



# JRS Dynamic Rollover Test

## 2009 Nissan Versa

*Sponsored By:*

**Automotive Safety Research Institute  
Charlottesville, VA.**

## Introduction

Center for Injury Research conducted a JRS dynamic rollover test consisting of two rolls of a 2009 Nissan Versa on April 27 and 28, 2010. This test report is organized in sections containing test information, data tables and photographs as follows:

Section 1 – Test Procedures and Summaries

Section 2 – Test Results, Data Tables and Selected Comparison Photographs for Roll 1.

Section 3 – Test Results, Data Tables and Selected Comparison Photographs for Roll 2.

Section 4 – Data Graphs

Section 5 – All Test Photographs

Enclosed with this report is a DVD of the video of both rolls.

### 2009 Nissan Versa



## Executive Summary

The test was a two roll event. The planned difference between the rolls was the pitch of the vehicle; 4.9 degrees in Roll 1 and 10.2 degrees in Roll 2 and the position of the Hybrid III dummy. For Roll 1, the dummy was located "out of position;" leaning towards the passenger side approximately 20°. For Roll 2, the dummy was placed in the nominal seating position. Table 1 describes the impact conditions of each test. Table 2 shows the injury assessment reference values for the low durometer neck that was used.

**Table 1** Summary of Test Conditions

Roll	Pitch	Road Speed	Contact Angle	Roll Rate
1	4.9 deg	14.9 mph	144 deg	187 deg/sec
2	10.2 deg	14.9 mph	145 deg	194 deg/sec

**Table 2** Lower Neck IARV's for 10% Probability of an AIS  $\geq$  3 Injury

Neck Type	My (Nm) Flexion	My (Nm) Extension	Mx (Nm)	Axial Fz (N)
Production	380	-156	268	4000
Low Durometer	90-110	-38--46	59-90	1640-2000
Human/Cadaver	58			1500

In Roll 1, the peak lower neck compressive load was 362 N and the peak lower neck moment was 19 Nm in flexion and 41 Nm in extension. The peak intrusion speed at the top of the A-Pillar was 5.0 mph with a peak crush of 4.5 inches.

In Roll 2, the peak lower neck compressive load was 590 N and the peak lower neck moment was 49 Nm in flexion and 43 Nm in extension. The peak intrusion speed at the top of the A-Pillar was 8.1 mph with a peak crush of 5.2 inches.

### 1. Test Procedure and Summaries

For each roll of the test, the following steps are performed:

1. Inspect the test vehicle for prior damage, rust or other factors that might influence the outcome of the test
2. Prepare the test equipment
3. Install and prepare the instrumentation and video cameras
4. Install the test vehicle in test fixture
5. Perform pre-test measurements
6. Photograph the vehicle
7. Conduct the test
8. Perform post test measurements
9. Photograph the vehicle following the test

The set up of the test vehicle in the fixture and the instrumentation in the vehicle was the same for Rolls 1 and 2 with the exception of the pitch angle; Roll 1 = 4.9° and Roll 2 = 10.2°.

The test weight of the vehicle was 2,891 pounds. The initial weight of the vehicle was 2,677 pounds. The test roll moment of inertia was approximately 329 lb\*ft\*sec<sup>2</sup> for a referenced value of 344 lb\*ft\*sec<sup>2</sup>.

The vehicle was suspended on mounts at the rear and at the front in a manner that allowed it to roll freely and be dropped, passenger side (the near side) leading.

Four string potentiometers were placed between the approximate longitudinal roll axis of the vehicle and the roof structure at the top of the driver's side A-pillar and B-pillar, at the header inboard of the A-pillar and at the top of the passenger's side A-pillar. An instrumented, restrained Hybrid III 50th percentile male test dummy was placed in the driver's seat. The dummy was instrumented with upper and lower neck load cells as well as a triaxial head accelerometer. In addition, seat belt load cells were utilized.

Each roll was conducted with a Hybrid III dummy equipped with a more biofidelic (low durometer) neck and lumbar joint, located in the driver's seat which was positioned in the mid seat position. The dummy was restrained using the vehicle's standard 3 point harness with a non-

deployed pre-tensioner. The dummy's head was chalked before each roll to locate impact marks during the tests. To make the Hybrid III dummy more biofidelic, the two cables in the lower spine of the dummy were removed. The upper neck mounting block was replaced with a block that increased the neck angle forward 30 degrees from the nominal position.

For the first roll the dummy was tethered "out of position" with a light wire that electronically disconnected at approximately 10° of roll. The "out of position" location of the dummy was found by rotating the vehicle by 90 degrees toward the passenger side. This orientation simulated the dummy accelerating toward the passenger side door at 1 g. For the second roll the dummy was placed in the nominal seating position.

Six vertical and two lateral load cells were placed in the moving roadway to record the impact characteristics of the test.

Two string potentiometers were placed on the fixture support towers to record vehicle vertical motion characteristics during the test. One string potentiometer was located in the front drop tower and the other was located in the rear drop tower.

A roll encoder was placed on the cable pulley which pulls the moving roadway to record the roadway velocity throughout the test. In addition, a roll rate sensor was placed inside the vehicle.

The equipment used in the conduct of this test is listed in Table 3 and the test vehicle identification data is shown in Table 4 below.

**Table 3**      Equipment and Instrumentation

<b>Item</b>	<b>MFR./Model</b>
String Potentiometer – Driver’s Side A-Pillar	Space Age Control – 301432
String Potentiometer – Driver’s Side B-Pillar	Space Age Control – 301432
String Potentiometer – Roof Header	Space Age Control – 301432
String Potentiometer – Passenger’s Side A-Pillar	Space Age Control – 301432
String Potentiometer – Front Fixture Support Tower	Space Age Control – 4332-01
String Potentiometer – Rear Fixture Support Tower	Space Age Control – 4332-01
Upper Neck Load Cell	RA Denton 1716A
Lower Neck Load Cell	RA Denton 1794A
Triaxial Head Accelerometer	Endevco, 7264C-2KTZ-2-240
Belt Load Cell - Lap	RADenton 3255
Belt Load Cell - Torso	RADenton 3255
Roll Rate Sensor	DTS ARS
Hybrid III, 50 <sup>th</sup> Percentile Male	Denton 50th Male
Vertical Load Cell 1	Transducer Techniques, SWP-20k – 173372
Vertical Load Cell 2	Transducer Techniques, SWP-20k – 176138
Vertical Load Cell 3	Transducer Techniques, SWP-20k – 176139
Vertical Load Cell 4	Transducer Techniques, SWP-20k – 176140
Vertical Load Cell 5	Transducer Techniques, SWP-20k – 176141
Vertical Load Cell 6	Transducer Techniques, SWP-20k – 176142
Lateral Load Cell 1	Transducer Techniques, DSM-8k – 149806
Lateral Load Cell 2	Transducer Techniques, DSM-8k – 149807
Roadway Velocity Roll Encoder	Contelec – RSC 2201 236 111 106
Vehicle Data Acquisition System	Diversified Technical Systems, TDAS PRO SIM
Roadway Data Acquisition System	Diversified Technical Systems, TDAS PRO SIM
JRS Fixture Acquisition System	Measurement Computing, USB – 1608FS

**Table 4**      General Test Vehicle Data      Test Vehicle: 2009 Nissan Versa

<b>Test Vehicle Information:</b>	
Manufacturer: Nissan	VIN: 3N1BC13E19L355761
Gross Weight: 3,770 lbs	Curb Weight: 2,747 lbs
Sunroof: No	2WD/4WD: 2WD
Equivalent Years: 2008- Present	Body Type: 4 Door Hatchback

## 2. Test Results, Data Tables and Selected Comparison Photographs for Roll 1.

The results of the first roll of the JRS Dynamic Rollover Test are presented in this section. In the roll, the vehicle dropped as planned and contacted the vehicle's roof structure.

### Roll 1 – 04/27/2010

#### Summary of Results

Instrument	Peak Value	Residual Intrusion (inches)	Peak Velocity (mph)
Sum of Vertical Load Cells (near side contact)	9,592 lbs		
Sum of Vertical Load Cells (far side contact)	19,451 lbs		
Sum of Lateral Load Cells (near side contact)	1,288 lbs		
Sum of Lateral Load Cells (far side contact)	1,246 lbs		
Driver's Side A-Pillar String Potentiometer*	-4.5 in	-2.0	-5.0
Driver's Side B-Pillar String Potentiometer	-1.6 in	-0.6	-3.2
Roof Header String Potentiometer	-1.9 in	-0.9	-4.0
Passenger's Side A-Pillar String Potentiometer**	-0.7	-0.1	1.7

\*A-Pillar trim contacted string pot cable. Values estimated based on video analysis

\*\* Dummy contacted string pot during test. Values estimated based on video analysis

Instrument	Maximum Value	Minimum Value
Lab Belt Load	237 lb	-1 lb
Shoulder Belt Load	175 lb	-2 lb
Dummy Head Acceleration Ax	44 g	-7 g
Dummy Head Acceleration Ay	67 g	-6 g
Dummy Head Acceleration Az	16 g	-61 g
Lower Neck Load Cell Fx	1,073 N	-92 N
Lower Neck Load Cell Fy	436 N	-94 N
Lower Neck Load Cell Fz	928 N	-362 N
Lower Neck Load Cell Mx	19 Nm	-20 Nm
Lower Neck Load Cell My	19 Nm	-41 Nm
Upper Neck Load Cell Fz	702 N	-2,498 N
HIC	268	N/A

The vertical load cells mounted on the roadway platform show the near and far side impacts. The vehicle struck the roadway on the near side at approximately 1.77 seconds. The entire roll sequence was completed by approximately 2.10 seconds.

The string potentiometers located on the fixture support towers show the vertical vehicle motion throughout the test. The front of the vehicle dropped 3.96 inches and the rear dropped 4.38 inches prior to initial touch down. The vehicle was pitched at 4.9 degrees at contact.

The roll encoder located on the cable pulley shows the roadway velocity throughout the roll. The roadway was traveling at 14.9 mph at contact. A roll rate sensor in the vehicle was used to determine the roll angle and rate at impact. The roll angle of the vehicle was 144 degrees and the roll rate was 187 degrees per second at the roadway impact.

During the first roll the windshield fractured. A small buckle type deformation occurred in the far side C-pillar.

## Roll 1 Comparison Photographs



Figure 1: Vehicle Pre Roll 1



Figure 2: Vehicle Post Roll 1

### 3. Test Results, Data Tables and Selected Comparison Photographs for Roll 2.

The results of the second roll of the JRS Dynamic Rollover Test are presented in this section. In the roll, the vehicle dropped as planned and contacted the vehicle's roof structure.

#### Roll 2 – 04/28/2010

##### Summary of Results

Instrument	Peak Value	Residual Intrusion (inches)	Peak Velocity (mph)
Sum of Vertical Load Cells (near side contact)	6,928 lbs		
Sum of Vertical Load Cells (far side contact)	19,151 lbs		
Sum of Lateral Load Cells (near side contact)	1,134 lbs		
Sum of Lateral Load Cells (far side contact)	1,053 lbs		
Driver's Side A-Pillar String Potentiometer	-5.2 in	-2.3	-8.1
Driver's Side B-Pillar String Potentiometer	-2.6 in	-0.9	-5.1
Roof Header String Potentiometer	-4.6 in	-1.8	-6.4
Passenger's Side A-Pillar String Potentiometer*	-1.0 in	-0.5	-2.6

\*Dummy contacted string pot. Values estimated based on video analysis

Instrument	Maximum Value	Minimum Value
Lab Belt Load	225 lb	-3 lb
Shoulder Belt Load	222 lb	-1 lb
Dummy Head Acceleration Ax	45 g	-30 g
Dummy Head Acceleration Ay	58 g	-67 g
Dummy Head Acceleration Az	15 g	-51 g
Lower Neck Load Cell Fx	991 N	-1,275 N
Lower Neck Load Cell Fy	770 N	-82 N
Lower Neck Load Cell Fz	1,232 N	-590 N
Lower Neck Load Cell Mx	15 Nm	-30 Nm
Lower Neck Load Cell My	49 Nm	-43 Nm
Upper Neck Load Cell Fz	1,427 N	-2,955 N
HIC	245	N/A

The vertical load cells mounted on the roadway platform show the near and far side impacts. The vehicle struck the roadway on the near side at approximately 1.77 seconds. The entire roll sequence was completed by approximately 2.07 seconds.

The string potentiometers located on the fixture support towers show the vertical vehicle motion throughout the test. The front of the vehicle dropped 4.44 inches and the rear dropped 3.84 inches prior to initial touch down. The vehicle was pitched at 10.2 degrees at contact.

The roll encoder located on the cable pulley shows the roadway velocity throughout the roll. The roadway was traveling at 14.9 mph at contact. A roll rate sensor in the vehicle was used to determine the roll angle and roll rate at impact. The roll angle of the vehicle was 145 degrees and the roll rate was 194 degrees per second at the roadway impact.

During the second roll the windshield fractured further. The driver's side window shattered completely. The deformation of the C-pillar buckle increased.

A test was conducted on the door handles to evaluate if any of the doors were jammed due to the second impact test. 80 lbs was applied at the handle of the driver door and it did not open, indicating it was jammed. Visual inspection shows that the top rear corner of the front driver's side door was 'tucked' behind the top front corner of the rear driver's side door. The rear door on the driver's side required 14 lbs to open. After the rear driver's side door was opened, the front driver door took 60 lbs to open. An average of 40 lbs was further required to fully open the front driver door.

## Roll 2 Comparison Photographs

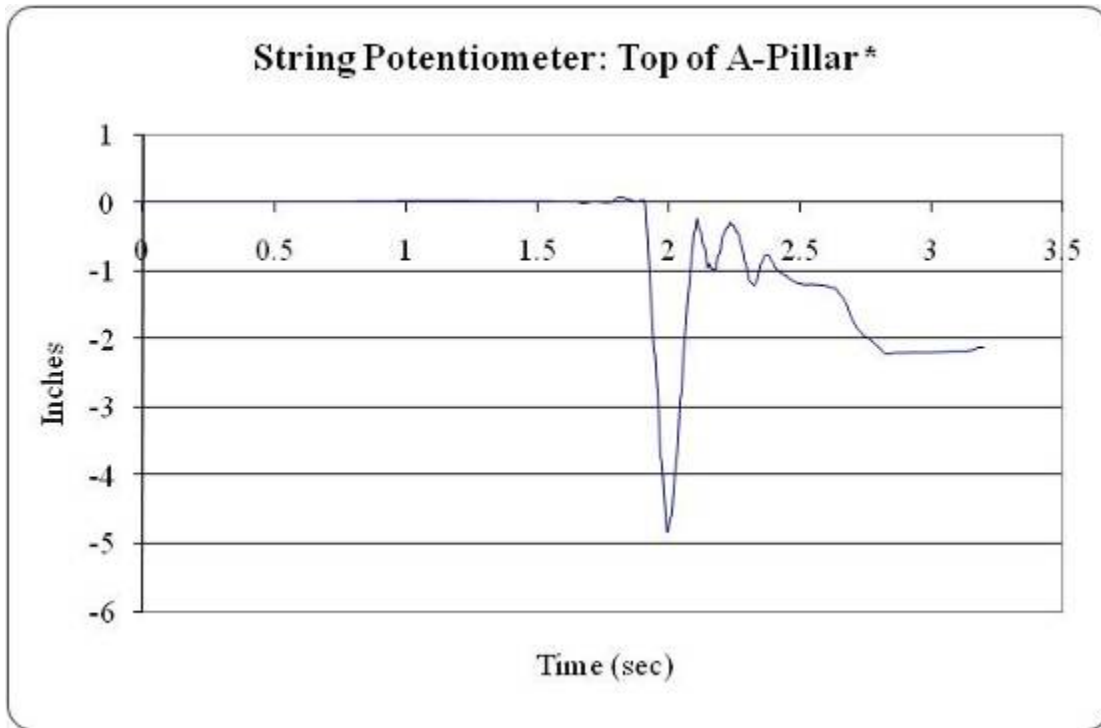


Figure 3: Vehicle Pre Roll 2

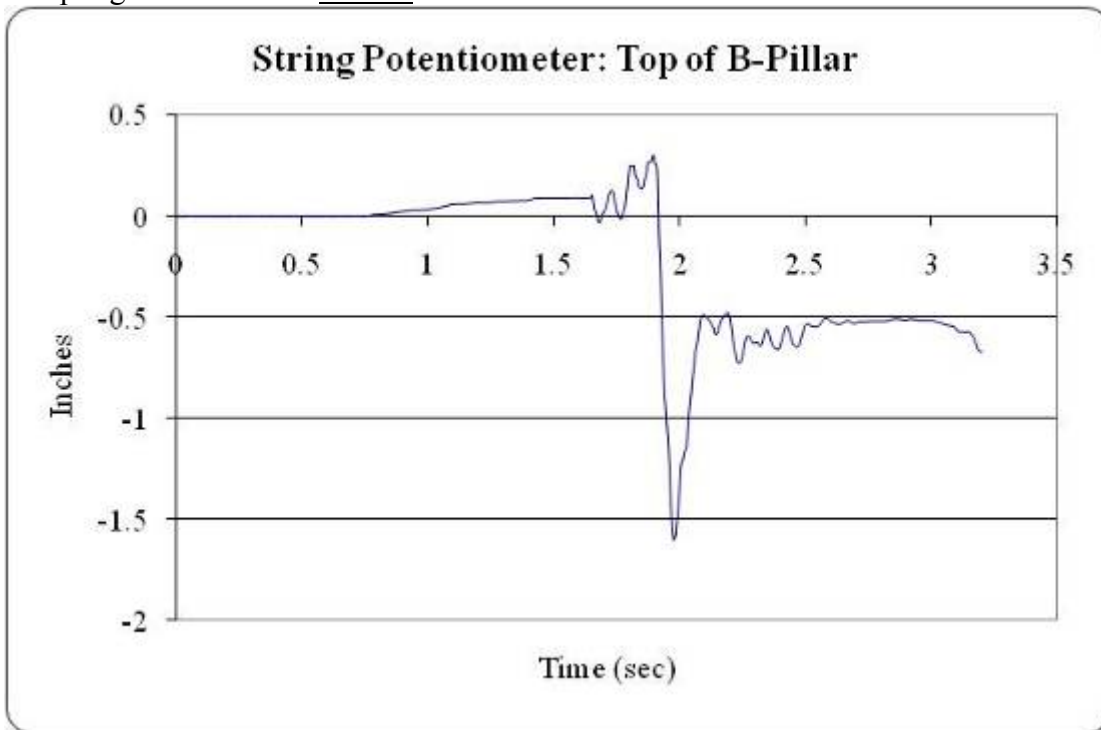


Figure 4: Vehicle Post Roll 2

**4. Data Graphs**  
**Roll 1 Data Plots – 4/27/2010**



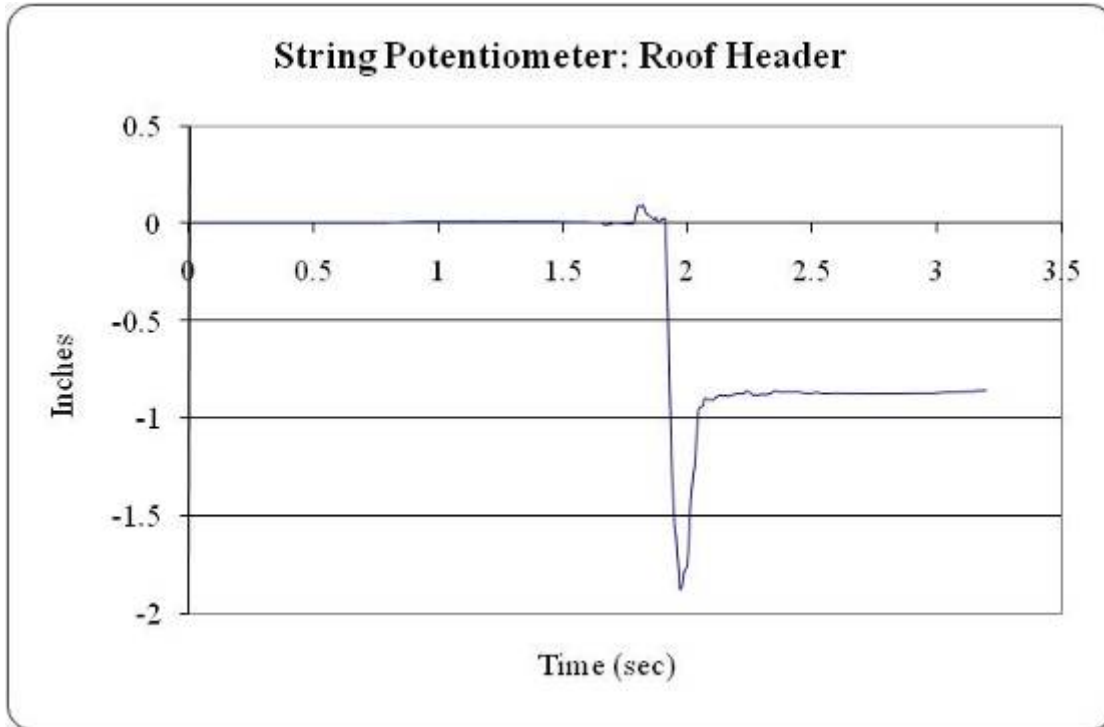
Plot 1: String Potentiometer Driver's Side A-Pillar Displacement v. Time  
 \*A-Pillar trim interfered with string pot. Peak Values estimated based on video analysis  
 Data Sampling Rate: 10 kHz



