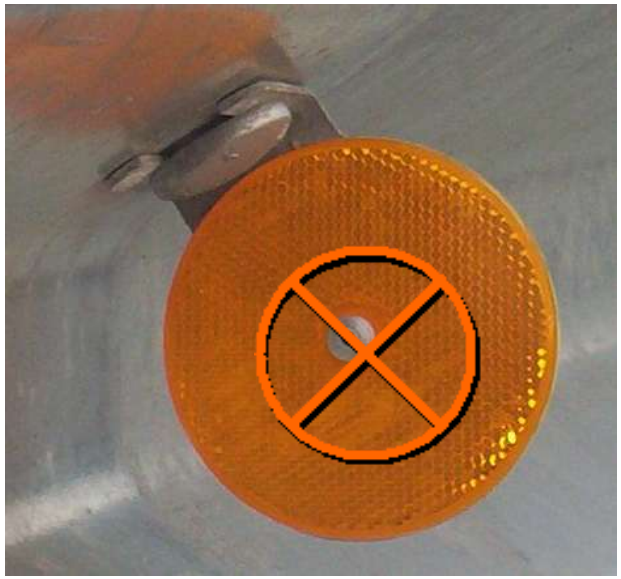
TEMPORARY DELINEATION SPACING				
	TANGENT	REVERSE CURVE	SHIFT	TAPER
TEMPORARY CONCRETE BARRIER	50′	25′	25′	25′

* WHEN ADJACENT SHOULDER IS USED AS A TRAVELED LANE, USE SPACING REQUIREMENTS AS SHOWN FOR TEMPORARY DELINEATION.

Q: IDOT reflector Type A details the use of butterfly delineators (metal) that slip under the bolt on guardrail.

Why are they not used on the Tollway?

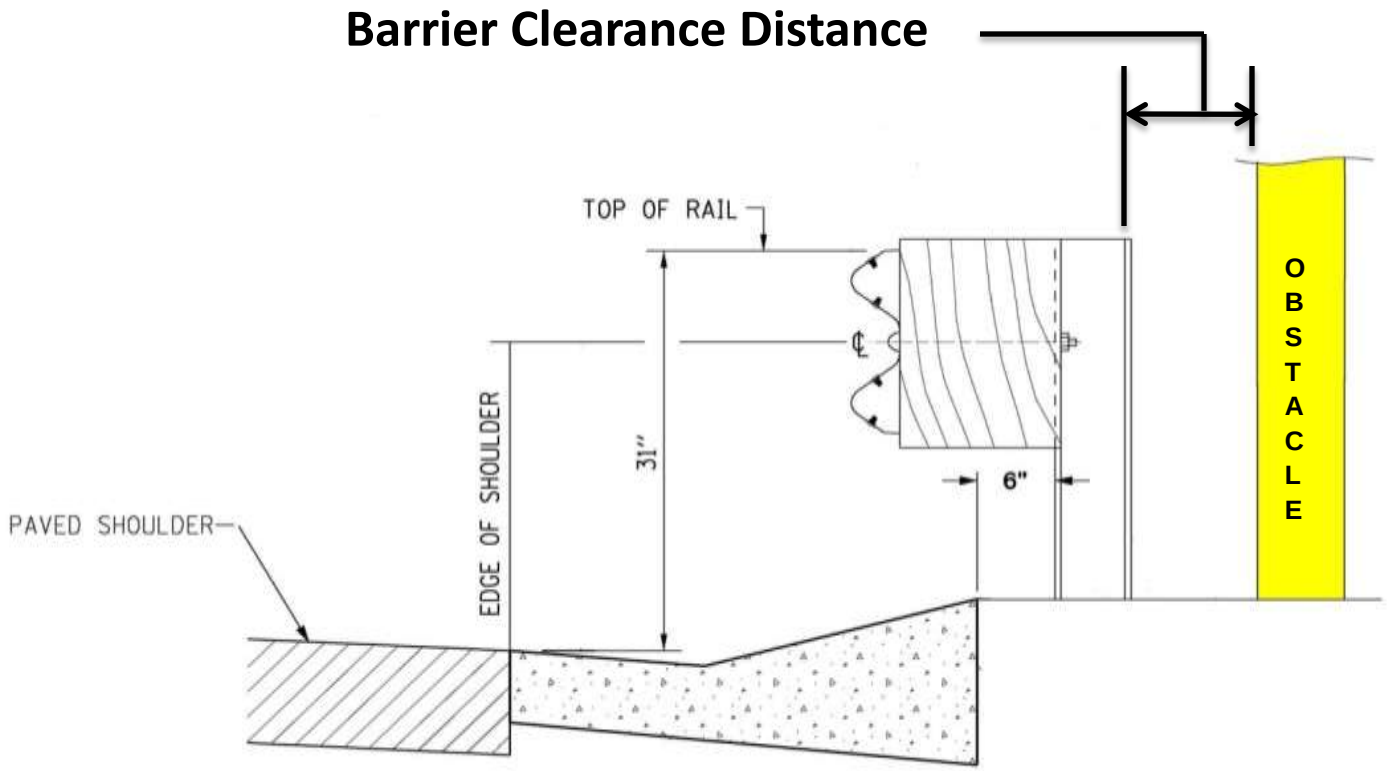
A: *This type delineator when connected at posts may imitate the behavior of the old steel washers and allow the rail to remain attached to the post and possibly become pulled down during impact events.*



Illinois Tollway

Barrier Clearance Distance

Barrier clearance distance is measured from back of post to face of obstacle.



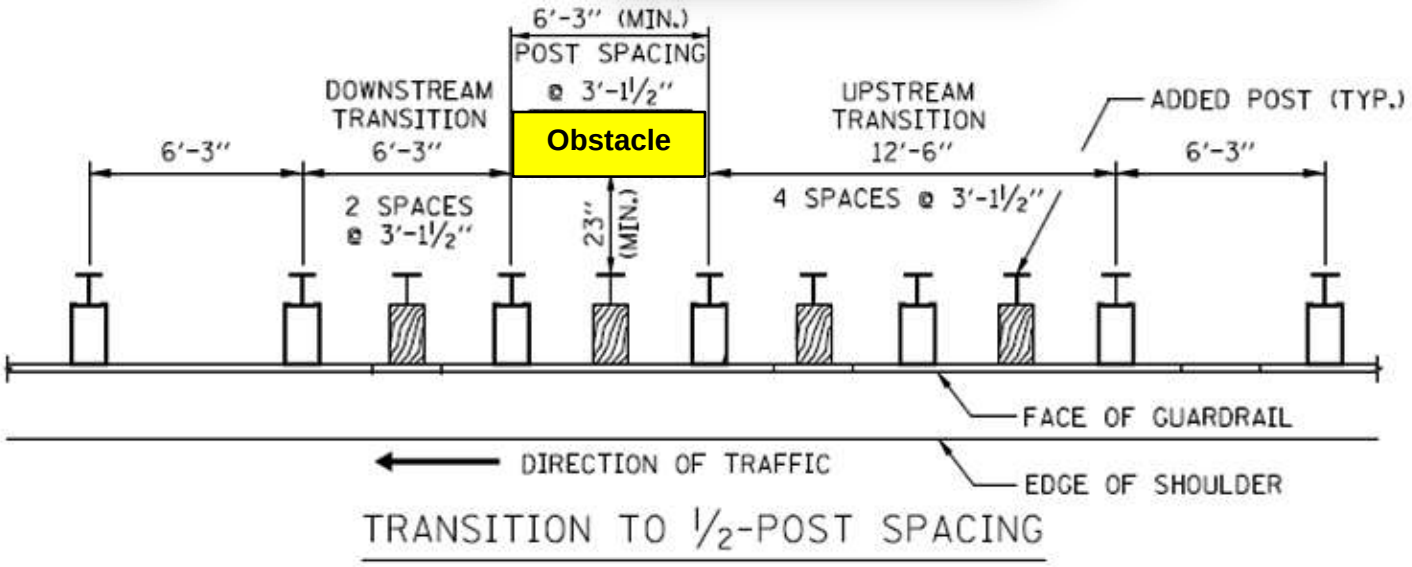
Midwest Guardrail System Video

Barrier Clearance Distance

Guardrail System	Post Spacing	Desirable Barrier Clearance Distance	Minimum Barrier Clearance Distance
MGS- 31” Type A	6’- 3”	42”	28”
MGS- 31” Type B ½ Post Spacing	3’- 1 ½”	30”	23”
MGS- 31” Type C ¼ Post Spacing	1-’6 ¾”	24”	14”

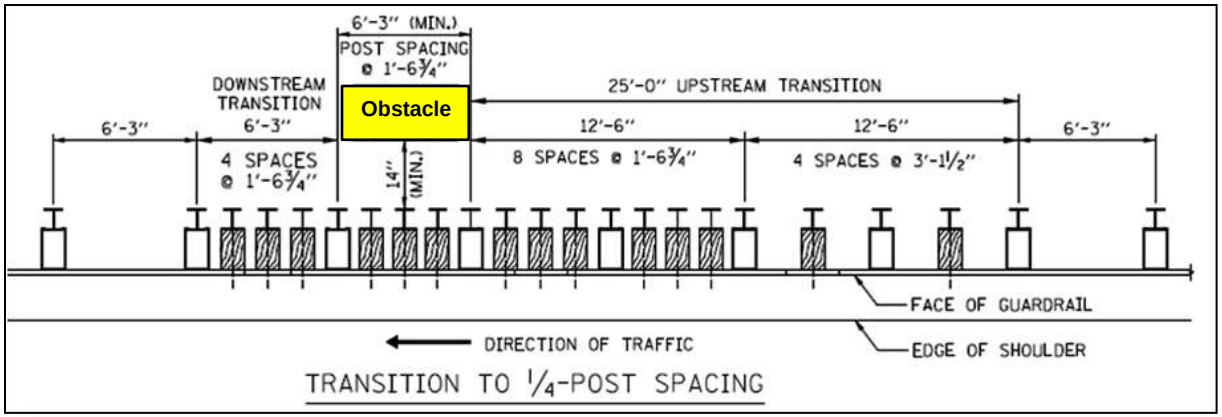
Minimum Barrier Clearance distances are only to be used for Existing Obstacles

Galvanized Steel Plate Beam Guardrail



TRANSITION TO ½-POST SPACING

Galvanized Steel Plate Beam Guardrail



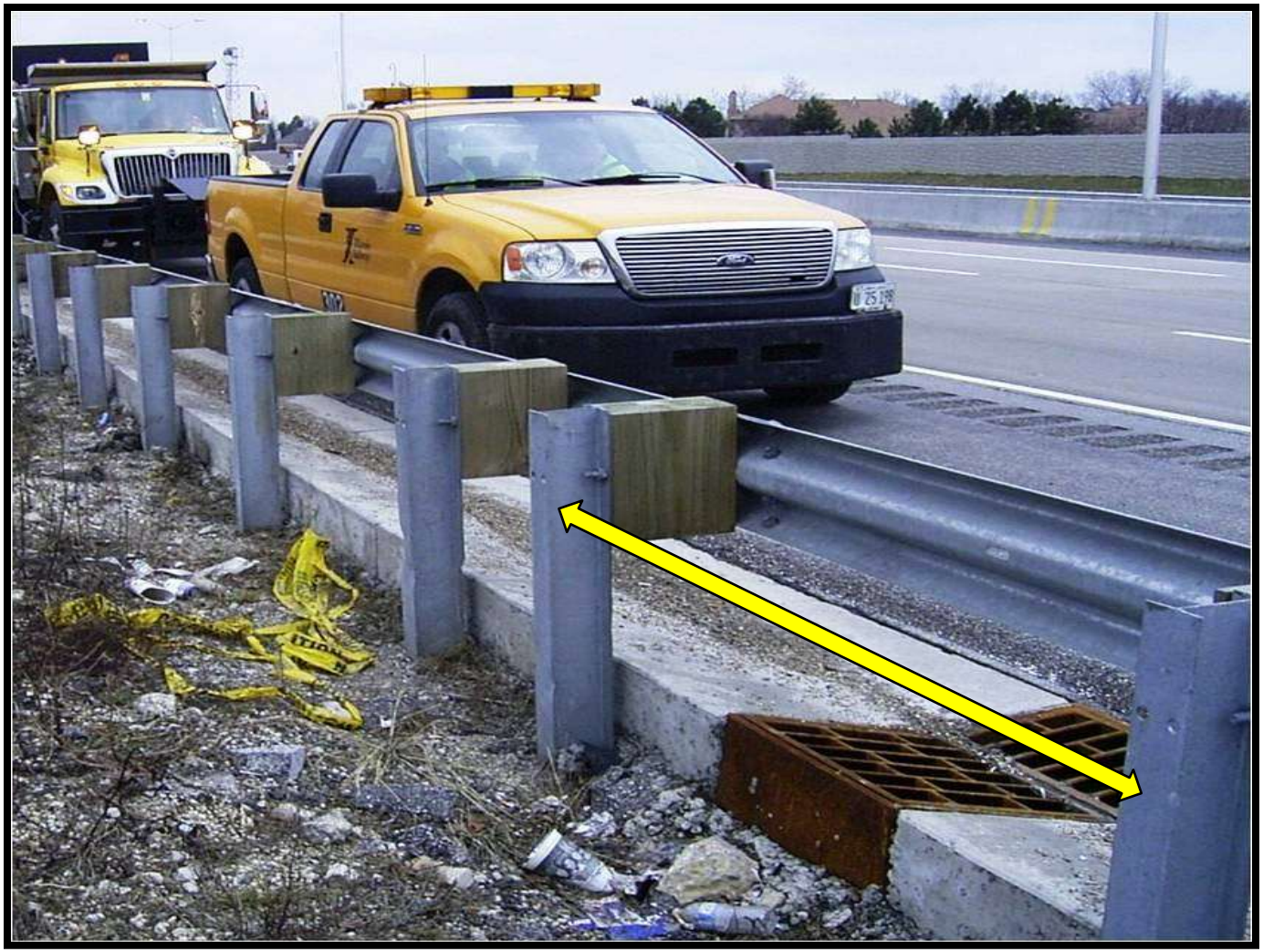
Storage Areas In Work Zones

- Materials or equipment when placed behind guardrail, shall be placed a minimum of 4 feet behind the guardrail posts.

Q: Guardrail crosses a drainage structure and post cannot be placed where required. Can additional block-outs be used to offset the post?

A: No;
the Tollway does
not allow additional
block-outs.

Maximum Post Spacing



Q: Guardrail crosses a drainage structure and post cannot be driven. Should post be omitted or moved?

***A*: Post should not be omitted. All posts should be used.**

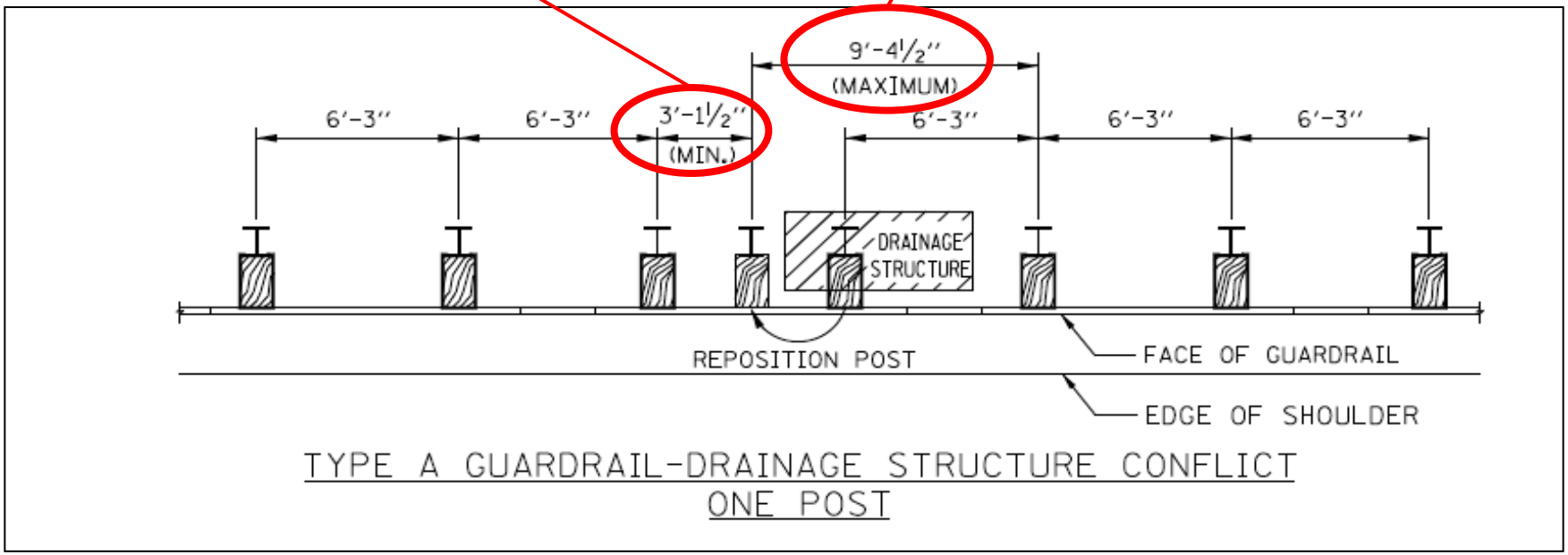
MGS (31-inch rail height) single rail section has been successfully tested to span up to 9'- 4½".

Long-Span Test (Too Long)

Galvanized Steel Plate Beam Guardrail Drainage Structure Conflict

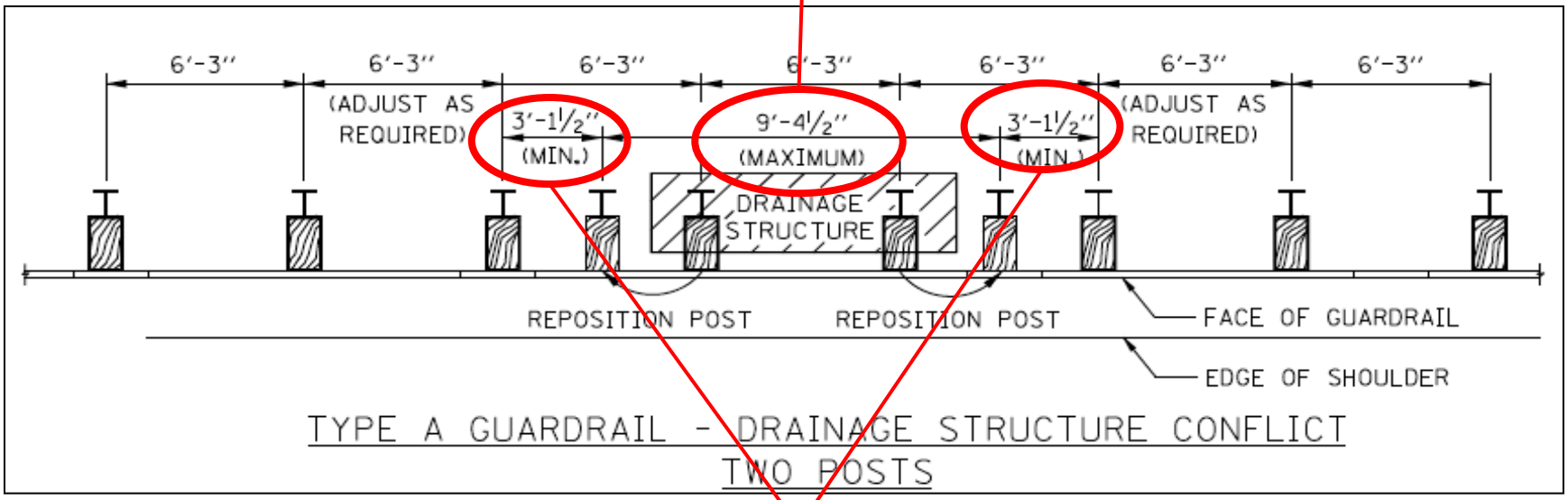
(0.5) x Normal Post Spacing

(1.5) x Normal Post Spacing



Galvanized Steel Plate Beam Guardrail Drainage Structure Conflict

(1.5) x Normal Post Spacing



(0.5) x Normal Post Spacing

Q: Would drilling a new hole in the Midwest Guardrail System (MGS) guardrail weaken the system?

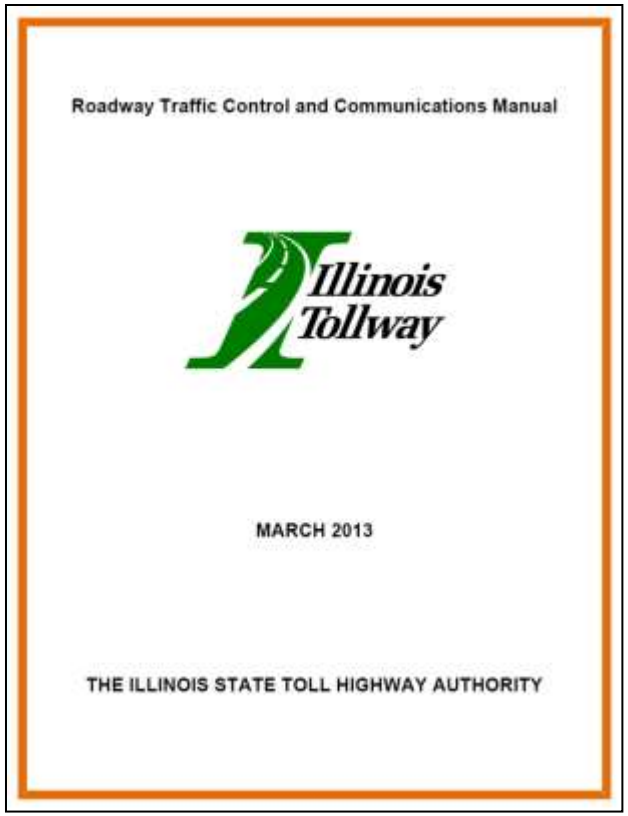
A: FHWA does not recommend altering a conventional w-beam rail by drilling new holes to accommodate the MGS.

However, **drilling** may be permitted to accommodate the repositioning of posts at drainage structures when pre-punched spacing rail cannot be configured.

<u>The use of torching is not allowed.</u>

Temporary Access To Work Area Remove and Reinstall Existing Guardrail

- MOT Manual identifies conditions in which this operation is allowed.



Questions?

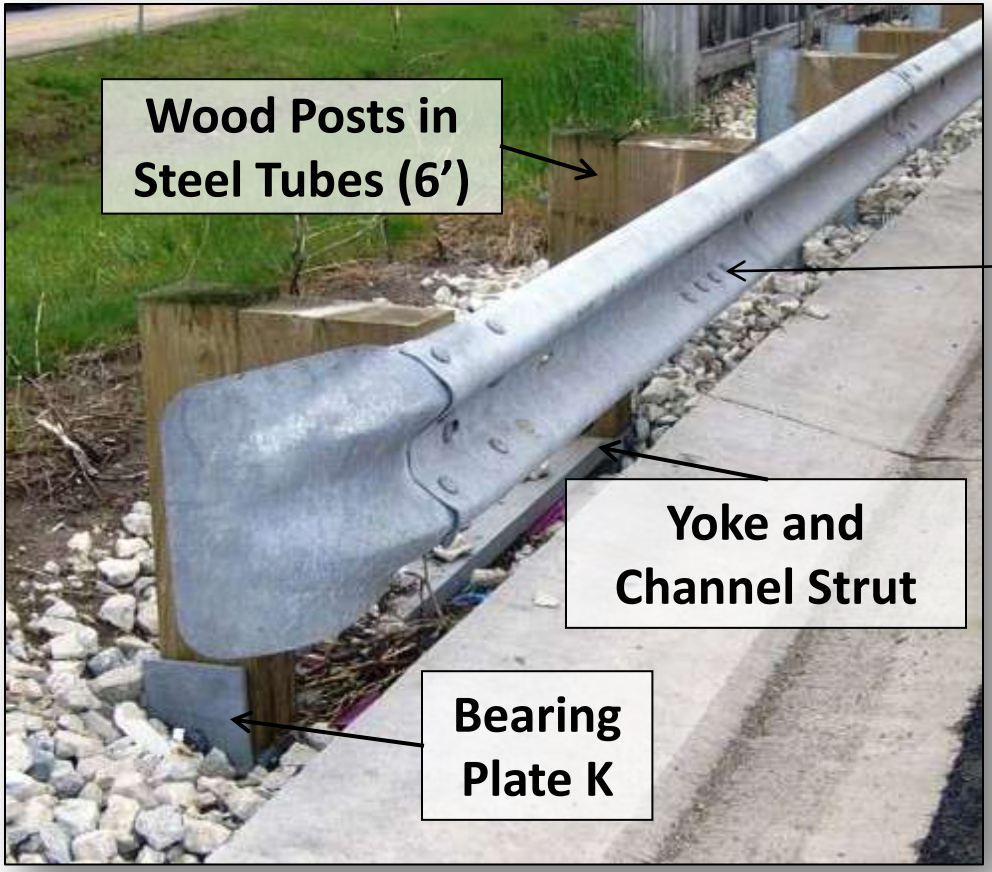
MGS

NON-PROPRIETARY TERMINALS

Non-Proprietary
Traffic Barrier Terminals

- Each run of guardrail needs to be anchored on each end with a terminal.
- Tollway Standards – Traffic Barrier Terminals
  - Type T2
  - Type T5
  - Type T10
  - Type T6
  - Type T6B

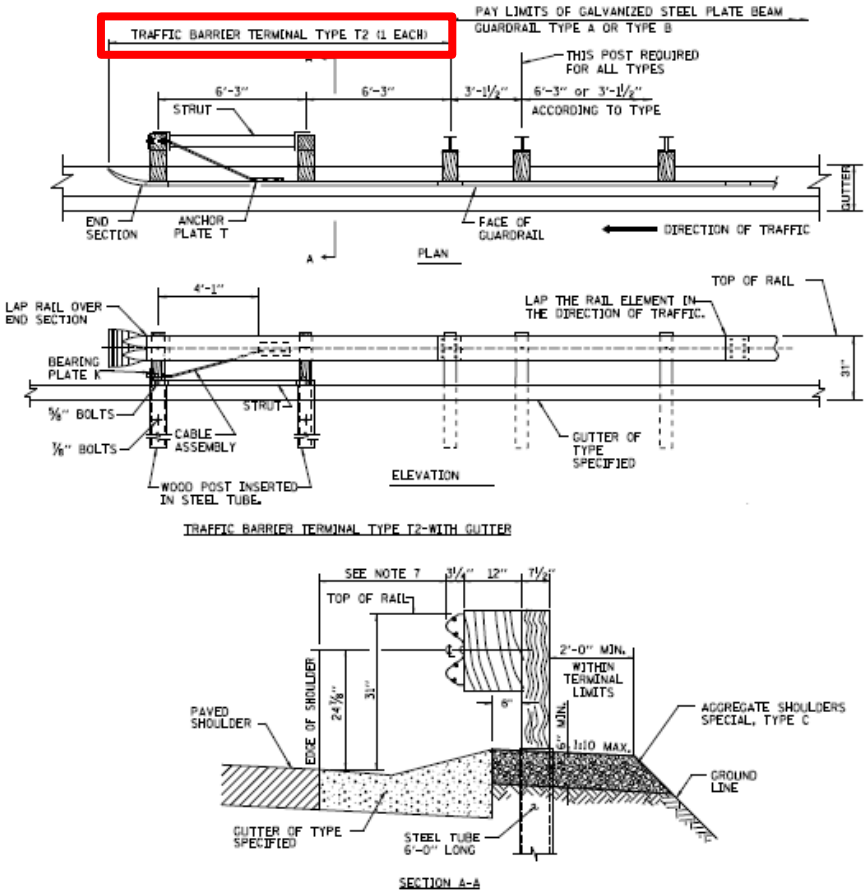
Standard C7:
Traffic Barrier Terminal Type T2



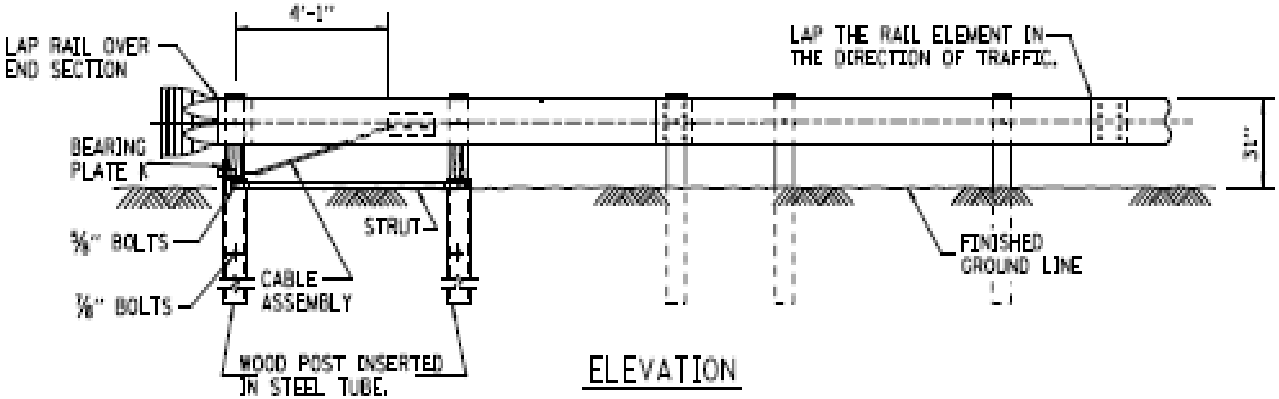
Typically utilized on the departing end of a steel plate beam guardrail system.

