NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C.

HIGHWAY FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

A. CRASH INFORMATION

Location:	State Route 12 (SR-12) mile marker 10.4, near Bryce Canyon City, Garfield County, Utah
Vehicle 1:	2017 Freightliner, Embassy body 37-passenger medium-size bus
Operator 1:	America Shengjia, Inc.
Date:	September 20, 2019
Time:	Approximately 11:30 a.m. MDT
NTSB #:	**HWY19MH012**

B. HIGHWAY FACTORS GROUP

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C. CRASH SUMMARY

For a summary of the crash, refer to the *Crash Summary Report* in the docket for this investigation.

D. DETAILS OF HIGHWAY INVESTIGATION

This Highway Group Chairman's Factual Report is based on reports, photographs, documents, and data provided by the Utah Department of Transportation (UDOT), and the Utah Highway Patrol (UHP), as well as information and photographs gathered on-scene by NTSB investigators. Data was obtained that included a limited construction history, daily traffic volumes, vehicle classification data, crash summaries, and highway design plans. Documentation of roadway evidence left by the 2017 Freightliner, Embassy body 37-passenger medium-size bus (bus) will also be discussed.

1. CRASH LOCATION

The collision occurred on eastbound State Route 12 (SR-12), at milepost 10.4 in front of the Pines Rest Area near Bryce Canyon City, Garfield County, Utah. The crash location, shown in **Figure 1**, was located approximately 3.5 miles northwest of Bryce Canyon City, Utah. An annotated ortho-mosaic aerial image of the crash scene is shown in **Figure 2**.[1]

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[1] See *Highway Photograph 1 – Orthomosaic Aerial Image of Crash Scene from sUAS*. An orthomosaic image is a map-quality overhead image created through the combination of numerous individual images which have been processed by computer software such that the photographs have been geometrically corrected for scale and to remove distortion.

Figure 1: Map of Crash Location (modified from Google Maps)

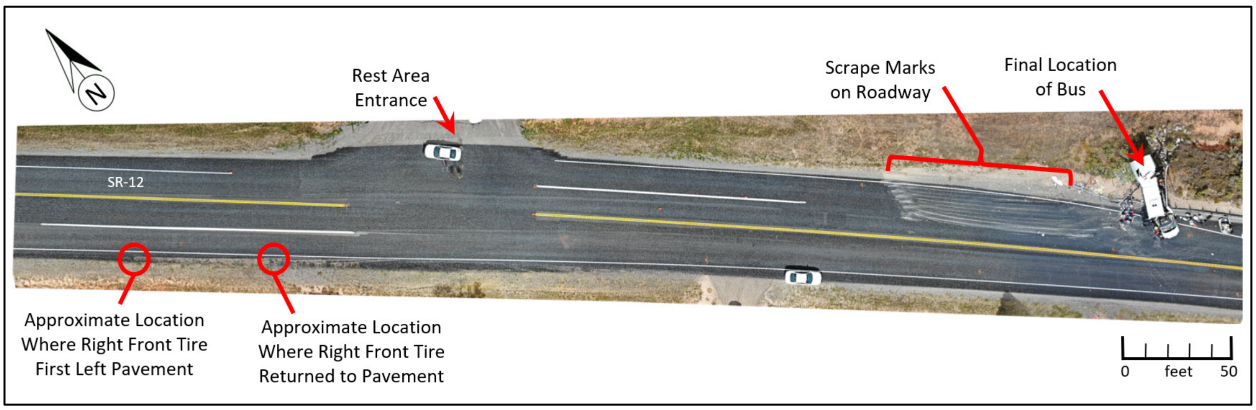

Figure 2: Orthomosaic Aerial Image of Crash Scene (source: Utah Highway Patrol, annotated)

2. HIGHWAY DESIGN

Preceding the area of the collision, between United States Highway 89 (US-89; milepost 0) and East Fork Road (milepost 10.7), SR-12 was a two-lane asphalt paved highway, consisting of one travel lane each in the eastbound and westbound directions. Each of the travel lanes were approximately 12-feet wide and were flanked by paved shoulders wider than 4-feet in most locations along this segment of roadway. There were bi-directional turn lanes[2] as well as dedicated left-turn and right-turn lanes near major intersections. Although not frequent, turnouts, access roads, and driveways were present along both sides of the roadway. Winding Road and Right Reverse Curve warning signs as well as Chevron Alignment signs were present as appropriate between milepost 2 and milepost 7. The speed limits along this segment of SR-12 range from 45 to 65 miles per hour (mph).

