



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:

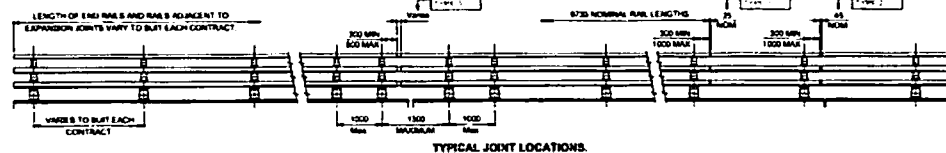
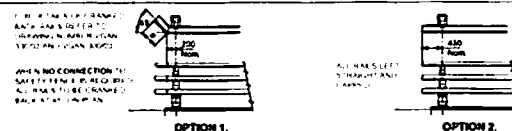
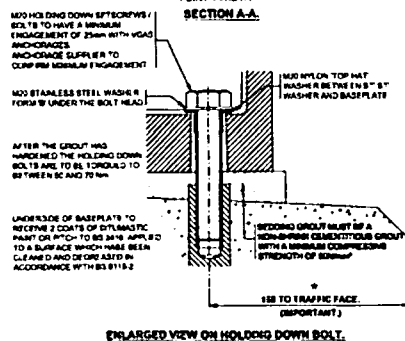
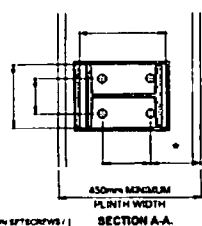
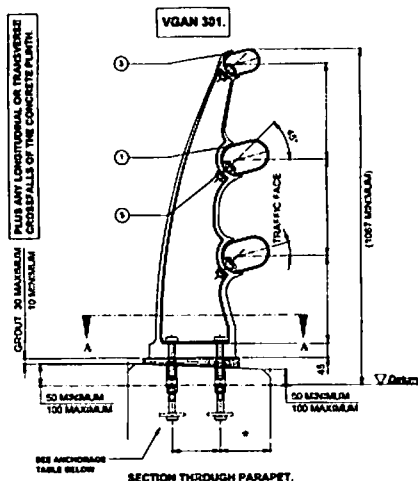
- This acceptance is limited to the crashworthiness characteristics of the system and does not cover their structural features, nor conformity with the Manual on Uniform Traffic Control Devices.
- Any changes that may adversely influence the crashworthiness of the system will require a new acceptance 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

**VDAN 201 PARAPET**

## GENERAL MOTORS

- |  |   |  |
|--|---|--|
| 1. ALL ASSEMBLY WELDING IS<br>APPLIED TO BE IN ACCORDANCE<br>WITH BS EN 1011                     | 2. MAIN WELDS CAN BE REDUCED TO BUT ON ONE CORNER<br>TO MINOR IN EACH OF THE OTHER CORNERS<br>SLOPPED PERFORMED BY SPECIAL AGREEMENT                        | 3. FABRICATION TO BE IN ACCORDANCE WITH BS EN 1011   |
| 2. WELDERS AND WELDING PROCEDURES<br>IN ACCORDANCE WITH BS EN 1011-2<br>AND BS EN 1011-3 MUST BE | 3. DIMENSIONS RELATIVE TO LIGHT DUTY ASSUMES THERE IS NO<br>TOLERANCE FALL ON THE PLATE. ADDITIONAL TOLERANCES TO<br>TOLERANCE OF THE PLATE ARE PERMISSIBLE | 4. AN EASY TO LOCATE IDENTIFICATION PLATE SHALL BE<br>APPLIED AND LOCATED NEAR TO THE TOP OF THE PLATE<br>POSITION APPROXIMATE TO THE EASY TO LOCATE<br>POSITION |

MATERIAL SPECIFICATION				APPROVED ANCHORAGE UNITS
ITEM	SPECIFICATION	ITEM	SPECIFICATION	DRAWING NUMBER
RAIL RAIL	ALL STEELWORKS ARE TO BE ALUMINUM ALLOY EN 48088	BOLTS	ALL BOLTS 1/2" METRIC TO CONFORM TO BS 3393 AND BS 3396 AND BS 3393 AND BS 3396 1/2" DRAGON SCALE	VS041
RAIL RAIL JOINT	ALL STEELWORKS ARE TO BE ALUMINUM ALLOY EN 48088			VS042
PEDESTRIAN RAIL	BS 5131, BS 5132, BS 5133, BS 5134, BS 5135, BS 5136, BS 5137, BS 5138, BS 5139, BS 5140, BS 5141, BS 5142, BS 5143, BS 5144, BS 5145, BS 5146, BS 5147, BS 5148, BS 5149, BS 5150, BS 5151, BS 5152, BS 5153, BS 5154, BS 5155, BS 5156, BS 5157, BS 5158, BS 5159, BS 5160, BS 5161, BS 5162, BS 5163, BS 5164, BS 5165, BS 5166, BS 5167, BS 5168, BS 5169, BS 5170, BS 5171, BS 5172, BS 5173, BS 5174, BS 5175, BS 5176, BS 5177, BS 5178, BS 5179, BS 5180, BS 5181, BS 5182, BS 5183, BS 5184, BS 5185, BS 5186, BS 5187, BS 5188, BS 5189, BS 5190, BS 5191, BS 5192, BS 5193, BS 5194, BS 5195, BS 5196, BS 5197, BS 5198, BS 5199, BS 5200, BS 5201, BS 5202, BS 5203, BS 5204, BS 5205, BS 5206, BS 5207, BS 5208, BS 5209, BS 5210, BS 5211, BS 5212, BS 5213, BS 5214, BS 5215, BS 5216, BS 5217, BS 5218, BS 5219, BS 5220, BS 5221, BS 5222, BS 5223, BS 5224, BS 5225, BS 5226, BS 5227, BS 5228, BS 5229, BS 5230, BS 5231, BS 5232, BS 5233, BS 5234, BS 5235, BS 5236, BS 5237, BS 5238, BS 5239, BS 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LIST OF ADDITIONAL REFERENCE DRAWING FOR THE VGAN 300 PARAPET	
DRAWING NUMBER	TITLE
VGAN 300 / 02	RAIL RAIL CONNECTION DETAILS
VGAN 300 / 03	PEDESTRIAN RAIL CONNECTION DETAILS

