U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA

DOT HS 813 081

April 2021

Special Crash Investigations: Guardrail End Terminal Investigation; Vehicle: 2000 Toyota Corolla; Location: Missouri; Crash Date: November 2018

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Suggested APA Format Citation:

Dynamic Science, Inc. (2021, April). *Special crash investigations: Guardrail end terminal investigation; Vehicle: 2000 Toyota Corolla; Location: Missouri; Crash date: November 2018* (Report No. DOT HS 813 081). National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 813 081		

4. Title and Subtitle	5. Report Date
Special Crash Investigations: Guardrail End Terminal Investigation; Vehicle: 2000 Toyota Corolla; Location: Missouri; Crash Date: November 2018	April 2021
	6. Performing Organization Code

7. Author	8. Performing Organization Report No.
Dynamic Science, Inc.	DS18028

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Dynamic Science, Inc. 26141 Marguerite Parkway, Suite C Mission Viejo, CA 92692	11. Contract or Grant No. 693JJ918C000012

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
National Highway Traffic Safety Administration 1200 New Jersey Avenue SE Washington, DC 20590	Technical Report November 2018
	14. Sponsoring Agency Code

15. Supplementary Notes

Each crash represents a unique sequence of events, and generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicles or their safety systems. This report and associated case data are based on information available to the Special Crash Investigation team on the date this report was published.

16. Abstract

This report documents the on-site guardrail end terminal investigation of the SoftStop guardrail end terminal struck by a 2000 Toyota Corolla during a crash and the possible injuries sustained by the driver. The investigation was conducted on behalf of FHWA. The report is meant to document the damage of the guardrail end terminal. The crash occurred in the afternoon in November 2018 in Missouri. As the Toyota entered a curve, it departed the roadway to the left and struck the end terminal with its front end. The cause of the road departure is not known. The driver indicated that he had struck his head, but EMS was unable to locate any obvious trauma. He also stated that he had no complaints of pain. A C-collar was placed on the driver, and he agreed to be transported to a local hospital for examination.

17. Key Words	18. Distribution Statement
guardrail, end terminal, non-injury	The document is available to the public from the National Technical Information Service, www.ntis.gov.

19 Security Classif. (of this report)	20. Security Classif. (of this page)	21 No. of Pages	22. Price
Unclassified	Unclassified	21	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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Guardrail End Terminal Investigation
Case Number: DS18028
Vehicle: 2000 Toyota Corolla
Location: Missouri
Crash Date: November 2018

Background

This report documents the on-site guardrail end terminal investigation of the SoftStop guardrail end terminal struck by a 2000 Toyota Corolla during a crash and the possible injuries sustained by the driver (Figure 1). The investigation was conducted on behalf of FHWA. The report is meant to document the damage of the guardrail end terminal. This case was initiated by the state transportation agency who notified the Federal Highway Administration (FHWA) of the crash. After reviewing the case and determining the guardrail end terminal qualified and the case was of interest, FHWA forwarded the notification along with on-scene images to the SCI group of the National Highway Traffic Safety Administration with instructions to deploy the SCI team. SCI assigned the case to Dynamic Science, Inc. in November 2018.

This single-vehicle crash occurred on a curved ramp transitioning from an eastbound interstate highway to a State highway. The crash occurred in the afternoon in November 2018 in Missouri.

Figure 1. The 2000 Toyota Corolla

Figure 2. SoftStop guardrail end terminal, looking northeast

As the Toyota entered the curve, the vehicle departed the roadway to the left and struck the end terminal with its front end (Figure 2). The cause of the road departure is not known. The driver indicated that he had struck his head, but EMS was unable to locate any obvious trauma. He also stated that he had no complaints of pain. A C-collar was placed on the driver, and he agreed to be transported to a local hospital for examination and then released.

Summary

Crash Site

The crash site was a curved, single-lane ramp transitioning from an eastbound interstate highway to a State highway (Figure 3). The roadway was level with a right curve radius of 325 m (1068 ft) and a superelevation of 5.2 percent. The curve was marked by multiple curve warning signs on the north side of the roadway. The concrete roadway was bordered on the right by a white fog line, a concrete shoulder, and a W-beam guardrail. The roadway was bordered on the left initially by a yellow fog line, a concrete shoulder, a widening grass-covered median, and a concrete barrier. As the curve continued, the roadway was bordered on the left by a W-beam guardrail with a SoftStop guardrail end terminal.