[2] Bi-directional turn lanes are a shared center lane that can be used for left-hand turns by vehicles traveling in either direction.

In the area of the collision, SR-12 was a two-lane asphalt paved roadway that widened to accommodate a dedicated left-turn lane for eastbound traffic and a dedicated right-turn lane for westbound traffic entering the rest area located on the northeast side of the highway.[3] In the area where the bus left the roadway, SR-12 consisted of an eastbound through travel lane, a centrally located dedicated eastbound left-turn lane, and a westbound through travel lane. The eastbound through travel lane was approximately 11-feet 4-inches wide, the eastbound left-turn lane was approximately 13-feet 4-inches wide, and the westbound through travel lane was approximately 12-feet 9-inches wide. Flanking the right side of the eastbound through travel lane was an approximate 2-foot-wide asphalt paved shoulder and an approximate 3-foot-wide gravel shoulder.[4] Flanking the right side of the westbound through travel lane was an approximate 5-foot-wide asphalt paved shoulder and an approximate 3-foot-wide gravel shoulder. The cross slopes of all three lanes were sloped down toward the south; and were measured to be 3.8% for the eastbound through travel lane, 3.6% for the eastbound left-turn lane, and 2.6% for the westbound through travel lane. The posted speed limit for both travel directions of SR-12 in the area of the collision was 65 mph.

Near the crash location, just east of East Fork Road, measurements were taken on a two-lane tangent (straight) section of SR-12. At this location, the eastbound travel lane was approximately 11-feet 9-inches wide, and the westbound travel lane was approximately 12-feet 3-inches wide. Flanking both the eastbound and westbound travel lanes were approximate 5-foot-wide paved shoulders and 3-1/2-foot-wide gravel shoulders. The cross-slope of the eastbound and westbound travel lanes were approximately 1.3% and 1.6% respectively, with both lanes being sloped down toward their respective shoulders.

3. FUNCTIONAL CLASSIFICATION

In the area of the collision, SR-12 is functionally classified as a rural principal arterial roadway and is a designated bicycle route.[5] The American Association of State Highway and Transportation Officials (AASHTO) describe a rural principal arterial system as follows:[6]

> *The rural principal arterial system consists of a network of routes with the following service characteristics:*
>
> *1. Corridor movement with trip length and density suitable for substantial statewide or interstate travel.*

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[3] See *Highway Photograph 2 - SR-12 Eastbound Travel Lane Prior to Crash Location – Facing East*, and *Highway Photograph 3 - SR-12 Eastbound Travel and Dedicated Left Turn Lanes Near Crash Location – Facing East*.

[4] The total paved width, measured from the center of the fog line to the pavement edge, was found to be approximately 2-feet. Utah DOT provided additional measurements that excluded the pavement that had been tapered to match the side slope of the gravel shoulder, which indicated the paved shoulder had an effective width that varied between 7 and 12 inches. See *Highway Attachment – Paved Shoulder Width Measurements Along Eastbound SR-12 Near Crash Location*.

[5] In this area, U.S. Bicycle Route System Route 70 is carried by SR-12. See *Highway Attachment – United States Bicycle Route System Map Index – Routes 70 and 79*.

[6] See section 1.4.3.3.1 – Rural Principal Arterial System in "A Policy on Geometric Design of Highways and Streets". American Association of State Highway and Transportation Officials (AASHTO), 7th edition.

2. Movements between all, or virtually all, urban areas with populations over 50,000 and a large majority of those with populations over 25,000.

3. Integrated movement without stub connections except where unusual geographic or traffic flow conditions dictate otherwise (e.g., international boundary connections or connections to coastal cities).