Plot 2: String Potentiometer Driver's Side B-Pillar Displacement v. Time

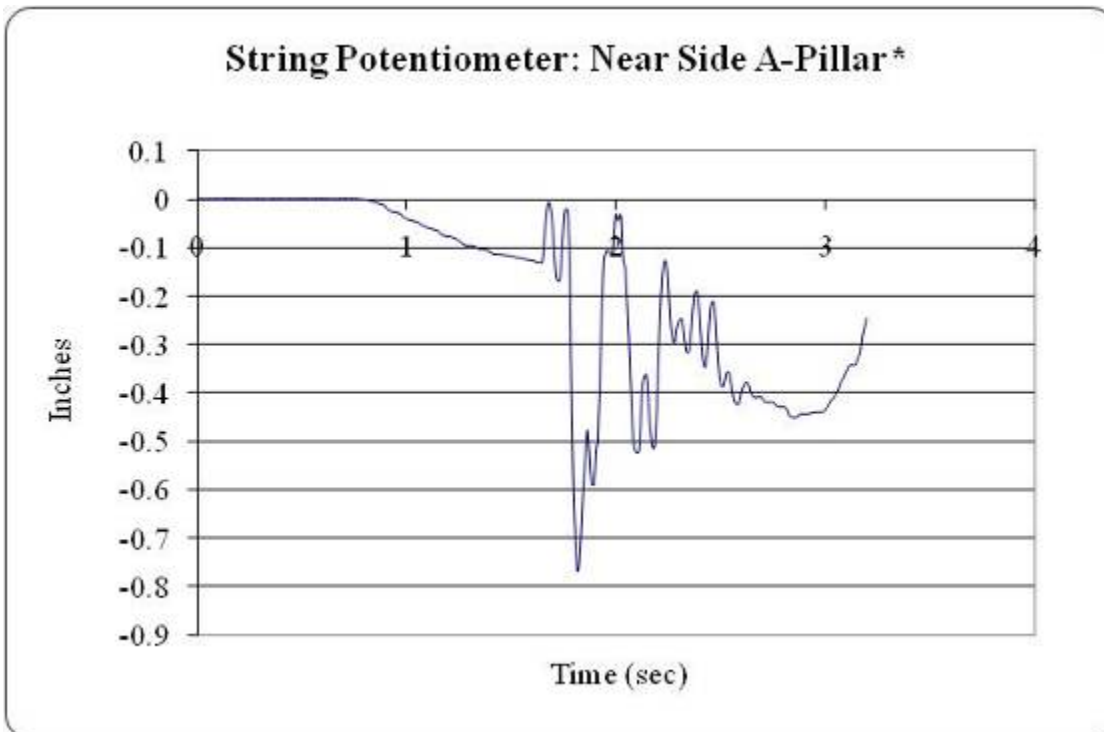
Data Sampling Rate: 10 kHz

Roll 1



Plot 3: String Potentiometer Driver's Side Roof Header Displacement v. Time

Data Sampling Rate: 10 kHz

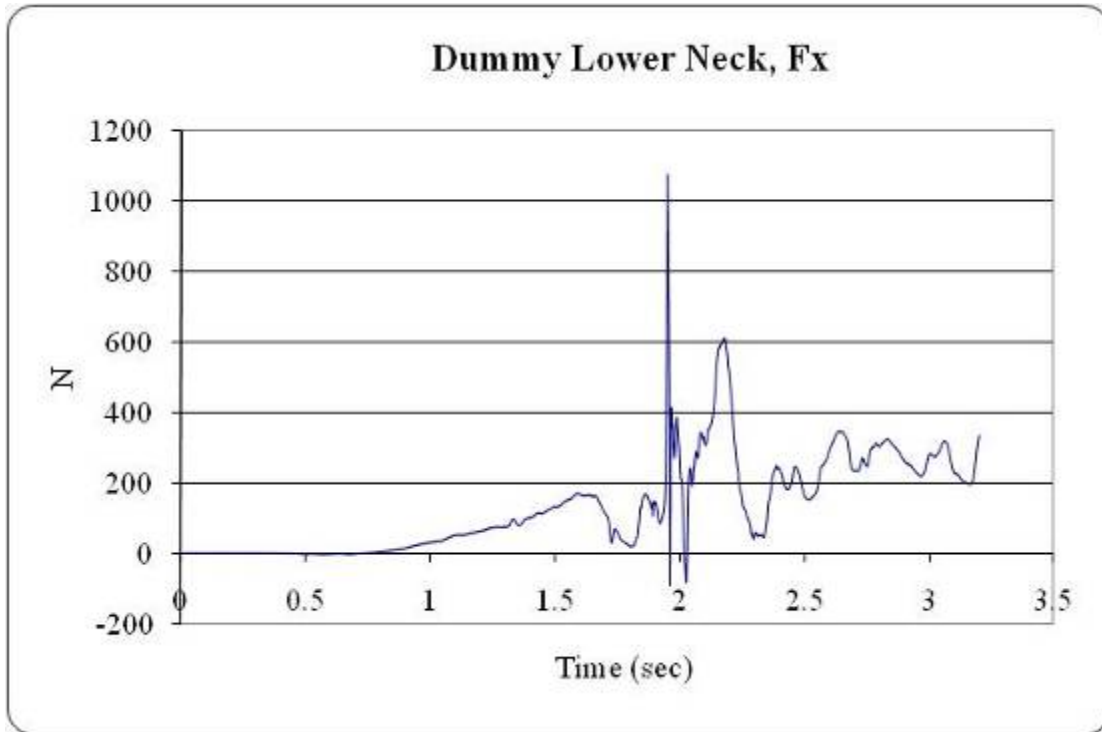


Plot 4: String Potentiometer Passenger's Side A-Pillar Displacement v. Time

\*\* Dummy interfered with string pot during test. Values estimated based on video analysis