The reported speed limit was 72 km/h (45 mph). The weather at the nearest report station was 9 °C (48 °F), 86 percent humidity, and the wind direction was out of the south at 19 km/h (12 mph). The police reported that the roadway was dry and the weather clear. A crash diagram is attached at the end of this technical report.

Figure 3. Eastbound approach

Figure 4. Roadway departure, looking east

Pre-Crash

The Toyota was driven by an unbelted 21-year-old male who reported he was talking to his girlfriend on his cell phone. He stated that the cell phone was on speaker, and that the phone itself was sitting on his thigh. The police reported that the driver had been drinking alcohol. The vehicle was traveling eastbound on the ramp at an unknown speed while negotiating a right curve. The driver lost control of the vehicle, and the vehicle began a clockwise yaw. The cause of the road departure is not known. The vehicle partially departed the roadway prior to the end terminal (Figure 4).

Crash

As the vehicle departed the shoulder on the left, the front plane struck the SoftStop end terminal (Figure 5). The WinSMASH damage-only program calculated a barrier equivalent speed of 23 km/h (15 mph). The driver's and passenger's frontal air bags deployed during this impact. The results are considered borderline because the end terminal yielded. Yielding objects are beyond

the scope of the WinSMASH reconstruction. As the front plane of the vehicle struck the end terminal, the vehicle pivoted around the end and began to rotate in a counterclockwise direction. The end terminal extruded to just past post 3. The Toyota continued to rotate until contacting the guardrail face with its right plane at post 7. The rotation continued until the vehicle came to rest on the ramp facing southwest.

Figure 5. Guardrail end terminal impact, looking east

Post-Crash

The driver was able to exit the vehicle under his own power. An ambulance unit was notified and arrived approximately 30 minutes after the crash. He was assessed on scene. EMS reported that the driver had a Glasgow Coma Scale (GCS) score of 15. The police assessed his level of sobriety and determined that he was impaired and could not operate a vehicle safely. He was placed under arrest at this time. The police reported that he sustained incapacitating injuries. The driver indicated that he had struck his head, but EMS was unable to locate any obvious trauma. He also stated that he had no complaints of pain. A C-collar was placed on the driver, and he agreed to be transported to a local hospital for examination where he arrived 45 minutes after the crash. An hour after the crash, a blood sample was taken from the driver. The results showed a blood alcohol concentration of .234 gm/dL. The vehicle was towed from the scene due to damage.

Guardrail End Terminal Discussion

The guardrail end terminal in this crash was a Trinity SoftStop tangent single-side redirective and gating terminal (Figure 6). It uses a moveable impact head on a W-beam rail section. During an end impact, the head travels down the anchored rails that are extruded toward the ground. The head measured 18 x 53 cm (7.0 x 20.8 in). The system was designed with an anchor post (post 0) and an anchor panel between post 0 and post 1. The head was located in front of post 1. The distance between post 0 and the terminal head was 129 cm (50.7 in). The guardrail height was 78 cm (30.7 in). During the crash, the head traveled east with 3.9 m (13 ft) extrusion toward the ground and came to a stop just beyond post 3. The total length of rail damaged was approximately 7.6 m (25 ft).

Figure 6. End terminal impact

2000 Toyota Corolla

Description

The 2001 Toyota Corolla was a 4-door sedan that was identified by the Vehicle Identification Number 2T1BR12E1YCxxxxxx and was manufactured in November 1999. The vehicle was configured with a 1.8-liter, 4-cylinder, gasoline engine, an automatic transmission, and front-wheel drive. The vehicle manufacturer's recommended tire size was P175/65R14 with a cold pressure of 207 kPa (30 psi). The vehicle was equipped with Sentury Touring P185/65R14 tires on the front, a Goodyear P185/65R14 tire on the left rear, and a Toyo Extensa P185/65R14 tire on the right rear. The specific tire information was as follows:

Position	Measured Tread Depth	Restricted	Damage
LF	6 mm (8/32 in)	Yes	Flat, tread penetrated
LR	3 mm (4/32 in)	No	Flat, debeaded
RR	4 mm (5/32 in)	No	None
RF	6 mm (8/32 in)	No	None

The Toyota was configured with seating for five occupants. The front row was equipped with bucket seats with adjustable head restraints. Both front seats were adjusted to the rear most track position. The second row was configured with a bench seat.