In the more densely populated areas, this class of highway includes most (but not all) heavily traveled routes that might warrant multilane improvements in the majority of states; the principal arterial system includes most (if not all) existing rural freeways.

The principal arterial system is stratified into the following three classifications: (1) Interstate highways, (2) other freeways, and (3) other principal arterials.

For design purposes, freeways are treated as a separate functional class from other arterials.

4. HORIZONTAL AND VERTICAL ALIGNMENT

Horizontal Alignment - The bus first left the roadway approximately 1,306-feet into an approximate 2,143-foot-long right-hand horizontal curve.[7] The horizontal curve had a radius of approximately 5,730-feet.

Vertical Alignment - The bus first left the roadway approximately 220-feet into an approximate 800-foot-long crest vertical curve providing a transition between a 0.77% downgrade and a 1.60% downgrade. The roadway had a measured 0.7% downhill grade at the location where the bus first left the roadway.

5. HIGHWAY SIGNAGE AND MARKINGS

The roadway signs along the eastbound approach to the crash location were documented for a distance of approximately 8.4-miles using video.[8] The existing sign inventory for the 3-mile segment of SR-12 between milepost 7.5 and 10.5 was provided by UDOT.[9]

At the crash location the eastbound through travel lane and the eastbound dedicated left-turn lane were separated by an 8-inch-wide white solid line. The eastbound left turn-turn lane and the westbound through travel lane were separated by a 4-inch-wide double yellow solid line. The eastbound and westbound through travel lanes were separated from the paved shoulders by 4-inch-wide white solid lines. All of the lines were retroreflective.

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[7] See *Highway Attachment – Design and Reconstruction Plans for SR-12 in the Vicinity of the Crash Location*.
[8] See *Highway Attachment – Eastbound Approach Video – SR-12, MP 2 to 11*.
[9] See *Highway Attachment – Existing Sign Inventory Eastbound SR-12 MP 7.5 – 10.5*.

6. RUMBLE STRIPS

At the crash location a continuous line of longitudinal rumble strips was scored into the roadway at the same location as the painted centerline. Each rumble strip groove was approximately 8-inches long and 6-inches wide. The grooves were spaced approximately 4-inches apart and the depression of the grooves was approximately 0.5-inches deep.

No shoulder rumble strips were present along the widened section of the roadway accommodating the turn lanes in the area of the collision.[10] According to the UDOT, several standards govern the placement of shoulder rumble strips along roadways and sections of roadways.[11] The current UDOT standard drawing does not recommend the placement of shoulder rumble strips along bicycle routes unless the width of the paved shoulder is greater than 3-feet.

7. CLEAR ZONE

The side slopes in the area where the right-side bus tires left the eastbound travel lane were measured every 20-feet over the distance that the right tires of the bus were off the roadway and are summarized in **Table 1**.[12] The width of the clear zone[13] measured approximately 44-feet from the edge of the traveled way to the tree line south of the roadway.[14]

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[10] Rumble strips were present along the shoulders of the two-lane (non-turn lane) segments of SR-12.

[11] See *Highway Attachment – UDOT Rumble Strip Policy and UDOT Standard Drawings PV-6A - Rumble Strips Location Details and PV-7A – Typical Rumble Strip Shoulder Sequencing and Applications*.

[12] Clear zone foreslopes, also referred to as side slopes, are commonly expressed as a ratio of the horizontal distance over which one foot of vertical change occurs (H:V). For example, a foreslope of 4:1 would represent a horizontal distance of 4 feet for every 1 foot of change in elevation.

[13] According to the AASHTO Roadside Design Guide, 4th Edition, 2011, Clear Zone is defined as: *"The total roadside border area, starting at the edge of the traveled way, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. The desired width is dependent upon the traffic volumes and speeds and on the roadside geometry."*

[14] See *Highway Photograph 4 – Eastbound Clear Zone Along South Side of SR-12 in the Area of the Collision – Facing East*.