None of length counts toward length of need

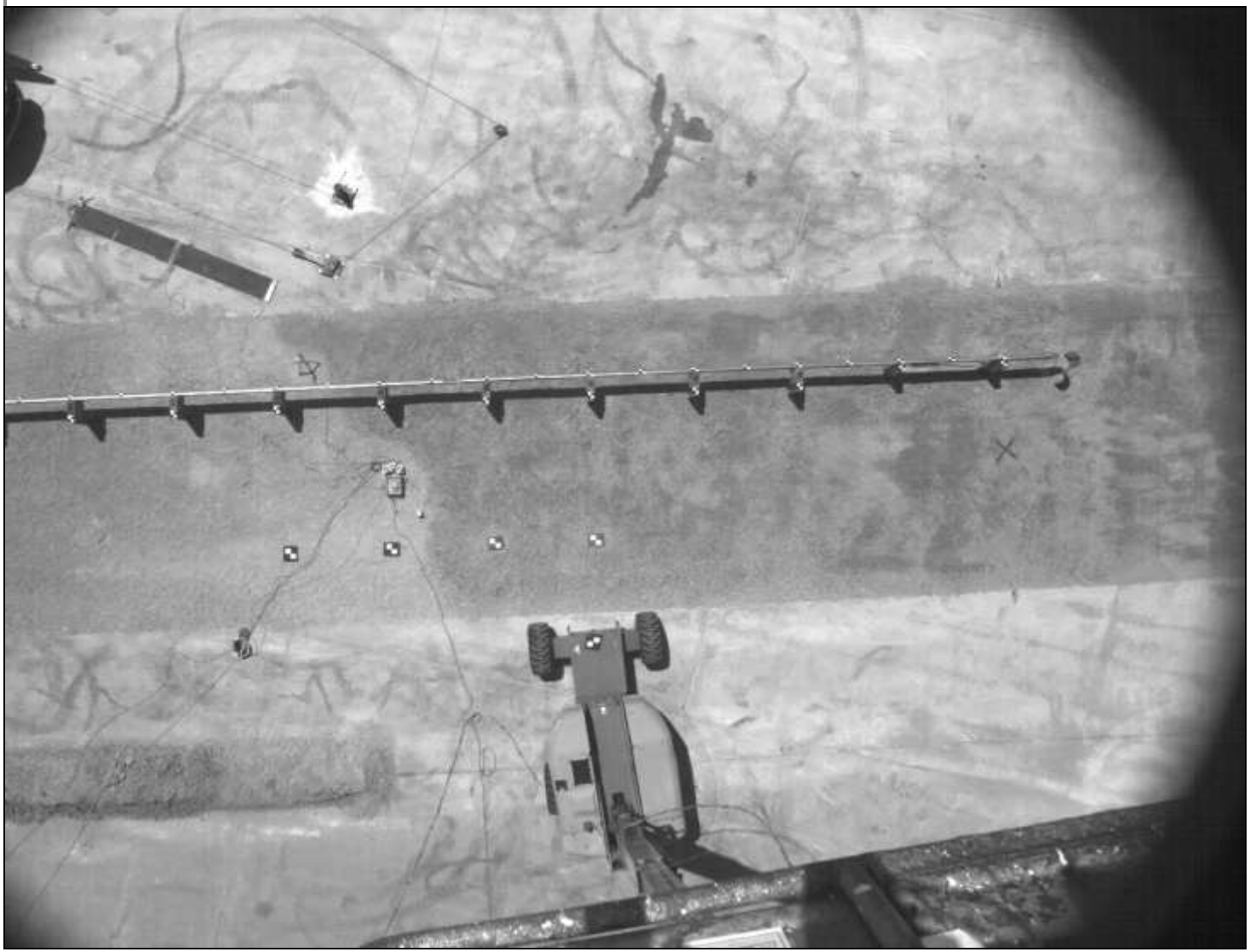
Traffic Barrier Terminal Type T2 with Gutter



Traffic Barrier Terminal Type T2 Without Gutter



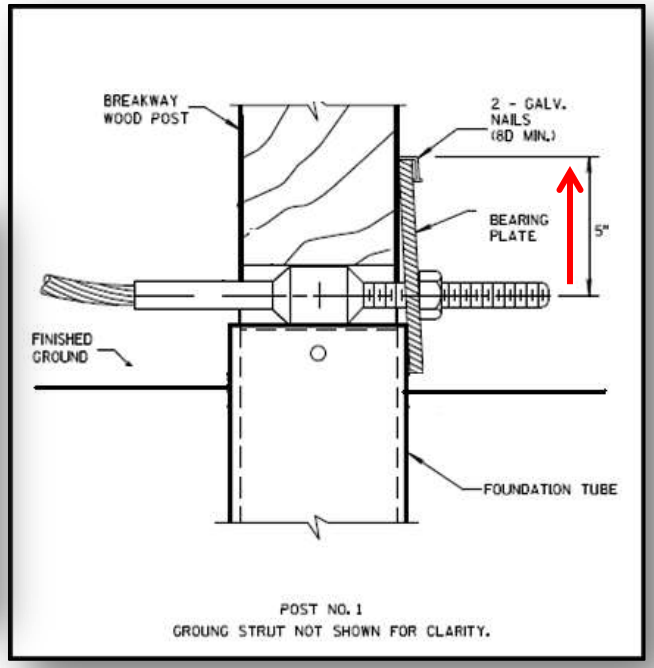
Traffic Barrier Terminal Type T2



Traffic Barrier Terminal Type T2

- Cable is tightened to a ***taut condition; cannot lift up on the cable more*** than 1 inch.

Traffic Barrier Terminal Type T2



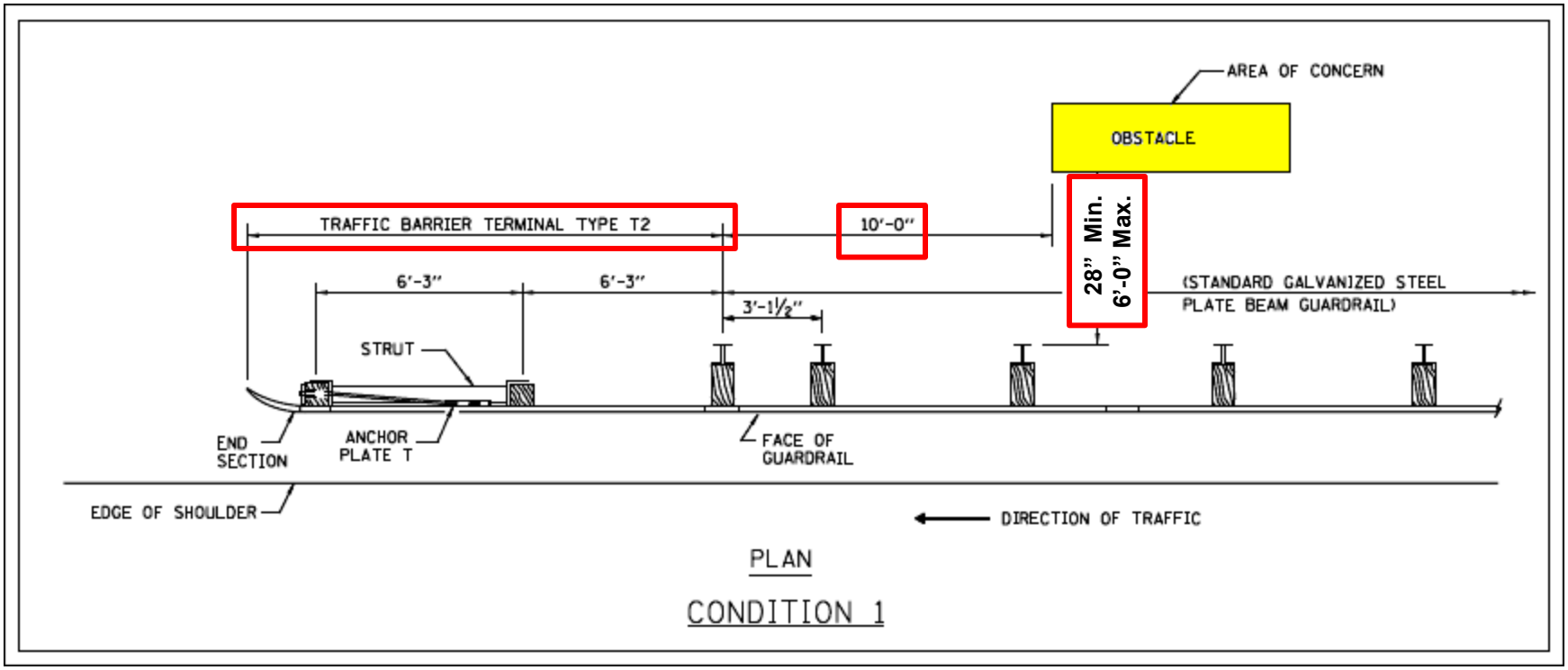
Bearing Plate K
Proper Orientation

Traffic Barrier Terminal Type T2

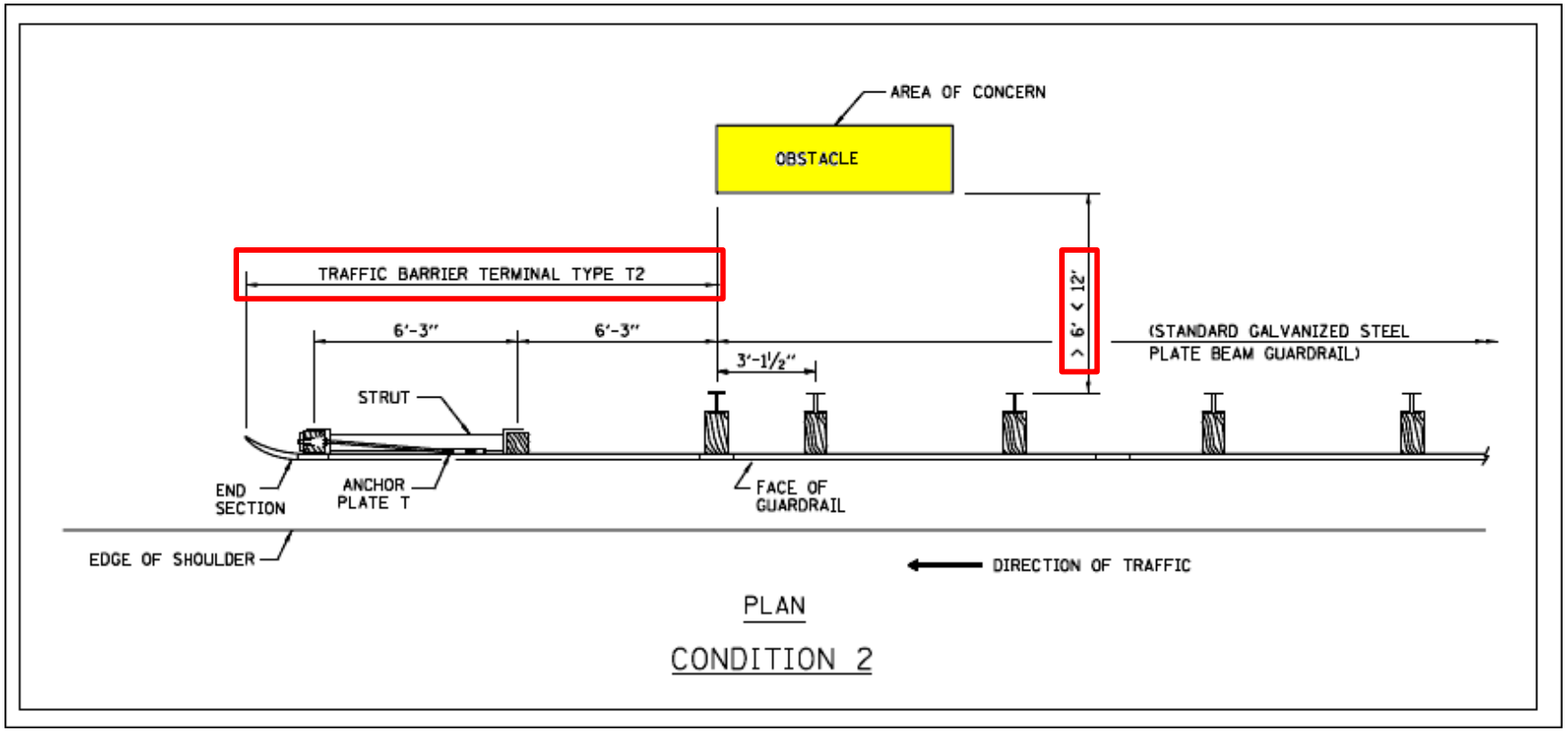
- Terminal location is dependent on offset distance to the obstacle.
  - Condition 1 (≥28”, ≤6’)
  - Condition 2 (>6’, <12’)
  - Condition 3 (≥ 12’)

Illinois Tollway

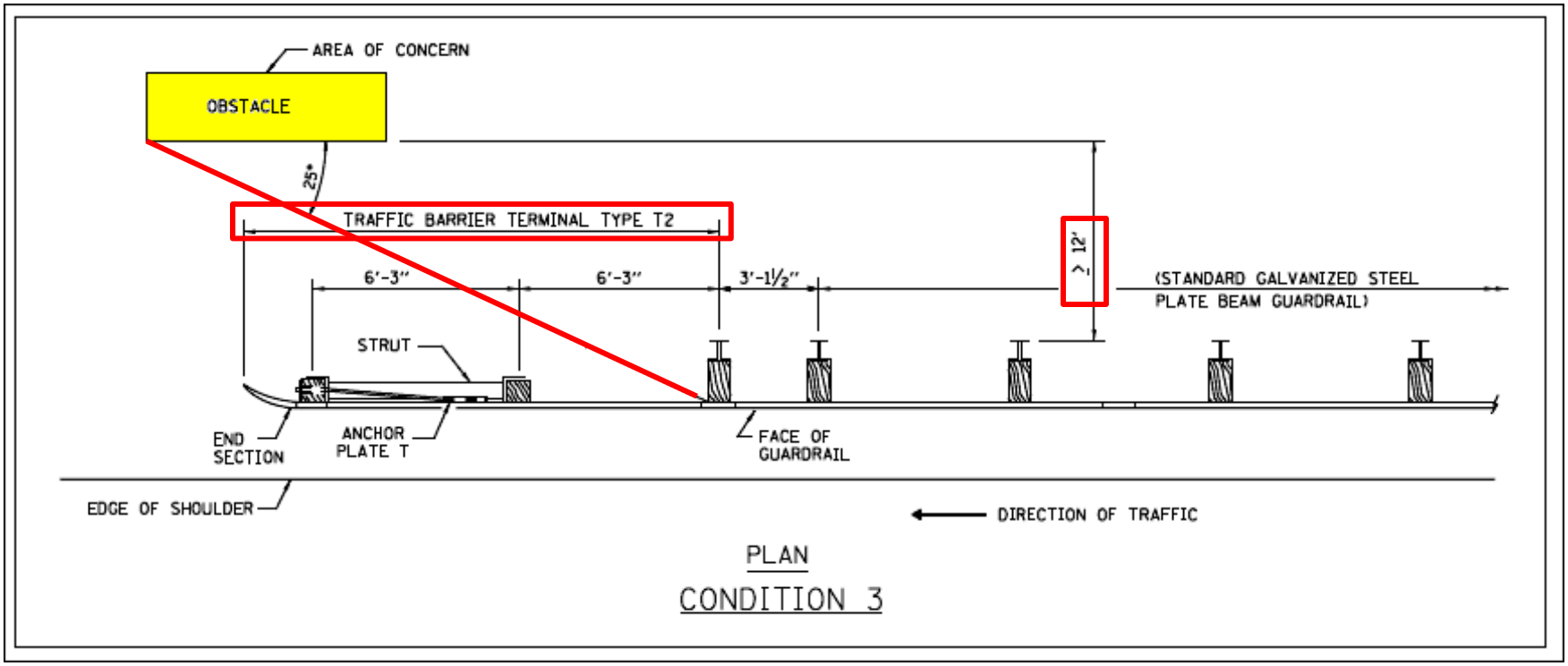
Traffic Barrier Terminal Type T2 Condition 1



Traffic Barrier Terminal Type T2 Condition 2



Traffic Barrier Terminal Type T2 Condition 3



Traffic Barrier Terminal Type T2

Deficiencies?

Steel Foundation Tubes Too High- Potential Snag Point

Bearing Plate K Not Correctly Orientated

No Aggregate Shoulder Material

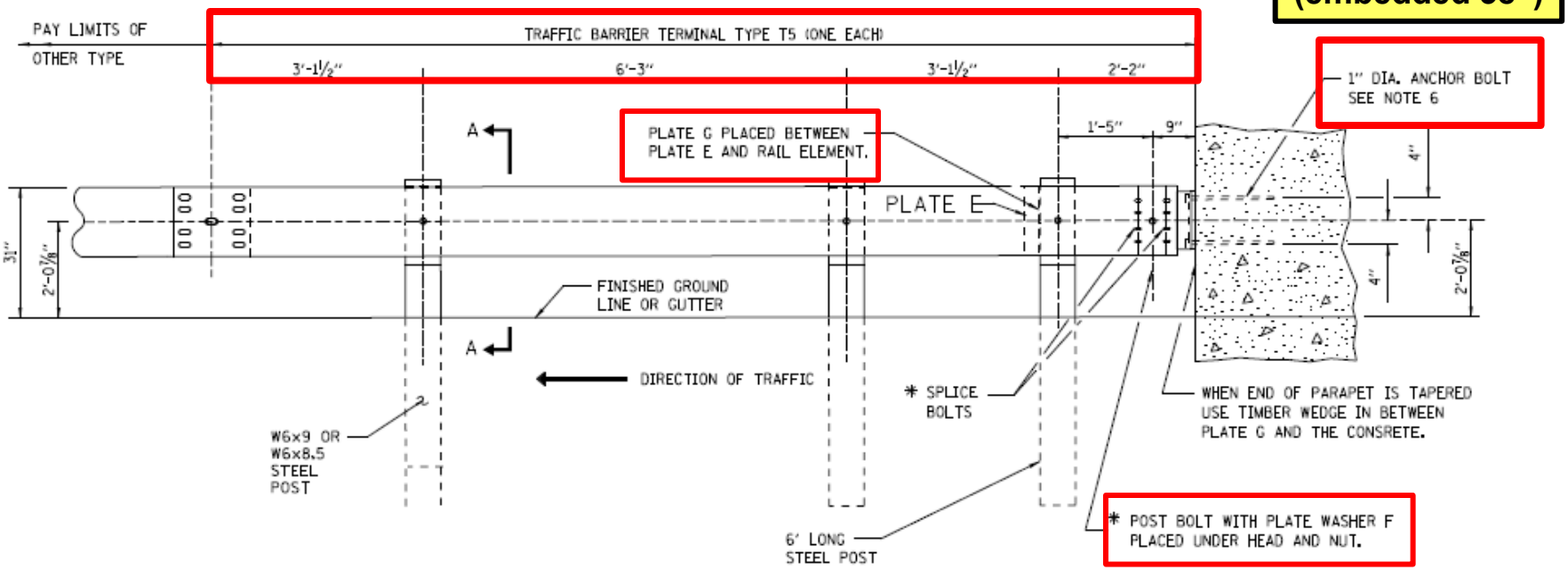
Standard C8:
Traffic Barrier Terminal Type T5

Terminal is typically utilized to connect to the departing end of a <u>NEW</u> bridge.

14.67’ counts toward length of need

Traffic Barrier Terminal Type T5

42” Length
(embedded 38”)



TYPE T5 - CONCRETE BRIDGE PARAPET

Traffic Barrier Terminal Type T5

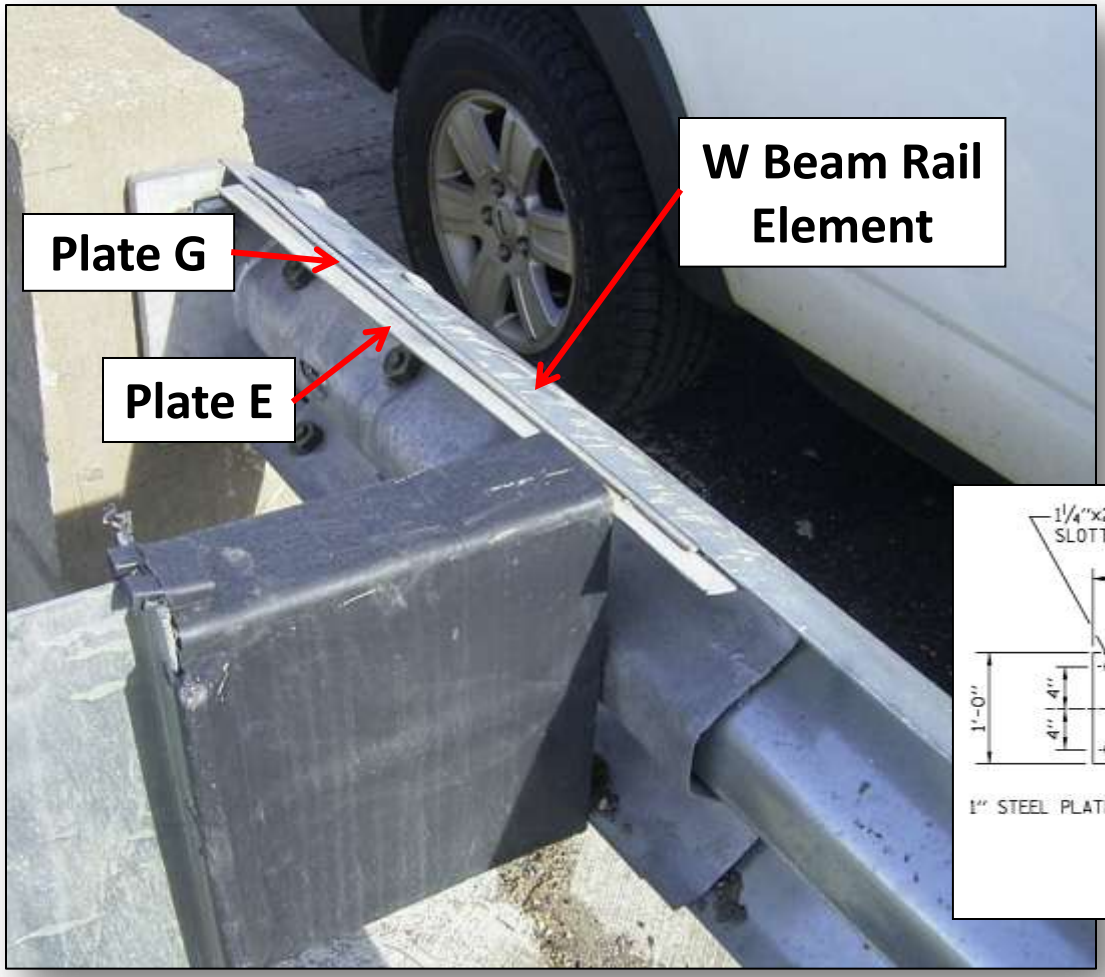
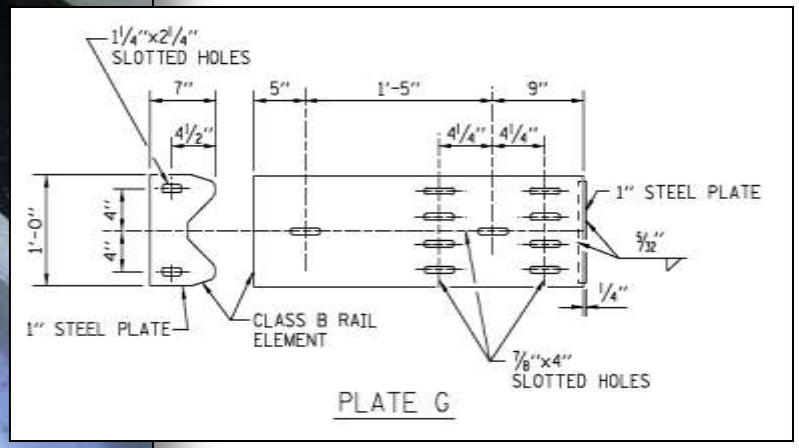


Plate G is placed between Plate E and the Rail Element .



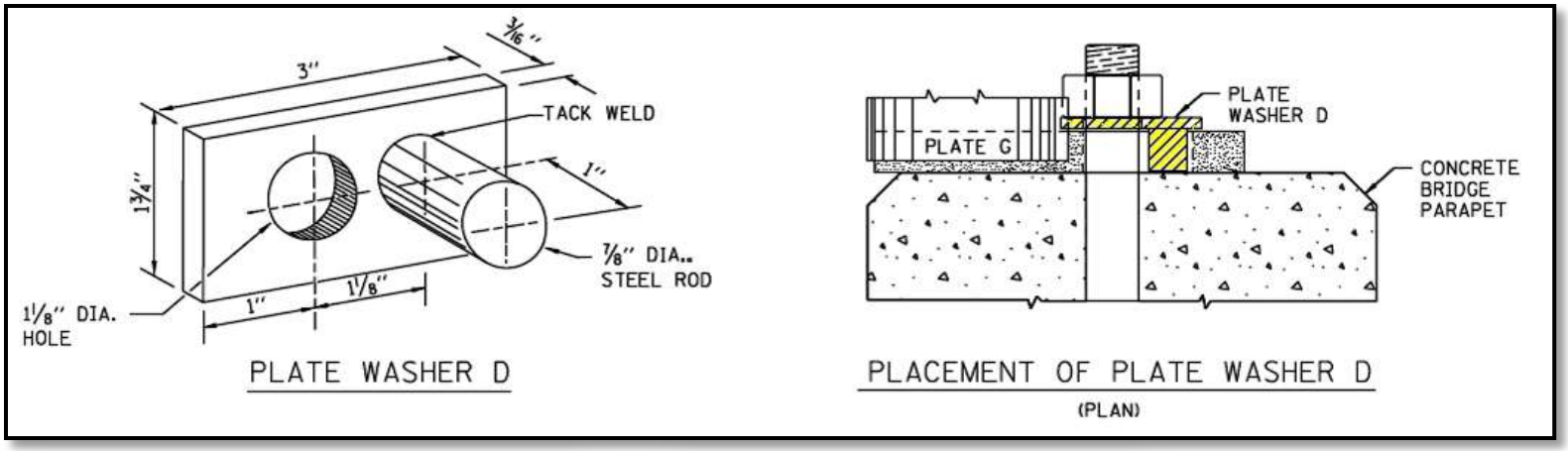
Traffic Barrier Terminal Type T5

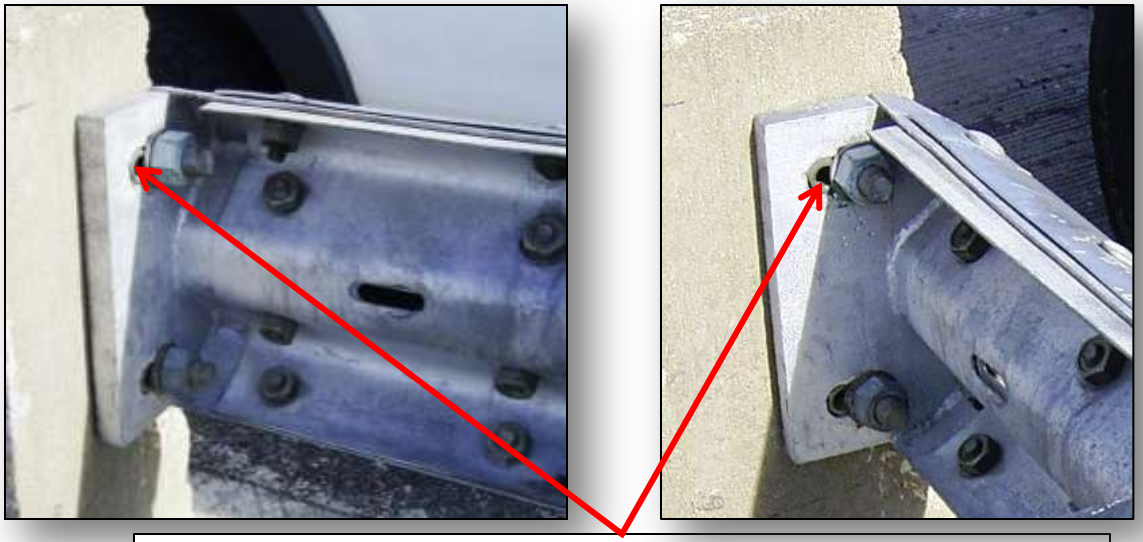
Plate G was placed over the rail element.

