U.S. Department of Transportation
Federal Highway Administration

1200 New Jersey Ave., SE
Washington, D.C. 20590

December 22, 2010

In Reply Refer To:
HSST/B-213

Mr. Daren Copeland
Varley and Gulliver Limited
Alfred Street, Sparkbrook
Birmingham, UK B12 8JR

Dear Mr. Copeland:

This letter is in response to your request for Federal Highway Administration (FHWA) acceptance of a roadside safety system for use on the National Highway System (NHS).

Name of system: Proprietary VGAN 300 Aluminum Permanent Bridge Barrier
Type of system: Post and Tube Railing Mounted on Reinforced Concrete Curb
Test Level: NCHRP Report 350 Test Level 4 (TL-4)
Testing conducted by: Texas Transportation Institute (TTI)
Date of Request: September 30, 2010
Drawing Designator: SBA07d

You requested that we find this system acceptable for use on the NHS under the provisions of National Cooperative Highway Research Program (NCHRP) Report 350 "Recommended Procedures for the Safety Performance Evaluation of Highway Features." (NCHRP Report 350)

Requirements
Roadside safety systems should meet the guidelines contained in the NCHRP Report 350. FHWA memorandum "ACTION: Identifying Acceptable Highway Safety Features" of July 25, 1997, provides further guidance on crash testing requirements of longitudinal barriers.

Decision
The following device was found acceptable, with details provided below:

• VGAN 300 Aluminum Permanent Bridge Barrier

Description
The Varley & Gulliver proprietary aluminum bridge railing system was mounted on a reinforced concrete curb. Overall length of the entire system was 29.3 m (96.0 ft) with posts spaced at 2.44 m (8.0 ft) for a total of 12 bays, 13 posts. The posts were cast A444.0 T4 aluminum and were anchored with four M20 stainless steel bolts. Extruded 6082 T6 aluminum tubes were used

for the railing. They were a flattened elliptical shape. The two lower rail elements were 152 mm (6.0 inches) in the long direction and 98 mm (3.8 inches) in the short direction and 5 mm (0.2 inch) wall thickness. The upper or pedestrian rail was 114 mm (4.5 inches) in the long direction and 85 mm (3.3 inches) in the short direction with 3 mm (0.12 inch) wall thickness. Splices were achieved with 6 mm (0.24 inch) wall thickness internal tubular sections in the main rails and 4 mm (0.16 inch) wall thickness internal tubular sections in the upper or pedestrian rail. The extruded rail elements had key way section on the lower back side that allow bolts to be placed in the key way and provides longitudinal adjustment.

The concrete foundation was specified to be 5800 psi and was 6318 psi at the time of the test and was anchored to the apron with "L" shaped bars welded to existing rebar. All rebar was specified to be 60 ksi. Steel reinforcement bar stirrups, 16 mm (0.6 inch) diameter, were placed at 150 mm (6.0 inches) on center with eight spaces under the post location and four spaces at 310 mm (12.2 inches) on center between the posts. There were 12 evenly spaced 16 mm (0.6 inch) diameter longitudinal bars in the foundation. Threaded inserts were placed in the concrete with templates. After the posts were bolted into the inserts, an epoxy grout pad was cast at each post support location. The four anchor bolts on one post upstream of impact, the impact post, and one post downstream of impact were instrumented with strain gages to measure force transmitted to the bolts.

Details of the VGAN 300 bridge rail test article are enclosed within this correspondence.

Crash Testing

The Proprietary VGAN 300 Aluminum Permanent Bridge Barrier was crash tested at the test facilities at TTI Proving Grounds Riverside Campus according to the following NCHRP Report 350 TL-4 tests for the evaluation of longitudinal barriers as described below.

NCHRP Report 350 Test Designation 4-10 with an 820 kg small passenger vehicle impacting the critical impact point (CIP) of the length-of-need (LON) of the bridge rail while traveling at an impact speed and angle of 100 km/h and 20 degrees. The purpose of this test is to evaluate the overall performance of the LON section, in general, and occupant risks, in particular.

NCHRP Report 350 Test Designation 4-11 with a 2000 kg pickup truck impacting the CIP of the LON while traveling at an impact speed and angle of 100 km/h and 25 degrees. The test is intended to evaluate strength of the section in containing and redirecting the 2000P vehicle.

NCHRP Report 350 Test Designation 4-12 with an 8000 kg single-unit box-van truck impacting the CIP of the LON while traveling at an impact speed and angle of 80 km/h and 15 degrees. This test is intended to evaluate the strength of the LON in containing and redirecting the heavy test vehicle.

The target CIP for each of the aforementioned tests was determined according to the information provided in NCHRP Report 350. For the test with the small car and the pickup, the CIP was determined to be at post 4. Post 4 is upstream of the first splice in the system. The CIP for the test with the single-unit box-van truck was determined to be 1 ft downstream of post 4. Crash Test summaries of each of these tests are enclosed within this correspondence.

Findings
The FHWA concurs to the submitted physical crash testing of the Proprietary VGAN 300 Aluminum Permanent Bridge Barrier to the proposed TL-4 designation. Therefore, the Proprietary VGAN 300 Aluminum Permanent Bridge Barrier meets the TL-4 impact conditions and evaluation criteria for a NCHRP 350, and is acceptable for use on the NHS when requested by a highway agency.

Please note the following standard provisions that apply to FHWA letters of acceptance:

- This acceptance is limited to the crashworthiness characteristics of the system and does not cover their structural features, nor conformity with the Manual on Uniform Traffic Control Devices.
- Any changes that may adversely influence the crashworthiness of the system will require a new acceptance letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals unacceptable safety problems, or that the system being marketed is significantly different from the version that was crash tested, we reserve the right to modify or revoke our acceptance.
- You will be expected to supply potential users with sufficient information on design and installation requirements to ensure proper performance.
- You will be expected to certify to potential users that the hardware furnished has essentially the same chemistry, mechanical properties, and geometry as that submitted for acceptance, and that it will meet the crashworthiness requirements of the FHWA and the NCHRP Report 350.
- To prevent misunderstanding by others, this letter of acceptance is designated as number B-213 and shall not be reproduced except in full. This letter and the test documentation upon which it is based are public information. All such letters and documentation may be reviewed at our office upon request.
- This acceptance letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented system for which the applicant is not the patent holder. The acceptance letter is limited to the crashworthiness characteristics of the candidate system, and the FHWA is neither prepared nor required to become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