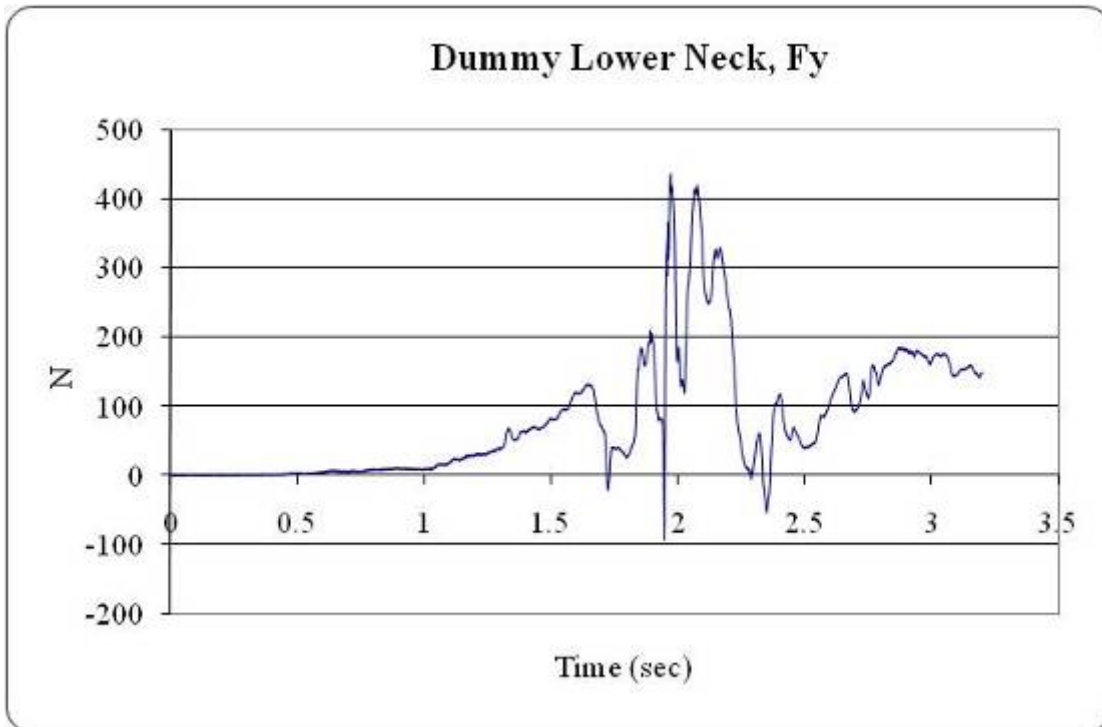
Data Sampling Rate: 10 kHz

Roll 1



Plot 5: Lower Neck Load, Fx, v. Time

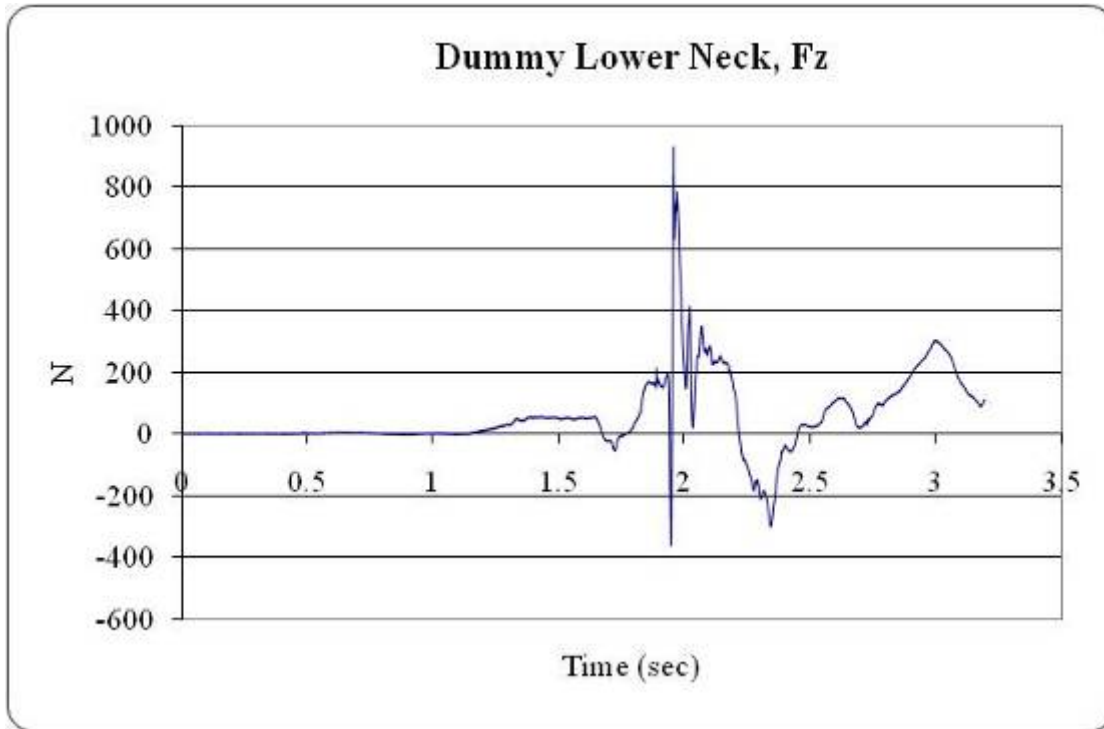
Data Sampling Rate: 10 kHz



Plot 6: Lower Neck Load, Fy, v. Time

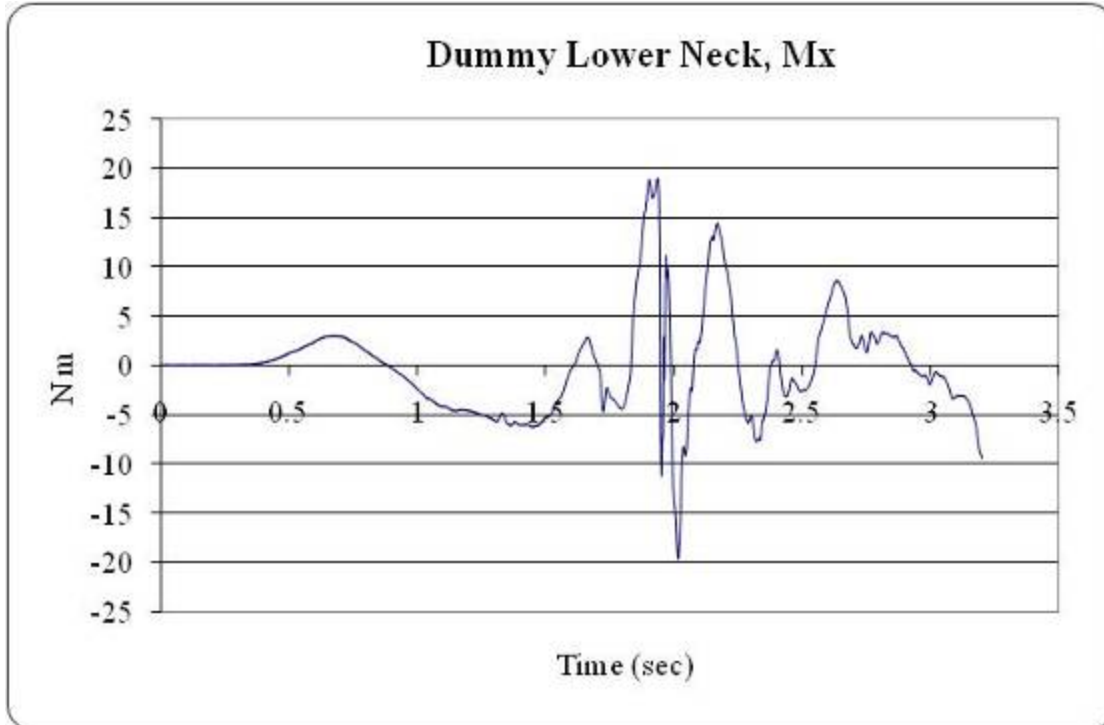
Data Sampling Rate: 10 kHz

Roll 1



Plot 7: Lower Neck Load, Fz, v. Time

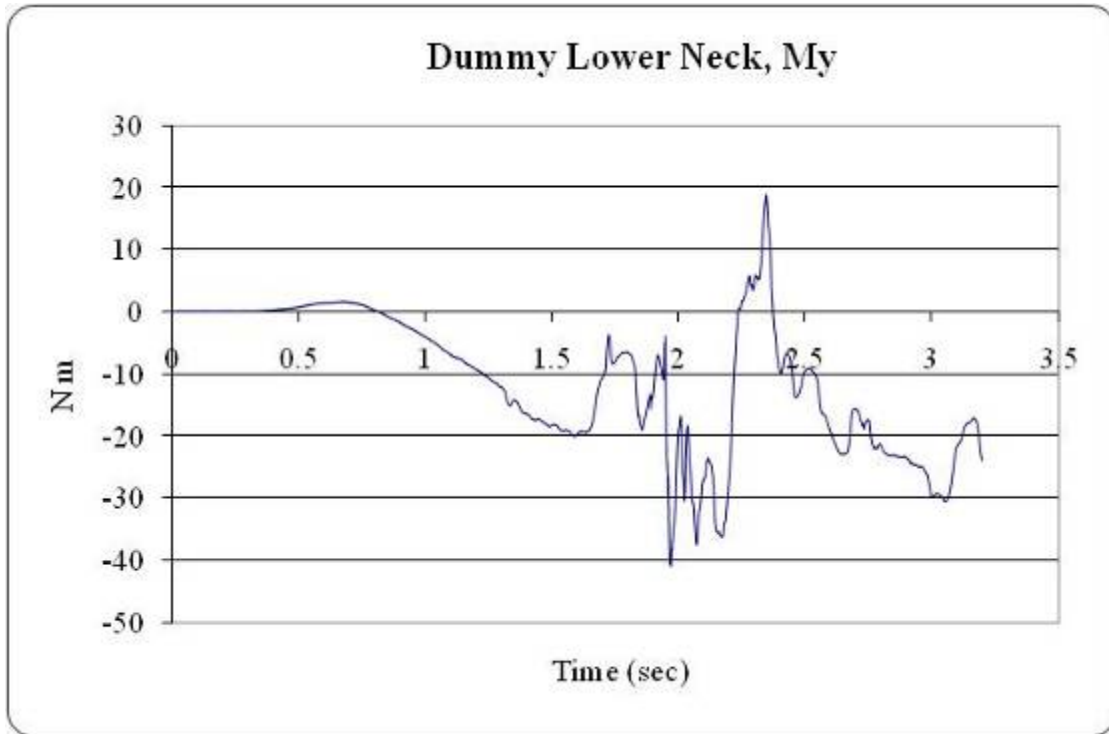
Data Sampling Rate: 10 kHz



Plot 8: Lower Neck Load, Mx, v. Time

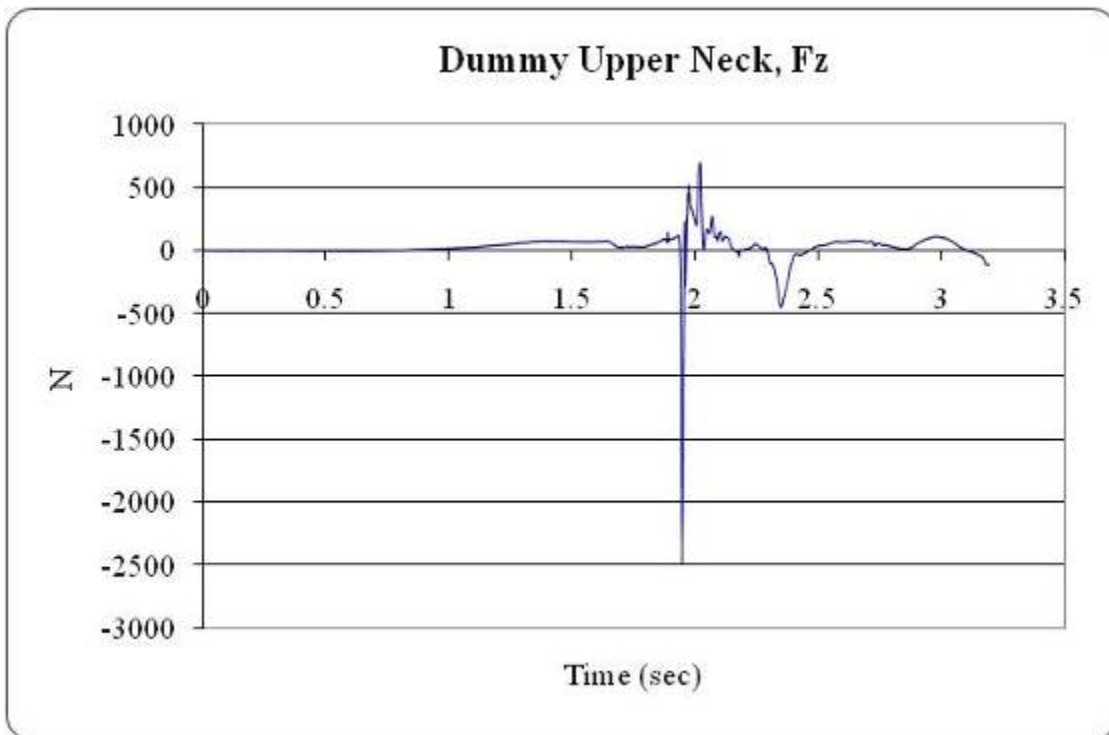
Data Sampling Rate: 10 kHz

Roll 1



Plot 9: Lower Neck Load, My, v. Time

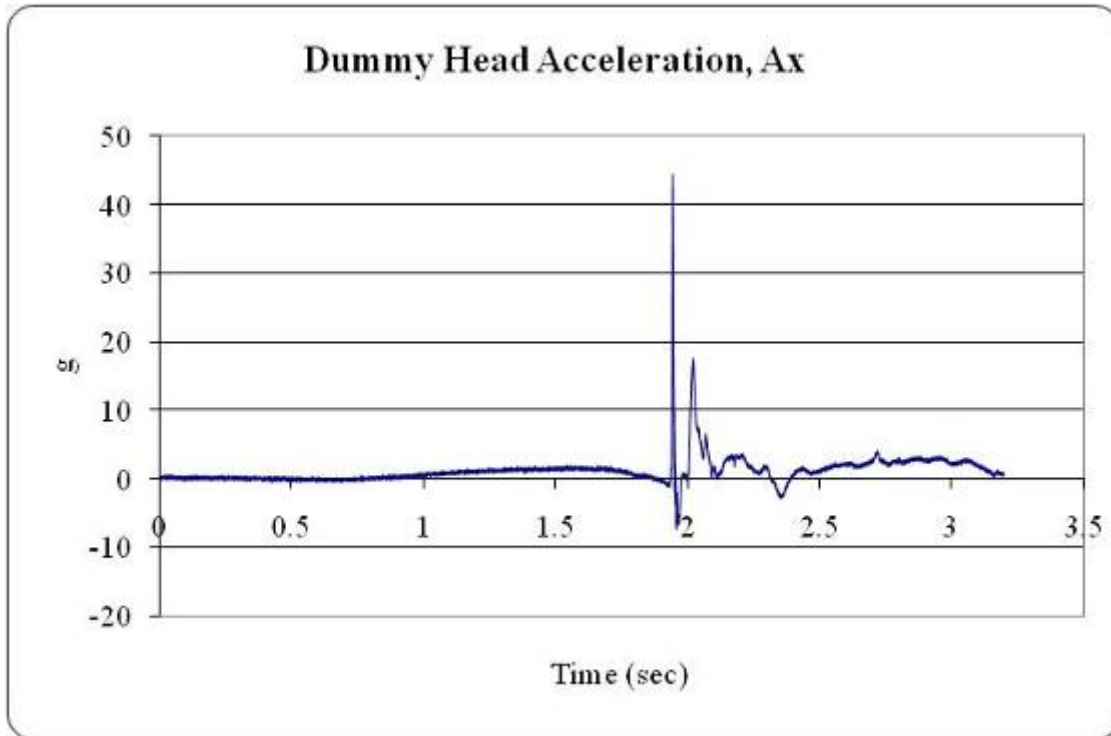
Data Sampling Rate: 10 kHz



Plot 10: Upper Neck Load, Fz, v. Time

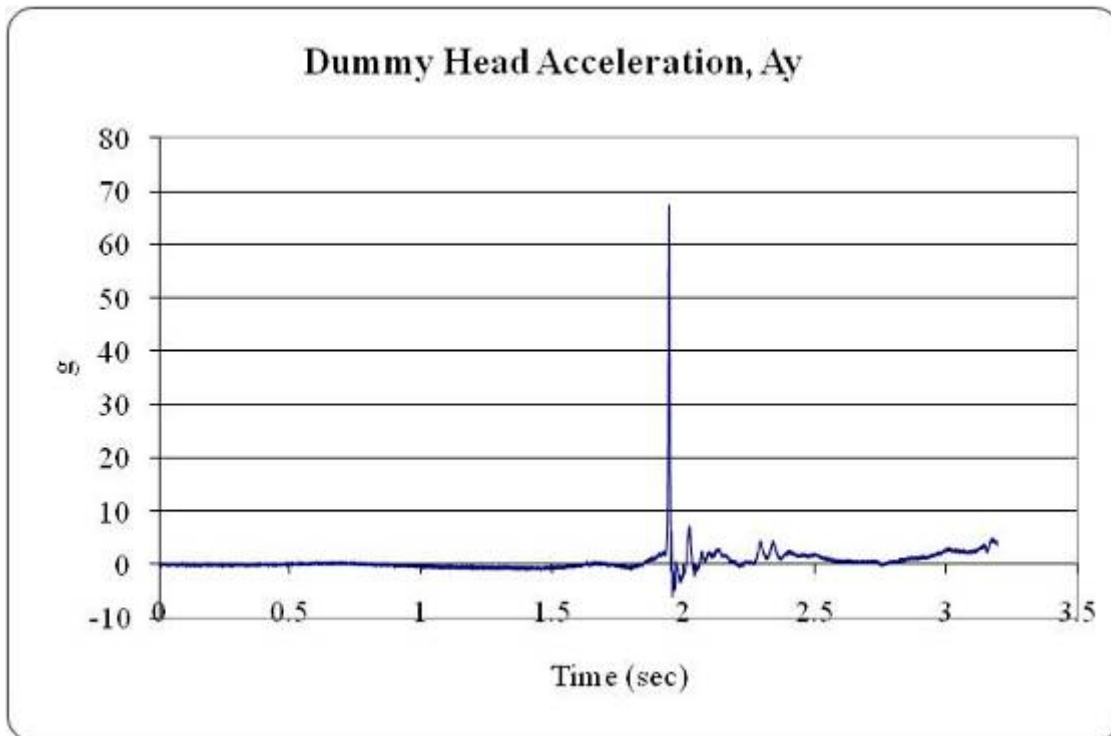
Data Sampling Rate: 10 kHz

Roll 1



Plot 11: Head Acceleration, Ax, vs. Time

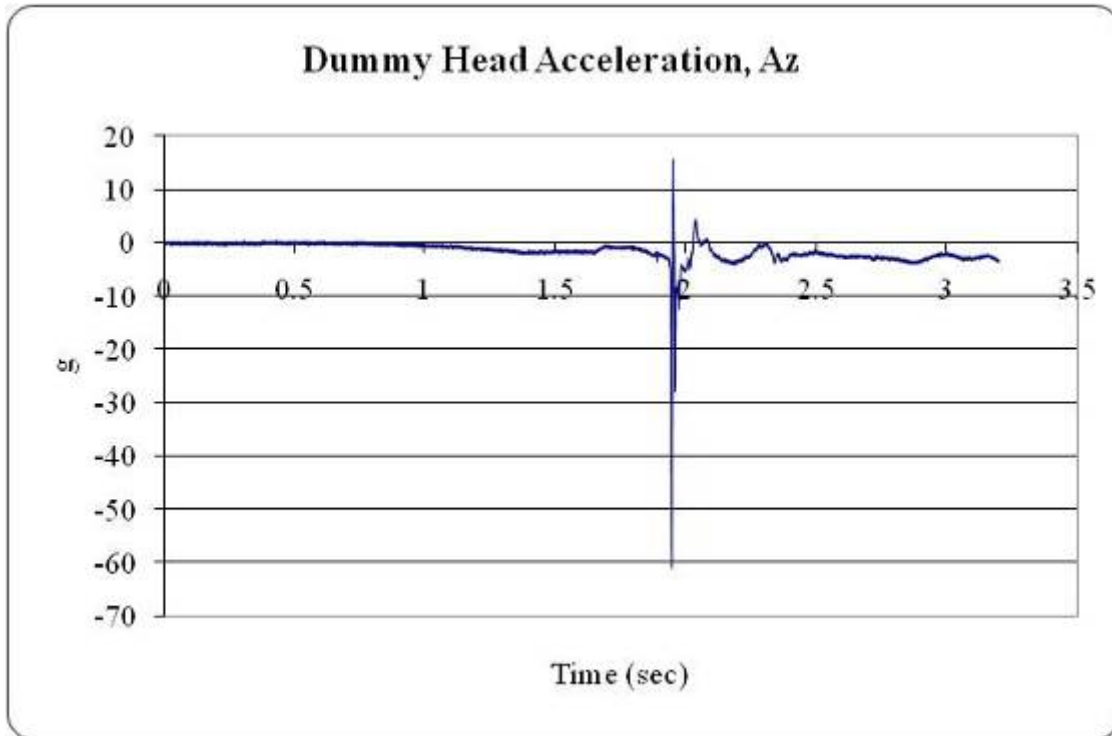
Data Sampling Rate: 10 kHz



Plot 12: Head Acceleration, Ay, vs. Time

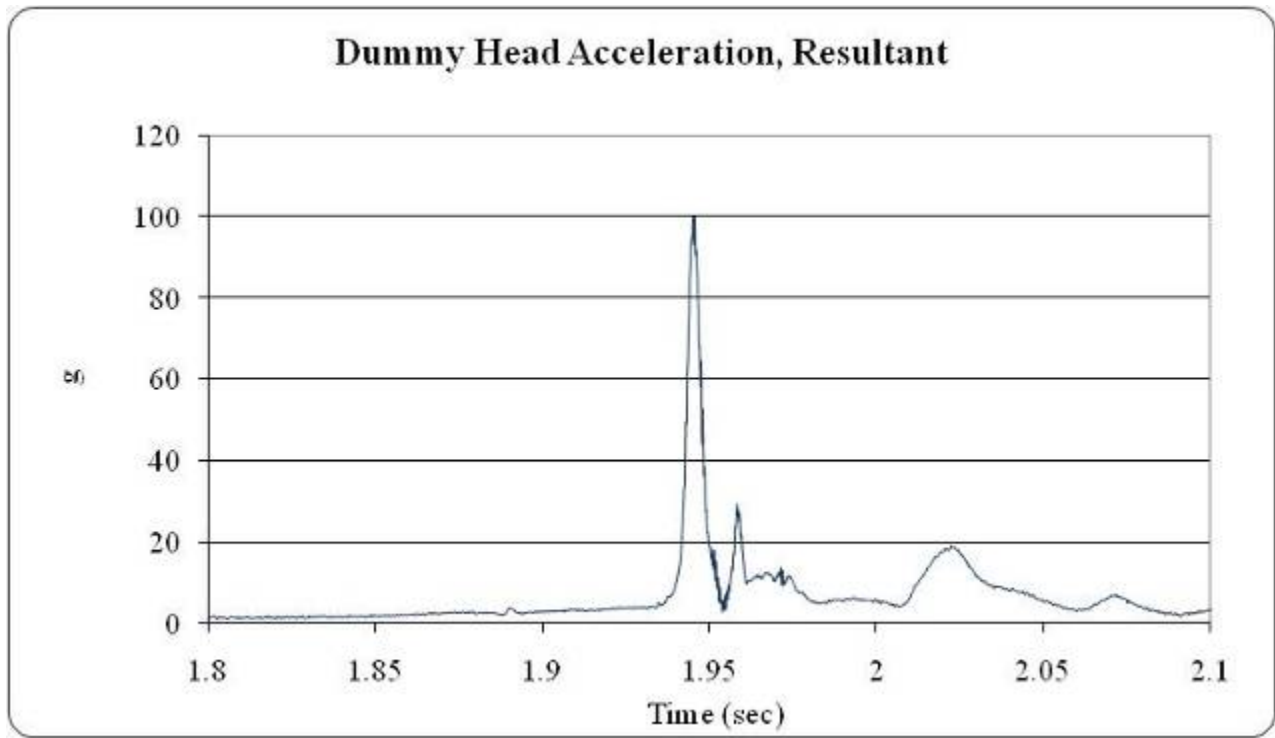
Data Sampling Rate: 10 kHz

**Roll 1**



Plot 13: Head Acceleration, Az, vs. Time