Exterior Damage

The Toyota was involved in two damage producing events. The vehicle sustained moderate front plane damage from the impact with the end terminal (Figure 7). The damage began at the left bumper corner and extended 40 cm (15.7 in) to the right. The vehicle end was shifted 41 cm (16.1 in) to the right. Fourteen measurements were taken at the backing bar level by the Nikon Total Station, and the Faro Blitz program computed crush measurement in six increments, as follows: C_1 = 19 cm (7.4 in), C_2 = 10 cm (3.9 in), C_3 = 14 cm (5.5 in), C_4 = 9 cm (3.5 in), C_5 = 0 cm, and C_6 = 0 cm. The Collision Deformation Classification (CDC) was 11FLEE3.

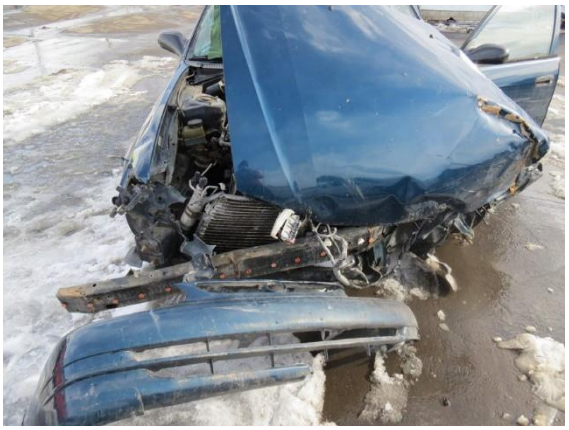


Figure 7. Frontal damage, the 2000 Toyota Corolla

The vehicle sustained minor scraping type damage to the right plane. The damage began 22 cm (8.6 in) aft of the rear axle and extended 229 cm (90.1 in) forward. The CDC was 05RYMS1.

Interior Damage

The Toyota sustained minor interior damage from occupant contacts and air bag deployments. There were occupant contacts to the windshield and lower instrument panel. The right windshield was fractured from the passenger air bag deployment. There was no other glazing damage. All the doors remained closed and operational.

Manual Restraint Systems

The front row was equipped with driver and front right passenger lap and shoulder seat belts. The driver's belt was equipped with continuous loop belt webbing, a sliding latch plate, an emergency locking retractor (ELR), and an adjustable upper anchor that was adjusted to between the mid and lower position. The front right passenger's seat belt was equipped the same as the driver's, but had a switchable ELR/automatic locking retractor. The front row seat belts were equipped with retractor pretensioners that actuated while in the stowed position.

Supplemental Restraint Systems

The Toyota's supplemental restraint systems included an air bag control module and driver and passenger redesigned frontal air bags. Both frontal air bags deployed during the initial guardrail end terminal impact. The driver's frontal air bag measured 56 cm (22.0 in) and had two vent ports and one tether. There was no indication of occupant contact on the air bag face. The front passenger air bag measured 55 x 60 cm (21.6 x 23.6 in). It was undamaged and unremarkable.

This vehicle was not supported by a commercially available tool to image the Event Data Recorder.

NHTSA Recalls and Investigations

There were no open recalls for this vehicle.

2000 Toyota Corolla Occupants

Driver Demographics

Age/sex:	21 years/male
Height:	188 cm (74 in)
Weight:	75 kg (165 lbs)
Eyewear:	None
Seat type:	Bucket
Seat track position:	Rear most position
Manual restraint usage:	Lap and shoulder belt available, not used
Usage source:	Vehicle inspection
Air bags:	Driver air bag available, deployed
Alcohol/drug data:	Under influence of alcohol, BAC = .234 g/dL
Egress from vehicle:	Under own power
Transport from scene:	Ambulance
Type of medical treatment:	Transported and released

Driver Injuries

The driver indicated that he had struck his head, but EMS was unable to locate any obvious trauma. EMS reported no obvious DCAP-BTLS body.[1] He also stated that he had no complaints of pain. A C-collar was placed on the driver, and he agreed to be transported to a local hospital for examination, where he arrived at 1502 hours. There were no codeable injuries.

