HIGHWAY FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

Houston, TX

HWY15FH010

(17 pages)

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

HIGHWAY FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

A. CRASH INFORMATION

Location:	Eastbound Interstate 610 (I-610) overpass above Telephone Road, Houston, Harris County, Texas
Vehicle #1:	Houston Independent School District (HISD) 47-passenger 2009 International School Bus
Vehicle #2:	2004 Buick LeSabre passenger vehicle
Date:	September 15, 2015
Time:	7:03 a.m. local time
NTSB #:	**HWY15FH010**

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 THE HIGHWAY FACTORS INVESTIGATION

The Highway Factors Factual Report provides the reader with a factual record of the highway and train conditions that existed at the time of the crash. The broad areas covered in the Highway Factors Factual Report include prefatory data, highway data, bridge rail data, seating chart of HISD school bus, and post-crash actions.

1. Prefatory Data

1.1 Crash Location

The crash occurred on the eastbound IH-610 overpass above Telephone Road at approximately Mile Marker 33 in Houston, Harris County, Texas. **Figure 1** is a crash map that illustrates the crash location was approximately 6 miles southeast of downtown Houston. A 47-passenger 2009 International Houston Independent School District (HISD) bus occupied by four HISD students including the driver was traveling eastbound on South Loop East Freeway (IH-610). The HISD school bus had entered eastbound IH-610 at South Wayside Drive and was transporting the four HISD students to Furr High School.

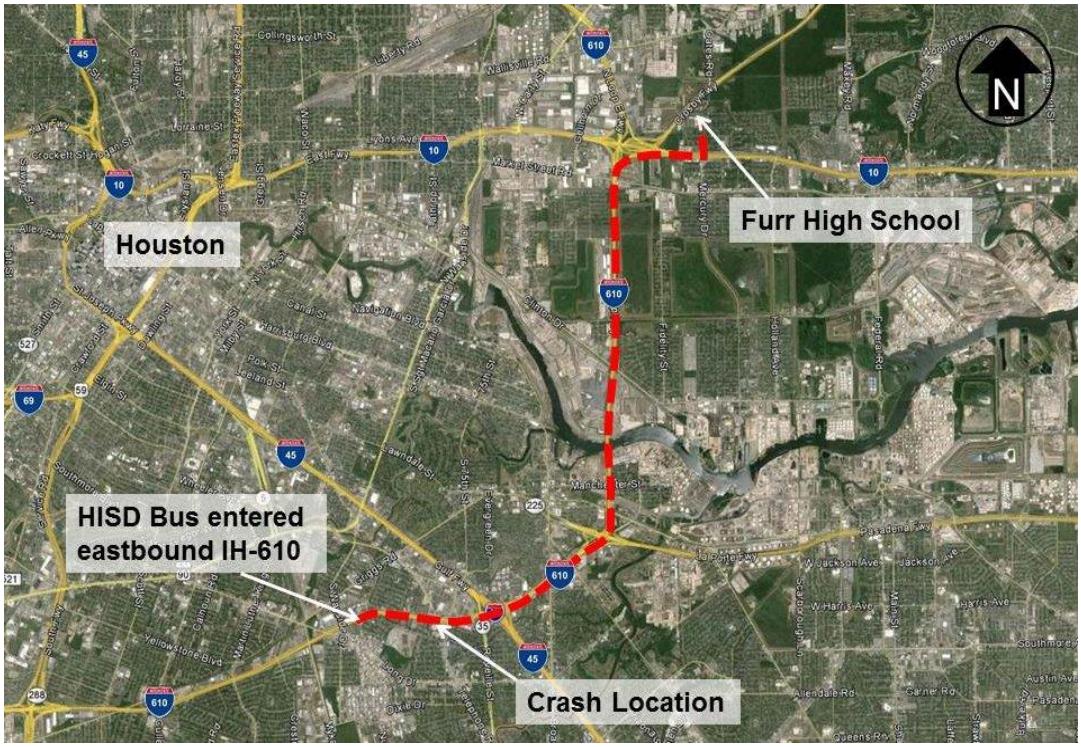


Figure 1 – Crash map

1.2 24-Hour Traffic Count and Vehicle Classification Study

Table 1 summarizes a 24-hour traffic count and vehicle classification study conducted by the Texas Department of Transportation (TxDOT) Houston District on October 27, 2015, in the vicinity of the crash on eastbound IH-610.