Traffic Barrier Terminal Type T5

- Plate G was placed behind Plate E.
- Bolts were epoxied into concrete.
- Plate Washer D was not installed.

Traffic Barrier Terminal Type T5





No Plate Washer D was installed. Standard Washer was used with nut set into Plate G end plate instead of rod.

Illinois Tollway

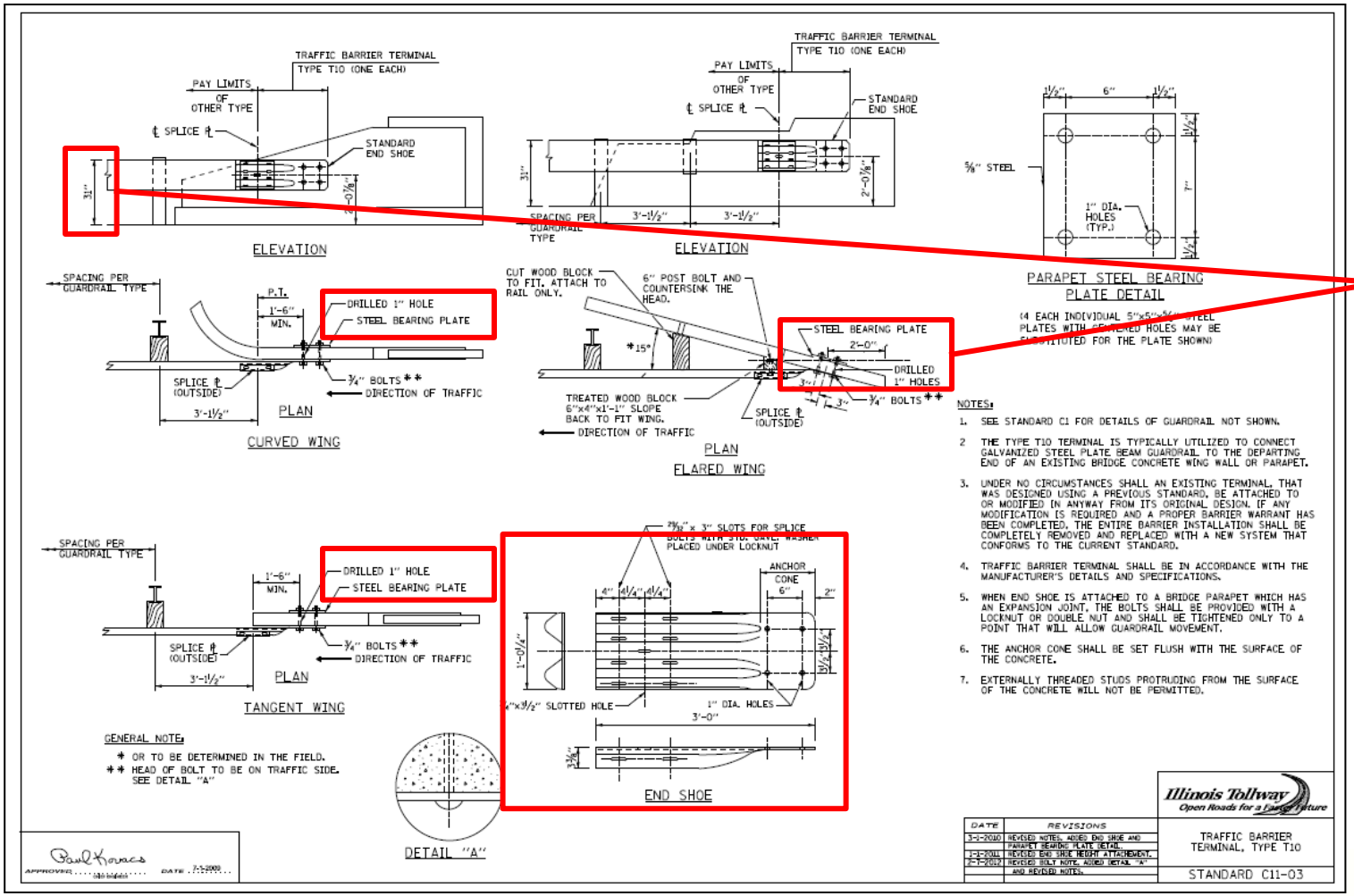
Standard C11:
Traffic Barrier Terminal Type T10

Typically utilized to connect to the departing end of an <u>existing</u> concrete structure.

Zero counts toward length of need

Illinois Tollway

Traffic Barrier Terminal Type T10



Mounting height and use of base plate is different than IDOT

Illinois Tollway

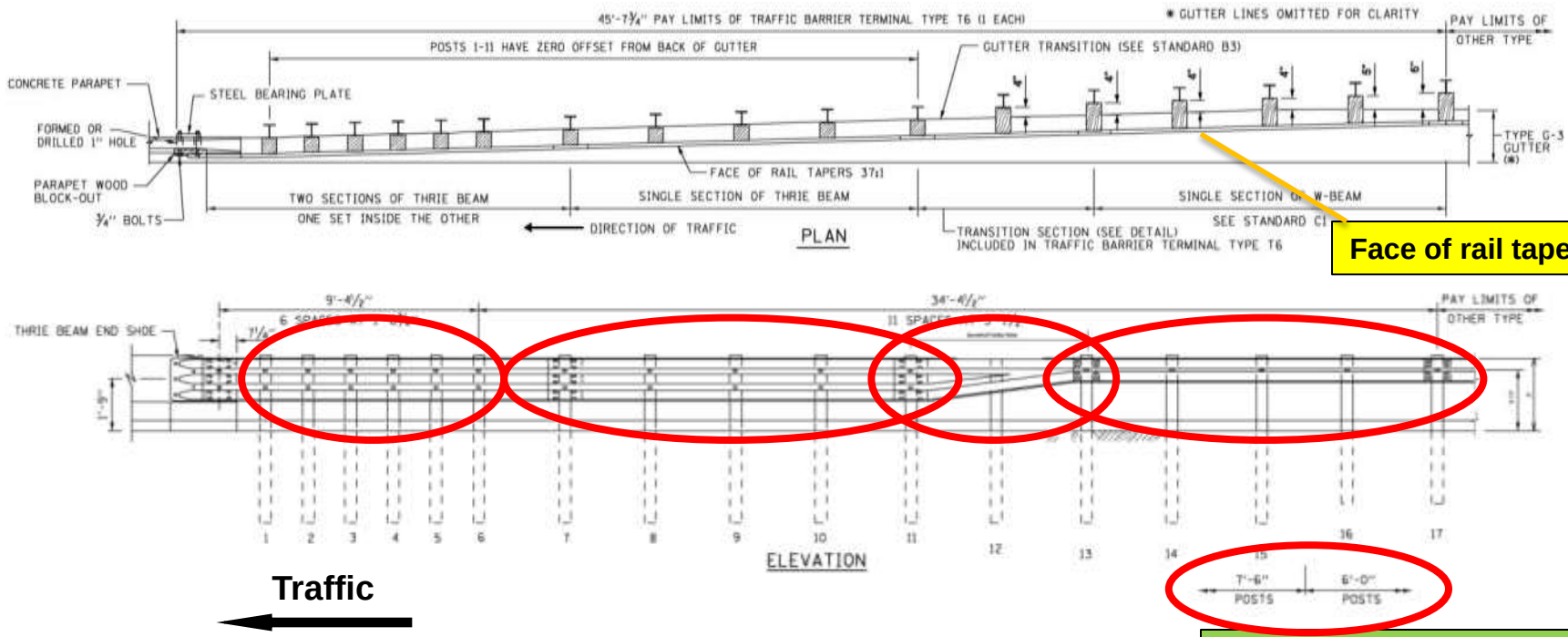
Standard C9:
Traffic Barrier Terminal Type T6

Typically utilized to attach to the upstream end of retaining walls and the bridge concrete parapet where <u>gutter</u> is installed.

43.15’ counts toward length of need

Illinois Tollway

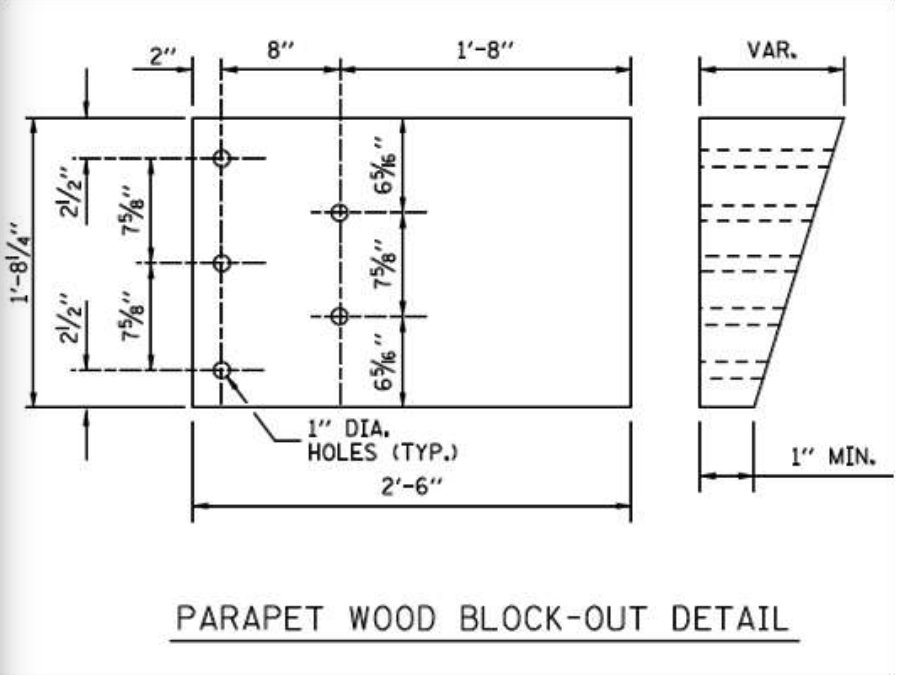
Standard C9:
Traffic Barrier Terminal Type T6



Post spacing becomes closer as it nears the bridge parapet and the rail is stiffened by transitioning to a single then double section of thrie beam

For Parapet (Safety Face) With Type G-3 Gutter

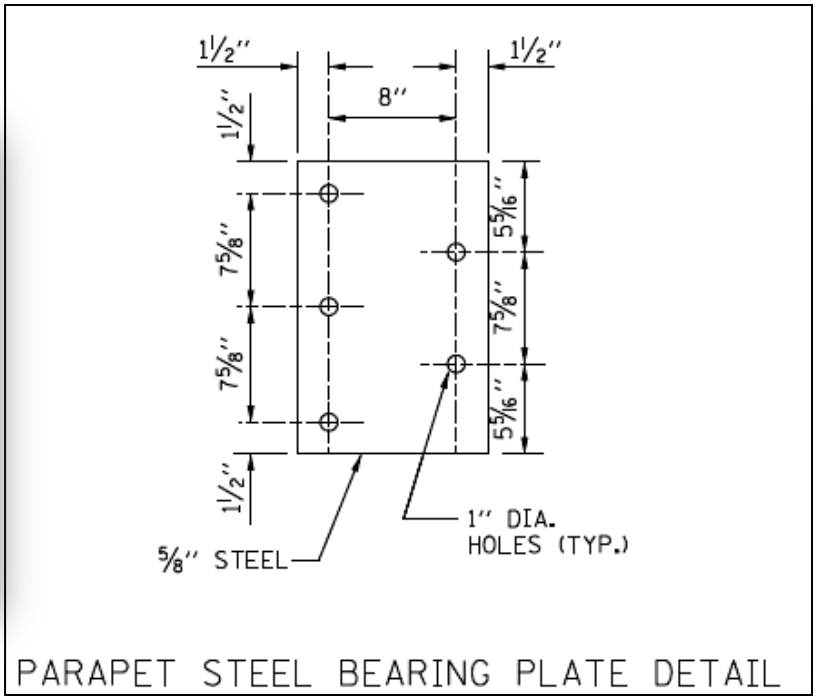
Traffic Barrier Terminal Type T6



PARAPET WOOD BLOCK-OUT DETAIL

Note that this is different than IDOT

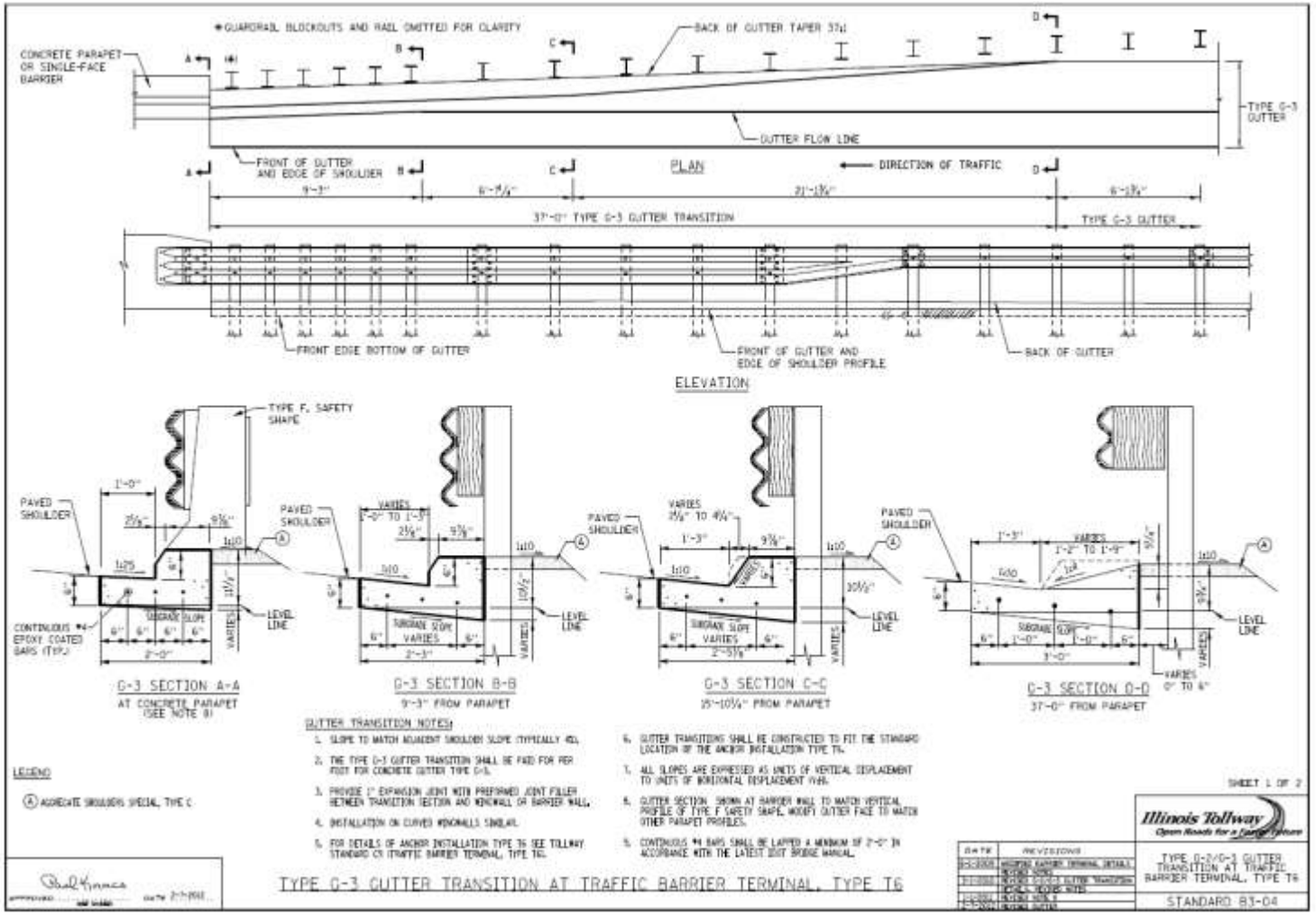
Traffic Barrier Terminal Type T6



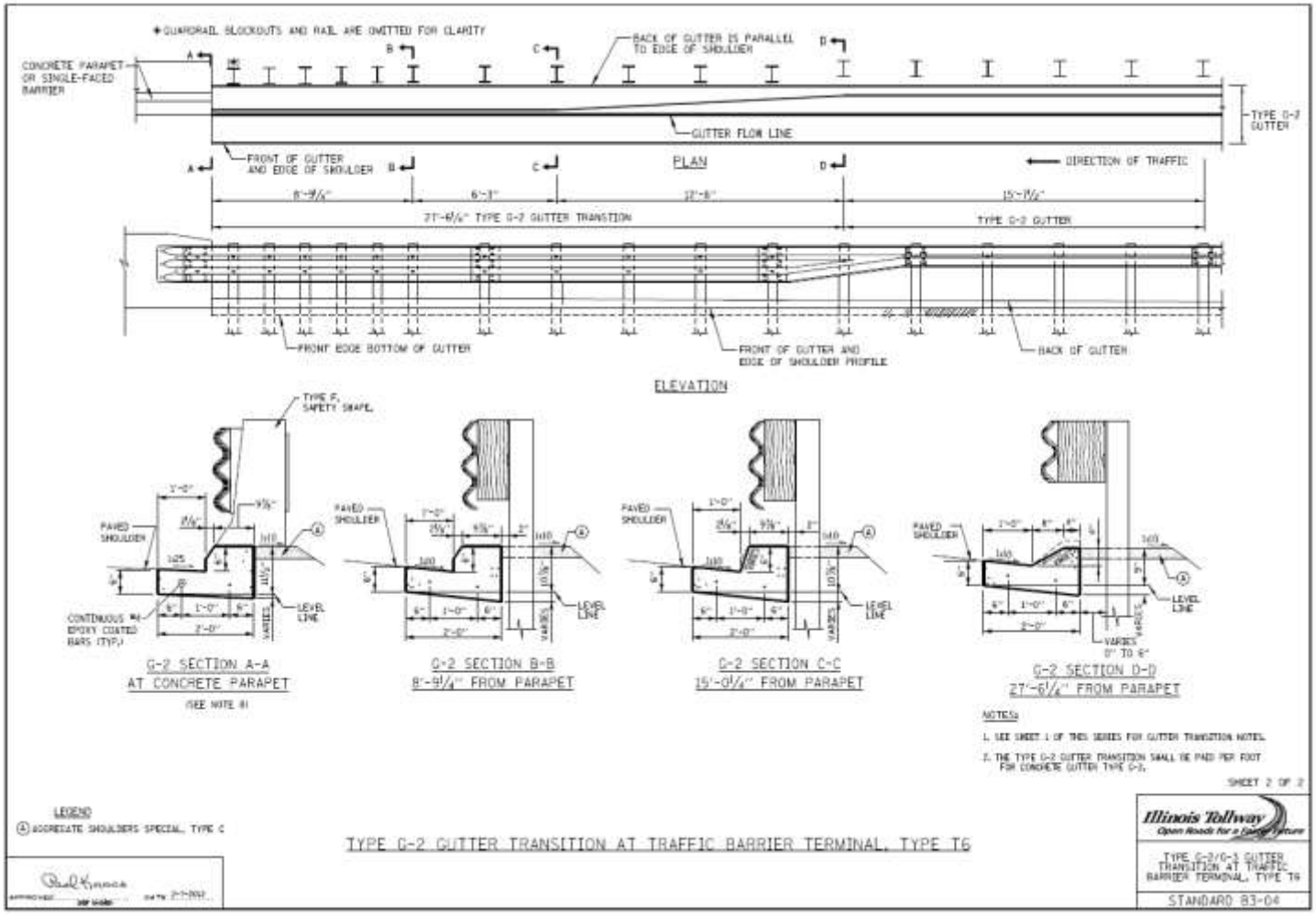
PARAPET STEEL BEARING PLATE DETAIL

Alternate Detail
Individual Plates

Standard B3:
Type G-3 Gutter Transition



Standard B3:
Type G-2 Gutter Transition



Gutter Transition at Terminal Type T6

Gutter profile transitions to match barrier wall face profile.

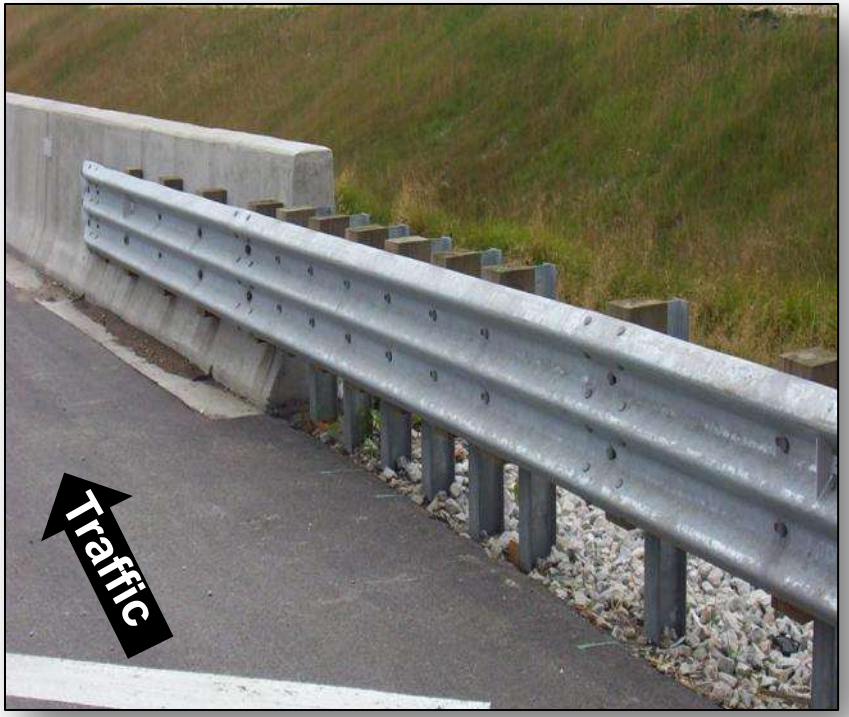
Gutter does not conflict with terminal posts.

Improper Gutter Transitions

Guardrail Block-outs

Use of multiple block-outs is not allowed.

Standard C10:
Traffic Terminal Barrier Type T6B

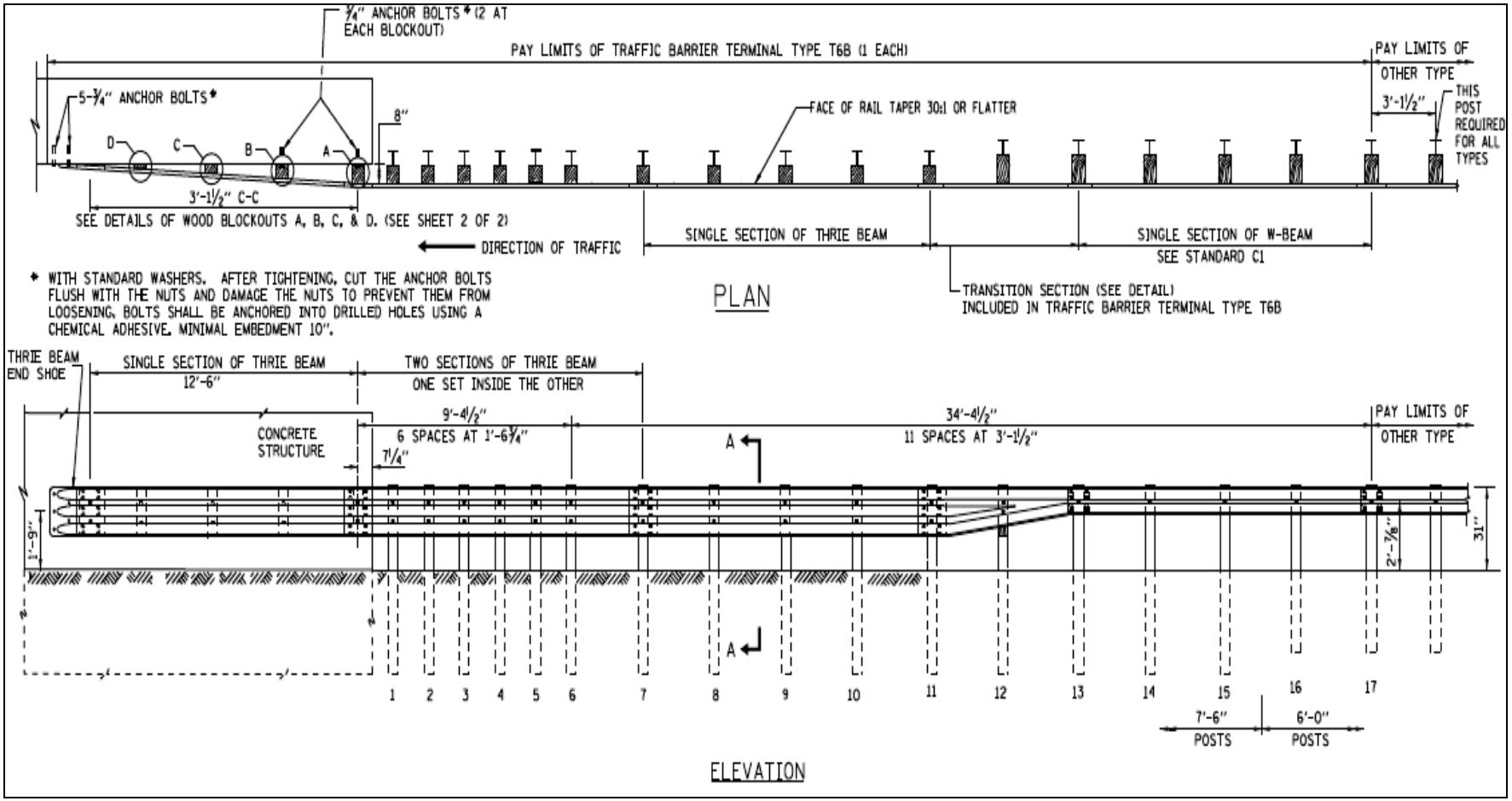


Typically utilized to attach at the upstream end of retaining walls and bridge concrete parapets where <u>gutter does not exist</u>

43.15' counts toward length of need

Illinois Tollway

Traffic Barrier Terminal Type T6B



Type T6 installed instead of Type T6B

Vehicle Impact (Wheel Snag)

Questions?