Sincerely yours,

Michael S. Griffith
Director, Office of Safety Technologies
Office of Safety

Enclosures

U.S. Department of Transportation
Federal Highway Administration

1200 New Jersey Ave., SE
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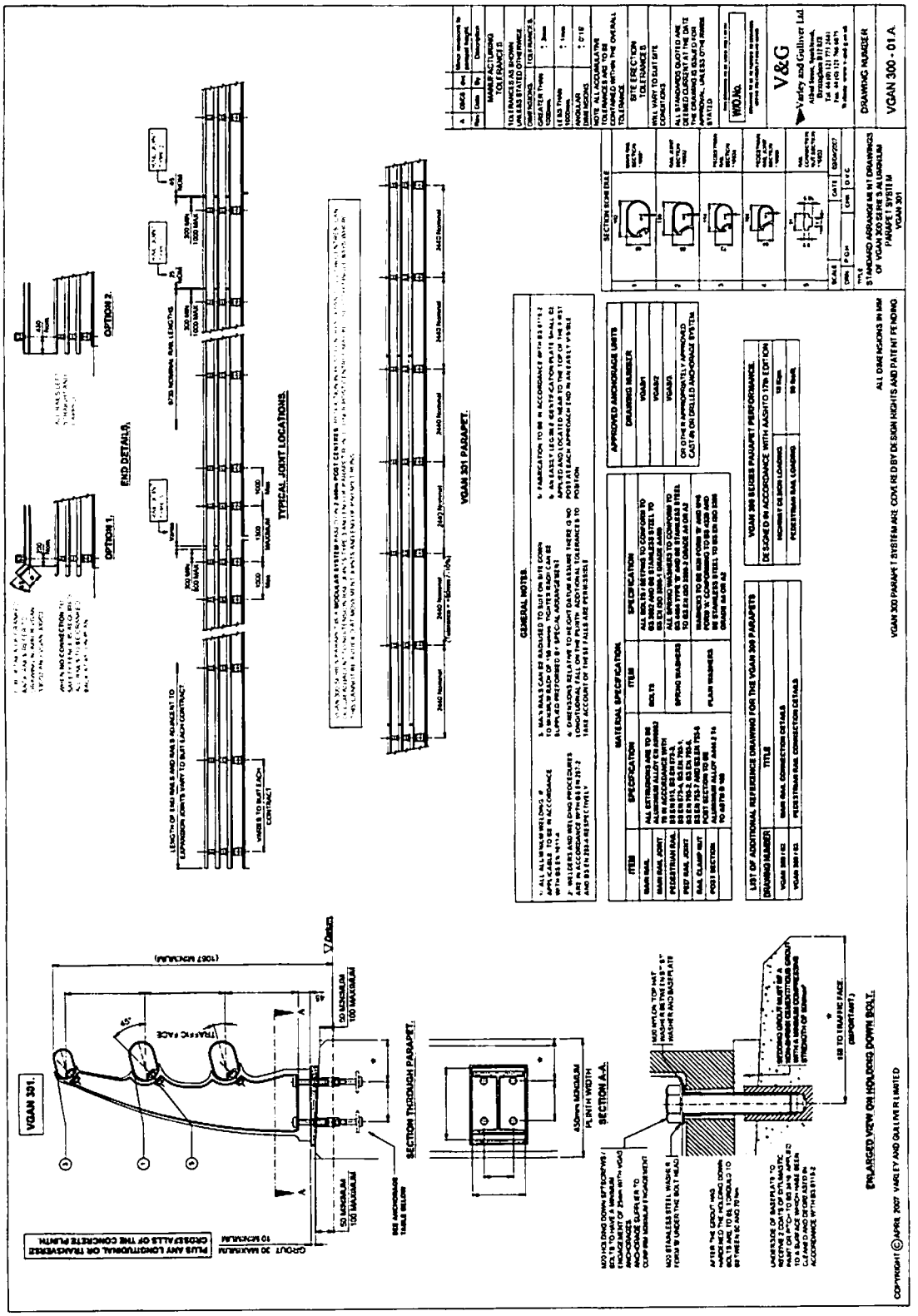
Sincerely yours,

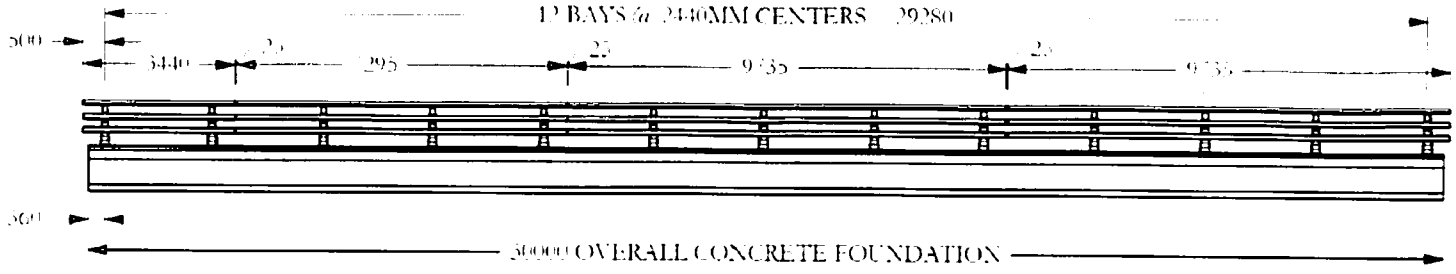
Michael S. Griffith
Director, Office of Safety Technologies
Office of Safety

Enclosures

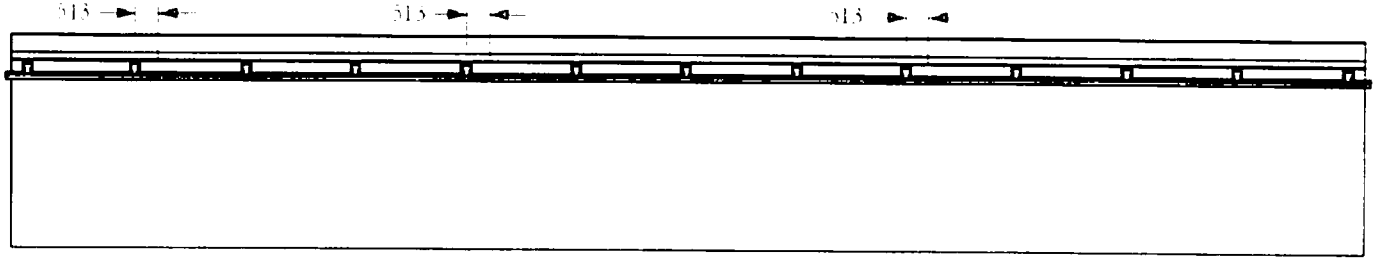
APPENDIX A. DETAILS OF THE TEST ARTICLE



FRONT ELEVATION



PLAN VIEW



The Texas A&M University System

Revisions:

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Texas Transportation Institute
College Station, Texas 77843

Date	Drawn By	Scale	Sheet No.
2010-2-22	JLH	1:130	1 of 10

Project No. 401761-VGL

Elevation View

VGL Bridge Rail

Approved:
Dean Alberson:

Signature

Date:
2010-05-03

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ITEM NO.	PART NAME	QTY.
1	Rebar Stirrup	184
2	Rebar, L	66
3	Rebar, 16	1
4	Rebar, 12	1
5	Main rail joint	6
6	Main rail 9735	4
7	Main rail 7295	2
8	Main rail 3440	2
9	Rail post	13
10	Pedestrian rail joint	3
11	Pedestrian rail 9735	2