Table 1: Clear Zone Side slopes in Area of Vehicle Runoff

Distance from Vehicle Leaving Roadway (ft)	Foreslope Ratio (H:V)
0[1]	3.9:1
20	4.0:1
40	4.0:1
60	4.2:1
80	4.6:1
100	5.8:1
120	4.7:1
140	5.3:1
160	3.9:1
180[2]	4.7:1

1 Location where the front right tire of the bus first left the roadway

2 All bus tires were back on the roadway approximately 175 feet from the point where the front right tire left the roadway.

Side slopes should be designed to enhance roadway stability and to provide a reasonable opportunity for recovery for an out-of-control vehicle. Slopes adjacent to the flow of traffic may be identified as recoverable, non-recoverable, or critical. The American Association of State Highway and Transportation Officials' (AASHTO) *Roadside Design Guide* characterizes each of these slopes as follows:[15]

- Recoverable slope – motorists who encroach on recoverable slopes generally can stop their vehicles or slow them enough to return to the roadway safely. Recoverable slopes are 4:1 or flatter.

- Non-recoverable slope – a slope that is traversable but from which most vehicles will not be able to stop or return to the roadway easily. Vehicles on such slopes typically can be expected to reach the bottom. Slopes between 4:1 and 3:1 generally fall into this category.

- Critical slope – a slope on which an errant vehicle has a higher propensity to overturn. Slopes steeper than 3:1 generally fall into this category.

The average clear zone side slope in the area where the bus traveled off the roadway was 4.5:1 and would be characterized as recoverable.

[15] Roadside Design Guide, American Association of State Highway and Transportation Officials; 2011, 4th Edition; section 3.2.1 - Foreslopes.

8. PAVEMENT EDGE DROP-OFF

At the location where the bus first left the roadway, there was an approximate 3-inch drop between the surface of the eastbound paved shoulder and the surface of the gravel shoulder.[16] There was an approximate 2-$^{3}/_{4}$-inch drop between the surface of the westbound paved shoulder and the surface of the gravel shoulder.

Eight additional pavement edge drop-off measurements were taken along the eastbound and westbound shoulders of SR-12 in the area of the collision. These measurements were all found to be 2-inches or less.

On January 22, 2020, UDOT performed repairs to the eastbound pavement edge. The work included repairing the edge of the asphalt paved shoulder that was damaged by the bus during the collision sequence, as well as re-grading the gravel shoulder in the area.[17] This work eliminated any pavement edge drop-off.

9. HIGHWAY CONSTRUCTION AND MAINTENANCE HISTORY

SR-12 in the area of the collision was first added to the Utah State Highway System in the early 1900's, and its current configuration was a result of a full reconstruction in 1966. The most recent asphalt overlay occurred in 2011 with the application of a $^{1}/_{2}$-inch layer of hot mix asphalt and chip seal.[18] This resurfacing project encompassed 6.38 miles of SR-12 between milepost 7.26 and milepost 13.64. Following the chip seal, rumble strips were installed, and new pavement markings were applied. The latest surface treatment occurred on August 19, 2019 with the application of another chip seal. The centerline was painted on August 19, 2019, with the remaining lines (turn lane and fog lines) being painted on September 19, 2019. The turn lane arrows were scheduled to be painted in early November 2019. Although the 2019 chip seal was applied over the top of the rumble strips cut in 2011, they were still present and effective in providing both audible and vibratory feedback to investigators when driven upon. The roadway surfaces are routinely monitored, and preventative maintenance items are conducted as needed between reconstruction and resurfacing cycles to maintain pavement integrity.

10. ROADWAY SURFACE FRICTION

10.1. ASTM FRICTION NUMBERS

Due to the recent chip seal application to the road surface, any previous friction test results would no longer be applicable, and a new set of friction tests was requested. The Utah Department of Transportation (UDOT) performed post-crash friction tests on SR-12 in the vicinity of the crash

[16] It should be noted that the gravel shoulder at this location had been disturbed and compacted by the bus tires as the bus left the roadway. See *Highway Photograph 5 – Eastbound Pavement Edge Drop-off in Area of Collision – Facing East-Southeast*.
[17] See *Highway Photograph 6 – Repaired and Re-graded Eastbound Shoulder in Area of Collision – Facing East-Southeast*.
[18] See *Highway Attachment - Design and Reconstruction Plans for SR-12 in the Vicinity of the Crash Location*.

