Texas A&M Transportation Institute
Proving Ground

Test Report No. TRNo. 618911-01-1 - 3

EVALUATION OF A FOUR BOLT SLIP BASE FOR BREAKAWAY LUMINAIRE SUPPORTS WITH VARIOUS POLE CONFIGURATIONS

Sponsored by
The Roadside Safety Pooled Fund

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16. Abstract

Luminaire poles are a vital aspect of our transportation system. Much work in recent years has been undertaken to evaluate luminaire poles to the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware (MASH)* evaluation criteria. Of this previous effort, most projects evaluated frangible transformer base supports; there was minimal research evaluating slip base connections for luminaire pole supports. Consequently, the Roadside Safety Pooled Fund prioritized an evaluation of common designs for luminaire pole slip base supports.

The primary objective of this study was to evaluate critical configurations of a non-proprietary four-bolt slip base luminaire support for MASH crashworthiness. This effort started with a literature review and a state survey, which was aimed at identifying commonly used designs of luminaire pole slip bases. With the results of the literature review and state survey, the research team selected a configuration for full-scale crash testing. The research team subsequently evaluated the luminaire pole and slip base supports with *MASH* crash testing. One of three evaluated systems successfully met *MASH* evaluation criteria. The results of this testing effort demonstrates the need for further research evaluating the crashworthiness of luminaire poles and their support structures. This report details the tasks performed by the research team.

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The results reported herein apply only to the article tested. The full-scale crash tests were performed according to TTI Proving Ground quality procedures and American Association of State Highway and Transportation Officials (AASHTO) Manual for Assessing Safety Hardware, Second Edition (*MASH*) guidelines and standards.

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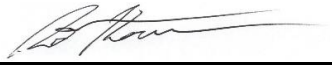

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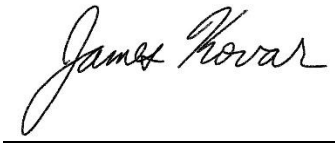

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REVISION LOG

Revision Number	Change(s) Made	Date

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	Square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lb/in^2

*SI is the symbol for the International System of Units

LIST OF ABBREVIATIONS

For your convenience, this table includes the following list of abbreviations that are used within the content of this report.

AASHTO	American Association of State Highway and Transportation Officials
CIP	Critical Impact Point
DOT	Department of Transportation
KDOT	Kansas Department of Transportation
MASH	Manual for Assessing Safety Hardware
MGS	Midwest Guardrail System
MwRSF	Midwest Roadside Safety Facility
NCHRP	National Cooperative Highway Research Program
NARD	Numerical Analysis of Roadside Design
RDG	Roadside Design Guide
TxDOT	Texas Department of Transportation

Chapter 1. INTRODUCTION

Luminaire poles are a vital aspect of our transportation system. Much work in recent years has been undertaken to evaluate luminaire poles to the American Association of State Highway and Transportation Officials (AASHTO) *Manual for Assessing Safety Hardware (MASH)* evaluation criteria. Of this previous effort, most projects evaluated frangible transformer base supports; there was minimal research evaluating slip base connections for luminaire pole supports. Consequently, the Roadside Safety Pooled Fund prioritized an evaluation of common designs for luminaire pole slip base supports.

The primary objective of this study was to evaluate critical configurations of a non-proprietary four-bolt slip base luminaire support for MASH crashworthiness. This effort started with a literature review and a state survey, which was aimed at identifying commonly used designs of luminaire pole slip bases. With the results of the literature review and state survey, the research team selected a configuration for full-scale crash testing. The research team subsequently evaluated the luminaire pole and slip base supports with *MASH* crash testing. This report details the tasks performed by the research team.

Chapter 2. LITERATURE REVIEW

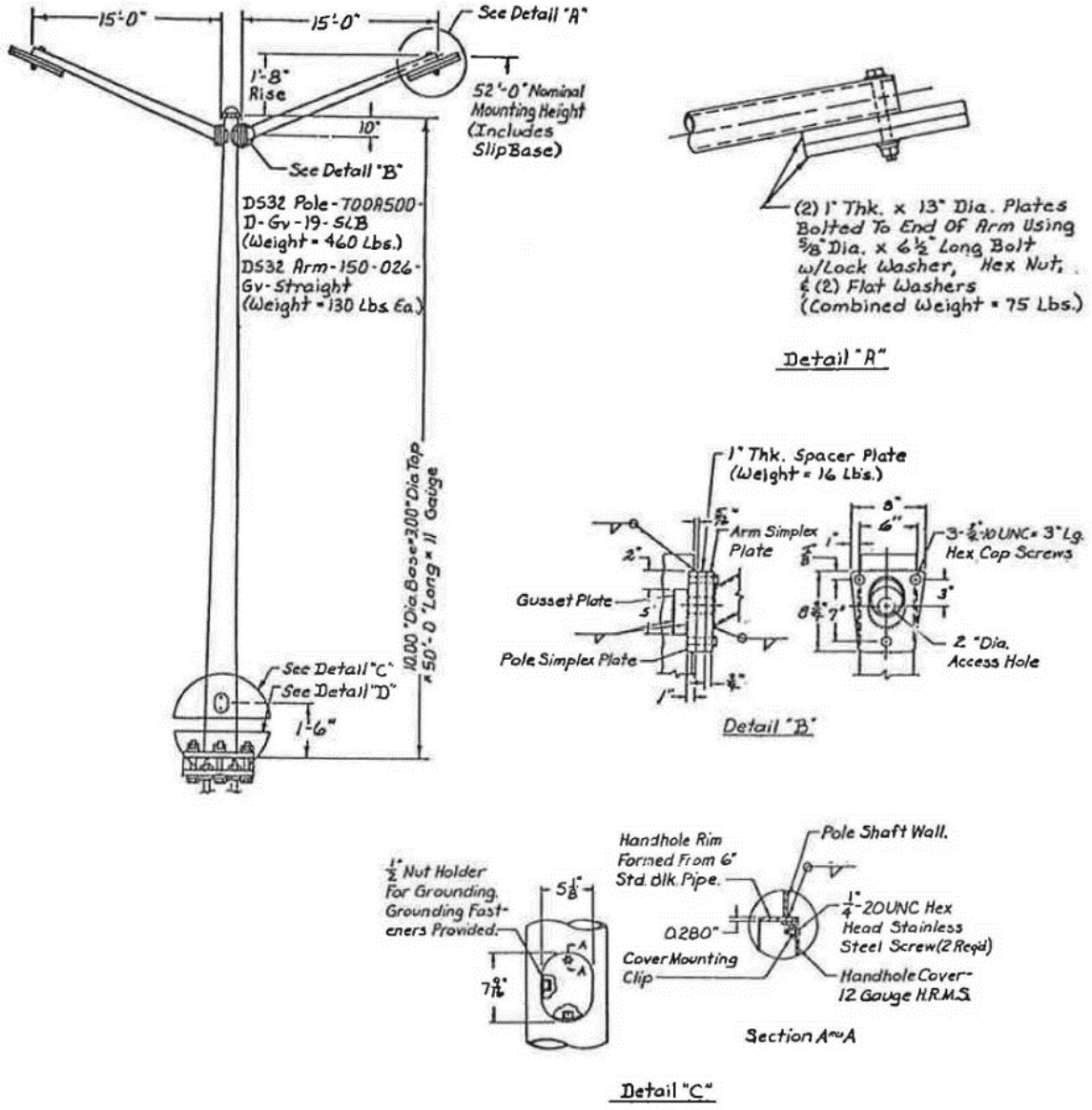
2.1. OVERVIEW

This chapter documents the literature review performed in Phase 1 of this project. The research team reviewed relevant research regarding luminaire pole configurations.

2.2. FULL-SCALE 1,800 LB. VEHICLE CRASH TESTS ON A 4-BOLT BREAKAWAY SLIP BASE DESIGN (TRP-03-25-91) (*3*)

The objective of the research conducted in this report was to evaluate the safety performance of the 4-bolt breakaway slip base luminaire support for Federal-air projects. Two full-scale crash tests were conducted under National Cooperative Highway Research Program (NCHRP) *Report 230* (*2*). The luminaire support had three major components: the luminaire support pole, two mast arms, and the permanent lower slip base assembly, the details for which are shown below in Figure 2.1 and Figure 2.2. The maximum height from the ground to top of the mast arms was a 52-ft. The height from the ground to the top of the luminaire pole was 50-ft 4-in. The two steel mast arms were attached to the luminaire 10-in below the top of the luminaire support pole and extended 15-ft outward from the pole.

The first crash test involved a 1,750 lb 1984 Dodge Colt, impacting the luminaire support at the center point of the bumper at a speed of 15-mi/h. The front bumper of the vehicle crushed inward upon impact, as the base started to slip. The support hit the roof of the car 2.33 seconds after impact. The vehicle change in speed was calculated using a combination of film and accelerometer data. The occupant impact velocity was determined to be 7.6 ft/s, the maximum ridedown deceleration of 3.5 g's, and the vehicle change in speed was 6.1 ft/s. All were well below the requirements set forth by the guidelines listed in the previous paragraph. The damage to the vehicle was minimal, with only a 9 in. crushing distance in the bumper and slight damage to the roof. The vehicle and assembly damage are shown below in Figure 2.3.



NOTES

1) KEEPER PLATE CONFORMS TO ASTM DESIGNATION: A446 GRADE A. COATING DESIGNATION: G90.
2) ALL THREADED FASTENERS TO BE GALVANIZED UNLESS OTHERWISE NOTED.
3) POLE AND ARM TO BE GALVANIZED TO ASTM DESIGNATION: A123.
4) ACCESSORIES TO BE GALVANIZED TO ASTM DESIGNATION: A153.

Figure 2.1. Details for Direct 4-bolt Slip base Luminaire Support (1/2) (*3*)

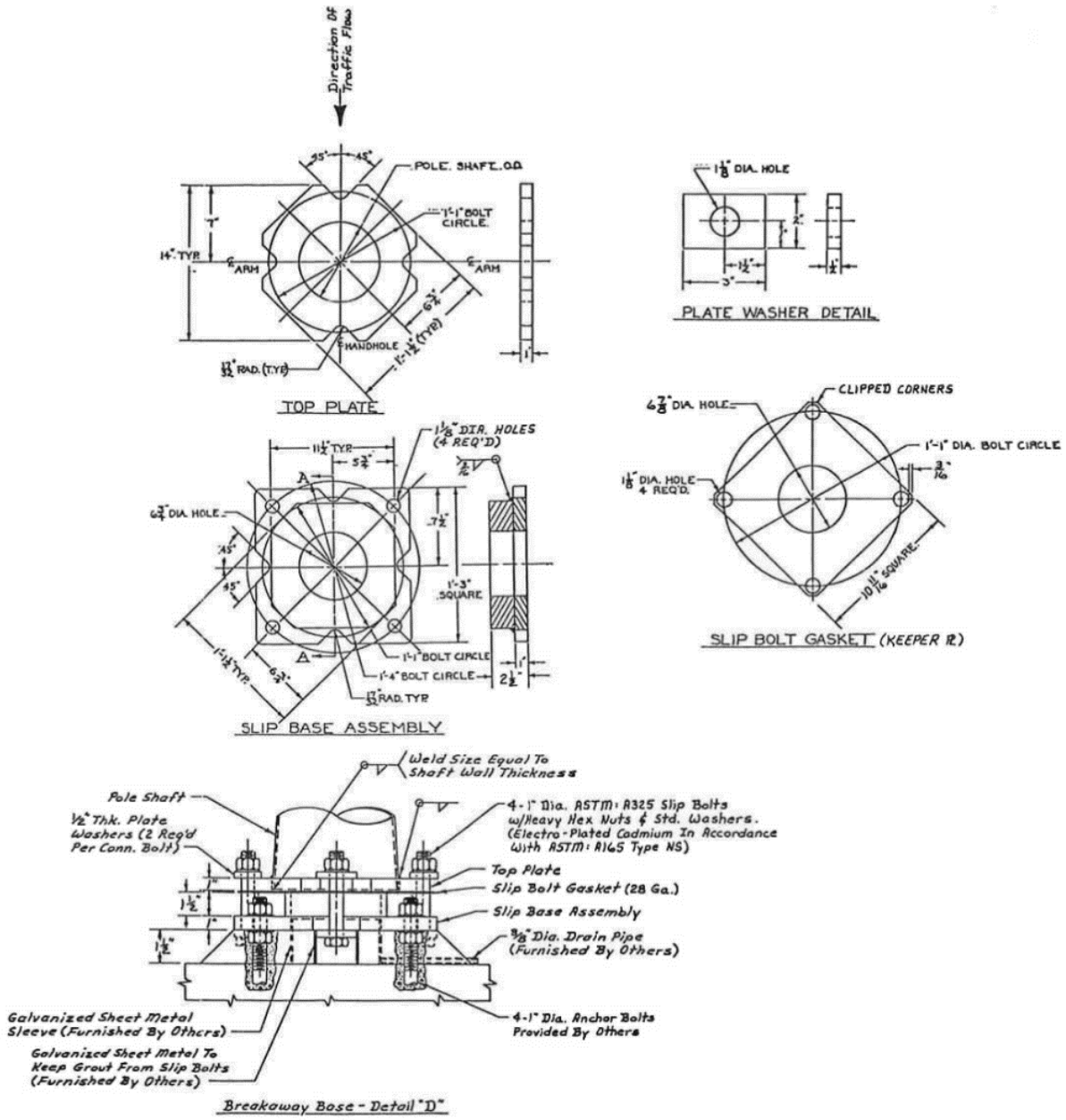


Figure 2.2. Details for Direct 4-bolt Slip base Luminaire Support (*3*).

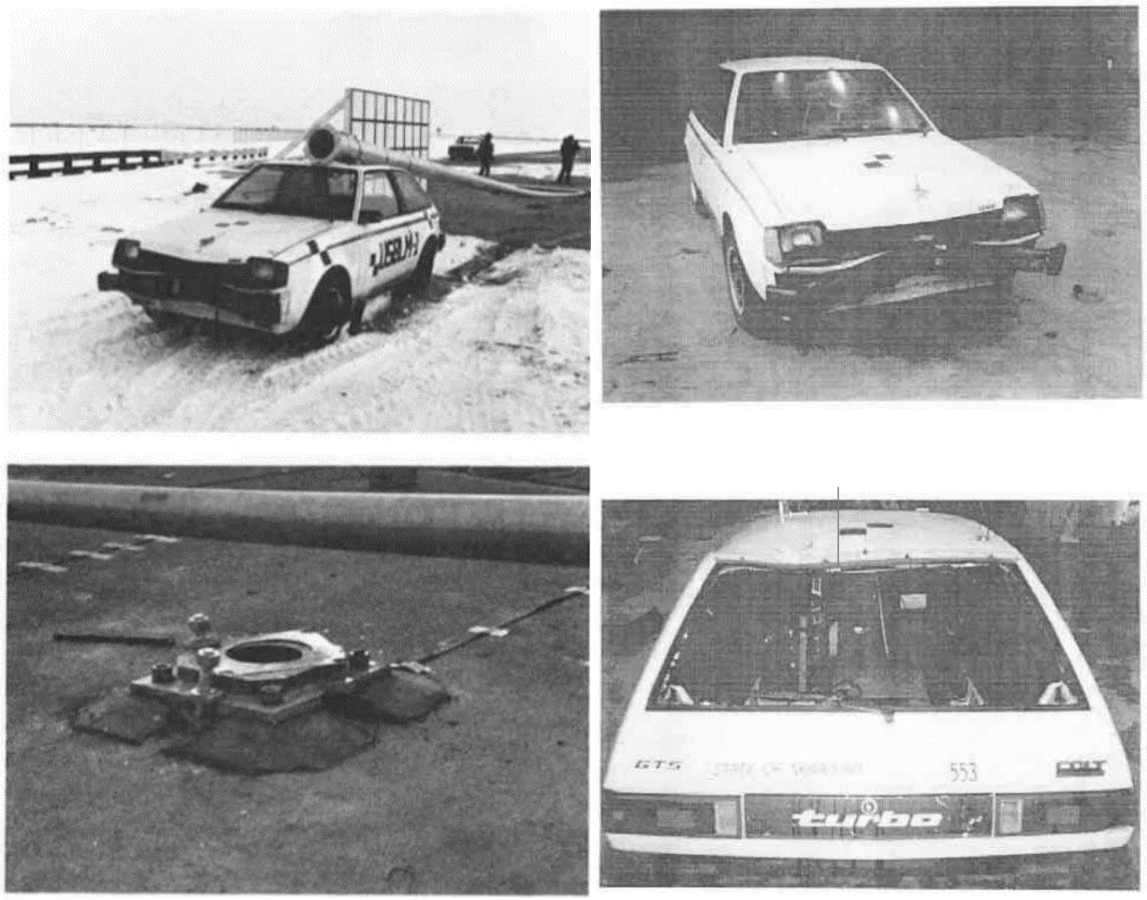


Figure 2.3. Post-Test images of Vehicle, Luminaire, and Slip base (*3*)

The second test was conducted using a repaired vehicle from the previous test. The center of the bumper impacted the luminaire support at a speed of 57.5 mi/h. The front of the bumper crushed upon impact as the base began to slip. The front of the vehicle began to lift up and continued on its rear wheels for 1 second after impact. The occupant impact velocity was determined to be 14.2 ft/s, the ridedown deceleration was 1.0 g's, and the change in speed was 13.5 ft/s. All were well below the requirements set forth by the guidelines listed previously. The only damage done to the vehicle was a maximum crushing distance of 12 in. on the bumper. The vehicle damage is shown below in Figure 2.4.

According to the results gathered from the two tests conducted in the report, the 4-bolt breakaway slip base design was considered acceptable according to NCHRP *Report 230* (*2*).

Figure 2.4. Post-Test Images of Vehicle

2.3. FULL-SCALE VEHICLE CRASH TESTS OF LUMINAIRE SUPPORTS (REPORT# 386-005) (4)

This effort involved a large series of crash tests evaluating a number of luminaire support configurations. In the ninth test, a 1963 Chevrolet impacted the luminaire support at a speed of 40.2 mi/h. The slip base on this pole became disengaged quickly, and the pole rotated upward. This allowed the vehicle to pass under it with relatively small change in speed. The change in momentum was determined to be 405 lb-sec from the high-speed film, and 425 lb-sec from the accelerometer. The assembly and vehicle damage are shown below in Figure 2.5.

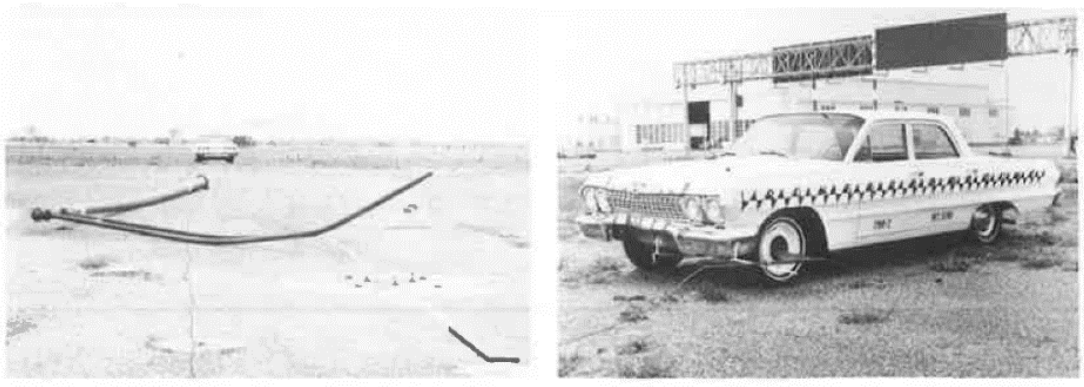


Figure 2.5. Post-Impact Images of the Vehicle and Assembly (Ninth Test) (*4*)

2.4. CRASH TESTING OF FLASHING BEACON SUPPORTS

The objective of the research conducted in this report was to evaluate the crashworthiness of warning sign supports with flashing beacons. The impacts involve test vehicles with masses of 1808 lbs and speeds of at 22 mi/h and 62 mi/h. The signs and beacons are mounted on a cut-down Type 15 light standard pole without the arm flange on a Type 30/31 slip base shown in Figure 2.6.

The first test conducted on the assembly had an impact angle and speed of 0 degrees and 23.7 mi/h. The impact point was 5.0 in. to the right of the pole's center. Upon impact, the vehicle began to deform as it came in contact with the assembly, and the slip base engaged as anticipated. The sign assembly rotated throughout the course of the impact until the top impacted the ground behind the vehicle. The entire front of the vehicle was moderately damaged from the initial impact. The front windshield was damaged along the roofline but was not penetrated. The roof had the largest deformation centered at the top of the windshield, approximately 3.5 in. It was determined that no significant occupant risk would have occurred. The occupant impact velocity was determined to be 16.4 ft/s and the maximum ridedown acceleration was determined to be 2.04 g's.

Figure 2.6. Pre-Test Assembly of the Warning Sign with Flashing Beacons (*5*)

Figure 2.7. Post-Test Image of Vehicle Damage (First Test) (*5*)

The second test conducted on the assembly had an impact angle of 0 degrees and location of 4.3 in. to the right of center of the pole at a speed of 63.8 mi/h. Upon impact, the vehicle began to deform as it came in contact with the assembly, and the slip base activated. The sign rotated and cleared the rest of the vehicle. The hood, bumper, headlamp area, grille, front fenders, and suspension components were damaged in the impact. The occupant impact velocity was determined to be 11.4 ft/s and the maximum ridedown acceleration was 4.40 g's.

Figure 2.8. Post-Test Image of Vehicle Damage (Second Test) (*5*)

2.5. LITERATURE REVIEW SUMMARY

The literature review resulted in previous research regarding luminaire pole supports. Much of the previous research evaluated transformer bases. This echoed the need for further research evaluating luminaire pole slip base supports to MASH criteria.

Chapter 3. STATE SURVEY

3.1. OVERVIEW

This survey was designed to gather information regarding luminaire pole assembly details found across the country in order to help develop a design concept for a multidirectional breakaway mechanism. The survey was administered online using Qualtrics and was sent to roadside safety pooled fund members. The survey received 19 total responses. Of the 19 responses, only 3 were used for assistance throughout the project.

3.2. SURVEY QUESTIONS AND RESPONSES

Q1: Does your state use a 4-bolt slip base for luminaire poles similar to what is shown below?

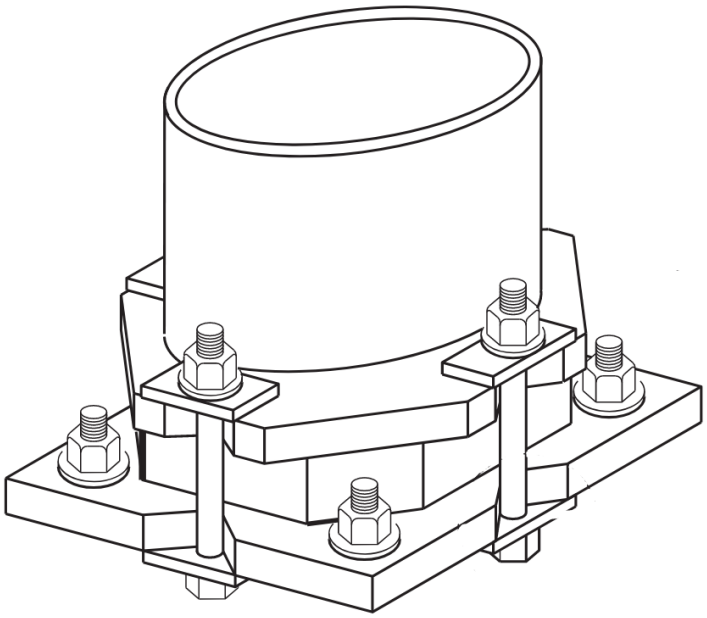


Figure 3.1. Question 1 Example Image

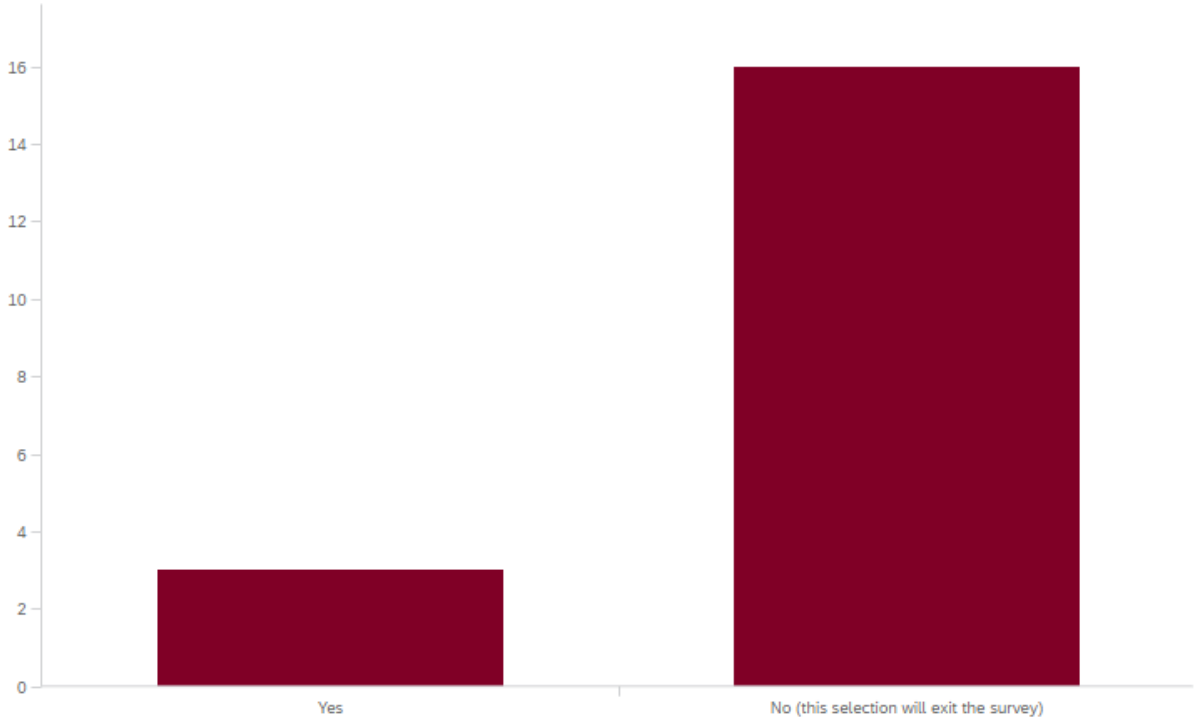
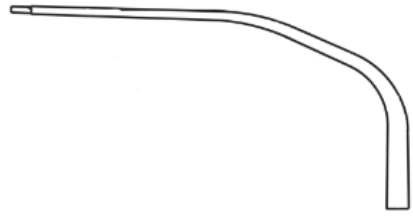


Figure 3.2. Question 1 Responses

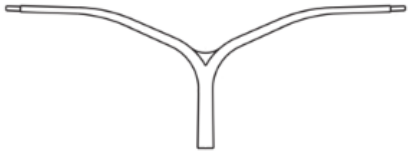
Q2 – The table presented on the next page will inquire about multiple luminaire components for different pole configurations. Each configuration represents one combination of pole height, mast arm length, etc. that your state may use. Please provide details on all configurations your state uses. Further explanation is provided below:

Mast Configuration: Either Single, Double, or other (explain if other).

Single:

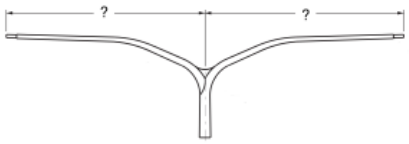


Double:



Pole Height: Height of the pole for that configuration in feet.

Mast Length: Length of mast for that configuration in feet.



Pole Material: Materials such as *Steel*, *Aluminum*, both, or others used for post construction.

Mast Material: Materials such as *Steel*, *Aluminum*, both, or others used for mast construction.

Figure 3.3. Illustrative Assistance for Question 2

Results are summarized in Table 3.1 through Table 3.3. Each state's responses are formatted in a table similar to what was asked to fill out in the question. States were

then asked to attach drawings for applicable pole configurations which are shown in Q2b.

Table 3.1. Colorado's Response Summary for Question 2

Configuration #	Mast Configuration	Pole Height (ft)	Mast Length (ft)	Pole Material	Mast Material
Configuration 1	Single	20' - 40'	6' - 10'	Steel or Aluminum	Steel or Aluminum
Configuration 2	Single	41' - 70'	6' - 10'	Round Tapered Galvanized Steel Pole	Steel
Configuration 3	Double	20' - 40'	6' - 10'	Steel or Aluminum	Steel or Aluminum

Table 3.2. New Mexico's Response Summary for Question 2

Configuration #	Mast Configuration	Pole Height (ft)	Mast Length (ft)	Pole Material	Mast Material
Configuration 1	Single	24'	10'	Aluminum	Aluminum
Configuration 2	Single	24'	10'	Steel	Steel
Configuration 3	Single	34'	10'	Aluminum	Aluminum
Configuration 4	Single	34'	10'	Steel	Steel
Configuration 5	Single	44'	10'	Aluminum	Aluminum
Configuration 6	Double	24'	10'	Aluminum	Aluminum
Configuration 7	Double	24'	10'	Steel	Steel
Configuration 8	Double	34'	10'	Aluminum	Aluminum
Configuration 9	Double	34'	10'	Steel	Steel
Configuration 10	Double	44'	10'	Aluminum	Aluminum

Table 3.3. Utah's Response Summary for Question 2

Configuration #	Mast Configuration	Pole Height (ft)	Mast Length (ft)	Pole Material	Mast Material
Configuration 1	Single	24'-9"	10'	Steel	Steel
Configuration 2	Single	34'-9"	10'	Steel	Steel
Configuration 3	Single	24'-9"	15'	Steel	Steel
Configuration 4	Single	34'-9"	15'	Steel	Steel
Configuration 5	Double	24'-9"	10'	Steel	Steel
Configuration 6	Double	34'-9"	10'	Steel	Steel
Configuration 7	Double	24'-9"	15'	Steel	Steel
Configuration 8	Double	34'-9"	15'	Steel	Steel

Q2b – Please attach a link to or upload a standard detail sheet, or drawing.

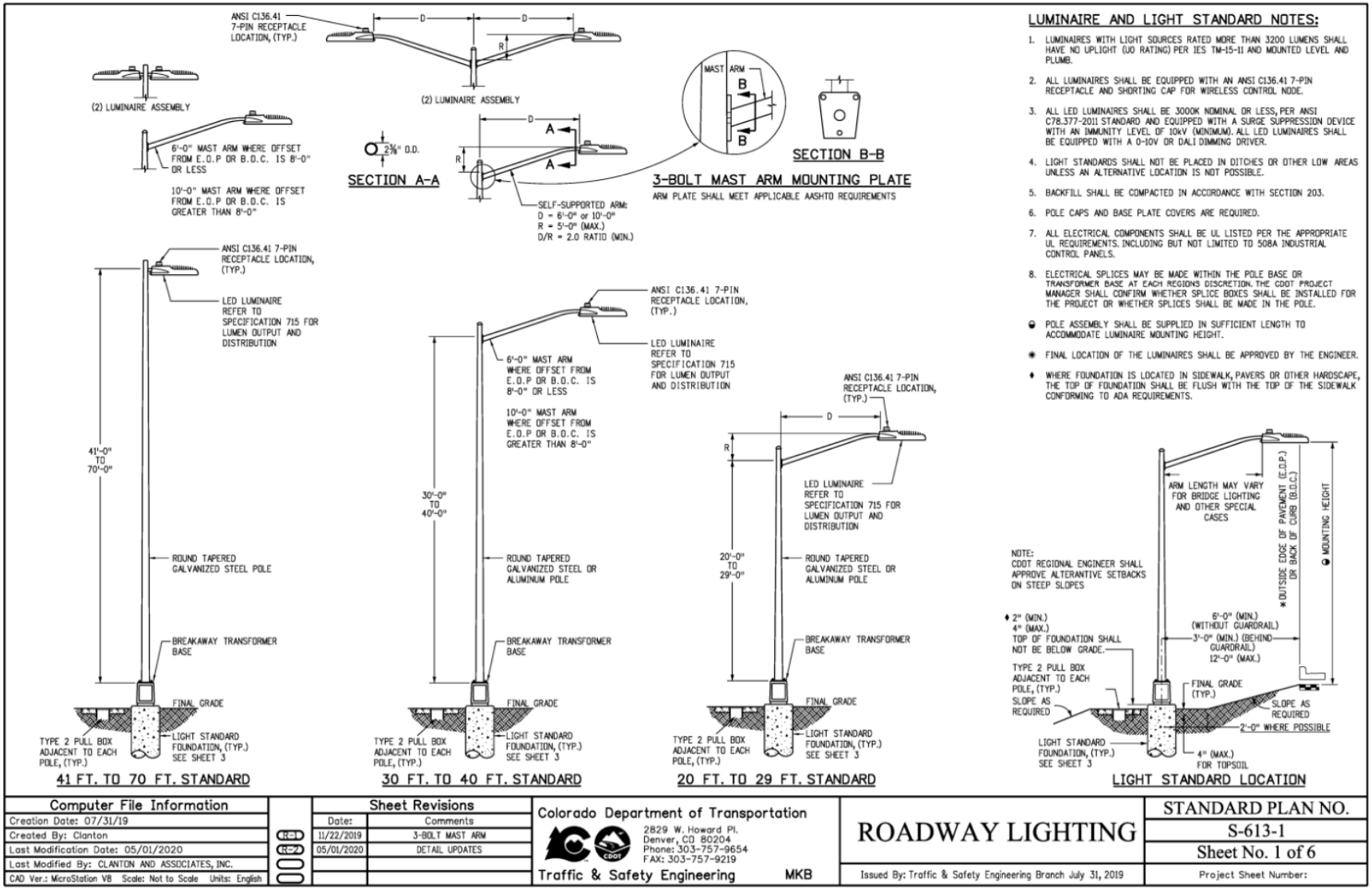
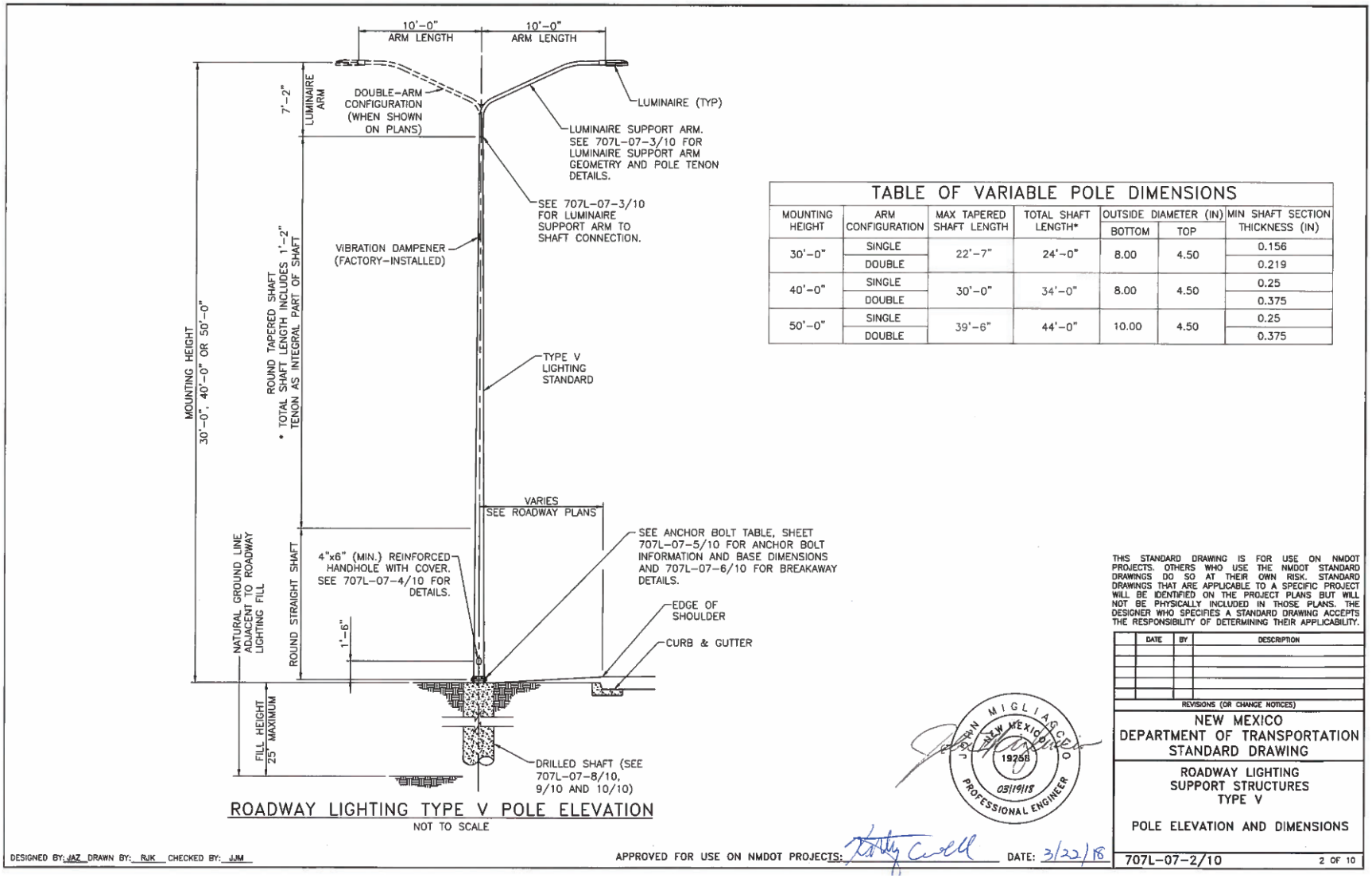


Figure 3.4. Colorado's Response for Question 2b.