Driver Kinematics

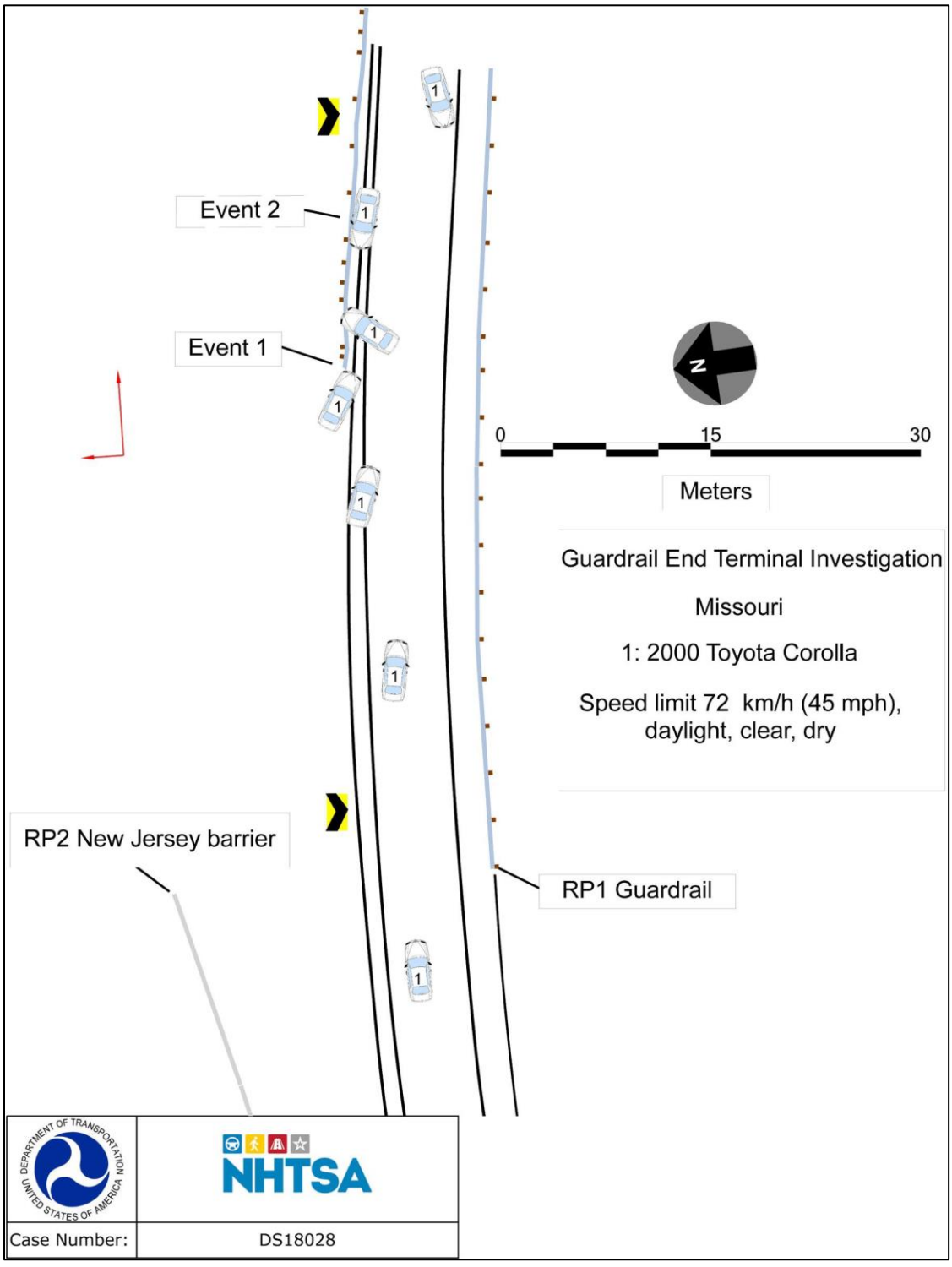
The 21-year-old unbelted male driver was seated in an unknown posture. The vehicle was negotiating a right curve. At impact with the end terminal, the driver was displaced forward and to the left and engaged the deployed frontal air bag. His right hand possibly contacted the windshield (Figure 8), and his left knee contacted the left lower instrument panel (Figure 9). His post-crash position is not known. He was able to exit the vehicle under his own power.