Terminals:

T2, T5, T10, T6, T6B

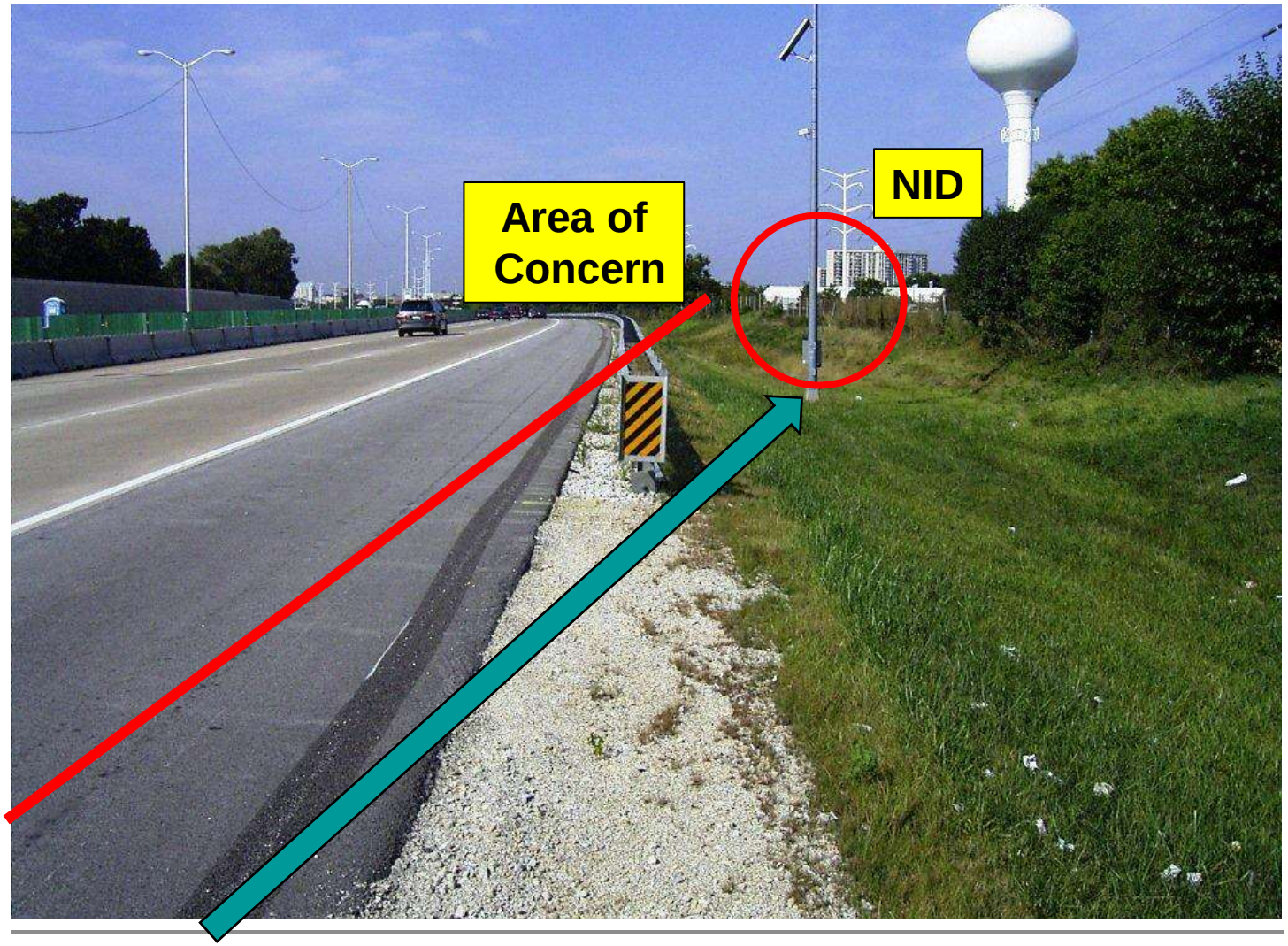
PROPRIETARY TERMINALS


Tracking

Standard C6: Traffic Barrier Terminal Type T1 (Special)

Traffic Barrier Terminal Type T1 (Special)
GATING PORTION OF TERMINAL

Runoff Path



Runoff Path

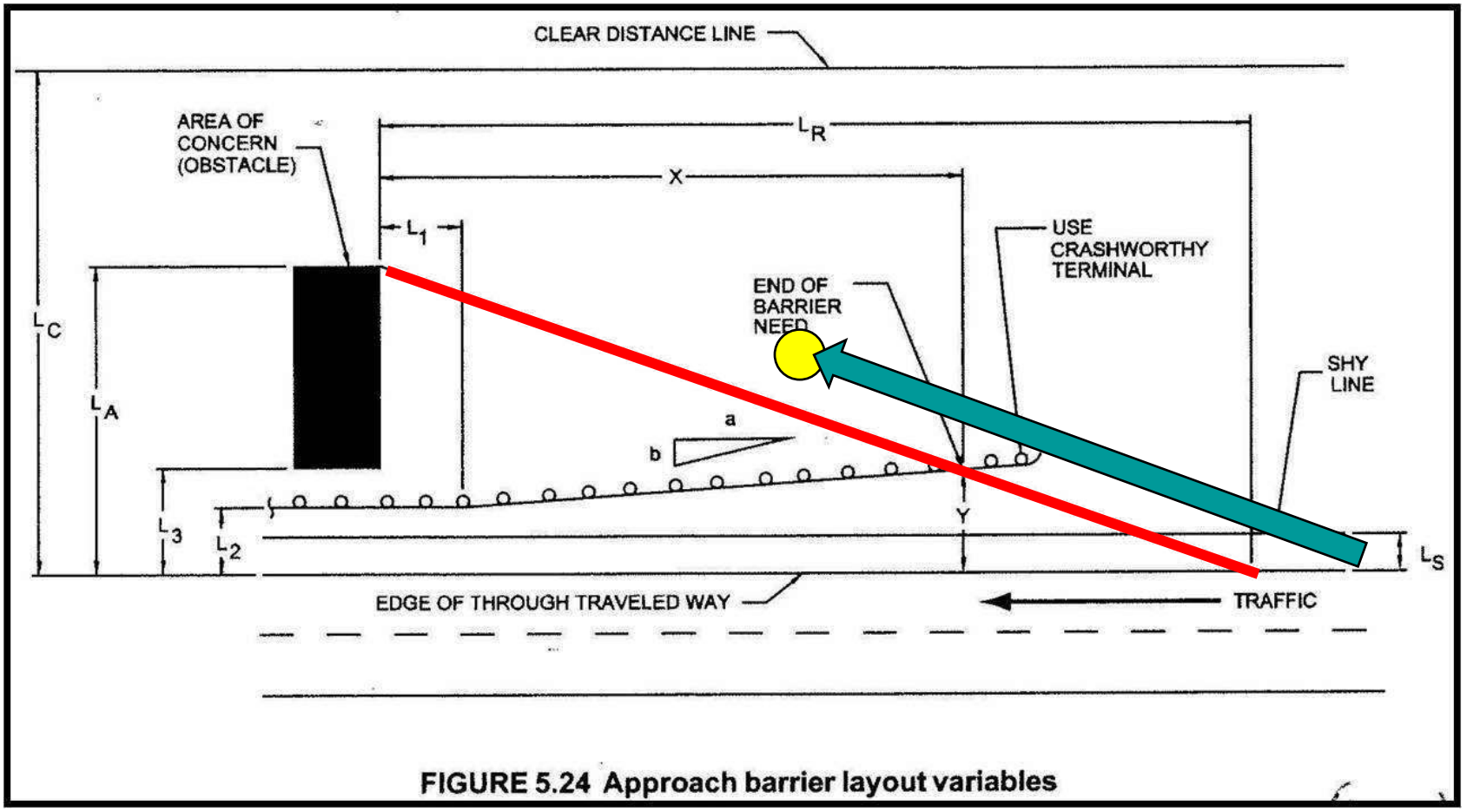
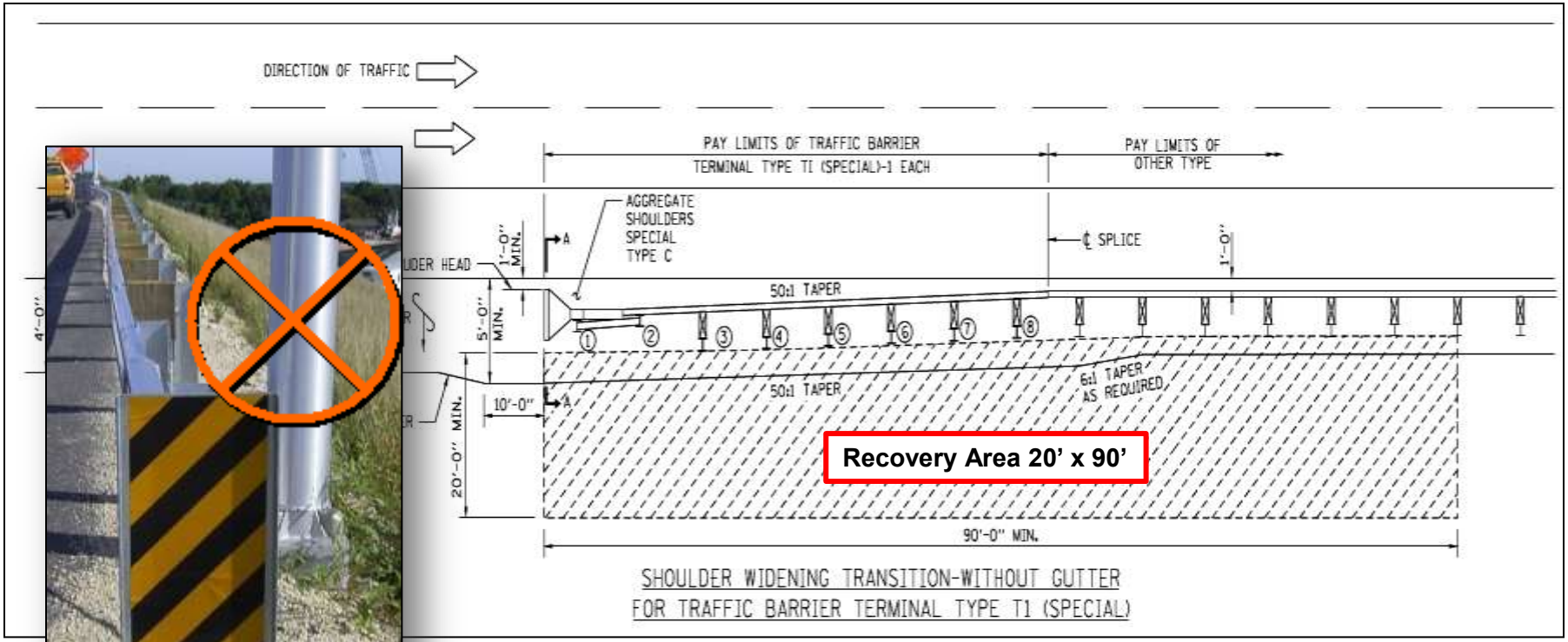


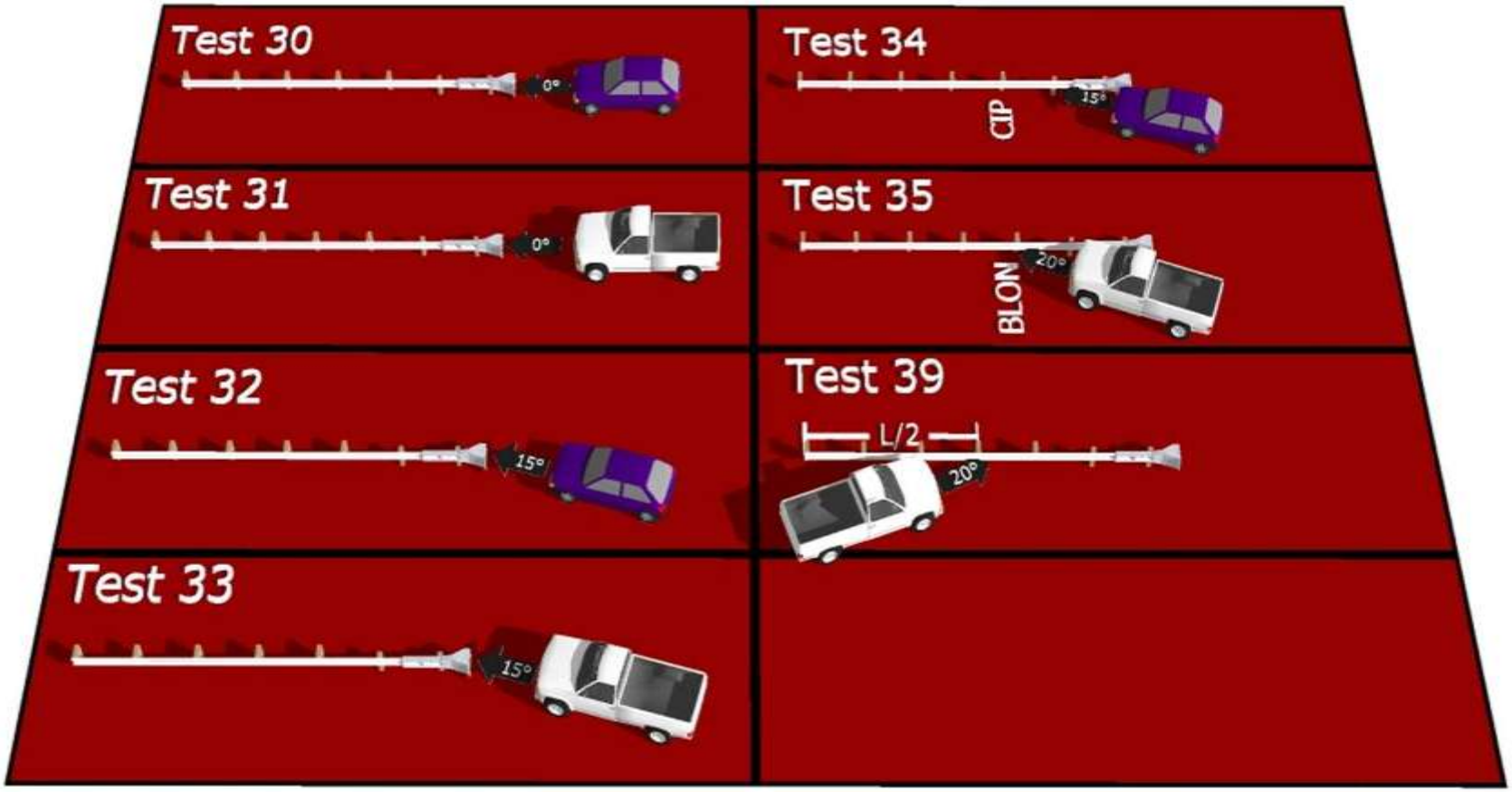
FIGURE 5.24 Approach barrier layout variables

Traffic Barrier Terminal Type T1 (Special)



37.5' counts toward length of need

NCHRP 350 Terminal Tests

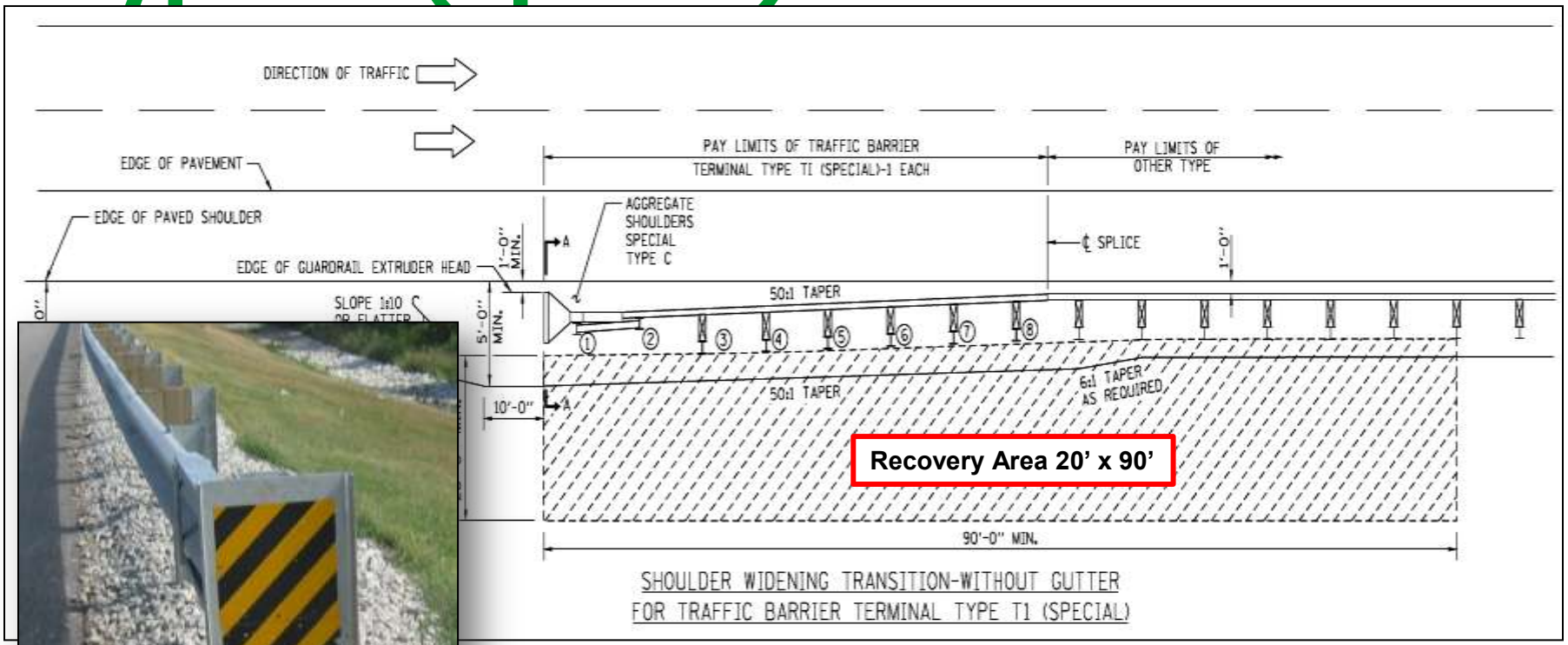


Traffic Barrier Terminal
Type T1(Special)

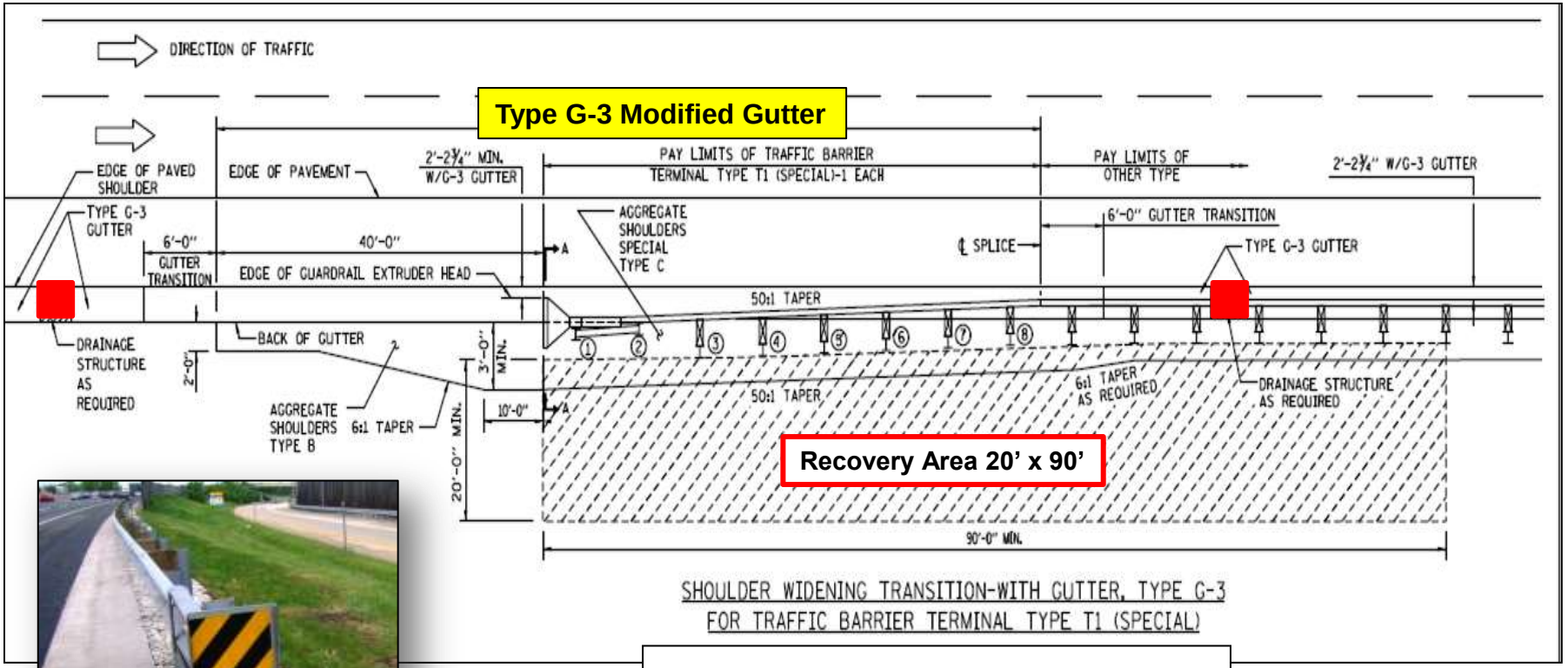
Traffic Barrier Terminal Type T1(Special)

Traffic Barrier Terminal Type T1(Special)-Anchor

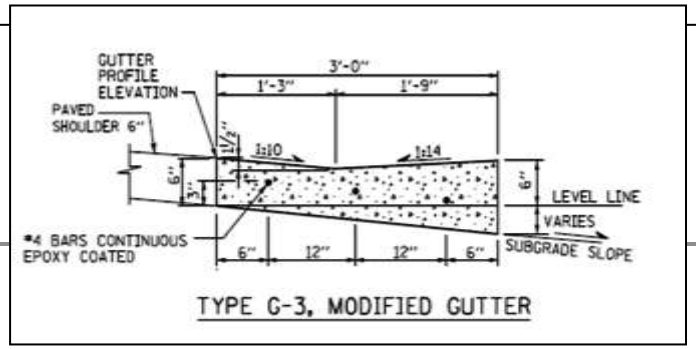
Traffic Barrier Terminal Type T1 (Special) without Gutter



Traffic Barrier Terminal
Type T1 (Special), w/ Gutter, Type G-3



SHOULDER WIDENING TRANSITION-WITH GUTTER, TYPE G-3
FOR TRAFFIC BARRIER TERMINAL TYPE T1 (SPECIAL)



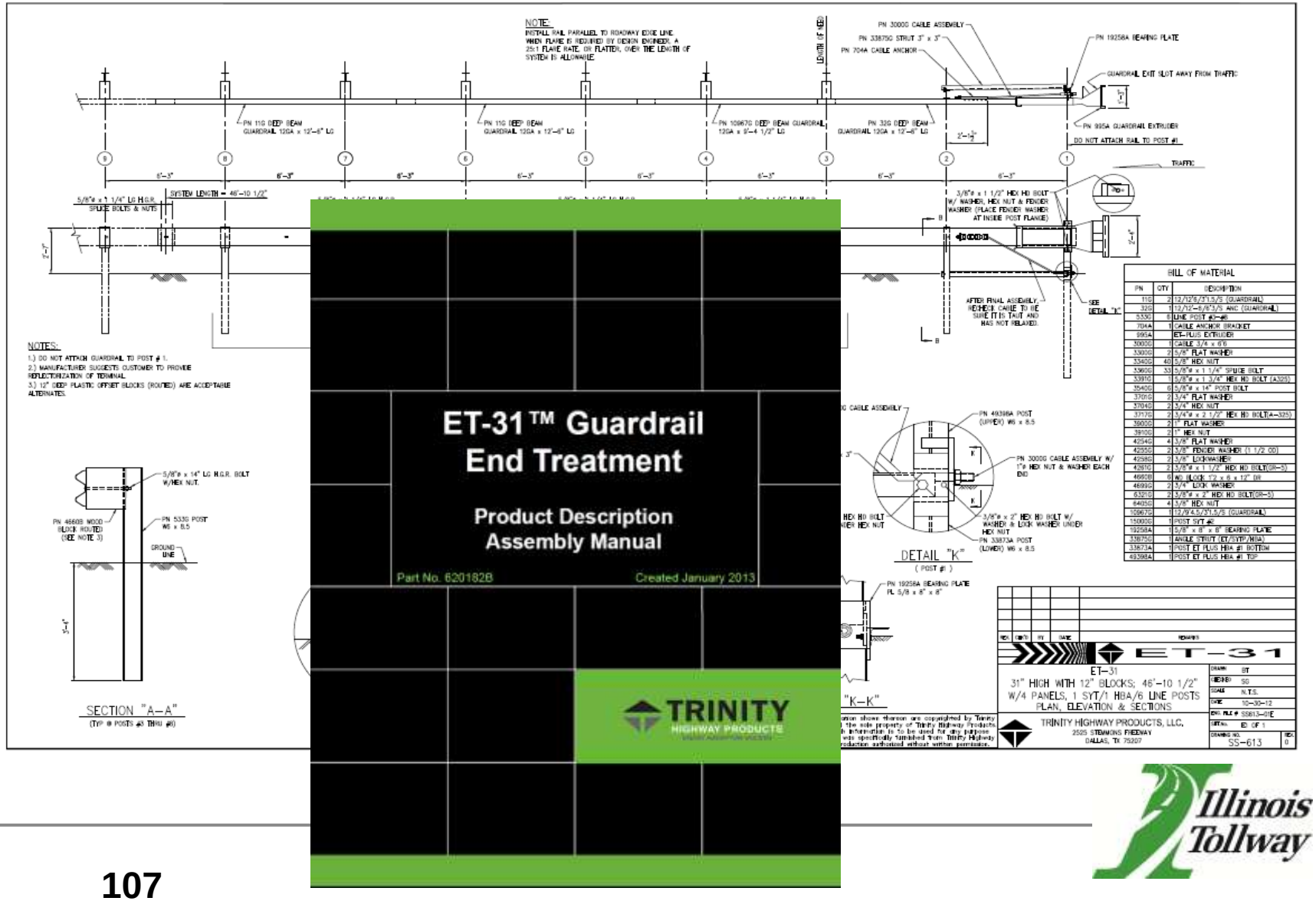
TYPE G-3, MODIFIED GUTTER

Trinity Highway Products

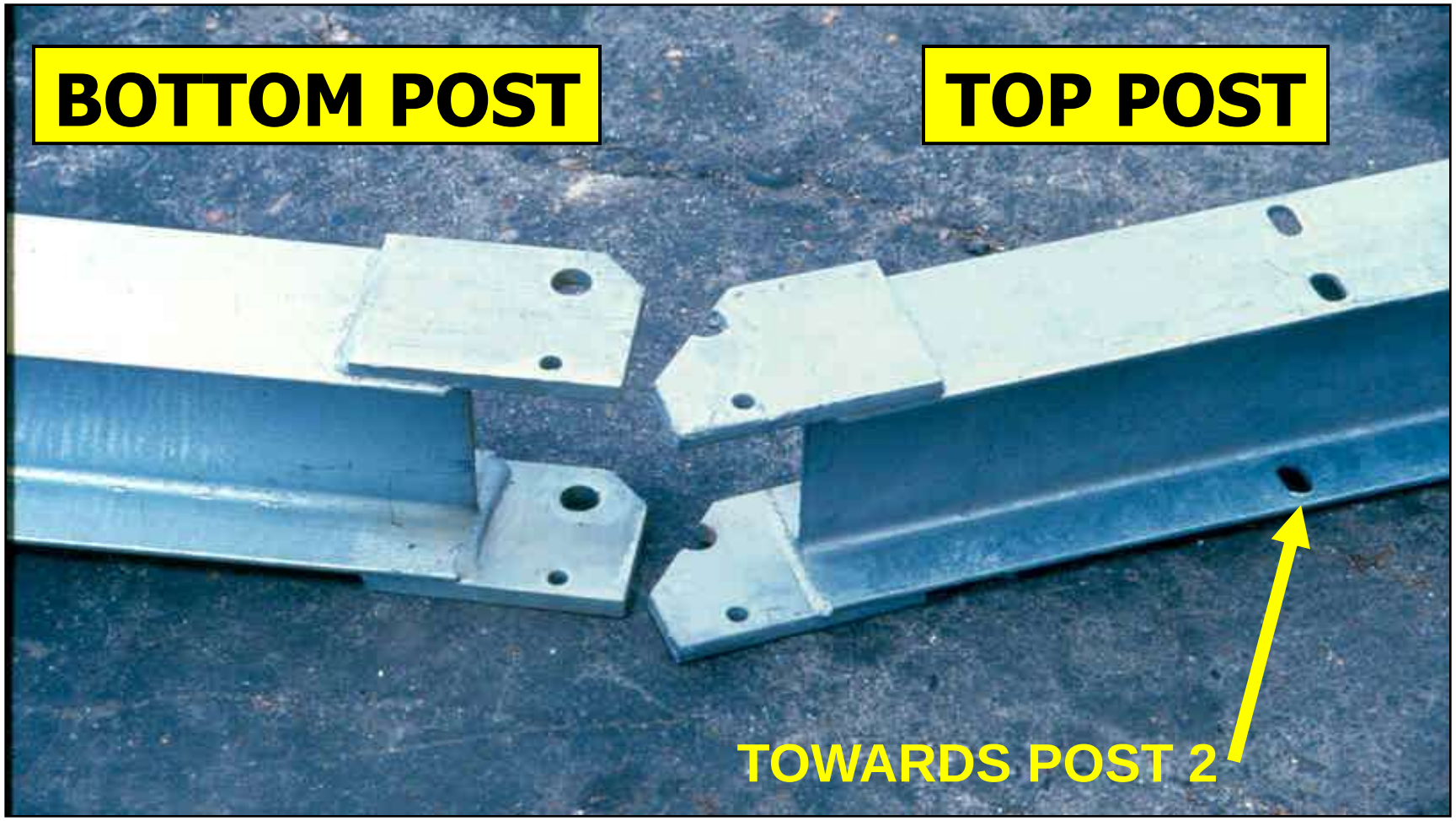
ET-31

Test Level 3

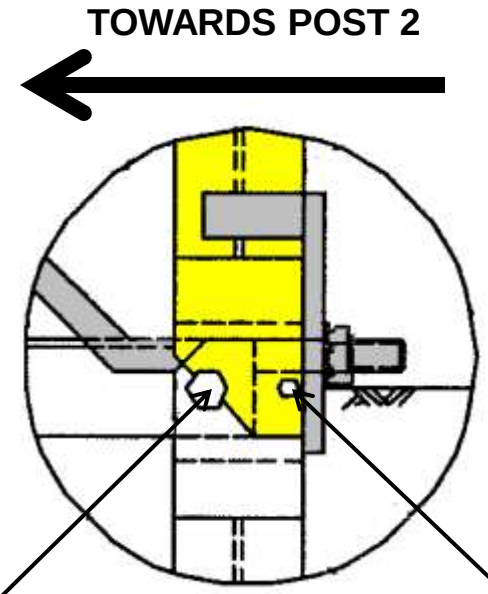
ET 31


ET-31™ Guardrail
End Treatment
Product Description
Assembly Manual
Part No. 620182B
Created January 2013
TRINITY
HIGHWAY PRODUCTS
NOTES:
1.) DO NOT ATTACH GUARDRAIL TO POST # 1.
2.) MANUFACTURER SUGGESTS CUSTOMER TO PROVIDE REFLECTORIZATION OF TERMINAL.
3.) 12" DEEP PLASTIC OFFSET BLOCKS (ROUTED) ARE ACCEPTABLE ALTERNATES.
SECTION "A-A"
DETAIL "K"
BILL OF MATERIAL
ET-31
31" HIGH WITH 12" BLOCKS; 46'-10 1/2" W/4 PANELS, 1 SYT/1 HBA/6 LINE POSTS
PLAN, ELEVATION & SECTIONS
TRINITY HIGHWAY PRODUCTS, LLC.
SS-613