ROADWAY LIGHTING TYPE V POLE ELEVATION

NOT TO SCALE

TABLE OF VARIABLE POLE DIMENSIONS						
MOUNTING HEIGHT	ARM CONFIGURATION	MAX TAPERED SHAFT LENGTH	TOTAL SHAFT LENGTH*	OUTSIDE DIAMETER (IN)		MIN SHAFT SECTION THICKNESS (IN)
				BOTTOM	TOP	
30'-0"	SINGLE	22'-7"	24'-0"	8.00	4.50	0.156
	DOUBLE					0.219
40'-0"	SINGLE	30'-0"	34'-0"	8.00	4.50	0.25
	DOUBLE					0.375
50'-0"	SINGLE	39'-6"	44'-0"	10.00	4.50	0.25
	DOUBLE					0.375

THIS STANDARD DRAWING IS FOR USE ON NMDOT PROJECTS. OTHERS WHO USE THE NMDOT STANDARD DRAWINGS DO SO AT THEIR OWN RISK. STANDARD DRAWINGS THAT ARE APPLICABLE TO A SPECIFIC PROJECT WILL BE IDENTIFIED ON THE PROJECT PLANS BUT WILL NOT BE PHYSICALLY INCLUDED IN THOSE PLANS. THE DESIGNER WHO SPECIFIES A STANDARD DRAWING ACCEPTS THE RESPONSIBILITY OF DETERMINING THEIR APPLICABILITY.

	DATE	BY	DESCRIPTION

REVISIONS (OR CHANGE NOTICES)

NEW MEXICO
DEPARTMENT OF TRANSPORTATION
STANDARD DRAWING

ROADWAY LIGHTING
SUPPORT STRUCTURES
TYPE V

POLE ELEVATION AND DIMENSIONS

707L-07-2/10 2 OF 10

JOSEPH MIGLIASCIO NEW MEXICO 19258 03/19/18 PROFESSIONAL ENGINEER

DESIGNED BY: JAZ DRAWN BY: RJK CHECKED BY: JJM

APPROVED FOR USE ON NMDOT PROJECTS: DATE: 3/22/18

Figure 3.5. New Mexico's Response for Question 2b (1/5).

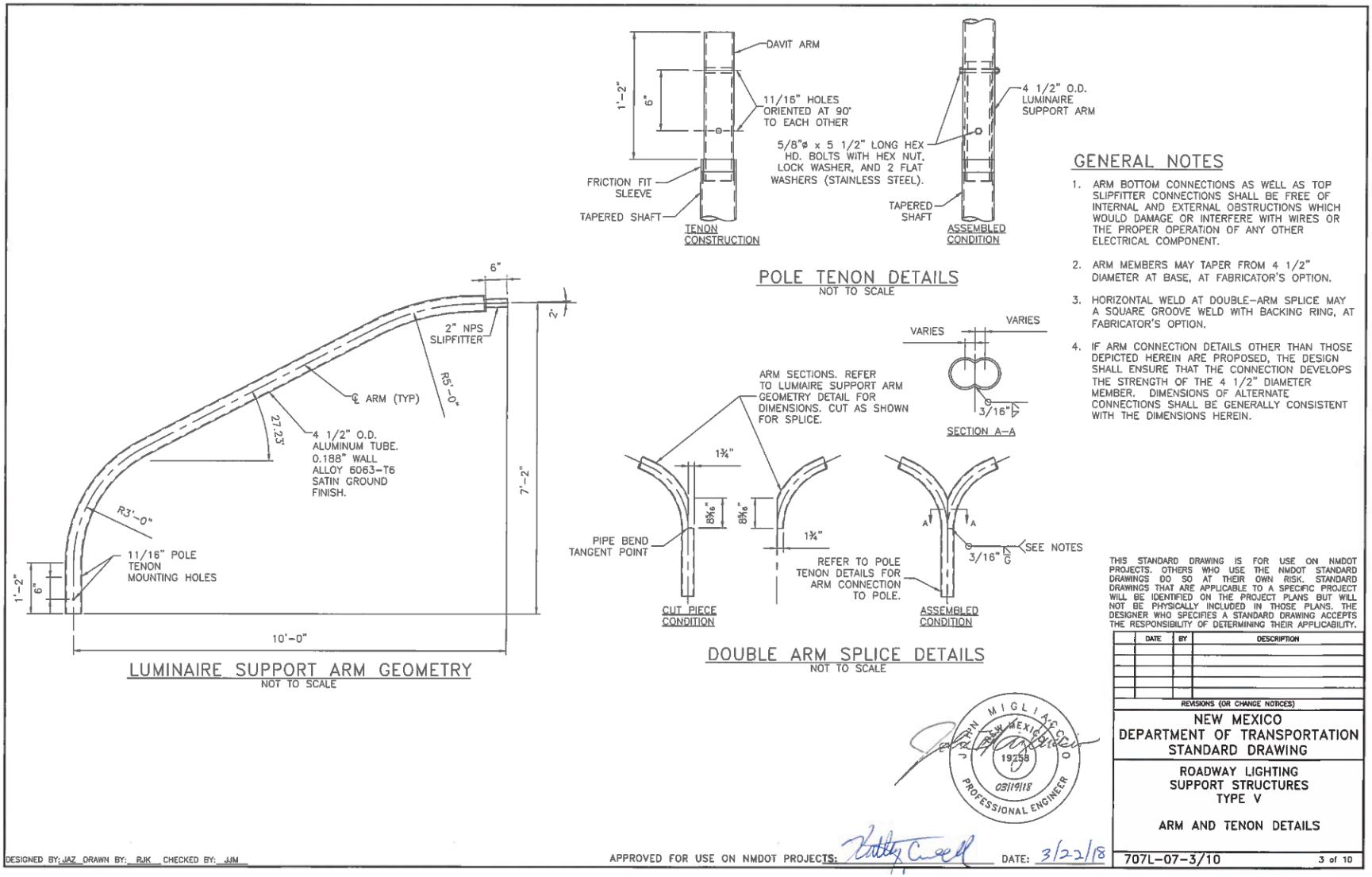


Figure 3.6. New Mexico's for Question 2b (2/5).

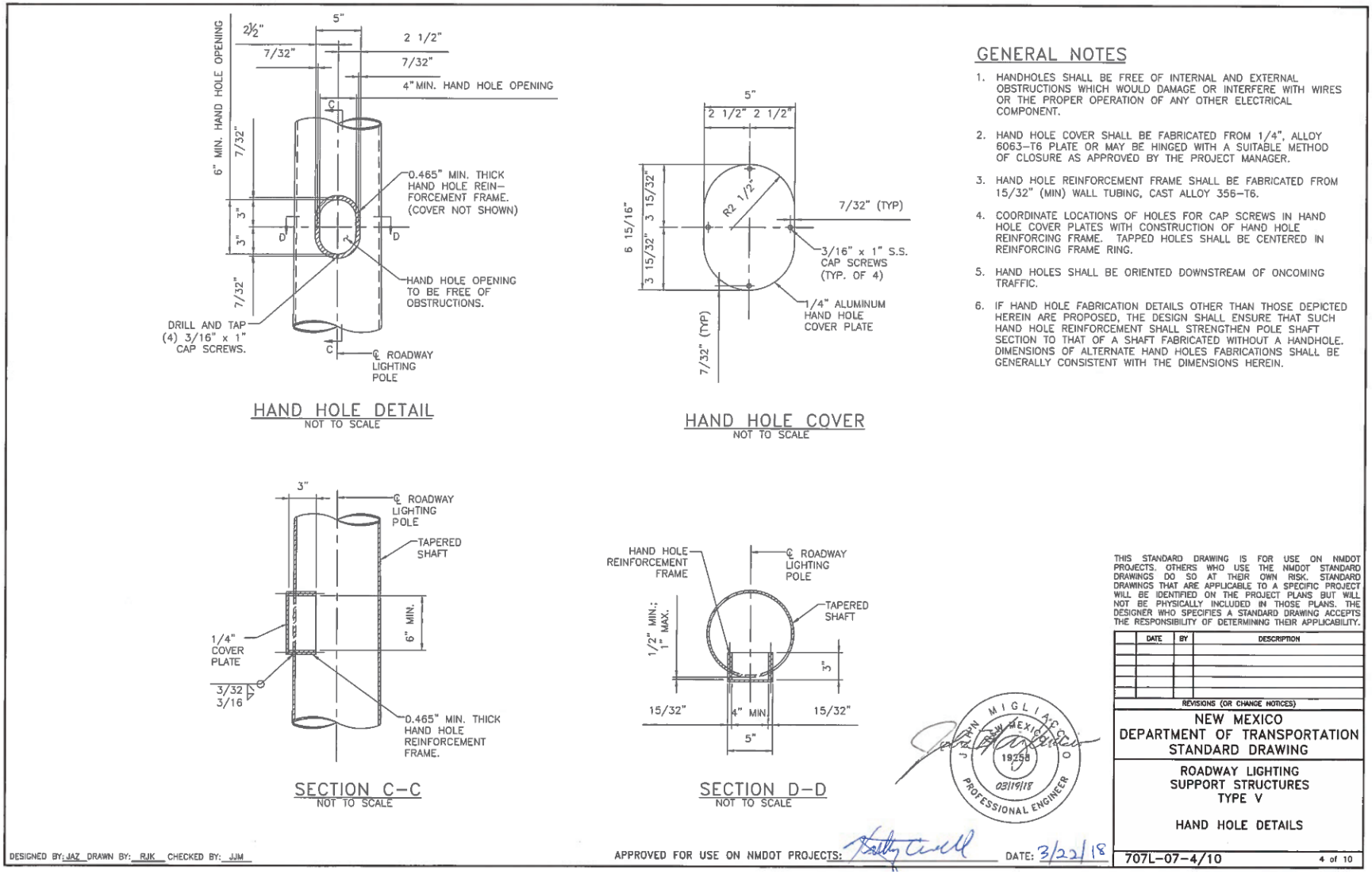


Figure 3.7. New Mexico's Response for Question 2b (3/5).

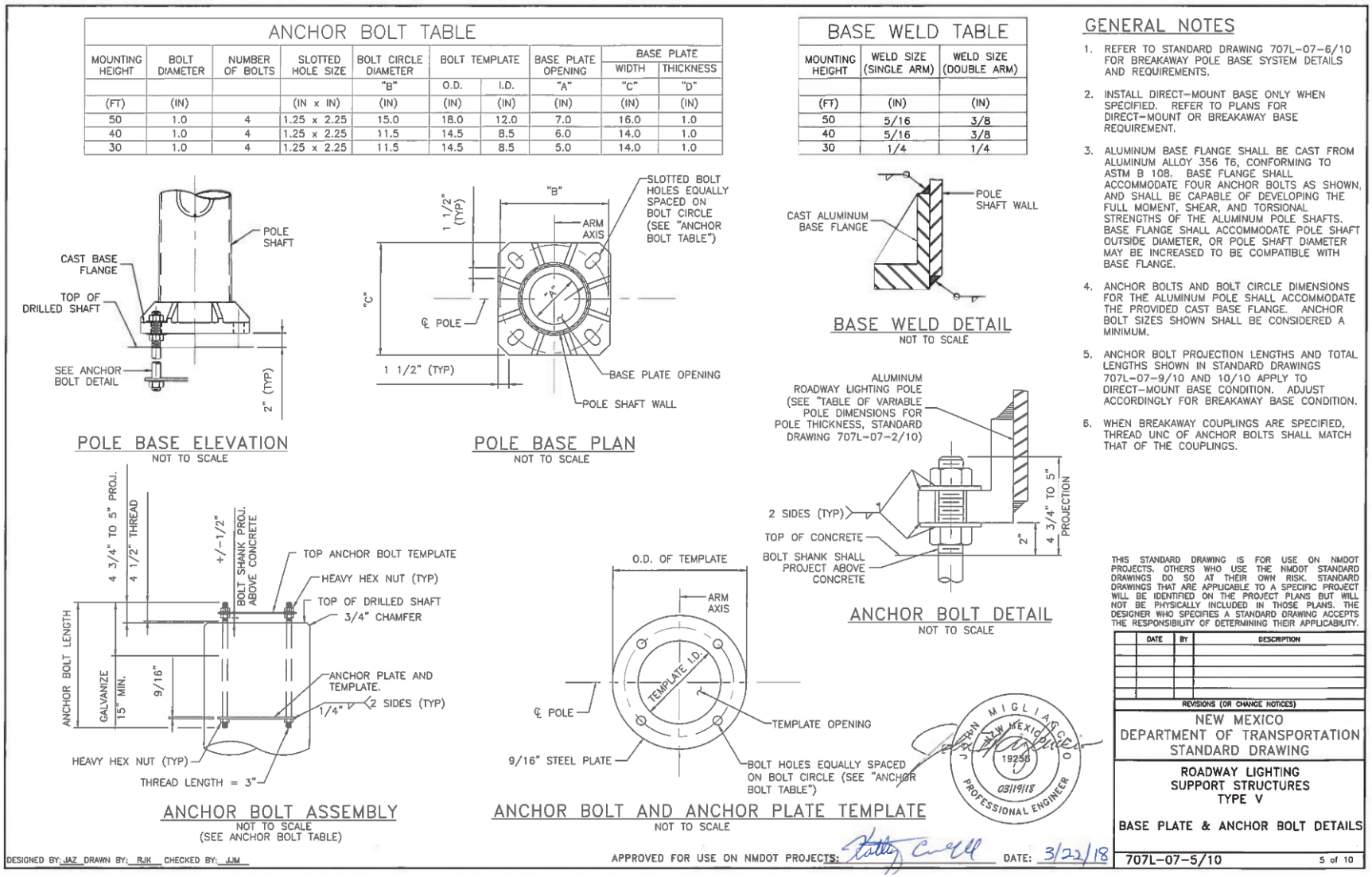


Figure 3.8. New Mexico's Response for Question 2b (4/5)

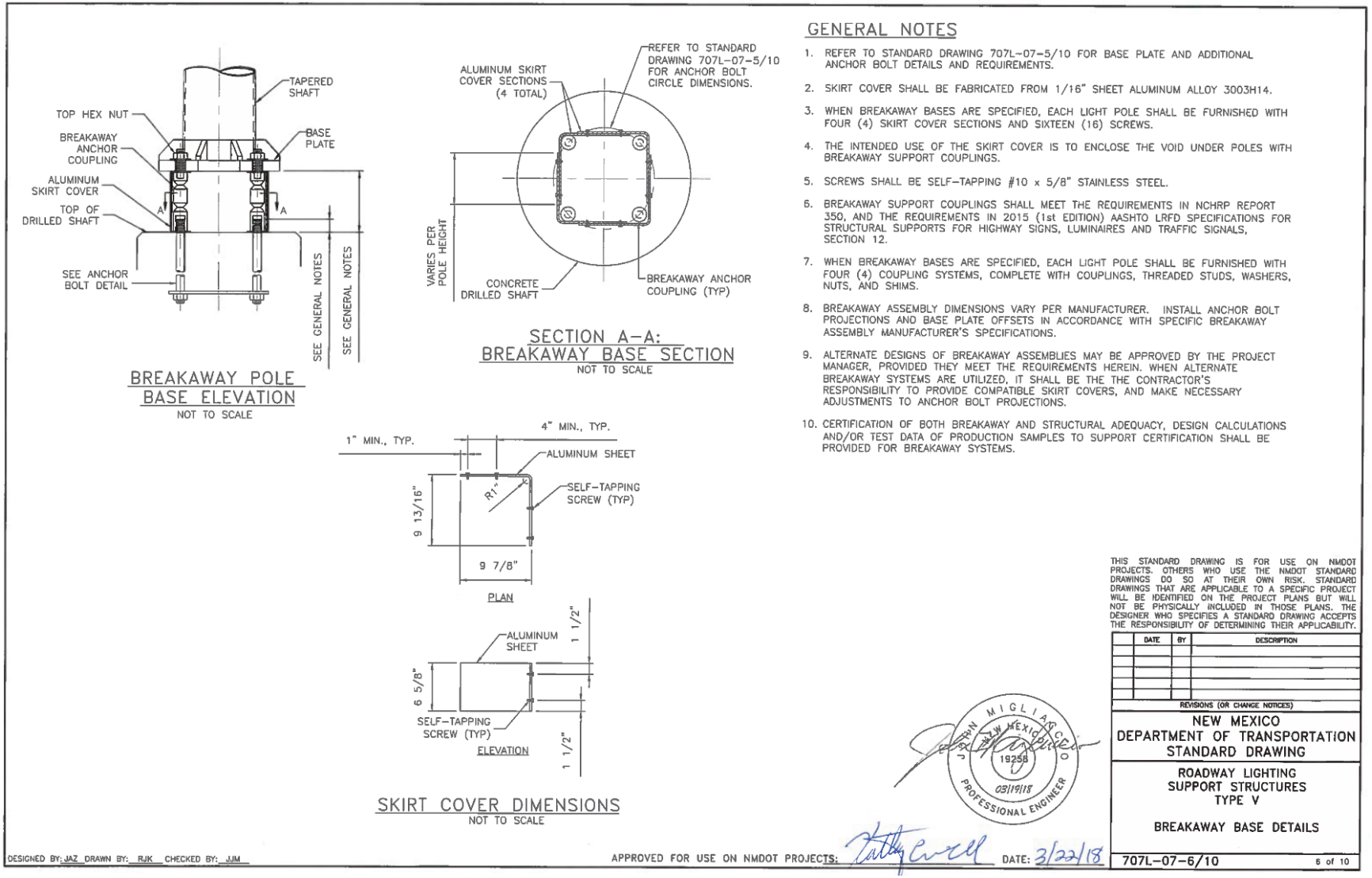


Figure 3.9. New Mexico's Response for Question 2b (5/5)

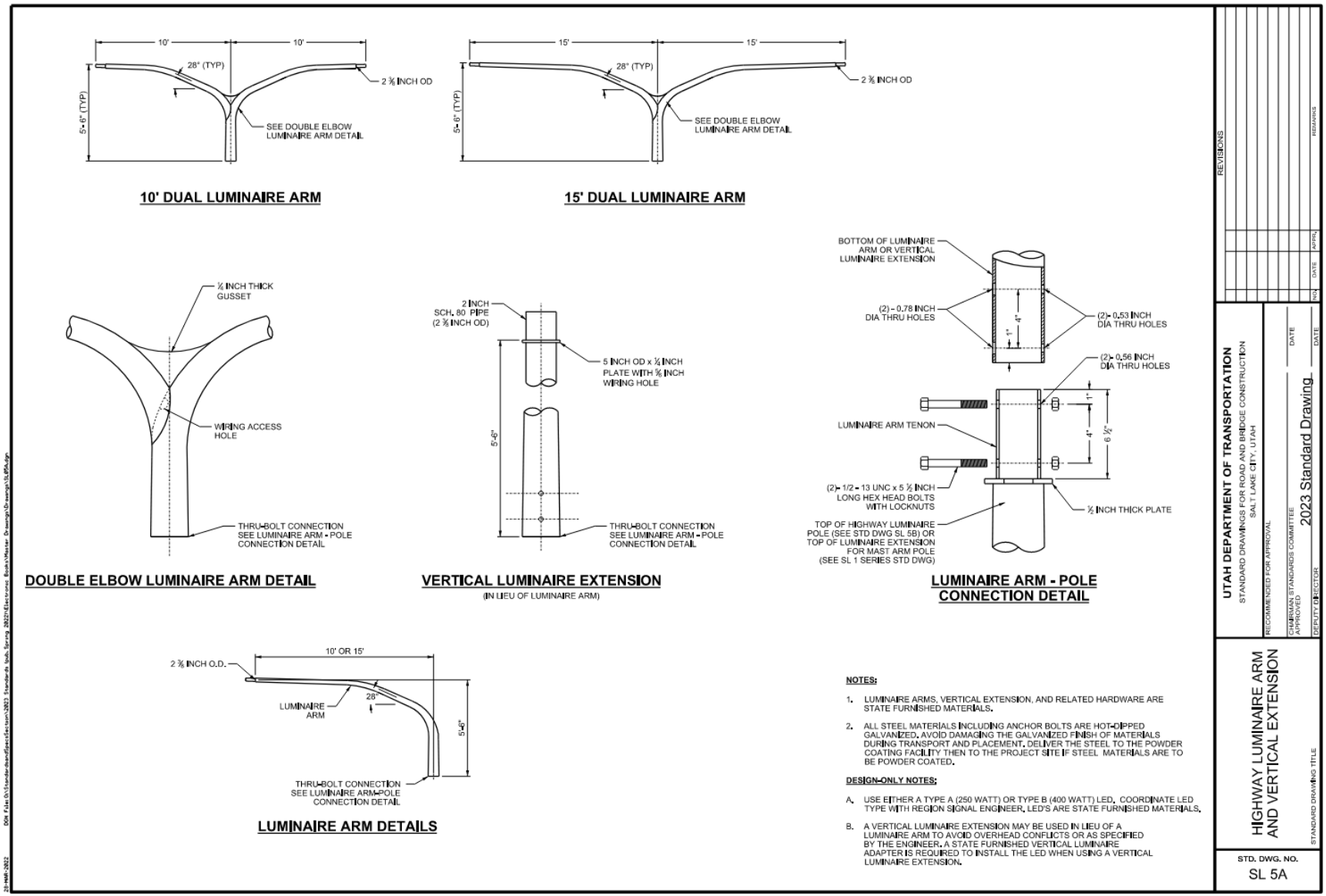


Figure 3.10. Utah's Response for Question 2b (1/4).

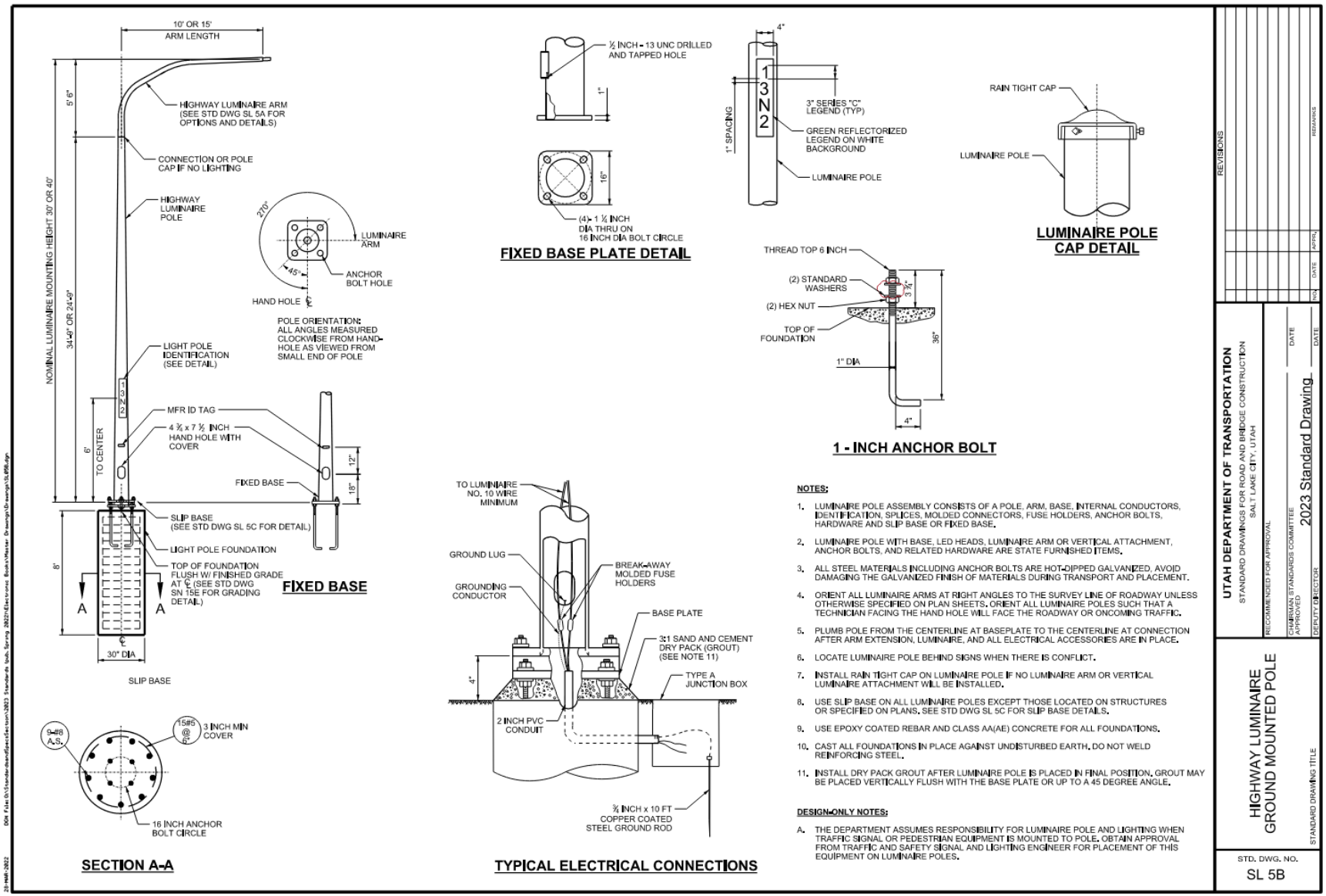


Figure 3.11. Utah's Response for Question 2b (2/4).

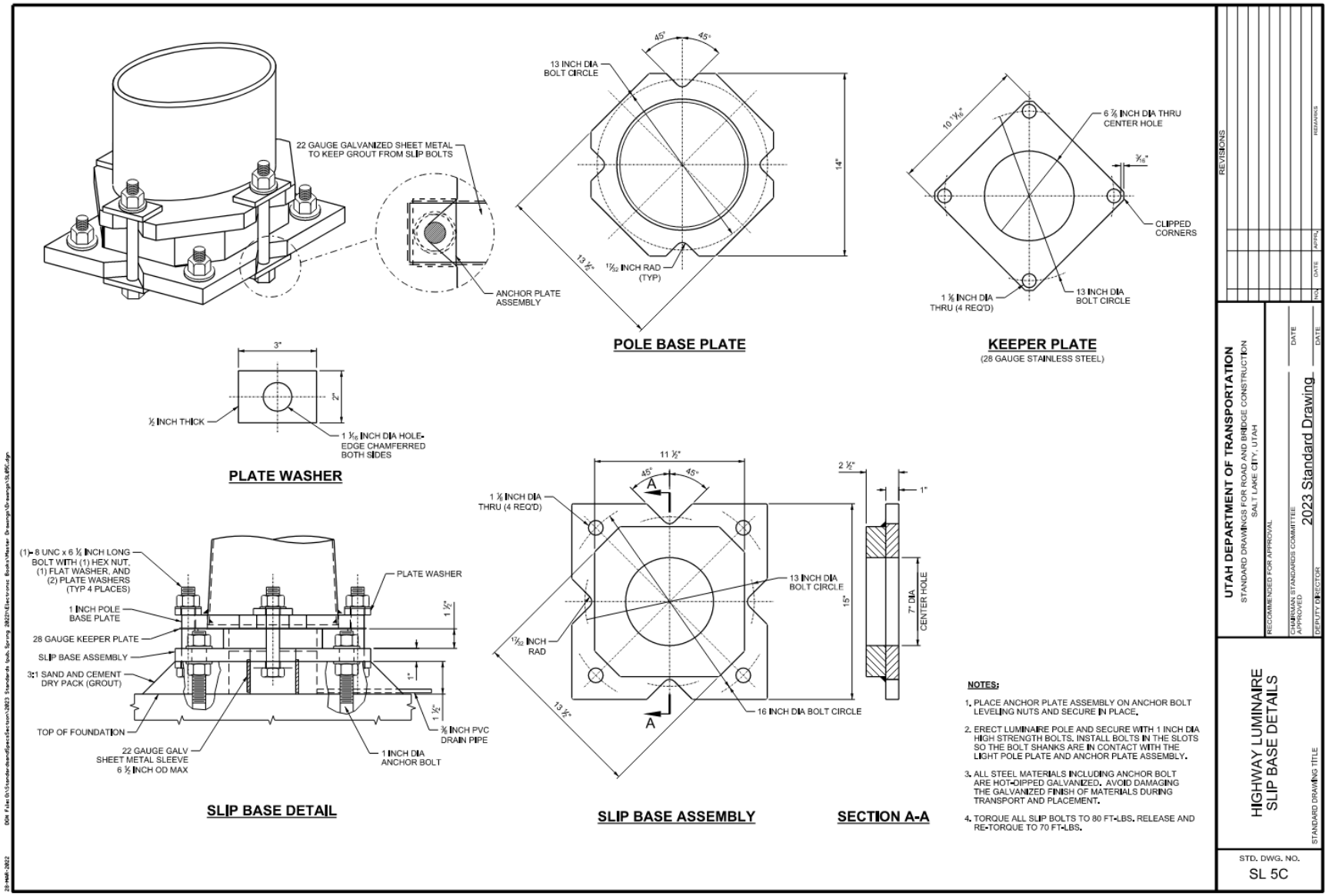


Figure 3.12. Utah's Response for Question 2b (3/4).

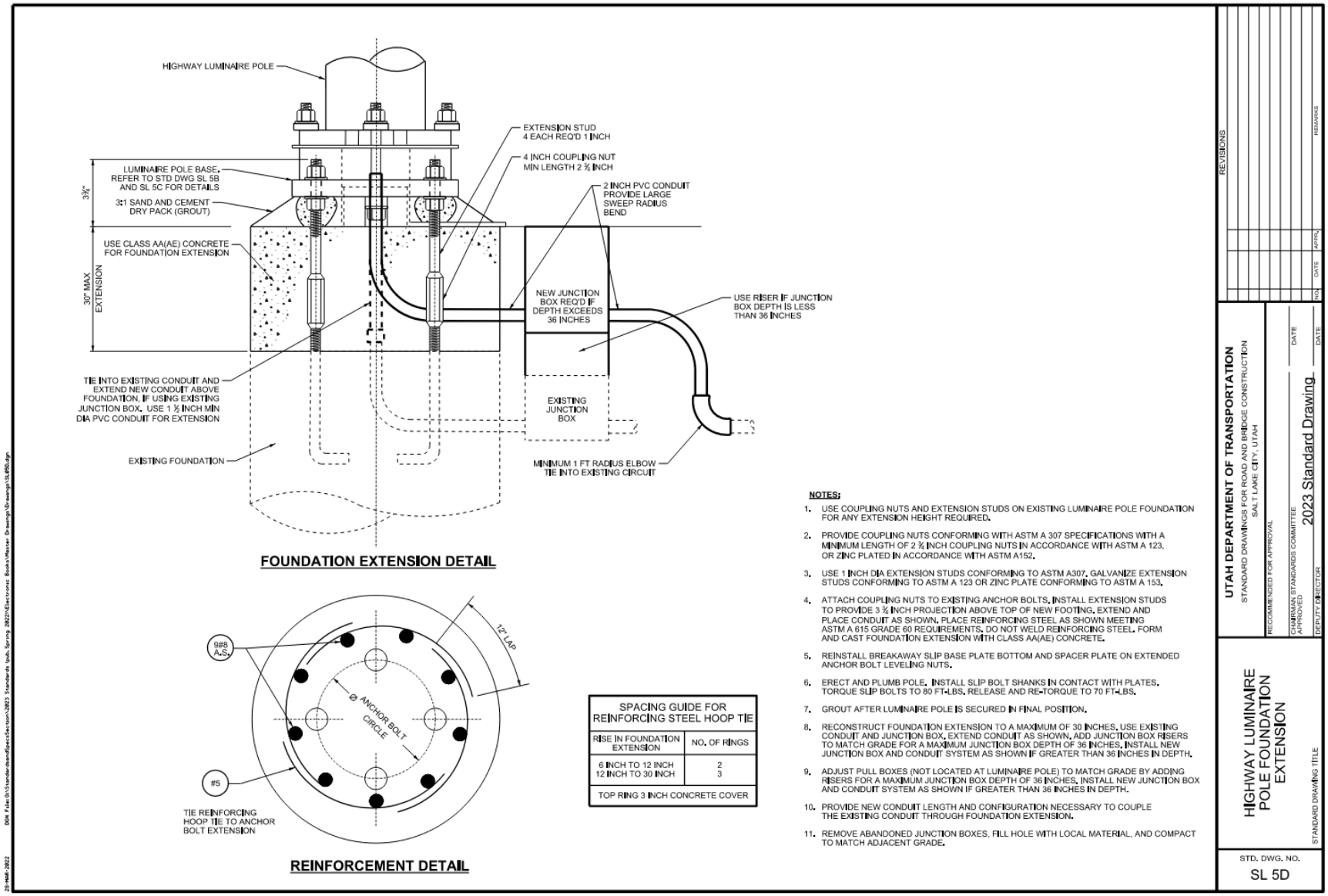


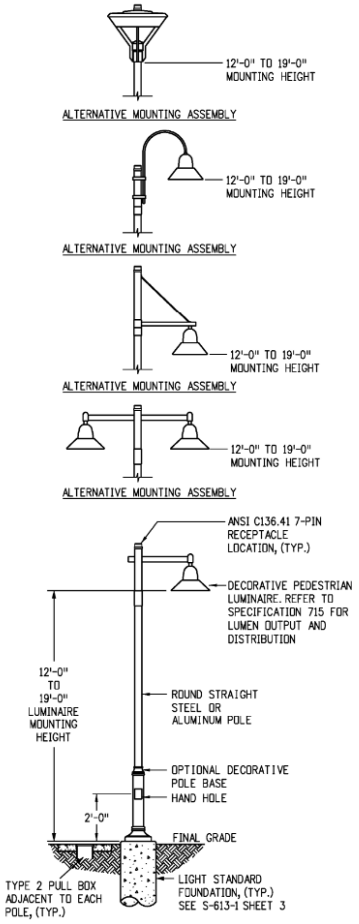
Figure 3.13. Utah's Response for Question 2b (4/4).

Q3 – Do you utilize any other hardware on luminaire poles?

Table 3.4. State Responses for Question 7.

State	Response
Colorado	“Yes, we have different lighting standard for parking lot and decorative lighting.”
Utah	“Attachments can include radar detection with pole mounted cabinets.”

Q3b – Please upload drawing of the hardware.



12 FT. TO 19 FT. STANDARD

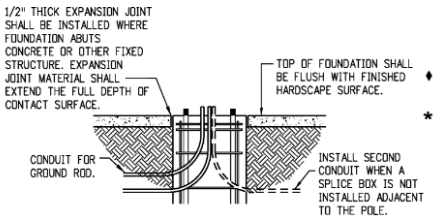
LUMINAIRE AND LIGHT STANDARD NOTES:

1. LUMINAIRES WITH LIGHT SOURCES RATED MORE THAN 3200 LUMENS SHALL HAVE NO UPLIGHT (UO RATING) PER IES TM-15-11 AND MOUNTED LEVEL AND PLUMB.
2. ALL LUMINAIRES SHALL BE EQUIPPED WITH AN ANSI C136.41 7-PIN RECEPTACLE AND SHORTING CAP FOR WIRELESS CONTROL NODE.
3. ALL LED LUMINAIRES SHALL BE 3000K NOMINAL OR LESS, PER ANSI C78.377-2011 STANDARD AND EQUIPPED WITH A SURGE SUPPRESSION DEVICE WITH AN IMMUNITY LEVEL OF 10kV (MINIMUM). ALL LED LUMINAIRES SHALL BE EQUIPPED WITH A 0-10V OR DALI DIMMING DRIVER.
4. LIGHT STANDARDS SHALL NOT BE PLACED IN DITCHES OR OTHER LOW AREAS UNLESS AN ALTERNATIVE LOCATION IS NOT POSSIBLE.
5. BACKFILL SHALL BE COMPACTED IN ACCORDANCE WITH SECTION 203.
6. POLE CAPS AND BASE PLATE COVERS (OR OPTIONAL NUT COVERS) ARE REQUIRED.
7. ALL ELECTRICAL COMPONENTS SHALL BE UL LISTED PER THE APPROPRIATE UL REQUIREMENTS. INCLUDING BUT NOT LIMITED TO 508A INDUSTRIAL CONTROL PANELS.
8. ELECTRICAL SPLICES MAY BE MADE WITHIN THE POLE BASE OR TRANSFORMER BASE AT EACH REGIONS DISCRETION. THE CDOT PROJECT MANAGER SHALL CONFIRM WHETHER SPLICE BOXES SHALL BE INSTALLED FOR THE PROJECT OR WHETHER SPLICES SHALL BE MADE IN THE POLE.

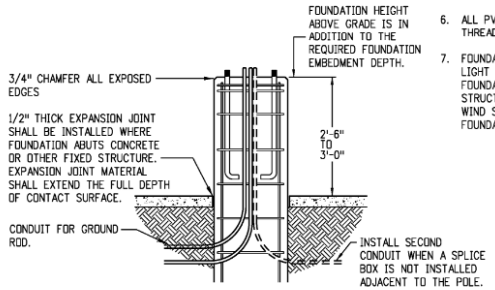
◒ POLE ASSEMBLY SHALL BE SUPPLIED IN SUFFICIENT LENGTH TO ACCOMMODATE LUMINAIRE MOUNTING HEIGHT.

✳ FINAL LOCATION OF THE LUMINAIRES SHALL BE APPROVED BY THE ENGINEER.