Figure 8. Windshield contact, the 2000 Toyota Corolla

Figure 9. Knee contact, the 2000 Toyota Corolla

[1] Mnemonic for EMT assessment in which each area of the body is evaluated for **D**eformities, **C**ontusions, **A**brasions, Punctures/Penetrations **B**urns, Tenderness, Lacerations, Swelling.

Crash Diagram



Appendix A: Federal Highway Administration Guardrail Form

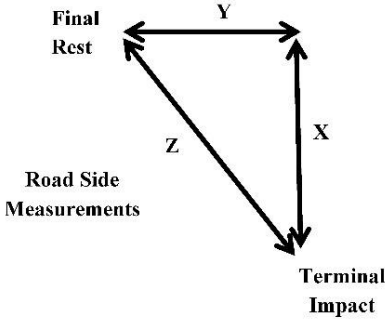
Case No.: DS18028

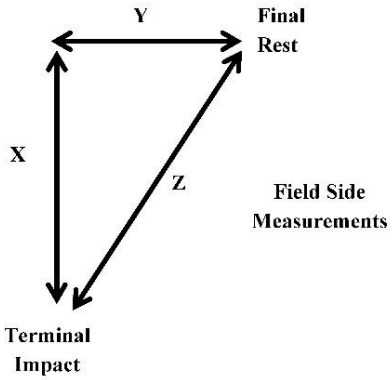
PREPOPULATED DATA (BY OTHERS)			
Date of Crash	November 2018	**TIME OF CRASH (MILITARY)**	Afternoon
Case Number	DS18028	**State**	MO
Traffic Route	Ramp to EB50	**Direction (Southbound = SB)**	EB
Ambient Conditions (at time of crash)			
Temperature (°F)	48	**Lighting**	Daylight
Atmospheric	Clear/Dry		

SCENE INFORMATION	
Type of area where crash occurred	☒Urban ☐Rural ☐Suburban
Terminal on a horizontal curve?	☐No ☐Curve/LT ☒Curve/RT
Estimated or Reconstructed Speed at Impact (MPH)	Unknown
Est. distance (straight line) from terminal impact to COM final rest position (ft.)	Z = 67 ft
Est. distance (longitudinal) along guardrail from terminal impact to COM final resting location (ft.)	X = 64 ft
Est. distance (normal) from either 1. the white paint line; or 2. roadway/shoulder/pavement edge to COM rest position (ft.)	Y = 18 ft
Super elevation	☒+2% ☐-2% ☐ NONE or FLAT
Curve Radius (ft.)	1,068

KEY:

- COM - Center of Mass of Vehicle
- Distance Measurements





Case No.: DS18028

ON-SCENE INFORMATION								
End Treatment Type	☒Extruder	☐ET2000	☐ET-PLUS 4in	☐ET-PLUS 5in	☐SKT	☐FLEAT	☒SOFT STOP	
	☐Telescope	☐X-LITE	☐X-TENSION					
Curb?	☒No ☐Yes	☐AASHTO Type A	☐AASHTO Type B	☐AASHTO Type C	☐AASHTO Type D	☐AASHTO Type E		
		☐AASHTO Type F	☐AASHTO Type G	☐AASHTO Type H				
Curb Height: NA								

GUARDRAIL INSTALLATION

Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
0					NA	None	4 ft-2 in	NA	NA
1	S	4 x 6	NA		No	None	4 ft - 4 in	NA	4ft-9 in
2	S	4 x 6	NA		No	None	5 ft-3 in	NA	6ft-3 in

Case No.: DS18028

GUARDRAIL INSTALLATION									
Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
3	S	4 x 6	NA		No	None	5ft-5 in	NA	6ft-3in
4	S	4 x 6	NA		No	None	5ft-2 in	NA	6ft-0in
5	S	4 x 6	C	4.5 x 8.5	No	None	5ft-1in	NA	6ft-2in
6	S	4 x 6	C	4.5 x 8.5	No	None	5ft-0 in	NA	6ft-2in