Data Sampling Rate: 10 kHz

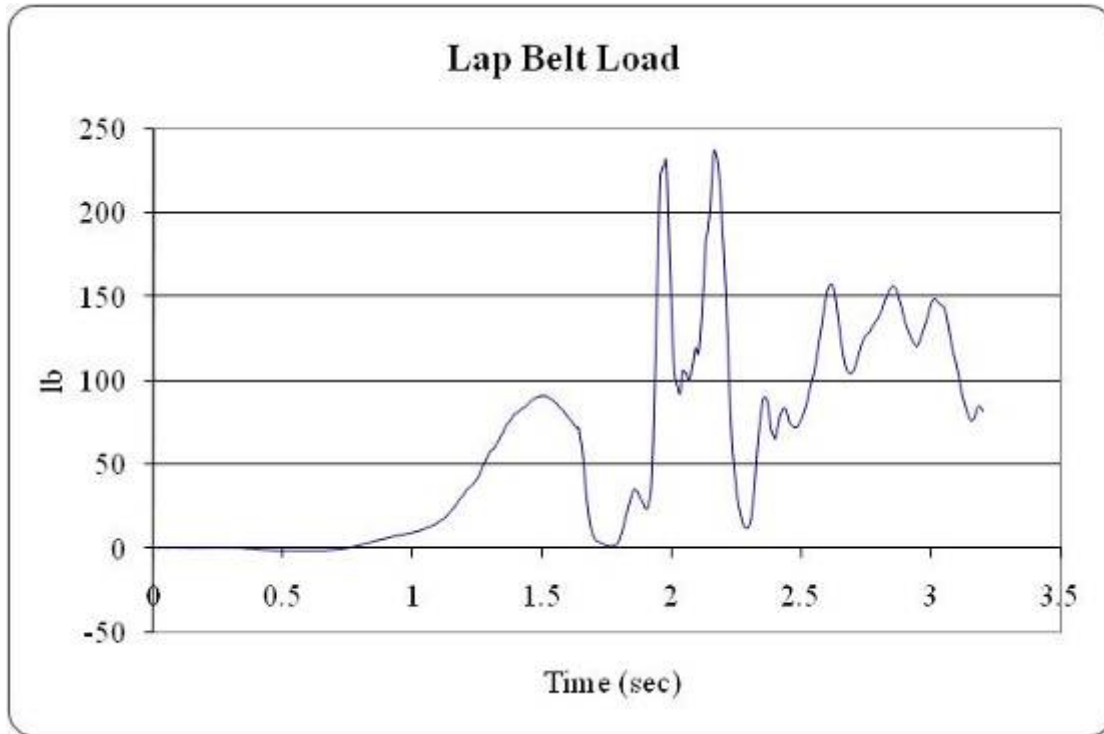


Plot 14: Resultant Head Acceleration vs. Time

HIC = 268

Data Sampling Rate: 10 kHz

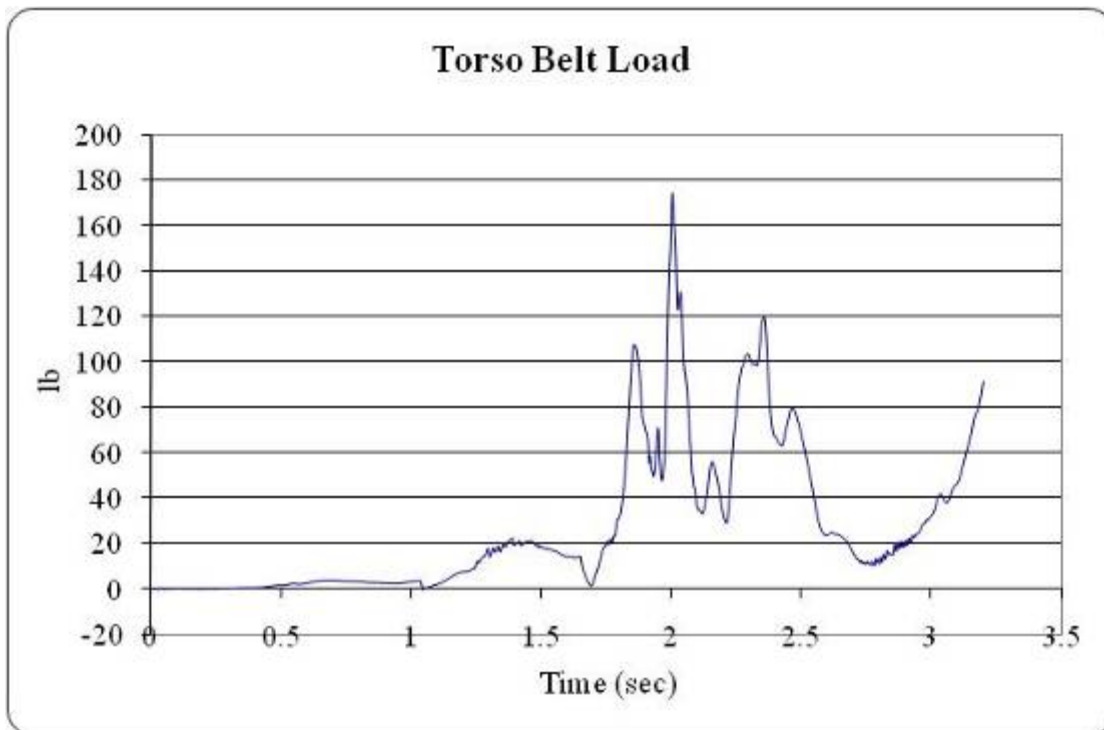
**Roll 1**



Plot 15: Lap Belt Load\* vs. Time

\*Measured on one side of the belt

Data Sampling Rate: 10 kHz

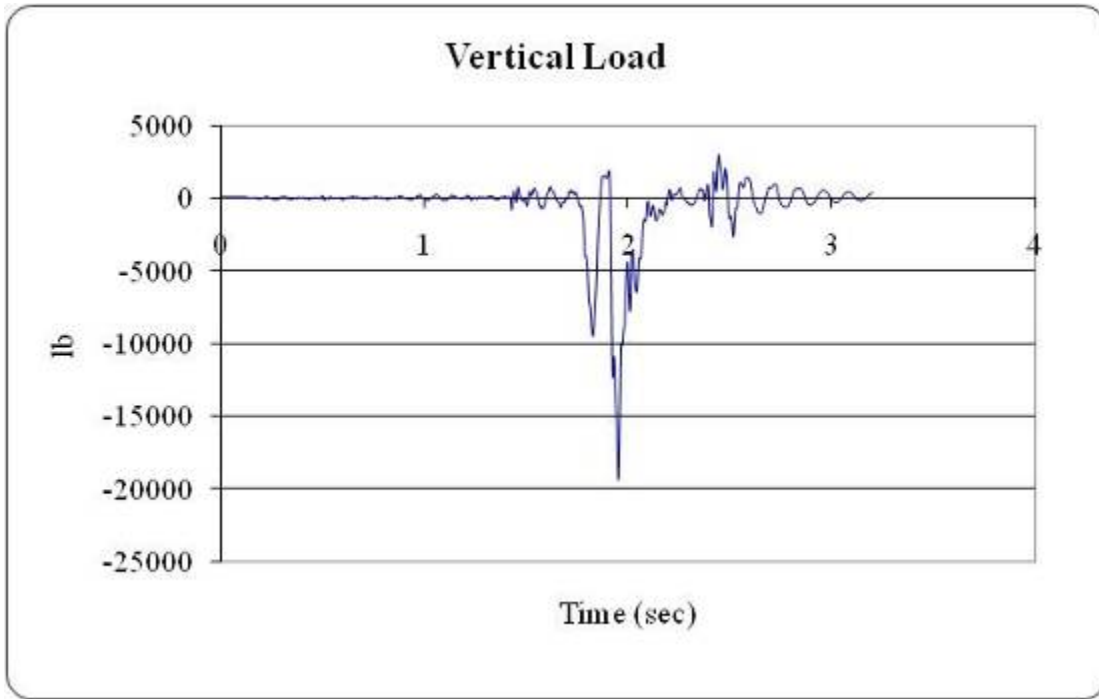


Plot 16: Torso Belt Load\* vs. Time

\*Measured on one side of the belt

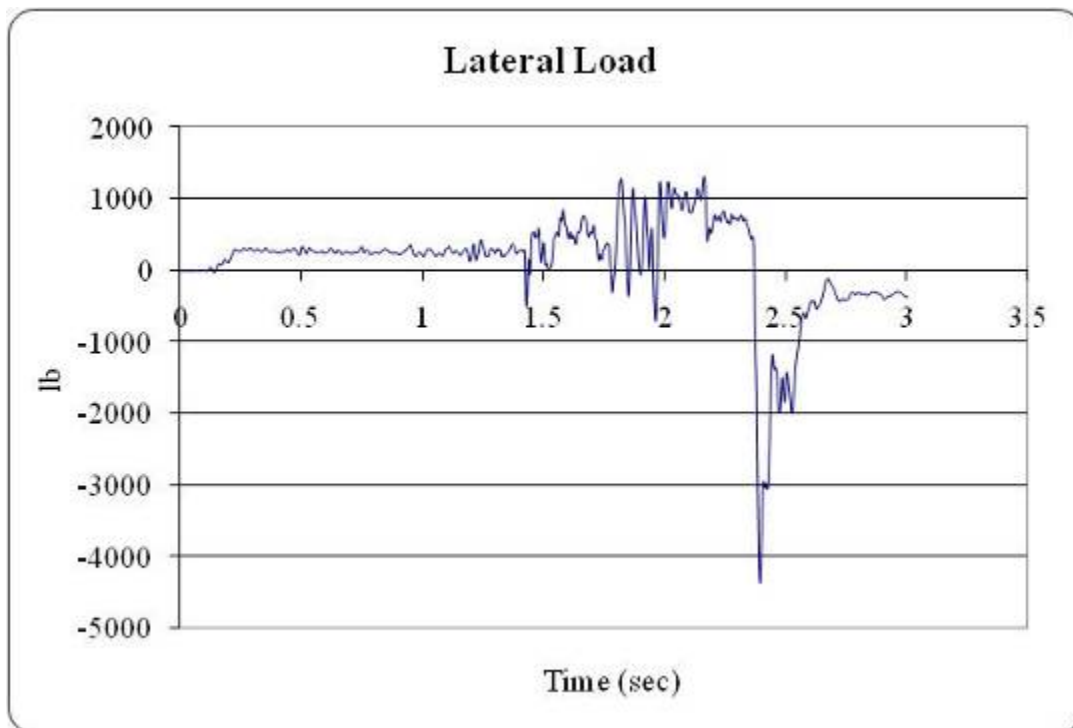
Data Sampling Rate: 10 kHz

Roll 1



Plot 17: Total Vertical Load v. Time

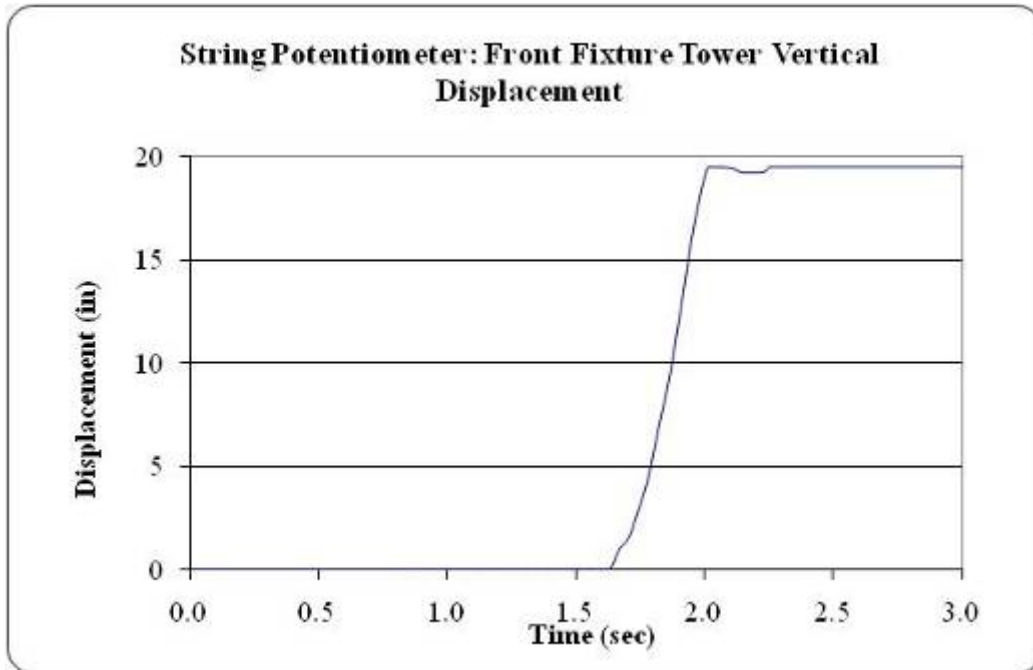
Data Sampling Rate: 10 kHz



Plot 18: Total Lateral Load v. Time

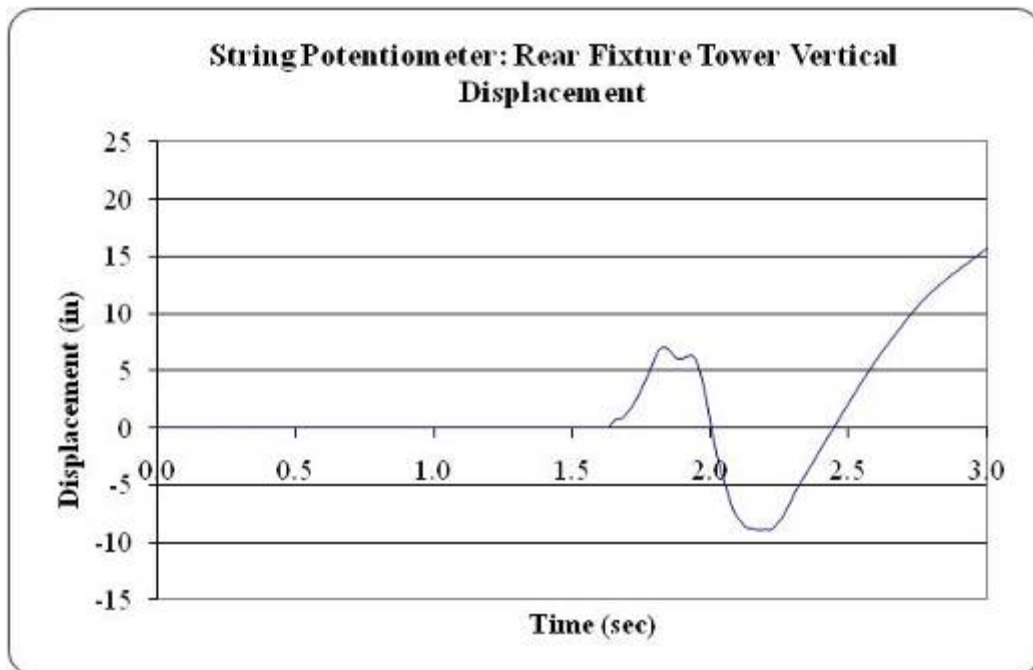
Data Sampling Rate: 10 kHz

Roll 1



Plot 19: String Potentiometer Front Fixture Support Tower Displacement vs. Time

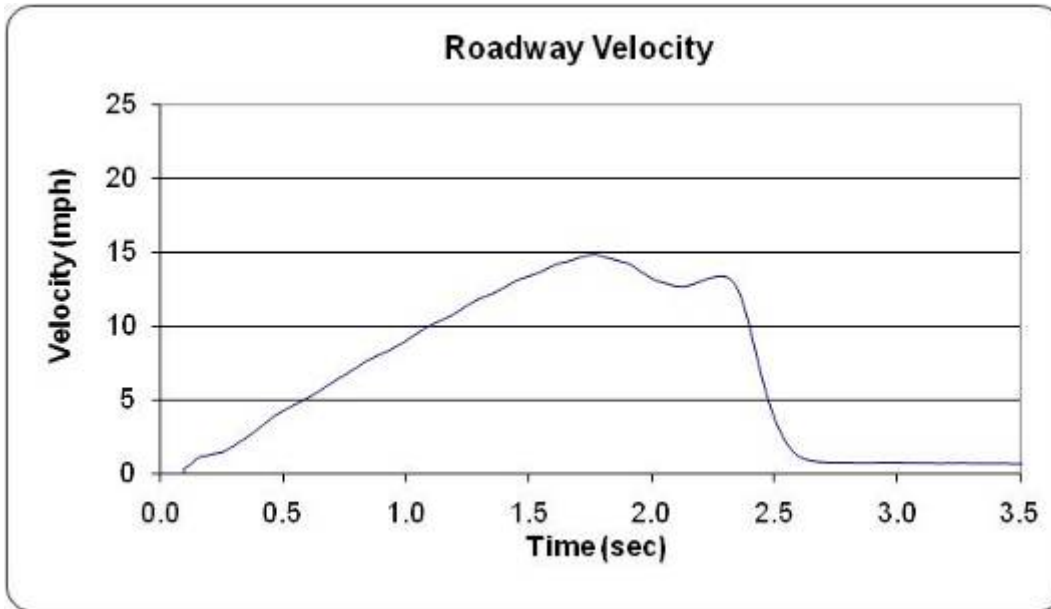
Data Sampling Rate: 1 kHz



Plot 20: String Potentiometer Rear Fixture Support Tower Displacement vs. Time

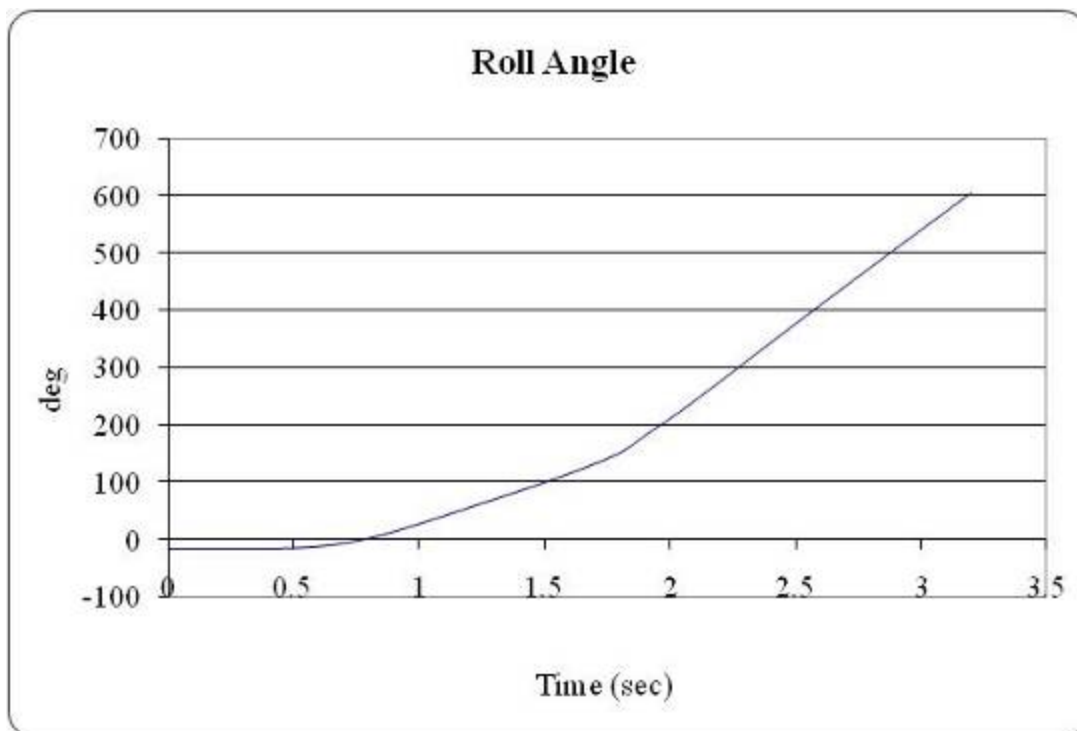
Data Sampling Rate: 1 kHz