on October 2, 2019.[19] Testing was performed in both the eastbound and westbound directions, broken down into approximate 0.1-mile intervals between mileposts 9 and 12 at speeds ranging from 41.5 to 43.9 mph. The average skid number (SN)[20] for each test segment was adjusted to reflect the equivalent skid number at a test speed of 40 mph (SN_{40}). The SN_{40} values for each segment in both the eastbound and westbound directions are summarized in **Table 2**.[21]

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[19] See *Highway Attachment – Friction Test Data for SR-12 in Vicinity of Crash Location*. The tests were conducted in accordance with the methods established by the American Society for Testing and Materials (ASTM) standard E274 "*Standard Test Method for Skid Resistance of Paved Surfaces Using a Full-Scale Tire*", using calibrated equipment.

[20] A skid number (also referred to as a friction number, or surface friction number) represents the frictional properties of the pavement. These numbers are used to evaluate the skid resistance of the pavement relative to other pavements and/or to evaluate the change in skid resistance of the pavement with time.

[21] As indicated in the UDOT Pavement Management Manual, surface friction values are categorized using the following condition ratings: SN_{40} values greater than 45 are considered sufficient, SN_{40} values between 35 and 45 are approaching the need for further evaluation, and SN_{40} values below 35 need further evaluation. For additional information, see *Highway Attachment – Selected Pages from UDOT Pavement Management Manual*.

Table 2: Pavement Friction Numbers for Eastbound and Westbound SR-12 in the Vicinity of the Collision

Eastbound Travel Lane		Westbound Travel Lane	
Location (Mile Post)	Adjusted Skid Number (SN_{40})	Location (Mile Post)	Adjusted Skid Number (SN_{40})
9.01	52.1	11.98	70.4
9.12	51.8	11.88	69.7
9.21	52.6	11.78	61.7
9.31	48.7	11.69	63.7
9.41	41.3	11.59	63.5
9.51	42.7	11.48	64.3
9.61	42.9	11.39	63.7
9.72	37.3	11.29	64.9
9.81	43.4	11.18	62.7
9.91	44.6	11.09	63.8
10.02	42.1	10.99	45.2
10.12	47.9	10.89	47.9
10.22	48.4	10.79	49.1
10.32	46.3	10.68	46.6
10.42	48.4	10.59	46.8
10.52	49.5	10.49	49.6
10.62	50.1	10.39	48.1
10.72	48.1	10.28	50.1
10.82	50.5	10.19	51.1
10.92	50.6	10.09	49.8
11.02	41.9	9.98	48.1
11.12	59.8	9.88	47.5
11.22	58.6	9.79	48.7
11.32	61.1	9.68	47.9
11.42	59.5	9.59	46.2
11.52	59.2	9.49	46.9
11.62	60.9	9.39	46.1
11.72	61.4	9.29	47.1
		9.19	45.4
		9.09	46.9
		8.98	45.5

10.2. VEHICLE DECELERATION TESTING

The Utah Highway Patrol performed several vehicle deceleration tests (skid tests) using a passenger vehicle in the eastbound lanes of SR-12 at the crash location on September 27, 2019.[22] The test vehicle was equipped with a Vericom® Computers VC-3000 vehicle performance computer. Five skid tests were performed, and the test results are summarized in **Table 3**.[23]

Table 3: Summary of Skid Test Results Performed by Utah Highway Patrol.

Trial #	Speed (mph)	Distance (ft)	Time (sec)	Average Deceleration (g's)
1	44.2	79.4	2.41	0.836
2	39.8	58.4	1.99	0.912
3	41.1	63.0	2.09	0.896
4	4.7	62.4	2.06	0.902
5	41.6	65.4	2.05	0.925
			Overall Average:	0.894

11. ANNUAL AVERAGE DAILY TRAFFIC VOLUMES AND CLASSIFICAITON

The most recent available annual average daily traffic (AADT) volumes and vehicle use classifications for SR-12 in the vicinity of the collision was provided by UDOT.[24] AADT data was provided for ten full years between 2008 and 2018. The AADT volumes for each of these years in summarized in **Table 4**. The vehicle classification data for 2018 is summarized in **Table 5**.