ITEM NO.	PART NAME	QTY.
12	Pedestrian rail 7295	1
13	Pedestrian rail 3440	1
14	Rail nut	54
15	Hex bolt M16 x 45	52
16	Nylon washer, M16	78
17	Stainless steel washer, M16	78
18	Spring washer, M16 for rail bolt	78
19	Stainless steel washer, M20 for anchor bolts	52
20	Nylon washer, M20 for anchor bolt	52
21	Hex bolt M20 x 100	52
22	Hex bolt M16 x 35	26
26	Hex bolt M20 x 100	52
27	B18.2.3.6M - Heavy hex bolt M20 x 2.5 x 80 --46N	52

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Project No. Materials

401761-VGL

VGL Bridge Rail

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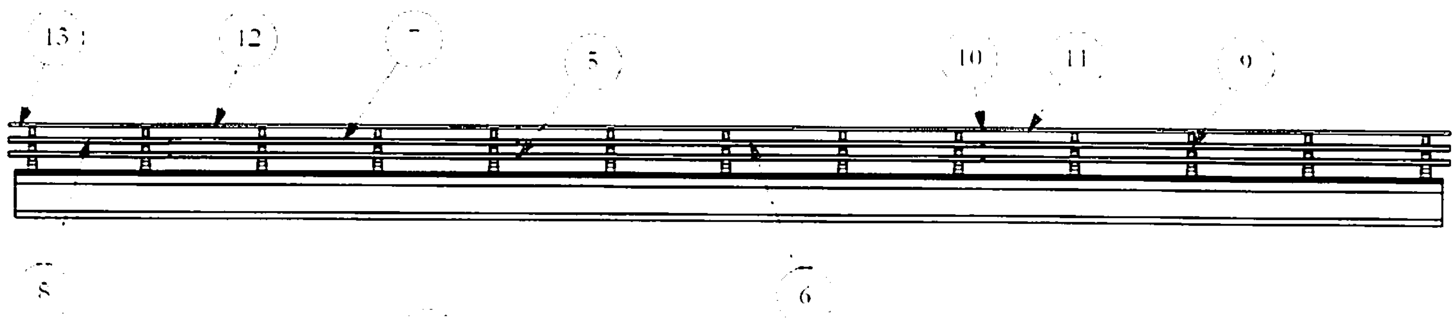

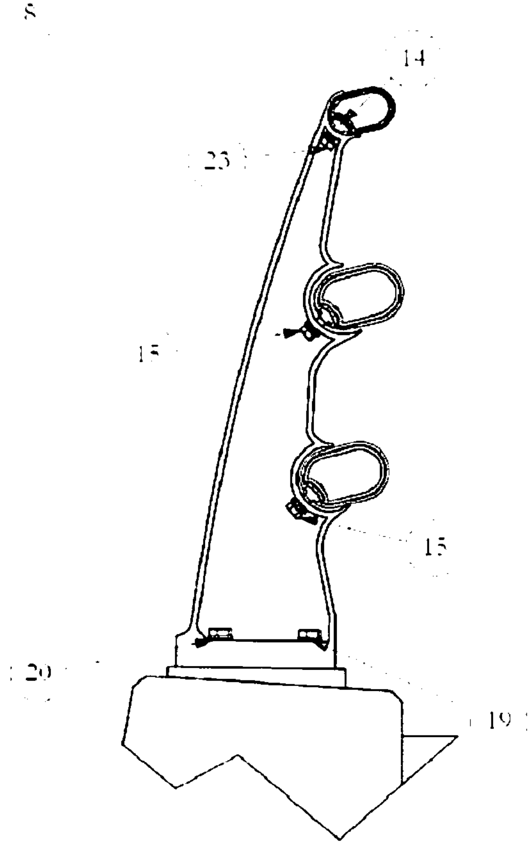

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College Station, Texas 77843

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Project No. Parts

401761-VGL

VGL Bridge Rail

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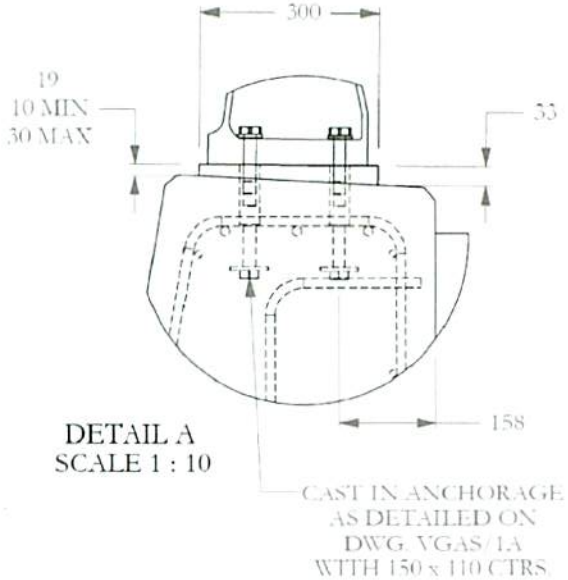

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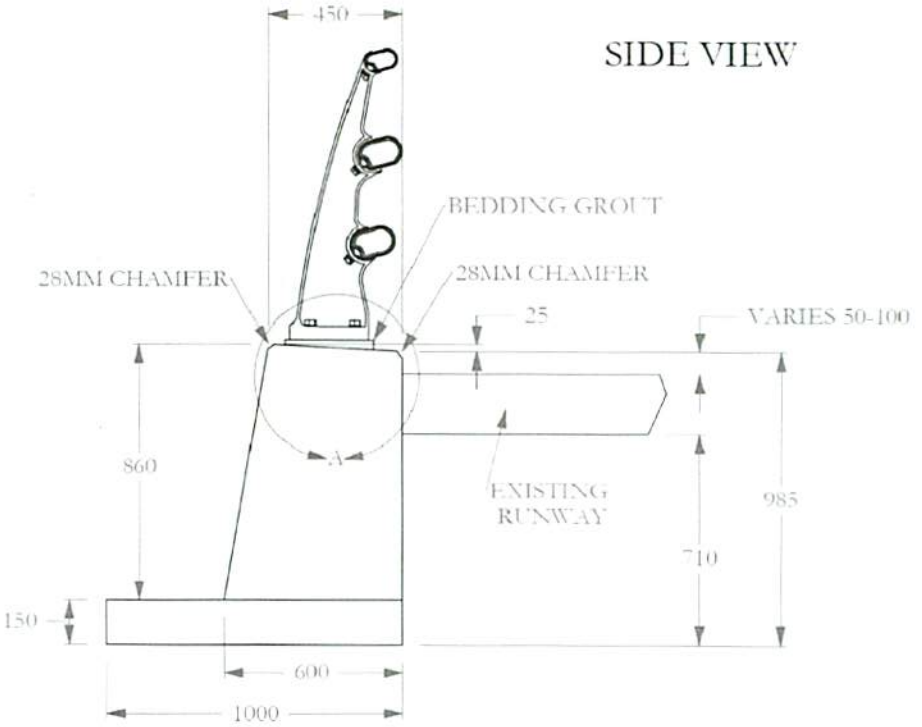
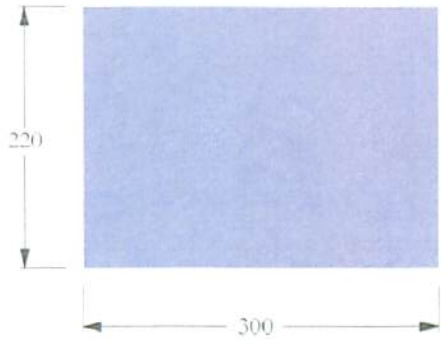