♦ WHERE FOUNDATION IS LOCATED IN SIDEWALK, PAVERS OR OTHER HARDSCAPE, THE TOP OF FOUNDATION SHALL BE FLUSH WITH THE TOP OF THE SIDEWALK CONFORMING TO ADA REQUIREMENTS.



*LIGHT STANDARD FOUNDATION IN HARDSCAPE



LIGHT STANDARD FOUNDATION IN PARKING LOT

WHERE LIGHT STANDARD FOUNDATIONS OCCUR IN OR AROUND PARKING AREAS AND ARE LOCATED LESS THAN 2'-0" BEHIND CURB, OR WHERE UNPROTECTED BY CURBS, THE FOUNDATION SHOULD BE EXTENDED A MINIMUM OF 2'-6" VERTICALLY, IN ADDITION TO FOUNDATION DEPTH LISTED INTHE FOUNDATION SCHEDULE, TO PROTECT THE LIGHT STANDARD FROM DAMAGE AND/OR KNOCK-DOWN DUE TO VEHICLE CONTACT.

LIGHT STANDARD FOUNDATION NOTES:

1. DIMENSIONS FOR THE TRANSFORMER BASE, ANCHOR BASE AND ANCHOR BOLTS ARE VARIABLE FOR THE HEIGHT OF THE LIGHT STANDARD AND THE MAST ARM CONFIGURATION. ALL COMPONENTS SHALL FIT AND ACCOMMODATE THE REQUIREMENTS OF THE LIGHT STANDARD SUPPLIED.

♦ 2. CONCRETE SHALL BE AIR ENTRAINED CLASS BZ AND SHALL CONFORM TO SECTION 601 FOR CONCRETE AND SECTION 602 FOR REINFORCING STEEL.

✱ 3. WHERE LIGHT STANDARD FOUNDATION OCCUR IN HARDSCAPE AREAS, WHERE AN EXPOSED FOUNDATION COULD CREATE A TRIPPING HAZARD, THE TOP OF FOUNDATION SHALL BE FLUSH TO THE FINISHED SURFACE TO MEET A.D.A. REQUIREMENTS. WHERE EXPOSED LIGHT STANDARD FOUNDATION COMPLIES WITH A.D.A. REQUIREMENTS, FOUNDATION SHALL BE INSTALLED 2 INCHES ABOVE HARDSCAPE WITH CDOT APPROVAL.

4. BOND (1) #4 STRANDED/INSULATED COPPER TO GROUND ROD IN PULL BOX / SPLICE BOX AND GROUNDING LUG IN POLE BASE HAND HOLE.
5. PROVIDE 4-TERMINAL SUBMERSIBLE UNDERGROUND RATED LUG CONNECTIONS TO FIT #12 AWG - #350 AWG COPPER WIRE.
6. ALL PVC CONDUIT ENDS SHALL HAVE END BELLS OR MALE ADAPTOR, THREADED TERMINAL ENDS WITH SCREW ON BUSHINC.
7. FOUNDATION DIMENSIONS PER FOUNDATION SCHEDULE BELOW AND AS NOTED. LIGHT STANDARDS HIGHER THAN 50 FEET OR WITH BANNERS, PRECAST FOUNDATION, VARYING SOIL, OR WIND CONDITIONS SHALL BE DESIGNED BY A STRUCTURAL ENGINEER LICENSED IN THE STATE OF COLORADO. FOR DESIGN WIND SPEEDS GREATER THAN V=155MPH ADD AN ADDITIONAL 1'-0" TO THE FOUNDATION DEPTH SHOWN IN THE FOUNDATION SCHEDULE BELOW.

FOUNDATION SCHEDULE

POLE HEIGHT	FOUNDATION DEPTH	FOUNDATION DIAMETER
< 20'	8'-0"	24"
20' - < 30'	9'-0"	24"
30' - 50'	12'-0"	24"
> 50'	P.S.E.	P.S.E.

P.S.E. (PER STRUCTURAL ENGINEER)
FOUNDATION DESIGN DATA:
BROMS' METHOD USING AASHTO LRFD LTS 1ST, 2015 WITH 2018 INTERIMS.

THE DESIGN ASSUMES FOLLOWING SOIL PARAMETERS:
SOIL DENSITY = 110 LB/CF
SOIL COHESION = 750 LB/SQFT FOR MEDIUM STIFF COHESIVE SOIL
SOIL ANGLE = 30° FOR MEDIUM DENSE COHESIONLESS SOIL
RESITANCE FACTOR = 0.4 FOR FLEXURE.

PARKING LOT AND DECORATIVE LIGHTING STANDARDS

Computer File Information		Sheet Revisions	
Creation Date: 05/01/2020		Date:	Comments
Created By: Clanton			
Last Modification Date:			
Last Modified By: CLANTON AND ASSOCIATES, INC.			
CAD Ver.: MicroStation V8 Scale: Not to Scale Units: English			

Colorado Department of Transportation
2829 W. Howard Pl.
Denver, CO 80204
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Traffic & Safety Engineering MKB

ALTERNATIVE ROADWAY LIGHTING

Issued By: Traffic & Safety Engineering Branch July 31, 2019

STANDARD PLAN NO.
S-613-2
Sheet No. 1 of 4
Project Sheet Number:

Figure 3.14. Colorado's Response for Question 3b (1/4).

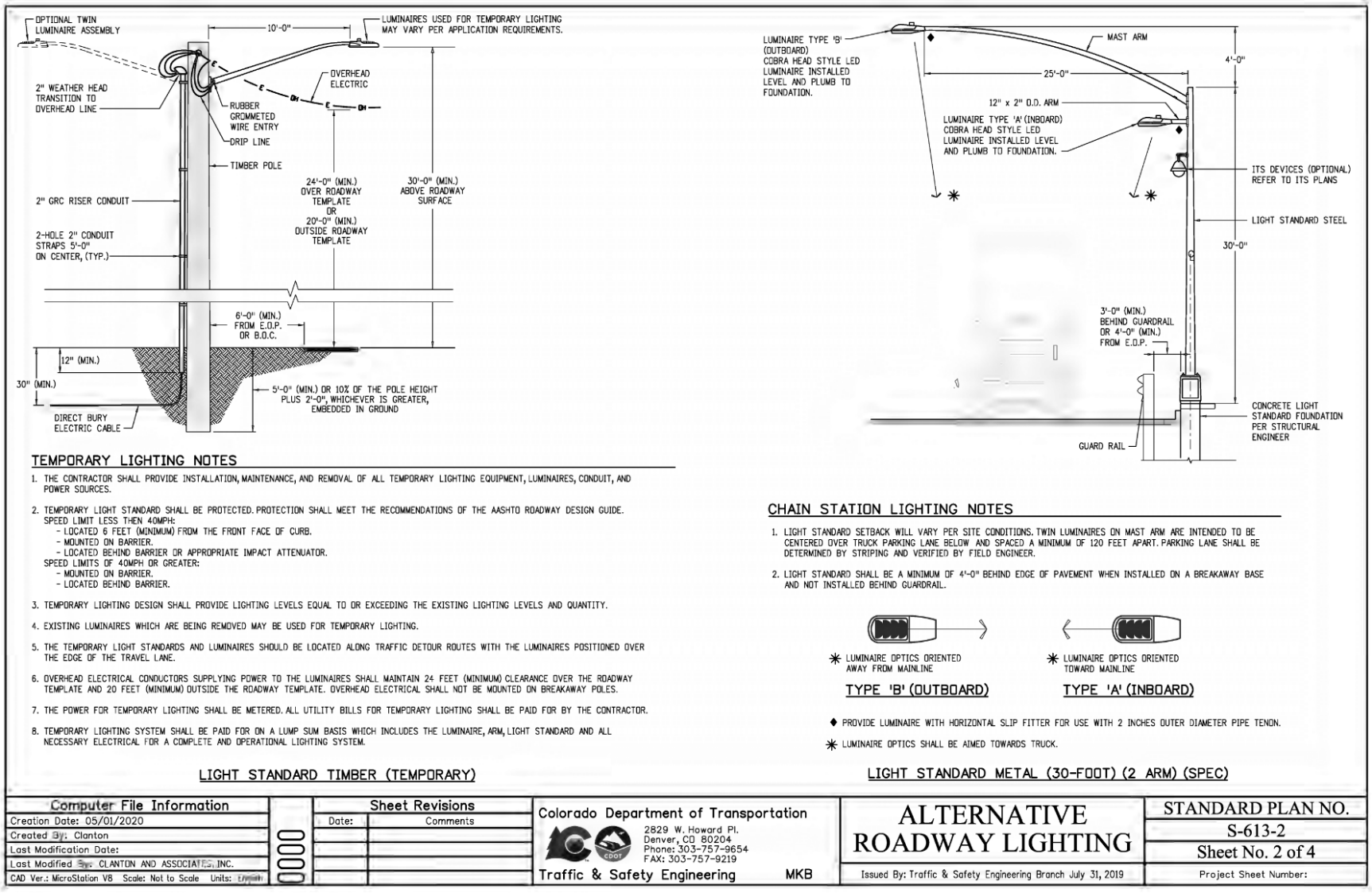
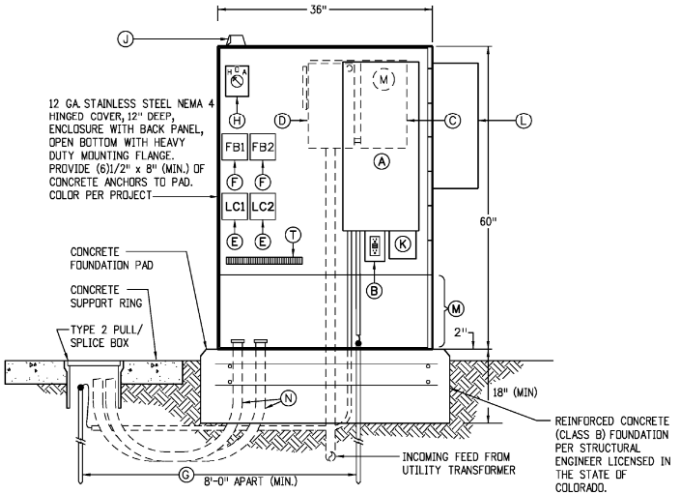


Figure 3.15. Colorado's Response for Question 3b (2/4).



COMPONENT LIST

(A) NEMA 1, SERVICE ENTRANCE RATED, SINGLE PHASE LOAD CENTERS. (SEE PANEL SCHEDULE FOR QUANTITY AND SIZE OF MAIN AND BRANCH BREAKERS). MOUNTED INSIDE NEMA 4 ENCLOSURE.

(B) GFCI MAINTENANCE RECEPTACLE IN A 1-GANG BACK BOX WITH COVER.

(C) 200A, 1 PH., NEMA 3R, METER HOUSING MOUNTED ON BACK SIDE OF NEMA 4 ENCLOSURE WITH LEVER BYPASS TO UTILITY COMPANY SPECIFICATIONS. PAINT TO MATCH NEMA 4 ENCLOSURE.

(D) 100A (MINIMUM AMPERAGE), 2 POLE, 250V, HEAVY DUTY, NEMA 3R, FUSED METER DISCONNECT, UL LISTED FOR SERVICE EQUIPMENT AND FRN-R FUSES AS SHOWN ON ONE-LINE DIAGRAM WITH NEUTRAL & GROUND BARS. MOUNTED ON BACK SIDE OF NEMA 4 ENCLOSURE. PAINT TO MATCH NEMA 4 ENCLOSURE. MAY BE OMITTED BY UTILITY COMPANY SPECIFICATIONS HOT SEQUENCE REQUIREMENTS.

✱(E) 4 POLE, 30A, 250V ELECTRICALLY HELD LIGHTING CONTACTORS WITH 120V COILS. TWO (2) REQUIRED.

✱(F) 4 POLE, 30A, FUSE BLOCKS WITH 30A, FRNR FUSES TO THE LIGHTING CONTACTORS AS REQUIRED BY UL 508A (2001 STANDARD FOR INDUSTRIAL CONTROL PANELS). TWO (2) REQUIRED.

(G) 3/4 INCH x 10 FEET LONG, COPPER-CLAD DRIVEN GROUND ROD WITH GROUND CONDUCTOR EXOTHERMIC WELD OR UNDERGROUND RATED LUG CONNECT GROUND CONDUCTOR TO GROUND ROD.

✱(H) H.O.A. SWITCH - HAND-OFF-AUTO WITH 15A 120V CONTACTS, BACK BOX, COVER, KNOB & LEGEND AND THE PHOTOCELL CONTROL WIRED IN THE AUTO POSITION.

✱(J) NEMA 3R 120V PHOTOELECTRIC CONTROL WITH 3-PRONG TWIST-LOCK RECEPTACLE BASE WIRED THROUGH THE H.O.A. SWITCH. THE PHOTOELECTRIC CONTROL SHALL BE MOUNTED ON THE NORTH SIDE ON ENCLOSURE OR WINDOW FACING NORTH OR DOWN TO MINIMIZE THE SUN'S INTERFERENCE.

(K) SURGE PROTECTION DEVICE-10KA, 120/240VAC SINGLE PHASE, 3W+G 200KAIC, PROTECTION MODES L-G, N-G, L-N OR L-L. STANDARD OPTIONS (RED & GREEN LED'S, AUDIBLE ALARM WITH ENABLE/DISABLE FEATURE) LEA #B70-00-7000 INTERNATIONAL OR APPROVED EQUAL.

(L) OPTIONAL CABINET HVAC PER ENGINEERING REQUEST. PAINT TO MATCH NEMA 4 ENCLOSURE.

(M) OPTIONAL 18 INCH HIGH SKIRT PER ENGINEER REQUEST.

(N) BRANCH RACEWAYS - PROVIDE BRANCH CIRCUIT RACEWAY TO ALL LIGHTING FED FROM THIS LCC. SEE PLAN AND FEEDER SCHEDULE FOR SIZE AND QUANTITY.

(T) TERMINAL STRIP - 600V RATED, LUGS TO ACCEPT #1 - 10 AWG COPPER WITH ALL MARKING STRIP, END CAPS AND MOUNTING HARDWARE. PROVIDE THE NUMBER OF TERMINAL POINTS AS REQUIRED, MINIMUM OF 36 POINTS.

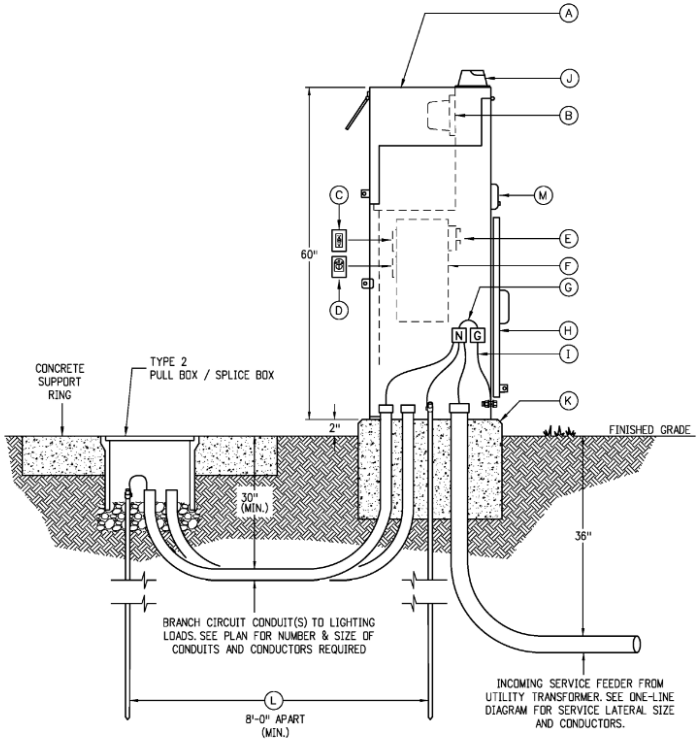
NOTE: ALL COMPONENTS LISTED SHALL BE INCLUDED IN THE LIGHTING CONTROL CENTER PAY ITEM. ALL ELECTRICAL COMPONENTS SHALL BE UL LISTED PER THE APPROPRIATE UL REQUIREMENTS. INCLUDING BUT NOT LIMITED TO 508A INDUSTRIAL CONTROL PANELS.

✱ ONLY REQUIRED FOR LOADS NOT CONTROLLED BY LOCAL NODES.

LIGHTING CONTROL CENTER

Computer File Information		Sheet Revisions		Colorado Department of Transportation	ALTERNATIVE ROADWAY LIGHTING	STANDARD PLAN NO.
Creation Date: 05/01/2020		Date:	Comments	2829 W. Howard Pl. Denver, CO 80204 Phone: 303-757-9654 FAX: 303-757-9219		S-613-2
Created By: Clanton				Traffic & Safety Engineering MKB		Sheet No. 3 of 4
Last Modification Date:					Issued By: Traffic & Safety Engineering Branch July 31, 2019	Project Sheet Number:
Last Modified By: CLANTON AND ASSOCIATES, INC.						
CAD Ver.: MicroStation V8 Scale: Not to Scale Units: English						

Figure 3.16. Colorado's Response for Question 3b (3/4).



CABINET COMPONENT LIST

(A) FULLY HINGED METER/TEST SECTION LOCKABLE COVER WITH HOLD OPEN ARM TO KEEP COVER FROM BLOWING SHUT PER UTILITY SPECIFICATION. COMBINATION ALL-IN-ONE COMMERCIAL METER POWER PEDESTAL IN A NEMA 3R STAINLESS STEEL ENCLOSURE. PAINT COLOR PER PROJECT.

(B) UTILITY METER INSIDE NEMA 3R ENCLOSURE. METER SHALL HAVE LEVER BYPASS AND INTERNAL LOCKING TAB ON METER COVER PER LOCAL UTILITY COMPANY SPECIFICATIONS.

(C) GFCI MAINTENANCE RECEPTACLE FLUSH MOUNTED IN PANEL DEAD FRONT INSIDE OF THE NEMA 3R ENCLOSURE.

(D) HAND-OFF-AUTO SWITCH - 15A-2P, H.O.A. SWITCH WITH LEGEND FLUSH MOUNTED IN PANEL DEAD FRONT INSIDE OF THE NEMA 3R ENCLOSURE.

(E) UTILITY TERMINATION LANDING LUGS.

(F) LOAD CENTERS WITH SERVICE MAIN AND BRANCH BREAKERS. ENGINEER SHALL PROVIDE PANEL SCHEDULE FOR BREAKERS REQUIRED.

(G) PROVIDE NEUTRAL TO GROUND BONDING JUMPER.

(H) LIFT OFF SERVICE COVER WITH PAD LOCK HASP.

(I) CABINET GROUND BOND #6 BARE COPPER CONDUCTOR.

(J) NEMA 3R 120V PHOTOELECTRIC CONTROL WITH 3-PRONG TWIST-LOCK RECEPTACLE BASE WIRED THROUGH THE H.O.A. SWITCH. THE PHOTOELECTRIC CONTROL SHALL BE MOUNTED ON THE NORTH SIDE ON ENCLOSURE OR WINDOW FACING NORTH OR DOWN TO MINIMIZE THE SUN'S INTERFERENCE.

(K) REINFORCED CONCRETE (CLASS B) FOUNDATION PER STRUCTURAL ENGINEER LICENSED IN THE STATE OF COLORADO. 2 INCH (MINIMUM) ABOVE GRADE, 3/4 INCH CHAMFER ALL EXPOSED EDGES, 3 INCH (MINIMUM), 6 INCH (MAXIMUM) OVERLAP ON ALL SIDES.

(L) 3/4 INCH X 10 FEET LONG, COPPER CLAD DRIVEN GROUND ROD. EXOTHERMIC WELD OR UNDERGROUND RATED LUG CONNECT CONDUCTOR TO GROUND ROD. (2) REQUIRED - 8 FEET APART (MINIMUM).

(M) T-HANDLE, PULL-OUT FUSE HOLDER WITH FRN-R FUSES, METER DISCONNECT FOR METER PROTECTION PER UTILITY SPECIFICATION, COLD SEQUENCE METER AND WEATHERPROOF COVER WITH TAB LOCKABLE. THIS ITEM MAY BE OMITTED BY LOCAL UTILITY COMPANY SPECIFICATIONS HOT SEQUENCE REQUIREMENTS.

TYPICAL CABINET REQUIREMENTS:

200AMP MCB, 120/240V-1Ph-3W SERVICE ENTRANCE RATED STAINLESS STEEL, NEMA 3R, METER/ POWER PEDESTAL WITH SEPARATE SEALABLE AND LOCKABLE CUSTOMER SECTION WITH:

1. LOAD CENTER (ENGINEER SHALL PROVIDE SCHEDULE FOR # OF CIRCUITS) FOR "ALWAYS ON" LOADS THAT INCLUDE: (APPLIES TO STREETLIGHTS AND PEDESTRIAN LIGHTS)
   - SERVICE ENTRANCE M.C.B. - ENGINEER TO PROVIDE SIZE ON THE PANEL SCHEDULE.
   - CONTROL POWER CIRCUIT BREAKER - ENGINEER TO PROVIDE SIZE ON THE PANEL SCHEDULE.
   - SWITCHED LOAD CENTER MAIN BREAKER - ENGINEER TO PROVIDE ON THE PANEL SCHEDULE.
   - BRANCH BREAKERS AS SHOWN - ENGINEER TO PROVIDE SIZE AND QUANTITY ON THE PANEL SCHEDULE.
   - CIRCUIT DIRECTORY TO DOCUMENT CONFIRGURATION IN POCKET ON HINGED DOOR.
   - MAINTENANCE RECEPTACLE FLUSH MOUNTED IN DEAD FRONT INSIDE ENCLOSURE.
2. CONTROL CIRCUIT INCLUDING: (ONLY APPLIES TO PEDESTRIAN LIGHTS OR OTHER LIGHTS THAT DO NOT HAVE INDIVIDUAL ANSI 7-PIN RECEPTACLES.)
   - PHOTOCELL RECEPTACLE, MOUNTED EXTERNALLY ON NEMA-3R ENCLOSURE.
   - ONE HAND-OFF-AUTO (H.O.A.) SWITCH FLUSH MOUNTED IN DEAD FRONT.
   - ONE LIGHTING CONTACTOR CONTROLLING ONE LOAD CENTER IN THIS SECTION.
   - ONE 12-CIRCUIT LOAD CENTER PHOTOCELL ON/OFF CONTROLLED.
   - A CIRCUIT DIRECTORY TO DOCUMENT CONFIGURATION IN POCKET ON HINGED DOOR.

NOTE:
ALL COMPONENTS LISTED SHALL BE INCLUDED IN THE LIGHTING CONTROL CENTER PAY ITEM. ALL ELECTRICAL COMPONENTS SHALL BE UL LISTED PER THE APPROPRIATE UL REQUIREMENTS. INCLUDING BUT NOT LIMITED TO 508A INDUSTRIAL CONTROL PANELS.

LIGHTING CONTROL CENTER (SPECIAL)

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ALTERNATIVE ROADWAY LIGHTING

Issued By: Traffic & Safety Engineering Branch July 31, 2019

STANDARD PLAN NO.
S-613-2
Sheet No. 4 of 4
Project Sheet Number:

Figure 3.17. Colorado's Response for Question 3b (4/4).

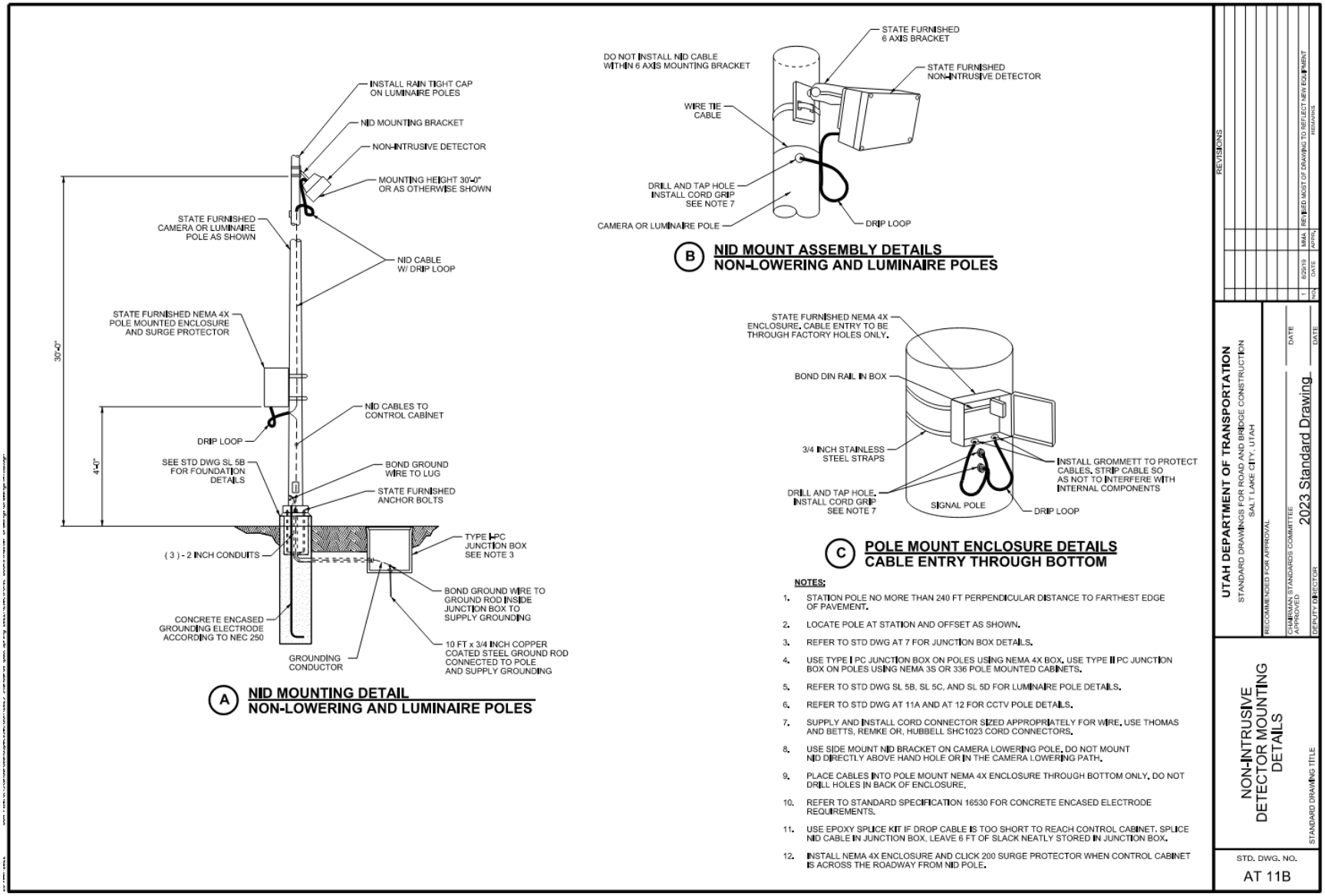


Figure 3.18. Utah's Response for Question 3b.

Chapter 4. SYSTEM DETAILS

4.1. TEST ARTICLE AND INSTALLATION DETAILS

Based on the literature review, the research team selected the test article design utilized for full-scale testing. The tests began with the heaviest pole, mast and luminaire combination available. The results of the testing caused the subsequent tests to be performed with lighter designs.

For test 618911-01-1, a luminaire pole 34 feet and 9 inches tall was used, with two luminaire arms that were 15 feet long, each with a luminaire at the end. The pole with the arms was connected to the base with four hex bolts. The assembly weighed approximately 730 pounds.

Figure 4.1 presents the overall information on the Four Bolt Slip Base Support for Luminaire Poles, and Figure 4.2 thru Figure 4.5 provide photographs of the installation.

For test 618911-01-2, a luminaire pole 24 feet and 10 inches tall was used . with two luminaire arms that were 15 feet long, each with have a luminaire at the end. The total height was approximately 30 feet. The pole with the arms was connected to the base with four hex bolts. The assembly weighed approximately 650 pounds.

Figure 4.6 presents the overall information on the Four Bolt Slip Base Support for Luminaire Poles, and Figure 4.7 thru Figure 4.10 provide photographs of the installation.

For test 618911-01-3, a Utah luminaire pole that was 34 feet and 9 inches tall was used, with one luminaire arm that was 15 feet long, with a luminaire at the end. The total height was approximately 40 feet. The arm was connected to the pole with four hex bolts. The assembly weighed approximately 560 pounds.

Figure 4.11 presents the overall information on the Four Bolt Slip Base Support for Luminaire Poles, and Figure 4.12 thru Figure 4.15 provide photographs of the installation.

Appendix A provides further details on the Four Bolt Slip Base Support for Luminaire Poles. Drawings were provided by the Texas A&M Transportation Institute (TTI) Proving Ground, and construction was performed by Bayer Electric and TTI Proving Ground personnel.

4.2. DESIGN MODIFICATIONS DURING TESTS

No modifications were made to the installation during the testing phase.

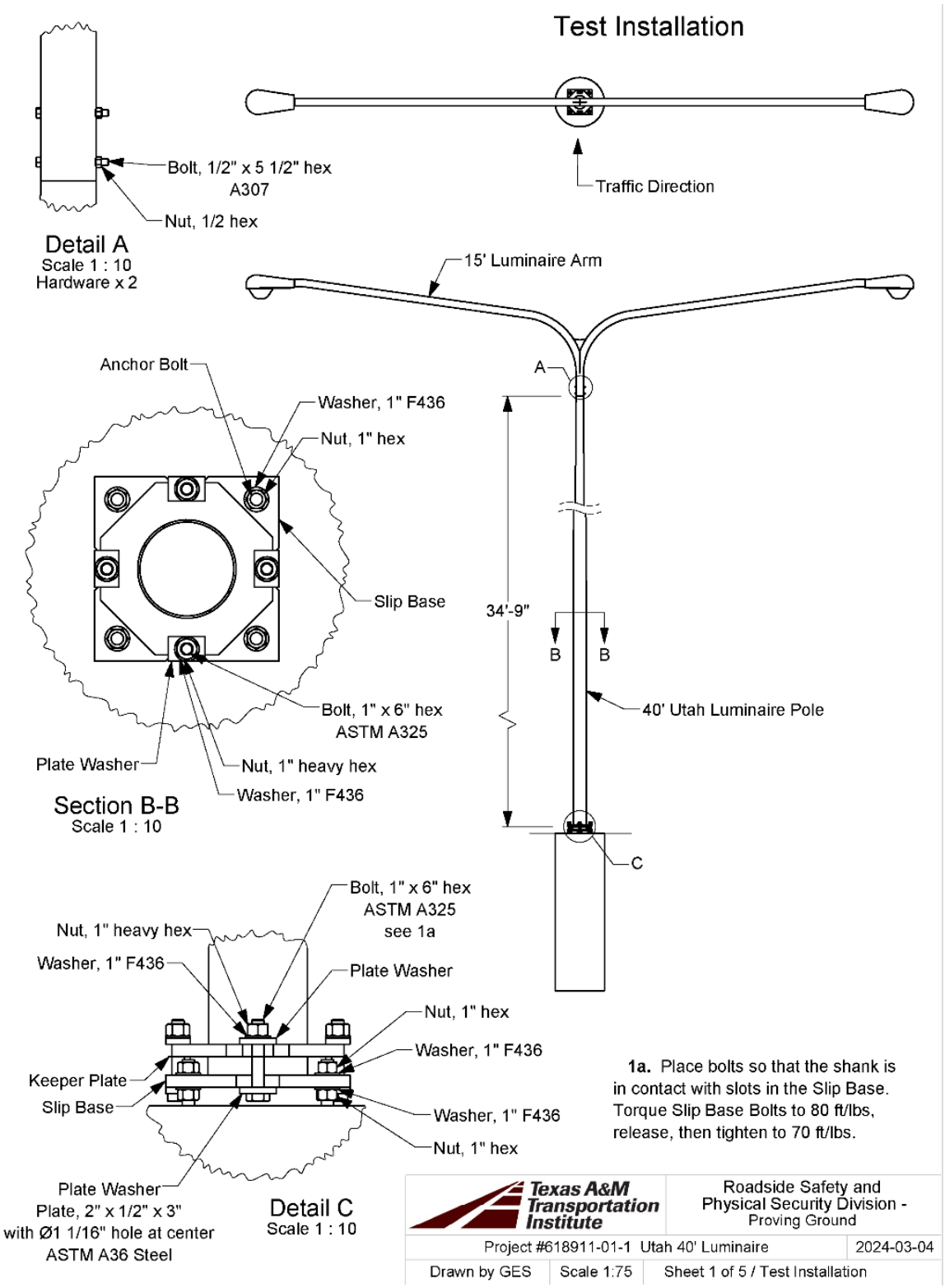


Figure 4.1. Details for Test 618911-01-1 of Four Bolt Slip Base Support for Luminaire Poles.

Figure 4.2. Four Bolt Slip Base Support for Luminaire Poles Prior to Testing 618911-01-1.

Figure 4.3. Closeup of the Base for the Four Bolt Slip Base Support for Luminaire Poles Prior to Testing 618911-01-1.

Figure 4.4. Luminaire Arms of Four Bolt Slip Base Support for Luminaire Poles Prior to Testing 618911-01-1.

Figure 4.5. Base and Footer of the Four Bolt Slip Base Support for Luminaire Poles Prior to Testing 618911-01-1.

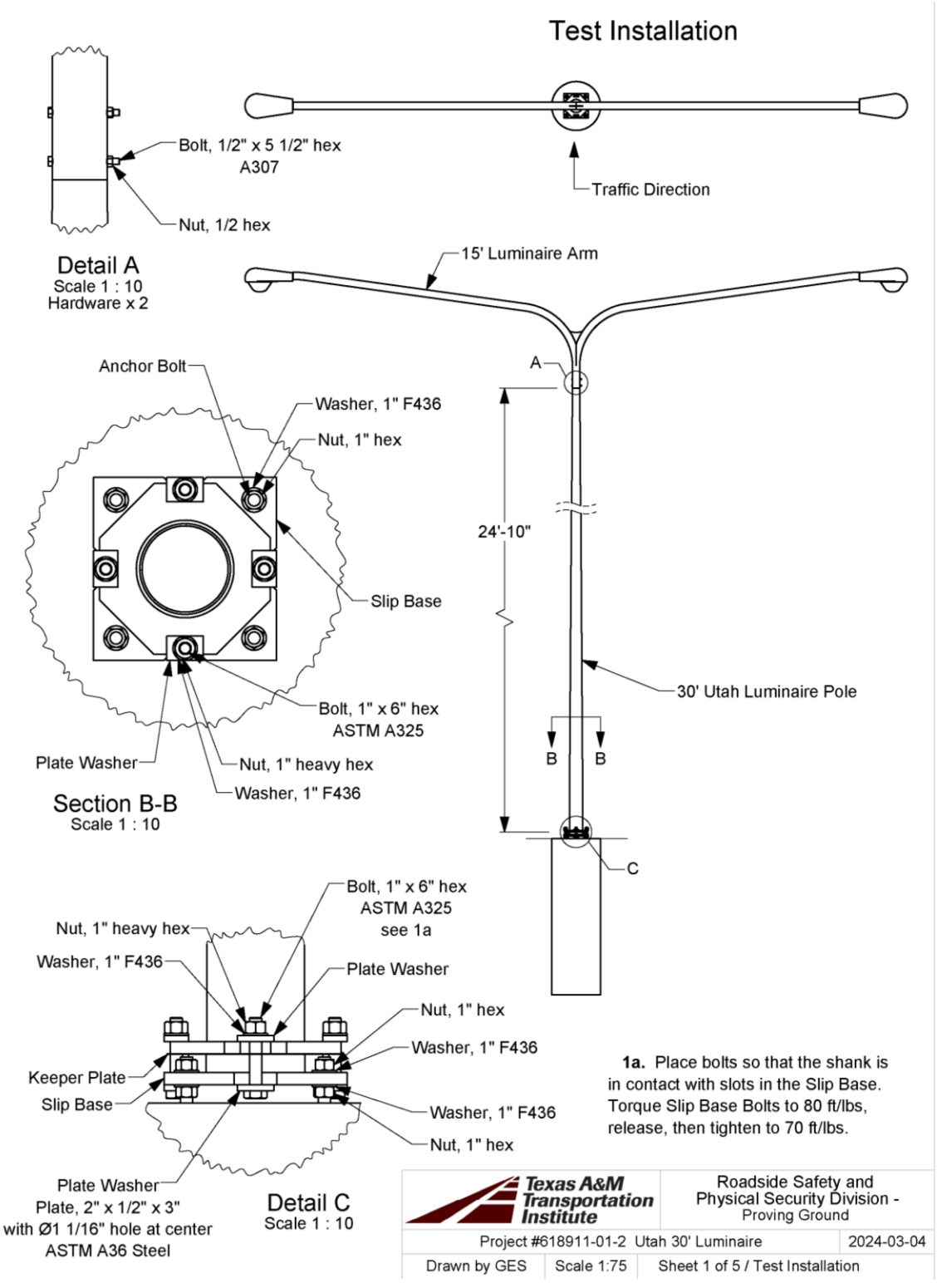


Figure 4.6. Details for Test 618911-01-2 of Four Bolt Slip Base Support for Luminaire Poles.

Figure 4.7. Four Bolt Slip Base Support for Luminaire Poles Prior to Testing 618911-01-2.

Figure 4.8. Base and Footer of the Four Bolt Slip Base Support for Luminaire Poles Prior to Testing 618911-01-2.

Figure 4.9. Closeup of the Base for the Four Bolt Slip Base Support for Luminaire Poles Prior to Testing 618911-01-2.

Figure 4.10. Non-Impact Side of Four Bolt Slip Base Support for Luminaire Poles Prior to Testing 618911-01-2.