**Roll 1**



Plot 21: Roll Encoder on Roadway Velocity vs. Time

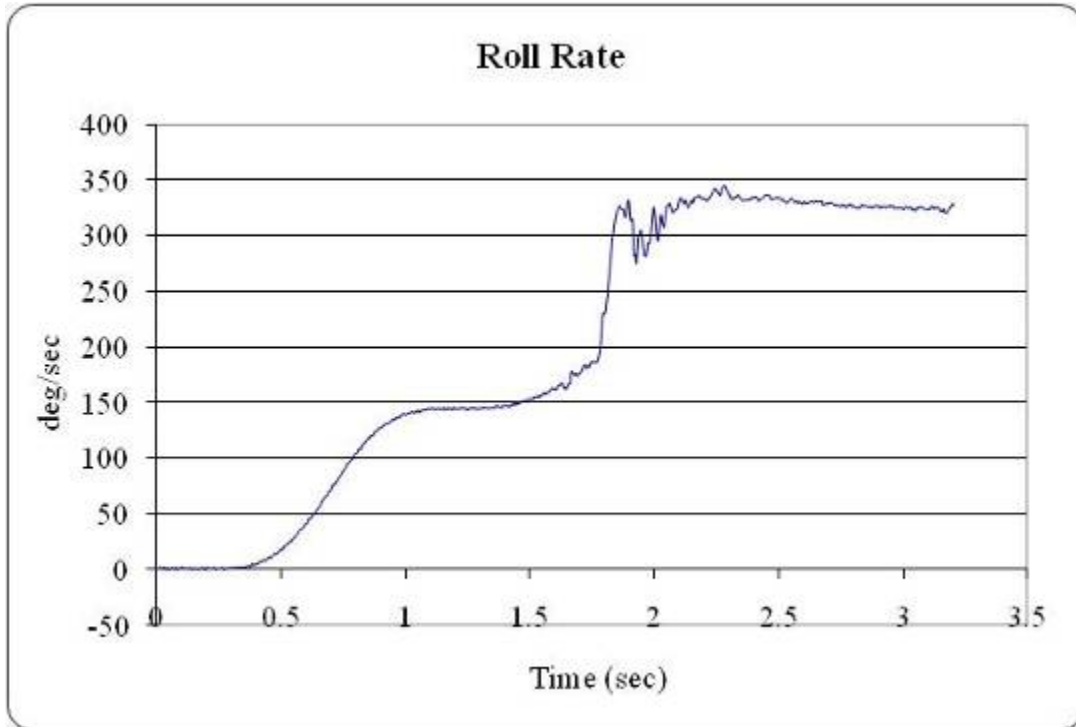
Data Sampling Rate: 1 kHz



Plot 22: Roll Angle vs. Time

Data Sampling Rate: 10 kHz

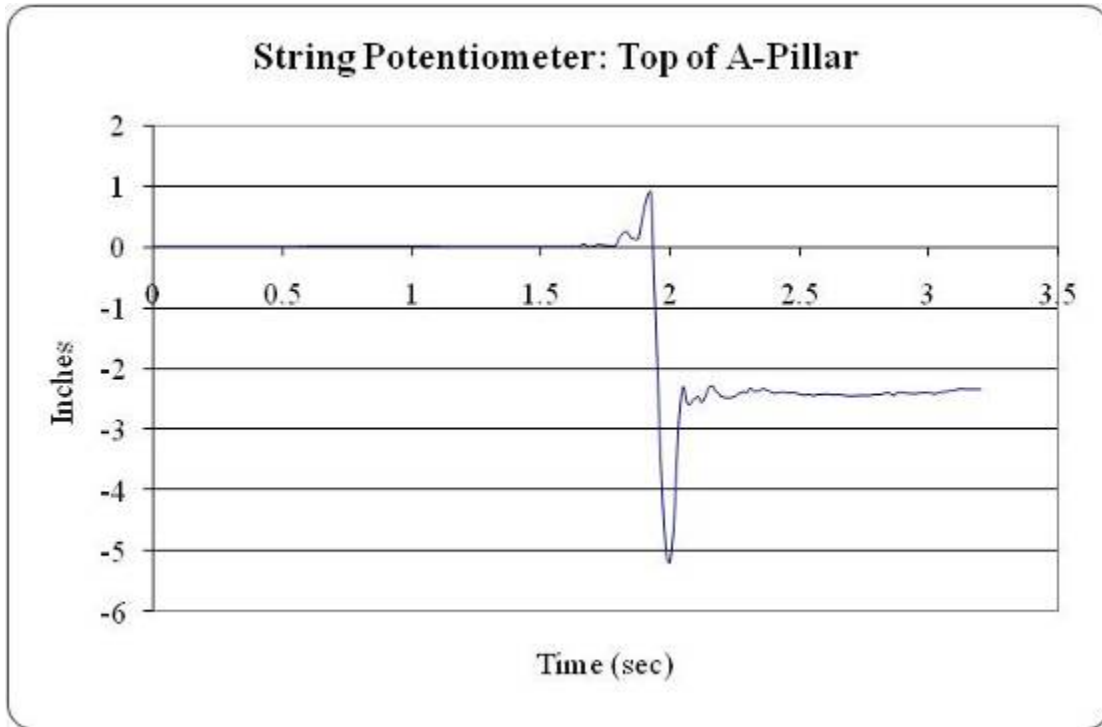
**Roll 1**



Plot 23: Roll Rate vs. Time

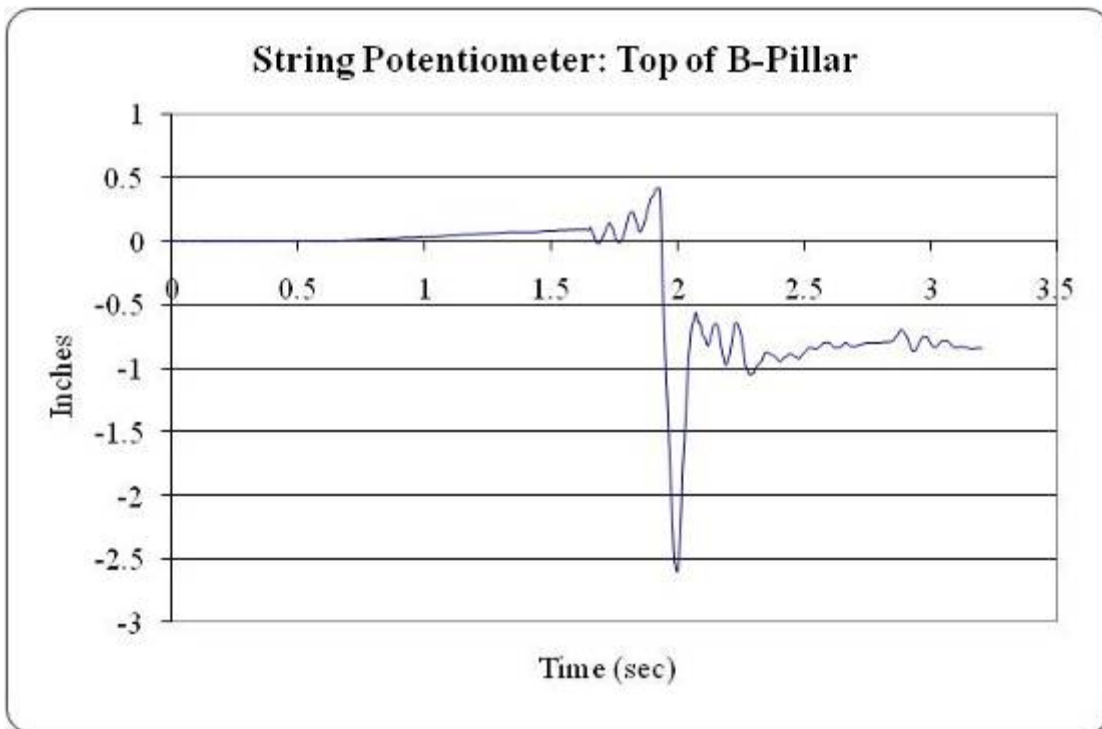
Data Sampling Rate: 10 kHz

Roll 2 Data Plots – 4/28/2010



Plot 24: String Potentiometer Driver's Side A-Pillar Displacement v. Time

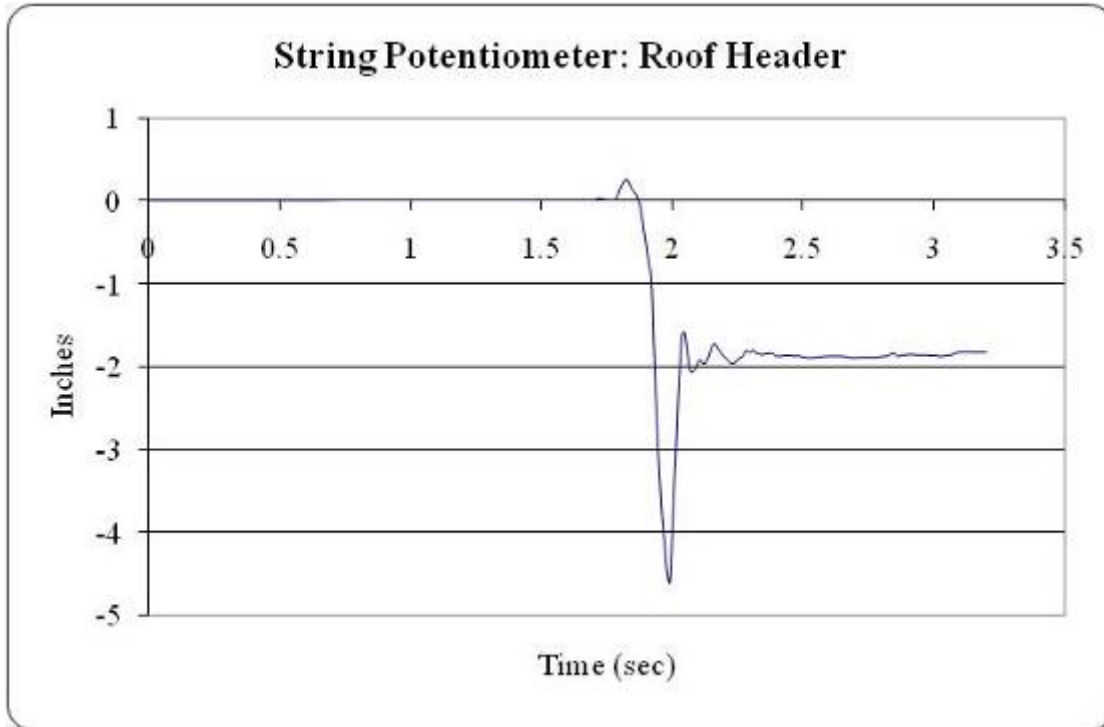
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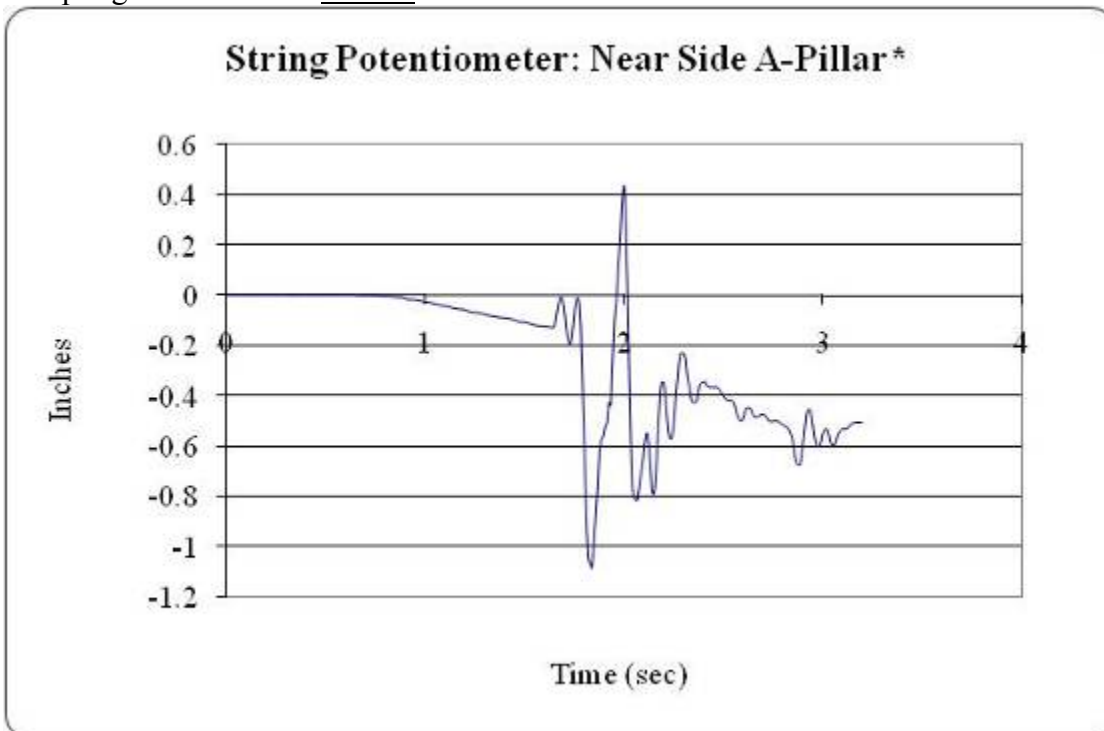
Plot 25: String Potentiometer Driver's Side B-Pillar Displacement v. Time

Data Sampling Rate: 10 kHz

Roll 2

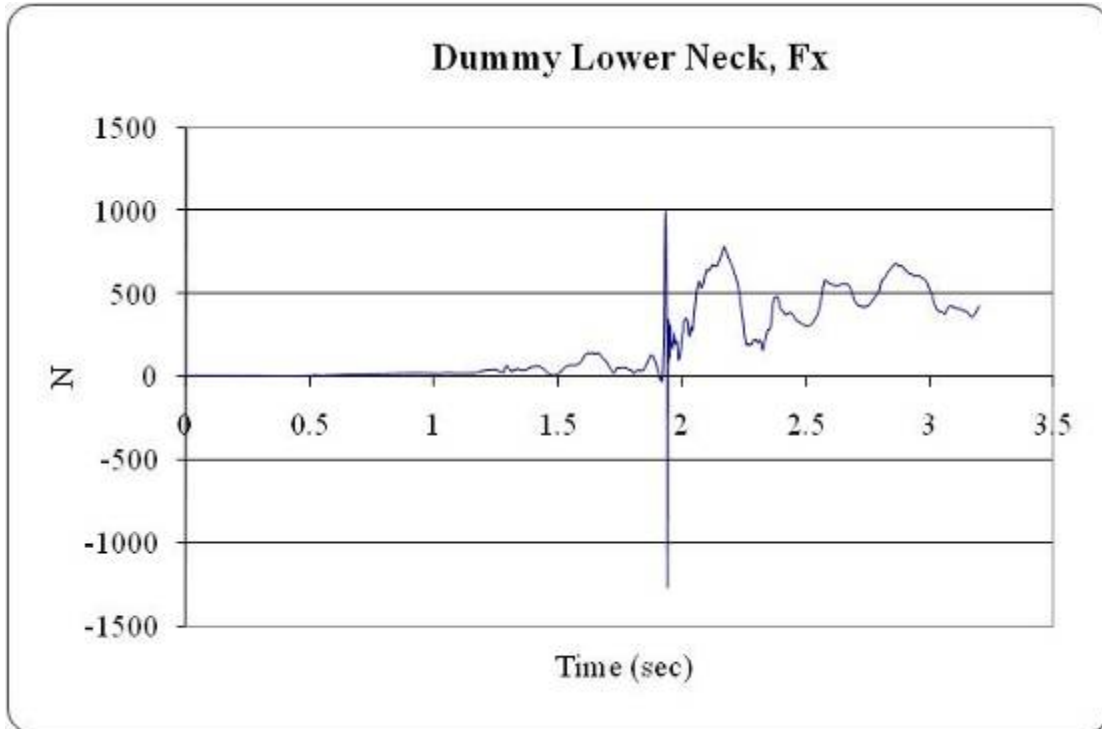


Plot 26: String Potentiometer Driver's Side Roof Header Displacement v. Time  
 Data Sampling Rate: 10 kHz



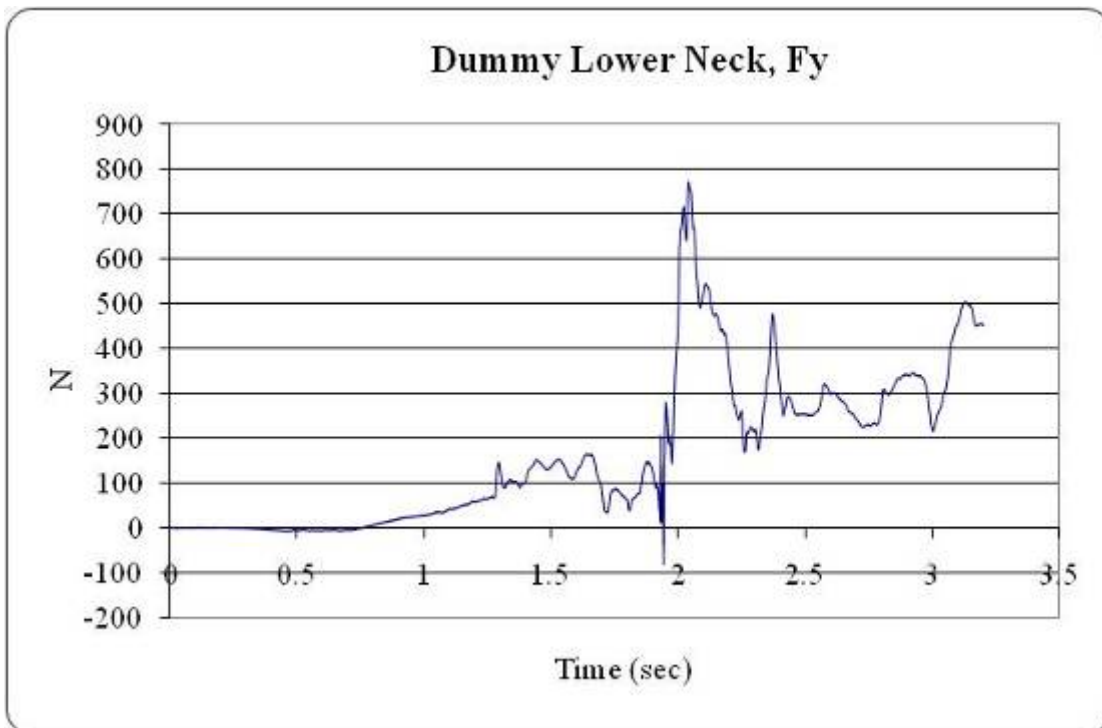
Plot 27: String Potentiometer Passenger's Side A-Pillar Displacement v. Time  
 \*Peak values estimated based on video analysis.  
 Data Sampling Rate: 10 kHz