APPROVED ANCHORAGE UNITS

DRAWING NUMBER

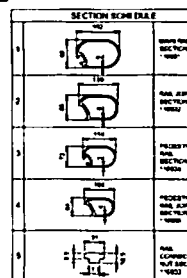
VCAS1

VCAS2

VCAS3

OR OTHER APPROPRIATELY APPROVED  
CAST-IN OR DRILLED-ANCHORAGE SYSTEM

VGM 300 SERIES PARAPET PERFORMANCE	
DESIGNED IN ACCORDANCE WITH AASHTO 17TH EDITION	
HIGHWAY DESIGN LOADING	18 Kips
PEDESTRIAN RAIL LOADING	20 Kips



SCALE		DATE	03/04/75
CRM	POM	CRM	DVC

7716  
STANDARD ARRANGEMENT DRAWING  
OF VGAN 300 SERIES ALUMINUM  
PARAPET SYSTEM  
VGAN 301

A	CHCA	PC	silence subjected to parquet height
By	Don	By	Chatterbox

MANUFACTURING  
TOLERANCES

TOL FRANCES AS SHOWN UNLESS STATED OTHERWISE	
CHRYSLER	TOL FRANCES
GREATER THAN 100000	0.25
LESS THAN 100000	0.15

NOTE: ALL ACCUMULATIVE TOLERANCES ARE TO BE CONTAINED WITHIN THE OVERALL TOLERANCE.

<p><b>SITE ERECTION TOLERANCES</b></p> <p>NO. 4. MAX. TO ELEV. DATE</p>
---

ALL STANDARDS QUOTED ARE  
DEEMED CURRENT AT THE DATE  
THE DRAWING IS ISSUED FOR  
APPROVAL, UNLESS OTHERWISE  
NOTED.

STATE OF TEXAS  
COUNTY OF DALLAS

WONG  
OFFICER IN CHARGE OF THE DISTRICT OF COLUMBIA  
OFFICE OF THE ATTORNEY GENERAL

V&G

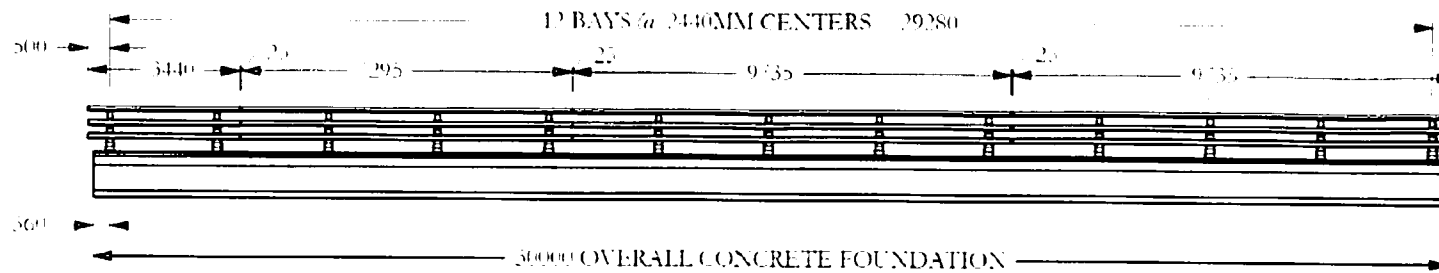
**Varley and Gulliver Ltd**  
Aired Street, Sparkbrook,

**Durhamham B17 RJ2**  
Tel: 44 (0) 121 771 2441  
Fax: 44 (0) 121 766 6875

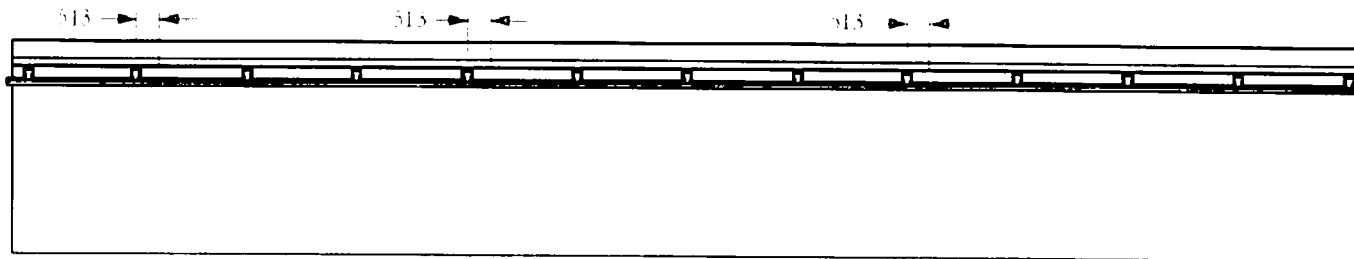
	DRAWING NUMBER
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VGAN 300 - 01.A.