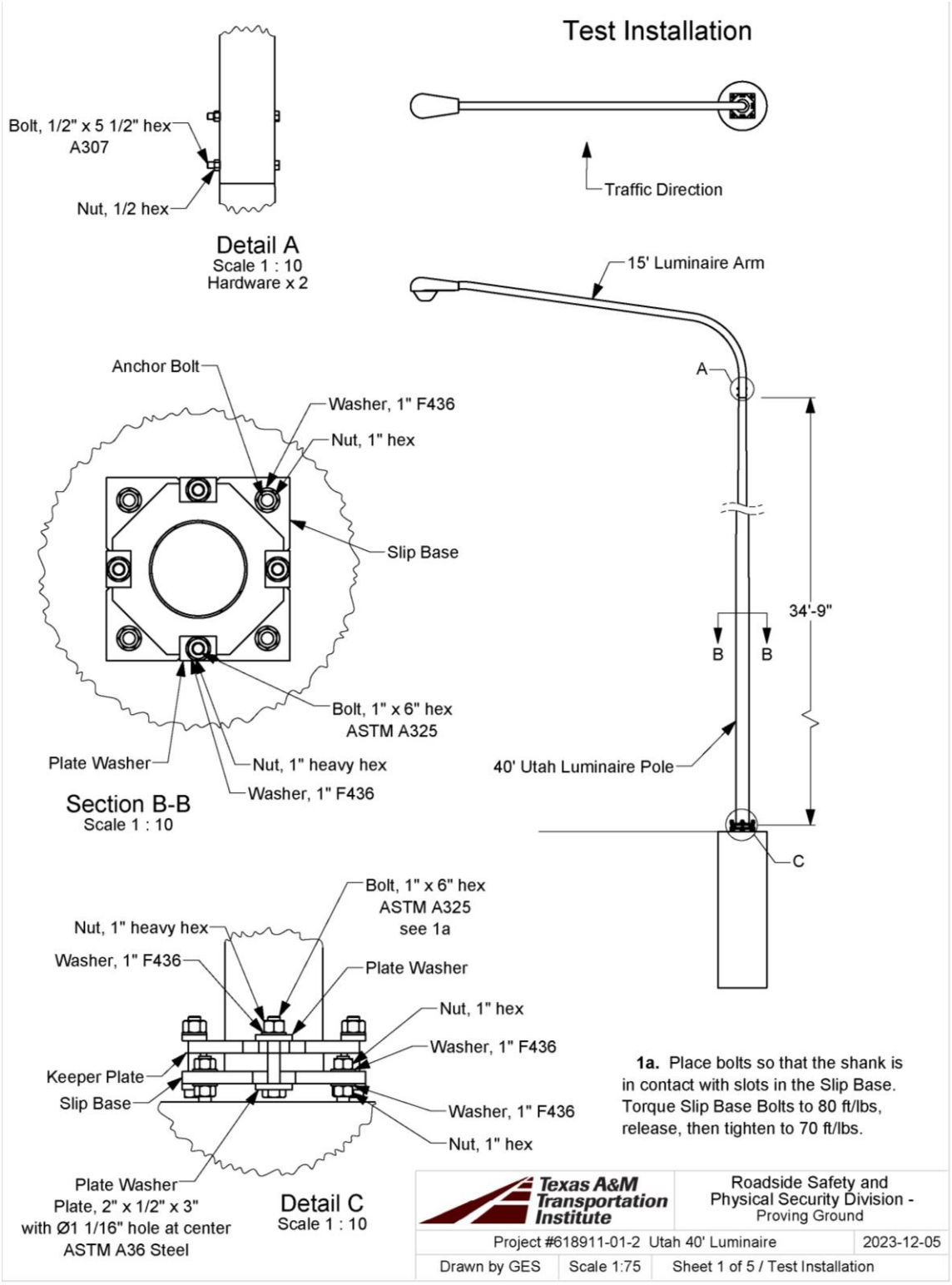


Figure 4.11. Details for Test 618911-01-3 of Four Bolt Slip Base for Luminaire Supports

Figure 4.12. Four Bolt Slip Base Support for Luminaire Poles Prior to Testing 618911-01-3.

Figure 4.13. Base and Footer of the Four Bolt Slip Base Support for Luminaire Poles Prior to Testing 618911-01-1.

Figure 4.14. Closeup of the Base for the Four Bolt Slip Base Support for Luminaire Poles Prior to Testing 618911-01-1.

Figure 4.15. Luminaire Arm on the Four Bolt Slip Base Support for Luminaire Poles Prior to Testing 618911-01-1.

4.3. MATERIAL SPECIFICATIONS

Appendix B provides material certification documents for the materials used to install/construct the Four Bolt Slip Base Support for Luminaire Poles. Table 4.1 shows the average compressive strengths of the concrete on the day of the first test, 2024-02-09.

Table 4.1. Concrete Strength.

Location	Design Strength	Avg. Strength	Age	Detailed Location
Footer	4000 psi	4257 psi	27 days	100% of Luminaire Footers

Chapter 5. TEST REQUIREMENTS AND EVALUATION CRITERIA

5.1. CRASH TEST PERFORMED/MATRIX

Table 5.1 shows the test conditions and evaluation criteria for *MASH* Test 3-60 for Support Structures. The target critical impact points (CIPs) for each test were selected to maximize interaction of the pole with the vehicle's roof, windshield, and back window. Tests 618911-01-1 and 618911-01-2 aligned the centerline of the vehicle with the centerline of the pole because of the symmetry of the test article. Test 618911-01-3 offset the centerline of the vehicle from the centerline of the pole to increase the likelihood of the asymmetric test article to roll across the roof of the vehicle. Figure 5.1 through Figure 5.3 show the target CIP for the *MASH* Test 3-60 tests on the Four Bolt Slip Base Support for Luminaire Poles.

Table 5.1. Test Conditions and Evaluation Criteria Specified for *MASH* Test 3-60 Support Structures.

Test Designation	Test Vehicle	Impact Speed	Impact Angle	Evaluation Criteria
3-60	1100C	19 mi/h	0º	B, D, F, H, I, N

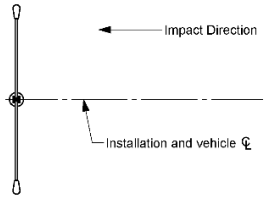


Figure 5.1. Target CIP for TEST 618911-01-1

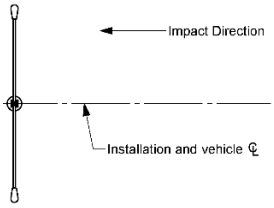


Figure 5.2. Target CIP for TEST 618911-01-2

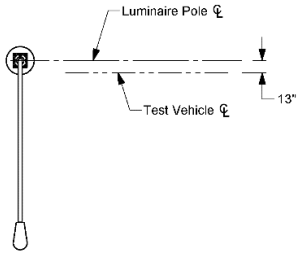


Figure 5.3. Target CIP for TEST 618911-01-3

The crash tests and data analysis procedures were in accordance with guidelines presented in *MASH*. Chapter 4 presents brief descriptions of these procedures.

5.2. EVALUATION CRITERIA

The appropriate safety evaluation criteria from Tables 2-5 and 5-1 of *MASH* were used to evaluate the crash tests reported herein. Table 5.1 lists the test conditions and evaluation criteria required for *MASH* Test 3-60, and Table 5.2 provides detailed information on the evaluation criteria.

Table 5.2. Evaluation Criteria Required for *MASH* Testing.

Evaluation Factors	Evaluation Criteria
B.	The test article should readily activate in a predictable manner by breaking away, fracturing, or yielding.
D.	Detached elements, fragments, or other debris from the test article should not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to other traffic, pedestrians, or personnel in a work zone. Deformations of, or intrusions into, the occupant compartment should not exceed limits set forth in Section 5.2.2 and Appendix E of *MASH*.
F.	The vehicle should remain upright during and after collision. The maximum roll and pitch angles are not to exceed 75 degrees.
H.	Occupant impact velocities (OIV) should satisfy the following limits: Preferred value of 10 ft/s, or maximum allowable value of 16 ft/s.
I.	The occupant ridedown accelerations should satisfy the following: Preferred value of 15.0 g, or maximum allowable value of 20.49 g.
N.	Vehicle trajectory behind the test article is acceptable.

Chapter 6. TEST CONDITIONS

6.1. TEST FACILITY

The full-scale crash tests reported herein were performed at the TTI Proving Ground, an International Standards Organization (ISO)/International Electrotechnical Commission (IEC) 17025-accredited laboratory with American Association for Laboratory Accreditation (A2LA) Mechanical Testing Certificate 2821.01. The full-scale crash tests were performed according to TTI Proving Ground quality procedures, as well as *MASH* guidelines and standards.

The test facilities of the TTI Proving Ground are located on The Texas A&M University System RELLIS Campus, which consists of a 2000-acre complex of research and training facilities situated 10 mi northwest of the flagship campus of Texas A&M University. The site, formerly a United States Army Air Corps base, has large expanses of concrete runways and parking aprons well suited for experimental research and testing in the areas of vehicle performance and handling, vehicle-roadway interaction, highway pavement durability and efficacy, and roadside safety hardware and perimeter protective device evaluation. The site selected for construction and testing are along an out-of-service apron/runway. The aprons consist of an unreinforced jointed-concrete pavement in 12.5-ft × 15-ft blocks nominally 6 inches deep. The aprons were built in 1942, and the joints have some displacement but are otherwise flat and level.

6.2. VEHICLE TOW AND GUIDANCE SYSTEM

For the testing utilizing the 1100C vehicle, each was towed into the test installation using a steel cable guidance and reverse tow system. A steel cable for guiding the test vehicle was tensioned along the path, anchored at each end, and threaded through an attachment to the front wheel of the test vehicle. An additional steel cable was connected to the test vehicle, passed around a pulley near the impact point and through a pulley on the tow vehicle, and then anchored to the ground such that the tow vehicle moved away from the test site. A 2:1 speed ratio between the test and tow vehicle existed with this system. Just prior to impact with the installation, the test vehicle was released and ran unrestrained. The vehicle remained freewheeling (i.e., no steering or braking inputs) until it cleared the immediate area of the test site.

6.3. DATA ACQUISITION SYSTEMS

6.3.1. Vehicle Instrumentation and Data Processing

Each test vehicle was instrumented with a self-contained onboard data acquisition system. The signal conditioning and acquisition system is a multi-channel data acquisition system (DAS) produced by Diversified Technical Systems Inc. The accelerometers, which measure the x, y, and z axis of vehicle acceleration, are strain gauge type with linear millivolt output proportional to acceleration. Angular rate sensors, measuring vehicle roll, pitch, and yaw rates, are ultra-small, solid-state units designed

for crash test service. The data acquisition hardware and software conform to the *MASH* recommended version of SAE J211, Instrumentation for Impact Test. Each of the channels is capable of providing precision amplification, scaling, and filtering based on transducer specifications and calibrations. During the test, data are recorded from each channel at a rate of 10,000 samples per second with a resolution of one part in 65,536. Once data are recorded, internal batteries back these up inside the unit in case the primary battery cable is severed. Initial contact of the pressure switch on the vehicle bumper provides a time zero mark and initiates the recording process. After each test, the data are downloaded from the DAS unit into a laptop computer at the test site. The Test Risk Assessment Program (TRAP) software then processes the raw data to produce detailed reports of the test results.

Each DAS is returned to the factory annually for complete recalibration and to ensure that all instrumentation used in the vehicle conforms to the specifications outlined by SAE J211. All accelerometers are calibrated annually by means of an ENDEVCO® 2901 precision primary vibration standard. This standard and its support instruments are checked annually and receive a National Institute of Standards Technology (NIST) traceable calibration. The rate transducers used in the data acquisition system receive calibration via a Genisco Rate-of-Turn table. The subsystems of each data channel are also evaluated annually, using instruments with current NIST traceability, and the results are factored into the accuracy of the total data channel per SAE J211. Calibrations and evaluations are also made anytime data are suspect. Acceleration data are measured with an expanded uncertainty of ±1.7 percent at a confidence factor of 95 percent (k = 2).

TRAP uses the DAS-captured data to compute the occupant to vehicle contact impact velocities, time of occupant to vehicle contact after vehicle impact, and highest 10-millisecond (ms) average ridedown acceleration. TRAP calculates change in vehicle velocity at the end of a given impulse period. In addition, maximum average accelerations over 50-ms intervals in each of the three directions are computed. For reporting purposes, the data from the vehicle-mounted accelerometers are filtered with an SAE Class 180-Hz low-pass digital filter, and acceleration versus time curves for the longitudinal, lateral, and vertical directions are plotted using TRAP.

TRAP uses the data from the yaw, pitch, and roll rate transducers to compute angular displacement in degrees at 0.0001-s intervals, and then plots yaw, pitch, and roll versus time. These displacements are in reference to the vehicle-fixed coordinate system with the initial position and orientation being initial impact. Rate of rotation data is measured with an expanded uncertainty of ±0.7 percent at a confidence factor of 95 percent (k = 2).

6.3.2. Anthropomorphic Dummy Instrumentation

An Alderson Research Laboratories Hybrid II, 50th percentile male anthropomorphic dummy, restrained with lap and shoulder belts, was placed in the front seat on the passenger's side of the 1100C vehicle for tests 618911-01-1&2, and it was placed in the front seat on the driver's side for test 618911-01-3. The dummy was not instrumented.

6.3.3. Photographic Instrumentation Data Processing

Photographic coverage of each test included two digital high-speed cameras:

- One placed with a field of view perpendicular to the impact path and in-line with the point of impact
- One placed downstream from the impact point at an oblique angle to the impact path

A flashbulb on the impacting vehicle was activated by a pressure-sensitive tape switch to indicate the instant of contact with the test article. The flashbulb was visible from each camera. The video files from these digital high-speed cameras were analyzed to observe phenomena occurring during the collision and to obtain time-event, displacement, and angular data. A digital camera recorded and documented conditions of each test vehicle and the installation before and after the test.

Chapter 7. *MASH* TEST 3-60 (CRASH TEST 618911-01-1)

7.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 7.1 for details of *MASH* impact conditions for this test and Table 7.2 for the exit parameters. Figure 7.1 and Figure 7.2 depict the target impact setup.

Table 7.1. Impact Conditions for *MASH* Test *3-60,* Crash Test 618911-01-1.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	19 mi/h	±2.5 mi/h	19.1 mi/h
Impact Angle	0°	±1.5°	0°
Kinetic Energy	34 kip-ft	≤34 kip-ft	29.8 kip-ft
Impact Location	Centerline of the vehicle aligned with the centerline of the luminaire pole	±6 inches	Centerline of the vehicle aligned with the centerline of the luminaire pole

Table 7.2. Exit Parameters for *MASH* Test *3-60,* Crash Test 618911-01-1.

Exit Parameter	Measured
Speed	12.2 mi/h
Brakes applied post impact	Brakes not applied
Vehicle at rest position	92 ft downstream of impact point 7 ft to the right side Vehicle positioned 5° right relative to the installation
Comments:	Vehicle remained upright and stable

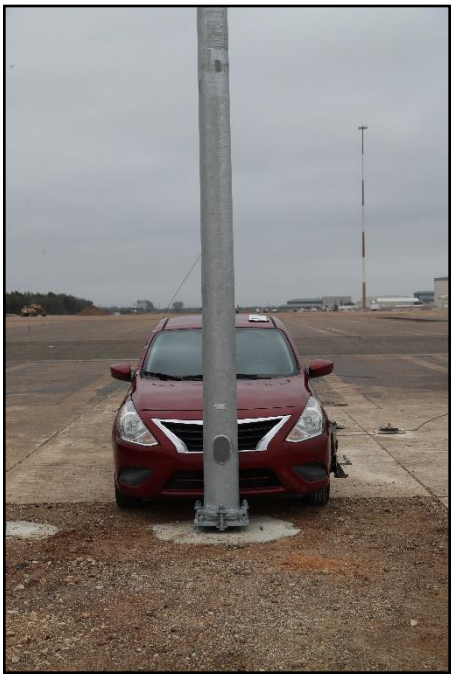


Figure 7.1. Four Bolt Slip Base Support for Luminaire Poles/Test Vehicle Geometrics for Test 618911-01-1.

Figure 7.2. Four Bolt Slip Base Support for Luminaire Poles/Test Vehicle Impact Location 618911-01-1.

7.2. WEATHER CONDITIONS

Table 7.3 provides the weather conditions for 618911-01-1.

Table 7.3. Weather Conditions 618911-01-1.

Date of Test	2024-02-09
Wind Speed	9 mi/h
Wind Direction	168°
Temperature	68°F
Relative Humidity	92%
Vehicle Traveling	170°

7.3. TEST VEHICLE

Figure 7.3 and Figure 7.4 show the 2018 Nissan Versa used for the crash test. Table 7.4 shows the vehicle measurements. Figure C.1 in Appendix C.1 gives additional dimensions and information on the vehicle.

Figure 7.3. Impact Side of Test Vehicle before Test 618911-01-1.

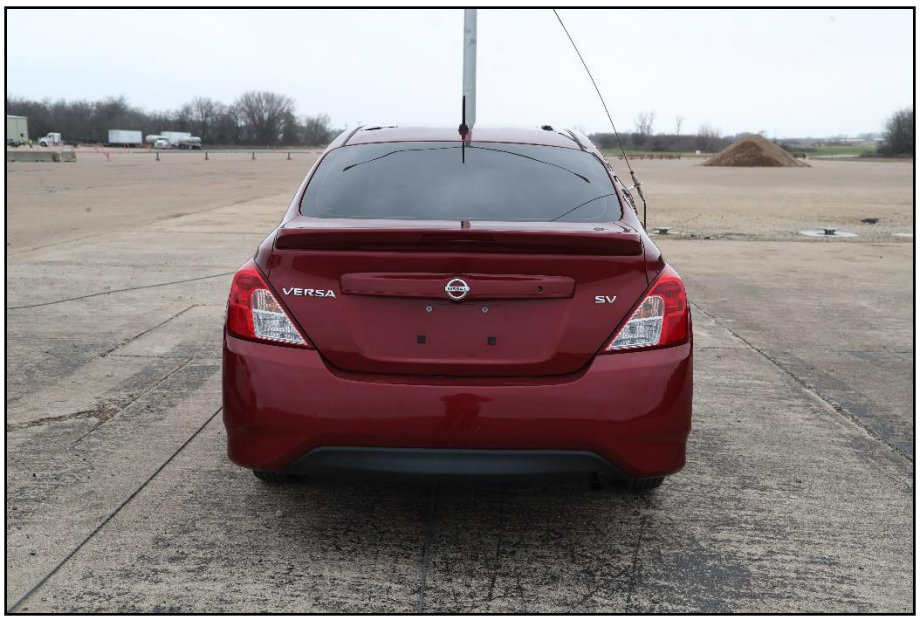


Figure 7.4. Opposite Impact Side of Test Vehicle before Test 618911-01-1.

Table 7.4. Vehicle Measurements for Test 618911-01-1.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a]	165 lb	N/A	165 lb
Inertial Mass	2420 lb	±55 lb	2443 lb
Gross Static[a] Mass	2585 lb	±55 lb	2608 lb
Wheelbase	98 inches	±5 inches	102.4 inches
Front Overhang	35 inches	±4 inches	32.5 inches
Overall Length	169 inches	±8 inches	175.4 inches
Overall Width	65 inches	±3 inches	66.7 inches
Hood Height	28 inches	±4 inches	30.5 inches
Track Width[b]	59 inches	±2 inches	58.4 inches
CG aft of Front Axle[c]	39 inches	±4 inches	41.3 inches
CG above Ground[c,d]	N/A	N/A	N/A

Note: N/A = not applicable; CG = center of gravity.
[a] If a dummy is used, the gross static vehicle mass should be increased by the mass of the dummy.
[b] Average of front and rear axles.
[c] For test inertial mass.
[d] 2270P vehicle must meet minimum CG height requirement.

7.4. TEST DESCRIPTION

Table 7.5 lists events that occurred during Test 618911-01-1. Figures C.4, C.5, and C.6 in Appendix C.2 present sequential photographs during the test.

Table 7.5. Events during Test 618911-01-1.

Time	Events
0.0000 s	Vehicle impacted the installation
0.0470 s	Slip base began to move
0.0530 s	Slip base released from base
1.7530 s	Pole impacted roof of vehicle

7.5. DAMAGE TO TEST INSTALLATION

The lights released from the support arms, and the base of the pole came to rest on the trunk of the vehicle. Figure 7.5 and Figure 7.6 show the test article post impact.

Figure 7.5. Four Bolt Slip Base Support for Luminaire Poles at Impact Location after Test 618911-01-1.

Figure 7.6. Luminaire Arms and Pole after Test 618911-01-1.

7.6. DAMAGE TO TEST VEHICLE

Figure 7.7 and Figure 7.8 show the damage sustained by the vehicle. Figure 7.9 and Figure 7.10 show the interior of the test vehicle. Table 7.6 and Table 7.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures C.2 and C.3 in Appendix C.1 provide exterior crush and occupant compartment measurements.

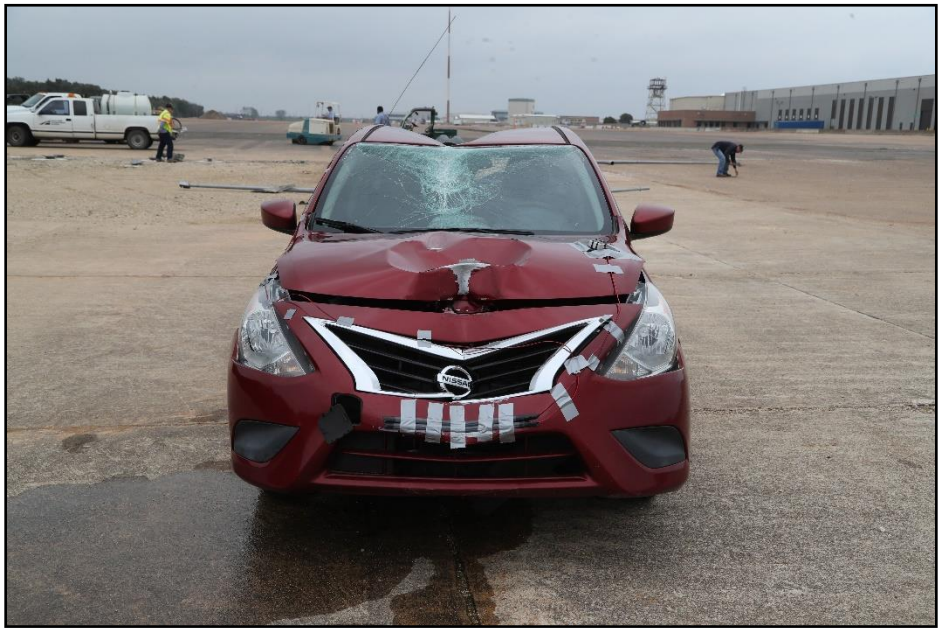


Figure 7.7. Impact Side of Test Vehicle after Test 618911-01-1.

Figure 7.8. Rear Impact Side of Test Vehicle after Test 618911-01-1.

Figure 7.9. Overall Interior of Test Vehicle after Test 618911-01-1.

Figure 7.10. Interior of Test Vehicle on Impact Side after Test 618911-01-1.

Table 7.6. Occupant Compartment Deformation 618911-01-1.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	6.3 inches
Windshield	≤3.0 inches	0 inches
A and B Pillars	≤5.0 overall/≤3.0 lateral inches	0 inches
Foot Well/Toe Pan	≤9.0 inches	0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	0 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 7.7. Exterior Vehicle Damage 618911-01-1.

Side Windows	Side windows remained intact
Maximum Exterior Deformation	12 inches at the front bumper
VDS	12FC5
CDC	12FCAW6
Fuel Tank Damage	None
Description of Damage to Vehicle:	The bumper, grill, hood, radiator, and roof were crushed. The front windshield was fractured, and the rear window glass was shattered. A section of the carpet inside the occupant compartment was ripped near the rear window. There was a small dent in the sheet metal under the rear windshield. There was a dent on the trunk lid and a cracked rear spoiler.

7.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 7.8. Figure C.7 in Appendix C.3 shows the vehicle angular displacements, and Figures C.8 through C.10 in Appendix C.4 show acceleration versus time traces.

Table 7.8. Occupant Risk Factors for Test 618911-01-1.

Test Parameter	Specification [a]	Measured	Time
OIV, Longitudinal	≤16.0 ft/s *10.0* ft/s	7.3 ft/s	0.3247 seconds on front of interior
OIV, Lateral	≤40.0 ft/s *30.0* ft/s	0.6 ft/s	0.3247 seconds on front of interior
Ridedown, Longitudinal	≤20.49 g *15.0* g	1.3 g	1.4741 - 1.4841 seconds
Ridedown, Lateral	≤20.49 g *15.0* g	0.8 g	1.8107 - 1.8207 seconds
Theoretical Head Impact Velocity (THIV)	N/A	2.2 m/s	0.3248 seconds on front of interior
Acceleration Severity Index	N/A	0.3	0.0496 - 0.0996 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	N/A	-3.8 g	0.0128 - 0.0628 seconds
50-ms MA Lateral	N/A	-0.7 g	0.1595 - 0.2095 seconds
50-ms MA Vertical	N/A	-2.8 g	0.1001 - 0.1501 seconds
Roll	≤75°	3.9°	4.9999 seconds
Pitch	≤75°	1°	1.7075 seconds
Yaw	N/A	0.8°	1.2330 seconds

[a] *Values in italics are the preferred MASH values*

7.8. TEST SUMMARY

Due to the 6.3 inch dent in the roof and the penetration of the base of the luminaire pole through the back glass, this test failed to meet evaluation criteria D of *MASH* for support structures. Figure 7.11 summarizes the results of *MASH* Test 618911-01-1.

0.000 s

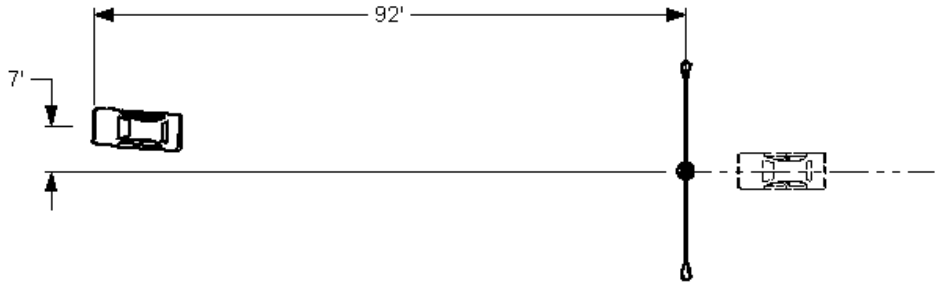
0.200 s

0.400 s

0.600 s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-60
Project No.:	618911-01-1
Test Date:	2024-02-09
TEST ARTICLE	
Type:	Support Structures
Name:	Four Bolt Slip Base Support for Luminaire Poles
Length:	34 feet and 9 inches
Key Materials:	Steel luminaire pole, two steel luminaire arms
Soil Type and Condition:	Native soil, dry
TEST VEHICLE	
Type/Designation:	1100C
Year, Make and Model:	2018 Nissan Versa
Inertial Mass:	2443 lb
Dummy Mass:	165 lb
Gross Static Mass:	2608 lb
IMPACT CONDITIONS	
Impact Speed / Impact Angle	19.1 mi/h / 0°
Impact Location	Centerline of vehicle aligned with centerline of luminaire pole
Kinetic Energy	29.8 kip-ft

EXIT CONDITIONS	
Exit Speed:	12.2mi/h
Stopping Distance:	92 ft downstream 7 ft to the right side
VEHICLE DAMAGE	
VDS:	12FC5
CDC:	12FCAW6
Max Exterior Deformation:	12 inches
Max Occupant Compartment Deformation:	6.3 inches in the roof
OCCUPANT RISK VALUES	
Longitudinal OIV:	7.3 ft/s
Lateral OIV:	0.6 ft/s
Longitudinal Ridedown:	1.3 g
Lateral Ridedown:	0.8 g
THIV:	2.2 m/s
ASI:	0.3
Max 50ms Longitudinal:	-3.8 g
Max 50ms Lateral:	-0.7 g
Max 50ms Vertical:	-2.8 g
Max Roll:	3.9°
Max Pitch:	1.0°
Max Yaw:	0.8°



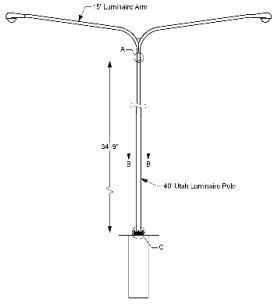


Figure 7.11. Summary of Results for *MASH* Test 3-60 on Four Bolt Slip Base Support for Luminaire Poles.

Chapter 8. *MASH* TEST 3-60 (CRASH TEST 618911-01-2)

8.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 8.1 for details of *MASH* impact conditions for this test and Table 8.2 for the exit parameters. Figure 8.1 and Figure 8.2 depict the target impact setup.

Table 8.1. Impact Conditions for *MASH* Test 3-60, Crash Test 618911-01-2.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	19 mi/h	±2.5 mi/h	19.1 mi/h
Impact Angle	0°	±1.5°	0°
Kinetic Energy	34 kip-ft	≤34 kip-ft	29.7 kip-ft
Impact Location	Centerline of the vehicle aligned with the centerline of the luminaire pole	±6 inches	Centerline of the vehicle aligned with the centerline of the luminaire pole

Table 8.2. Exit Parameters for *MASH* Test 3-60, Crash Test 618911-01-2.

Exit Parameter	Measured
Speed	11.7mi/h
Brakes applied post impact	1.9 seconds
Vehicle at rest position	52 ft downstream of impact point 3 ft to the right side Vehicle positioned 5° right relative to the installation
Comments:	Vehicle remained upright and stable

Figure 8.1. Four Bolt Slip Base Support for Luminaire Poles/Test Vehicle Geometrics for Test 618911-01-2.

Figure 8.2. Four Bolt Slip Base Support for Luminaire Poles/Test Vehicle Impact Location 618911-01-2.

8.2. WEATHER CONDITIONS

Table 8.3 provides the weather conditions for 618911-01-2.

Table 8.3. Weather Conditions 618911-01-2.

Date of Test	2024-02-09
Wind Speed	5 mi/h
Wind Direction	188°
Temperature	75°F
Relative Humidity	89%
Vehicle Traveling	170°

8.3. TEST VEHICLE

Figure 8.3 and Figure 8.4 show the 2019 Nissan Versa used for the crash test. Table 8.4 shows the vehicle measurements. Figure D.1 in Appendix D.1 gives additional dimensions and information on the vehicle.

Figure 8.3. Impact Side of Test Vehicle before Test 618911-01-2.

Figure 8.4. Opposite Impact Side of Test Vehicle before Test 618911-01-2.

Table 8.4. Vehicle Measurements 618911-01-2.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a]	165 lb	N/A	165 lb
Inertial Mass	2420 lb	±55 lb	2435 lb
Gross Static[a] Mass	2420 lb	±55 lb	2600 lb
Wheelbase	98 inches	±5 inches	102.4 inches
Front Overhang	35 inches	±4 inches	32.5 inches
Overall Length	169 inches	±8 inches	175.4 inches
Overall Width	65 inches	±3 inches	66.7 inches
Hood Height	28 inches	±4 inches	30.5 inches
Track Width[b]	59 inches	±2 inches	58.4 inches
CG aft of Front Axle[c]	39 inches	±4 inches	41 inches
CG above Ground[c,d]	N/A	N/A	N/A

Note: N/A = not applicable; CG = center of gravity.
[a] If a dummy is used, the gross static vehicle mass should be increased by the mass of the dummy.
[b] Average of front and rear axles.
[c] For test inertial mass.
[d] 2270P vehicle must meet minimum CG height requirement.

8.4. TEST DESCRIPTION

Table 8.5 lists events that occurred during Test 618911-01-2. Figures D.4, D.5, and D.6 in Appendix D.2 present sequential photographs during the test.

Table 8.5. Events during Test 618911-01-2.

Time (s)	Events
0.0000 s	Vehicle impacted the installation
0.0580 s	Slip base began to move
0.0630 s	Slip base released free of base
1.4883 s	Pole impacted roof of vehicle
1.7390 s	Back window shattered

8.5. DAMAGE TO TEST INSTALLATION

The luminaires released from the arms and the base of the luminaire pole came to rest 31 feet downstream. Figure 8.5 and Figure 8.6 show the damage to the Four Bolt Slip Base Support for Luminaire Poles.

Figure 8.5. Test Article at Impact Location after Test 618911-01-2.

Figure 8.6. Mast Arms after Test 618911-01-2.

8.6. DAMAGE TO TEST VEHICLE

Figure 8.7 and Figure 8.8 show the damage sustained by the vehicle. Figure 8.9 show the interior of the test vehicle. Table 8.6 and Table 8.7 provide details on the occupant compartment deformation and exterior vehicle damage. Figures D.2 and D.3 in Appendix D.1 provide exterior crush and occupant compartment measurements.

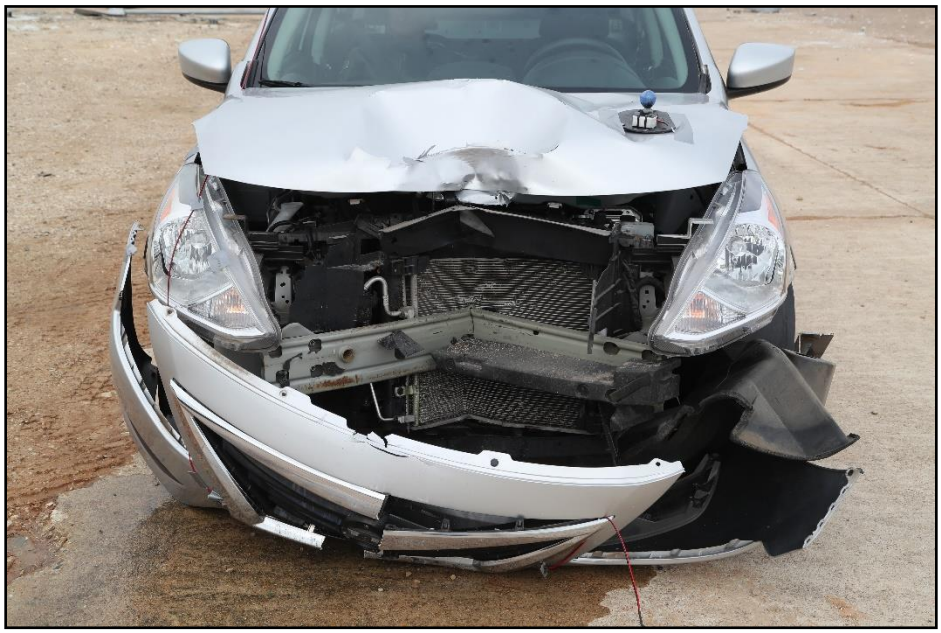


Figure 8.7. Front of Test Vehicle after Test 618911-01-2.

Figure 8.8. Rear of Test Vehicle after Test 618911-01-2.

Figure 8.9. Interior of Test Vehicle after Test 618911-01-2.

Table 8.6. Occupant Compartment Deformation 618911-01-2.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	1.8 inches
Windshield	≤3.0 inches	0 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0 inches
Foot Well/Toe Pan	≤9.0 inches	0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0 inches
Side Front Panel	≤12.0 inches	0 inches
Front Door (above Seat)	≤9.0 inches	0 inches
Front Door (below Seat)	≤12.0 inches	0 inches

Table 8.7. Exterior Vehicle Damage 618911-01-2.

Side Windows	Side windows remained intact
Maximum Exterior Deformation	13 inches at the front bumper
VDS	12FC5
CDC	12FCHW6
Fuel Tank Damage	None
Description of Damage to Vehicle:	The hood, bumper, grill, radiator, and cross bar support were bent. There were two cracks at the top of the windshield, with a 33-inch-wide x 5-inch-long x 1.8-inch-deep dent in the roof. There was carpet ripped and two small dents inside the vehicle occupant compartment near where the rear window was shattered. There was a small dent on the trunk lid, and the rear spoiler was cracked.

8.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 8.8. Figure D.7 in Appendix D.3 shows the vehicle angular displacements, and Figures D.8 through D.10 in Appendix D.4 show acceleration versus time traces.

Table 8.8. Occupant Risk Factors for Test 618911-01-2.

Test Parameter	***Specification*** [a]	Measured	Time
OIV, Longitudinal	≤16.0 ft/s *10.0* ft/s	9.6 ft/s	0.2641 seconds on front of interior
OIV, Lateral	≤40.0 ft/s *30.0* ft/s	0.3 ft/s	0.2641 seconds on front of interior
Ridedown, Longitudinal	≤20.49 g *15.0* g	1.1 g	1.5656 - 1.5756 seconds
Ridedown, Lateral	≤20.49 g *15.0* g	0.6 g	1.5610 - 1.5710 seconds
Theoretical Head Impact Velocity (THIV)	N/A	2.9 m/s	0.2640 seconds on front of interior
Acceleration Severity Index	N/A	0.4	0.0565 - 0.1065 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	N/A	-4.6 g	0.0186 - 0.0686 seconds
50-ms MA Lateral	N/A	0.8 g	0.0724 - 0.1224 seconds
50-ms MA Vertical	N/A	-2.6 g	0.1114 - 0.1614 seconds
Roll	≤75°	2.3°	1.5987 seconds
Pitch	≤75°	1.1°	0.4705 seconds
Yaw	N/A	1.8°	1.6992 seconds

[a.] Values in italics are the preferred MASH values

8.8. TEST SUMMARY

Due to occupant compartment penetration in the back window from the test article, this test failed to meet evaluation criteria D of *MASH.* Figure 8.10 summarizes the results of *MASH* Test 618911-01-2.