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[22] According to published data, the coefficient of friction for a decelerating passenger car on a newly paved, dry asphalt surface will typically range between 0.65 and 1.00. – Northwestern University Traffic Institute – Traffic Accident Reconstruction, Volume 2. Lynn B. Fricke; Institute of Police Training and Management (IPTM) – Handout on Selected Drag Factors – Revised January 15, 2000; and Motor Vehicle Accident Reconstruction and Cause Analysis – Rudolf Limpert, Fourth Edition

[23] See *Highway Attachment – Passenger Vehicle Deceleration Test Results Performed by Utah Highway Patrol*.

[24] See *Highway Attachment – Traffic Volume and Classification Data for SR-12 in Vicinity of Crash Location*.

Table 4: Annual Average Daily Traffic Volumes on State Route 12 Near Crash Location

Year	Annual Average Daily Traffic
2008	2,897
2009	2,877
2010	2,800
2011	2,640
2012	2,460
2013	2,315
2014	2,305
2015	2,310
2016	2,385
2017	2,410
2018	2,320

Table 5: Vehicle Classification Counts on SR-12 near Crash Location

	2018	
Vehicle Classification	Volume	Percent (%)
Cars[1]	2,252	78.3%
Single Unit Trucks[2]	398	13.8%
Combination Unit Trucks[3]	227	7.9%

[1] This class includes: motorcycles, passenger cars, and other two-axle four-tire single-unit vehicles (such as pick-up trucks and vans)

[2] This class includes: buses, two-axle six-tire single-unit trucks, three-axle single-unit trucks, and four or more axle single-unit trucks

[3] This class includes: four or fewer axle single-trailer trucks, five-axle single-trailer trucks, six or more axle single-trailer trucks, five or fewer axle multi-trailer trucks, six-axle multi-trailer trucks, seven or more axle multi-trailer trucks, and unclassified vehicles

12. TRAFFIC AND FATAL CRASH SUMMARY

Traffic crash data was obtained for SR-12 in the vicinity of the collision for the 10-year period between 2009 and 2018.[25] During this 10-year period, 4 crashes occurred in the curved segment of road that included the crash location (Milepost 10.4), between Milepost 10.15 and Milepost 10.56. Of the 4 collisions that occurred during this timeframe on this curve, 2 were rear-end collisions resulting in possible to minor injuries.[26] Of the two remaining collisions, one involved a vehicle striking a domesticated animal resulting in possible injuries to the vehicle occupants, and the other involved a vehicle striking a wild animal with no report of injuries to the vehicle occupants. None of the collisions involved commercial motor vehicles, such as heavy trucks or busses, and none involved vehicles running off the roadway. The crashes for this segment of SR-12 are summarized in **Table 7**.

[25] See *Highway Attachment – 10-Year Crash History for SR-12 in Vicinity of Crash Location*.

[26] Crash information, including crash type and injury information, was captured from police reports.

Table 6: Crash Summary for SR-12 from 2009 to 2018 in Vicinity of Crash Location

Year	Fatal	Incapacitating Injury	Non-Incapacitating Injury	Possible Injury	No Injury	Total
2009	-	-	-	-	-	0
2010	-	-	-	-	-	0
2011	-	-	-	1	-	1
2012	-	-	-	-	-	0
2013	-	-	-	-	-	0
2014	-	-	-	-	-	0
2015	-	-	-	-	-	0
2016	-	-	-	1	-	1
2017	-	-	-	-	1	1
2018	-	-	1	-	-	1
Total	0	0	1	2	1	4

E. SCENE AND ROADWAY DOCUMENTATION

The crash scene was documented by Troopers from the Utah Highway Patrol (UHP) Major Crash Investigation Team (MCIT) who used a small unmanned aerial system (sUAS) to photograph the crash scene and surrounding area from an aerial perspective. A highly accurate 3-dimensional model was produced from the sUAS photos. Ground based photographs were also taken.