ET 31, Post 1 (Hinged Breakaway™)



ET 31, HBA Post 1



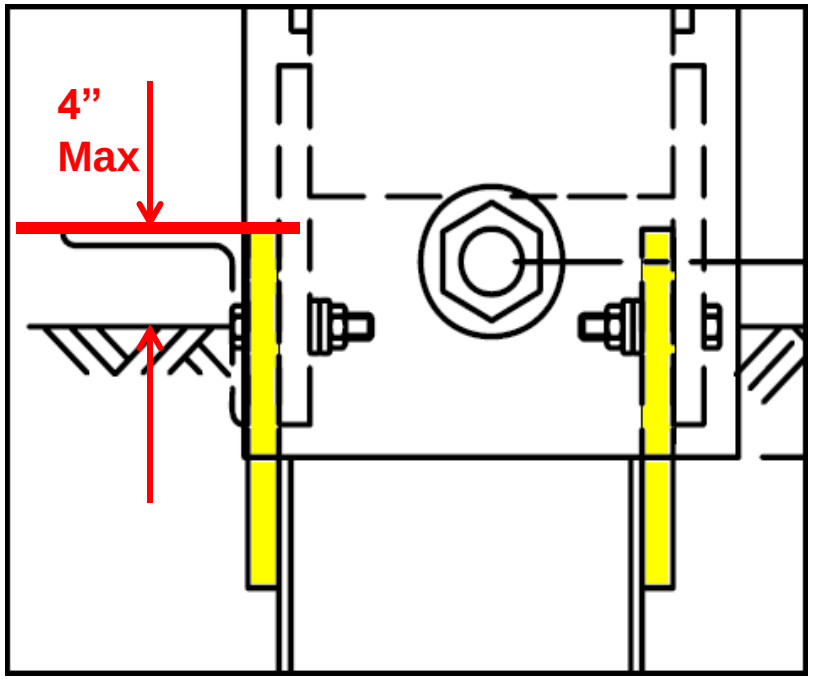
3/4” DIA. X 2 ½” HEX HD BOLT W/WASHER AND LOCK WASHER UNDER HEX NUT

3/8” DIA. X 2” HEX HD BOLT W/WASHER AND LOCK WASHER UNDER HEX NUT

HIGH STRENGTH BOLTS

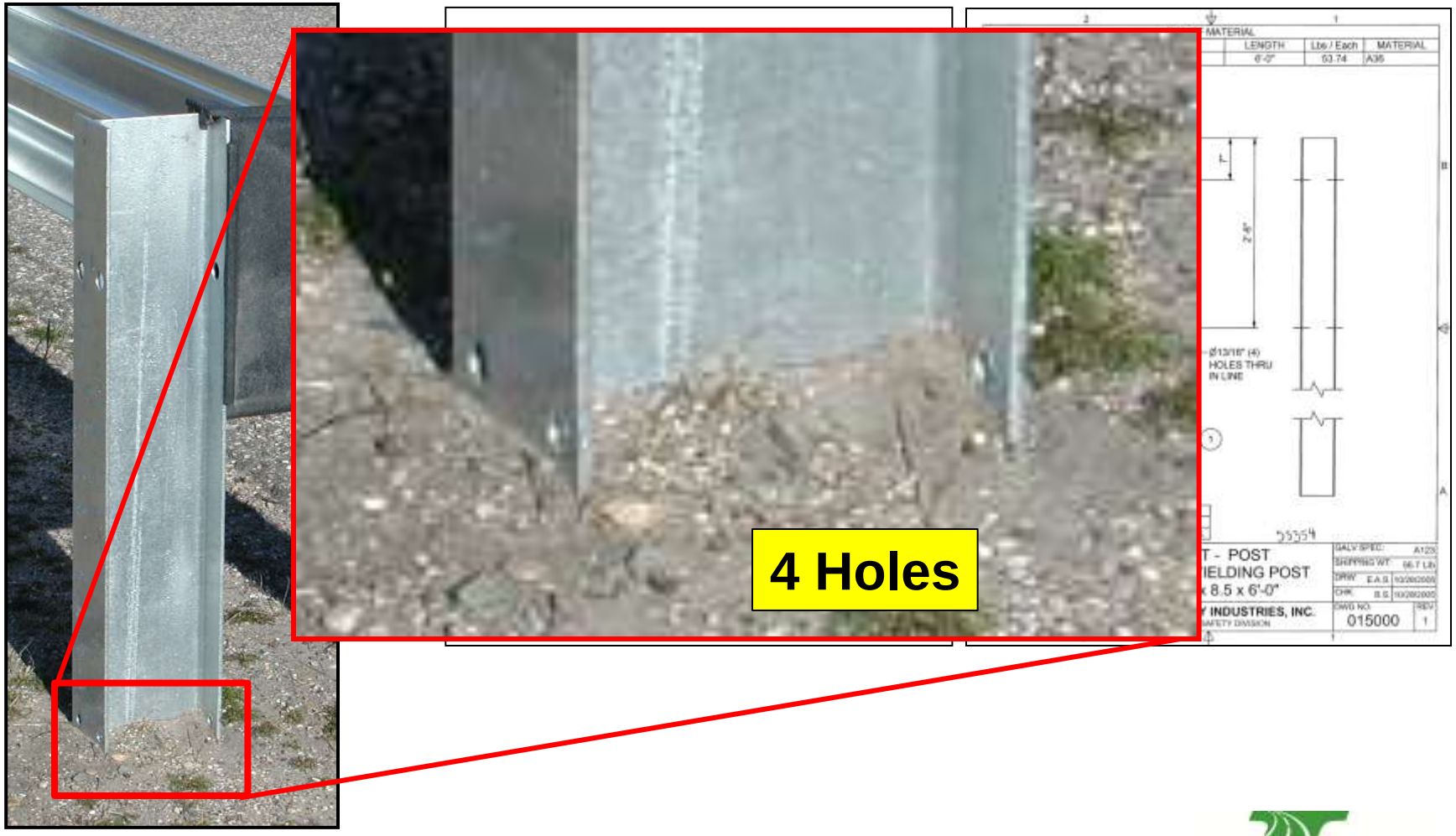
Illinois Tollway

ET 31, HBA Post 1

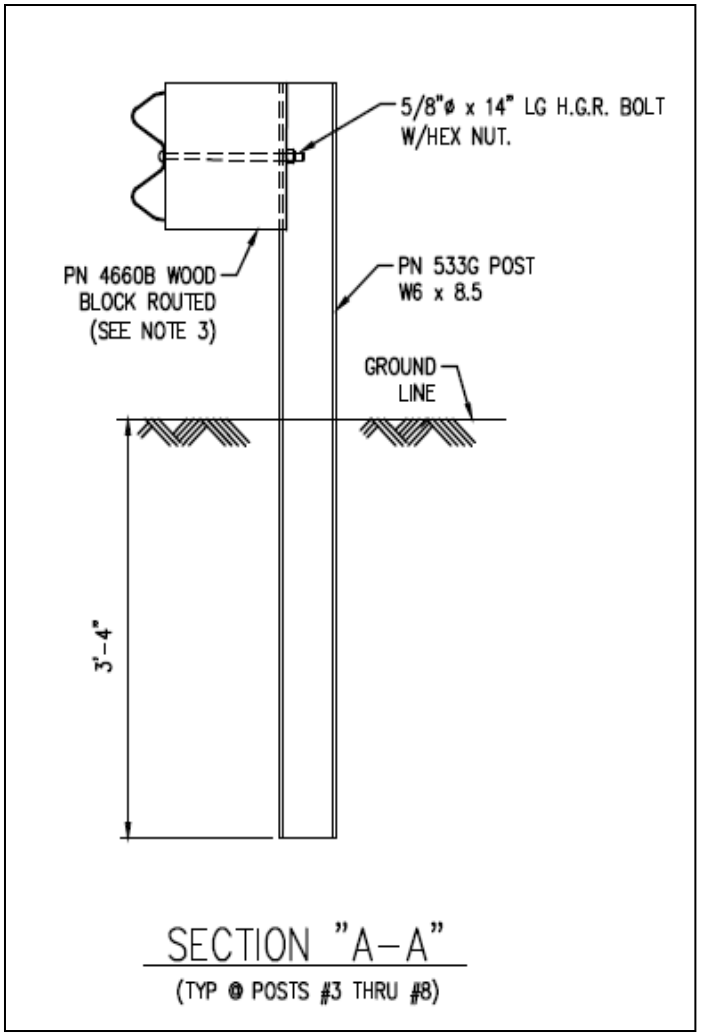


THE EARS ON THE HBA BOTTOM POSTS SHOULD NOT BE MORE THAN 4” ABOVE THE FINISHED GRADE.

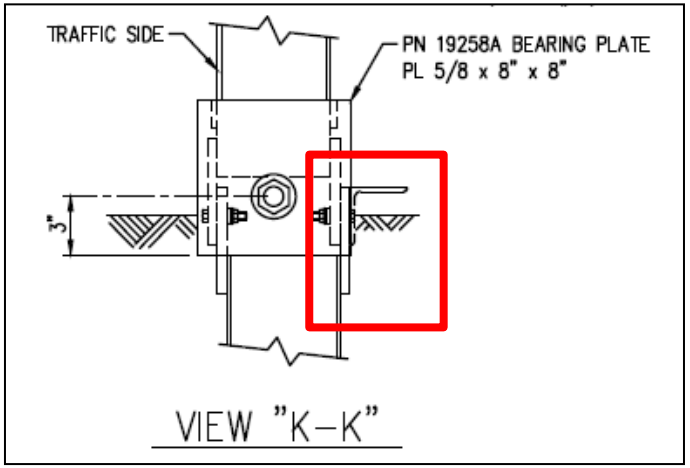
ET 31, Post 2 (Steel Yielding Post)



ET 31, Posts 3-8 (Standard Line Posts)

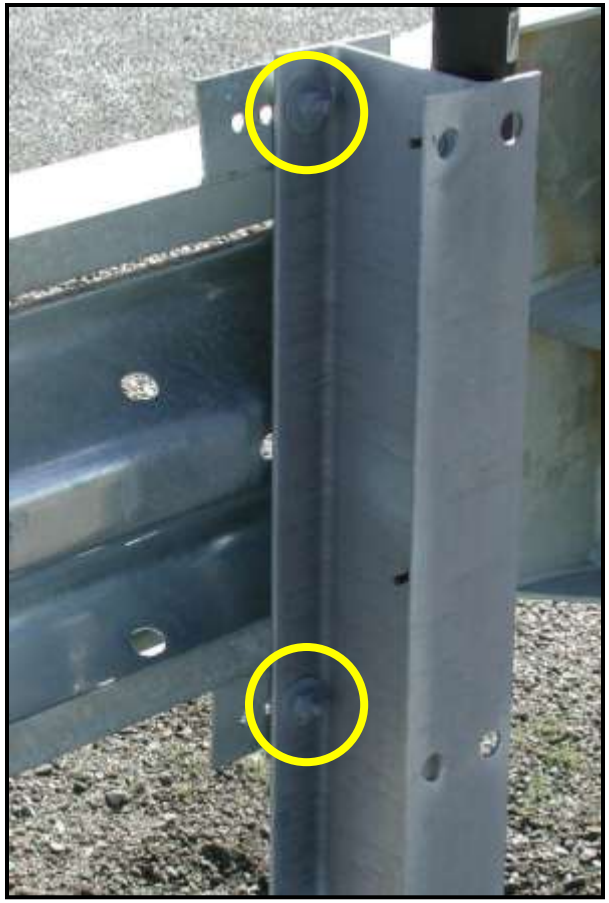


ET 31, Installation of the Strut

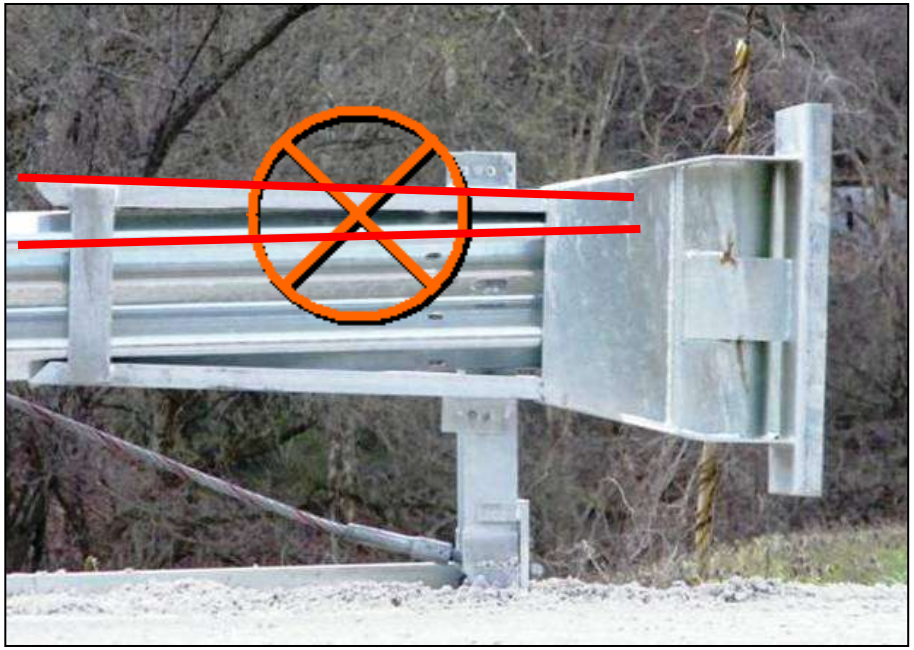


ET 31, Post 1

ET 31, Attaching the Extruder head

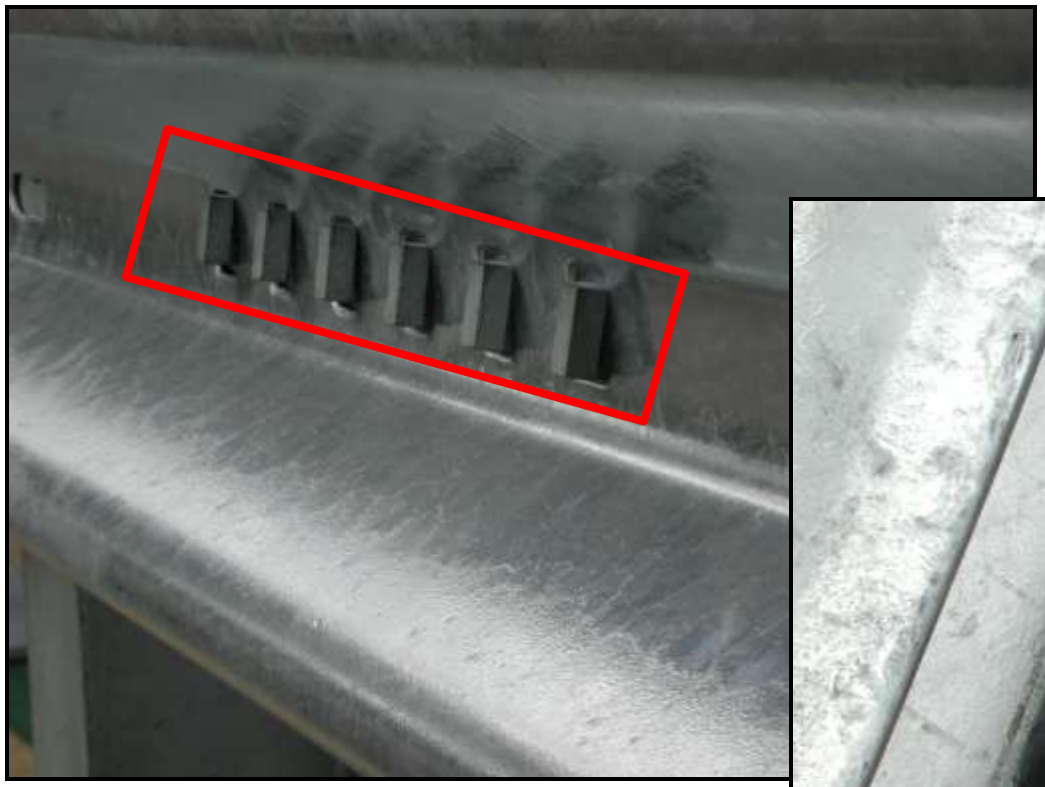


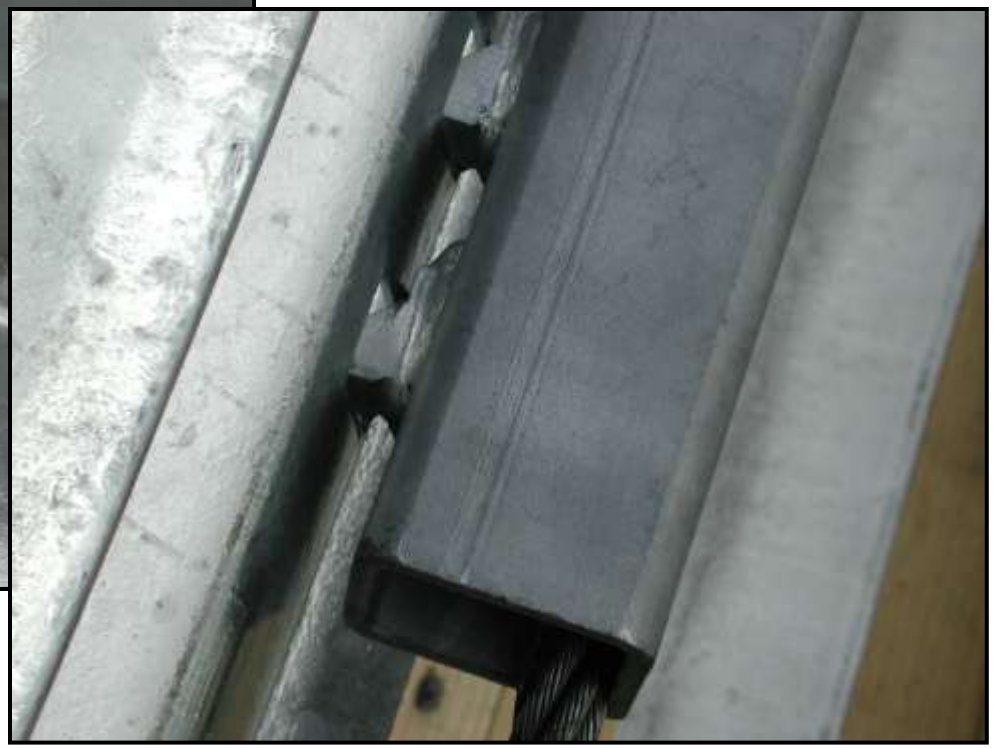
ET 31, Attaching the Extruder head



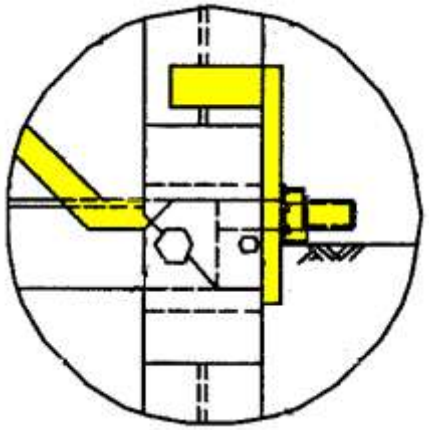
Extruder Head should be Parallel to the Guardrail – Not dipping down.

ET 31, Installation of Anchor Bracket





ET 31, Installation of Cable and Bearing Plate

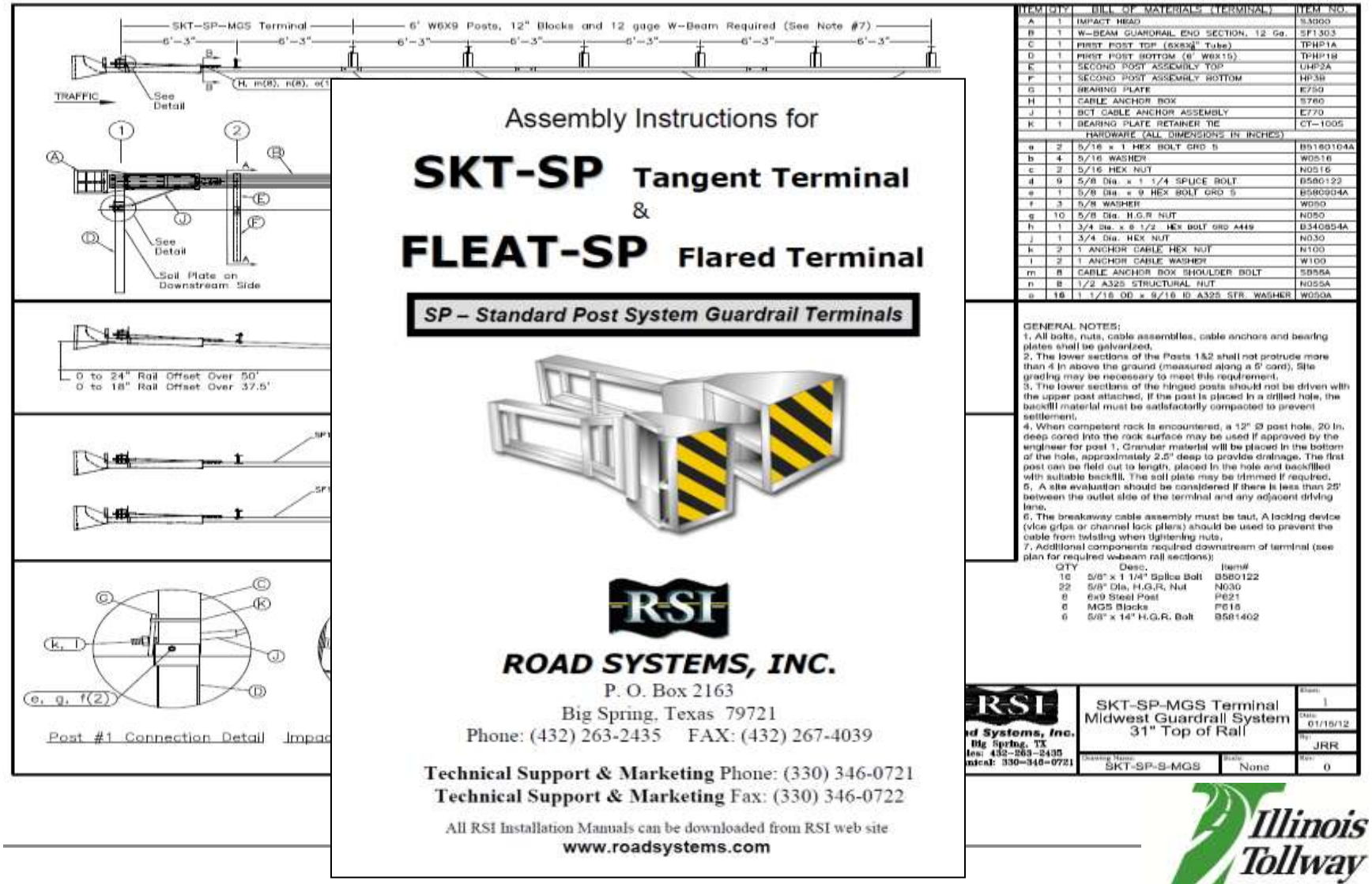


Road Systems, Inc.