0.000 s

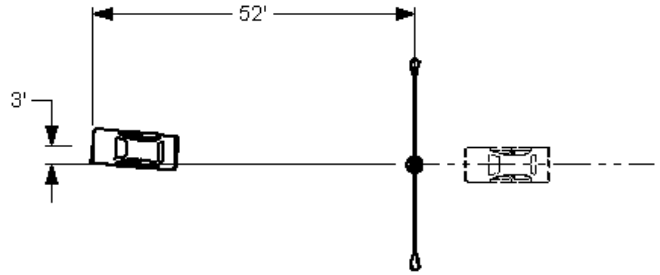
0.275 s

[Seq 4, #1] s

[Seq 6, #1]s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-60
Project No.:	618911-01-2
Test Date:	2024-02-09
TEST ARTICLE	
Type:	Support Structures
Name:	Four Bolt Slip Base Support for Luminaire Poles
Length:	24 feet and 10 inches
Key Materials:	Steel luminaire pole, two steel luminaire arms
Soil Type and Condition:	Native soil, dry
TEST VEHICLE	
Type/Designation:	1100C
Year, Make and Model:	2019 Nissan Versa
Inertial Mass:	2435 lb
Dummy Mass:	165 lb
Gross Static Mass:	2600 lb
IMPACT CONDITIONS	
Impact Speed / Impact Angle	19.1 mi/h / 0°
Impact Location	Centerline of vehicle aligned with centerline of luminaire
Kinetic Energy	29.7 kip-ft

EXIT CONDITIONS	
Exit Speed:	11.7mi/h
Stopping Distance:	52 ft downstream 3 ft to the right side
VEHICLE DAMAGE	
VDS:	12FC5
CDC:	12FCHW6
Max Exterior Deformation:	13 inches
Max Occupant Compartment Deformation:	1.8 inches in the roof
OCCUPANT RISK VALUES	
Longitudinal OIV:	9.6 ft/s
Lateral OIV:	0.3 ft/s
Longitudinal Ridedown:	1.1 g
Lateral Ridedown:	0.6 g
THIV:	2.9 m/s
ASI:	0.4
Max 50ms Longitudinal:	-4.6 g
Max 50ms Lateral:	0.8 g
Max 50ms Vertical:	-2.6 g
Max Roll:	2.3°
Max Pitch:	1.1°
Max Yaw:	1.8°



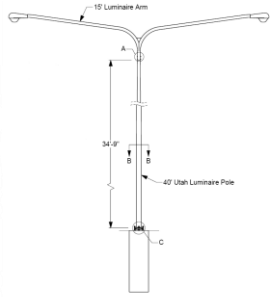


Figure 8.10. Summary of Results for *MASH* Test 3-60 on Four Bolt Slip Base Support for Luminaire Poles.

Chapter 9. *MASH* TEST 3-60 (CRASH TEST 618911-01-3)

9.1. TEST DESIGNATION AND ACTUAL IMPACT CONDITIONS

See Table 9.1 for details on *MASH* impact conditions for this test and Table 9.2 for the exit parameters. Figure 9.1 and Figure 9.2 depict the target impact setup.

Table 9.1. Impact Conditions for *MASH* Test 3-60, Crash Test 618911-01-3.

Test Parameter	Specification	Tolerance	Measured
Impact Speed	19 mi/h	±2.5 mi/h	19.4 mi/h
Impact Angle	0°	±1.5°	0°
Kinetic Energy	34 kip-ft	≤34 kip-ft	30.5 kip-ft
Impact Location	Centerline of the luminaire pole aligned 13 inches to the right	±6 inches	Centerline of the luminaire pole aligned 13 inches to the right

Table 9.2. Exit Parameters for *MASH* Test 3-60, Crash Test 618911-01-3.

Exit Parameter	Measured
Speed	13.3mi/h
Brakes applied post impact	> 5 seconds
Vehicle at rest position	95 ft downstream of impact point 16 ft to the right side Vehicle positioned 5° right relative to the installation
Comments:	Vehicle remained upright and stable

Figure 9.1. Four Bolt Slip Base Support for Luminaire Poles/Test Vehicle Geometrics for Test 618911-01-3.

Figure 9.2. Four Bolt Slip Base Support for Luminaire Poles/Test Vehicle Impact Location 618911-01-3.

9.2. WEATHER CONDITIONS

Table 9.3 provides the weather conditions for 618911-01-3.

Table 9.3. Weather Conditions 618911-01-3.

Date of Test	2024-03-07
Wind Speed	10 mi/h
Wind Direction	164°
Temperature	76°F
Relative Humidity	73%
Vehicle Traveling	170°

9.3. TEST VEHICLE

Figure 9.3 and Figure 9.4 show the 2018 Nissan Versa used for the crash test. Table 9.4 shows the vehicle measurements. Figure E.1 in Appendix E.1 gives additional dimensions and information on the vehicle.

Figure 9.3. Impact Side of Test Vehicle before Test 618911-01-3.

Figure 9.4. Opposite Impact Side of Test Vehicle before Test 618911-01-3.

Table 9.4. Vehicle Measurements 618911-01-3.

Test Parameter	Specification	Tolerance	Measured
Dummy Mass (if applicable)[a]	165 lb	N/A	165 lb
Inertial Mass	2420 lb	±55 lb	2428 lb
Gross Static[a] Mass	2585 lb	±55 lb	2593 lb
Wheelbase	98 inches	±5 inches	102.4 inches
Front Overhang	35 inches	±4 inches	32.5 inches
Overall Length	169 inches	±8 inches	175.4 inches
Overall Width	65 inches	±3 inches	66.7 inches
Hood Height	28 inches	±4 inches	30.5 inches
Track Width[b]	59 inches	±2 inches	58.4 inches
CG aft of Front Axle[c]	39 inches	±4 inches	41.6 inches
CG above Ground[c,d]	N/A	N/A	N/A

Note: N/A = not applicable; CG = center of gravity.
[a] If a dummy is used, the gross static vehicle mass should be increased by the mass of the dummy.
[b] Average of front and rear axles.
[c] For test inertial mass.
[d] 2270P vehicle must meet minimum CG height requirement.

9.4. TEST DESCRIPTION

Table 9.5 lists events that occurred during Test 618911-01-3. Figures E.2, E.3, and E.4 in Appendix E.2 present sequential photographs during the test.

Table 9.5. Events during Test 618911-01-3.

Time (s)	Events
0.0000 s	Vehicle impacted the installation
0.0470 s	Slip Base began to release
1.2010 s	Pole impacted roof and windshield of vehicle
1.5190 s	Luminaire pole impacted rear window and began to shatter it
2.7050 s	Base of luminaire pole fell to the side of the vehicle

9.5. DAMAGE TO TEST INSTALLATION

The final resting location of the base of the luminaire pole landed 40 feet downstream and 9 feet right from the impact with the top landing upstream. The luminaire pole released from the base and was dented at the impact point. The luminaire also released from the arm and shattered. Figure 9.5 and Figure 9.6 show the damage to the Four Bolt Slip Base Support for Luminaire Poles.

Figure 9.5. Four Bolt Slip Base Support for Luminaire Poles at Impact Location after Test 618911-01-3.

Figure 9.6. Closeup of a Mast Arm End for Four Bolt Slip Base for Luminaire Supports after Test 618911-01-3.

9.6. DAMAGE TO TEST VEHICLE

Figure 9.7 and Figure 9.8 show the damage sustained by the vehicle. Figure 9.9 and Figure 9.10 show the interior of the test vehicle. Table 9.6 and Table 9.7 provide details on the occupant compartment deformation and exterior vehicle damage.

Figure 9.7. Front of Test Vehicle after Test 618911-01-3.

Figure 9.8. Rear of Test Vehicle after Test 618911-01-3.

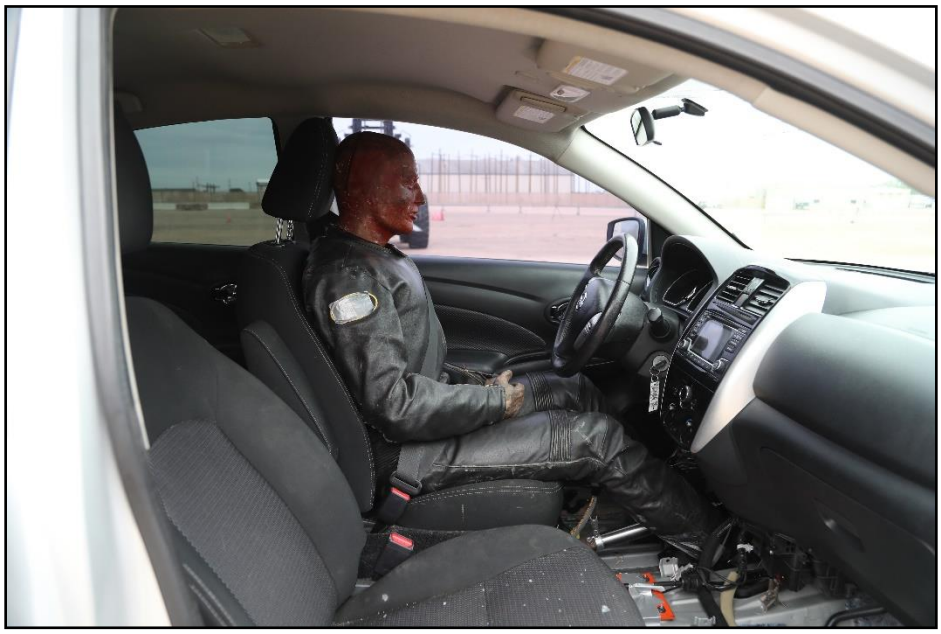


Figure 9.9. Overall Interior of Test Vehicle after Test 618911-01-3.

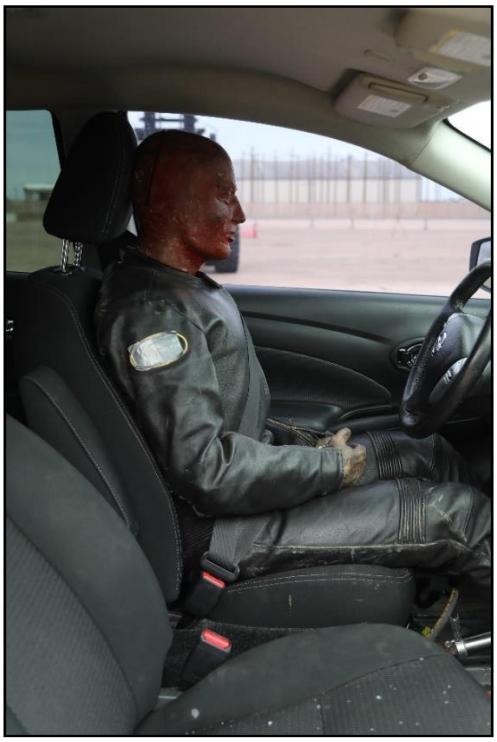


Figure 9.10. Interior of Test Vehicle on Impact Side after Test 618911-01-3.

Table 9.6. Occupant Compartment Deformation 618911-01-3.

Test Parameter	Specification	Measured
Roof	≤4.0 inches	2.8 inches
Windshield	≤3.0 inches	0.0 inches
A and B Pillars	≤5.0 overall/≤3.0 inches lateral	0.0 inches
Foot Well/Toe Pan	≤9.0 inches	0.0 inches
Floor Pan/Transmission Tunnel	≤12.0 inches	0.0 inches
Side Front Panel	≤12.0 inches	0.0 inches
Front Door (above Seat)	≤9.0 inches	0.0 inches
Front Door (below Seat)	≤12.0 inches	0.0 inches

Table 9.7. Exterior Vehicle Damage 618911-01-3.

Side Windows	Side windows remained intact
Maximum Exterior Deformation	9 inches at the front bumper
VDS	12FC4
CDC	12FCHW4
Fuel Tank Damage	None
Description of Damage to Vehicle:	The roof was damaged with a max depth of 2.8 inches. The front windshield was cracked but no holes were present. The back windshield was shattered but there was no indication of occupant compartment penetration. The bumper, grill, and hood were damaged.

9.7. OCCUPANT RISK FACTORS

Data from the accelerometers were digitized for evaluation of occupant risk, and the results are shown in Table 9.8. Figure E.5 in Appendix E.3 shows the vehicle angular displacements, and Figures E.6 through E.8 in Appendix E.4 show acceleration versus time traces.

Table 9.8. Occupant Risk Factors for Test 618911-01-3.

Test Parameter	***Specification*** [a]	Measured	Time
OIV, Longitudinal	≤16.0 ft/s *10.0* ft/s	8 ft/s	0.2915 seconds on front of interior
OIV, Lateral	≤40.0 ft/s *30.0* ft/s	2.3 ft/s	0.2915 seconds on front of interior
Ridedown, Longitudinal	≤20.49 g *15.0* g	0.9 g	0.6233 - 0.6333 seconds
Ridedown, Lateral	≤20.49 g *15.0* g	1.5 g	2.4015 - 2.4115 seconds
Theoretical Head Impact Velocity (THIV)	N/A	2.6 m/s	0.2945 seconds on front of interior
Acceleration Severity Index	N/A	0.4	0.0439 - 0.0939 seconds
50-ms Moving Avg. Accelerations (MA) Longitudinal	N/A	-4.7 g	0.0145 - 0.0645 seconds
50-ms MA Lateral	N/A	1.4 g	0.0057 - 0.0557 seconds
50-ms MA Vertical	N/A	-1.7 g	0.0364 - 0.0864 seconds
Roll	≤75°	1.2°	0.2003 seconds
Pitch	≤75°	1.9°	1.6251 seconds
Yaw	N/A	8.4°	2.9857 seconds

[a.] Values in italics are the preferred MASH values

9.8. TEST SUMMARY

Figure 9.11 summarizes the results of *MASH* Test 618911-01-3.

0.000 s

0.200 s

0.400 s

0.600 s

GENERAL INFORMATION	
Test Agency:	Texas A&M Transportation Institute (TTI)
Test Standard/Test No.:	*MASH* 2016, Test 3-60
Project No.:	618911-01-3
Test Date:	2024-03-07

TEST ARTICLE	
Type:	Support Structures
Name:	Four Bolt Slip Base Support for Luminaire Poles
Length:	34 ft 9in
Key Materials:	Steel luminaire pole, one steel luminaire arm
Soil Type and Condition:	Native soil, dry

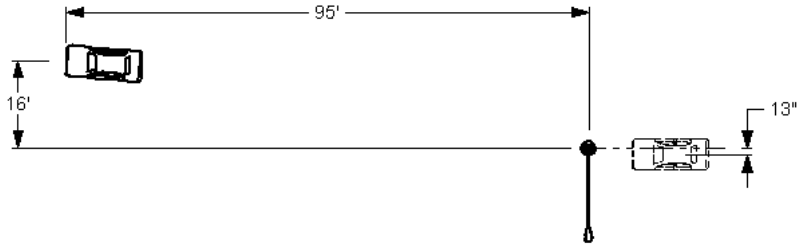
TEST VEHICLE	
Type/Designation:	1100C
Year, Make and Model:	2018 Nissan Versa
Inertial Mass:	2428 lb
Dummy Mass:	165 lb
Gross Static Mass:	2593 lb

IMPACT CONDITIONS	
Impact Speed / Impact Angle	19.4 mi/h / 0°
Impact Location	Centerline of the luminaire pole aligned 13 inches to the right
Kinetic Energy	30.5 kip-ft

EXIT CONDITIONS	
Exit Speed:	13.5 mi/h
Stopping Distance:	95 ft downstream 16 ft to the right side

VEHICLE DAMAGE	
VDS:	12FC4
CDC:	12FCHW4
Max Exterior Deformation:	9 inches
Max Occupant Compartment Deformation:	2.8 inches in the roof

OCCUPANT RISK VALUES	
Longitudinal OIV:	8.0 ft/s
Lateral OIV:	2.3 ft/s
Longitudinal Ridedown:	0.9 g
Lateral Ridedown:	1.5 g
THIV:	8.1 m/s
ASI:	0.4
Max 50ms Longitudinal:	-4.7 g
Max 50ms Lateral:	1.4 g
Max 50ms Vertical:	-1.7 g
Max Roll:	1.2°
Max Pitch:	1.9°
Max Yaw:	8.4°



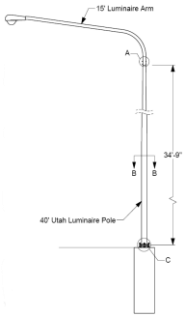


Figure 9.11. Summary of Results for *MASH* Test 3-60 on Four Bolt Slip Base Support for Luminaire Poles.

Chapter 10. SUMMARY AND CONCLUSIONS

10.1. ASSESSMENT OF TEST RESULTS

The three crash tests reported herein were performed in accordance with *MASH* Test 3-60, on the Four Bolt Slip Base Support for Luminaire Poles.

Table 10.1 shows that the Four Bolt Slip Base Support for Luminaire Poles evaluated in test 618911-01-3 met the performance criteria for *MASH* Test 3-60 Support Structures.

Table 10.1. Assessment Summary for *MASH* Test 3-60 Tests on Four Bolt Slip Base Support for Luminaire Poles.

Evaluation Criteria	**Description**	**Test 618911-01-1** *(MASH* Test 3-60)	**Test 618911-01-2** *(MASH* Test 3-60)	**Test 618911-01-3** *(MASH* Test 3-60)
B	Test Article Broke Away, Fractured, Yielded	S	S	S
D	No Penetration into Occupant Compartment	FAIL	FAIL	S
F	Roll and Pitch Limit	S	S	S
H	OIV Threshold	S	S	S
I	Ridedown Threshold	S	S	S
N	Vehicle Trajectory Behind Test Article Acceptable	S	S	S
Overall	Evaluation	Fail	Fail	Pass

Note: S = Satisfactory; N/A = Not Applicable.
[1] See Table 5.2 for details

10.2. CONCLUSIONS AND FUTURE RESEARCH

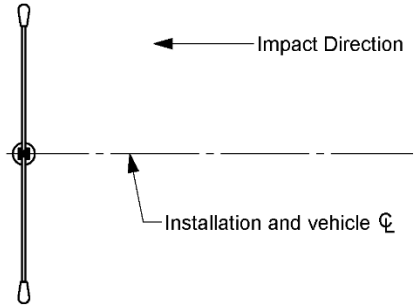
The luminaire pole and slip base support designed evaluated in tests 618911-01-1 and 618911-01-2 failed to meet *MASH* evaluation criteria for test 3-60. The design evaluated in test 618911-01-3 successfully met *MASH* evaluation criteria for test 3-60. The low-speed small car crash test for support structures has historically been viewed

as a critical test, as the higher speed tests are anticipated to rotate the luminaire pole above the vehicle. However, limited *MASH* testing has been completed on the slip base supports for luminaire poles. Therefore, additional *MASH* testing is recommended to evaluate the high-speed impact performance of the luminaire poles with slip bases. The results of this testing effort demonstrate the need for further research evaluating the crashworthiness of luminaire poles and their support structures.

REFERENCES

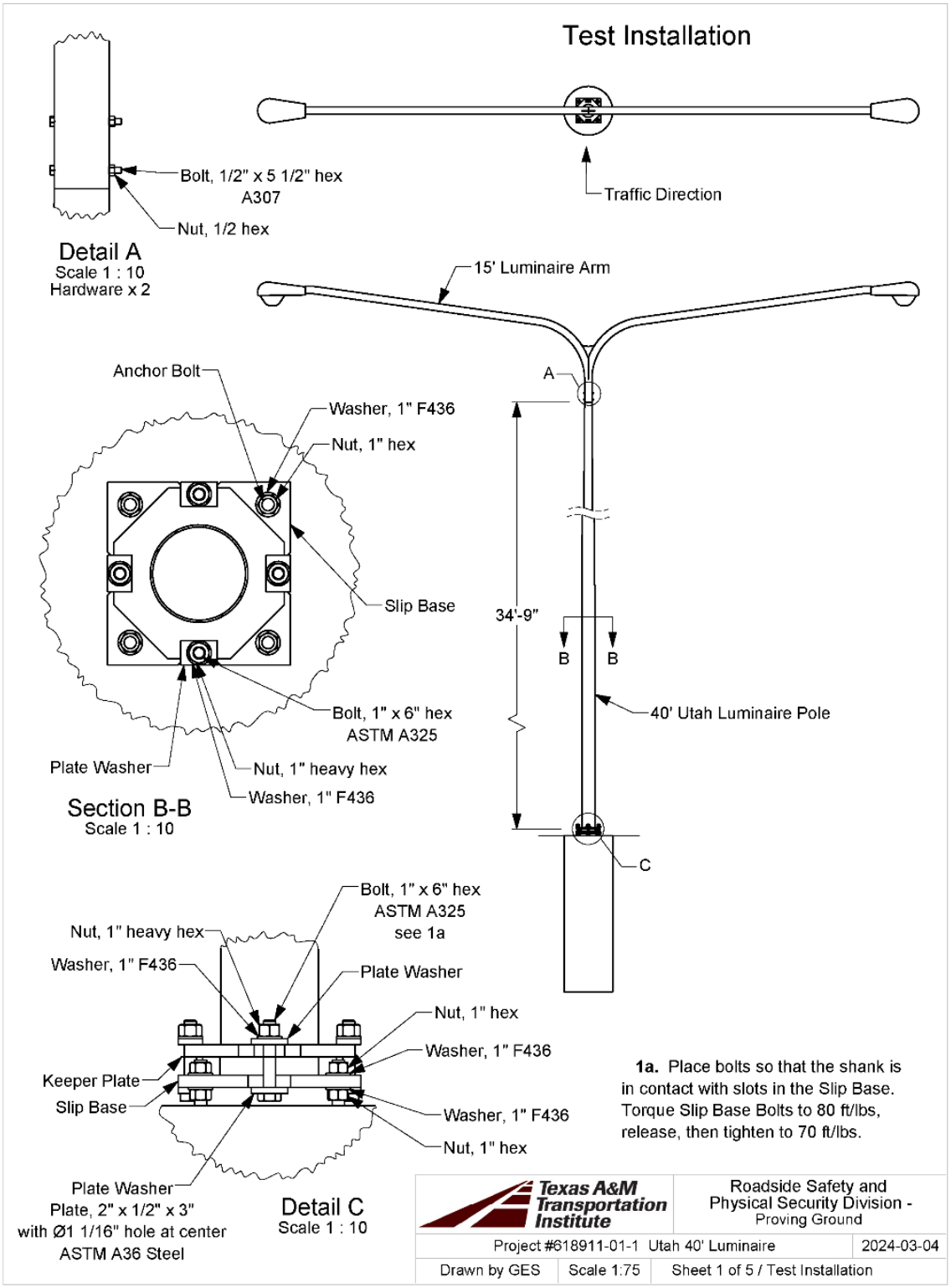
1. AASHTO. *Manual for Assessing Safety Hardware*, Second Edition. American Association of State Highway and Transportation Officials, Washington, DC, 2016.
2. Michie, J.D., *"Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances,"* NCHRP Report 230, Transportation Research Board, Washington, D.C., 1981.
3. Pfeifer, B. G., Faller, R. K., Holloway, J. C., & Post, E. R, *Full-Scale 1,800 lb. Vehicle Crash* Test*s on a 4-Bolt Breakaway Slipbase Design*. Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, NE, 1991.
4. Buth, E., & Ivey, D. L., *Full-Scale Vehicle Crash* Test*s of Luminaire Supports*. Texas Transportation Institute, College Station, TX, 1972.

APPENDIX A. DETAILS FOR TEST 618911-01-1

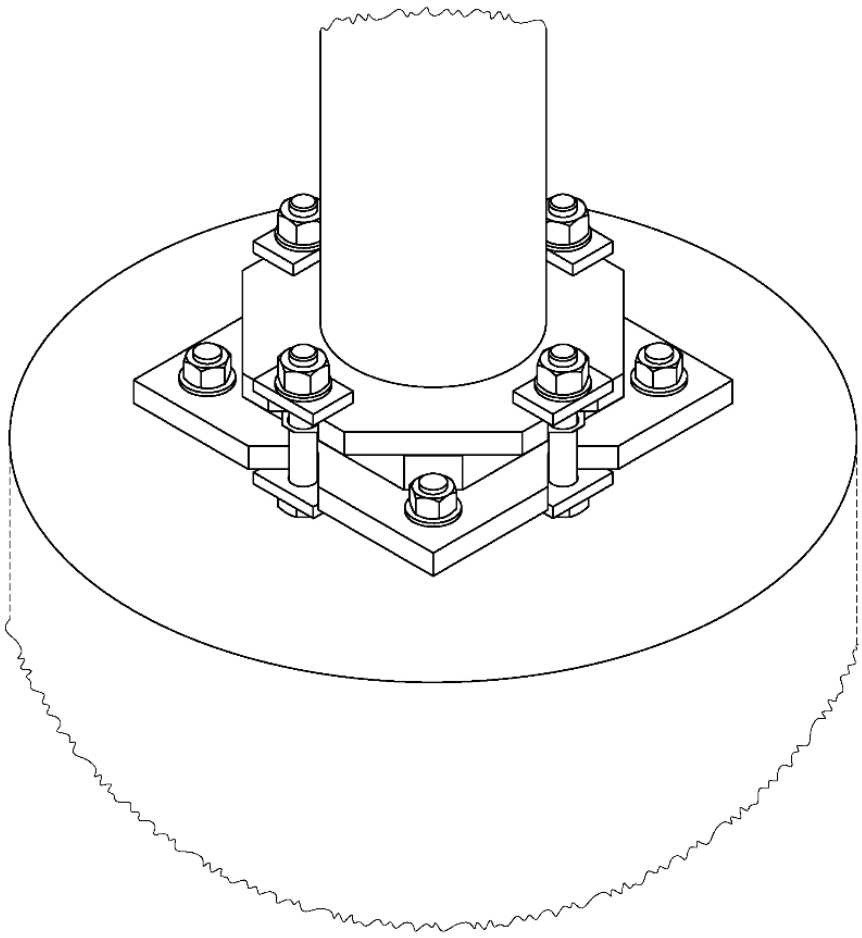


Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground
Project #618911-01-2	
Drawn by GES	Sheet 1 of 1 Impact

S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-2 (3-60) Utah 30'\Drafting, 618911-01-2\618911-01-2 Impacts and Summary

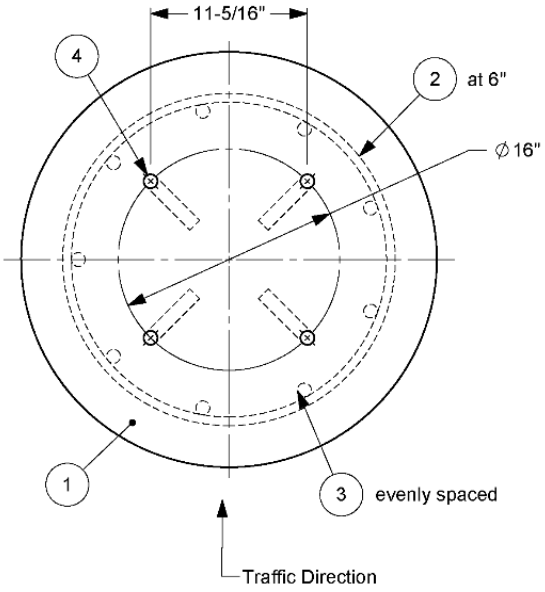

Test Installation
Bolt, 1/2" x 5 1/2" hex
A307
Nut, 1/2 hex
Traffic Direction
Detail A
Scale 1 : 10
Hardware x 2
15' Luminaire Arm
Anchor Bolt
Washer, 1" F436
Nut, 1" hex
Slip Base
Bolt, 1" x 6" hex
ASTM A325
Plate Washer
Nut, 1" heavy hex
Washer, 1" F436
Section B-B
Scale 1 : 10
A
34'-9"
B
B
40' Utah Luminaire Pole
C
Bolt, 1" x 6" hex
ASTM A325
see 1a
Nut, 1" heavy hex
Washer, 1" F436
Plate Washer
Nut, 1" hex
Washer, 1" F436
Keeper Plate
Slip Base
Washer, 1" F436
Nut, 1" hex
Plate Washer
Plate, 2" x 1/2" x 3"
with Ø1 1/16" hole at center
ASTM A36 Steel
Detail C
Scale 1 : 10
1a. Place bolts so that the shank is in contact with slots in the Slip Base. Torque Slip Base Bolts to 80 ft/lbs, release, then tighten to 70 ft/lbs.
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #618911-01-1 Utah 40' Luminaire
2024-03-04
Drawn by GES
Scale 1:75
Sheet 1 of 5 / Test Installation

Isometric View

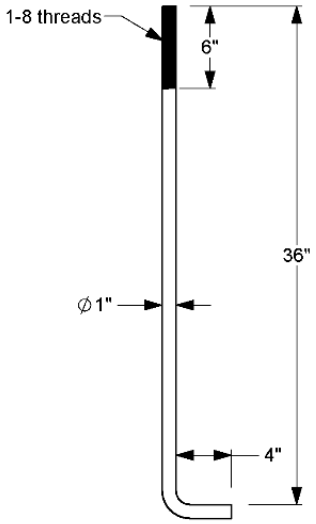


Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #618911-01-1 Utah 40' Luminaire		2024-03-04
Drawn by GES	Scale 1:5	Sheet 2 of 5 / Isometric View

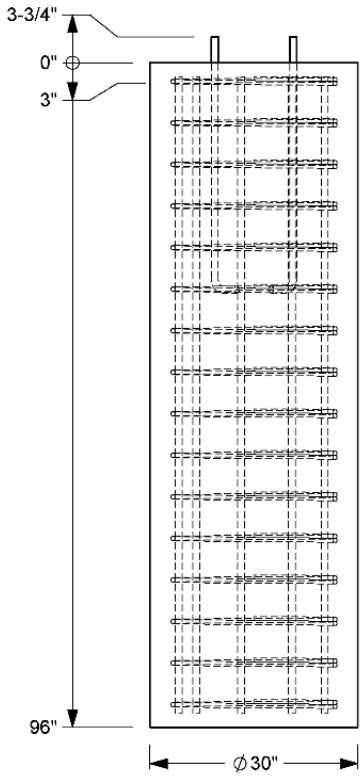
S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-1 (3-60)\Drafting, 618911-01-1\618911-01-1 Drawing



Foundation



Anchor Bolt
ASTM A325



#	Part Name	QTY.
1	4,000 psi Concrete	1
2	Rebar Ring, Ø5/8" x 24" OD	16
3	Rebar, Ø1" x 92"	9
4	Anchor Bolt	4

3a. Rebar is grade 60.

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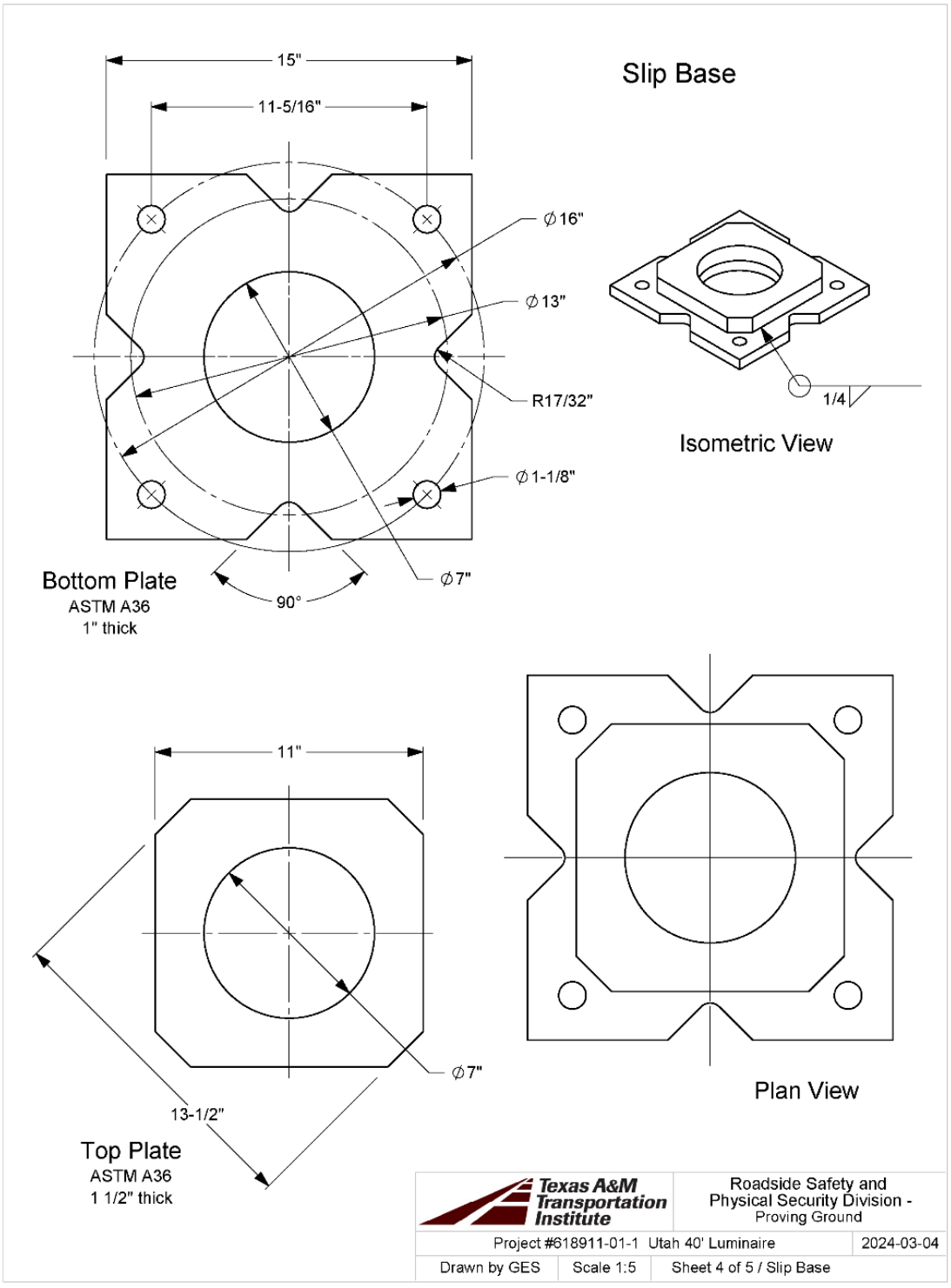
Drawn by GES | Scale 1:20 | Sheet 3 of 5 / Foundation

S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-1 (3-60)\Drafting, 618911-01-1\618911-01-1 Drawing


Slip Base
15"
11-5/16"
Ø16"
Ø13"
R17/32"
Ø1-1/8"
Ø7"
90°
Bottom Plate
ASTM A36
1" thick
1/4
Isometric View
11"
Ø7"
13-1/2"
Top Plate
ASTM A36
1 1/2" thick
Plan View
Texas A&M Transportation Institute
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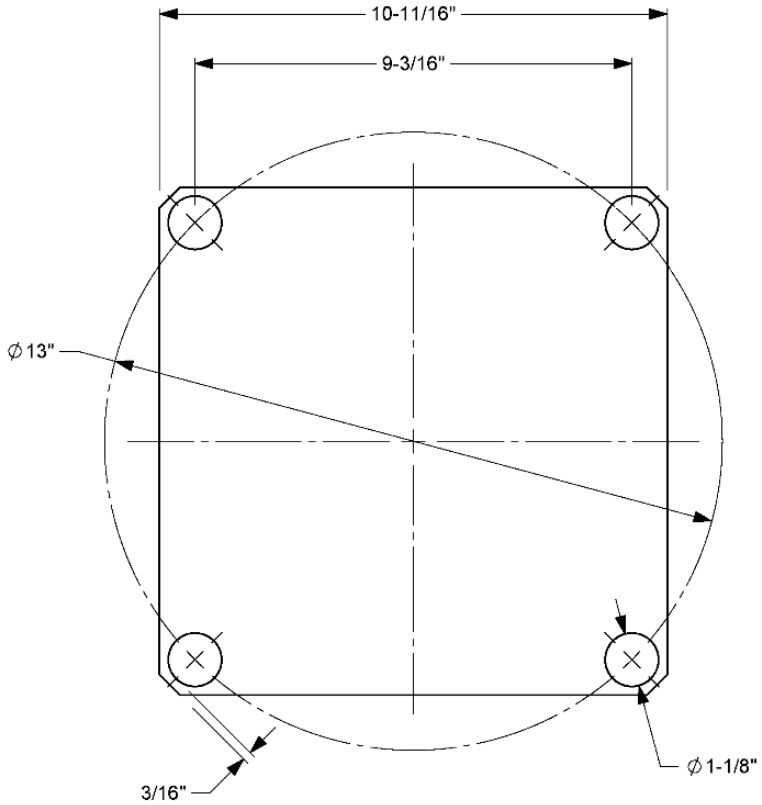
Drawn by GES
Scale 1:5
Sheet 4 of 5 / Slip Base
S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-1 (3-60)\Drafting, 618911-01-1\618911-01-1 Drawing

Keeper Plate

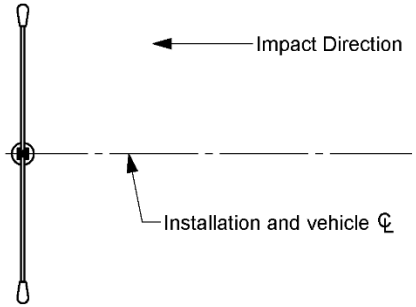
28 gauge stainless steel



Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #618911-01-1 Utah 40' Luminaire		2024-03-04
Drawn by GES	Scale 1:3	Sheet 5 of 5 / Keeper Plate