BEDDING GROUT



The Texas A&M University System

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College Station, Texas 77843

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Project No.		Concrete	
401761-VGL			
VGL Bridge Rail			

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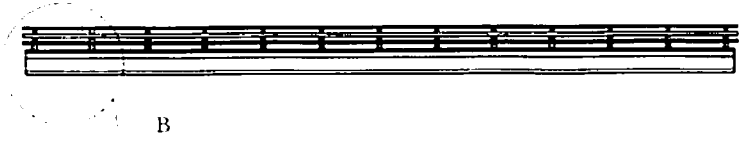
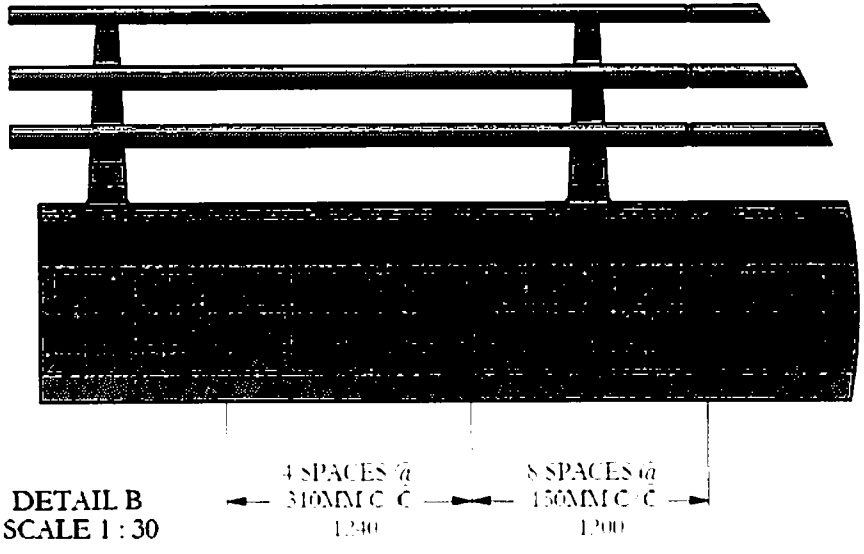
FRONT VIEW





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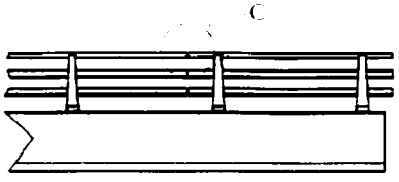
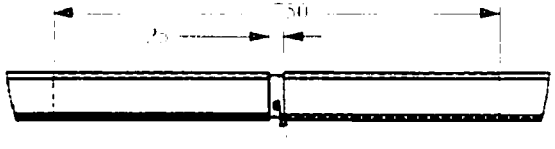
BACK VIEW





DETAIL C
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STIRRUP SPACING TYPICAL-
FULL INSTALLATION

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Project No. Stirrup Spacing
401761-VGL
VGL Bridge Rail

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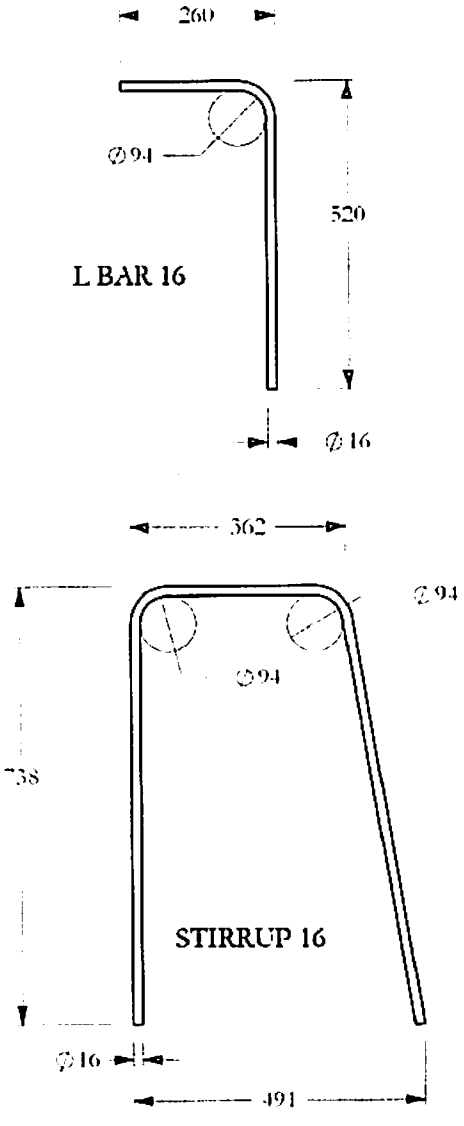