SKT SP-MGS

Test Level 3

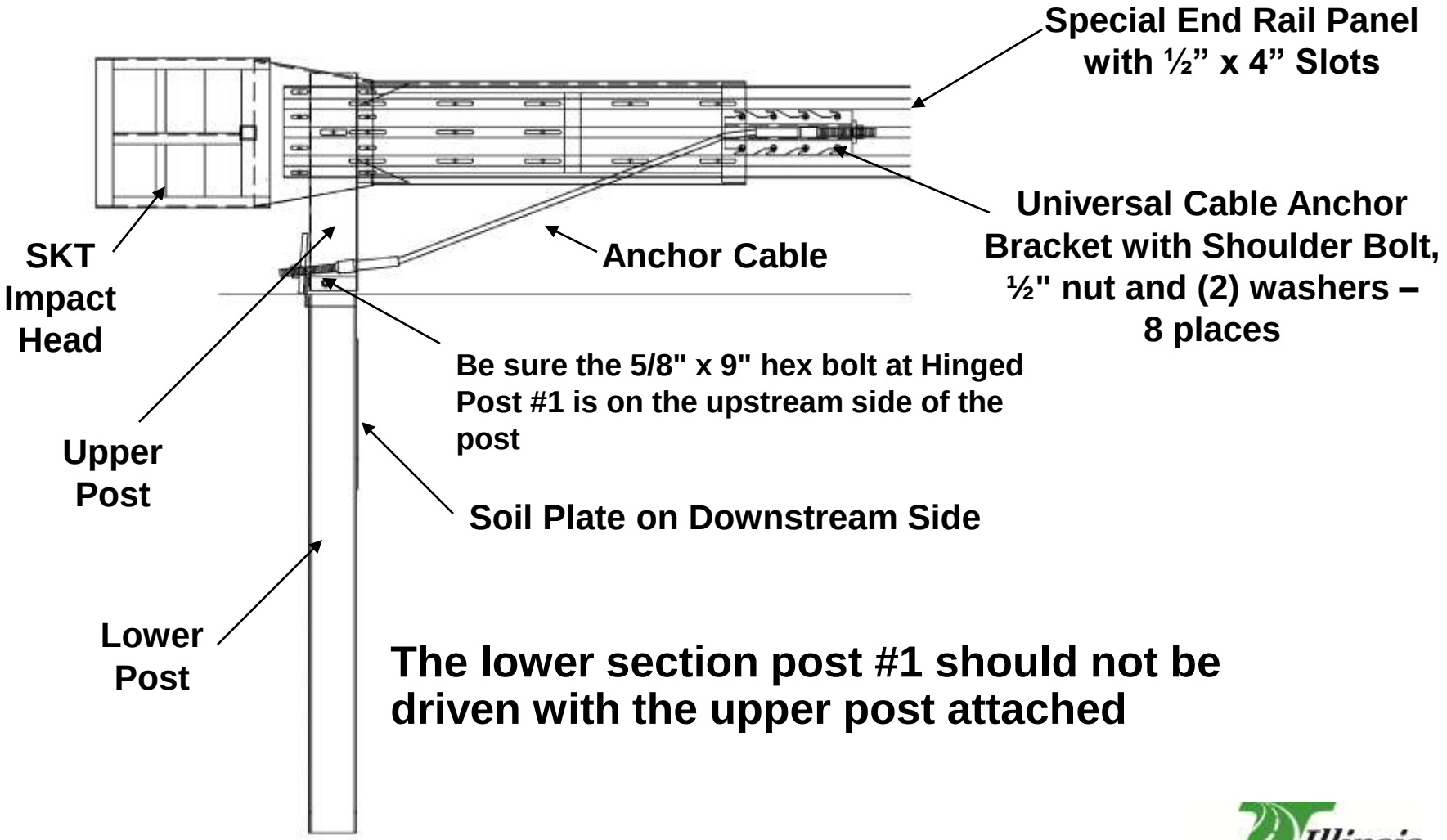
SKT-SP-MGS


SKT-SP-MGS Terminal
6' W6X9 Posts, 12" Blocks and 12 gage W-Beam Required (See Note #7)
TRAFFIC
See Detail
Soil Plate on Downstream Side
0 to 24" Rail Offset Over 50'
0 to 18" Rail Offset Over 37.5'
Post #1 Connection Detail
Assembly Instructions for
SKT-SP Tangent Terminal
&
FLEAT-SP Flared Terminal
SP – Standard Post System Guardrail Terminals
RSI
ROAD SYSTEMS, INC.
P. O. Box 2163
Big Spring, Texas 79721
Phone: (432) 263-2435 FAX: (432) 267-4039
Technical Support & Marketing Phone: (330) 346-0721
Technical Support & Marketing Fax: (330) 346-0722
All RSI Installation Manuals can be downloaded from RSI web site
www.roadsystems.com
BILL OF MATERIALS (TERMINAL)
ITEM QTY DESCRIPTION ITEM NO.
A 1 IMPACT HEAD SJ3000
B 1 W-BEAM GUARDRAIL END SECTION, 12 Ga. SF1303
C 1 FIRST POST TOP (6x8x3/16" Tube) TPHP1A
D 1 FIRST POST BOTTOM (6' W6x15) TPHP1B
E 1 SECOND POST ASSEMBLY TOP UHP2A
F 1 SECOND POST ASSEMBLY BOTTOM HP3B
G 1 BEARING PLATE E759
H 1 CABLE ANCHOR BOX S760
J 1 BCT CABLE ANCHOR ASSEMBLY E770
K 1 BEARING PLATE RETAINER TIE CT-1005
HARDWARE (ALL DIMENSIONS IN INCHES)
a 2 5/16 x 1 HEX BOLT GRD 5 B51601004A
b 4 5/16 WASHER W0516
c 2 5/16 HEX NUT N0516
d 9 5/8 Dia. x 1 1/4 SPLICE BOLT B580122
e 1 5/8 Dia. x 9 HEX BOLT GRD 5 B580904A
f 3 5/8 WASHER W050
g 10 5/8 Dia. H.G.R NUT N050
h 1 3/4 Dia. x 8 1/2 HEX BOLT GRD A449 B340854A
j 1 3/4 Dia. HEX NUT N030
k 2 1 ANCHOR CABLE HEX NUT N100
l 2 1 ANCHOR CABLE WASHER W100
m 8 CABLE ANCHOR BOX SHOULDER BOLT SB55A
n 8 1/2 A325 STRUCTURAL NUT N055A
o 16 1 1/16 OD x 9/16 ID A325 STR. WASHER W050A
GENERAL NOTES:
1. All bolts, nuts, cable assemblies, cable anchors and bearing plates shall be galvanized.
2. The lower sections of the Posts 1&2 shall not protrude more than 4 in above the ground (measured along a 5' cord). Site grading may be necessary to meet this requirement.
3. The lower sections of the hinged posts should not be driven with the upper post attached. If the post is placed in a drilled hole, the backfill material must be satisfactorily compacted to prevent settlement.
4. When competent rock is encountered, a 12" Ø post hole, 20 in. deep cored into the rock surface may be used if approved by the engineer for post 1. Granular material will be placed in the bottom of the hole, approximately 2.5" deep to provide drainage. The first post can be field cut to length, placed in the hole and backfilled with suitable backfill. The soil plate may be trimmed if required.
5. A site evaluation should be considered if there is less than 25' between the outlet side of the terminal and any adjacent driving lane.
6. The breakaway cable assembly must be taut. A locking device (vice grips or channel lock pliers) should be used to prevent the cable from twisting when tightening nuts.
7. Additional components required downstream of terminal (see plan for required w-beam rail sections):
QTY Desc. Item#
16 5/8" x 1 1/4" Splice Bolt B580122
22 5/8" Dia. H.G.R. Nut N030
8 6x9 Steel Post P621
8 MGS Blocks P618
6 5/8" x 14" H.G.R. Bolt B581402
RSI
SKT-SP-MGS Terminal
Midwest Guardrail System
31" Top of Rail
Sheet: 1
Date: 01/18/12
By: JRR
Drawing Name: SKT-SP-S-MGS
Scale: None
Rev: 0

SKT-SP-MGS

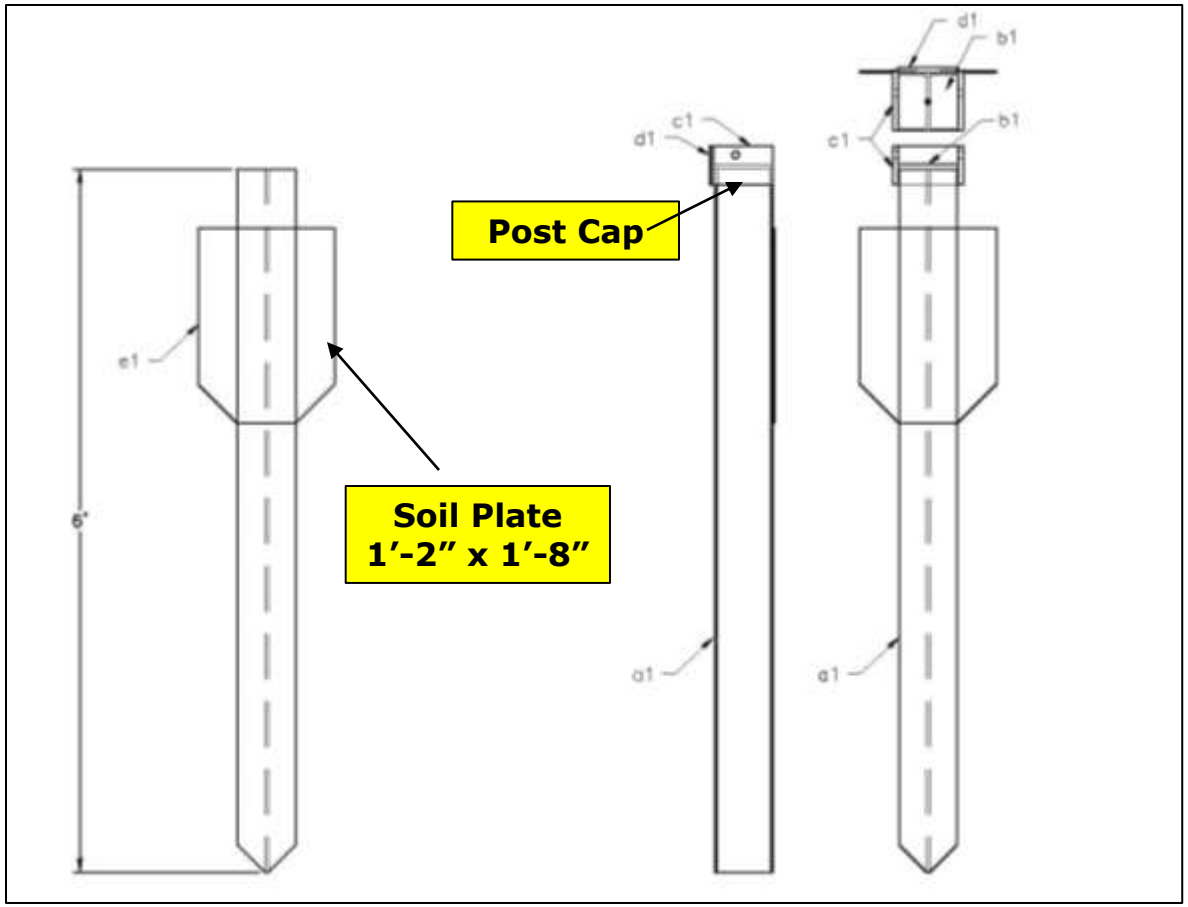

Standard steel guardrail posts at locations #3 and beyond.
Special Slots in End Panel
No Rail to Post Attachment at Post #1
Impact Head
Hinged Post #1 & #2

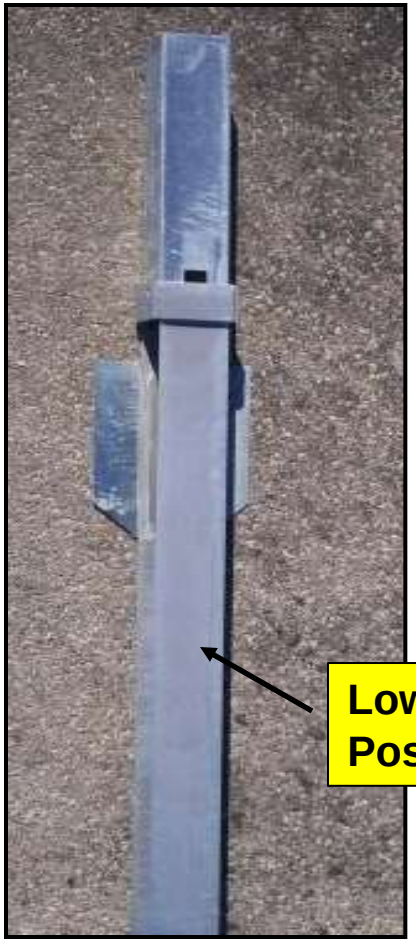
SKT-SP-MGS Post 1



The lower section post #1 should not be driven with the upper post attached

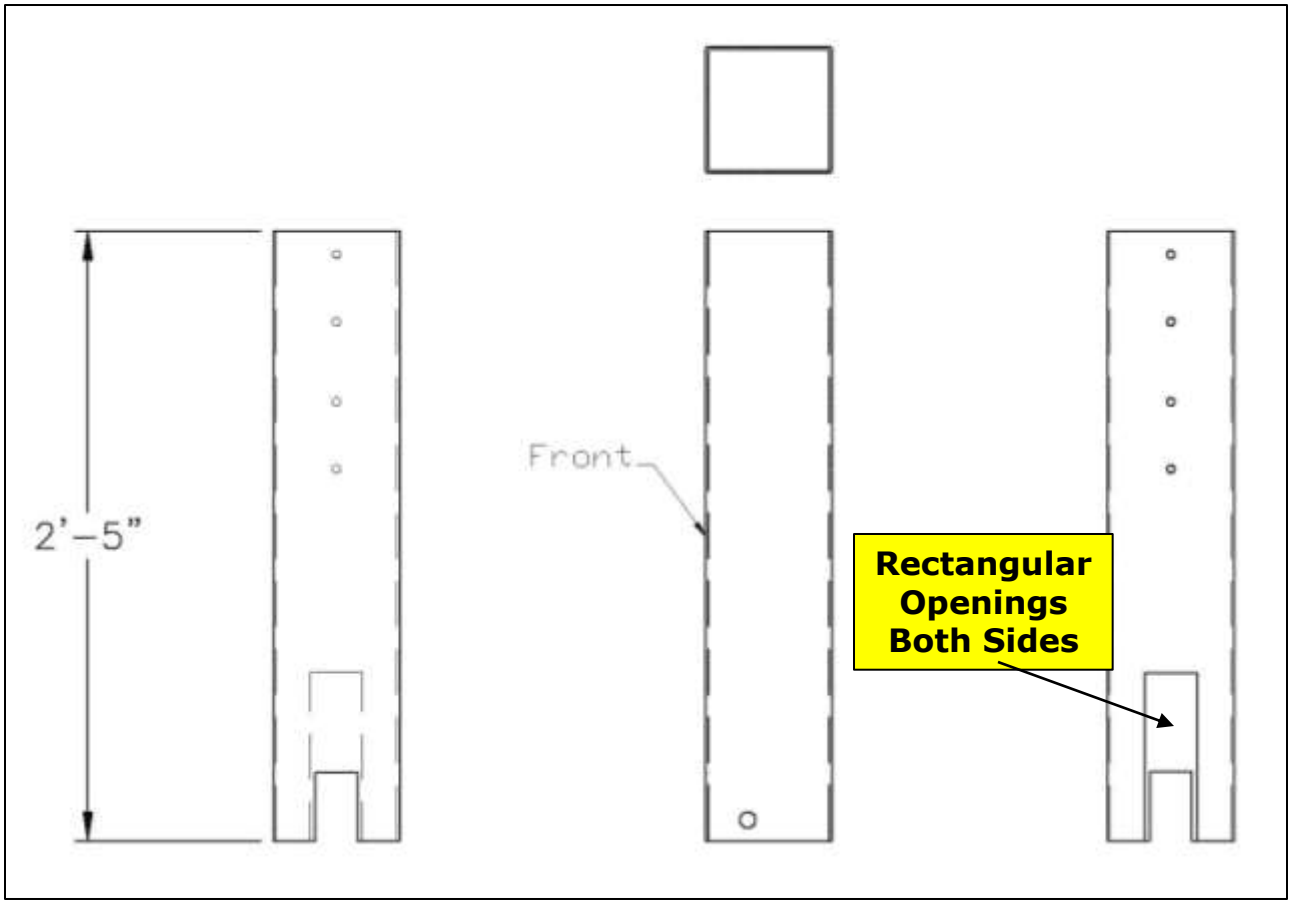
SKT-SP-MGS Post 1





Lower Post #1 W6” x 15# Post

SKT-SP-MGS Post 1



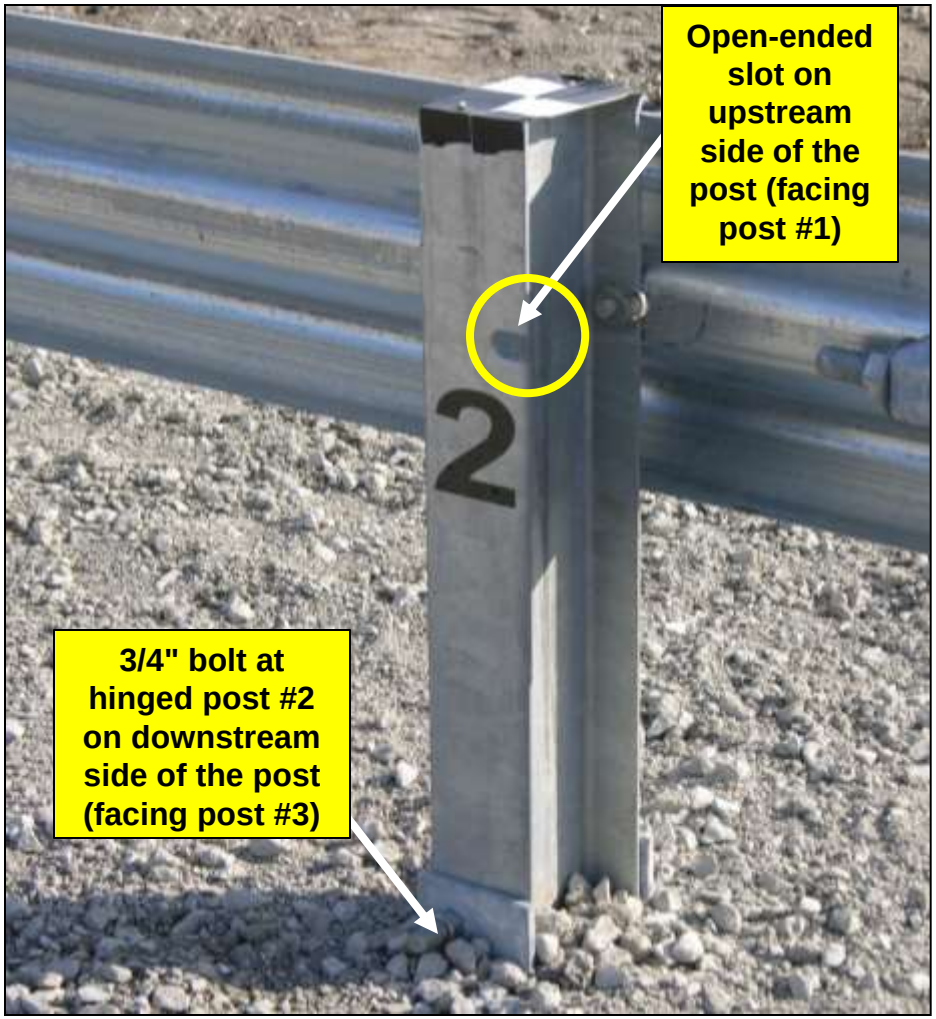
Upper Post #1 6" x 6" x ⅛ Tube

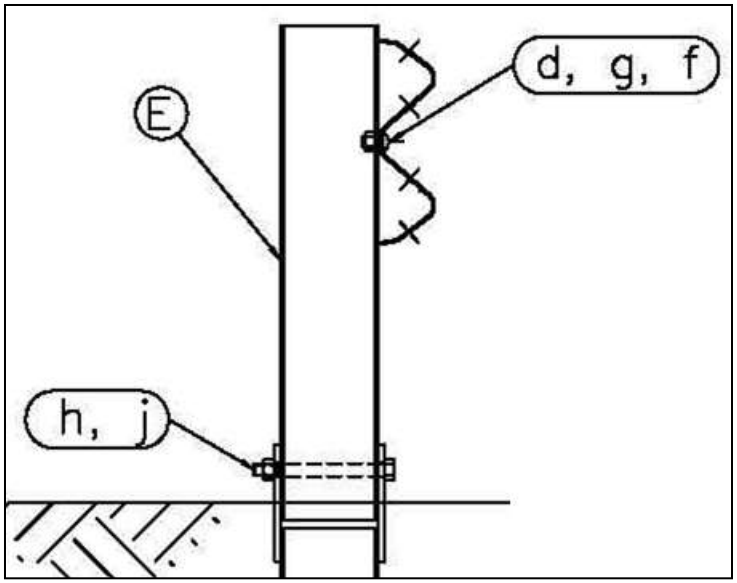
SKT-SP-MGS Posts 1-2 (Hinged Post)

3/4" bolt at hinged post #2 on downstream side of the post

5/8" bolt at hinged post #1 on upstream side of the post

SKT-SP-MGS Post 2 (Hinged Post)



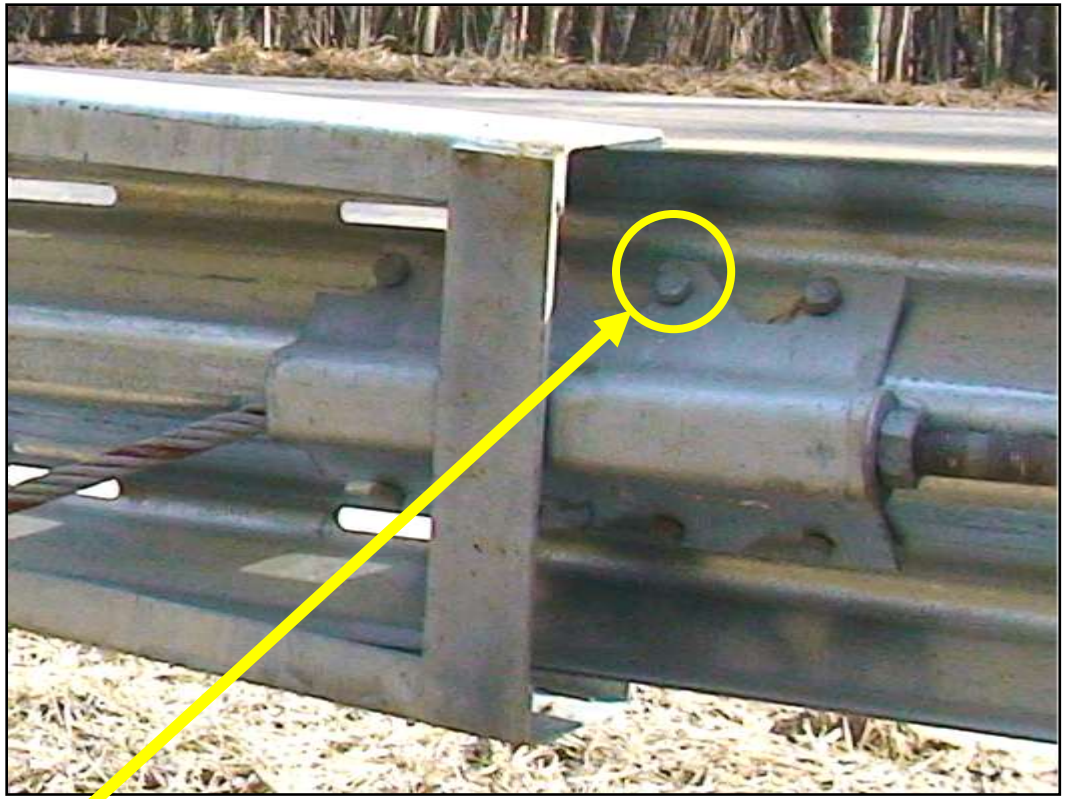


E	Upper Post #2 W6"
d	5/8" x 1 ¼" Guardrail Splice Bolt
f	5/8" Washer
g	5/8" Nut
h	¾" x 8 ½" Hex Bolt
j	¾" Nut

Illinois Tollway

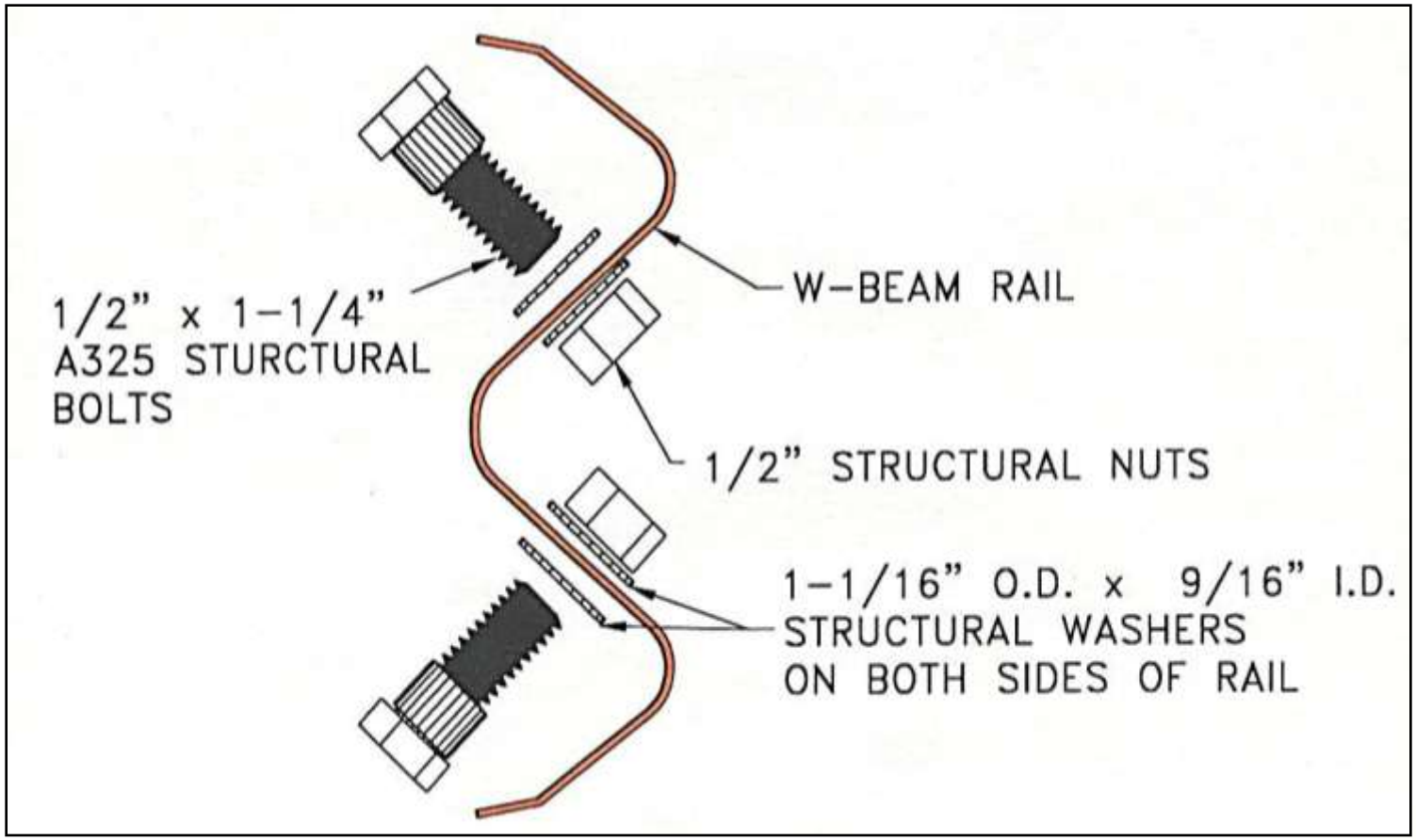
SKT-SP-MGS Posts 3-8 (Standard Line Posts)

SKT-SP-MGS Cable Anchor Bracket



Bolted to Rail w/ Special Shoulder Bolts
(8 places)

SKT-SP-MGS Anchor Bracket Shoulder Bolts

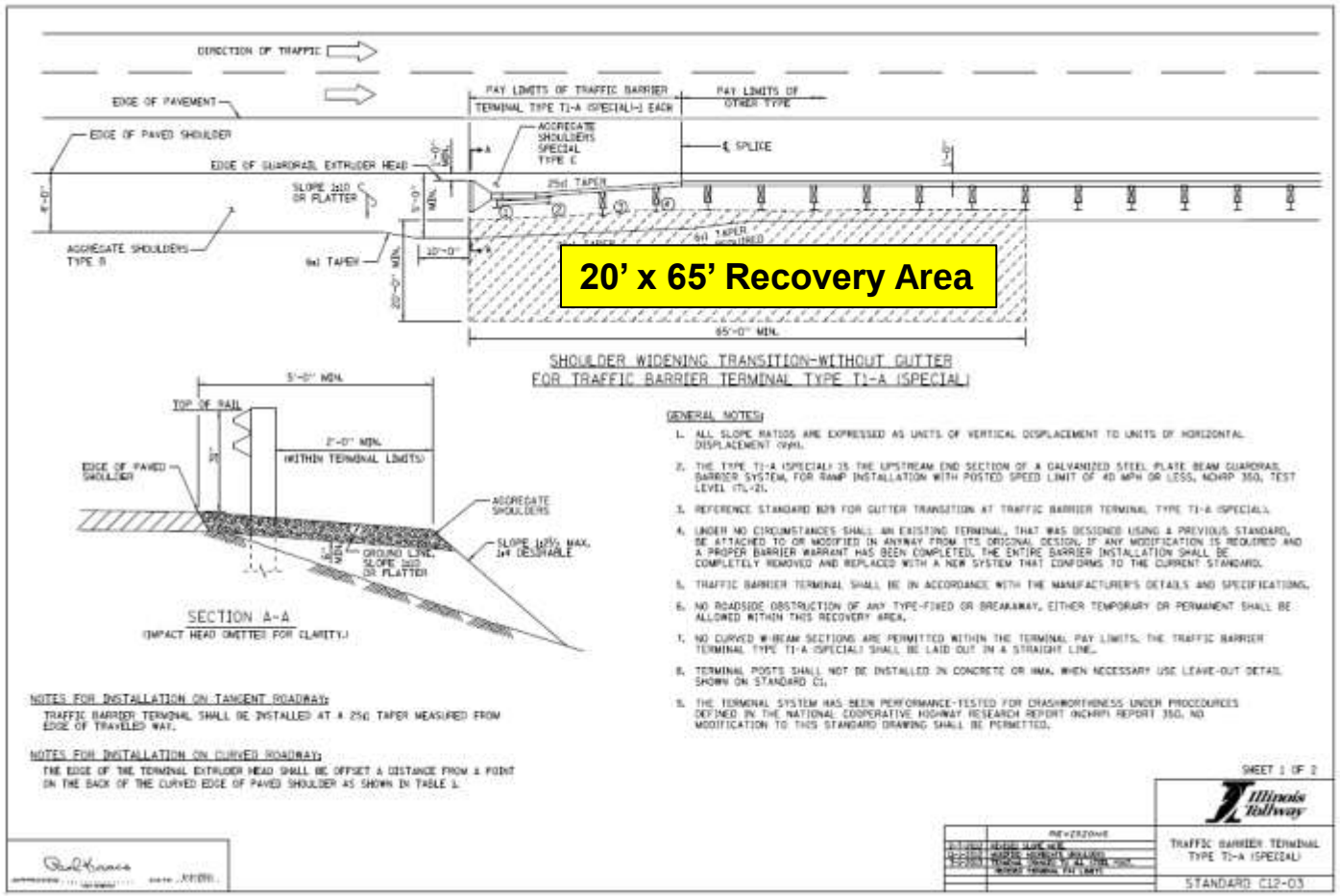


PROPRIETARY TERMINALS (cont.)