Table 1 – 24-hour traffic count and vehicle classification study on eastbound IH-610

FHWA Vehicle Classification	Volume	Percent (%)	Volume (Percent) of Single Unit Vehicles[1]	Volume (Percent) of Heavy Vehicles[2]
Class 1 **Motorcycles**	122	0.2%	-	-
Class 2 **Passenger Cars**	33,518	46.3%	46.3%	-
Class 3	33,410	46.2%	46.2%	-

[1]Single unit vehicles are considered Class 2 (passenger cars) through Class 3 (other two-axle, four-tire single unit vehicles).
[2]Heavy vehicles are considered Class 5 (two-axle, six-tire, single-unit trucks) through Class 13 (seven or more axle multi-trailer trucks).

Other Two-Axle, Four-Tire Single Unit Vehicles				
Class 4 **Buses**	184	0.3%	-	-
Class 5 **Two-Axle, Six-Tire, Single-Unit Trucks**	849	1.2%	-	1.2%
Class 6 **Three-axle Single-Unit Trucks**	903	1.2%	-	1.2%
Class 7 **Four or More Axle Single-Unit Trucks**	86	0.1%	-	0.1%
Class 8 **Four or Fewer Axle Single-Trailer Trucks**	227	0.3%	-	0.3%
Class 9 **Five-Axle Single-Trailer Trucks**	3,005	4.2%	-	4.2%
Class 10 **Six or More Axle Single-Trailer Trucks**	25	0.0%	-	0.0%
Class 11 **Five or Fewer Axle Multi-Trailer Trucks**	6	0.0%	-	0.0%
Class 12 **Six-Axle Multi-Trailer Trucks**	1	0.0%	-	0.0%
Class 13 **Seven or More Axle Multi-Trailer Trucks**	2	0.0%	-	0.0%
Totals	72,338	100%	66,928 (92.5%)	5,104 (7.0%)

2. Highway Data

2.1 Highway Design

The eastbound side of IH-610 consisted of four travel lanes and left and right paved shoulders. The total width of the four travel lanes was approximately 51 feet and the width of the right paved shoulder was approximately 8.5 feet.