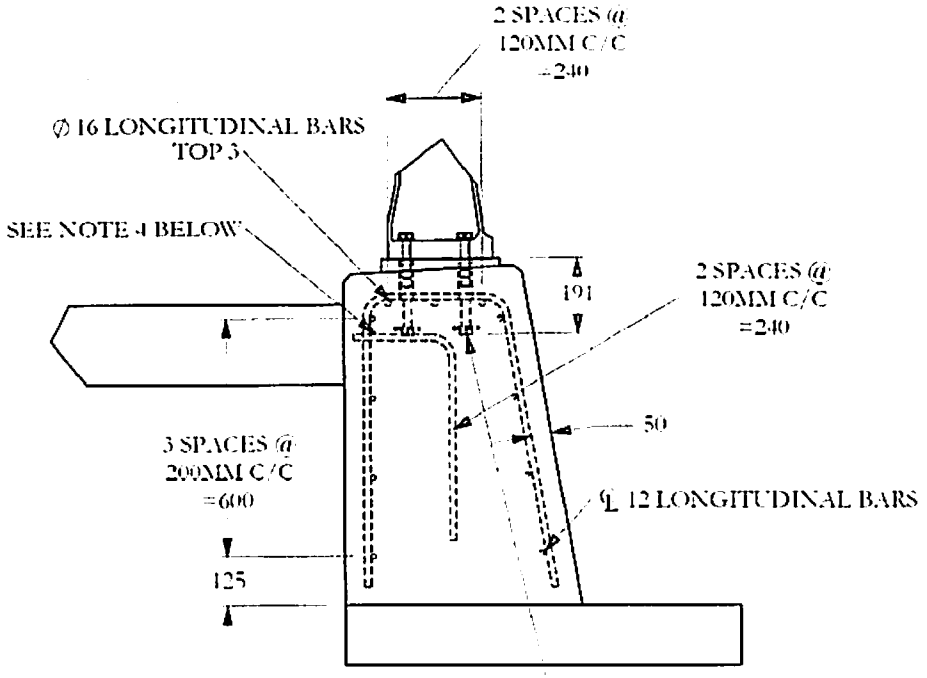

1. CONCRETE STRENGTH : 5800
2. REBAR LAP LENGTH: 815
3. REBAR : GRADE 60
4. WELDED TO EXISTING REBAR (NOT SHOWN)

The Texas A&M University System

Texas Transportation Institute
College Station, Texas 77843

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Project No. 401761-VGL

Rebar Details

VGL Bridge Rail

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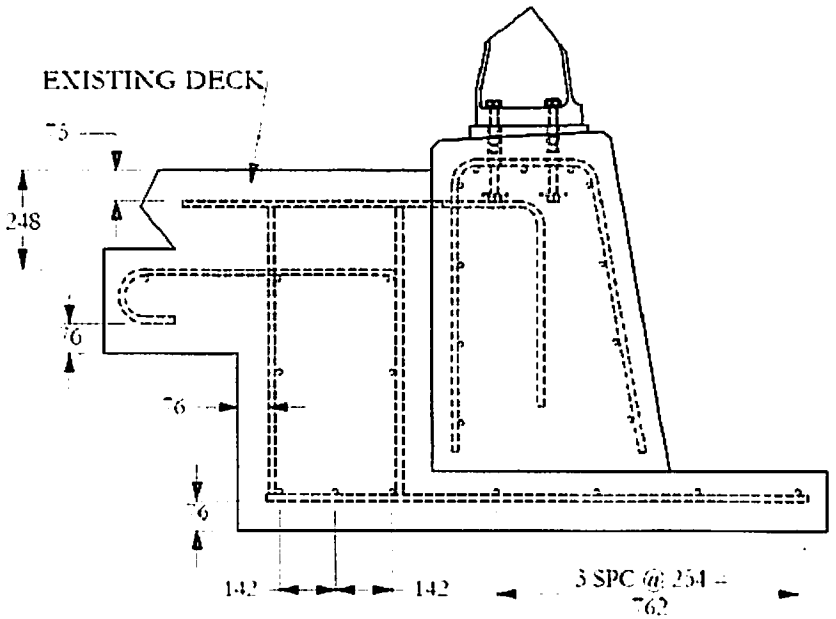

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College Station, Texas 77843

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3.				Project No.		Existing rebar	
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5.				VGL Bridge Rail			

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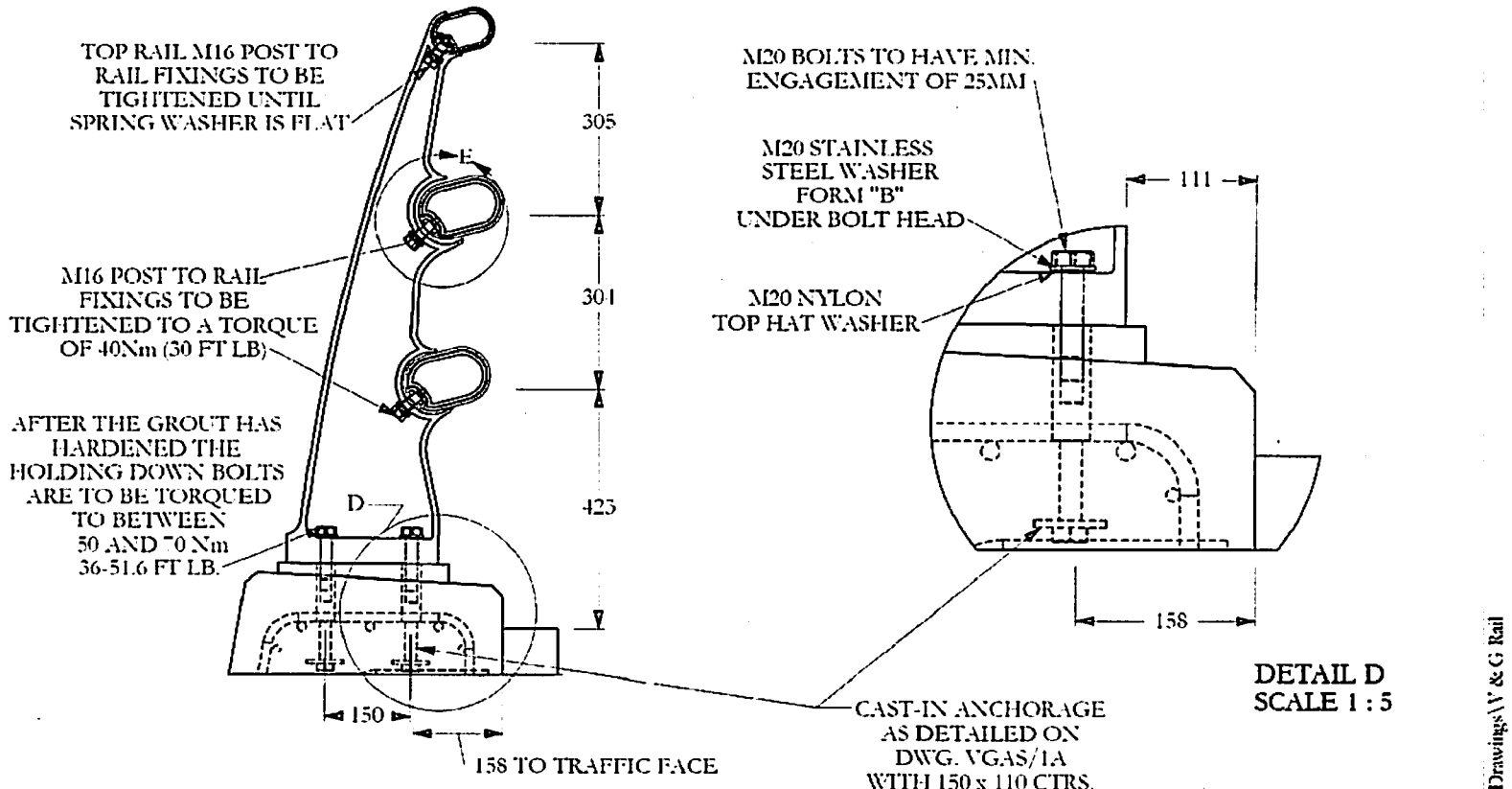