# FRONT ELEVATION



# PLAN VIEW



The Texas A&M University System

Texas Transportation Institute  
College Station, Texas 77843

## Revisions:

No.	Date	By	Chk	Date	Drawn By	Scale	Sheet No.
1.				2010-2-22	JLH	1:130	1 of 10
2.							
3.							
4.							
5.							

Project No. 401-61-VGL  
Elevation View

VGL Bridge Rail  
Signature: *[Signature]*  
Date: 2010-05-03

Approved: *[Signature]*  
Dean Alberson:

T:\2009 2010\401-61 VGL\SolidWorks\Drawings\V & G Rail 2010-03-03

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 3-40	2
9	Rail post	13
10	Pedestrian rail joint	3
11	Pedestrian rail 9735	2

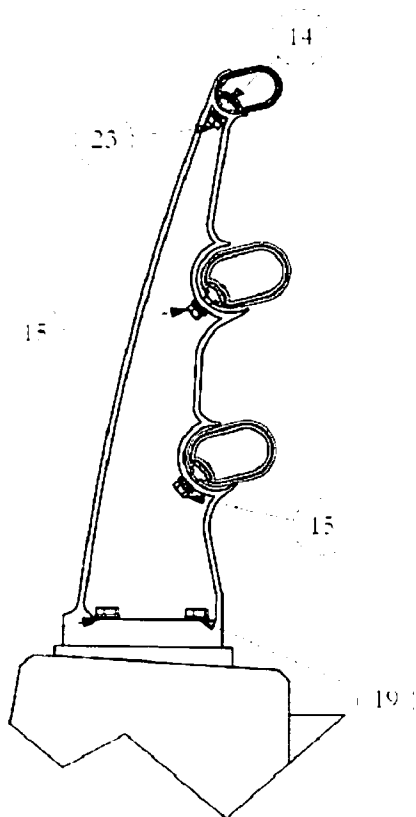
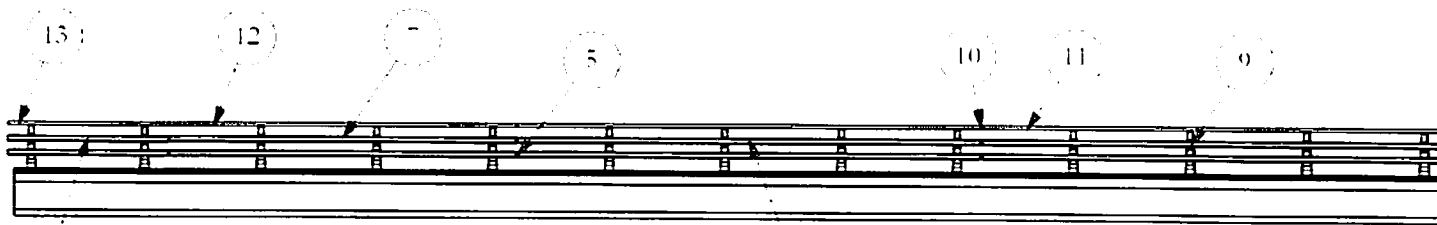
ITEM NO.	PART NAME	QTY.
12	Pedestrian rail 7295	1
13	Pedestrian rail 3-40	1
14	Rail nut	54
15	Hex bolt M16 x 45	52
16	Nylon washer, M16	78
17	Stainless steel washer, M16	78
18	Spring washer, M16 for rail bolt	78
19	Stainless steel washer, M20 for anchor bolts	52
20	Nylon washer, M20 for anchor bolt	52
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

The Texas A&M University System

Revisions:

No.	Date	By	Chk	Date	Drawn By	Scale	Sheet No.
1.							
2.				2010-02-22	JLH	1:10	2 of 10
3.					Project No.	Materials	
4.					401761-VGL		
5.					VGL Bridge Rail		

T:\2009-2010\401761-VGL\SolidWorks\Drawings\N & G Rail 2010-03-03



# Revisions:

No.	Date
1.	
2.	
3.	
4.	
5.	

The Texas A&M University System

Texas Transportation Institute  
College Station, Texas 77843

By Chk

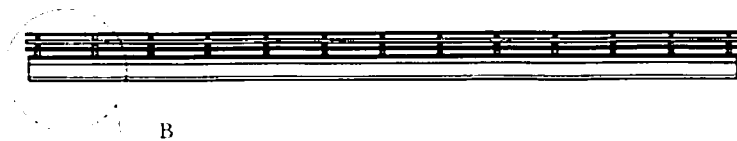
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2010-02-22	JLH	1:120	3 of 10
Project No.		Parts	
401761-VGL			
VGL Bridge Rail			

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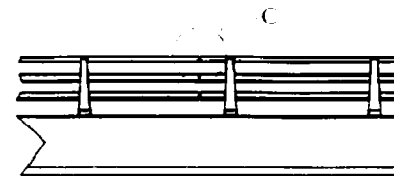