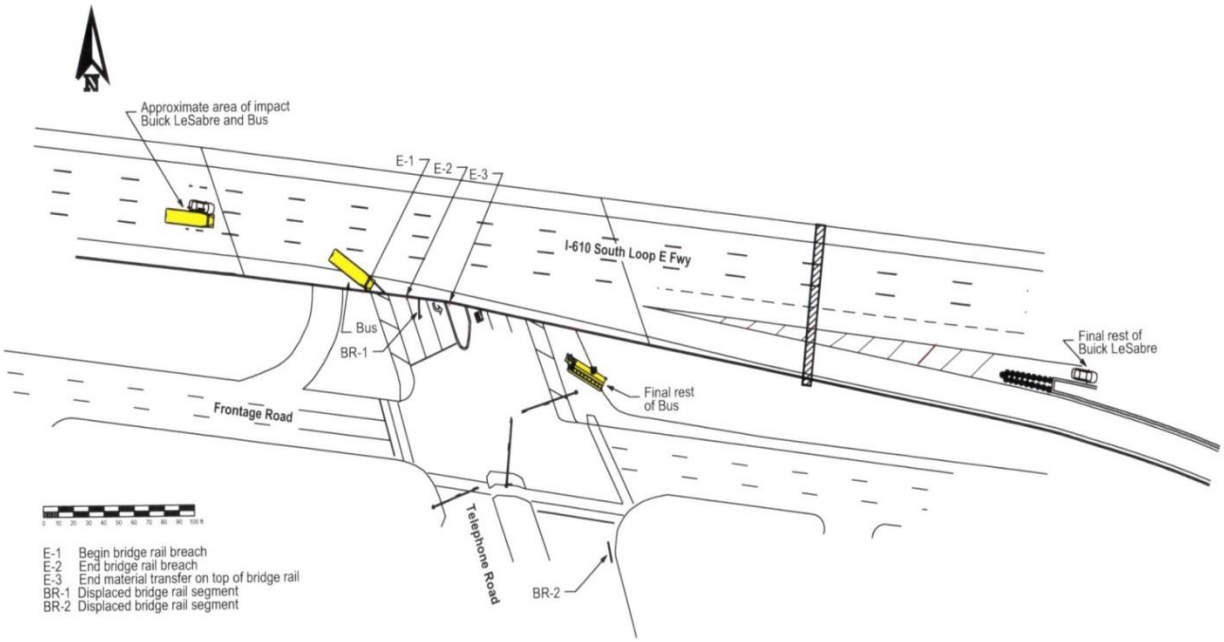
2.2 Crash Scene Description and Diagram

The HISD school bus occupied by four students plus the driver was traveling eastbound on South Loop East Freeway (IH-610) in the right center lane[3] of the four-lane limited access highway. The bus had entered eastbound IH-610 at South Wayside Drive. After traveling approximately one mile on eastbound IH-610, the school bus approached the overpass above Telephone Road. About the same time, a 2004 Buick LeSabre passenger vehicle was traveling

[3]The right center lane is considered the second lane viewed by the driver in the direction of travel looking from right to left.

eastbound on IH-610 in the left center lane[4] at an estimated speed of 69 mph.[5] As the Buick overtook the school bus, the Buick departed its lane of travel to the right and collided with the school bus in the vicinity of the left front wheel. The school bus moved to the right, traversed the right travel lane[6] and shoulder, and impacted the bridge rail[7] at an approximate 28 degree angle[8]. The bus overrode the concrete portion of the bridge rail; and breached the metal railing along the top of the concrete parapet leaving an approximate 30 foot long opening in the metal rail before falling approximately 21 feet onto Telephone Road. The bus came to rest on its left side facing westward on the east side of Telephone Road. The Buick came to rest on the right shoulder of IH-610 beyond the overpass.

Figure 2 illustrates a crash scene diagram showing the approximate area of impact between the passenger vehicle and the bus, the approximate point of impact in which the bus impacted the bridge rail, and the final rest positions of the bus and passenger vehicle. **Figure 2** also illustrates the approximate beginning and end points of the bridge rail breach, the approximate end of material transfer on top of the bridge rail, and the final rest positions of the displaced bridge rail segments.



[4]The left center lane is considered the third lane viewed by the driver in the direction of travel looking from right to left.

[5]The estimated speed of 69 mph for the passenger vehicle was determined through an NTSB analysis of the HISD school bus video.

[6]The right lane is considered the first lane viewed by the driver in the direction of travel looking from right to left.

[7]The bridge rail was described as a Type C4 (modified) railing that consisted of a one foot and six inch (1'-6") high concrete parapet with metal posts and rail bringing the total design height to three feet (3').

[8]The 28 degree angle is the angle turned from a line parallel with the bridge rail to a line parallel with the tire friction marks. The tire friction marks were left by the HISD school bus and found on the right shoulder.