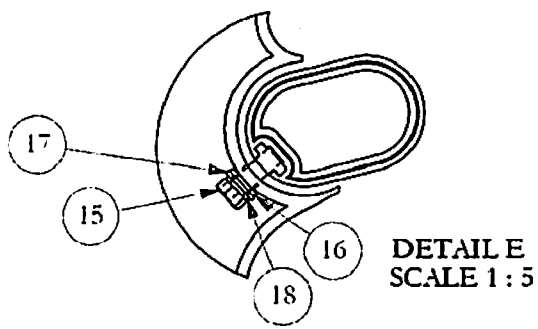

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Project No. 401761-VGL

Anchor Bolt Details

VGL Bridge Rail

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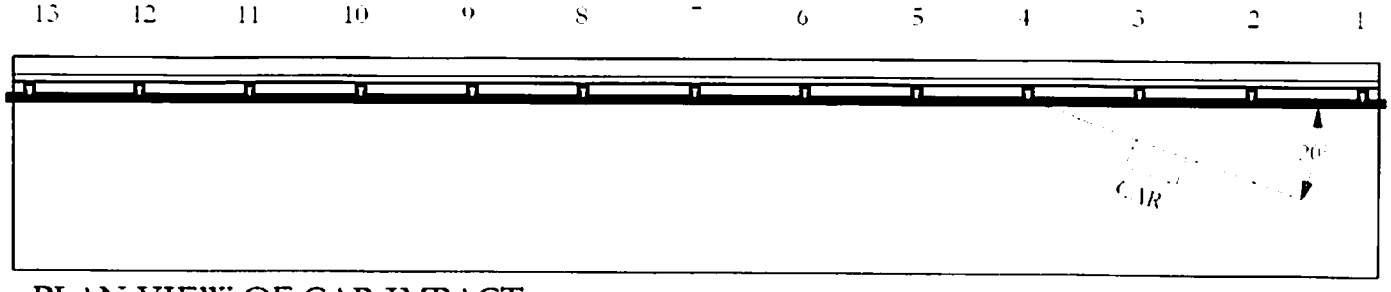
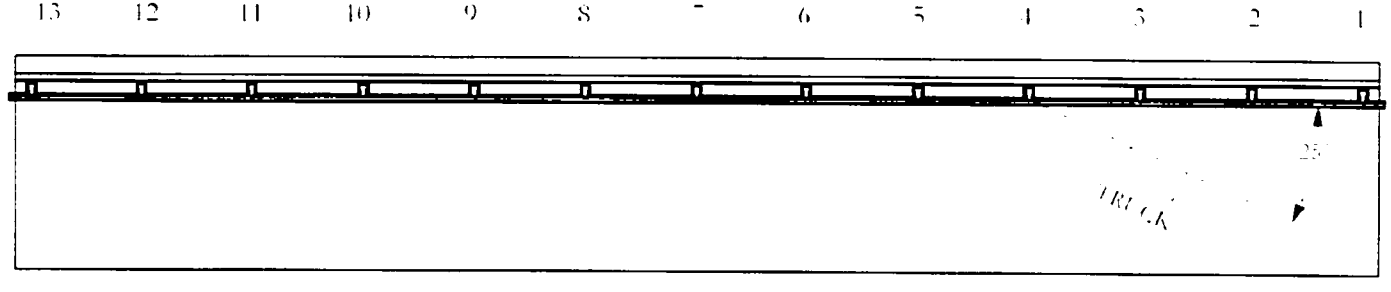


PLAN VIEW OF CAR IMPACT



PLAN VIEW OF TRUCK IMPACT

The Texas A&M University System

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Project No. Impact 1 & 2

401761-VGL

VGL Bridge Rail

Approved: Signature: Date:

Dean Alberson:

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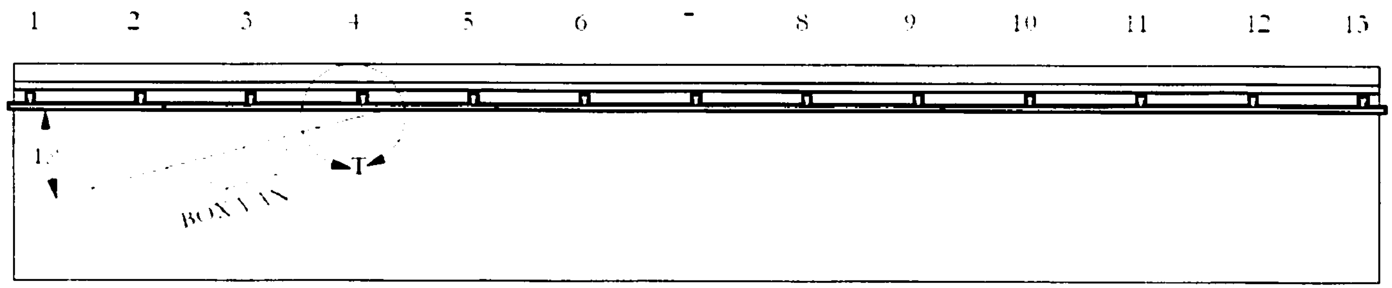
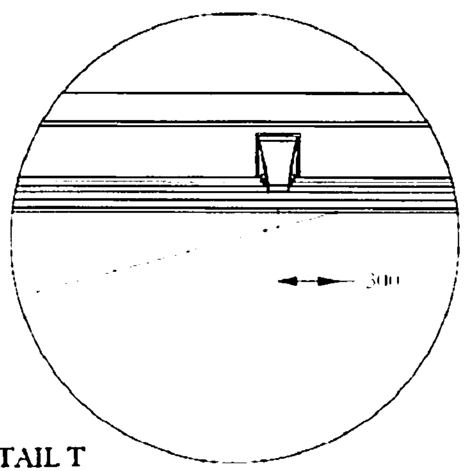


PLAN VIEW OF BOX VAN IMPACT



DETAIL T
SCALE 1 : 30

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Project No. 401761-VGL

Impact 3

VGL Bridge Rail

Approved: Dean Alberson:

Signature:

Date:

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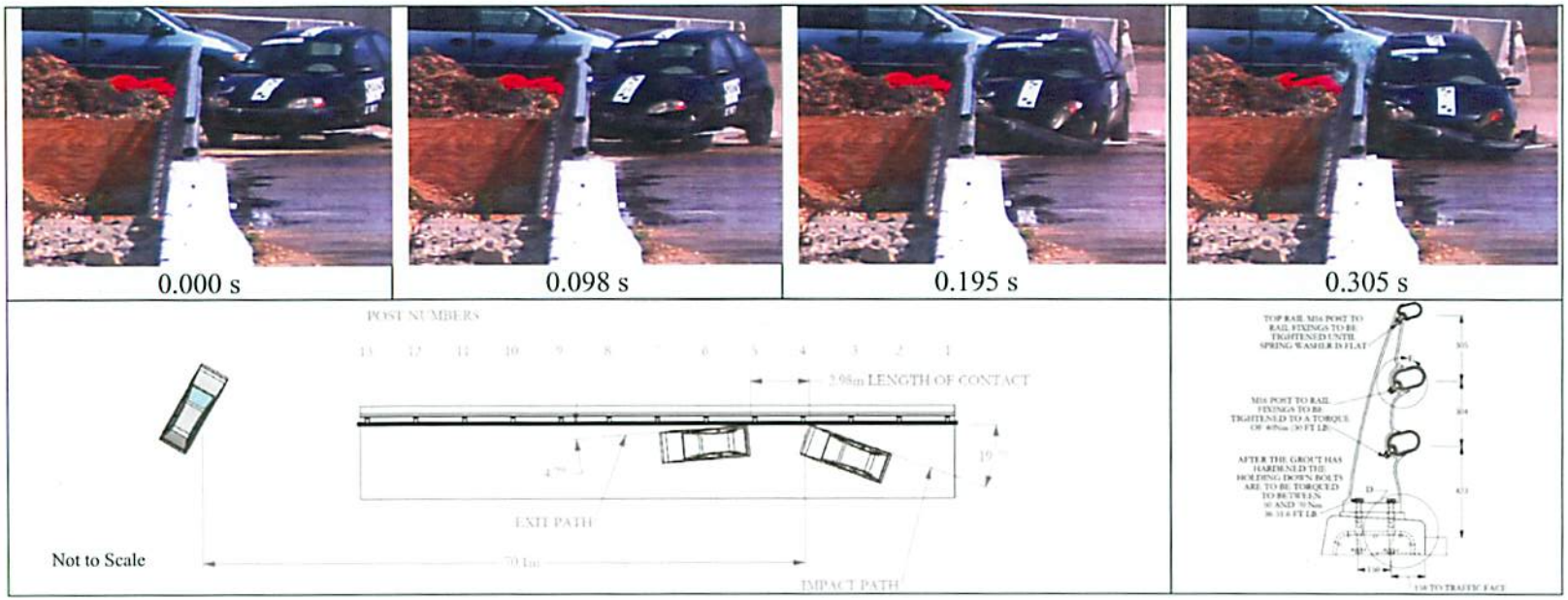