# FRONT VIEW



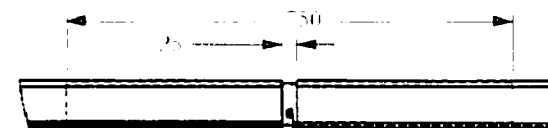
# BACK VIEW



DETAIL B  
SCALE 1 : 30

4 SPACES @ 310MM C-C 1240  
8 SPACES @ 156MM C-C 1248

STIRRUP SPACING TYPICAL-  
FULL INSTALLATION



Stirrups PIN



DETAIL C  
SCALE 1 : 10

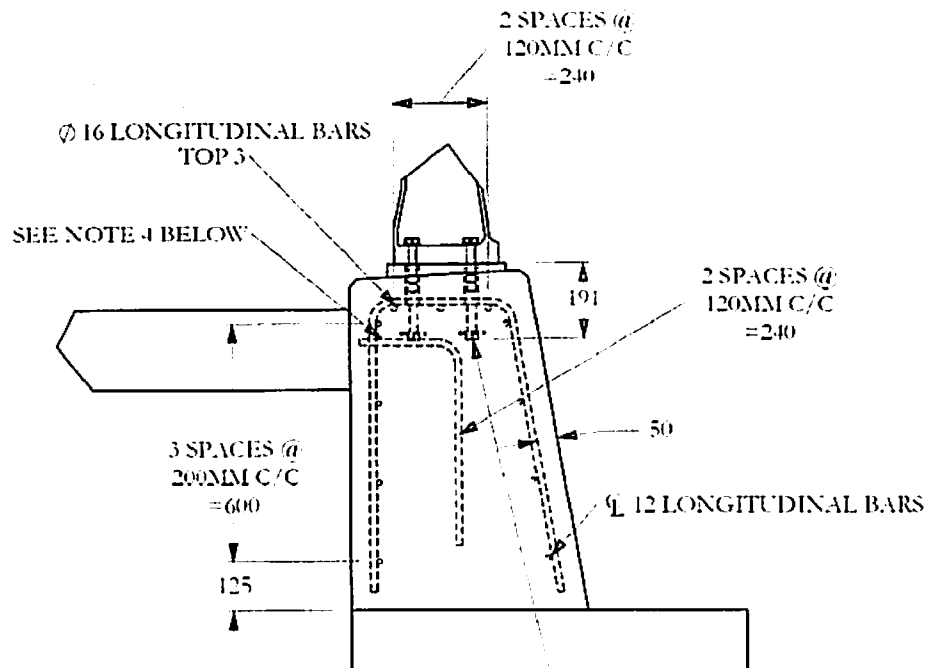
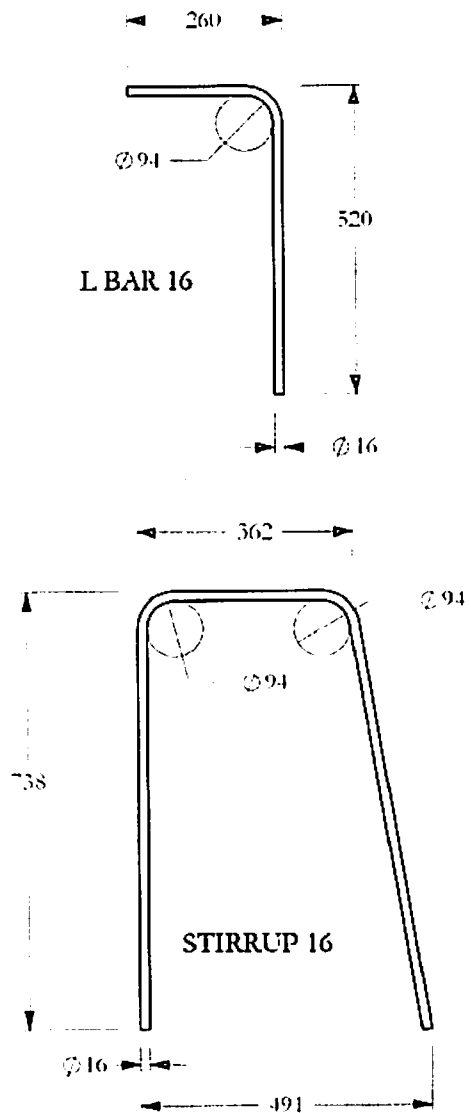
## Revisions:

No.	Date	By	Chk
1.			
2.			
3.			
4.			
5.			

The Texas A&M University System

Texas Transportation Institute  
College Station, Texas 77843

Date	Drawn By	Scale	Sheet No.
2010-02-22	JLH	1:20	5 of 10
Project No.		Stirrup Spacing	
401761-VGL			
VGL Bridge Rail			



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

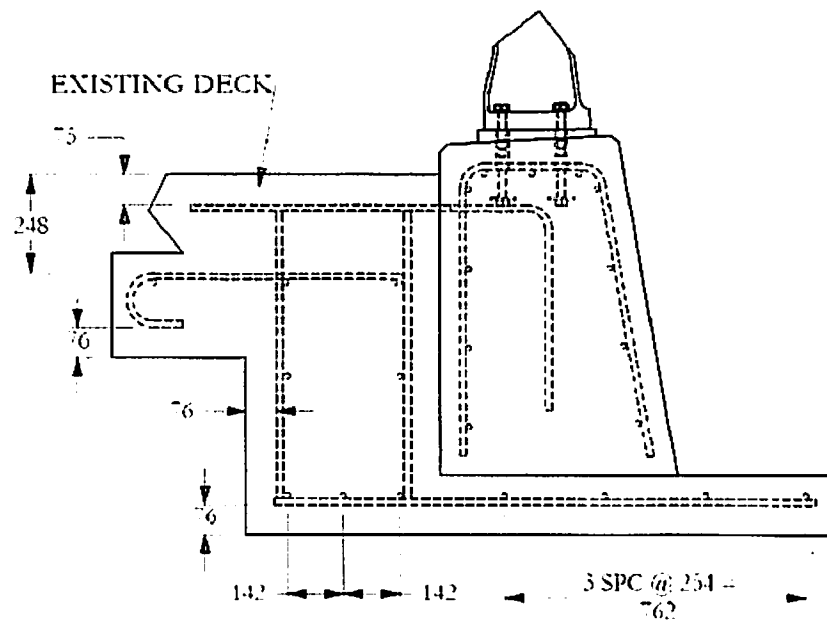
The Texas A&M University System

Texas Transportation Institute  
College Station, Texas 77843

Revisions:

No.	Date	By	Chk	Date	Drawn By	Scale	Sheet No.
1.							
2.				2010-02-22	JLH	1:15	6 of 10
3.							
4.							
5.							

Project No. 401761-VGL  
VGL Bridge Rail



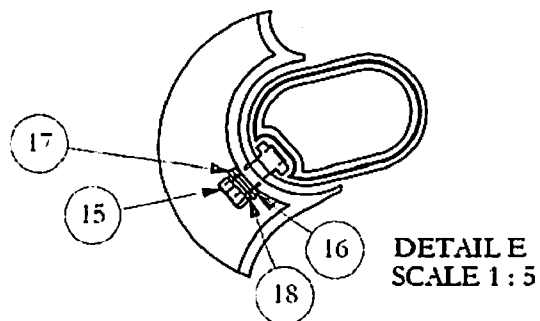
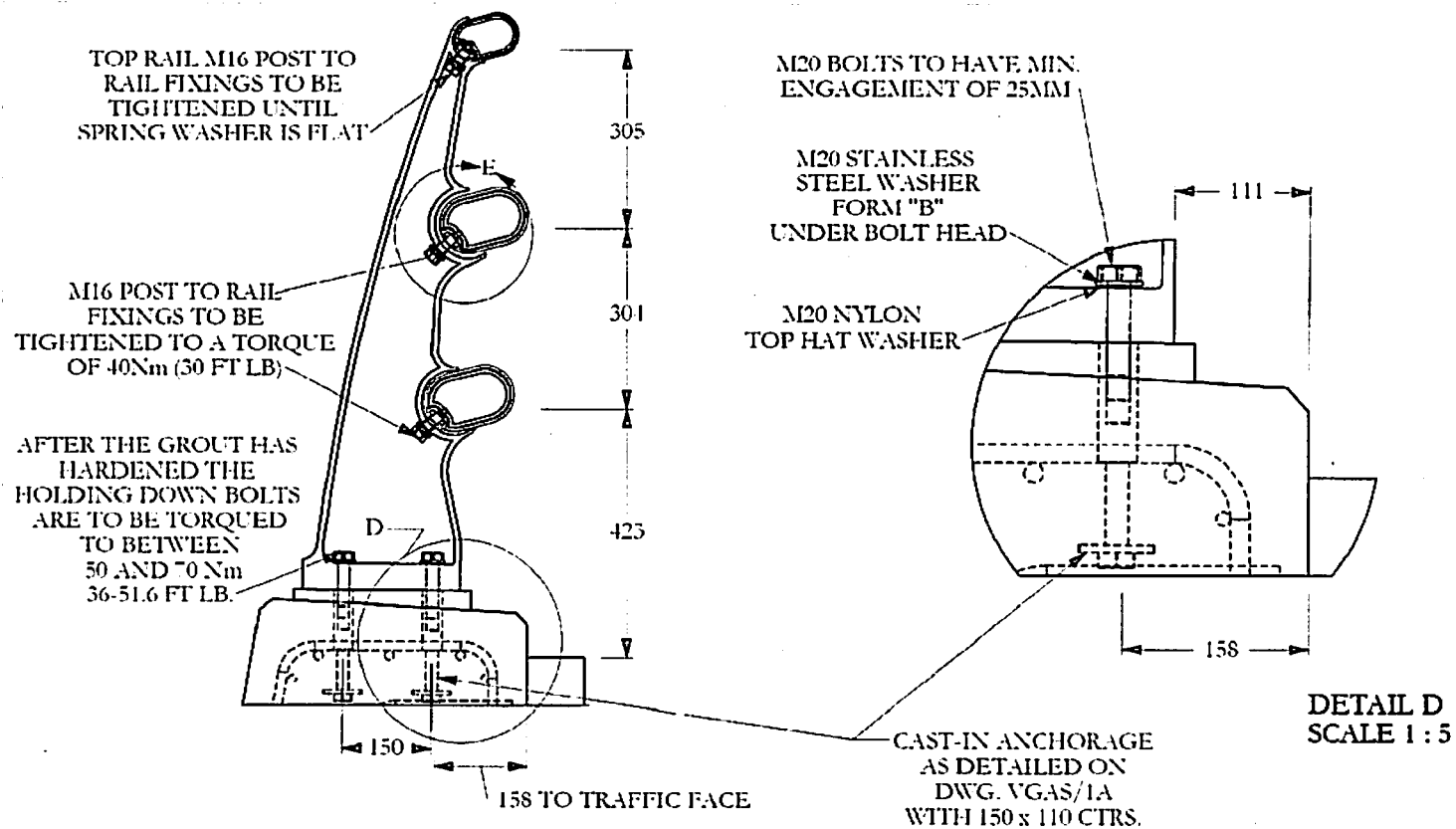
The Texas A&M University System