Standard C12:
Traffic Barrier Terminal Type T1-A

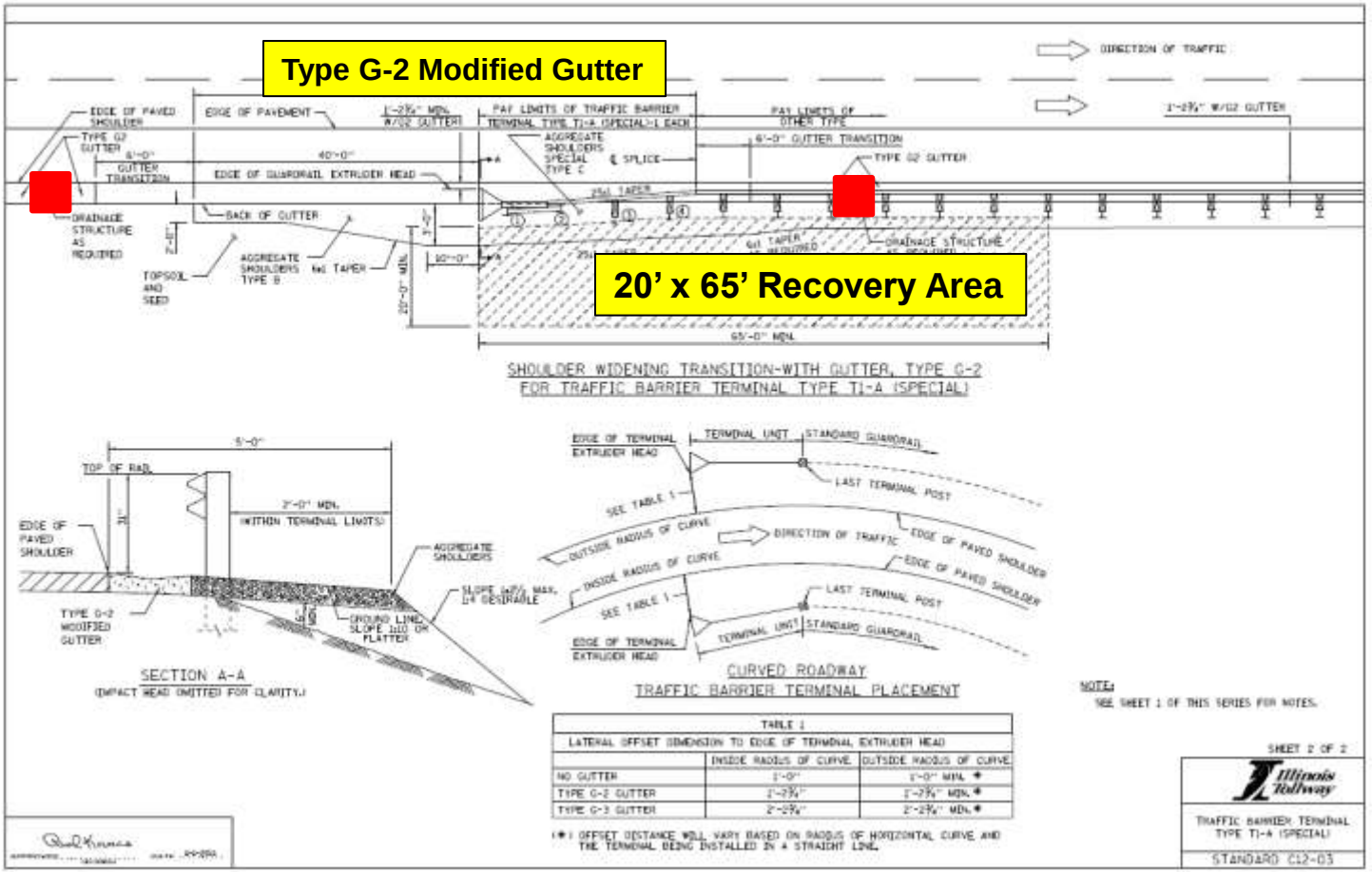
For Ramp Installation with Design Speed ≤ 40 MPH

Traffic Barrier Terminal Type T1-A (Special) without Gutter

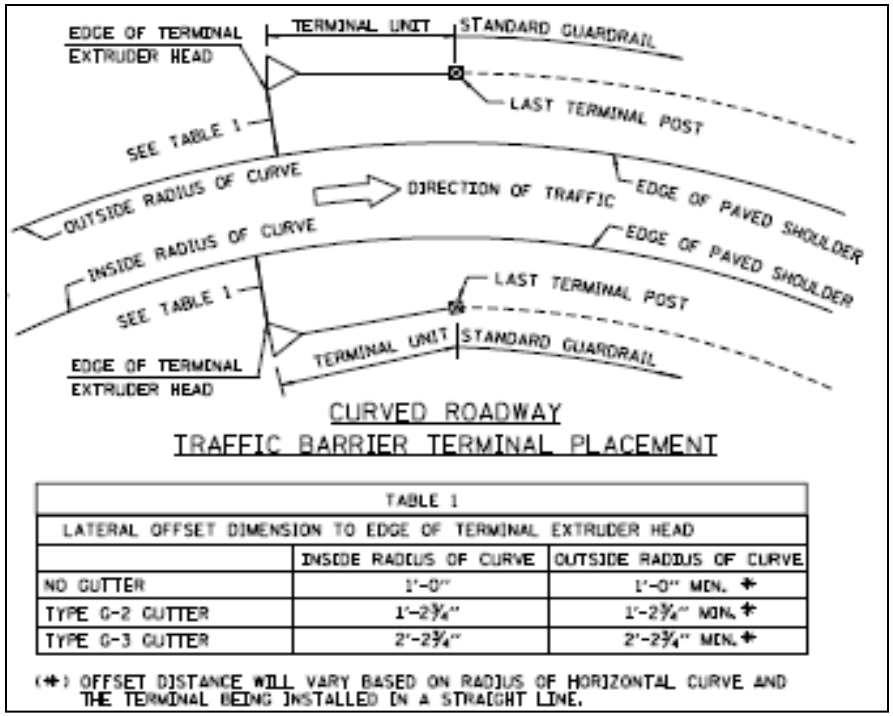


12.5’ counts toward length of need

Traffic Barrier Terminal Type T1-A (Special) with Gutter, Type G-2



Installation on Curve:
Traffic Barrier Terminal Type T1 (Special)
Traffic Barrier Terminal Type T1-A (Special)



CURVED ROADWAY
TRAFFIC BARRIER TERMINAL PLACEMENT

TABLE 1

LATERAL OFFSET DIMENSION TO EDGE OF TERMINAL EXTRUDER HEAD		
	INSIDE RADIUS OF CURVE	OUTSIDE RADIUS OF CURVE
NO GUTTER	1'-0"	1'-0" MIN. ✚
TYPE G-2 GUTTER	1'-2¾"	1'-2¾" MIN. ✚
TYPE G-3 GUTTER	2'-2¾"	2'-2¾" MIN. ✚

(✚) OFFSET DISTANCE WILL VARY BASED ON RADIUS OF HORIZONTAL CURVE AND THE TERMINAL BEING INSTALLED IN A STRAIGHT LINE.

No curved W-beam sections are permitted within terminal limits

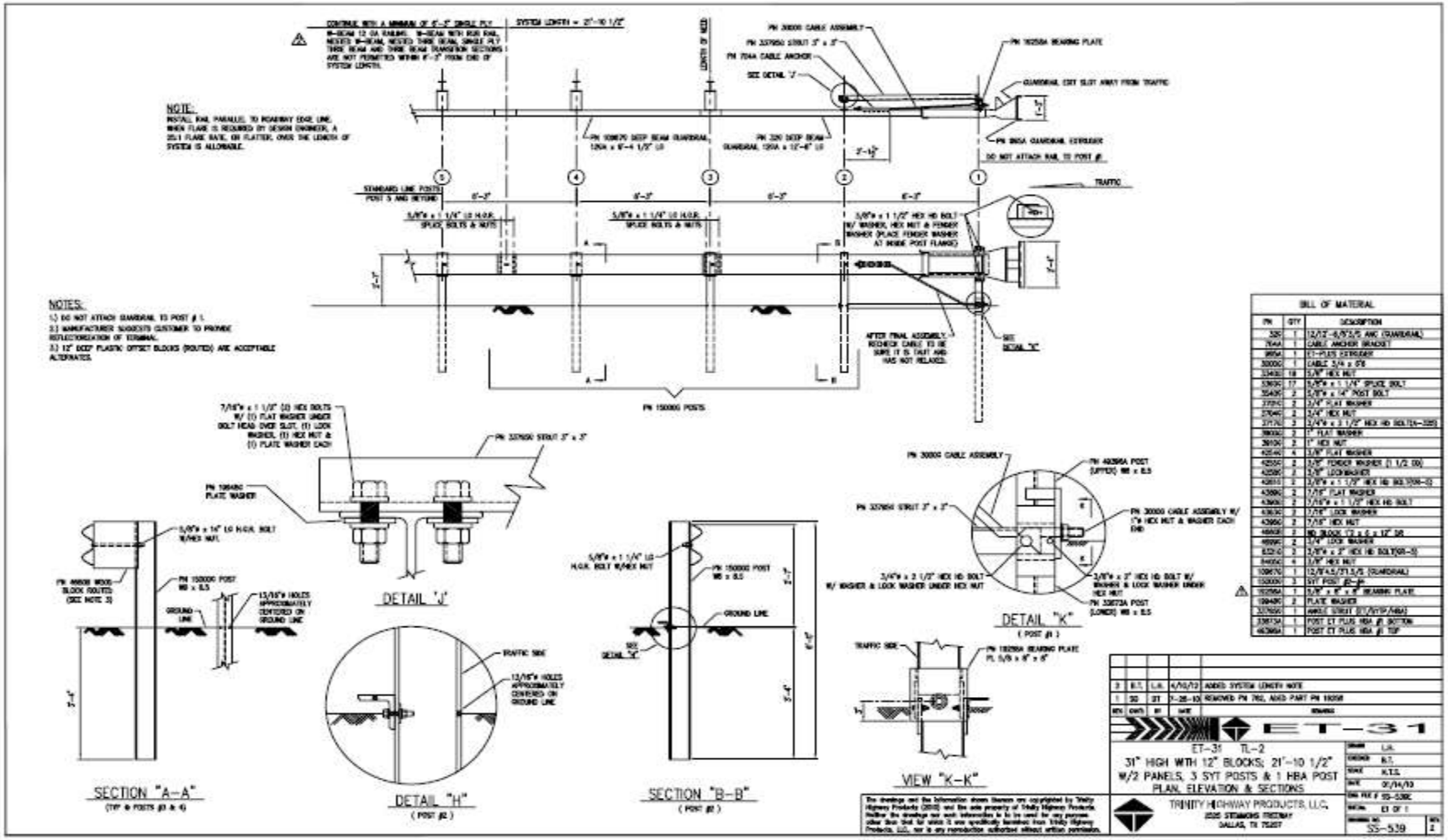
Illinois Tollway

Trinity Highway Products

ET-31

Test Level 2

ET-31, TL-2


NOTE:
INSTALL RAIL PARALLEL TO ROADWAY EDGE LINE. WHEN FLARE IS REQUIRED BY DESIGN ENGINEER, A 20:1 FLARE RATE, OR FLATTER, OVER THE LENGTH OF SYSTEM IS ALLOWABLE.
NOTES:
1.) DO NOT ATTACH GUARDRAIL TO POST # 1.
2.) MANUFACTURER SUGGESTS CUSTOMER TO PROVIDE REFLECTORIZATION OF TERMINAL.
3.) 12" DEEP PLASTIC OFFSET BLOCKS (ROUTED) ARE ACCEPTABLE ALTERNATES.
STANDARD LINE POSTS POST 5 AND BEYOND
TRAFFIC
AFTER FINAL ASSEMBLY, RECHECK CABLE TO BE SURE IT IS TAUT AND HAS NOT RELAXED.
PN 150000 POSTS
DETAIL "J"
DETAIL "K"
(POST #1)
SECTION "A-A"
(TYP @ POSTS #2 & 4)
DETAIL "H"
(POST #2)
SECTION "B-B"
(POST #3)
VIEW "K-K"
BILL OF MATERIAL
ET-31
ET-31 TL-2
31" HIGH WITH 12" BLOCKS, 21'-10 1/2" W/2 PANELS, 3 SYT POSTS & 1 HBA POST
PLAN, ELEVATION & SECTIONS
TRINITY HIGHWAY PRODUCTS, LLC.
SS-539

Road Systems, Inc.

SKT SP-MGS

Test Level 2

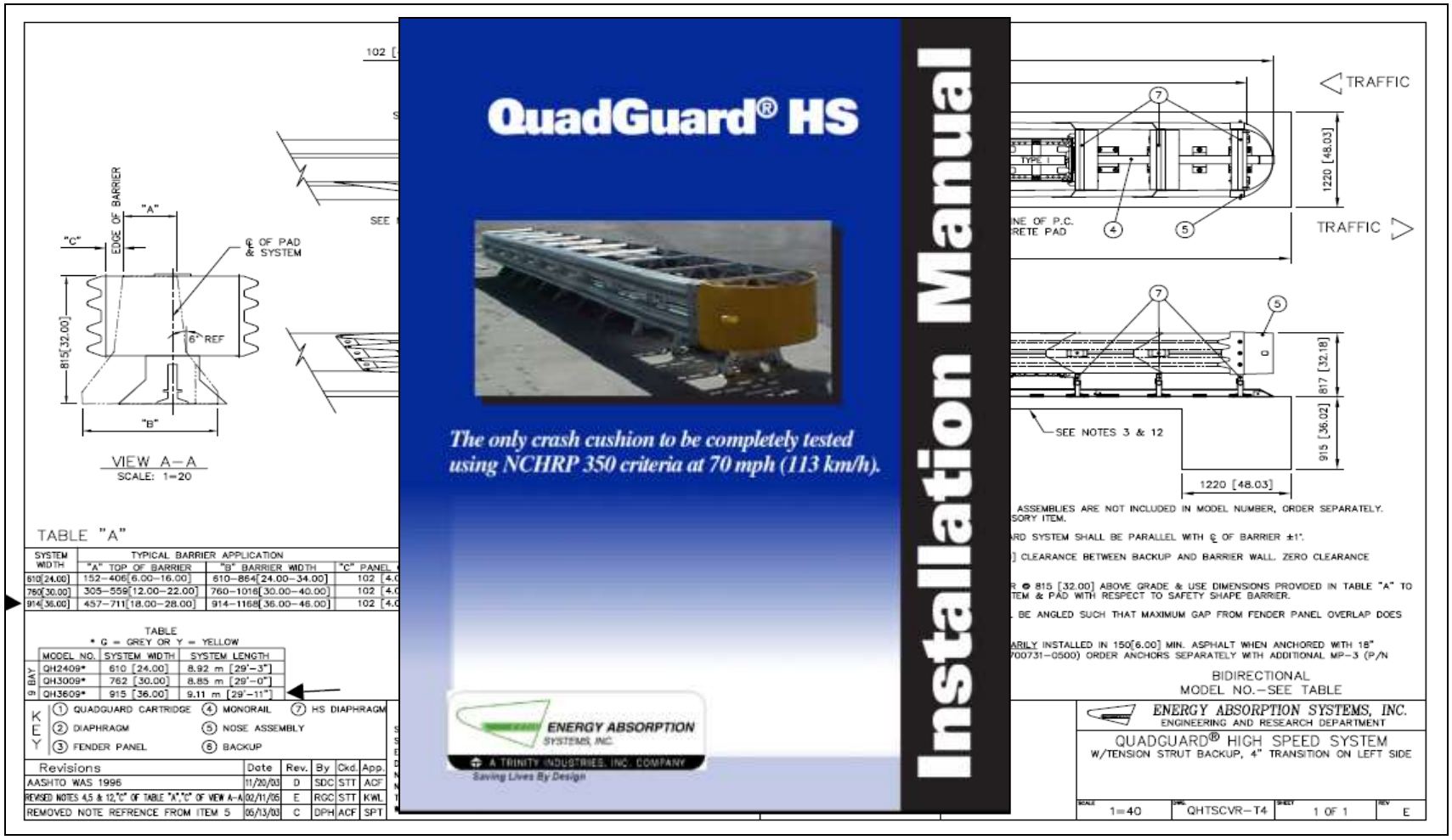
Questions?

Terminals:

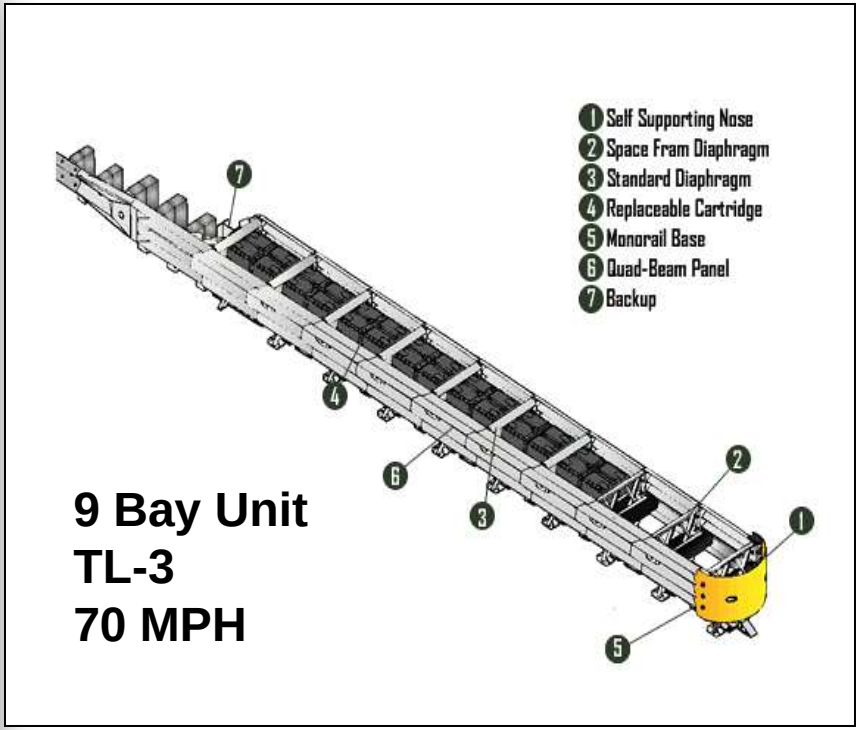
T1 (Special), T1-A (Special)

ENERGY ATTENUATOR

QuadGuard HS-Energy Attenuator



QuadGuard HS-Energy Attenuator



QuadGuard HS-Energy Attenuator

QuadGuard – Concrete Pad

Pad shall be installed per manufacturer's requirements

Site Considerations

- Cross Slope ≤ 8%
- Slope △ front to back ≤ 2%
- Maximum curb height ≤ 2”
- Cross slopes in front of unit

Illinois Tollway

QuadGuard – Monorail

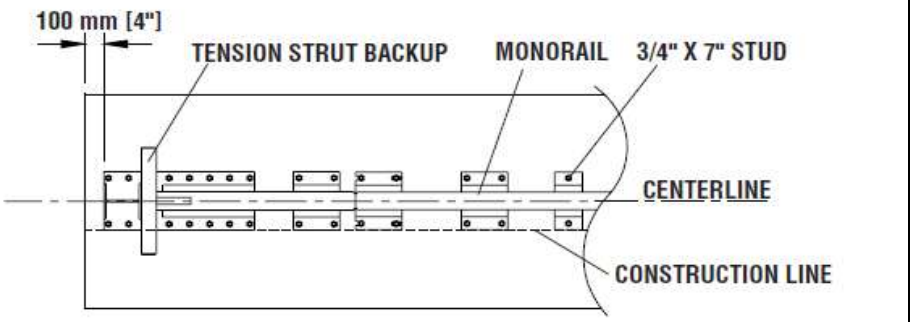
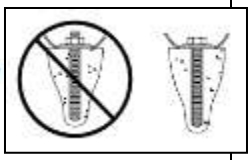


Figure 16
Backup and Monorail Location for Tension Strut Backup



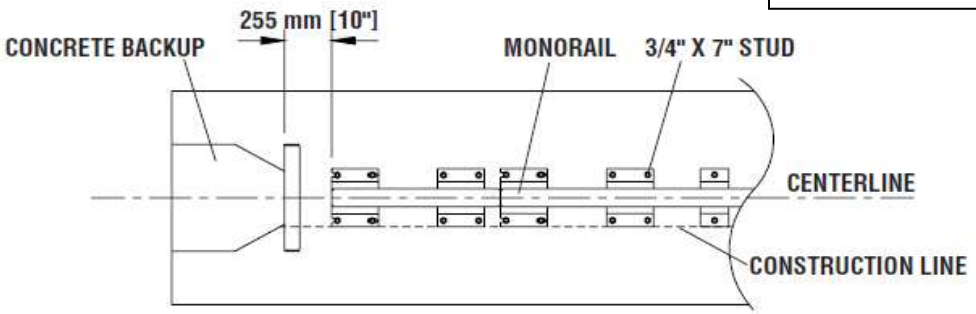


Figure 17
Monorail Location for Concrete Backup

Every hole and slot in backup and monorail must have an MP-3 bolt anchoring it.

Illinois Tollway

QuadGuard – Backup Assembly

Concrete Backup

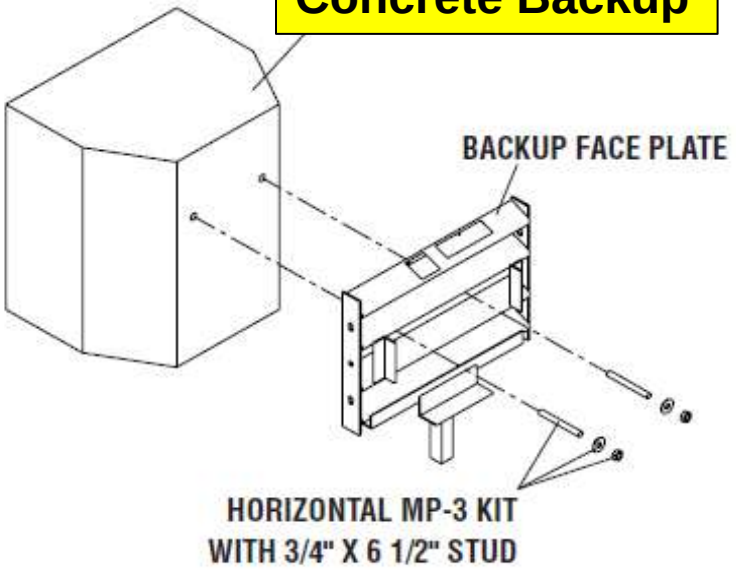


Figure 14
Anchoring Backup Face Plate to Concrete Backup

Tension Strut Backup

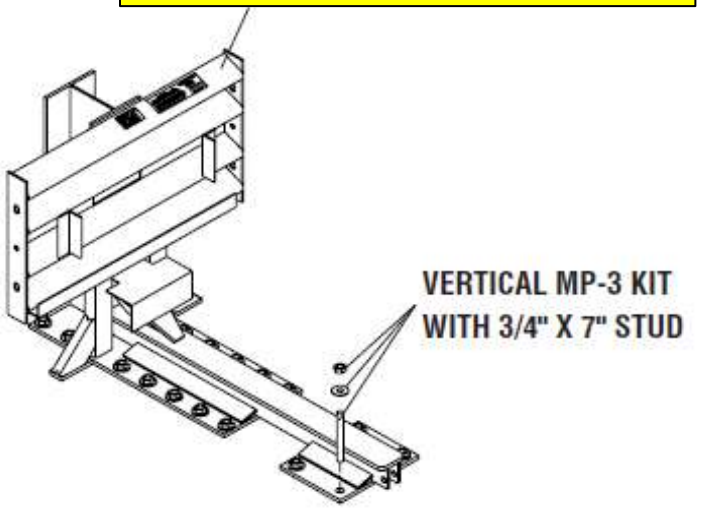


Figure 15
Anchoring Tension Strut Backup to Foundation

Illinois Tollway

QuadGuard – Quad-Beam Diaphragms

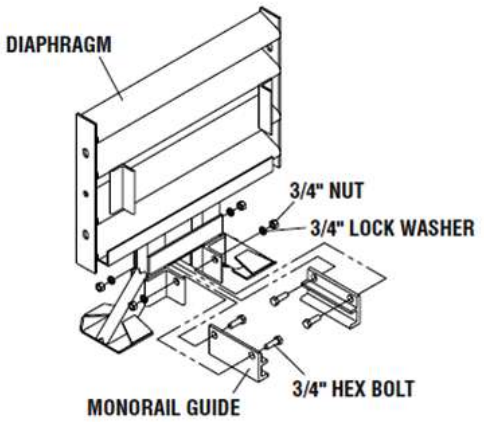


Figure 19
Monorail Guide Attachment
(Diaphragms 4 through 9)

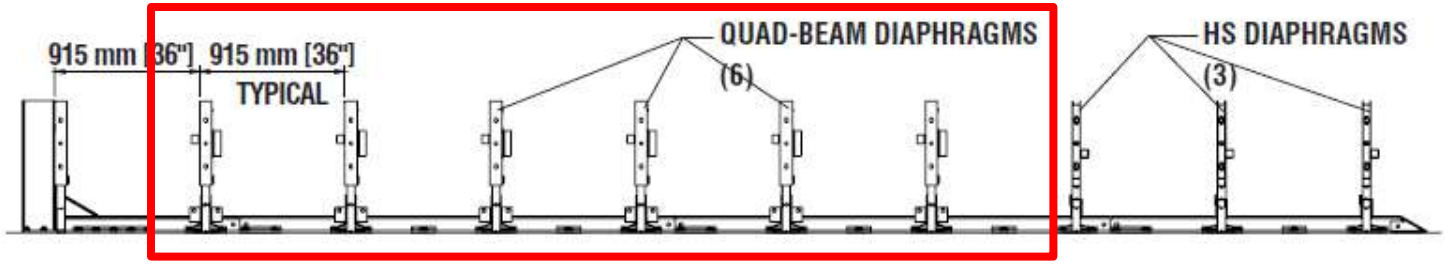
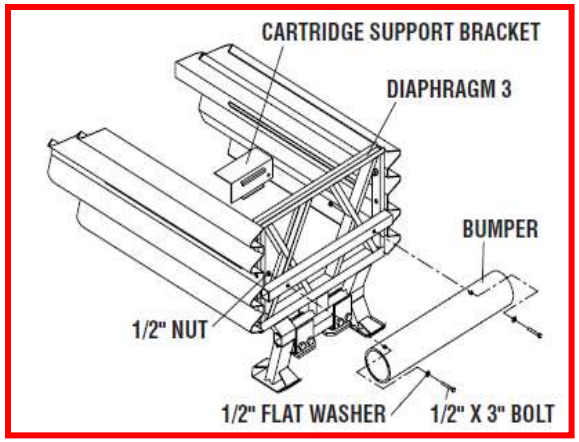
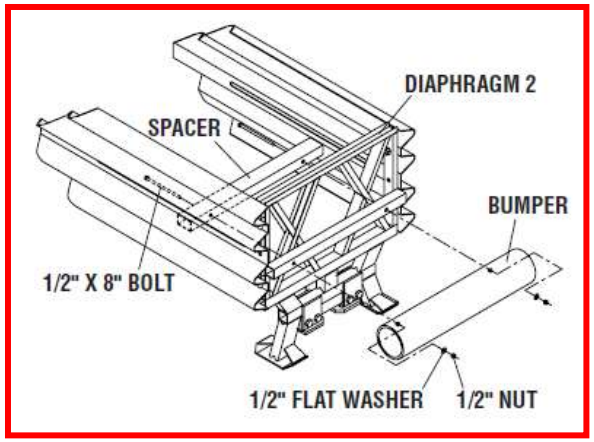
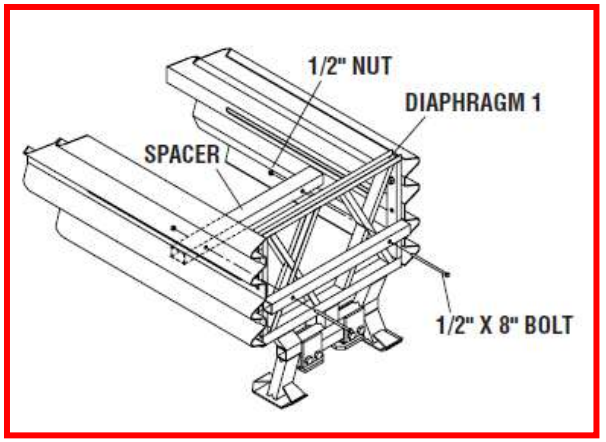