S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-1 (3-60)\Drafting, 618911-01-1\618911-01-1 Drawing

APPENDIX B. DETAILS FOR TEST 618911-01-2



Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground
Project #618911-01-2	
Drawn by GES	Sheet 1 of 1 Impact

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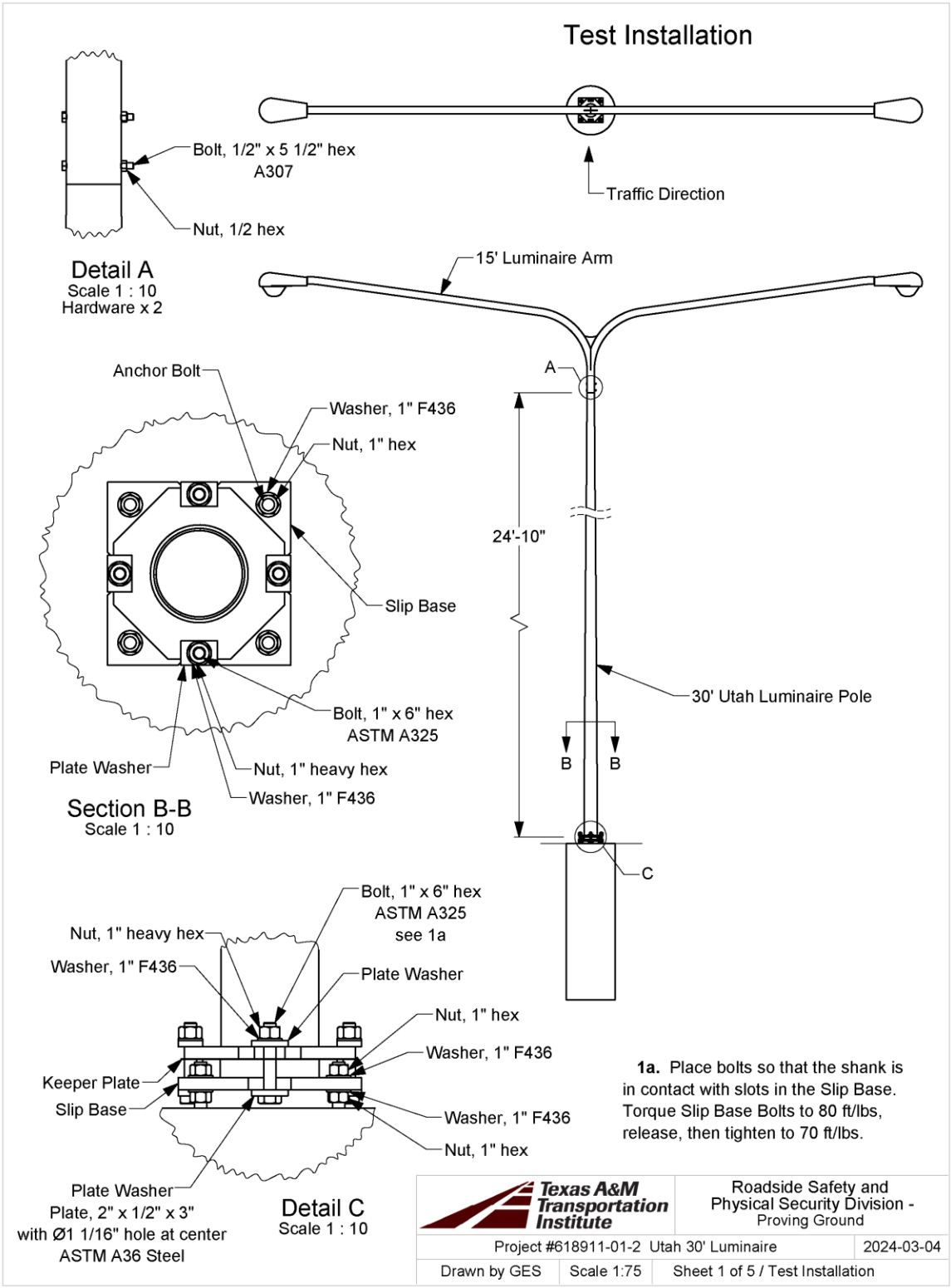
Test Installation
Bolt, 1/2" x 5 1/2" hex
A307
Nut, 1/2 hex
Traffic Direction
Detail A
Scale 1 : 10
Hardware x 2
15' Luminaire Arm
A
Anchor Bolt
Washer, 1" F436
Nut, 1" hex
Slip Base
24'-10"
30' Utah Luminaire Pole
B
B
Bolt, 1" x 6" hex
ASTM A325
Plate Washer
Nut, 1" heavy hex
Washer, 1" F436
Section B-B
Scale 1 : 10
C
Bolt, 1" x 6" hex
ASTM A325
see 1a
Nut, 1" heavy hex
Washer, 1" F436
Plate Washer
Nut, 1" hex
Washer, 1" F436
Keeper Plate
Slip Base
Washer, 1" F436
Nut, 1" hex
Plate Washer
Plate, 2" x 1/2" x 3"
with Ø1 1/16" hole at center
ASTM A36 Steel
Detail C
Scale 1 : 10
1a. Place bolts so that the shank is in contact with slots in the Slip Base. Torque Slip Base Bolts to 80 ft/lbs, release, then tighten to 70 ft/lbs.
Texas A&M Transportation Institute
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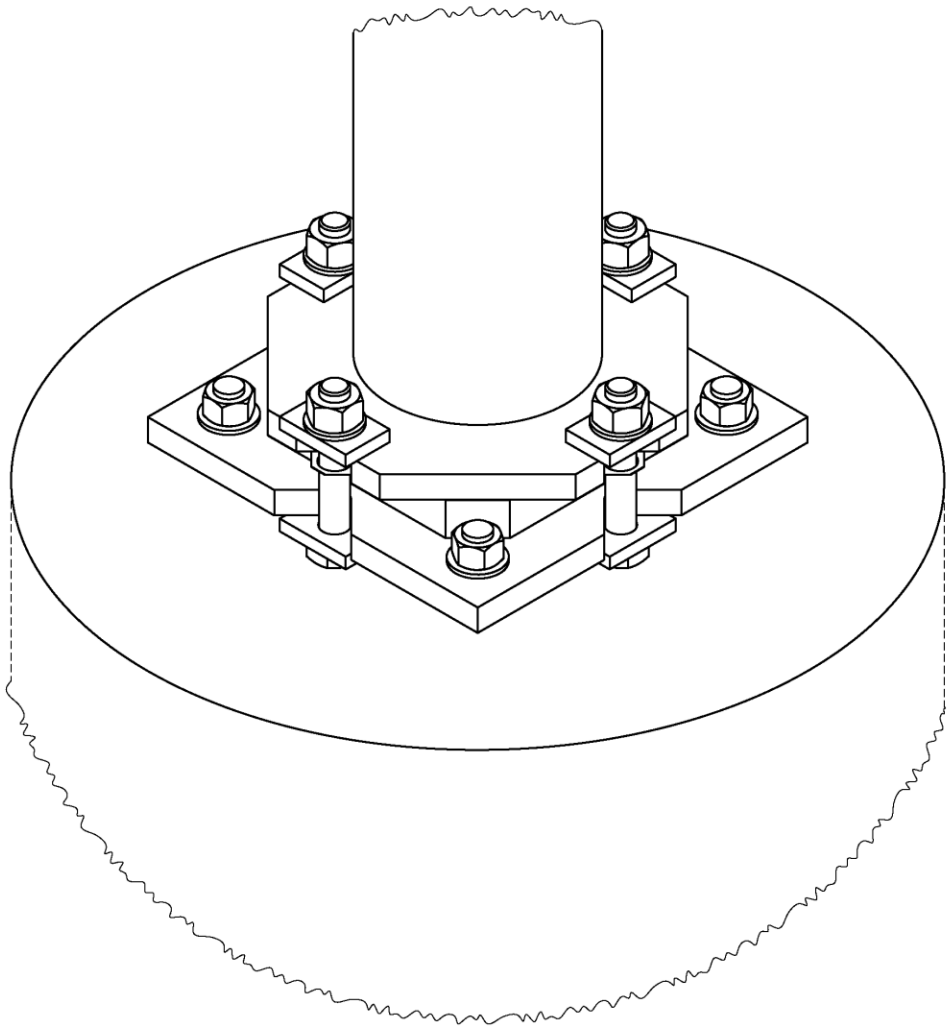
Project #618911-01-2 Utah 30' Luminaire
2024-03-04
Drawn by GES
Scale 1:75
Sheet 1 of 5 / Test Installation
S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-2 (3-60)\Drafting, 618911-01-2\618911-01-2 Drawing

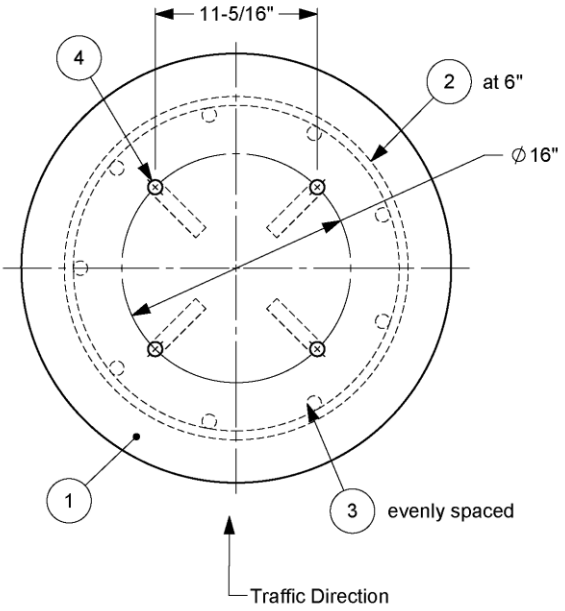
Isometric View

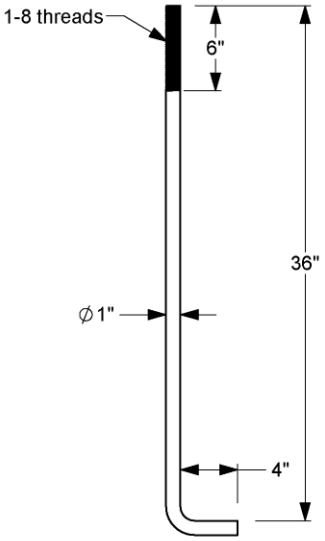


Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #618911-01-2 Utah 30' Luminaire		2024-03-04
Drawn by GES	Scale 1:5	Sheet 2 of 5 / Isometric View

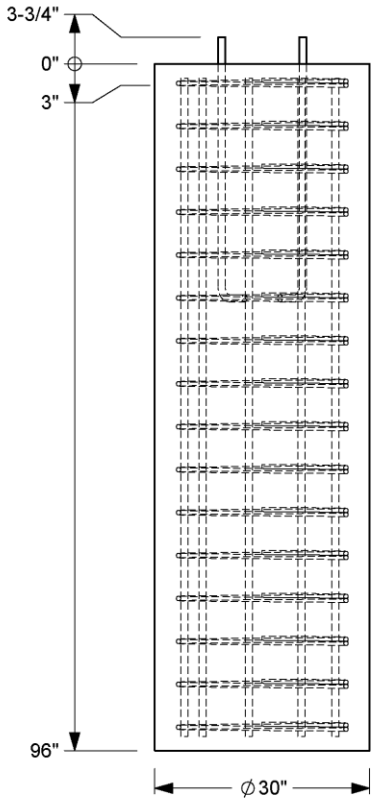
S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-2 (3-60)\Drafting, 618911-01-2\618911-01-2 Drawing

Foundation





Anchor Bolt
ASTM A325



#	Part Name	QTY.
1	4,000 psi Concrete	1
2	Rebar Ring, Ø5/8" x 24" OD	16
3	Rebar, Ø1" x 92"	9
4	Anchor Bolt	4

3a. Rebar is grade 60.

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Roadside Safety and Physical Security Division - Proving Ground

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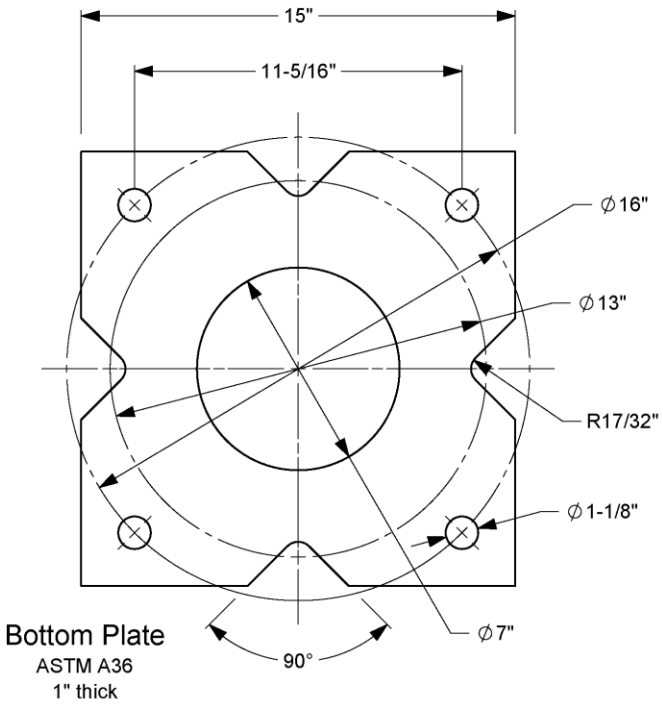
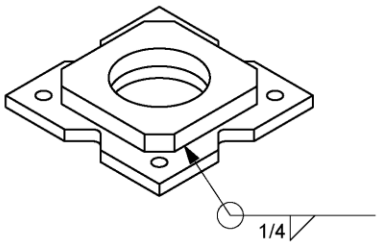
Drawn by GES	Scale 1:20	Sheet 3 of 5 / Foundation

S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-2 (3-60)\Drafting, 618911-01-2\618911-01-2 Drawing

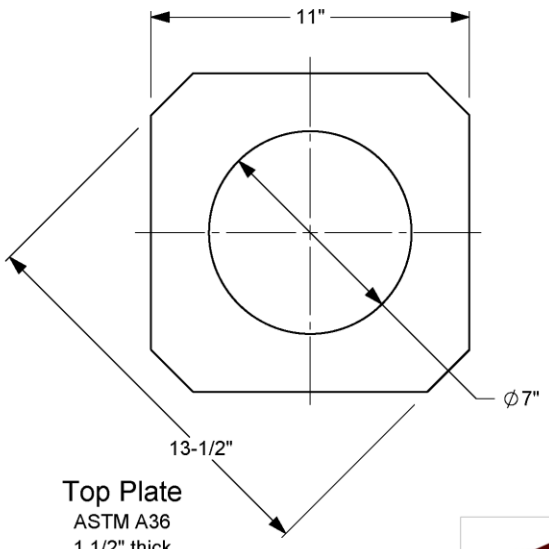


Slip Base

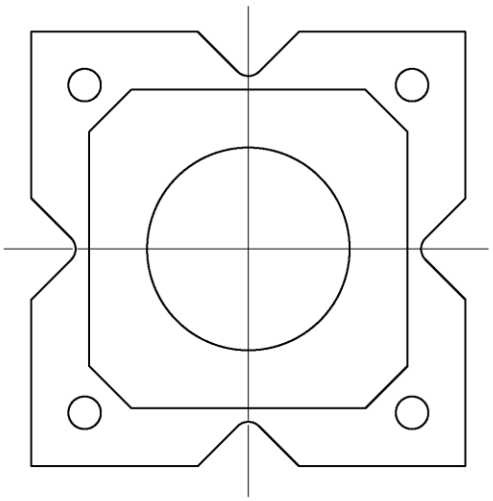


Isometric View

Bottom Plate
ASTM A36
1" thick



Top Plate
ASTM A36
1 1/2" thick



Plan View

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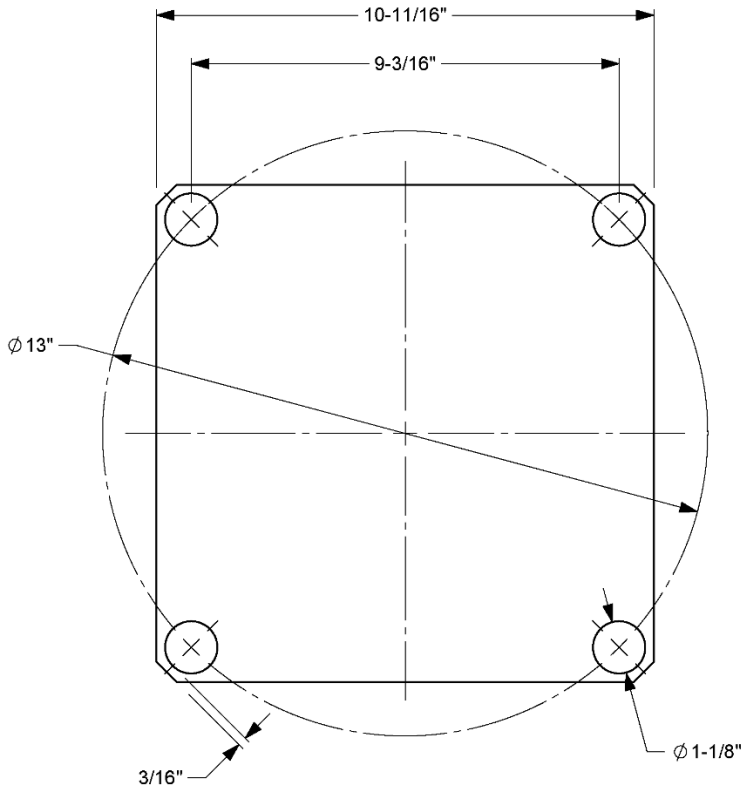
Drawn by GES	Scale 1:5	Sheet 4 of 5 / Slip Base

S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-2 (3-60)\Drafting, 618911-01-2\618911-01-2 Drawing

Keeper Plate

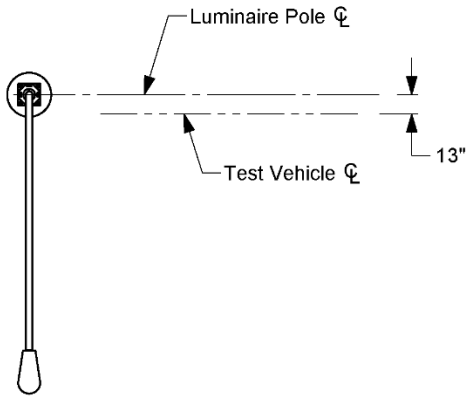
28 gauge stainless steel



Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #618911-01-2 Utah 30' Luminaire		2024-03-04
Drawn by GES	Scale 1:3	Sheet 5 of 5 / Keeper Plate

S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-2 (3-60)\Drafting, 618911-01-2\618911-01-2 Drawing

APPENDIX C. DETAILS FOR TEST 618911-01-3



Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground
Project #618911-01-3	
Drawn by GES	Sheet 1 of 1 Impact

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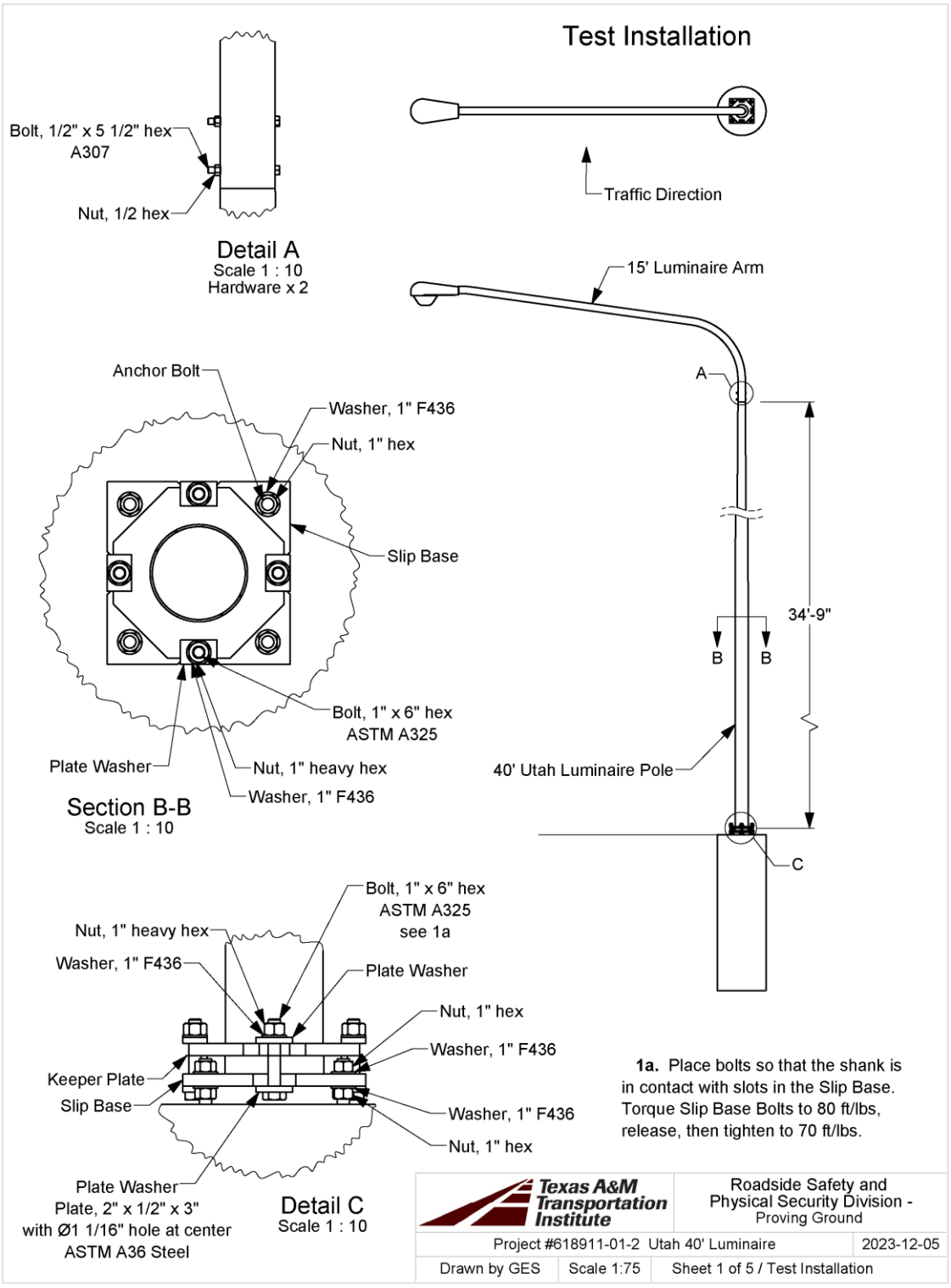
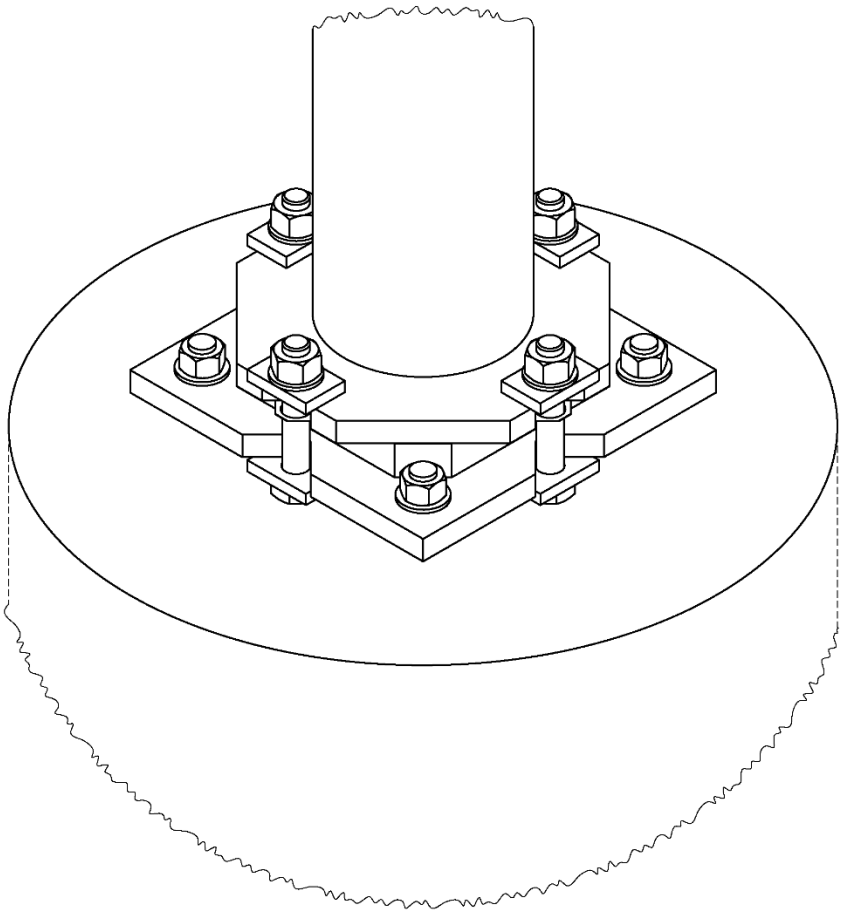

Test Installation
Traffic Direction
Bolt, 1/2" x 5 1/2" hex
A307
Nut, 1/2 hex
Detail A
Scale 1 : 10
Hardware x 2
15' Luminaire Arm
A
34'-9"
B
B
C
40' Utah Luminaire Pole
Anchor Bolt
Washer, 1" F436
Nut, 1" hex
Slip Base
Bolt, 1" x 6" hex
ASTM A325
Plate Washer
Nut, 1" heavy hex
Washer, 1" F436
Section B-B
Scale 1 : 10
Bolt, 1" x 6" hex
ASTM A325
see 1a
Nut, 1" heavy hex
Washer, 1" F436
Plate Washer
Nut, 1" hex
Washer, 1" F436
Keeper Plate
Slip Base
Washer, 1" F436
Nut, 1" hex
Plate Washer
Plate, 2" x 1/2" x 3"
with Ø1 1/16" hole at center
ASTM A36 Steel
Detail C
Scale 1 : 10
1a. Place bolts so that the shank is in contact with slots in the Slip Base. Torque Slip Base Bolts to 80 ft/lbs, release, then tighten to 70 ft/lbs.
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division - Proving Ground
Project #618911-01-2 Utah 40' Luminaire
2023-12-05
Drawn by GES
Scale 1:75
Sheet 1 of 5 / Test Installation
S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-3 (3-60)\Drafting, 618911-01-3\618911-01-3 Drawing

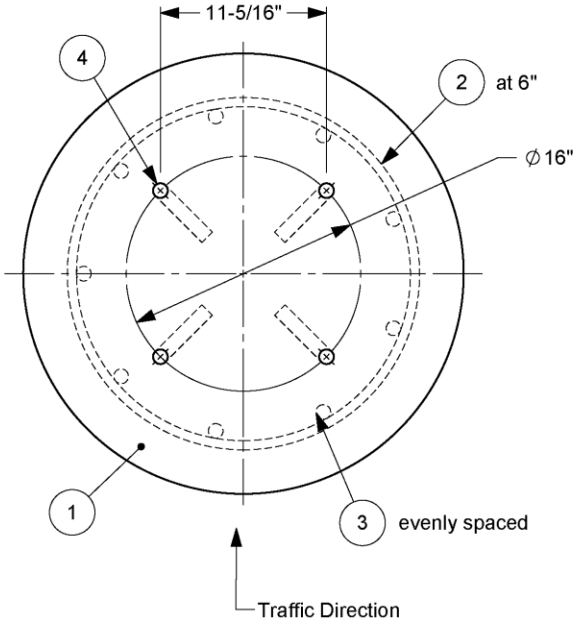
Isometric View

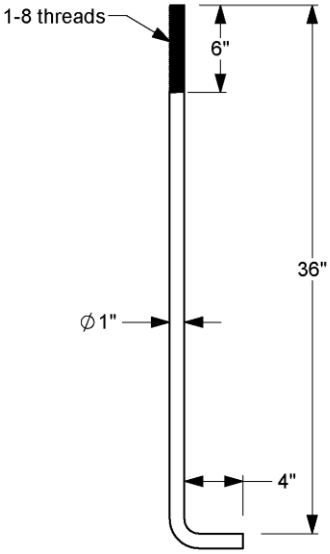


Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #618911-01-2 Utah 40' Luminaire		2023-12-05
Drawn by GES	Scale 1:5	Sheet 2 of 5 / Isometric View

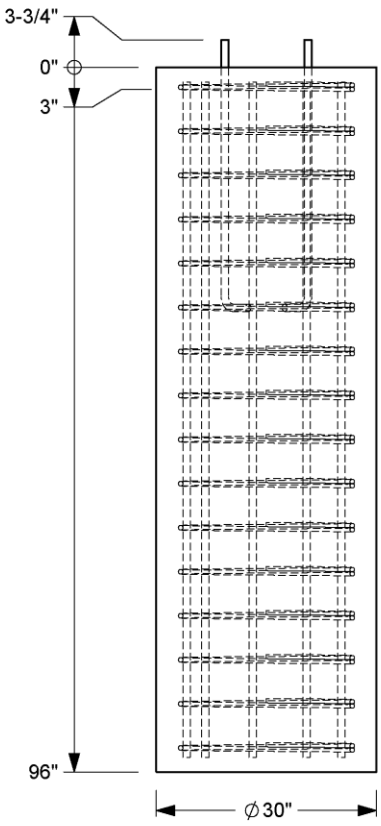
S:\Accreditation-17025-2017\EIR-000 Project Files \618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-3 (3-60)\Drafting, 618911-01-3\618911-01-3 Drawing

Foundation





Anchor Bolt
ASTM A325



#	Part Name	QTY.
1	4,000 psi Concrete	1
2	Rebar Ring, Ø5/8" x 24" OD	16
3	Rebar, Ø1" x 92"	9
4	Anchor Bolt	4

3a. Rebar is grade 60.

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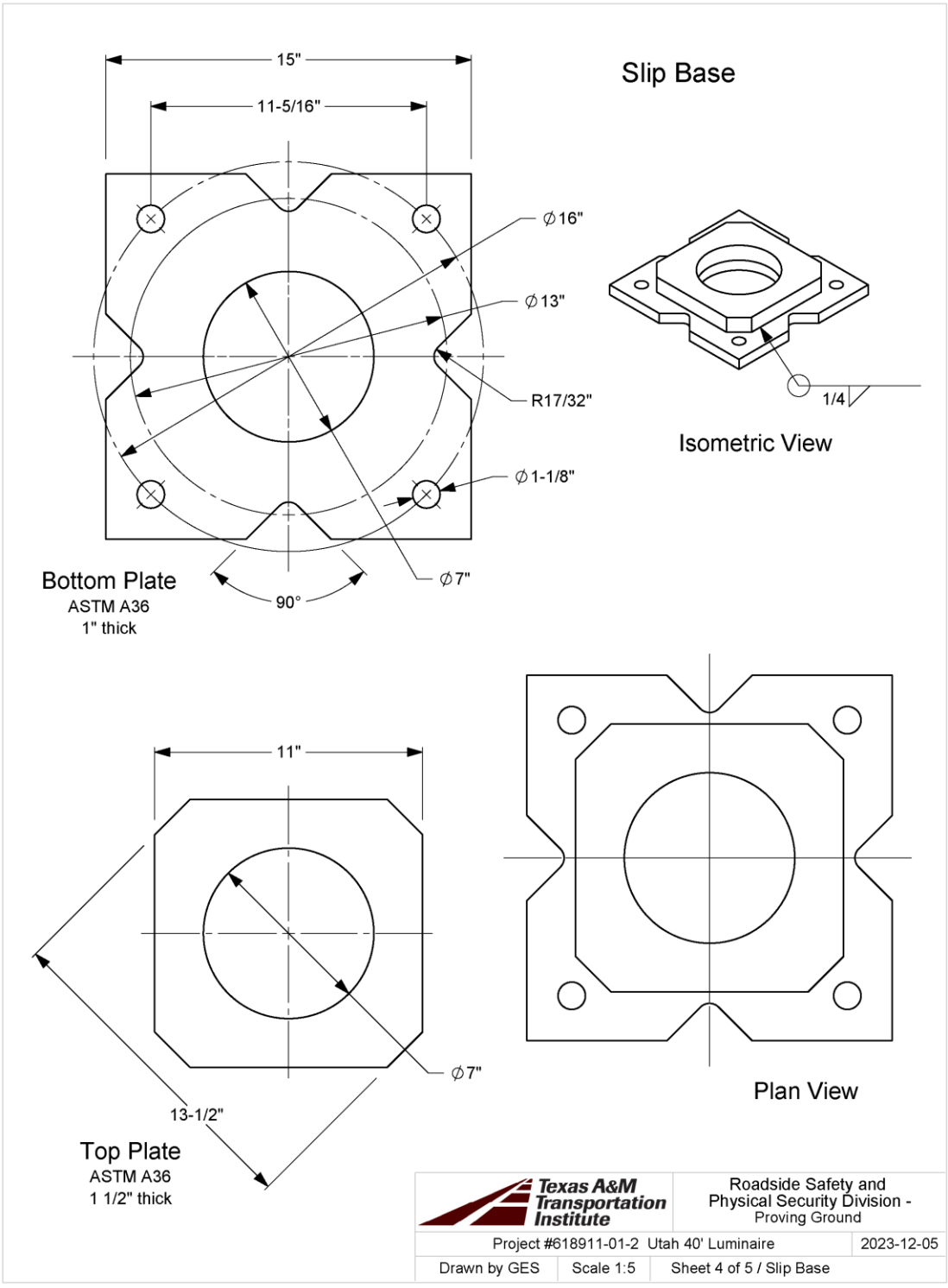
Project #618911-01-2 Utah 40' Luminaire | 2023-12-05

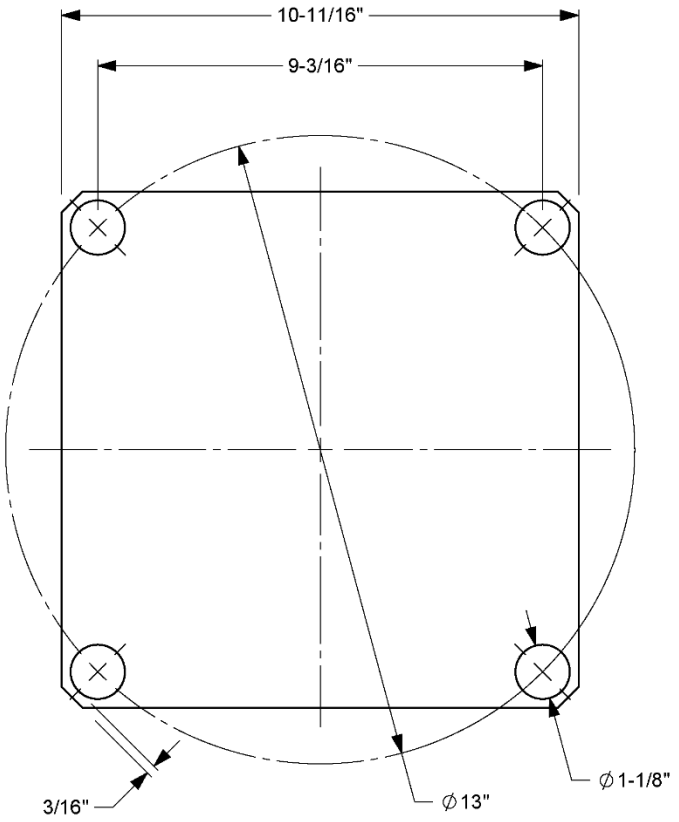
Drawn by GES | Scale 1:20 | Sheet 3 of 5 / Foundation

S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-3 (3-60)\Drafting, 618911-01-3\618911-01-3 Drawing


Slip Base
15"
11-5/16"
Ø16"
Ø13"
R17/32"
Ø1-1/8"
Ø7"
90°
Bottom Plate
ASTM A36
1" thick
1/4
Isometric View
11"
Ø7"
13-1/2"
Top Plate
ASTM A36
1 1/2" thick
Plan View
Texas A&M Transportation Institute
Roadside Safety and Physical Security Division -
Proving Ground
Project #618911-01-2 Utah 40' Luminaire
2023-12-05
Drawn by GES
Scale 1:5
Sheet 4 of 5 / Slip Base
S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-3 (3-60)\Drafting, 618911-01-3\618911-01-3 Drawing

Keeper Plate

28 gauge stainless steel



Texas A&M Transportation Institute	Roadside Safety and Physical Security Division - Proving Ground	
Project #618911-01-2 Utah 40' Luminaire		2023-12-05
Drawn by GES	Scale 1:3	Sheet 5 of 5 / Keeper Plate

S:\Accreditation-17025-2017\EIR-000 Project Files\618911-4 Bolt Slip Base for Luminaire-Kovar\618911-01-3 (3-60)\Drafting, 618911-01-3\618911-01-3 Drawing

APPENDIX D. SUPPORTING CERTIFICATION DOCUMENTS

CONCRETE COMPRESSIVE STRENGTH TEST REPORT

Report Number: A1171057.0287
Service Date: 01/11/24
Report Date: 02/08/24
Task: PO# 618911-01

Terracon
6198 Imperial Loop
College Station, TX 77845-5765
979-846-3767 Reg No: F-3272

Client
Texas Transportation Institute
Attn: Bill Griffith
TTI Business Office
3135 TAMU
College Station, TX 77843-3135

Project
Riverside Campus
Riverside Campus
Bryan, TX

Project Number: A1171057

Material Information
Specified Strength: 4,000 psi @ 28 days

Mix ID: BCSN40500
Supplier: Texcrete
Batch Time: 1043 **Plant:**
Truck No.: **Ticket No.:** 87307

Sample Information
Sample Date: 01/11/24 **Sample Time:** 1115
Sampled By: Devin Bennett
Weather Conditions: Cloudy strong wind
Accumulative Yards: 10 **Batch Size (cy):** 10
Placement Method: Chute
Water Added Before (gal): 0
Water Added After (gal): 0
Sample Location: Piers
Placement Location: Piers
Sample Description: 6-inch diameter cylinders

Field Test Data

Test	Result	Specification
Slump (in):	5	
Air Content (%):	3.2	
Concrete Temp. (F):	70	
Ambient Temp. (F):	64	
Plastic Unit Wt. (pcf):	154.8	
Yield (Cu. Yds.):		

Laboratory Test Data

Set No.	Spec ID	Cyl. Cond.	Avg Diam. (in)	Area (sq in)	Date Received	Date Tested	Age at Test (days)	Max Load (lbs)	Comp Strength (psi)	Frac Type	Tested By
1	A	Good	6.00	28.27		02/07/24	27 F	123,840	4,380	1	DD
1	B	Good	6.00	28.27		02/07/24	27 F	122,390	4,330	2	DD
1	C	Good	6.00	28.27		02/07/24	27 F	114,720	4,060	2	DD
1	D						Hold				

Initial Cure: Outside Plastic Lids **Final Cure:** Field Cured

Comments: **F = Field Cured**
Note: Reported air content does not include Aggregate Correction Factor (ACF).