Texas Transportation Institute  
College Station, Texas 77843

Revisions:

No.	Date	By	Chk	Date	Drawn By	Scale	Sheet No.
1.							
2.				2010-02-22	JLH	1:15	7 of 10
3.					Project No.		Existing rebar
4.					401761-VGL		
5.					VGL Bridge Rail		

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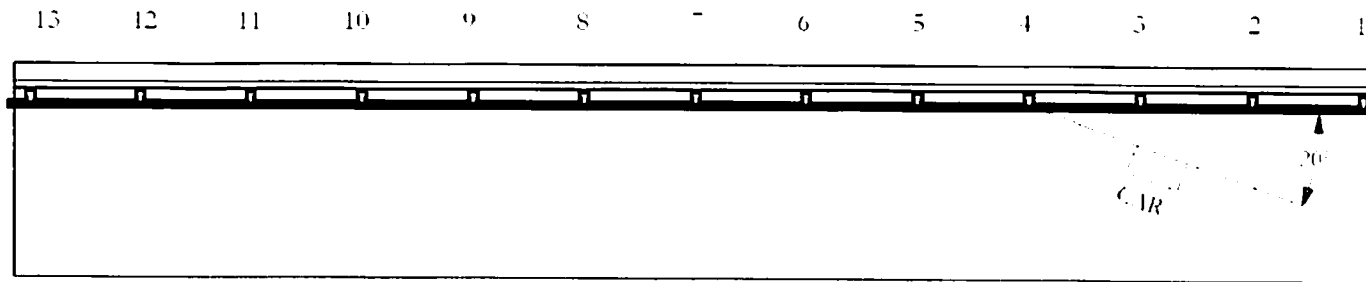
## Revisions:

No.	Date	By	Chk
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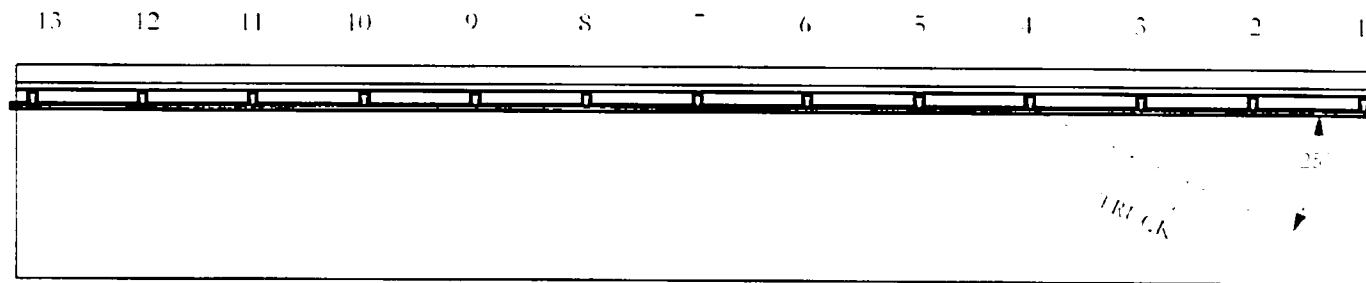
The Texas A&amp;M University System

Texas Transportation Institute  
College Station, Texas 77843

Date	Drawn By	Scale	Sheet No.
2010-02-22	JLH	1:10	8 of 10
Project No.		Anchor Bolt Details	
401761-VGL			
VGL Bridge Rail			



PLAN VIEW OF CAR IMPACT



PLAN VIEW OF TRUCK IMPACT

The Texas A&M University System

Texas Transportation Institute  
College Station, Texas 77843

Revisions:

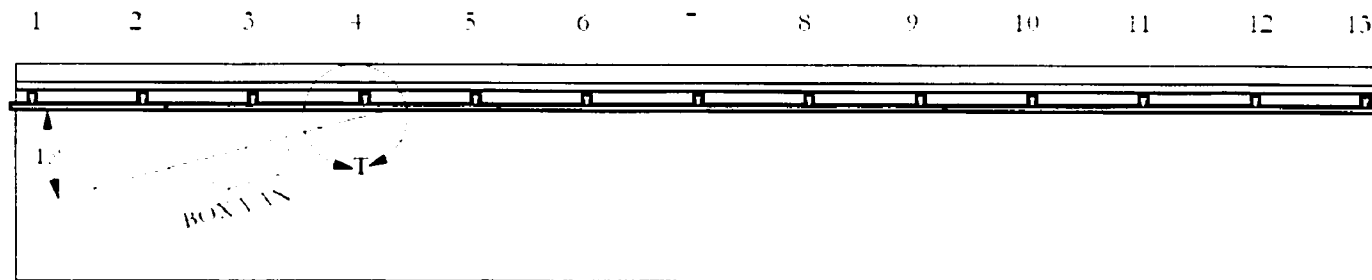
No.	Date	By	Chk
1.			
2.			
3.			
4.			
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Date	Drawn By	Scale	Sheet No.
2010-2-22	JLH	1:130	9 of 10
Project No.		Impact 1 & 2	
401761-VGL			
VGL Bridge Rail			