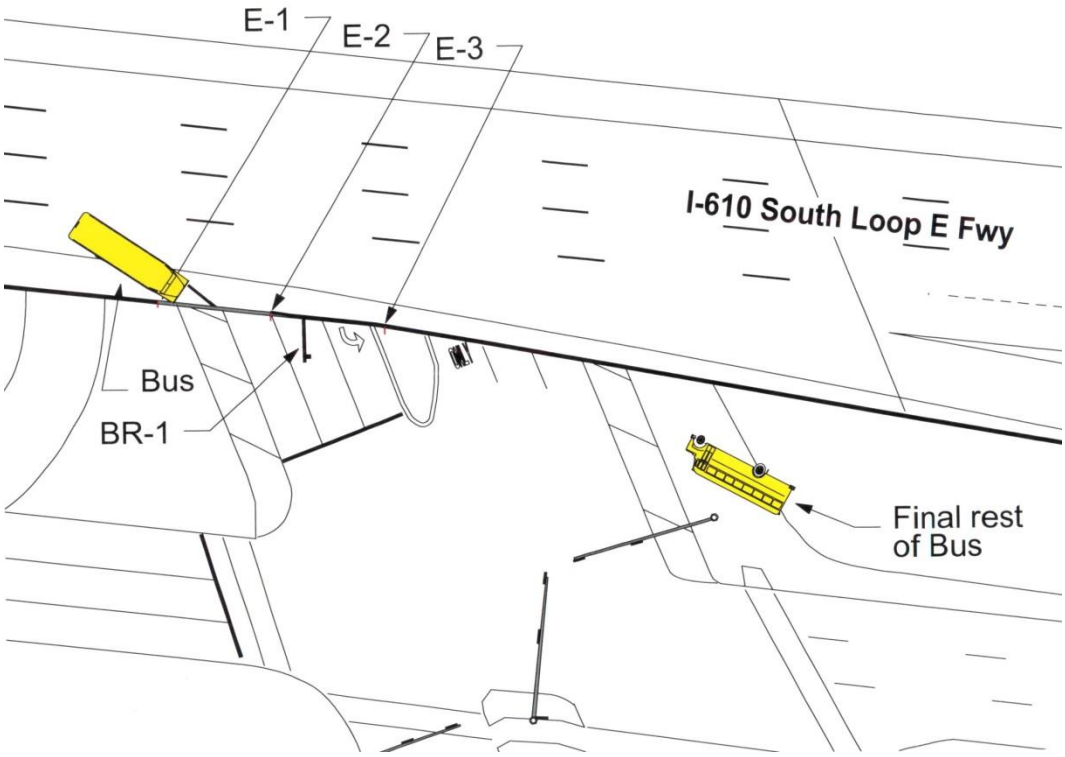


Figure 2 – Crash scene diagram

2.3 Speed Limit

The speed limit for eastbound IH-610 in the vicinity of the crash was 60 miles per hour (mph).

2.4 85th Percentile Speed

Table 2 summarizes an 85th percentile speed study[9] conducted by the Texas Department of Transportation (TxDOT) Houston District on October 21, 2015 in the vicinity of the crash on eastbound IH-610.

[9]The 85th percentile speed is the speed at which 85% of the vehicle traffic is traveling either at or below that speed or, 15% of the vehicle traffic is traveling above that speed.

Table 2 – 85th percentile speed study on eastbound IH-610

Automobiles		
Miles Per Hour	**Number of Automobiles**	**Cumulative Total**
76 mph	1	155
73 mph	1	154
71 mph	1	153
70 mph	2	152
69 mph	2	150
68 mph	2	148
67 mph	3	146
66 mph	3	143
65 mph	3	140
64 mph	12	137
63 mph	12	125
62 mph	12	113
61 mph	14	101
60 mph	8	87
59 mph	9	79
58 mph	10	70
57 mph	6	60
56 mph	6	54
55 mph	1	48
54 mph	10	47
53 mph	3	37
52 mph	1	34
51 mph	7	33
50 mph	2	26
49 mph	4	24
48 mph	1	20
47 mph	1	19
46 mph	6	18
45 mph	1	12
44 mph	1	11
43 mph	3	10
42 mph	1	7
41 mph	3	6
40 mph	1	3
36 mph	1	2
34 mph	1	1
Top Speed Automobiles = 76 mph **Total Automobiles = 155** **85th Percentile Total Automobiles = 132** **85th Percentile Speed Automobiles = 64 mph**		

2.5 Fatal Accident History

The TxDOT Houston District provided a fatal accident history from 2010 to 2015 in the vicinity of the crash that revealed one fatality occurred on December 14, 2012 in which a vehicle overturned traveling westbound on IH-610. A contributing cause to the crash was the driver's failure to drive in a single lane due to the influence of alcohol and drugs.

Another fatal accident occurred on June 14, 2014 on the service/frontage road of IH-610 at Telephone Road. The fatal accident involved a motor vehicle striking a traffic signal pole. The fatal accident did not occur on the main travel lanes of IH-610.