Roll 2



Plot 28: Lower Neck Load, Fx, v. Time

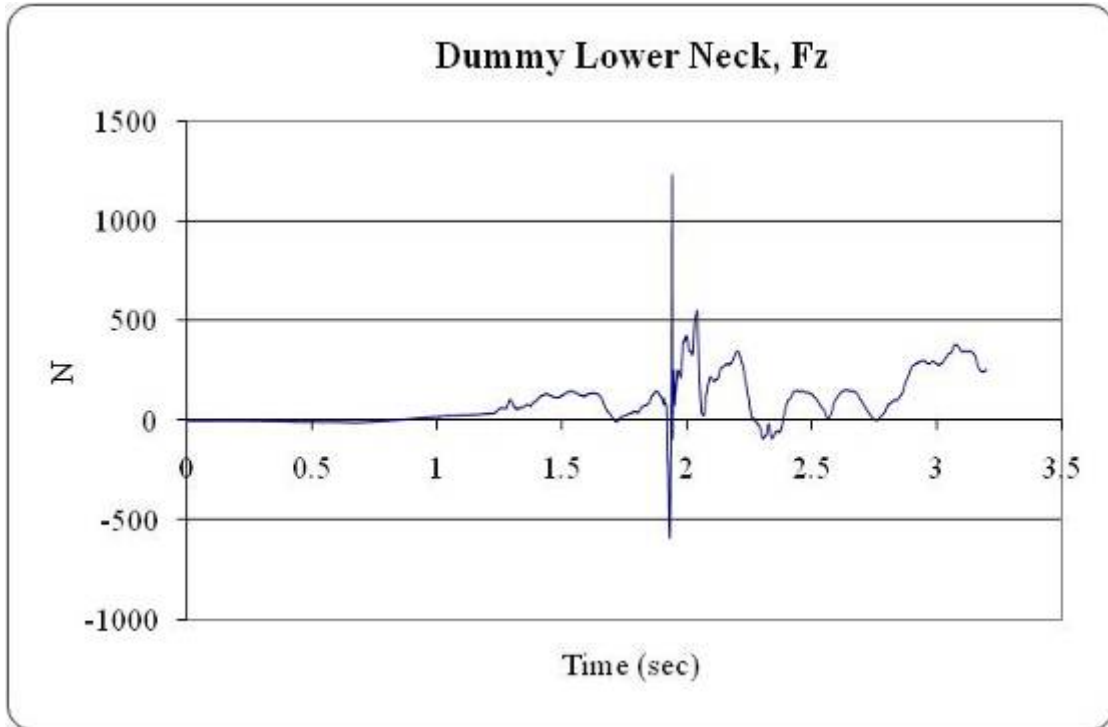
Data Sampling Rate: 10 kHz



Plot 29: Lower Neck Load, Fy, v. Time

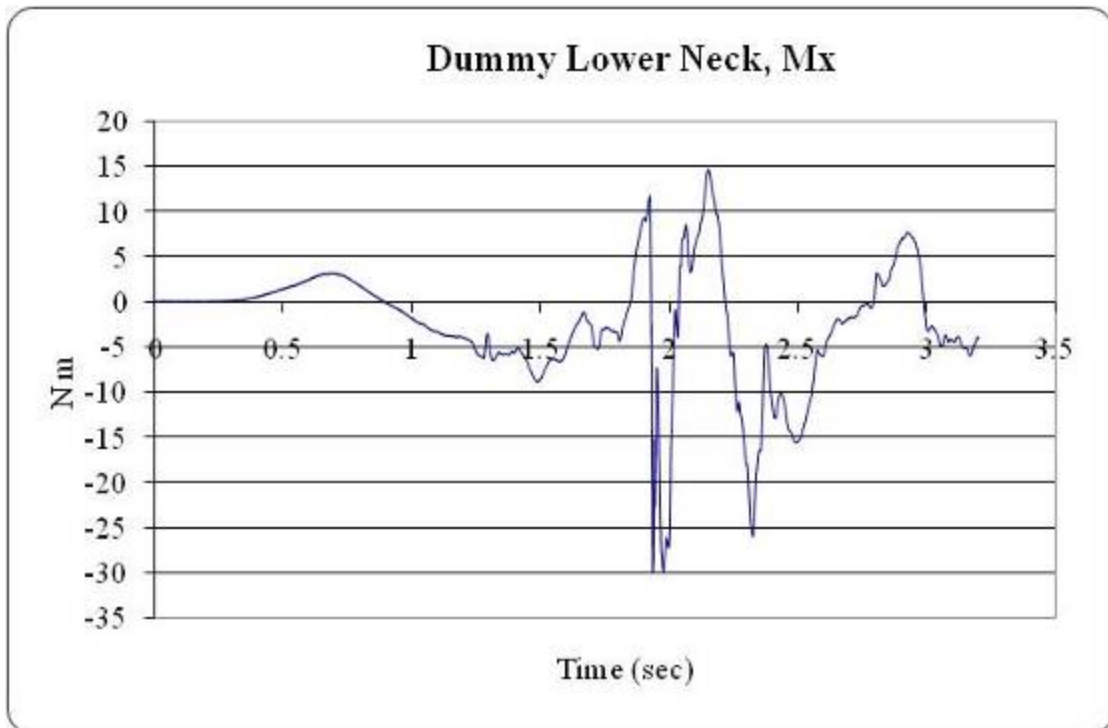
Data Sampling Rate: 10 kHz

Roll 2



Plot 30: Lower Neck Load, Fz, v. Time

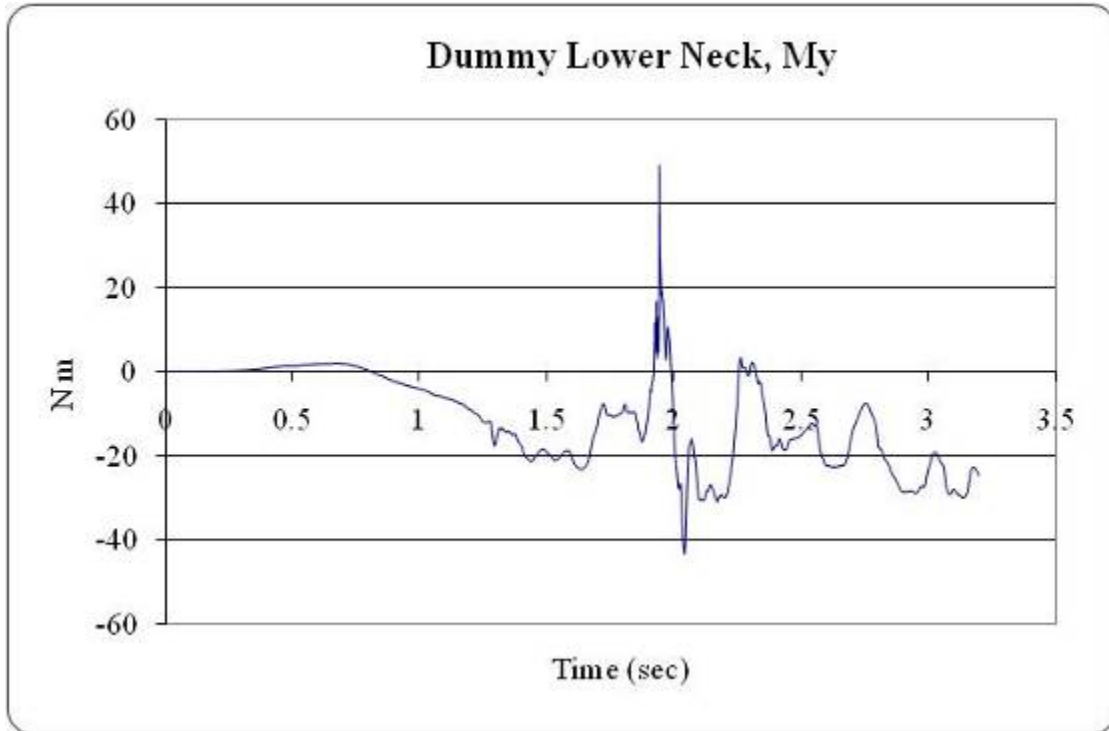
Data Sampling Rate: 10 kHz



Plot 31: Lower Neck Load, Mx, v. Time

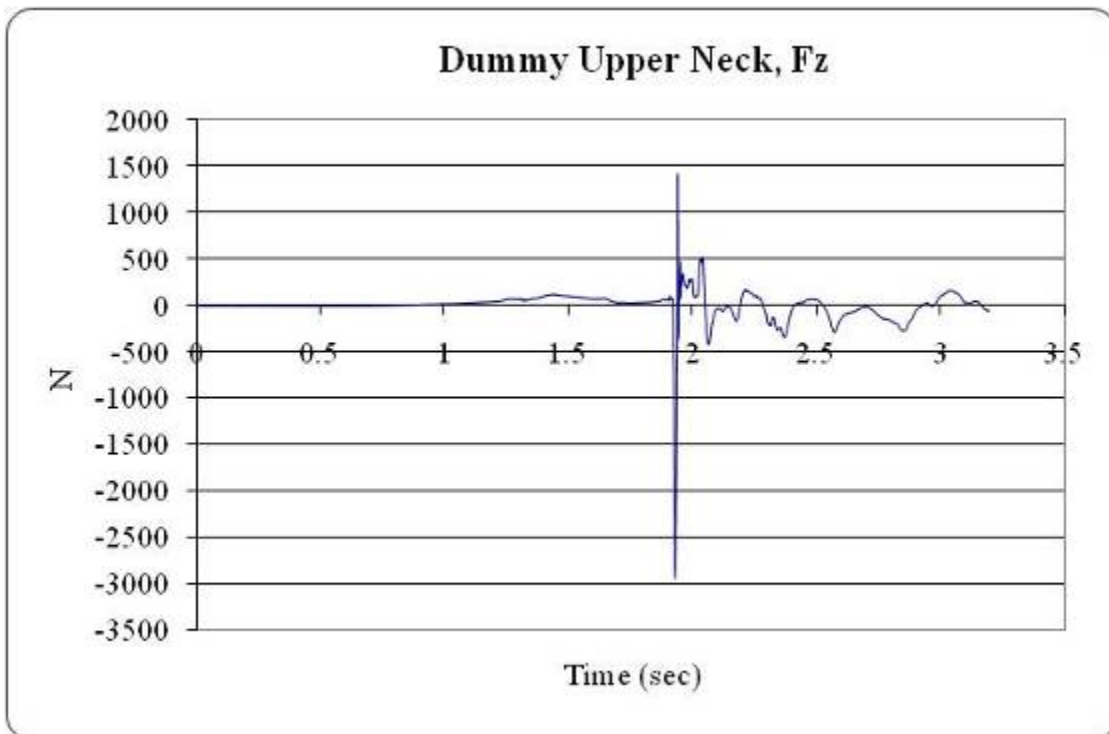
Data Sampling Rate: 10 kHz

Roll 2



Plot 32: Lower Neck Load, My, v. Time

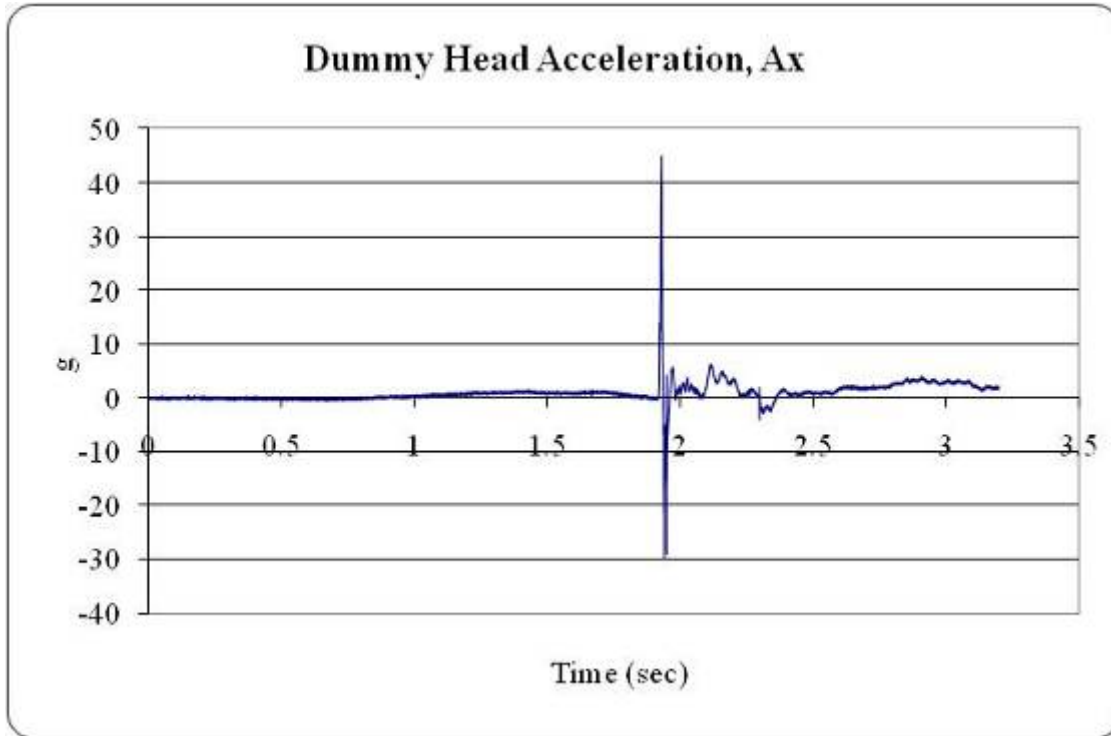
Data Sampling Rate: 10 kHz



Plot 33: Upper Neck Load, Fz, v. Time

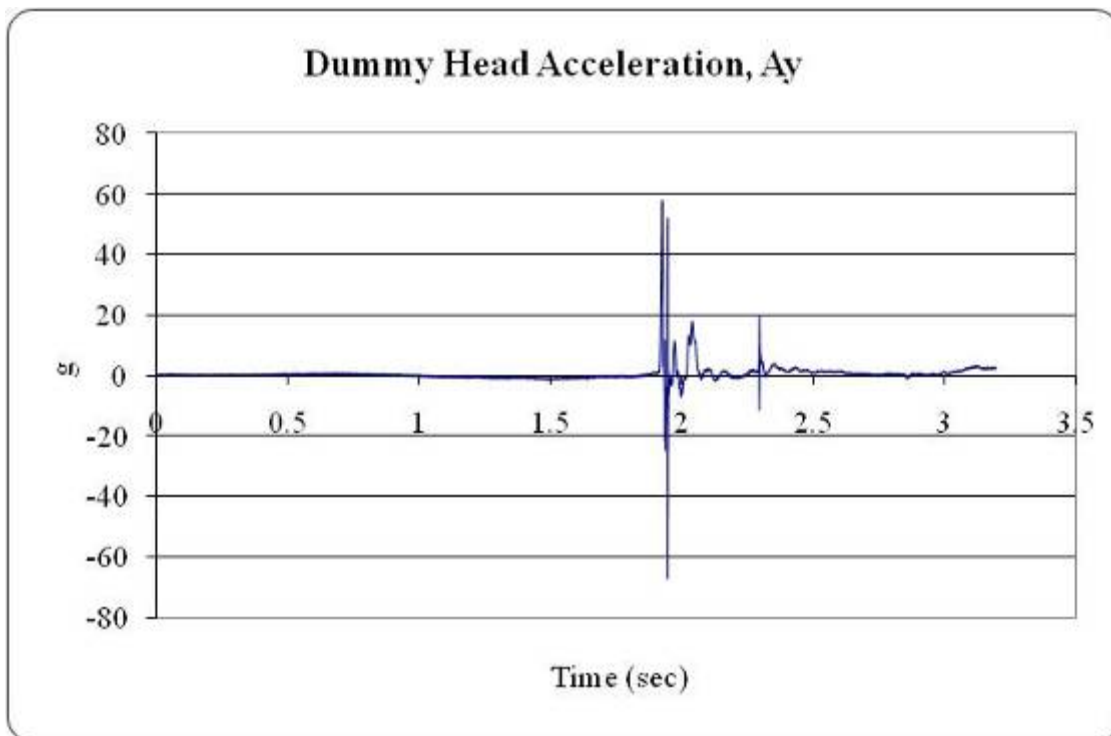
Data Sampling Rate: 10 kHz

Roll 2



Plot 34: Head Acceleration, Ax, vs. Time

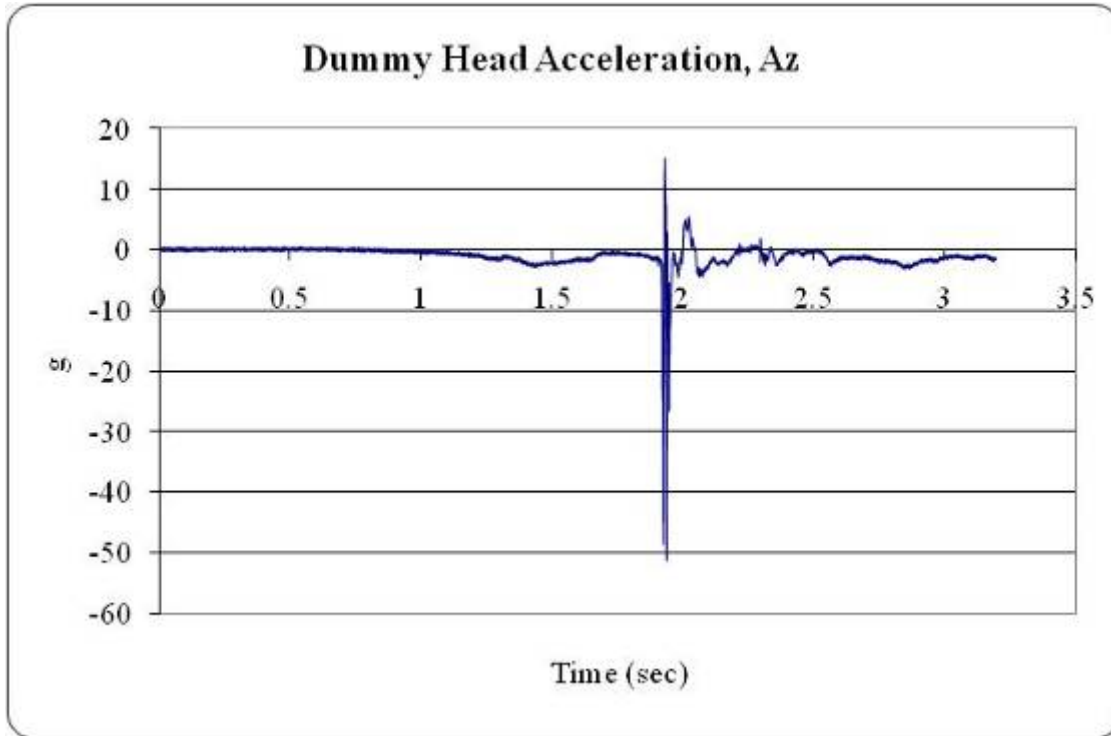
Data Sampling Rate: 10 kHz



Plot 35: Head Acceleration, Ay, vs. Time

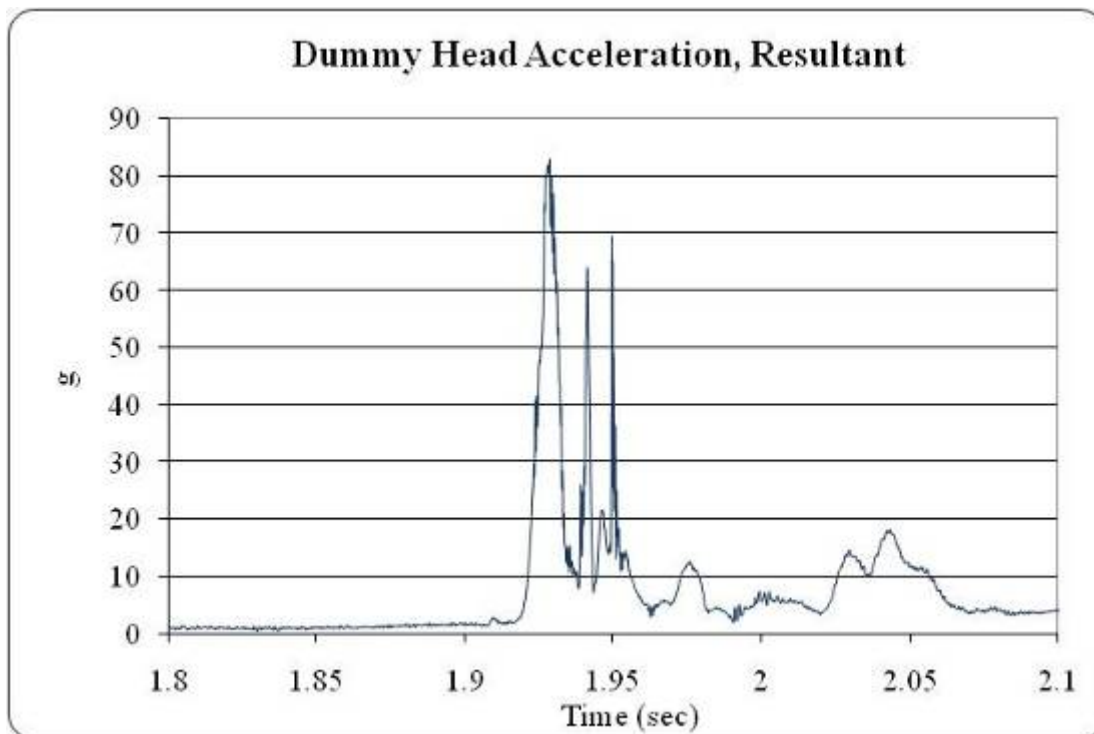
Data Sampling Rate: 10 kHz

**Roll 2**



Plot 36: Head Acceleration, Az, vs. Time

Data Sampling Rate: 10 kHz

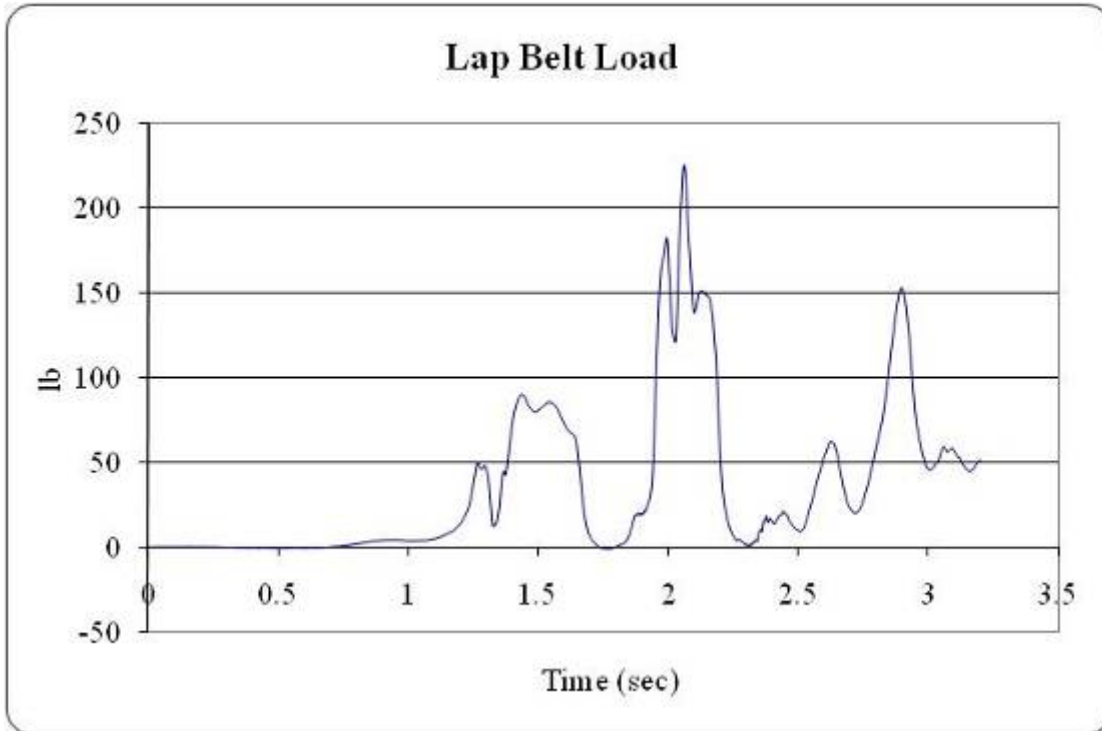


Plot 37: Resultant Head Acceleration vs. Time

HIC = 245

Data Sampling Rate: 10 kHz

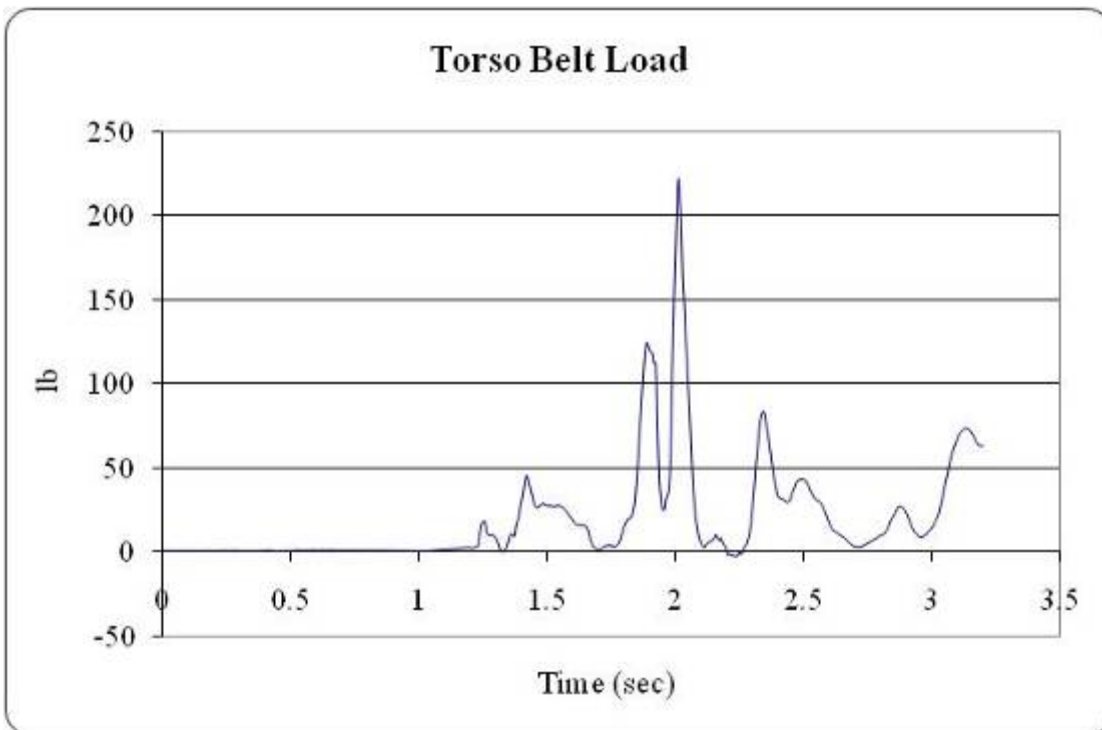
**Roll 2**



Plot 38: Lap Belt Load\* vs. Time

\*Measured on one side of the belt

Data Sampling Rate: 10 kHz