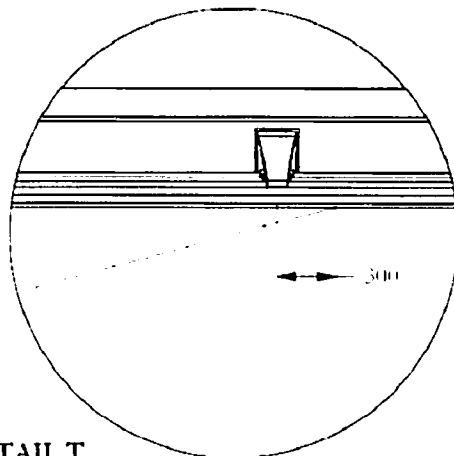
Approved:  
Dean Alberson:

Signature:

Date:

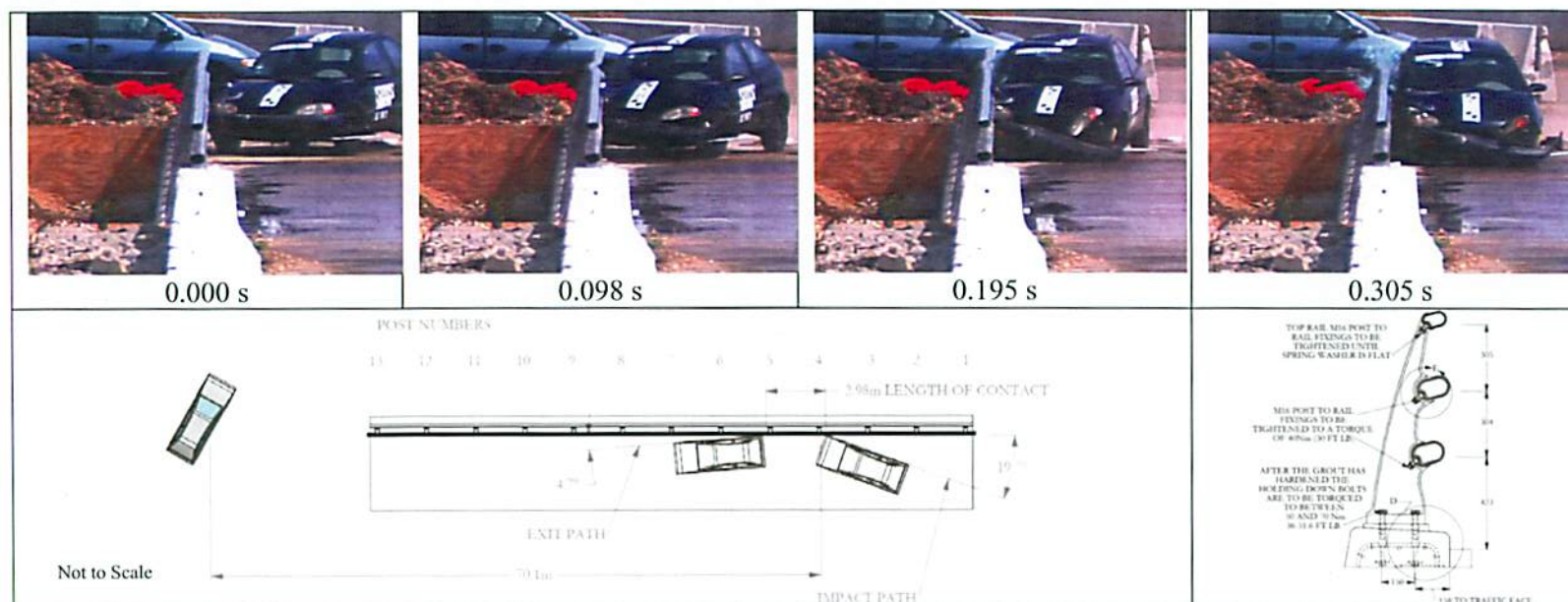


PLAN VIEW OF BOX VAN IMPACT



DETAIL T  
SCALE 1 : 30

Revisions:					The Texas A&M University System			
No.	Date	By	Chk		Texas Transportation Institute			
					College Station, Texas 77843			
1.				Date	Drawn By	Scale	Sheet No.	
2.				2010-2-22	JLH	1:130	10 of 10	
3.				Project No.		Impact 3		
4.				401761-VGL				
5.				VGL Bridge Rail				
Approved:					Signature:		Date:	
Dean Alberson:								