3. Bridge Rail Data

3.1 Type C4 (Modified) Bridge Railing

The IH-610 overpass above Telephone Road was constructed in 1970 and consisted of four spans. The Type C4 (modified) bridge railing consisted of a one foot, six inch (1' - 6") high concrete parapet with metal posts and rail bringing the total height to three feet (3'). A three inch bonded overlay had been applied to the bridge deck in 1987, bringing the concrete parapet height to one foot, three inches (1' - 3") and total rail height to two feet, nine inches (2' - 9"). The typical metal post spacing was ten feet.

The rail posts were attached to the concrete parapets using base plates with slotted holes, anchored using two U-bolts and four hexagonal nuts and steel washers. The posts were seated on elastomeric pads, one pad at some locations and up to three pads at other locations. The design plans required that all metal components of the rail be galvanized, including the anchor bolts.

NTSB investigators requested an official interpretation of the Type C4 (modified) bridge railing by the Federal Highway Administration (FHWA) Office of Safety in terms of its acceptance on the National Highway System. FHWA's response was documented in an email to NTSB investigators dated November 6, 2015:

> *"As the subject bridge was built in 1970, the railings were expected to be designed in conformance with the then-current AASHTO bridge specifications. Though there was no requirement of bridge railing full-scale crash-testing, this design procedure only considered horizontal loads on the rails applied at various lengths and elevations to produce a railing with adequate strength to withstand those loads. In 1986, FHWA policy was changed to state that bridge rails should meet the crash test criteria contained in NCHRP Report 350. The Texas*

Department of Transportation (TxDOT) evaluated the structural design aspects of the C4 rail and compared them to another crash-tested railing, the T4 rail. TxDOT concluded that the C4 rail also met the criteria of Test Level 3 (TL-3) in NCHRP Report 350. TxDOT does not request FHWA eligibility letters for their bridge railings individually, nor is it a requirement, but bridge railing details are incorporated into the State standards which are subject to FHWA review and approval."

A description of Test Level 3 (TL-3) in NCHRP Report 350[10] is summarized below:

- Successful tests of a 1,800 pound car impacting a barrier at an angle of 20 degrees and a 4,400 pound pickup truck impacting a barrier at an angle of 25 degrees, both at speeds of 62 mph.

The total weight of the HISD school bus involved in the crash was approximately 16,300 pounds[11]. The Type C4 (modified) bridge railing in its designed condition would not be expected to be able to perform adequately to withstand a collision of the HISD school bus weighing approximately 16,300 pounds.

Figure 3 illustrates a view of the bridge rail after impact by the HISD school bus looking to the southeast.

[10]National Cooperative Highway Research Program NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, H.E. Ross, Jr, D.L. Sicking, and R.A. Zimmer, Texas Transportation Institute, Texas A&M University System, College Station, Texas and J.D. Michie, Dynatech Engineering Inc., San Antonio, Texas, Prepared for the Transportation Research Board, Washington, D.C., 1993.
[11]The total weight includes 15,600 pounds for the bus only and 700 pounds for the passengers and driver.

Figure 3 – View of the bridge rail after impact by the HISD school bus looking to the southeast

3.2 Bridge Inspection Records

NTSB investigators reviewed the bridge inspection reports of the IH-610 overpass above Telephone Road and found a photograph taken on December 27, 2012. The photograph is shown in **Figure 4** and depicts severe spalling with exposed reinforcing steel at the anchor bolt connections. The location of the severe spalling and exposed reinforcing steel is located along the south edge of eastbound IH-610 immediately east of where the HISD bus surmounted the bridge rail on September 15, 2015.

Date	12/27/2012
County	102
Cont-Sec	0271-16
Structure	363

Impact Damaged Bridge Rail

Looking: Northeast

NOTE: Several areas of moderate to severe impact damage to Bridge Railing. Severe spalling with exposed reinforcing steel @ anchor bolt connections.