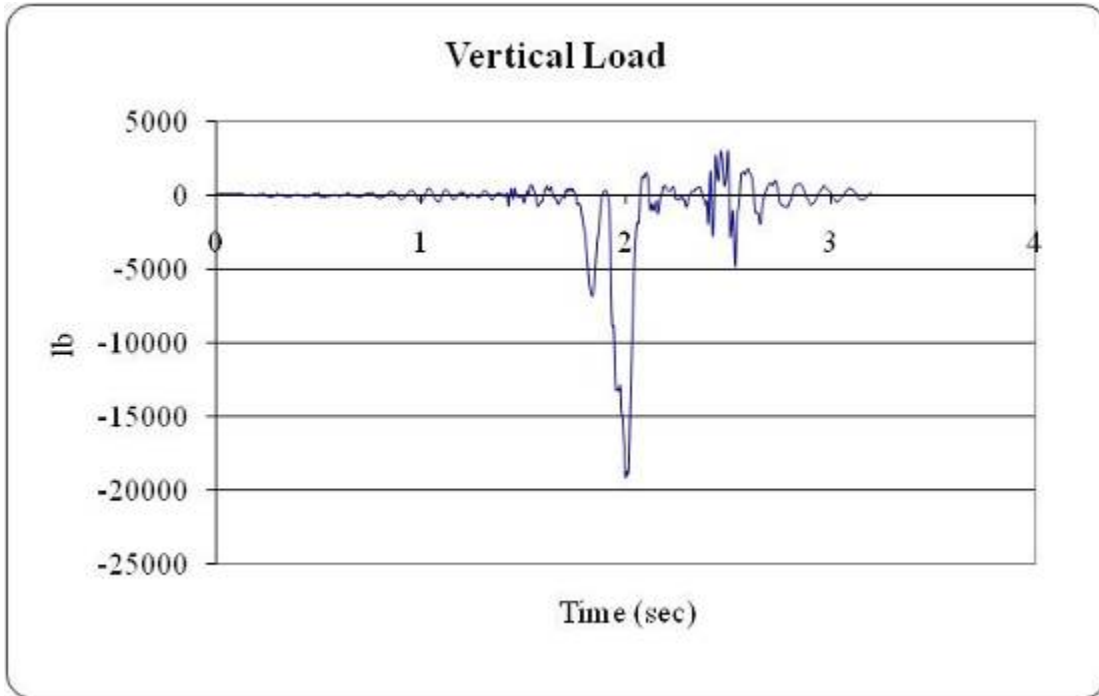


Plot 39: Torso Belt Load\* vs. Time

\*Measured on one side of the belt

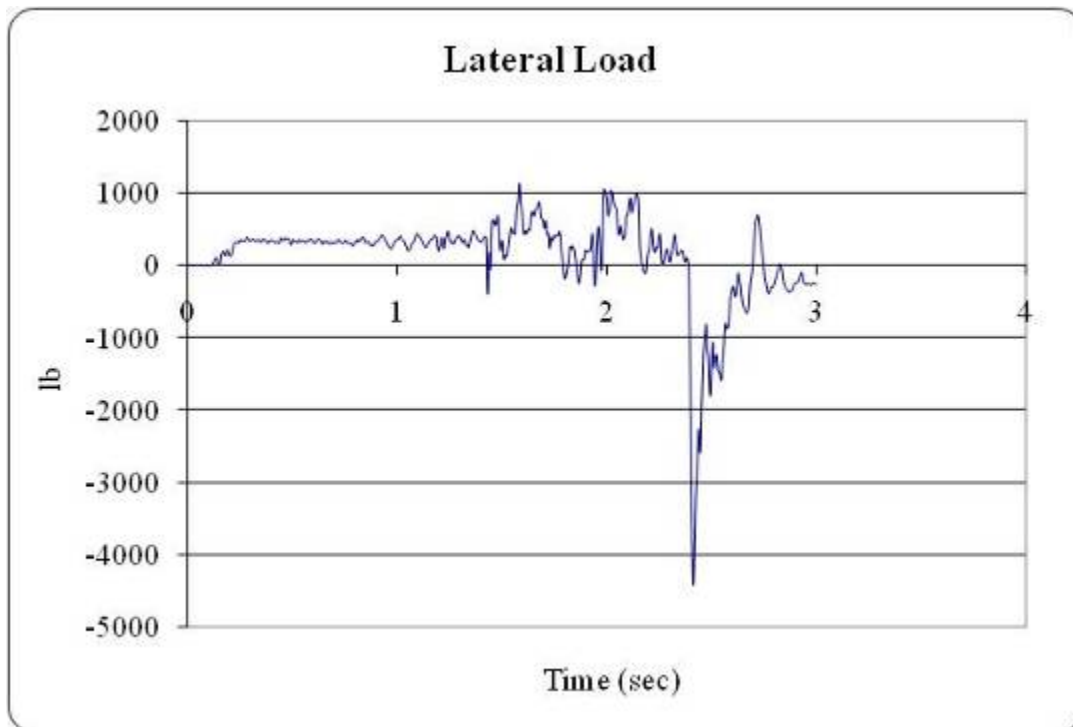
Data Sampling Rate: 10 kHz

Roll 2



Plot 40: Total Vertical Load v. Time

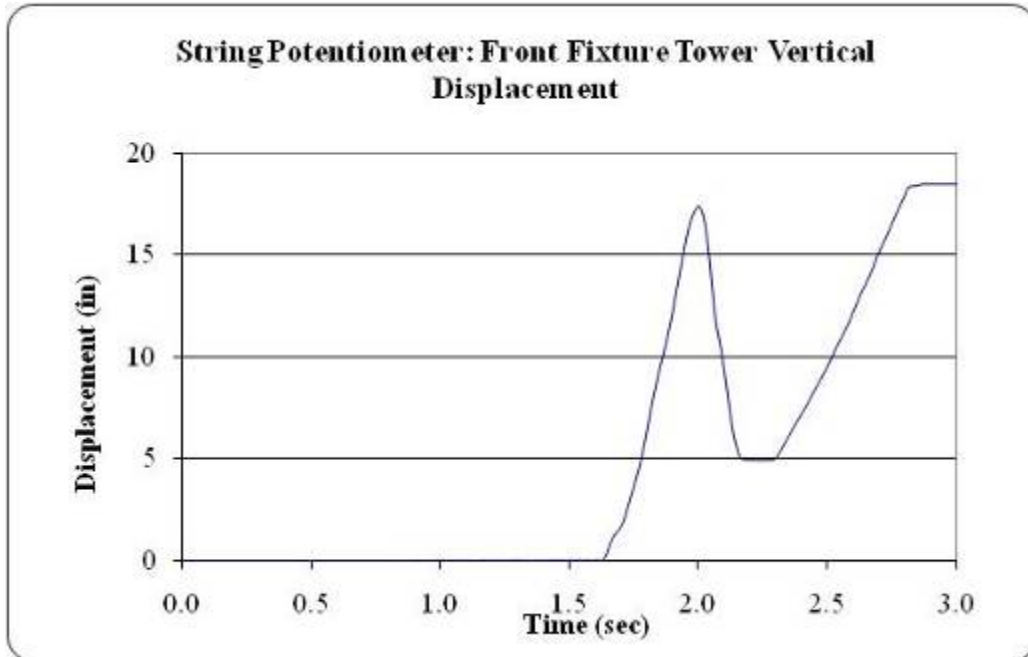
Data Sampling Rate: 10 kHz



Plot 41: Total Lateral Load v. Time

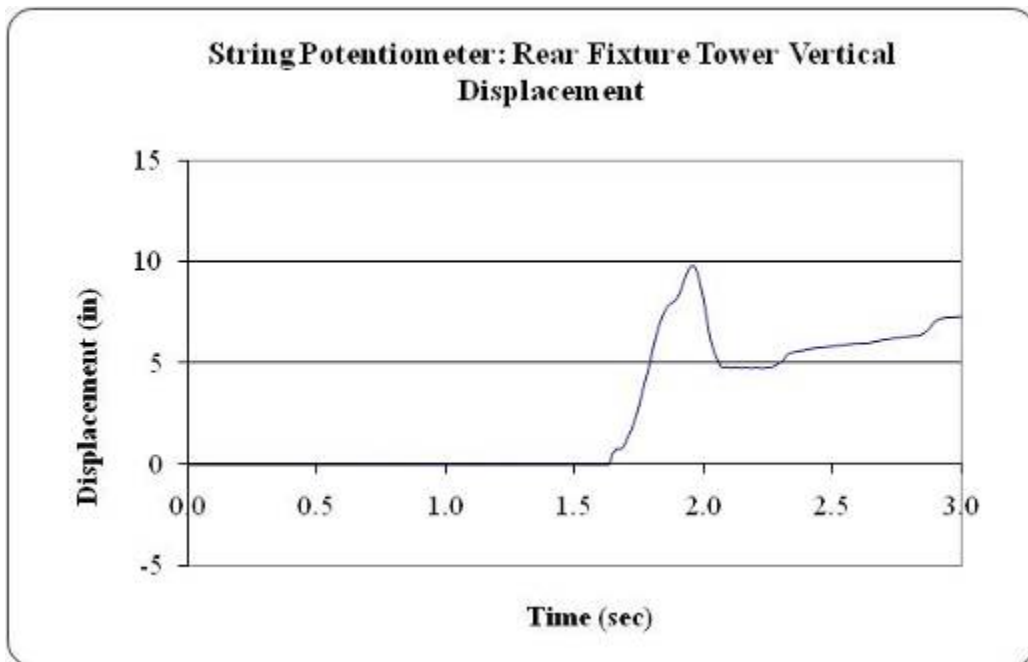
Data Sampling Rate: 10 kHz

Roll 2



Plot 42: String Potentiometer Front Fixture Support Tower Displacement vs. Time

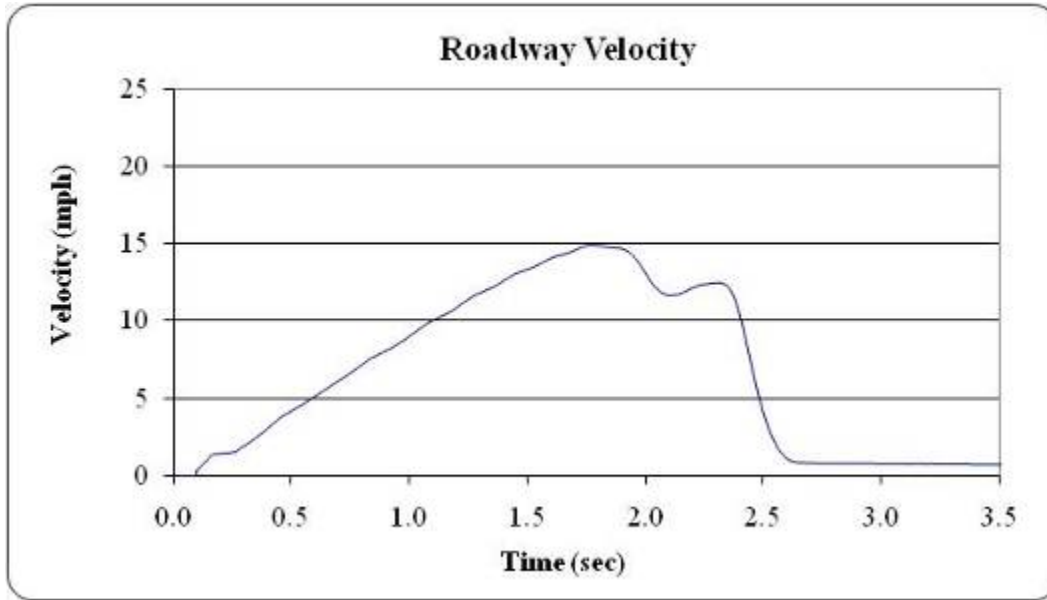
Data Sampling Rate: 1 kHz



Plot 43: String Potentiometer Rear Fixture Support Tower Displacement vs. Time

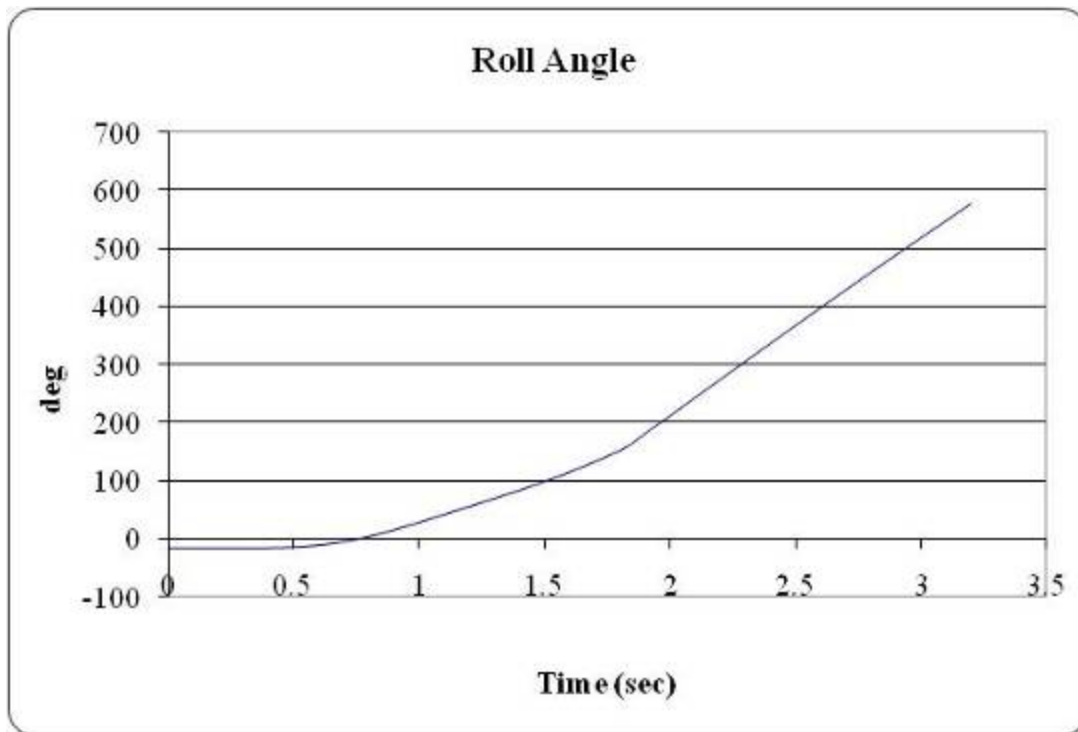
Data Sampling Rate: 1 kHz

Roll 2



Plot 44: Roll Encoder on Roadway Velocity vs. Time

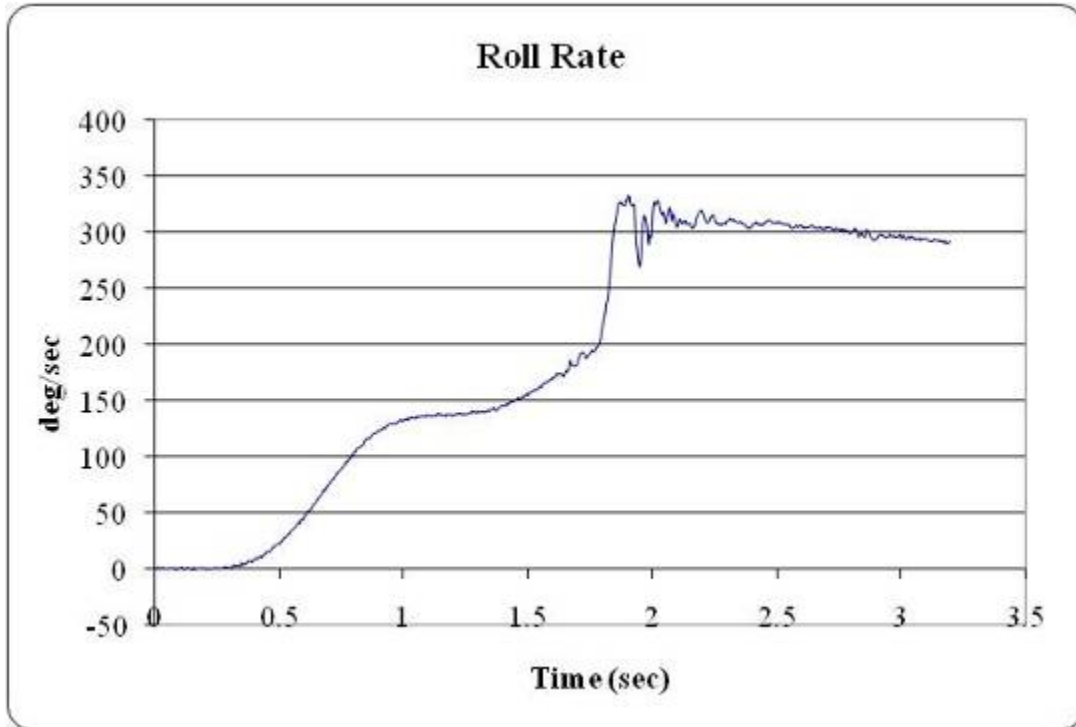
Data Sampling Rate: 1 kHz



Plot 45: Roll Angle vs. Time

Data Sampling Rate: 10 kHz

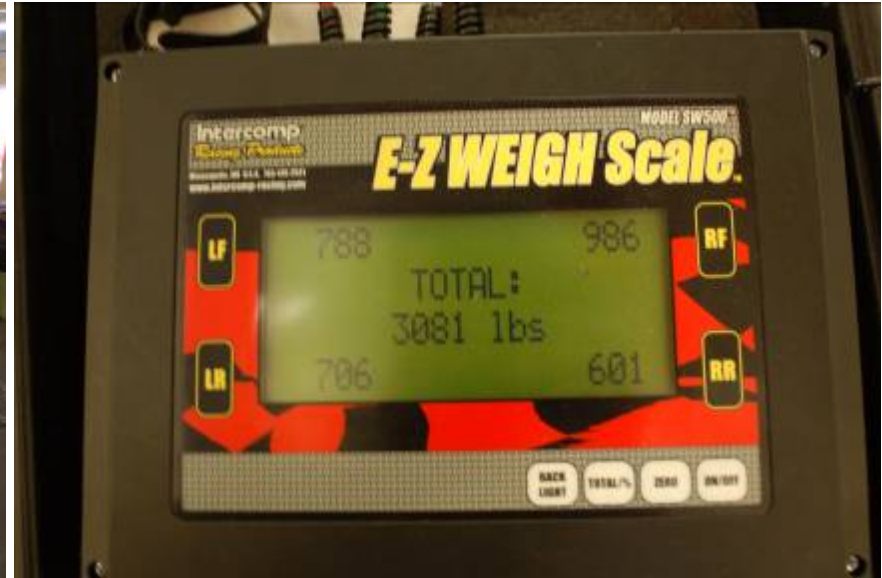
**Roll 2**



Plot 46: Roll Rate vs. Time

Data Sampling Rate: 10 kHz

5. All Test Photographs – Test Setup



**Vehicle Instrumentation**



### Vehicle Instrumentation



**Roll 1 Photographs – 04/27/2010 – Dummy Inspection**



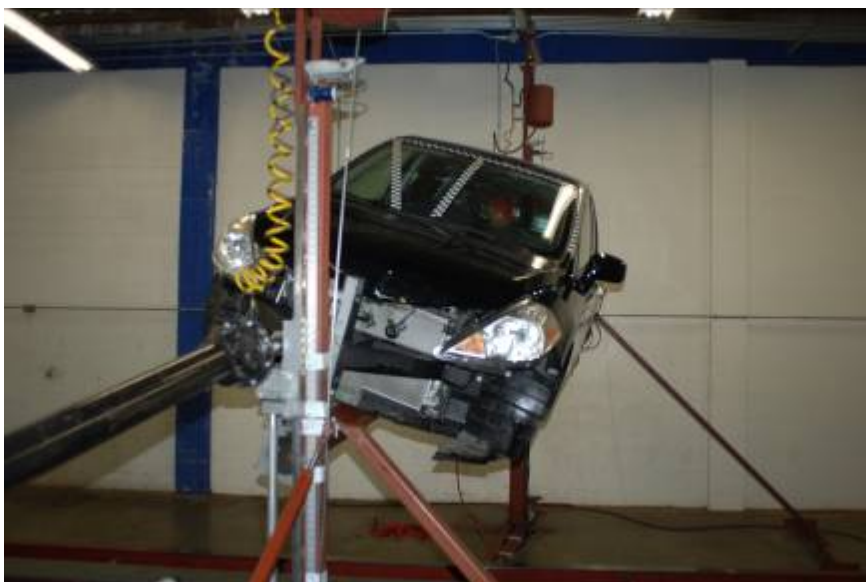
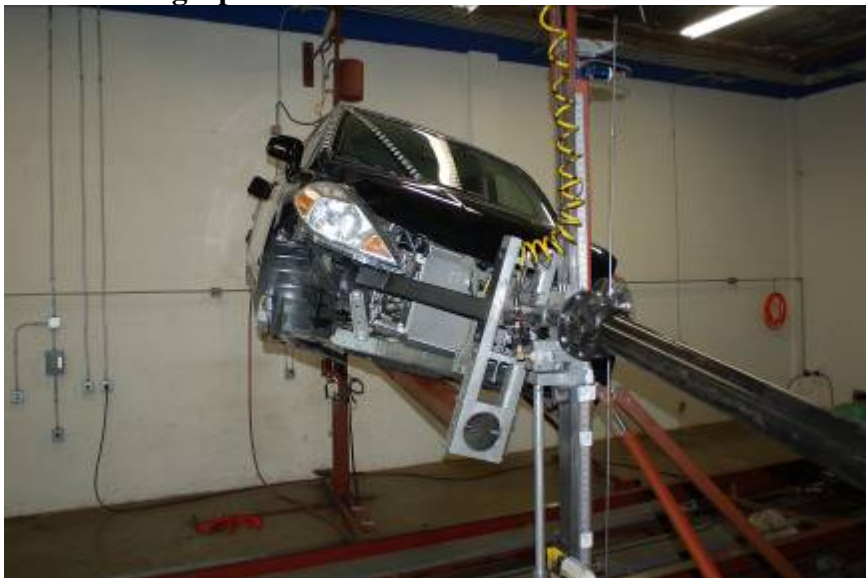
**Roll 1 Photographs – 04/27/2010 – Dummy Inspection**