#### 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

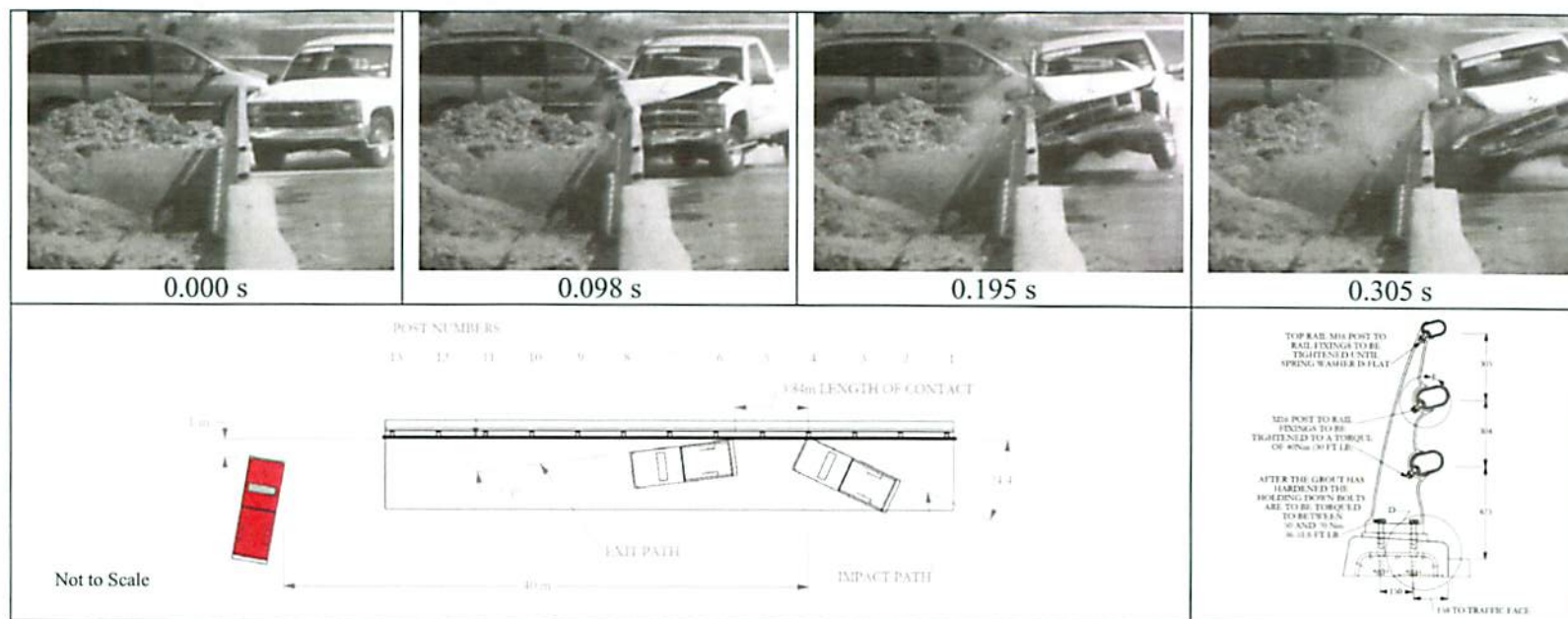
#### Test Article Deflections

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 downstrm  
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

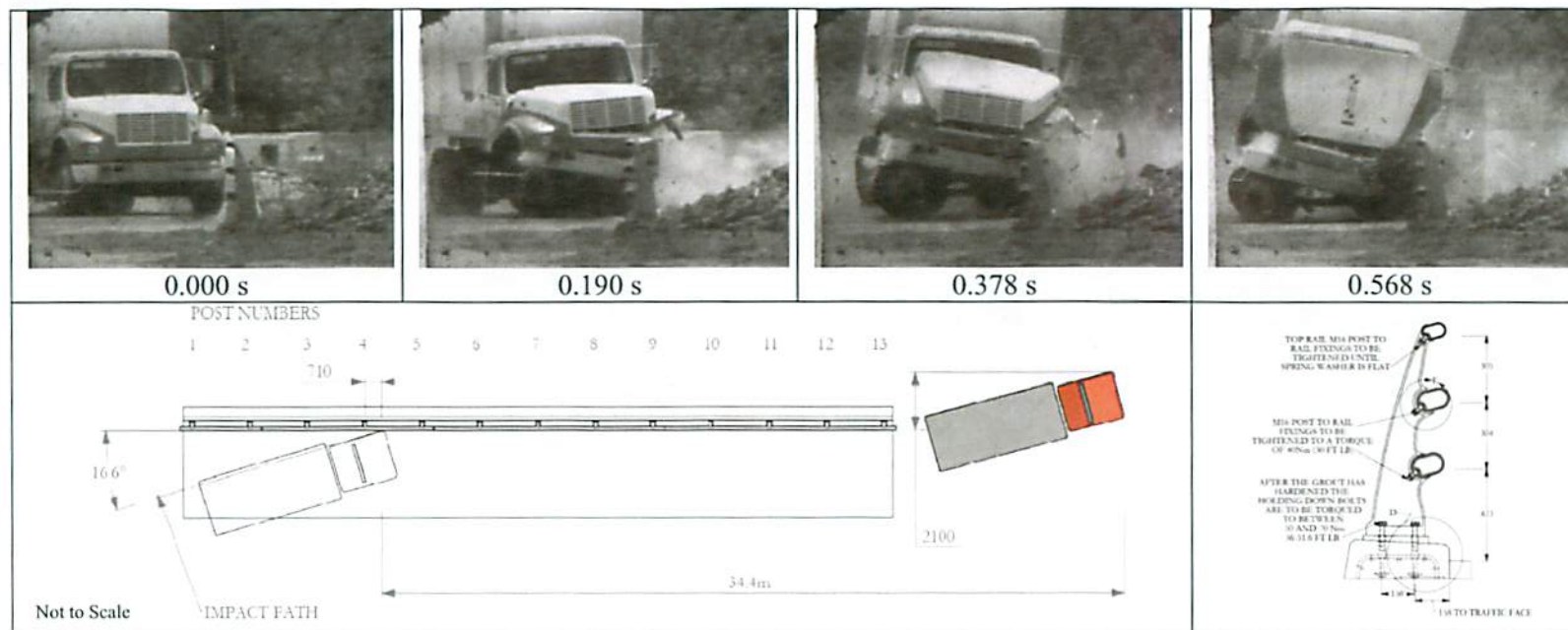
Dynamic..... 360 mm  
Permanent ..... 190 mm  
Working Width ..... 520 mm

#### 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

#### 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.