Figure 4 – Photograph taken on December 27, 2012 depicting severe spalling with exposed reinforcing steel at the anchor bolt connections

4. Seating Chart of HISD School Bus

The 47-passenger HISD school bus had 8 rows of seats on each side of the bus and each seat was capable of carrying a maximum of 3 students. The half seat at the back of the bus on the driver side was capable of carrying a maximum of 2 students. The HISD school bus was equipped with a standard lap seat belt for each of its passengers. Each seat was equipped with three lap belts.[12] The driver's seat was equipped with a three-point seat belt. At the time of the crash, the four HISD students were seated and not wearing seat belts, however, the driver was wearing the three-point seat belt. The HISD provided a copy of its seat policy to NTSB investigators:

> *"The District's rules for transportation in District buses or other vehicles shall include a requirement that all riders remain seated and, if available, wear three-point seat belts."*

Figure 5 is a seating chart of the HISD school bus that illustrates the gender, age, injury level, and whether the passengers were ejected from the bus. The two HISD students who were ejected from the bus were the same two students who were fatally injured in the crash.

[12]With only two lap belts available for the half seat location at the rear of the bus.

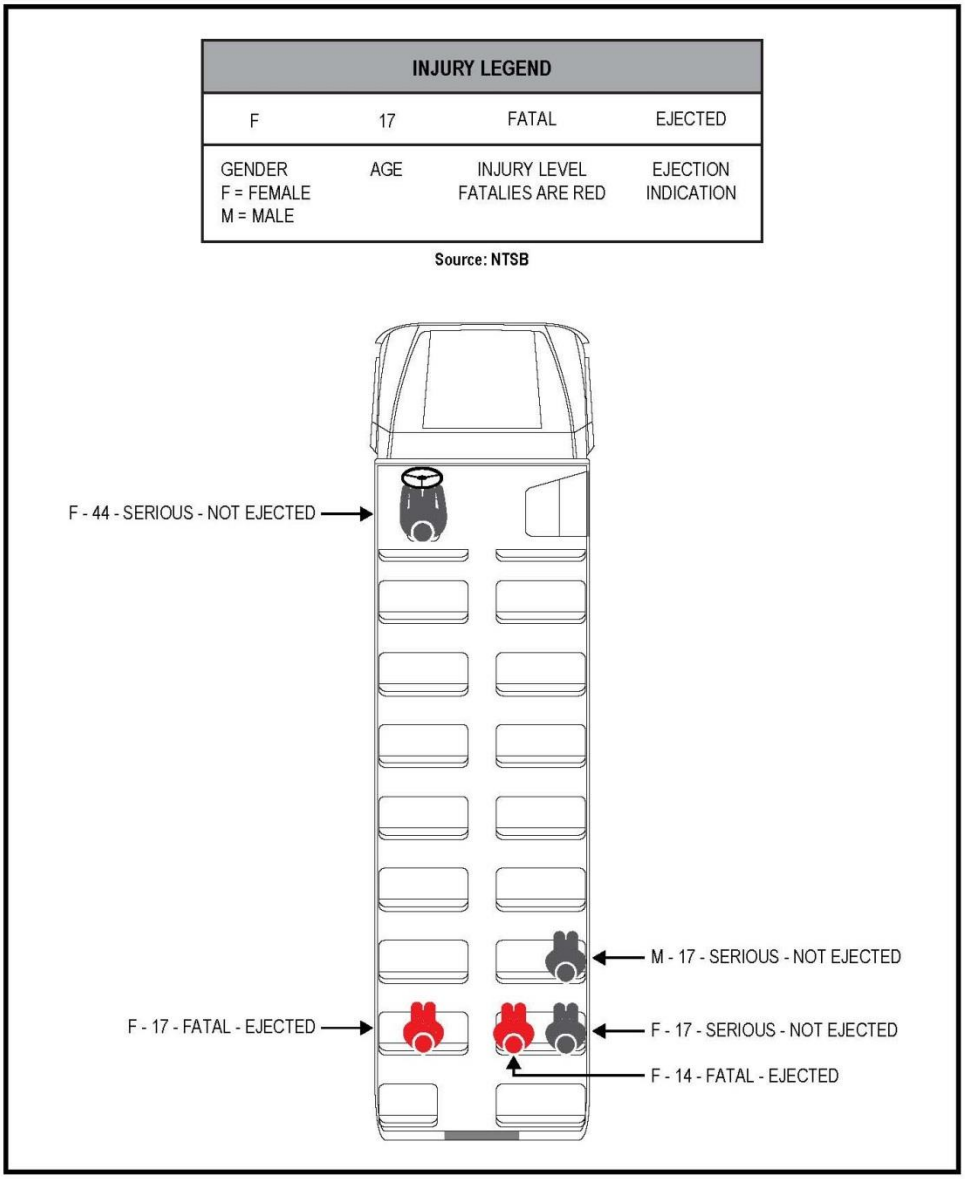


Figure 5 – Seating chart of HISD school bus involved in the crash

5. Post-Crash Actions

5.1 New Single-Sloped Concrete Traffic Rail

Figure 6 illustrates a new single-sloped concrete traffic rail installed by the TxDOT Houston District after the crash, looking to the southeast. The height of the new single-sloped concrete traffic rail was three feet (3'). The new rail was installed along the entire south edge of eastbound IH-610 over Telephone Road for a distance of approximately 300 feet. The new rail was completed on December 15, 2015. Since the new single-sloped concrete traffic rail was

used in a retrofit condition, meaning the existing rail was removed and a new rail was installed, TxDOT certified the new rail to Test Level 3 (TL-3). However, if the single-sloped concrete traffic rail was used in new construction, TxDOT would certify the new rail to Test Level 4 (TL-4)[13].

Figure 6 – New single-sloped concrete traffic rail installed by the TxDOT Houston District after the crash looking to the southeast (Source: TxDOT Houston District)

5.2 TxDOT Bridge Damage Assessment Report

TxDOT conducted a thorough Bridge Damage Assessment Report to determine if there was a systemic anchor bolt corrosion issue or any other widespread deterioration issues with the Type C4 (modified) bridge rail.