Figure 23
Diaphragm spacing

QuadGuard – HS Diaphragms







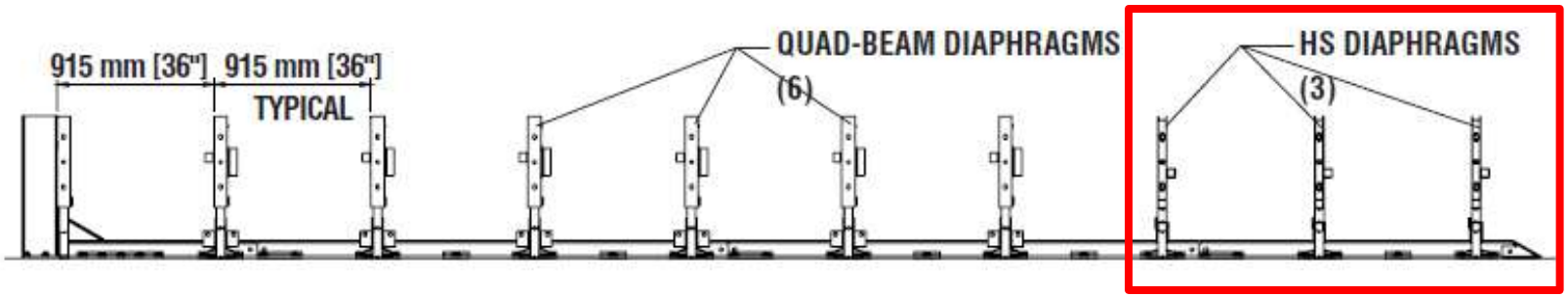


Figure 23
Diaphragm spacing

QuadGuard – Fender Panel Assembly

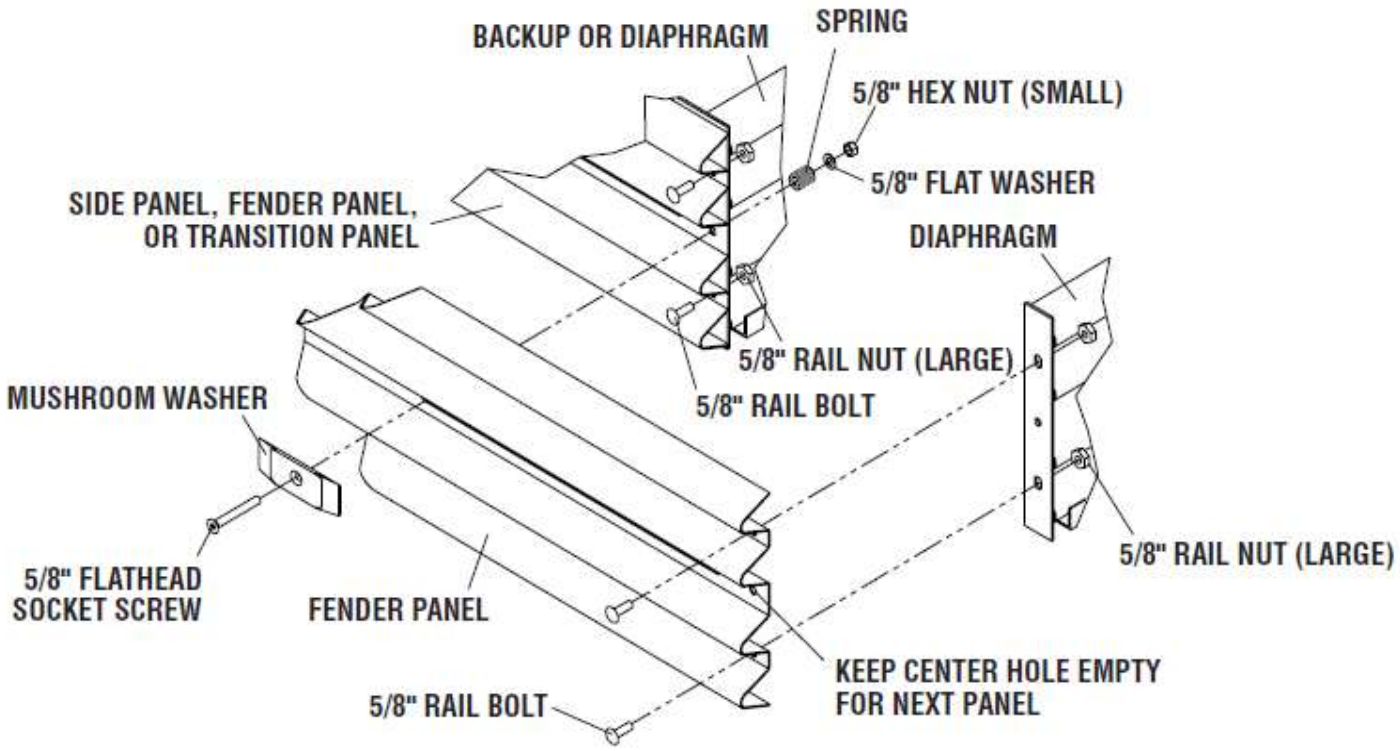


Figure 25
Fender Panel Assembly

QuadGuard – Fender Panel Assembly

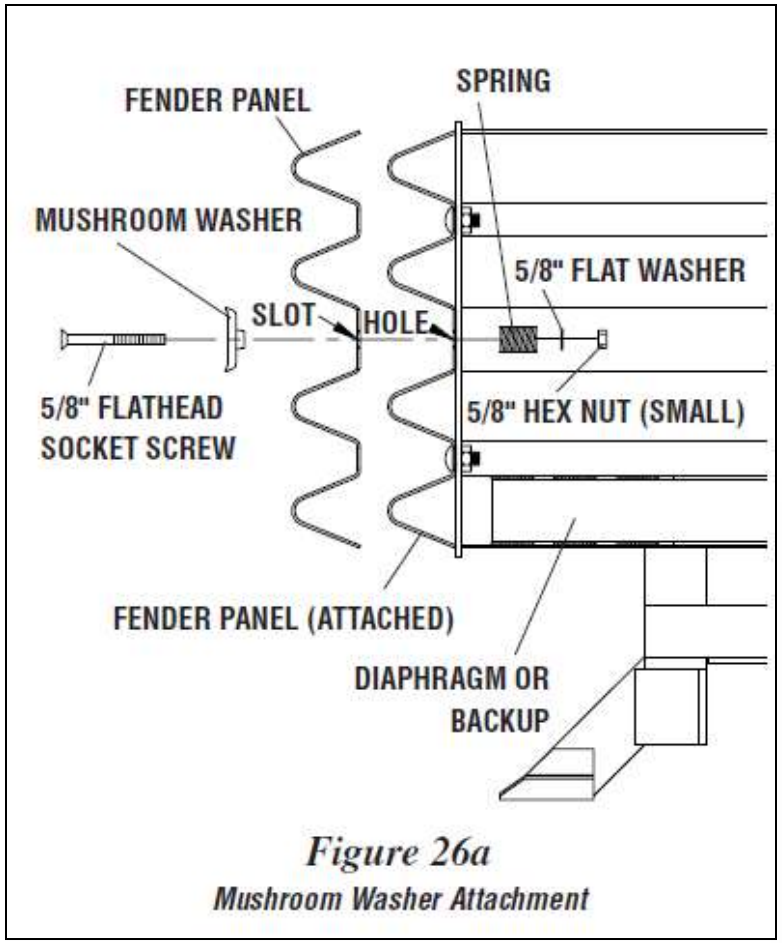


Figure 26a
Mushroom Washer Attachment

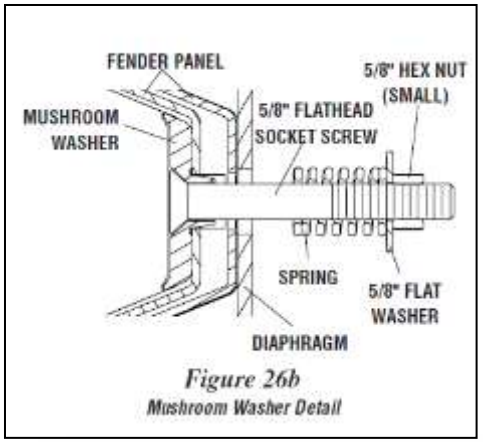


Figure 26b
Mushroom Washer Detail

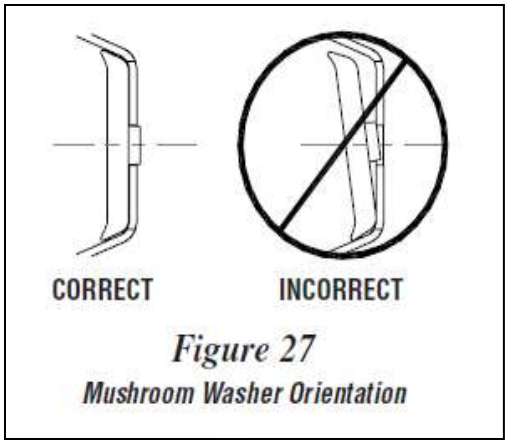
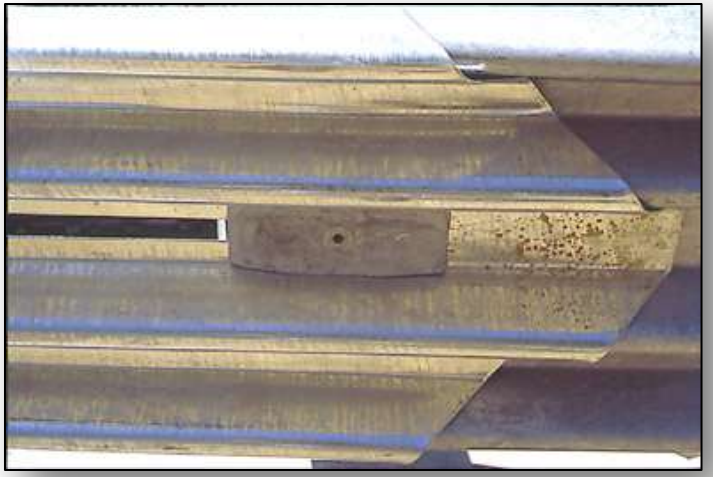


Figure 27
Mushroom Washer Orientation



QuadGuard – Transition Panels

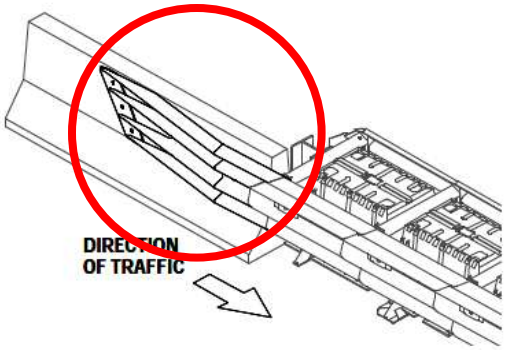


Figure 5
Quad-Beam to Safety Barrier Transition Panel

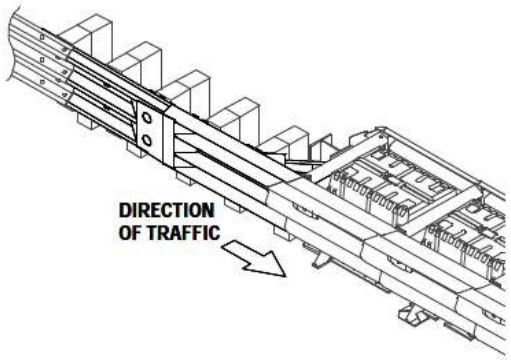


Figure 6
Quad-Beam to Thrie Transition Panel

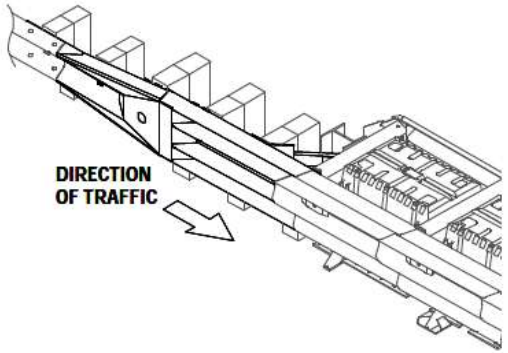


Figure 7
Quad-Beam to W Transition Panel

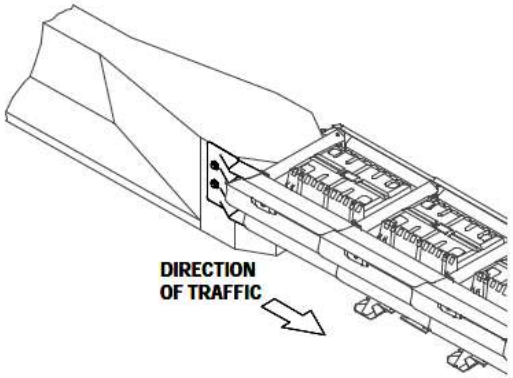


Figure 8
Quad-Beam End Shoe Transition Panel

QuadGuard – Transition Panels

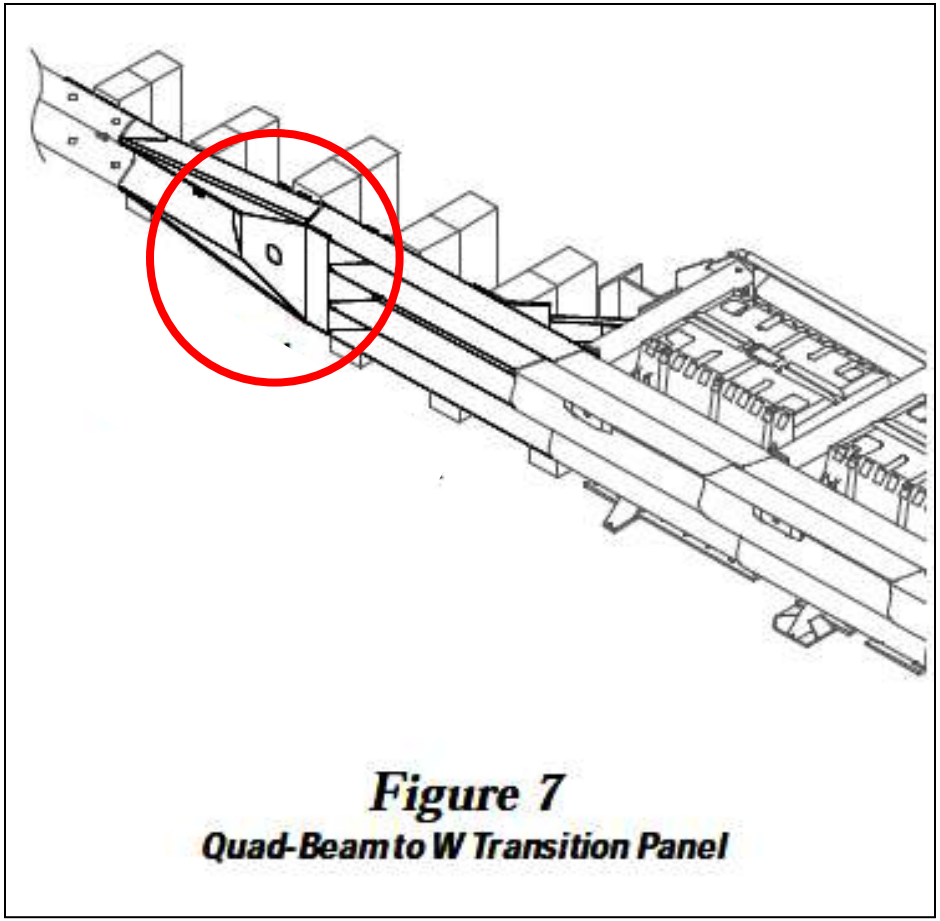


Figure 7
Quad-Beam to W Transition Panel

Transition Panel to Guardrail

Asymmetrical – connects to MGS

Symmetrical – connects to previous standard

Cartridge Installation

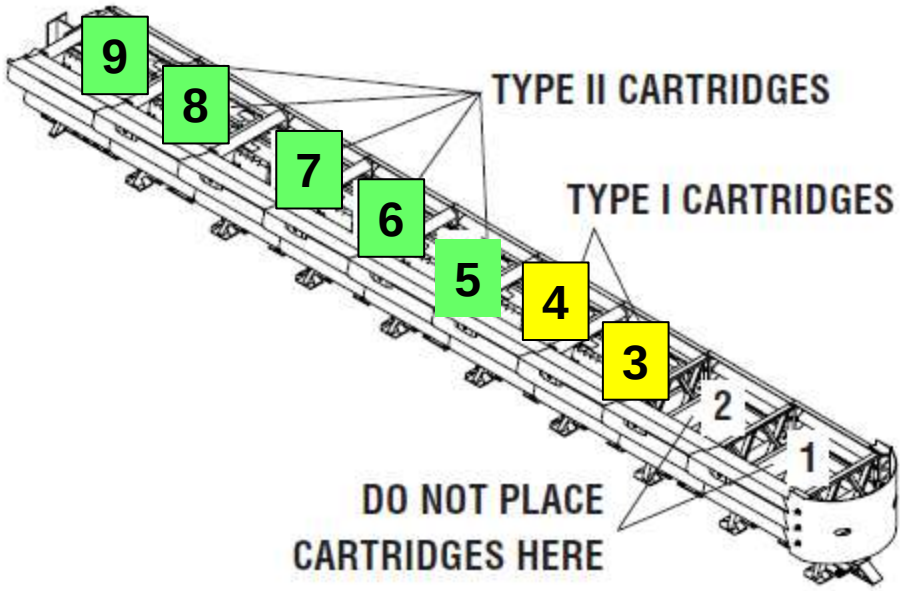


Figure 39

Cartridge Placement

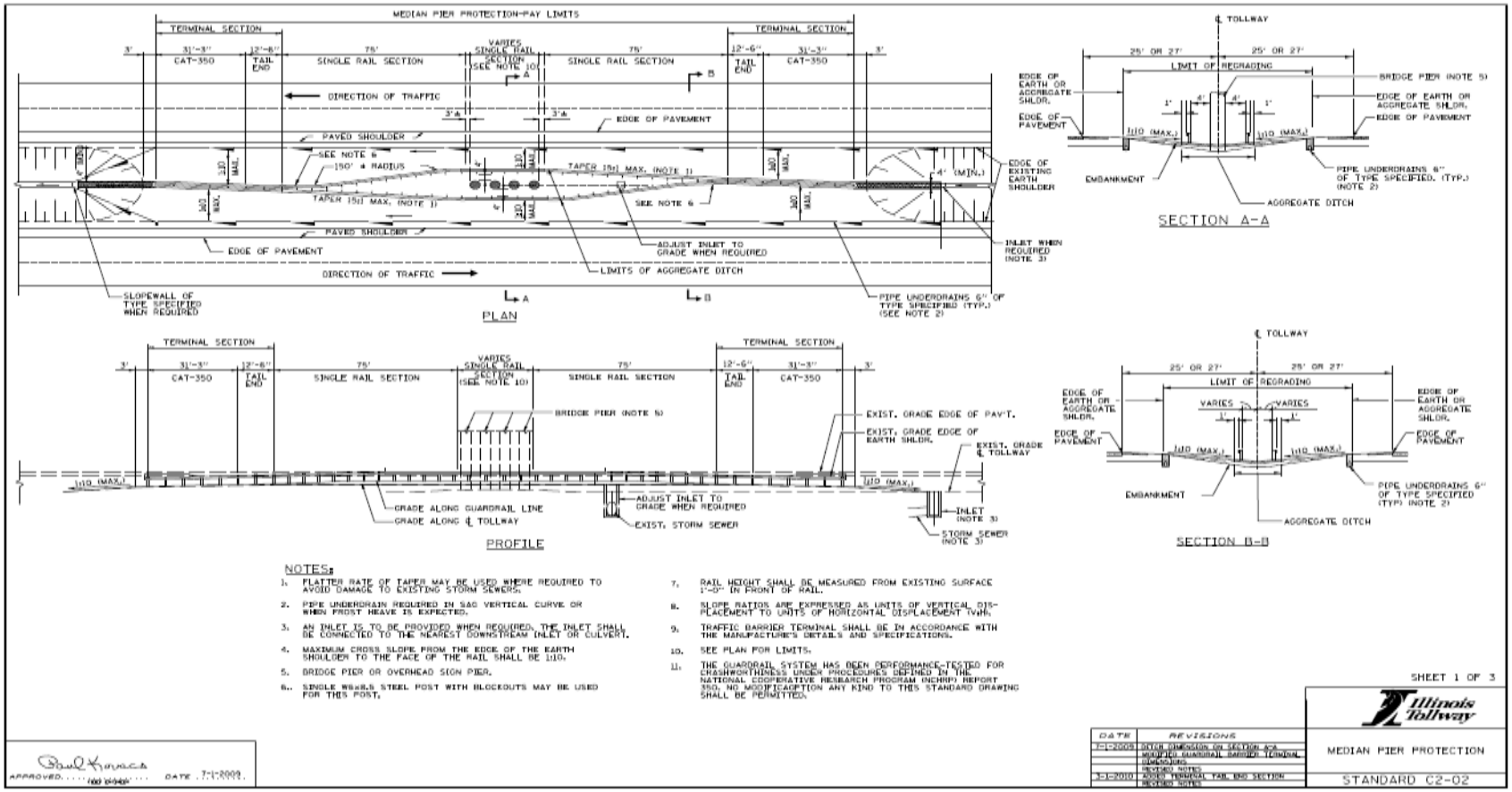
Placing a cartridge in the first or second bays, or placing a cartridge in the wrong bay may result in unacceptable crash performance as described in NCHRP 350.

Questions?

Energy Attenuators: QuadGuard

MEDIAN PIER PROTECTION

Standard C2:
Median Pier Protection



NOTES:

1. FLATTER RATE OF TAPER MAY BE USED WHERE REQUIRED TO AVOID DAMAGE TO EXISTING STORM SEWERS.
2. PIPE UNDERDRAIN REQUIRED IN SAG VERTICAL CURVE OR WHEN FROST HEAVE IS EXPECTED.
3. AN INLET IS TO BE PROVIDED WHEN REQUIRED. THE INLET SHALL BE CONNECTED TO THE NEAREST DOWNSTREAM INLET OR CULVERT.
4. MAXIMUM CROSS SLOPE FROM THE EDGE OF THE EARTH SHOULDER TO THE FACE OF THE RAIL SHALL BE 1:10.
5. BRIDGE PIER OR OVERHEAD SIGN PIER.
6. SINGLE W6x8.5 STEEL POST WITH BLOCKOUTS MAY BE USED FOR THIS POST.
7. RAIL HEIGHT SHALL BE MEASURED FROM EXISTING SURFACE 1'-0" IN FRONT OF RAIL.
8. SLOPE RATIOS ARE EXPRESSED AS UNITS OF VERTICAL DISPLACEMENT TO UNITS OF HORIZONTAL DISPLACEMENT (V:H).
9. TRAFFIC BARRIER TERMINAL SHALL BE IN ACCORDANCE WITH THE MANUFACTURER'S DETAILS AND SPECIFICATIONS.
10. SEE PLAN FOR LIMITS.
11. THE GUARDRAIL SYSTEM HAS BEEN PERFORMANCE-TESTED FOR CRASHWORTHINESS UNDER PROCEDURES DEFINED IN THE NATIONAL COOPERATIVE RESEARCH PROGRAM (NCHRP) REPORT 350. NO MODIFICATION OF ANY KIND TO THIS STANDARD DRAWING SHALL BE PERMITTED.

APPROVED ..... DATE 7-1-2009

DATE	REVISIONS
7-1-2009	DITCH EROSION ON SECTION A-A
	MODIFIED GUARDRAIL BARRIER TERMINAL DIMENSIONS
	REVISED NOTES
3-5-2010	ADDED TERMINAL TAIL END SECTION
	REVISED NOTES

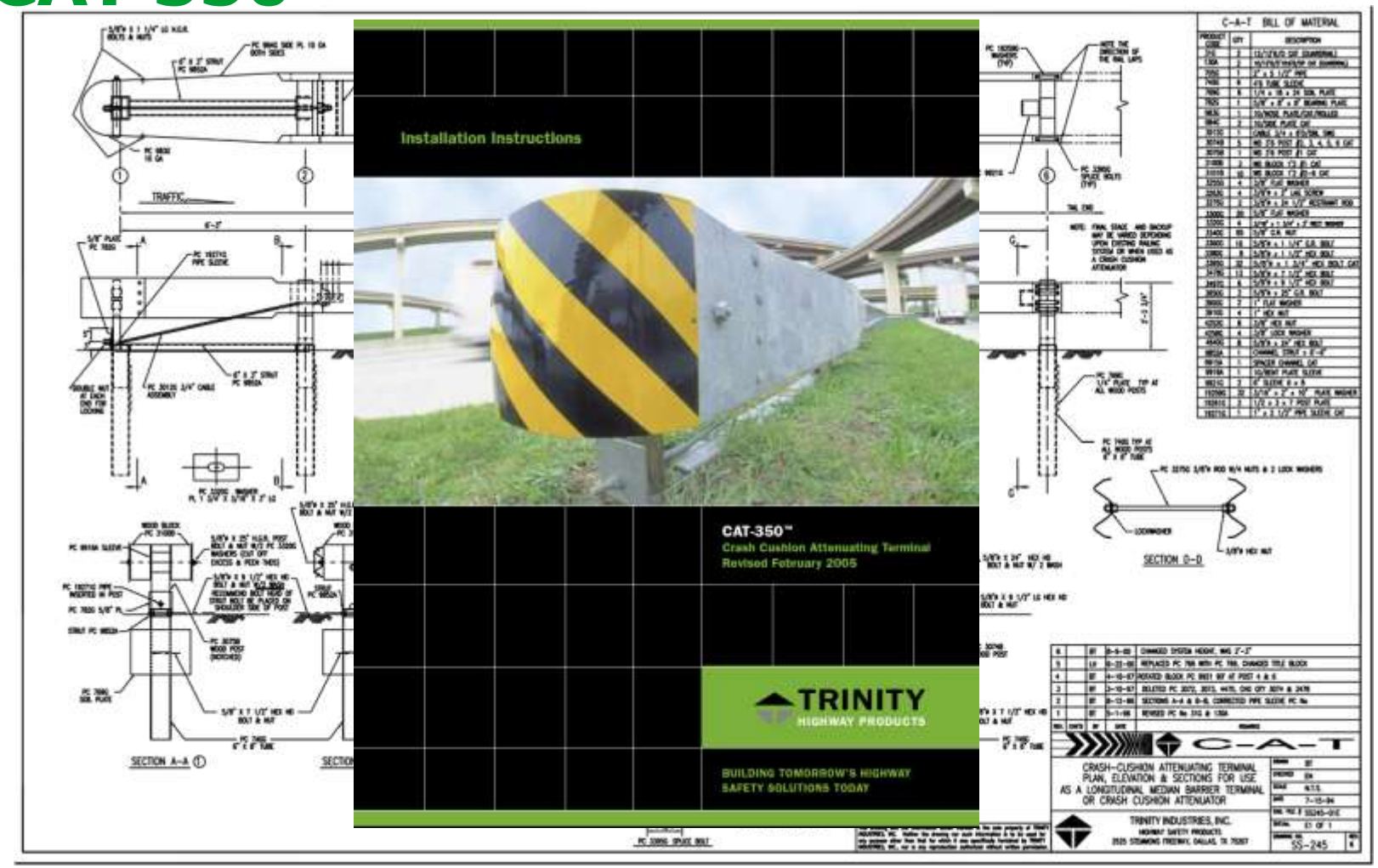
SHEET 1 OF 3

Illinois Tollway

MEDIAN PIER PROTECTION

STANDARD C2-02

CAT 350


Installation Instructions
CAT-350™
Crash Cushion Attenuating Terminal
Revised February 2005
TRINITY
HIGHWAY PRODUCTS
BUILDING TOMORROW'S HIGHWAY
SAFETY SOLUTIONS TODAY
C-A-T BILL OF MATERIAL
C-A-T
CRASH-CUSHION ATTENUATING TERMINAL
PLAN, ELEVATION & SECTIONS FOR USE
AS A LONGITUDINAL MEDIAN BARRIER TERMINAL
OR CRASH CUSHION ATTENUATOR
TRINITY INDUSTRIES, INC.
SS-245

Questions ?

E-Mail: tborchardt@getipass.com