Samples Made By: Terracon
Services: Obtain samples of fresh concrete at the placement locations (ASTM C 172), perform required field tests and cast, cure, and test compressive strength samples (ASTM C 31, C 39, C 1231).

Terracon Rep.: Devin Bennett **Start/Stop:** 1030-1230
Reported To: Will w/ TTI
Contractor:
Report Distribution:
(1) Texas Transportation Institute, Bill Griffith (1) Texas Transportation Institute, Adam Mayer

Reviewed By: Alexander Dunigan, P.E.
Project Manager

Test Methods: ASTM C 31, ASTM C143, ASTM C231, ASTM C1064

Photo Log

Report Number:	A1171057.0287
Service Date:	01/11/24
Report Date:	02/08/24
Task:	PO# 618911-01

Terracon
6198 Imperial Loop
College Station, TX 77845-5765
979-846-3767 Reg No: F-3272

(P1) The piers that were poured

TEXCRETE
Redi-mix Concrete Company

183751

REMIT PAYMENT TO:
P.O. BOX138
KURTEN, TX 77862

5222 Sandy Point RD.
Bryan, TX 77807

18935 Circle Lake Dr.
Pinehurst, TX 77362

17534 SH 6 South
College Station, TX 77845

2687 HWY 105
Montgomery, TX 77333

BCS DISPATCH - 979-316-2906
PINEHURST DISPATCH - 936-232-5815
OFFICE - 979-985-3636

TEXAS A&M TRANSPORTATIO
RELLIS CAMPUS, BRYAN TX

RT 2818, RT HWY 21, LT SILVER HILL, RT AT THE "T", RT HWY 47, LT INTORELLIS ENTRANCE, STAY STRAIGHTALL THE WAY DOWN TO THE GATE

TIME	FORMULA	LOAD SIZE	YARD ORDERED		DRIVER/TRUCK		PLANT TRANSACTION#
10:43	BCSN40500	5.00	5.00	PO#	CASTILLO, JUL8		89112
DATE		**LOAD#**	**YARDS DEL.**	**BATCH#**	**WATER TRIM**	**SLUMP**	**TICKET NUMBER**
1/11/24	PROJECT TTIRELL	5.00	5.00			5.00 in	87307

QUANTITY	CODE	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
5.00 yd	BCSN40500	MUN, 4000, BLND, 5"		
1.00 ea	FUEL	Fuel Charge		

Thank you for your business

LEFT PLANT	ARRIVED JOB	START UNLOADING	SLUMP	CONCRETE TEMP.	AIR TEMP
10:52	11:37				
FINISH UNLOADING	**LEFT JOB**	**ARRIVED AT PLANT**	**ON SITE TESTING**		
			TESTING LAB: TERRACON GESSNER CME OTHER		
TESTED			**AIR**	**CYLINDERS**	
☐ YES ☐ NO					

Tax
Prev. AMT
Ticket Total

ADDITIONAL CHARGE 1 _____

ADDITIONAL CHARGE 2 _____

GRAND TOTAL

WARNING
IRRITATING TO THE SKIN AND EYES

Contains Portland Cement, Wear Rubber Boots and Gloves. PROLONGED CONTACT MAY CAUSE BURNS. Avoid Contact With Eyes and Prolonged Contact with Skin. In Case of Contact with Skin or Eyes, Rinse Thoroughly With Water. If Irritation Persists. Get Medical Attention. **KEEP CHILDREN AWAY.**

CONCRETE is a PERISHABLE COMMODITY and BECOMES THE PROPERTY of the PURCHASER UPON LEAVING the PLANT. ANY CHANGES or CANCELLATION of ORIGINAL INSTRUCTIONS MUST be TELEPHONED to the OFFICE BEFORE LOADING starts. The undersigned promises to pay all costs, including reasonable attorney's fees. incurred in collecting any sums owed.

All accounts not paid within 30 days of delivery will bear interest at the rate of 18% per annum. Not Responsible For Reactive Aggregate or Color Quality. No Claim Allowed Unless Made at Time Material is Delivered.
A $25.00 Service Charge and Loss of the Cash Discounted will be Collected on all Returned Checks. Demerge charge after 90 min. will be $100.00/hr.

PROPERTY DAMAGE RELEASE
(TO BE SIGNED IF DELIVERY TO BE MADE INSIDE CURB LINE)

Dear Customer - The driver of this truck in presenting this RELEASE to you for your signature is of the opinion that the size and weight of this truck may possibly cause damage to the premises and/or adjacent property if he places the material in this load where you desire it. It is our wish to help you in everyway that we can, but in order to do this the driver is requesting that you sign this RELEASEreleving him and this supplier from any responsibility from damage that may occur to the premises and or adjacent property, buildings, sidewalks, driveways, curbs, etc. by the delivery of this material and that you also agree to help him remove mud from the wheels of his vehicle so that he will not liter the public streets. Further as additional consideration; the undersigned agrees to indemnify and hold harmless the driver of this truck and this supplier for any and all damage to the premises and /or adjacent property which may be claimed by anyone to have arisen out of delivery of this order SIGNED:

X _____

Excessive Water is Detrimental to Concrete Performance.
H_2O Added by Request/Authorized By:

_____ GAL X _____
WEIGHMASTER

Surcharge for credit cards

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE HEALTH WARNING NOTICE AND SUPPLIER WILL NOT BE RESPONSIBLE FOR ANY DAMAGE CAUSED WHEN DELIVERING INSIDE CURB LINE.

LOAD RECEIVED BY

x _____

183751

CMC STEEL TEXAS
1 STEEL MILL DRIVE
SEGUIN TX 78155-7510

CERTIFIED MILL TEST REPORT

For additional copies call
800-227-6489

We hereby certify that the test results presented here are accurate and conform to the reported grade specification

Drew M Fischer
Quality Assurance Manager

HEAT NO.:3125293 SECTION: REBAR 16MM (#5) 20'0" 420/60 GRADE: ASTM A615-22 Gr 420/60 ROLL DATE: 12/08/2023 MELT DATE: 09/05/2023 Cert. No.: 85640145 / 125293A371	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 85640145 BOL#: 75713568 CUST PO#: 968874 CUST P/N: DLVRY LBS / HEAT: 48072.000 LB DLVRY PCS / HEAT: 2304 EA

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.45%				
Mn	1.03%				
P	0.010%				
S	0.046%				
Si	0.15%				
Cu	0.36%				
Cr	0.05%				
Ni	0.10%				
Mo	0.026%				
V	0.000%				
Cb	0.000%				
Sn	0.011%				
Al	0.001%				

The Following is true of the material represented by this MTR:

*Material is fully killed and is Hot Rolled Steel
*100% melted, rolled, and manufactured in the USA
*EN10204 2004 3.1 compliant
*Contains no weld repair
*Contains no Mercury contamination
*Manufactured in accordance with the latest version of the plant quality manual
*Meets the "Buy America" requirements of 23 CFR635.410, 49 CFR 661
*Warning: This product can expose you to chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov

REMARKS :

CMC STEEL TEXAS
1 STEEL MILL DRIVE
SEGUIN TX 78155-7510

CERTIFIED MILL TEST REPORT

For additional copies call
800-227-6489

We hereby certify that the test results presented here are accurate and conform to the reported grade specification

Drew M Fischer
Quality Assurance Manager

HEAT NO.:3125060 SECTION: REBAR 25MM (#8) 20'0" 420/60 GRADE: ASTM A615-22 Gr 420/60 ROLL DATE: 09/04/2023 MELT DATE: 08/27/2023 Cert. No.: 85538039 / 125060A041	SOLD TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	SHIP TO	CMC Construction Svcs College Stati 10650 State Hwy 30 College Station TX US 77845-7950 979 774 5900	Delivery#: 85538039 BOL#: 75548405 CUST PO#: 960186 CUST P/N: DLVRY LBS / HEAT: 46667.000 LB DLVRY PCS / HEAT: 874 EA

Characteristic	Value	Characteristic	Value	Characteristic	Value
C	0.43%	Bend Test Diameter	5.000IN		
Mn	1.09%				
P	0.007%				
S	0.050%				
Si	0.23%				
Cu	0.31%				
Cr	0.07%				
Ni	0.14%				
Mo	0.053%				
V	0.000%				
Cb	0.000%				
Sn	0.010%				
Al	0.001%				
Yield Strength test 1	64.4ksi				
Tensile Strength test 1	106.8ksi				
Elongation test 1	13%				
Elongation Gage Lgth test 1	8IN				
Tensile to Yield ratio test1	1.66				
Bend Test 1	Passed				

The Following is true of the material represented by this MTR:

**Material is fully killed and is Hot Rolled Steel*
**100% melted, rolled, and manufactured in the USA*
**EN10204:2004 3.1 compliant*
**Contains no weld repair*
**Contains no Mercury contamination*
**Manufactured in accordance with the latest version of the plant quality manual*
**Meets the "Buy America" requirements of 23 CFR635.410, 49 CFR 661*
**Warning: This product can expose you to chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov*

REMARKS :

APPENDIX E. *MASH* TEST 3-60 (CRASH TEST 618911-01-1)

E.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2024-02-09 Test No.: 618911-01-1 VIN No.: 3N1CN7AP5JL863497

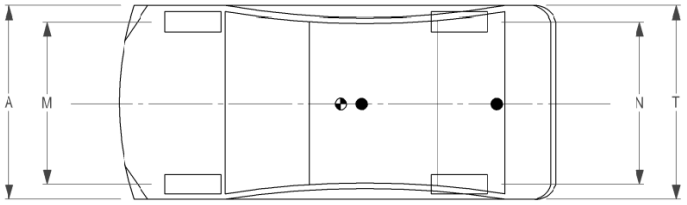
Year: 2018 Make: Nissan Model: Versa

Tire Inflation Pressure: 36 PSI Odometer: 84158 Tire Size: P185/65R15

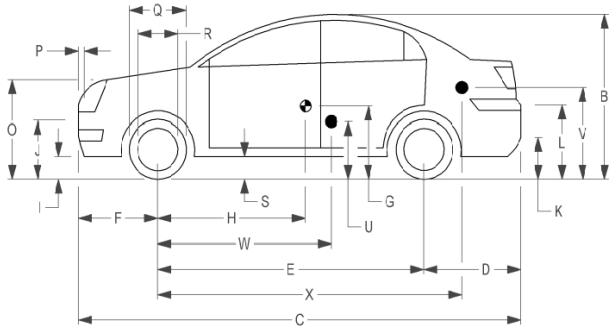
Describe any damage to the vehicle prior to test: None

● Denotes accelerometer location.

NOTES: None



Engine Type: 4 CYL
Engine CID: 1.6 L
Transmission Type:
☑ Auto or ☐ Manual
☑ FWD ☐ RWD ☐ 4WD
Optional Equipment:
None



Dummy Data:
Type: 50th Percentile Male
Mass: 165 lb
Seat Position: PASSENGER SIDE

Geometry: inches

A	66.70	F	32.50	K	12.50	P	4.50	U	15.50
B	59.60	G	0.00	L	26.00	Q	24.00	V	21.25
C	175.40	H	41.32	M	58.30	R	16.25	W	41.00
D	40.50	I	7.00	N	58.50	S	7.50	X	79.75
E	102.40	J	22.50	O	30.50	T	64.50		
	Wheel Center Ht Front	11.50		Wheel Center Ht Rear	11.50			W-H	-0.32

RANGE LIMIT: A = 65 ±3 inches; C = 169 ±8 inches; E = 98 ±5 inches; F = 35 ±4 inches; H = 39 ±4 inches; O (Top of Radiator Support) = 28 ±4 inches
(M+N)/2 = 59 ±2 inches; W-H < 2 inches or use MASH Paragraph A4.3.2

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	1750	M_{front}	1444	1457	1542
Back	1687	M_{rear}	948	986	1066
Total	3389	M_{Total}	2392	2443	2608

Allowable TIM = 2420 lb ±55 lb | Allowable GSM = 2585 lb ± 55 lb

Mass Distribution:
lb LF: 762 RF: 695 LR: 488 RR: 498

Figure C.1. Vehicle Properties for Test 618911-01-1.

Date: 2024-02-09 Test No.: 618911-01-1 VIN No.: 3N1CN7AP5JL863497

Year: 2018 Make: Nissan Model: Versa

VEHICLE CRUSH MEASUREMENT SHEET[1]

Complete When Applicable	
End Damage	Side Damage
Undeformed end width _____	Bowing: B1 _____ X1 _____
Corner shift: A1 _____	B2 _____ X2 _____
A2 _____	
End shift at frame (CDC)	Bowing constant
(check one)	$\frac{X1+X2}{2}$ = _____
< 4 inches _____	
≥ 4 inches _____	

Note: Measure C_1 to C_6 from Driver to Passenger Side in Front or Rear Impacts – Rear to Front in Side Impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max*** Crush								
1	AT FRONT BUMPER	18	12	0	-	-	-	-	-	-	0
2	AT FNT BUMPER	36	8	0	-	-	-	-	-	-	0
	Measurements recorded										
	☑ **inches or** ☐ **mm**										

[1]Table taken from National Accident Sampling System (NASS).

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

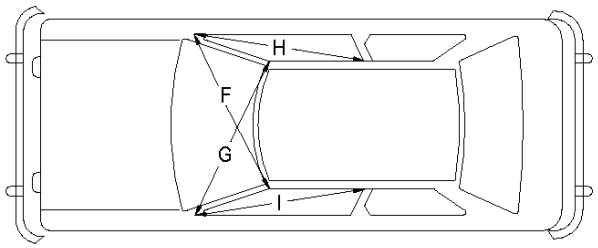
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

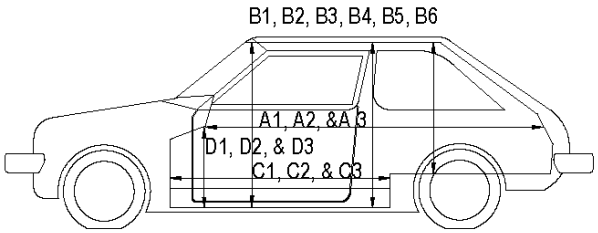
***Measure and document on the vehicle diagram the location of the maximum crush.

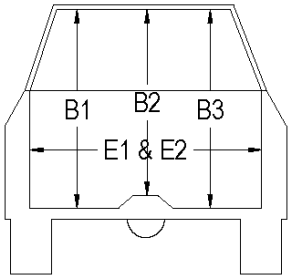
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure C.2. Exterior Crush Measurements for Test 618911-01-1.

Date:	2024-02-09	Test No.:	618911-01-1	VIN No.:	3N1CN7AP5JL863497
Year:	2018	Make:	Nissan	Model:	Versa







OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	67.50	67.50	0.00
A2	67.25	67.25	0.00
A3	67.75	67.75	0.00
B1	40.50	40.50	0.00
B2	39.00	34.25	-4.75
B3	40.50	40.50	0.00
B4	36.25	35.25	-1.00
B5	36.00	29.75	-6.25
B6	36.25	35.25	-1.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	9.50	9.50	0.00
D2	0.00	0.00	0.00
D3	9.50	9.50	0.00
E1	51.50	51.50	0.00
E2	51.00	51.00	0.00
F	51.00	51.00	0.00
G	51.00	51.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	51.00	51.00	0.00

*Lateral area across the cab from driver's side kick panel to passenger's side kick panel.

Figure C.3. Occupant Compartment Measurements for Test 618911-01-1.

E.2. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.275 s

(c) 0.550 s (d) 0.825 s

(e) 0.1.100 s (f) 1.375 s

(g) 1.650 s (h) 1.925 s

Figure C.5. Sequential Photographs for Test 618911-01-1 (Frontal Views).

(a) 0.000 s (b) 0.275 s

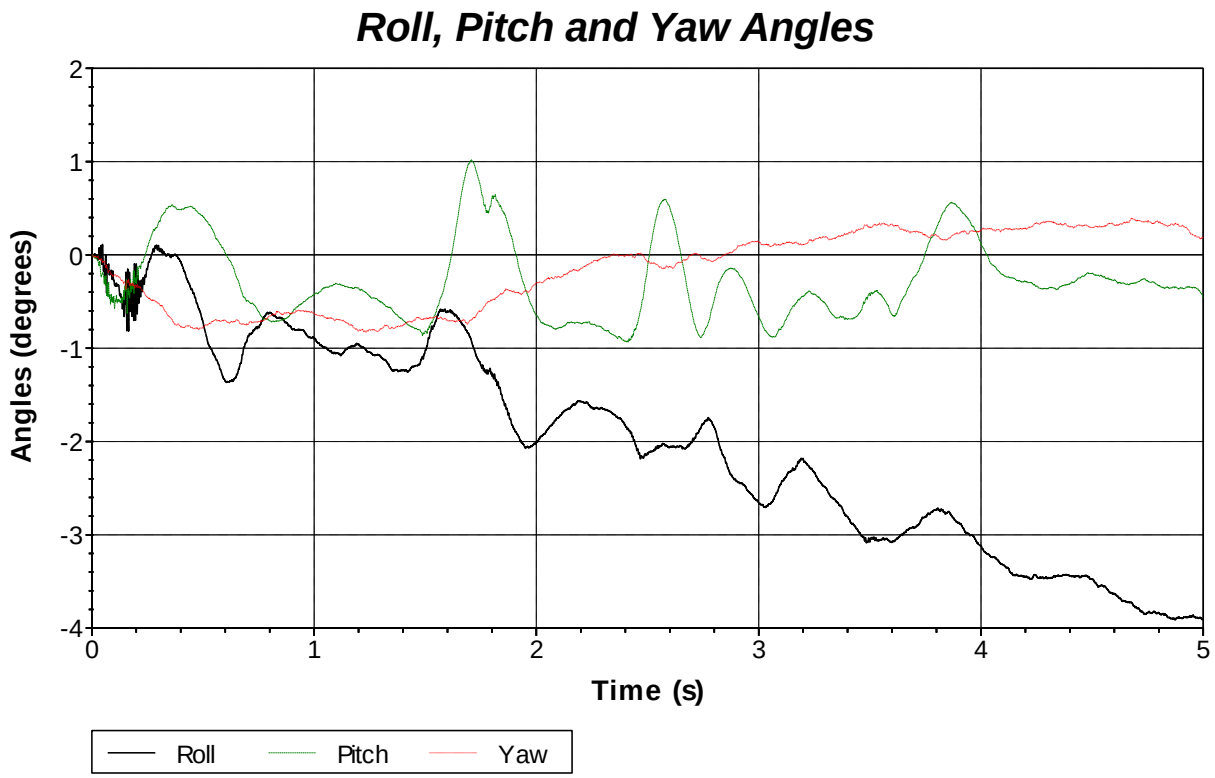
(c) 0.550 s (d) 0.825 s

(e) 0.1.100 s (f) 1.375 s

(g) 1.650 s (h) 1.925 s

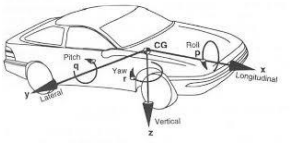
Figure C.6. Sequential Photographs for Test 618911-01-1 (Perpendicular Views).

E.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

1. Yaw.
2. Pitch.
3. Roll.



Test Number: 618911-01-1
Test Standard Test Number: *MASH* Test 3-60
Test Article: Four Bolt Slip Base Support for Luminaire Poles
Test Vehicle: 2018 Nissan Versa
Inertial Mass: 2443 lbs
Gross Mass: 2608 lbs
Impact Speed: 19.1 mi/h
Impact Angle: 0°

Figure C.7. Vehicle Angular Displacements for Test 618911-01-1.

E.4. VEHICLE ACCELERATIONS

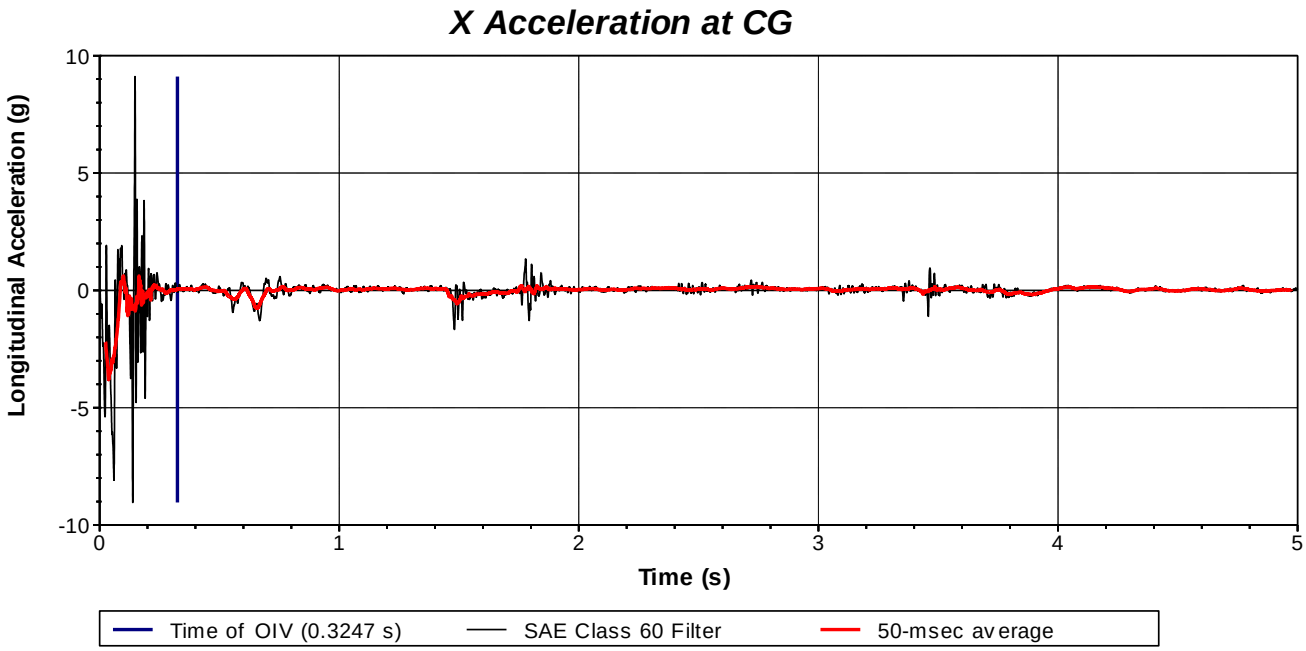


Figure C.8. Vehicle Longitudinal Accelerometer Trace for Test 618911-01-1 (Accelerometer Located at Center of Gravity).

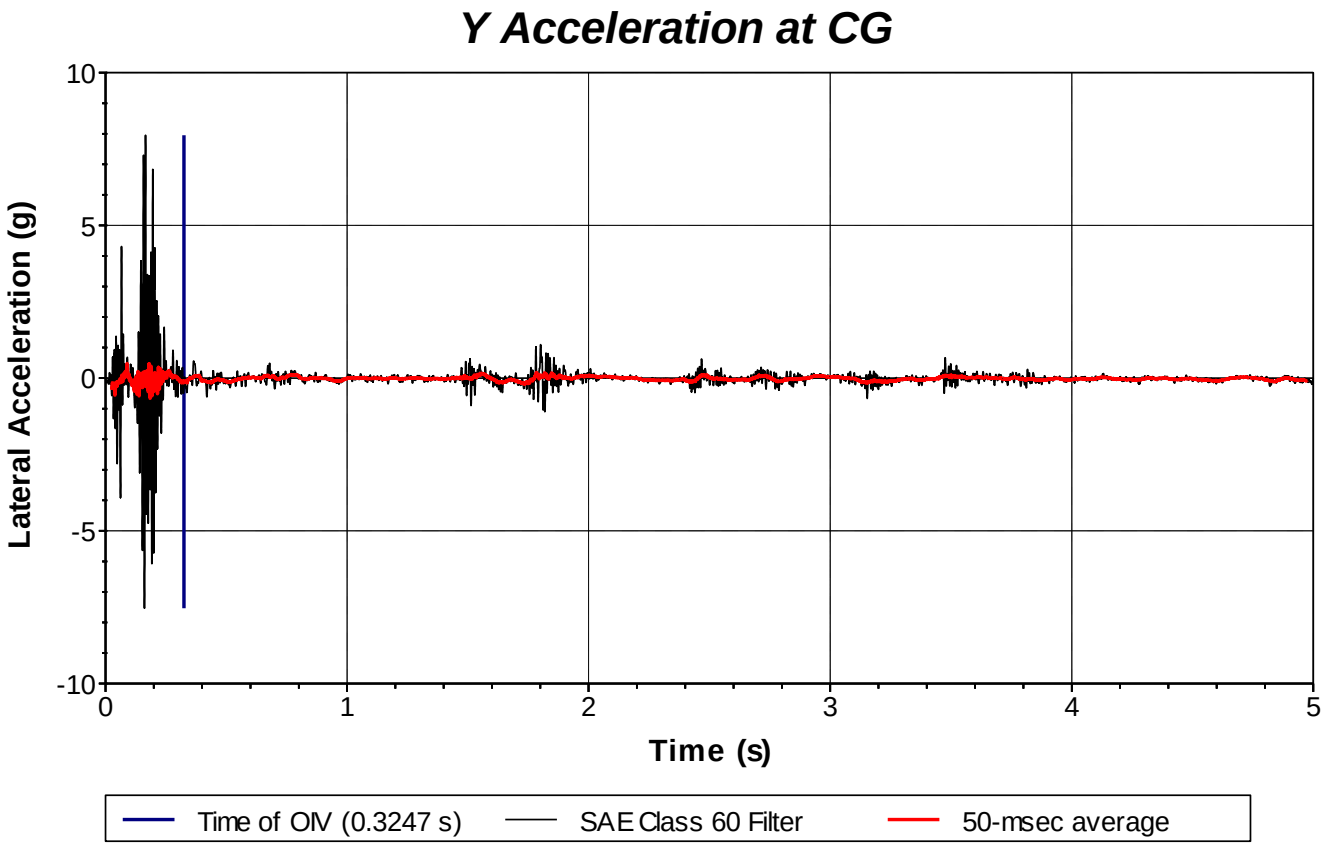


Figure C.9. Vehicle Lateral Accelerometer Trace for Test 618911-01-1 (Accelerometer Located at Center of Gravity).

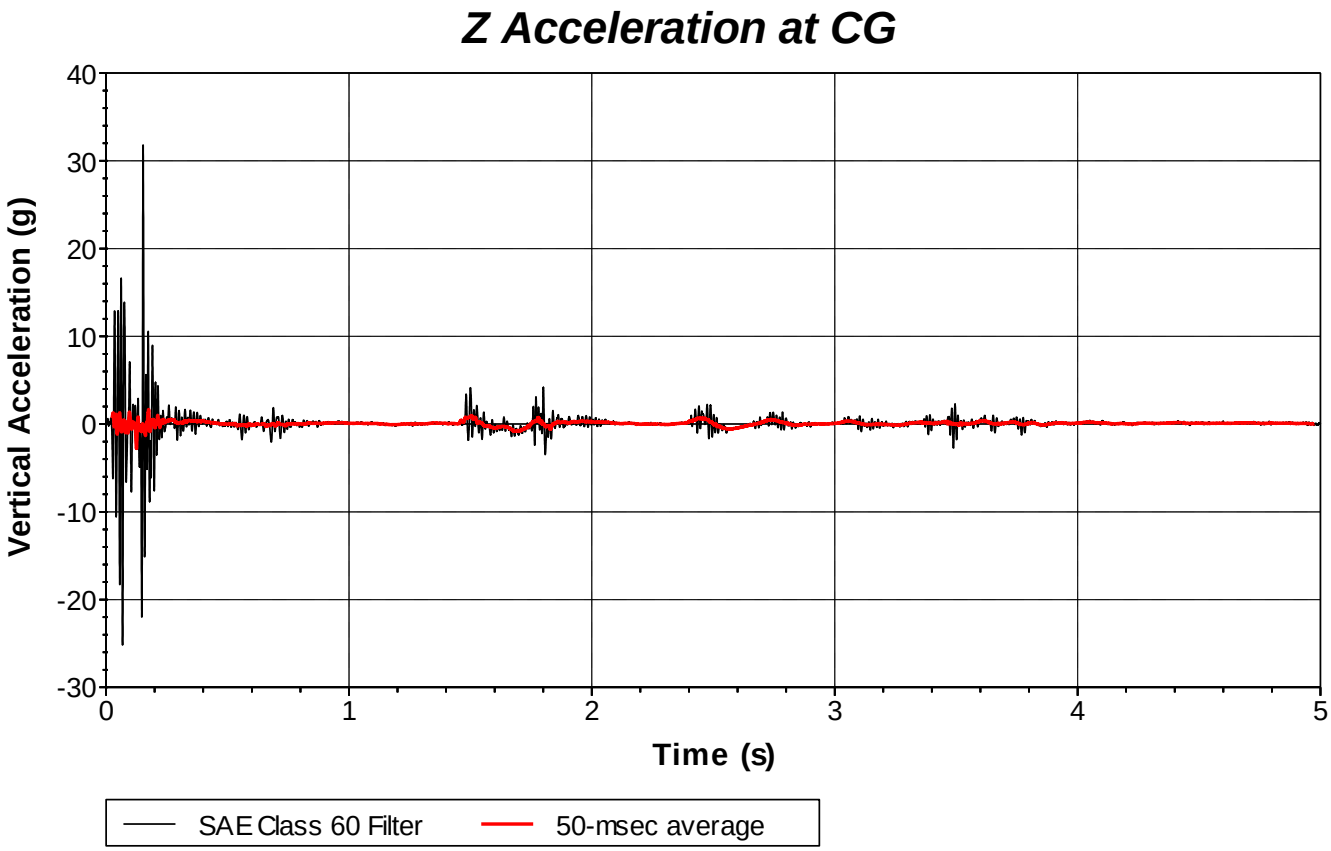


Figure C.10. Vehicle Vertical Accelerometer Trace for Test 618911-01-1 (Accelerometer Located at Center of Gravity).

APPENDIX F. *MASH* TEST 3-60 (CRASH TEST 618911-01-2)

F.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2024-02-09 Test No.: 618911-01-2 VIN No.: 3N1CN7AP2KL875916

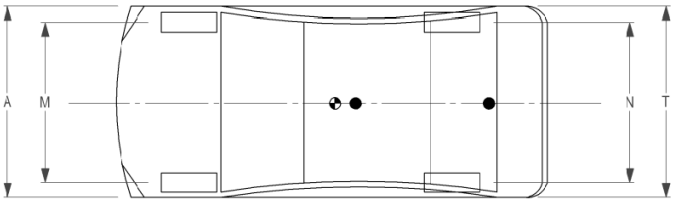
Year: 2019 Make: Nissan Model: Versa

Tire Inflation Pressure: 36 PSI Odometer: 73361 Tire Size: P185/65R15

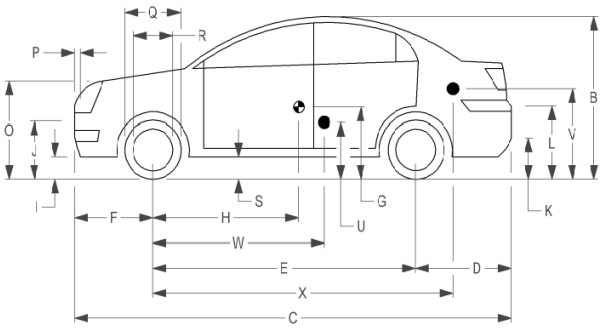
Describe any damage to the vehicle prior to test: None

● Denotes accelerometer location.

NOTES: None



Engine Type: 4 CYL
Engine CID: 1.6 L
Transmission Type:
☑ Auto or ☐ Manual
☑ FWD ☐ RWD ☐ 4WD
Optional Equipment:
None



Dummy Data:
Type: 50th Percentile Male
Mass: 165 lb
Seat Position: PASSENGER SIDE

Geometry: inches

A	66.70	F	32.50	K	12.50	P	4.50	U	15.50
B	59.60	G	0.00	L	26.00	Q	24.00	V	21.25
C	175.40	H	41.00	M	58.30	R	16.25	W	41.00
D	40.50	I	7.00	N	58.50	S	7.50	X	79.75
E	102.40	J	22.50	O	30.50	T	64.50		
Wheel Center Ht Front	11.50			Wheel Center Ht Rear	11.50			W-H	0.00

RANGE LIMIT: A = 65 ±3 inches; C = 169 ±8 inches; E = 98 ±5 inches; F = 35 ±4 inches; H = 39 ±4 inches; O (Top of Radiator Support) = 28 ±4 inches
(M+N)/2 = 59 ±2 inches; W-H < 2 inches or use MASH Paragraph A4.3.2

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	1750	M_{front}	1433	1460	1545
Back	1687	M_{rear}	955	975	1055
Total	3389	M_{Total}	2388	2435	2600

Allowable TIM = 2420 lb ±55 lb | Allowable GSM = 2585 lb ± 55 lb

Mass Distribution:
lb LF: 745 RF: 715 LR: 510 RR: 465

Figure D.1. Vehicle Properties for Test 618911-01-2.

Date: 2024-02-09 Test No.: 618911-01-2 VIN No.: 3N1CN7AP2KL875916

Year: 2019 Make: Nissan Model: Versa

VEHICLE CRUSH MEASUREMENT SHEET[1]

Complete When Applicable	
End Damage	Side Damage
Undeformed end width _____	Bowing: B1 _____ X1 _____
Corner shift: A1 _____	B2 _____ X2 _____
A2 _____	
End shift at frame (CDC)	Bowing constant
(check one)	$\frac{X1+X2}{2}$ = _____
< 4 inches _____	
≥ 4 inches _____	

Note: Measure C_1 to C_6 from Driver to Passenger Side in Front or Rear Impacts – Rear to Front in Side Impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L***	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max**** Crush								
1	AT FRONT BUMPER	18	13	0	-	-	-	-	-	-	0
2	ABOVE FNT BUMPER	36	9	0	-	-	-	-	-	-	0
	Measurements recorded										
	☑ **inches or** ☐ **mm**										

[1]Table taken from National Accident Sampling System (NASS).

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

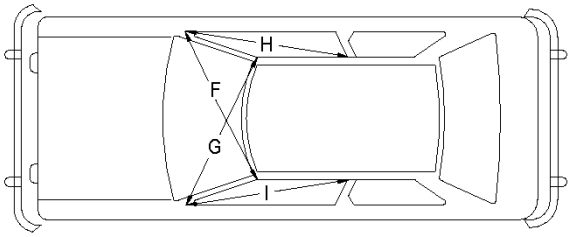
***Measure and document on the vehicle diagram the location of the maximum crush.

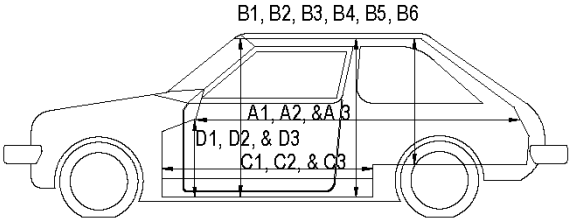
Note: Use as many lines/columns as necessary to describe each damage profile.

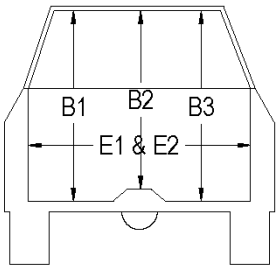
Figure D.2. Exterior Crush Measurements for Test 618911-01-2.

Date: 2024-02-09 Test No.: 618911-01-2 VIN No.: 3N1CN7AP2KL875916

Year: 2019 Make: Nissan Model: Versa







OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	67.50	67.50	0.00
A2	67.25	67.25	0.00
A3	67.75	67.75	0.00
B1	40.50	39.50	-1.00
B2	39.00	37.25	-1.75
B3	40.50	39.50	-1.00
B4	36.25	36.25	0.00
B5	36.00	35.25	-0.75
B6	36.25	36.25	0.00
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	9.50	9.50	0.00
D2	0.00	0.00	0.00
D3	9.50	9.50	0.00
E1	51.50	51.50	0.00
E2	51.00	51.00	0.00
F	51.00	51.00	0.00
G	51.00	51.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	51.00	51.00	0.00

*Lateral area across the cab from driver's side kick panel to passenger's side kick panel.