F. GUARDRAIL DAMAGE DOCUMENTATION

The AASHTO *Roadside Design Guide* describes blocked-out strong-post W-beam guardrail as follows:[27]

> *Strong-post W-beam is the most common barrier system in use today. It consists of wood posts and wood blockouts or steel posts… that support a W-beam rail element blocked out from the posts with routed timber or composite blockouts. These blockouts minimize vehicle snagging on the posts and reduce the likelihood of a vehicle vaulting over the barrier by maintaining the rail height during the initial stages of post deflection. Resistance in this and all strong-post systems results from a combination of tensile and flexural stiffness of the rail and the bending or shearing resistance of the posts. The blockouts are typically timber or recycled plastic with a 150 mm [6 in] width to match each post's dimensions.*

[27] Roadside Design Guide, American Association of State Highway and Transportation Officials; 2011, 4th Edition; section 5.4.1.6 – Blocked-Out W-Beam (Strong Post).

An approximate 1,312-foot-long section of blocked-out strong post W-beam guardrail had been installed along the westbound travel lane. The guardrail began at a point approximately 90 feet east of the centerline of East Fork Road and terminated at a point approximately 240-feet east of the entrance to the rest area. Both ends of the guardrail were equipped with energy-absorbing terminals. The longitudinal centerline of the W-beam guardrail was mounted approximately 21-inches above the surface of the gravel shoulder. The guardrail posts were installed at a spacing of 6-feet 3-inches on center. The two posts nearest each end were steel breakaway posts spot-welded to their bases. The next four posts in from each end were wood breakaway posts designed to break off near ground level upon being impacted. The remaining 199 posts were steel strong posts.

During the rollover portion of the collision sequence, the bus impacted the west end of the guardrail and end terminal.[28] The two endmost steel breakaway posts (posts 1 and 2)[29] were broken away from their bases at the spot-welds. The next three wooden breakaway posts (posts 3, 4, and 5) were broken off at ground level and were found lying on the ground several feet to the east of their original locations. The fourth wooden breakaway post (post 6) was lodged in the boarding door side of the bus forward of the rear axle. The first two steel strong posts (posts 7 and 8) were bent down and pointed generally toward the southeast. Post 7's composite blockout was damaged but remained attached to the steel post. Post 8's composite blockout was detached from the post and the majority of it was missing. The third steel strong post (post 9) remained nearly upright but had been moved slightly to the southeast. Post 9's composite blockout remained attached to the steel post, but the W-beam rail had been pulled down and away from the composite blockout.[30] The W-beam guardrail remained attached to the remainder of the posts. The westernmost approximate 50-feet of W-beam guardrail was broken away from the first nine posts and crushed downward onto and toward the ground. The energy absorbing terminal and the last several feet of guardrail (within the terminal) were folded to the southeast against the rest of the guardrail, which was lying on the ground.

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[28] See *Highway Photograph 7 – West End of Guardrail and End Terminal Showing Collision Damage*.
[29] For the purposes of this report, the posts will be given a number starting at the west end of the guardrail system, with the post numbers increasing incrementally toward the east.
[30] See *Highway Photograph 8 – Collision Damage to West End of Blocked-Out Strong-Post W-Beam Guardrail*.

G. DOCKET MATERIAL

The following attachments and photographs are included in the docket for this investigation:

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Highway Attachment –	Paved Shoulder Width Measurements Along Eastbound SR-12 Near Crash Location
Highway Attachment –	United States Bicycle Route System Map Index – Routes 70 and 79
Highway Attachment –	Design and Reconstruction Plans for SR-12 in the Vicinity of the Crash Location
Highway Attachment –	Eastbound Approach Video – SR-12, MP 2 to 11
Highway Attachment –	Existing Sign Inventory Eastbound SR-12 MP 7.5 – 10.5
Highway Attachment –	UDOT Rumble Strip Policy and UDOT Standard Drawings PV-6A - Rumble Strips Location Details and PV-7A – Typical Rumble Strip Shoulder Sequencing and Applications
Highway Attachment –	Friction Test Data for SR-12 in Vicinity of Crash Location
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END OF REPORT

Steve Prouty, P.E.
Senior Highway Engineer