Case No.: DS18028

GUARDRAIL INSTALLATION									
Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.	Yes No Unknown	Describe	Travel way	Curb	
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)					
7	S	4 x 6	C	4.5 x 8.5	No	None	4ft-11 in	NA	6ft-3in
8	S	4 x 6	C	4.5 x 8.5	No	None	4ft-10 in	NA	6ft-3in

Case No.: DS18028

Post No.	Post		Offset Block		PRE-Existing Damage		Offset to post or post hole (ft.)		Spacing to next post (ft. -in.)
	Type	Dim.	Type	Dim.					
	Steel Wood Other	D x W (in.) or Dia. (in.)	Steel Wood Composite	D x W (in.)	Yes No Unknown	Describe	Travel way	Curb	
9	S	4 x 6	C	4.5 x 8.5	No	None	4ft-10in	NA	6ft-4in
10	S	4 x 6	C	4.5 x 8.5	No	None	4ft-9in	NA	3ft-1in
11	S	4 x 6	C	4.5 x 8.5	No	None	4ft-10in	NA	6ft-3in
12	S	4 x 6	C	4.5 x 8.5	No	None	4ft-11 in	NA	6ft-3in

Additional Comments

Case No.: DS18028

EXTRUDER			
Feeder Channel Width at impact head	☐4inches ☐5 inches ☒Other ___5.5 in_____		
Guide Chute Exit Height (in.)	24		
Connection of feeder channels to head damaged?	☒No ☐Yes	Are Welds Broken?	☒No ☐Yes
Anchor Cable Present?	☒No ☐Yes	Connected?	☐No ☐Yes
Rail Extrusion?	☐No ☒Yes	Length (ft. in.)	13ft
Rail Extrusion Direction	☐Traffic Side ☐Field Side - NA (ground)		
Total Length of Rail Damaged (ft.) [total length would include extruded rail plus damaged rail downstream from head.]	25		

TELESCOPE				
Rail Displacement	☐No	☐Yes; Length:	No of Panels Displaced	☐1 ☐2 ☐3 ☐4 ☐5 ☐6

ALL-SYSTEM PERFORMANCE			
Railkinks Downstream of Head?	☒No	☐Yes;	No. of Kinks in Rail: 0
Was there intrusion into the Occupant Compartment by foreign object (guardrail)?	☒No ☐Yes		
Did vehicle impact other objects after impact with terminal?	☐No ☒Yes		
Object Contacted	Guardrail face		

ALL-SYSTEM PERFORMANCE ENVIRONMENT			
SIDESLOPE	**50 ft in advance of Post 1**	**At Post 1**	**50 ft Past Post 1**
Percent - %	16	3.6	12
Adjacent Lane Width (ft)	18		
Lane Type (NAS EDS Variable: Sur. Type)	Concrete		
Shoulder Type	Concrete		
Shoulder Width (ft)	4ft-2in		
Guardrail Height (in)	32		

Case No.: DS18028

VEHICLE INFORMATION	
Vehicle Type (NHTSA Input)	2000 Toyota Corolla
Vehicle Identification Number (VIN)	2T1BR12E1YCxxxxxx
Vehicle Mass (NASS var.: veh.wgt)	1,145 kg
Vehicle orientation upon impact	☐ Case Type 1 ☐ Case Type 2 ☐ Case Type 3 ☒ Case Type 4 ☐ Case Type 5 ☐ Case Type 6 ☐ Case Type 7 ☐ Case Type 8 ☐ Other
If 'Other', describe	
Collision Deformation Classification	11FLEE3
Delta-V	BES = 23 km/h (15 mph)
Occupant Compartment Penetration of rail	☒ No ☐ Yes; Describe:
Quarter Turns (NASS EDS variable: Rollover)	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17+
Object Precipitating Rollover, (NASS EDS variable: Rollobj)	NA
Rollover Type, Terhune Scale, (NASS EDS variable: rolintyp)	NA

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**National Highway
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Administration**

15135-032921-v2