General Information
- Test Agency ..... Texas Transportation Institute
- Testing Standard Test No. ..... *NCHRP Report 350* 4-10
- Test No. 401761-VGL1
- Date 2010-04-27

Test Article
- Type ..... Bridge Rail
- Name ..... VGAN 300 Aluminum Bridge Parapet
- Installation Length ..... 30.3 m
- Material or Key Elements ..... 3 horizontal extruded 6082 T6 aluminum tubes sections on A444.0 T4 aluminum posts spaced at 2.44 m

Soil Type and Condition ..... Concrete Bridge Deck, Dry

Test Vehicle
- Type/Designation 820C
- Make and Model ..... 1995 Geo Metro
- Curb ..... 837 kg
- Test Inertial ..... 845 kg
- Dummy ..... 75 kg
- Gross Static ..... 920 kg

Impact Conditions
- Speed ..... 101.9 km/h
- Angle ..... 19.7 degrees
- Location/Orientation ..... At post 4

Exit Conditions
- Speed ..... 88.4 km/h
- Angle ..... 4.7 degrees

Occupant Risk Values
- Impact Velocity
  - Longitudinal ..... 3.7 m/s
  - Lateral ..... 8.1 m/s
- Ridedown Accelerations
  - Longitudinal ..... -6.1 G
  - Lateral ..... -9.1 G
- THIV ..... 32.5 km/h
- PHD ..... 9.2 G
- ASI 1.72
- Max. 0.050-s Average
  - Longitudinal ..... -6.8 G
  - Lateral ..... -14.6 G
  - Vertical ..... 2.2 G

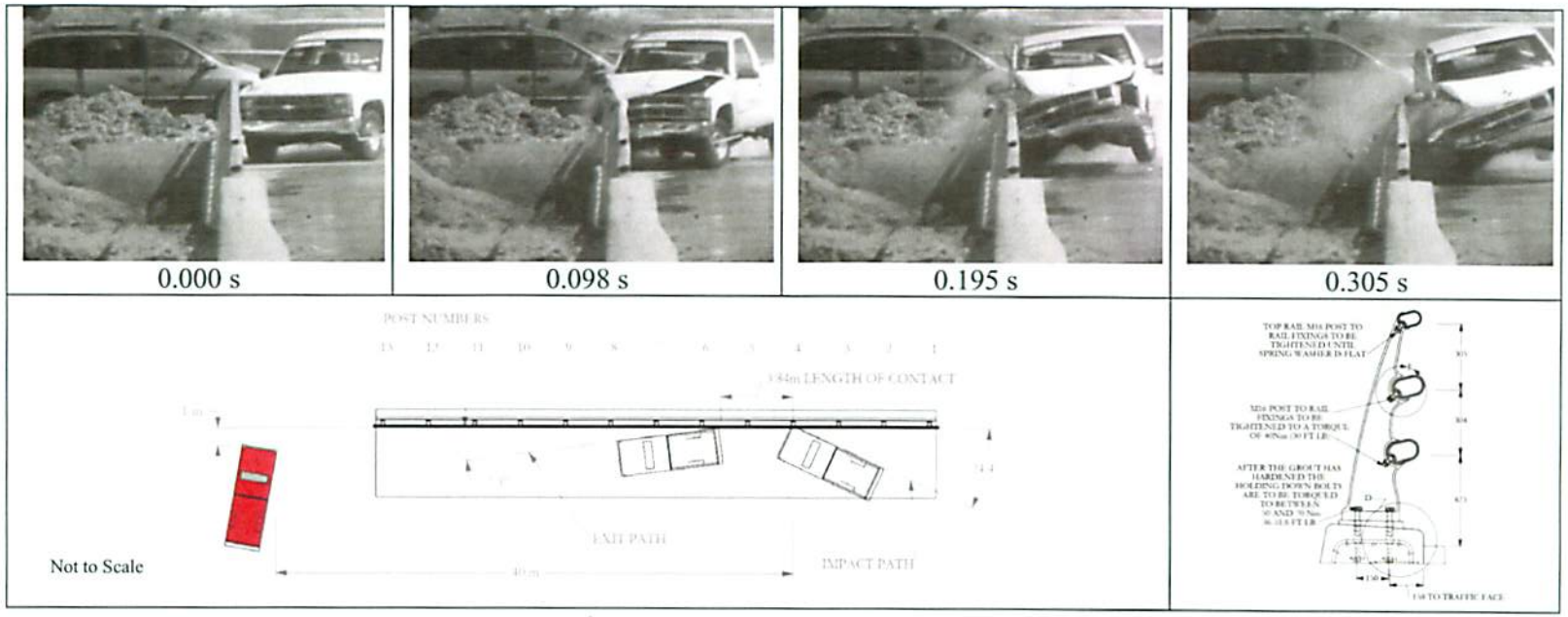
Post-Impact Trajectory
- Stopping Distance ..... 70.1 m

Vehicle Stability
- Maximum Yaw Angle ..... 432 degrees
- Maximum Pitch Angle ..... 9 degrees
- Maximum Roll Angle ..... 15 degrees
- Vehicle Snagging ..... No
- Vehicle Pocketing ..... No

Test Article Deflections
- Dynamic ..... 155 mm
- Permanent ..... 5 mm
- Working Width ..... 159 mm

Vehicle Damage
- VDS 01RFQ4
- CDC 01FREW3
- Max. Exterior Deformation ..... 220 mm
- Max. Occupant Compartment Deformation ..... 30 mm

Figure 10. Summary of results for *NCHRP Report 350* test 4-10 on the VGAN 300 aluminum bridge rail.