Figure D.3. Occupant Compartment Measurements for Test 618911-01-2.

F.2. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.275 s

(c) 0.550 s (d) 0.825 s

(e) 1.100 s (f) 1.375 s

(g) 1.650 s (h) 1.925 s

Figure D.5. Sequential Photographs for Test 618911-01-2 (Frontal Views).

(a) 0.000 s (b) 0.275 s

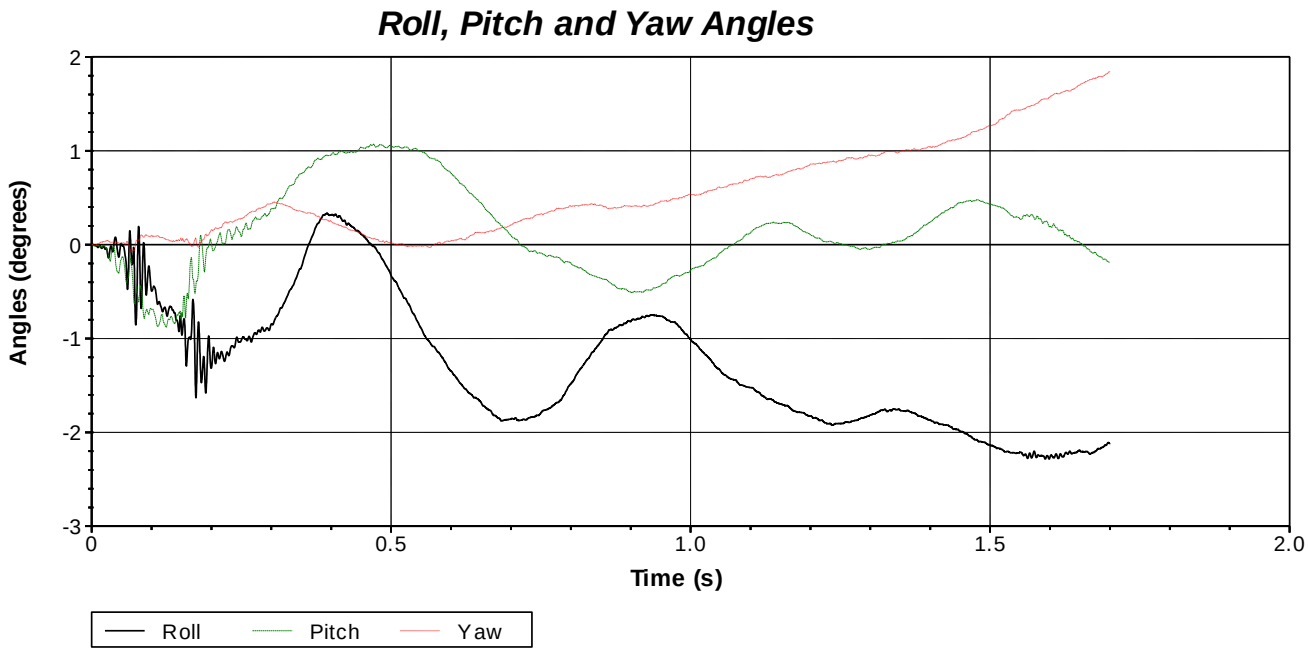
(c) 0.550 s (d) 0.825 s

(e) 1.100 s (f) 1.375 s

(g) 1.650 s (h) 1.925 s

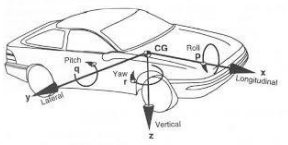
Figure D.6. Sequential Photographs for Test 618911-01-2 (Perpendicular Views).

F.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

4. Yaw.
5. Pitch.
6. Roll.



Test Number: 618911-01-2
Test Standard Test Number: *MASH* Test 3-60
Test Article: Four Bolt Slip Base Support for Luminaire Poles
Test Vehicle: 2019 Nissan Versa
Inertial Mass: 2435 lbs
Gross Mass: 2600 lbs
Impact Speed: 19.1 mi/h
Impact Angle: 0°

Figure D.7. Vehicle Angular Displacements for Test 618911-01-2.

F.4. VEHICLE ACCELERATIONS

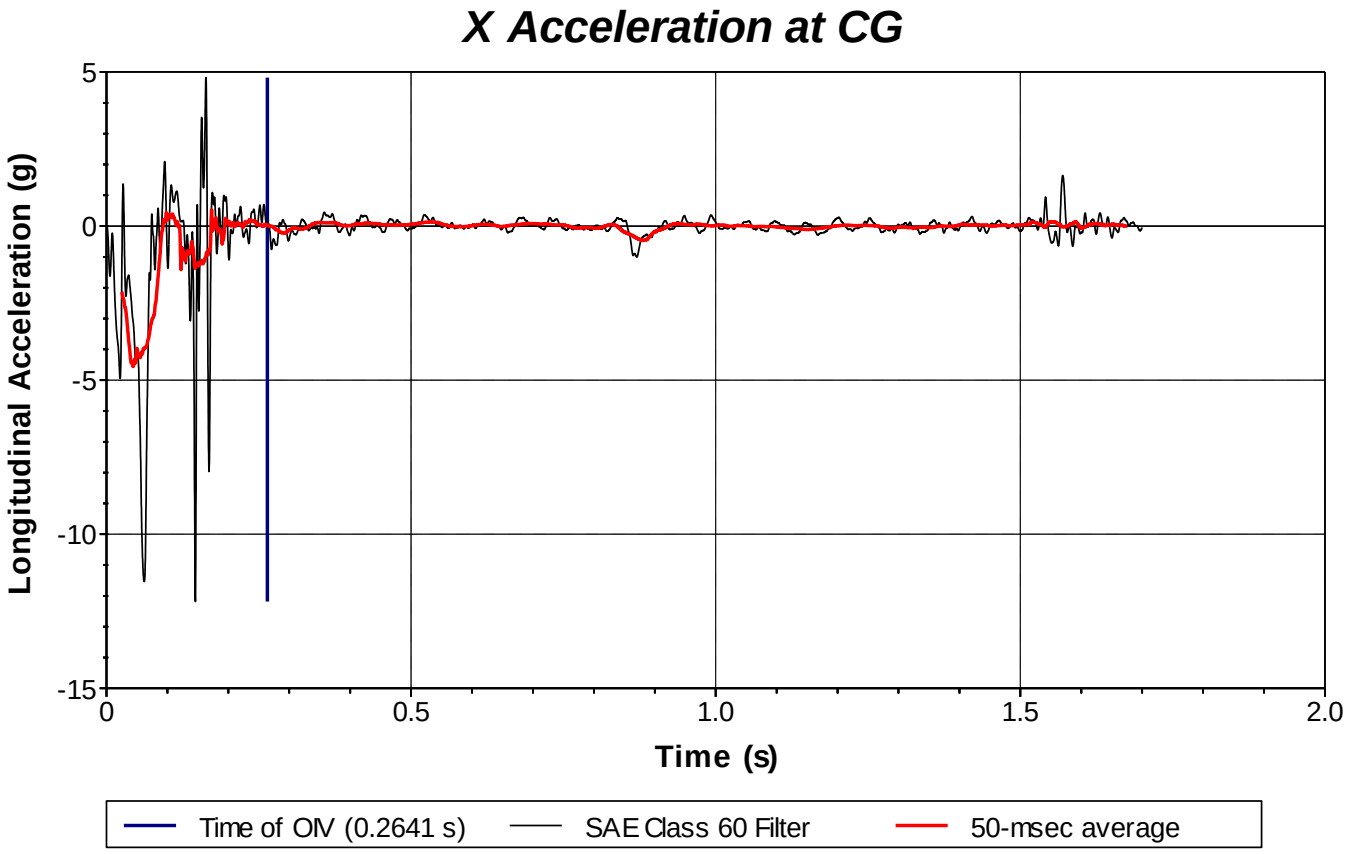


Figure D.8. Vehicle Longitudinal Accelerometer Trace for Test 618911-01-2 (Accelerometer Located at Center of Gravity).

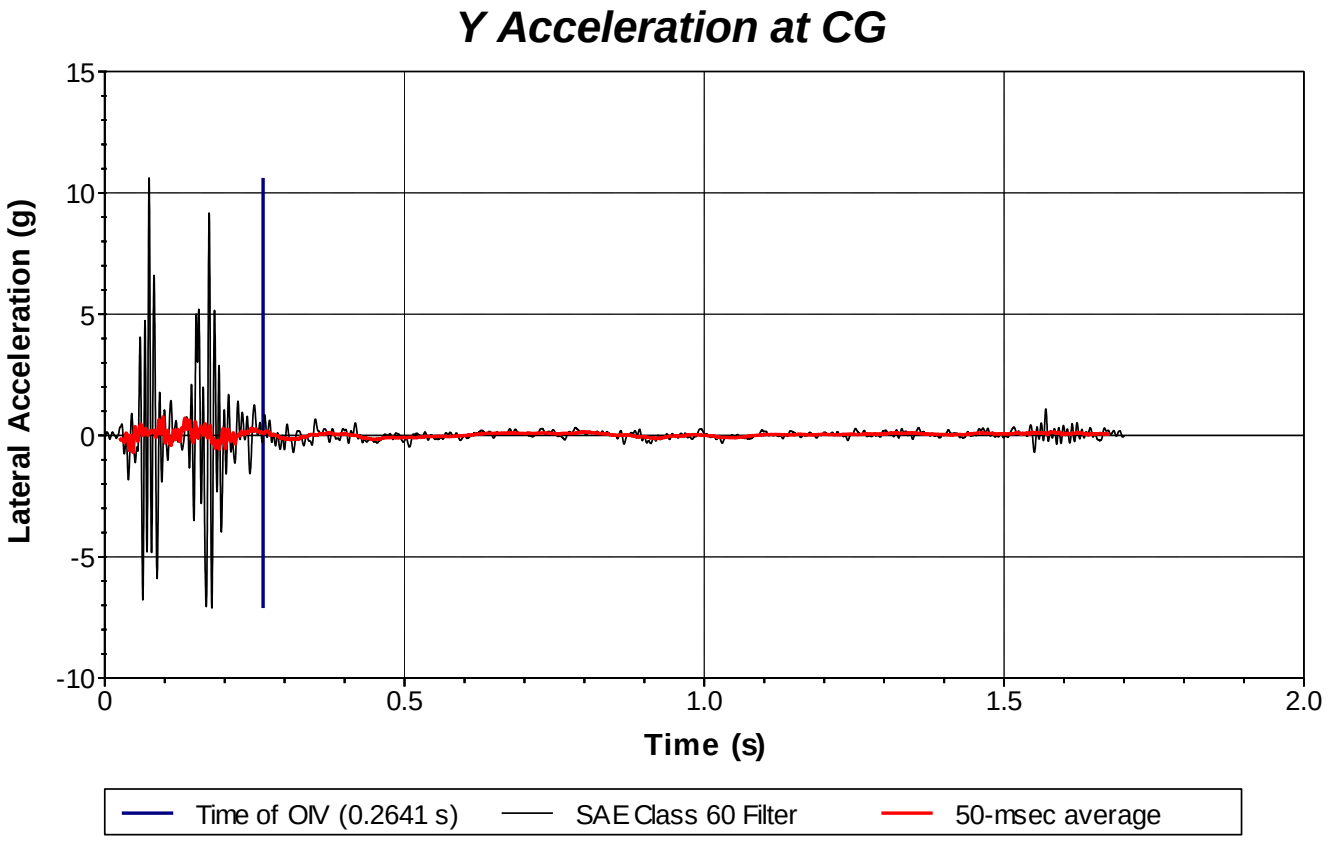


Figure D.9. Vehicle Lateral Accelerometer Trace for Test 618911-01-2 (Accelerometer Located at Center of Gravity).

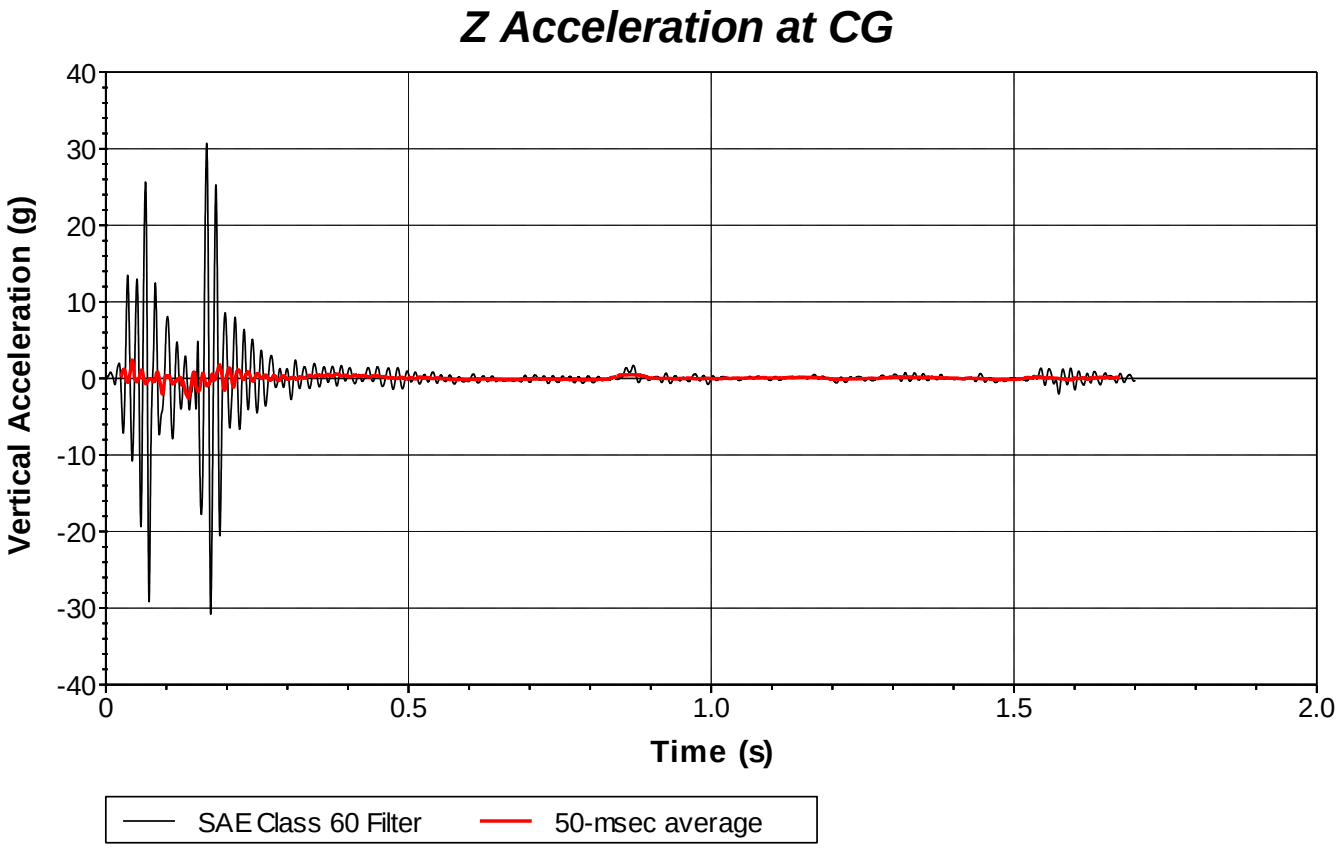


Figure D.10. Vehicle Vertical Accelerometer Trace for Test 618911-01-2 (Accelerometer Located at Center of Gravity).

APPENDIX G. *MASH* TEST 3-60 (CRASH TEST 618911-01-3)

G.1. VEHICLE PROPERTIES AND INFORMATION

Date: 2024-03-07 Test No.: 618911-01-3 VIN No.: 3N1CN7AP2JL869967

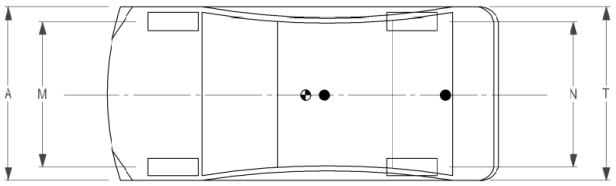
Year: 2018 Make: Nissan Model: Versa

Tire Inflation Pressure: 36 PSI Odometer: 147348 Tire Size: P185/65R15

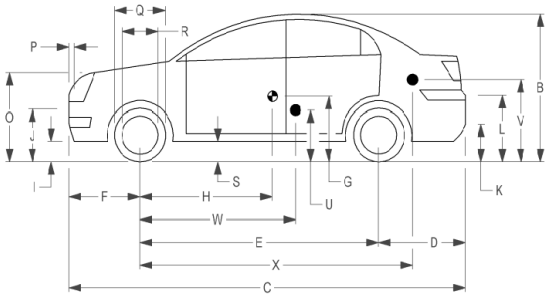
Describe any damage to the vehicle prior to test: None

● Denotes accelerometer location.

NOTES: None



Engine Type: 4 CYL
Engine CID: 1.6 L
Transmission Type:
☑ Auto or ☐ Manual
☑ FWD ☐ RWD ☐ 4WD
Optional Equipment:
None



Dummy Data:
Type: 50th Percentile Male
Mass: 165 lb
Seat Position: DRIVERS SIDE

Geometry: inches

A	66.70	F	32.50	K	12.50	P	4.50	U	15.50
B	59.60	G	0.00	L	26.00	Q	24.00	V	21.25
C	175.40	H	41.54	M	58.30	R	16.25	W	41.50
D	40.50	I	7.00	N	58.50	S	7.50	X	79.75
E	102.40	J	22.50	O	30.50	T	64.50		
	Wheel Center Ht Front	11.50		Wheel Center Ht Rear	11.50		W-H	-0.04	

RANGE LIMIT: A = 65 ±3 inches; C = 169 ±8 inches; E = 98 ±5 inches; F = 35 ±4 inches; H = 39 ±4 inches; O (Top of Radiator Support) = 28 ±4 inches
(M+N)/2 = 59 ±2 inches; W-H < 2 inches or use MASH Paragraph A4.3.2

GVWR Ratings:		**Mass:** lb	Curb	Test Inertial	Gross Static
Front	1750	M_{front}	1427	1443	1528
Back	1687	M_{rear}	982	985	1065
Total	3389	M_{Total}	2409	2428	2593

Allowable TIM = 2420 lb ±55 lb | Allowable GSM = 2585 lb ± 55 lb

Mass Distribution:
lb LF: 747 RF: 696 LR: 495 RR: 490

Figure D.1. Vehicle Properties for Test 618911-01-3.

Date: 2024-03-07 Test No.: 618911-01-3 VIN No.: 3N1CN7AP2JL869967

Year: 2018 Make: Nissan Model: Versa

VEHICLE CRUSH MEASUREMENT SHEET[1]

Complete When Applicable	
End Damage	Side Damage
Undeformed end width _____	Bowing: B1 _____ X1 _____
Corner shift: A1 _____	B2 _____ X2 _____
A2 _____	
End shift at frame (CDC)	Bowing constant
(check one)	$\frac{X1+X2}{2}$ = _____
< 4 inches _____	
≥ 4 inches _____	

Note: Measure C_1 to C_6 from Driver to Passenger Side in Front or Rear Impacts – Rear to Front in Side Impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max*** Crush								
1	AT FRONT BUMPER	18	9	6	-	-	-	-	-	-	-7
2	AT HOOD	31	6.5	7	-	-	-	-	-	-	-6
	Measurements recorded										
	☑ **inches or** ☐ **mm**										

[1]Table taken from National Accident Sampling System (NASS).

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

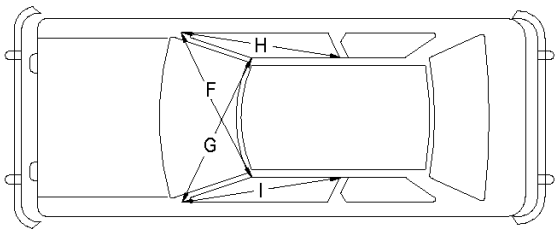
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle).

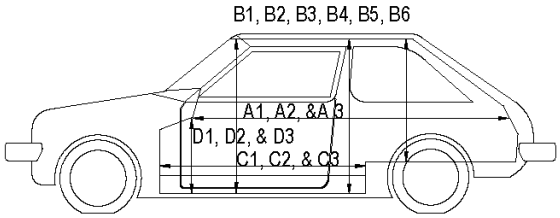
***Measure and document on the vehicle diagram the location of the maximum crush.

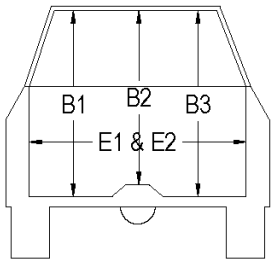
Note: Use as many lines/columns as necessary to describe each damage profile.

Figure D.2. Exterior Crush Measurements for Test 618911-01-3.

Date:	2024-03-07	Test No.:	618911-01-3	VIN No.:	3N1CN7AP2JL869967
Year:	2018	Make:	Nissan	Model:	Versa







OCCUPANT COMPARTMENT DEFORMATION MEASUREMENT

	Before	After (inches)	Differ.
A1	67.50	67.50	0.00
A2	67.25	67.25	0.00
A3	67.75	67.75	0.00
B1	40.50	40.50	0.00
B2	39.00	39.00	0.00
B3	40.50	39.50	-1.00
B4	36.25	36.25	0.00
B5	36.00	33.25	-2.75
B6	36.25	35.75	-0.50
C1	26.00	26.00	0.00
C2	0.00	0.00	0.00
C3	26.00	26.00	0.00
D1	9.50	9.50	0.00
D2	0.00	0.00	0.00
D3	9.50	9.50	0.00
E1	51.50	51.50	0.00
E2	51.00	51.00	0.00
F	51.00	51.00	0.00
G	51.00	51.00	0.00
H	37.50	37.50	0.00
I	37.50	37.50	0.00
J*	51.00	51.00	0.00

*Lateral area across the cab from driver's side kick panel to passenger's side kick panel.

Figure D.3. Occupant Compartment Measurements for Test 618911-01-3.

G.2. SEQUENTIAL PHOTOGRAPHS

(a) 0.000 s (b) 0.275 s

(c) 0.550 s (d) 0.825 s

(e) 1.100 s (f) 1.375 s

(g) 1.650 s (h) 1.925 s

Figure D.5. Sequential Photographs for Test 618911-01-3 (Frontal Views).

(a) 0.000 s (b) 0.275 s

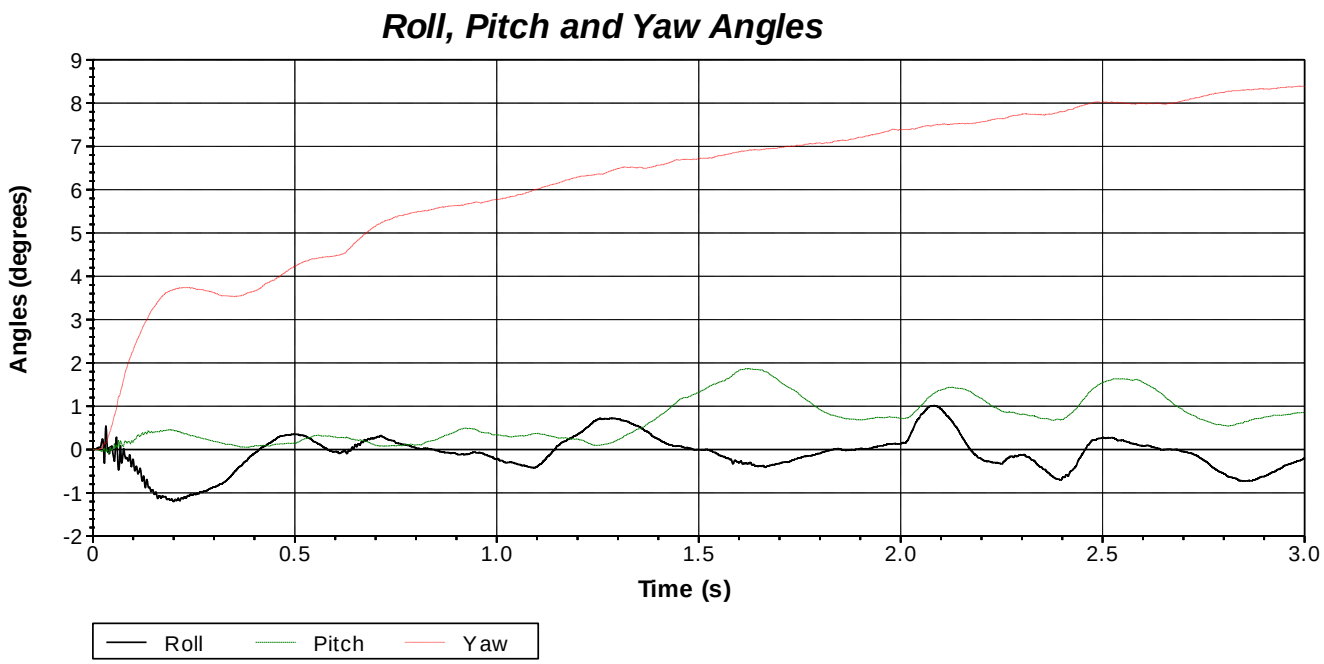
(c) 0.550 s (d) 0.825 s

(e) 1.100 s (f) 1.375 s

(g) 1.650 s (h) 1.925 s

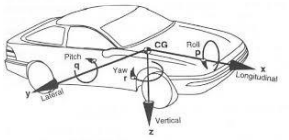
Figure D.6. Sequential Photographs for Test 618911-01-3 (Perpendicular Views).

G.3. VEHICLE ANGULAR DISPLACEMENTS



Axes are vehicle-fixed.
Sequence for determining orientation:

7. Yaw.
8. Pitch.
9. Roll.



Test Number: 618911-01-3
Test Standard Test Number: *MASH* Test 3-60
Test Article: Four Bolt Slip Base Support for Luminaire Poles
Test Vehicle: 2018 Nissan Versa
Inertial Mass: 2428 lbs
Gross Mass: 2593 lbs
Impact Speed: 19.4 mi/h
Impact Angle: 0°

Figure D.7. Vehicle Angular Displacements for Test 618911-01-3.

G.4. VEHICLE ACCELERATIONS

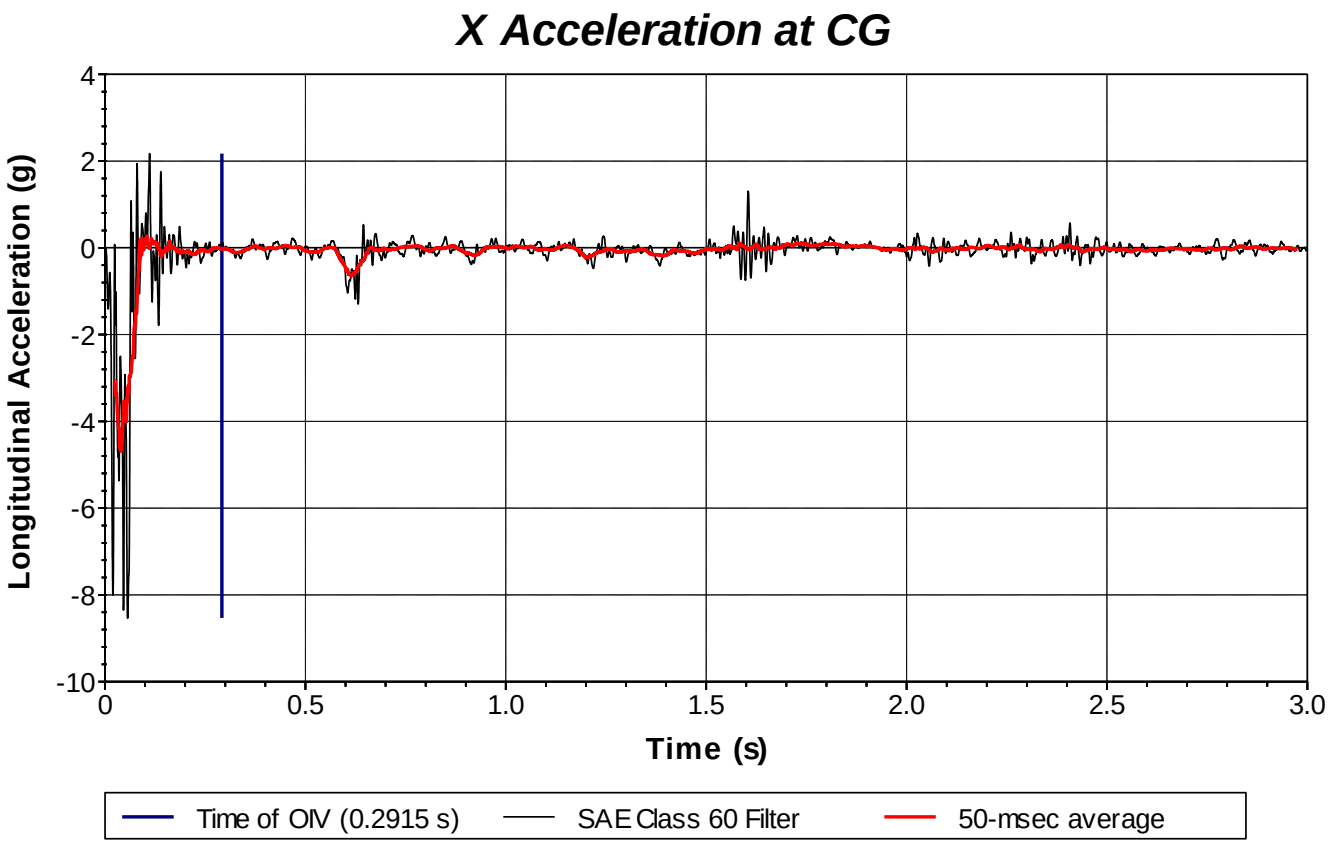


Figure D.8. Vehicle Longitudinal Accelerometer Trace for Test 618911-01-3 (Accelerometer Located at Center of Gravity).

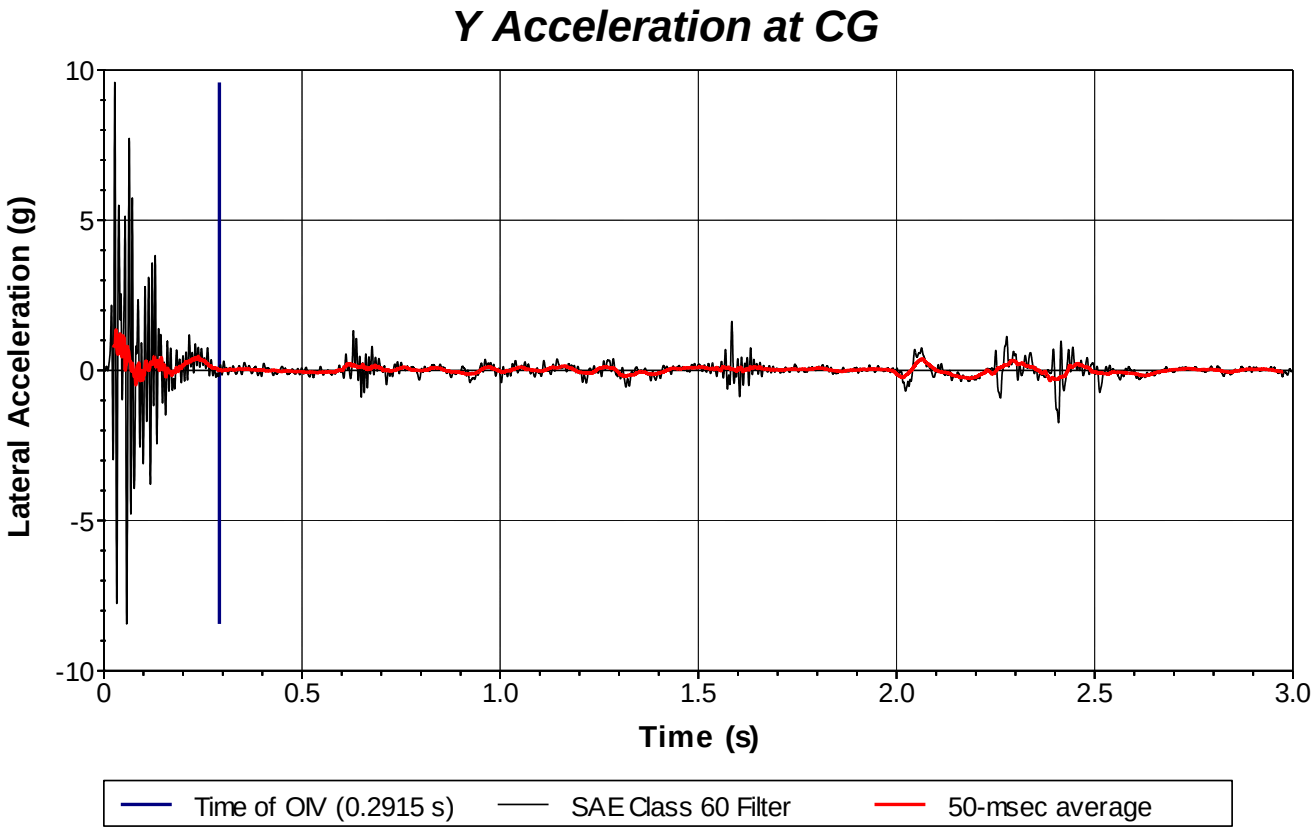


Figure D.9. Vehicle Lateral Accelerometer Trace for Test 618911-01-3 (Accelerometer Located at Center of Gravity).

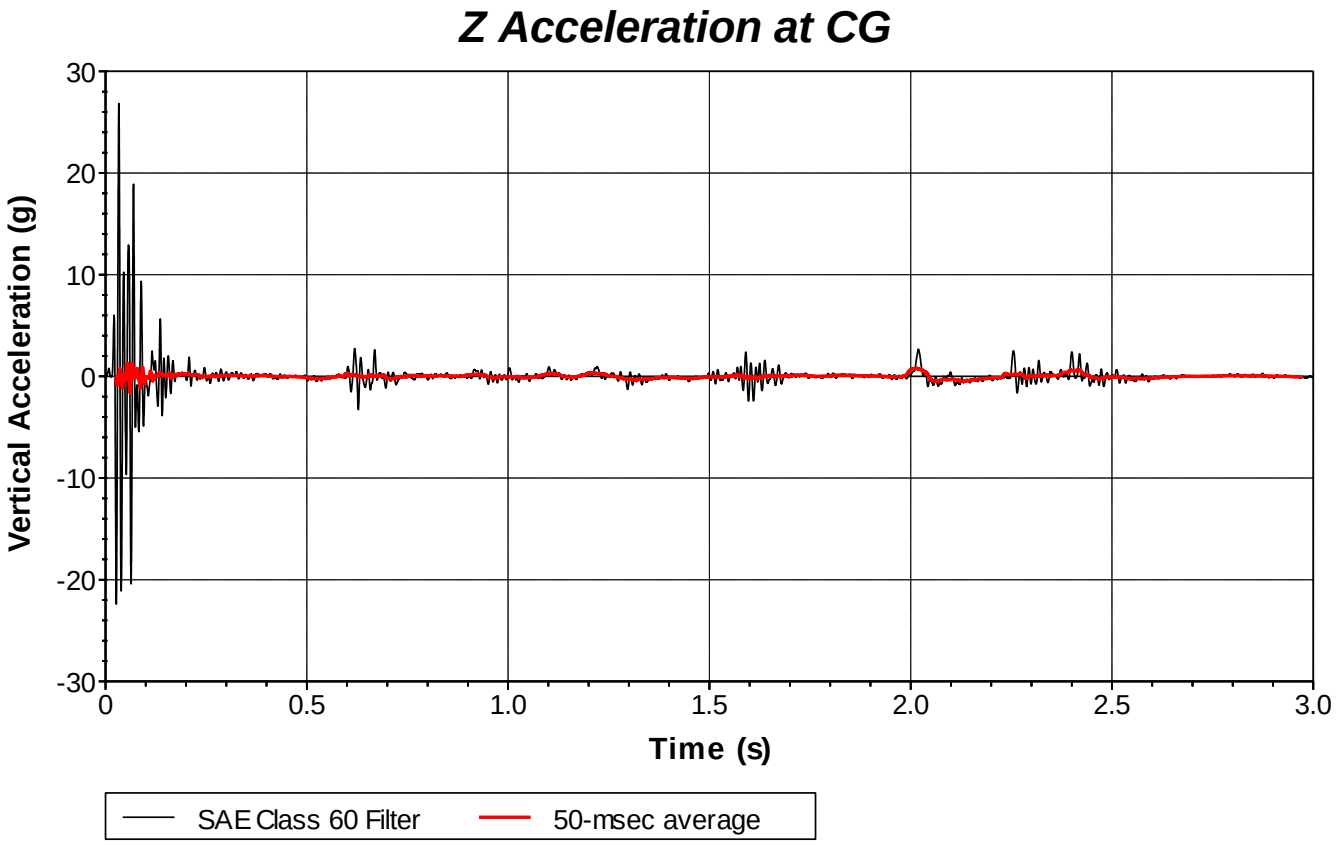


Figure D.10. Vehicle Vertical Accelerometer Trace for Test 618911-01-3 (Accelerometer Located at Center of Gravity).