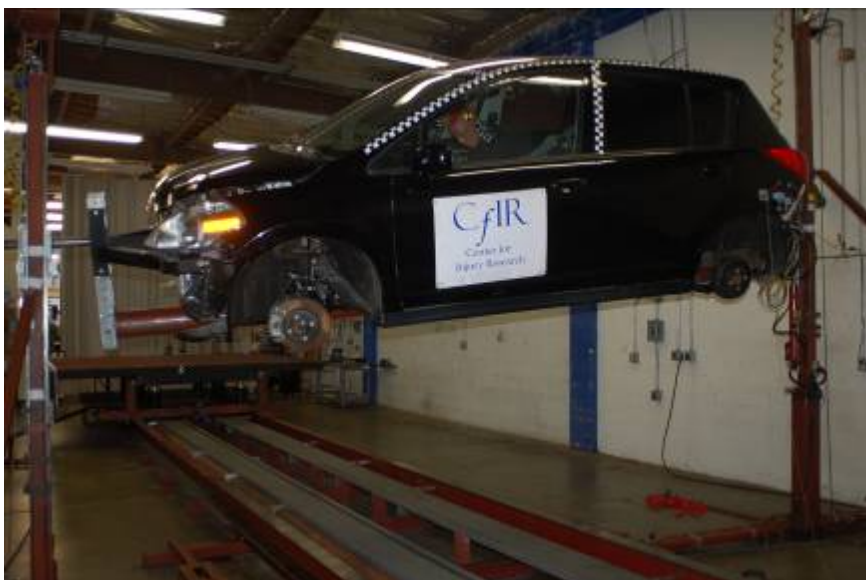
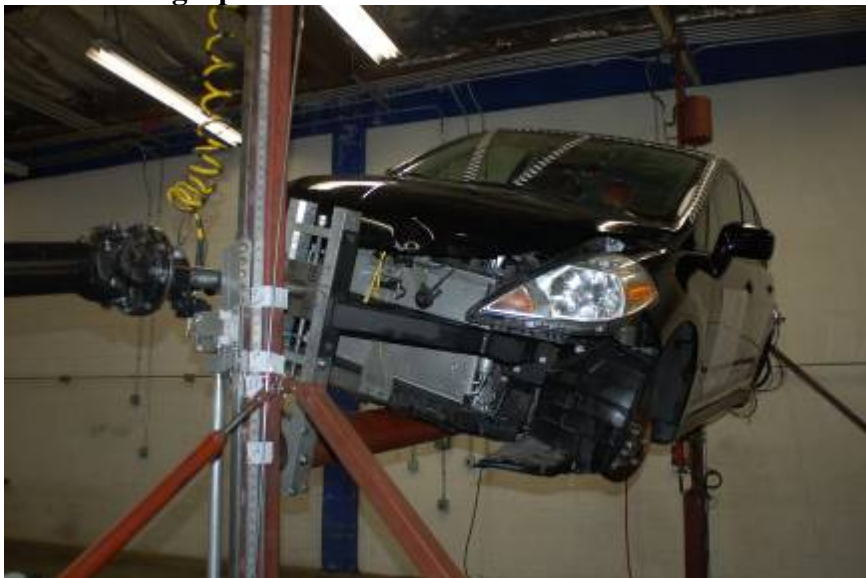
**Roll 1 Photographs – 04/27/2010 – Pre-Roll**



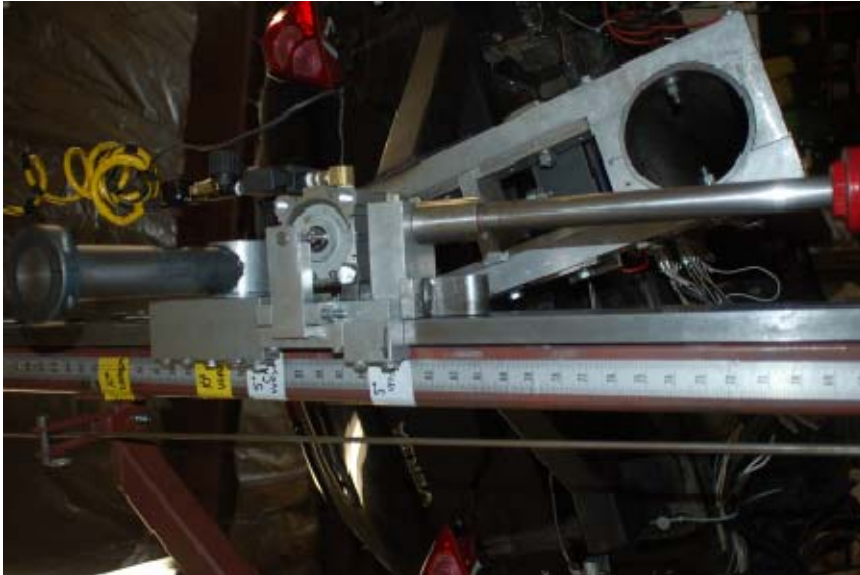
**Roll 1 Photographs – 04/27/2010 – Pre-Roll**



**Roll 1 Photographs – 04/27/2010 – Pre-Roll**



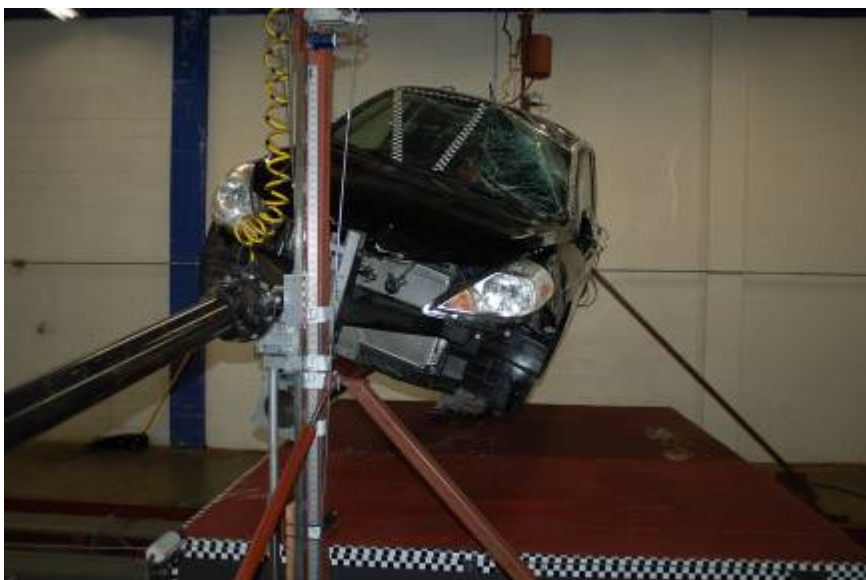
**Roll 1 Photographs – 04/27/2010– Pre-Roll**



**Roll 1 Photographs – 04/27/2010 – Post-Roll**



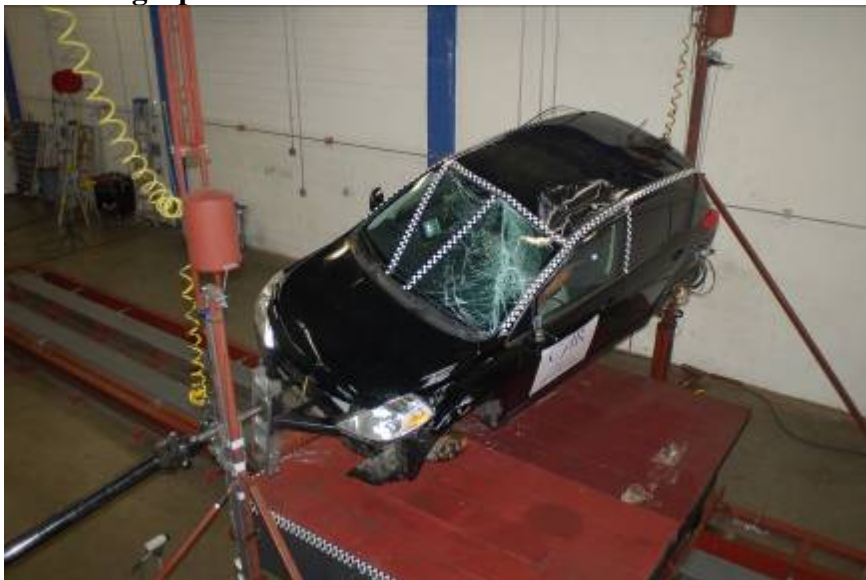
**Roll 1 Photographs – 04/27/2010 – Post-Roll**



**Roll 1 Photographs – 04/27/2010 – Post-Roll**



**Roll 1 Photographs – 04/27/2010– Post-Roll**



Roll 2 Photographs – 04/28/2010 – Dummy Inspection



Roll 2 Photographs – 04/28/2010 – Dummy Inspection



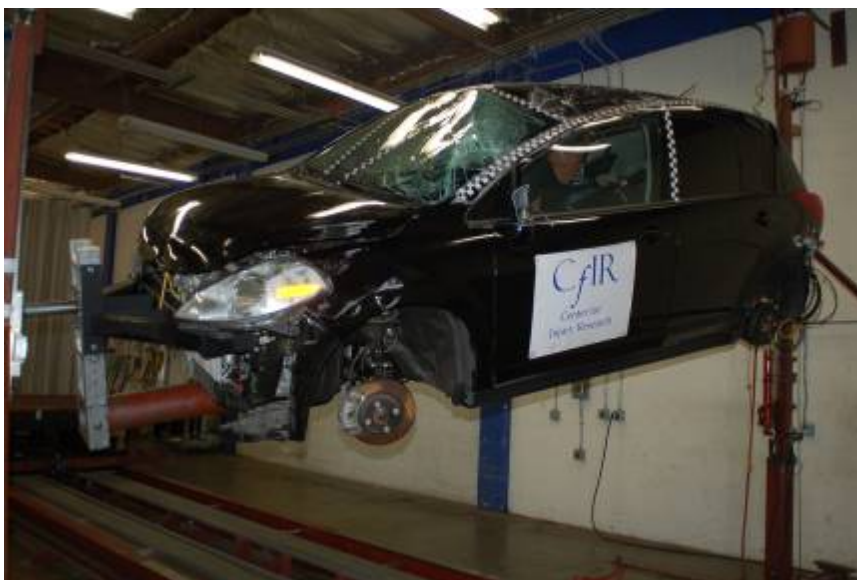
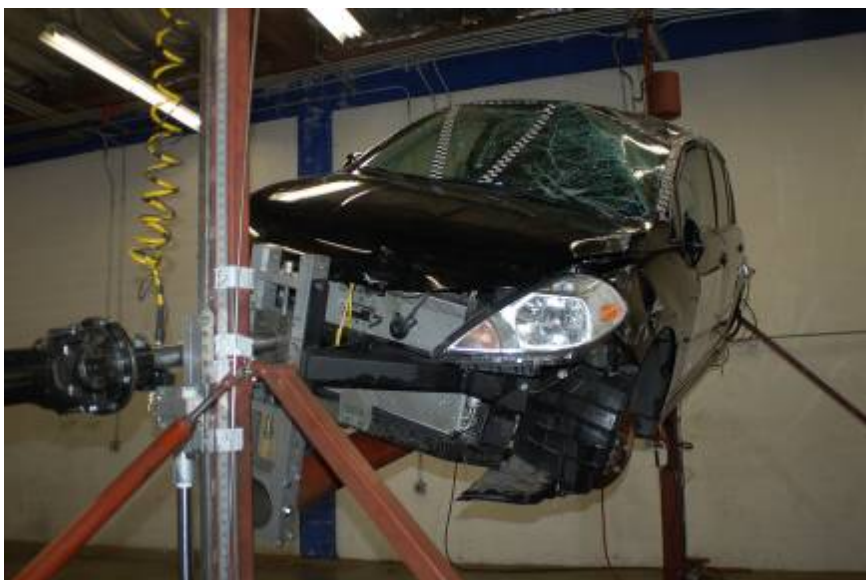
**Roll 2 Photographs – 04/28/2010 – Pre-Roll**



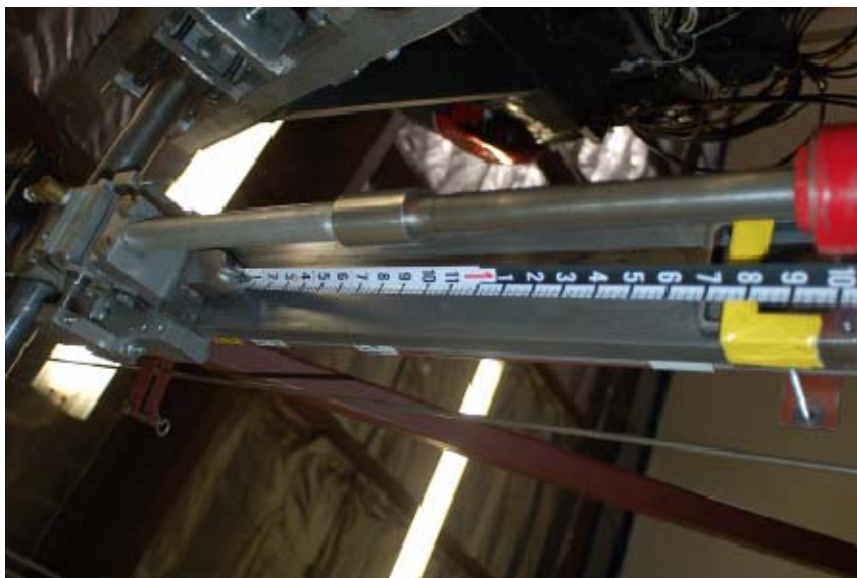
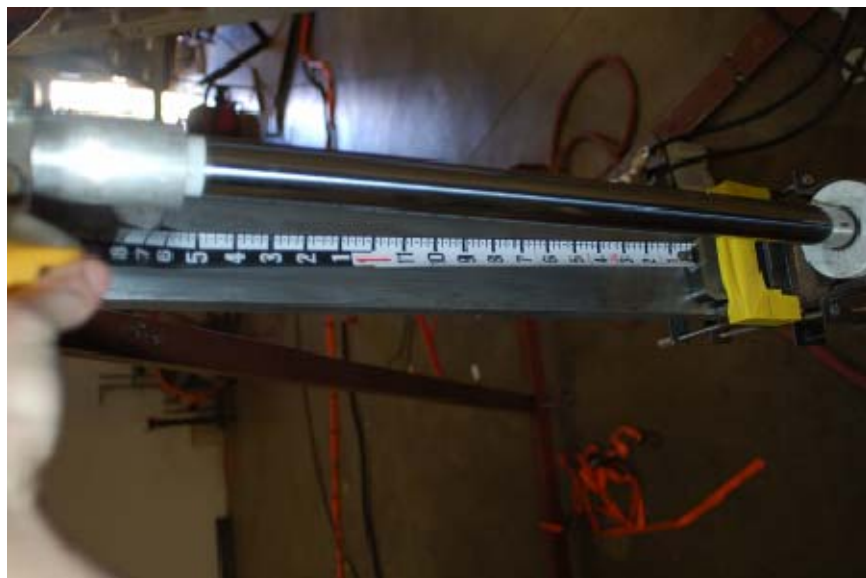
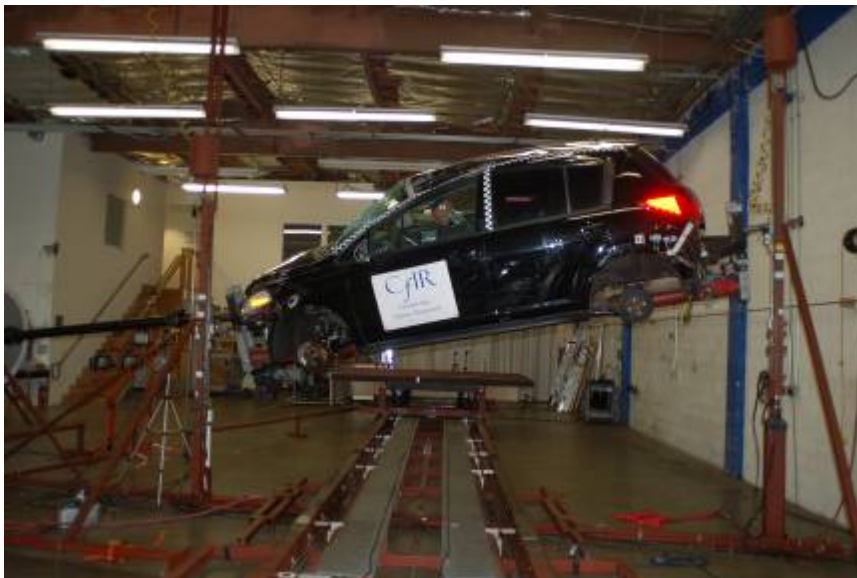
**Roll 2 Photographs – 04/28/2010 – Pre-Roll**



**Roll 2 Photographs – 04/28/2010 – Pre-Roll**



**Roll 2 Photographs – 04/28/2010 – Pre-Roll**



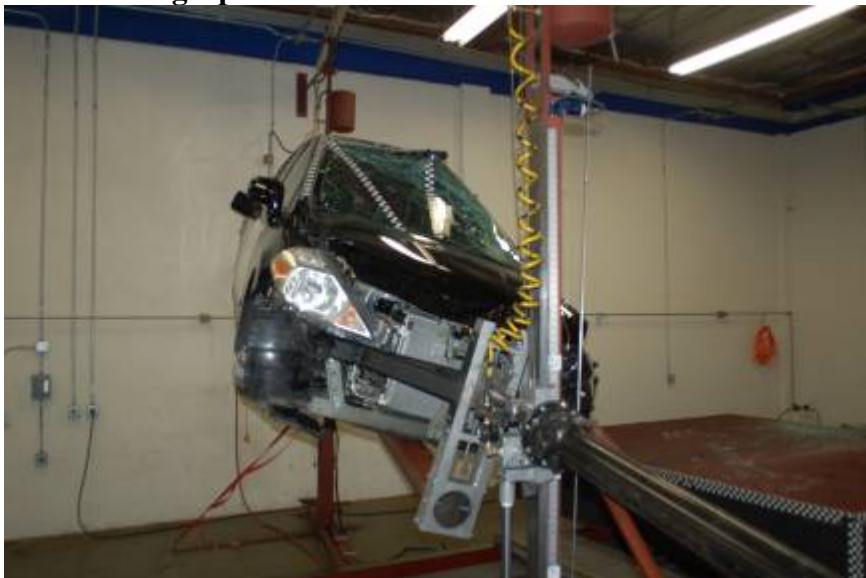
**Roll 2 Photographs – 04/28/2010 – Pre-Roll**



**Roll 2 Photographs – 04/28/2010 – Post-Roll**



**Roll 2 Photographs – 04/28/2010 – Post-Roll**



**Roll 2 Photographs – 04/28/2010 – Post-Roll**



**Pre-Test**



Pre-Test



**Pre-Test**



**Post-Test**



**Post-Test**



**Post-Test**