General Information
- Test Agency ..... Texas Transportation Institute
- Testing Standard Test No. ..... *NCHRP Report 350* 4-11
- Test No. 401761-VGL2
- Date 2010-04-28

Test Article
- Type ..... Bridge Rail
- Name ..... VGAN 300 Aluminum Bridge Parapet
- Installation Length ..... 30.3 m
- Material or Key Elements ..... 3 horizontal extruded 6082 T6 aluminum tubes sections on A444.0 T4 aluminum posts spaced at 2.44 m

Soil Type and Condition ..... Concrete Deck, Dry

Test Vehicle
- Type/Designation 2000P
- Make and Model ..... 1997 Chevrolet C2500 Pickup
- Curb ..... 2174 kg
- Test Inertial ..... 2083 kg
- Dummy ..... No dummy
- Gross Static ..... 2083 kg

Impact Conditions
- Speed ..... 100.7 km/h
- Angle ..... 24.4 degrees
- Location/Orientation ..... At post 4

Exit Conditions
- Speed ..... 68.5 km/h
- Angle ..... 7.2 degrees

Occupant Risk Values
- Impact Velocity
  - Longitudinal ..... 6.6 m/s
  - Lateral ..... 7.5 m/s
- Ridedown Accelerations
  - Longitudinal ..... -18.2 G
  - Lateral ..... -12.6 G
- THIV ..... 35.7 km/h
- PHD ..... 9.9 G
- ASI 1.48
- Max. 0.050-s Average
  - Longitudinal ..... -10.7 G
  - Lateral ..... -11.7 G
  - Vertical ..... 5.7 G

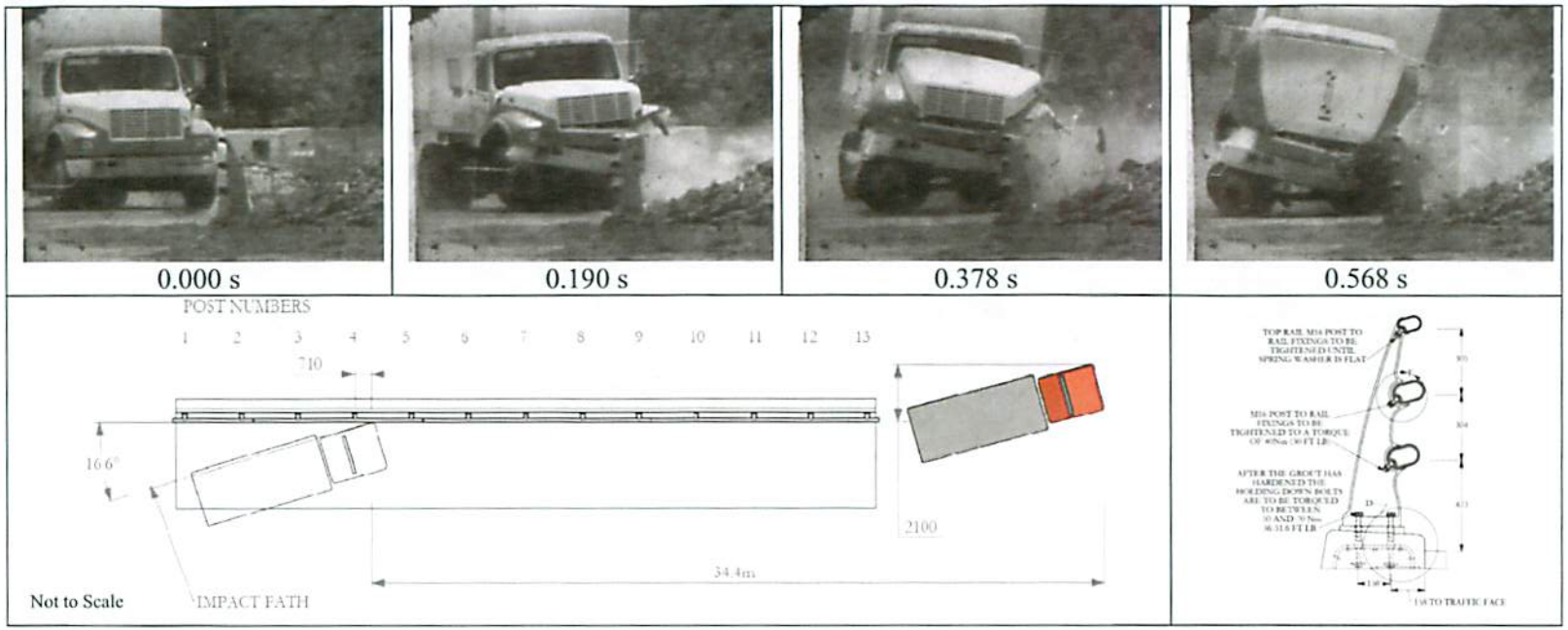
Post-Impact Trajectory
- Stopping Distance ..... 40.2 m dwnstrm, 1 m twd traffic

Vehicle Stability
- Maximum Yaw Angle ..... 114 degrees
- Maximum Pitch Angle ..... 19 degrees
- Maximum Roll Angle ..... -27 degrees
- Vehicle Snagging ..... No
- Vehicle Pocketing ..... No

Test Article Deflections
- Dynamic ..... 360 mm
- Permanent ..... 190 mm
- Working Width ..... 520 mm

Vehicle Damage
- VDS 01RFQ4
- CDC 01RFEW3
- Max. Exterior Deformation ..... 600 mm
- Max. Occupant Compartment Deformation ..... 100 mm

Figure 17. Summary of results for *NCHRP Report 350* test 4-11 on the VGAN 300 aluminum bridge rail.



General Information
- Test Agency: Texas Transportation Institute
- Testing Standard Test No.: *NCHRP Report 350* 4-12
- Test No.: 401761-VGL3
- Date: 2010-04-29

Test Article
- Type: Bridge Rail
- Name: VGAN 300 Aluminum Bridge Parapet
- Installation Length: 30.3 m
- Material or Key Elements: 3 horizontal extruded 6082 T6 aluminum tubes sections on A444.0 T4 aluminum posts spaced at 2.44 m

Soil Type and Condition: Concrete Deck, Dry

Test Vehicle
- Type/Designation: 8000S
- Make and Model: 1999 International 4700
- Curb: 5647 kg
- Test Inertial: 7951 kg
- Dummy: No dummy
- Gross Static: 7951 kg

Impact Conditions
- Speed: 82.1 km/h
- Angle: 16.6 degrees
- Location/Orientation: 710 mm dwn of post 4

Exit Conditions
- Speed: Not obtainable
- Angle: Not obtainable

Occupant Risk Values
- Impact Velocity
  - Longitudinal: 3.9 m/s
  - Lateral: 3.4 m/s
- Ridedown Accelerations
  - Longitudinal: -4.4 G
  - Lateral: 6.5 G
- THIV: 19.8 km/h
- PHD: 7.2 G
- ASI: 0.42
- Max. 0.050-s Average
  - Longitudinal: -3.7 G
  - Lateral: 3.6 G
  - Vertical: 2.7 G

Post-Impact Trajectory
- Stopping Distance: 40.2 m dwnstrm 1 m twd traffic

Vehicle Stability
- Maximum Yaw Angle: -17 degrees
- Maximum Pitch Angle: 14 degrees
- Maximum Roll Angle: -18 degrees
- Vehicle Snagging: No
- Vehicle Pocketing: No

Test Article Deflections
- Dynamic: Not obtainable
- Permanent: 300 mm
- Working Width: 787 mm

Vehicle Damage
- VDS: 01LFQ4
- CDC: 01LFEW3
- Max. Exterior Deformation: 50 mm
- Max. Occupant Compartment Deformation: 0 mm

Figure 23. Summary of results for *NCHRP Report 350* test 4-12 on the VGAN 300 aluminum bridge rail.