Based on existing repairs, TxDOT found there had been a previous severe impact to the bridge rail in the same location of where the HISD school bus had surmounted the bridge rail on September 15, 2015. TxDOT could not determine when the previous severe impact occurred because the TxDOT Districts (a total of 25 Districts statewide) do not keep maintenance records that document prior bridge railing improvements and cost of repair. The previous severe impact resulted in significant damage to the concrete parapet and the anchor bolts. There was evidence

[13]Test Level 4 (TL-4) can be summarized as the successful test of a 22,000 pound single-unit truck impacting a barrier at an angle of 15 degrees, at speeds of 56 mph.

that the bolts were bent over by the impact, then bent back and reused rather than being replaced. The previous severe impact also resulted in significant damage at the posts. Repair mortar had been used to patch spalls at the posts due to the impact. The quality of the repair mortar was inferior in overall quality to the original concrete and was completely carbonated in some locations, which significantly increased the corrosion potential for the embedded steel. The combination of compromised galvanizing, poor quality spall repair material, and contaminants ponding around the anchor bolts within the slotted holes resulted in severe corrosion and section loss in the exact location that the HISD school bus hit on September 15, 2015.

TxDOT also found that rail segments not previously damaged due to major vehicular impact showed no evidence of significant corrosion or reduced capacity from deterioration. Even in areas where previous vehicular impact caused only minor to moderate damage the galvanizing was still effectively preventing corrosion from occurring in the metal rail components, including the U-bolt anchors.

TxDOT concluded that they believe there was no systemic deterioration issues associated with the Type C4 (modified) bridge rail or other similar rail types where the components had been galvanized, even where contaminants pooled around anchor bolts in slotted holes. TxDOT intends to provide direction to all 25 Districts that the proper procedure for repairing damaged rail is to install new anchor bolts as opposed to bending back and re-using damaged bolts.

5.3 TxDOT Internal Changes

As a result of the crash, two issues were identified that are summarized below with a response by TxDOT in an email to NTSB investigators dated January 28, 2016:

> **Issue #1**: Providing direction to all TxDOT Districts that the proper procedure for repairing damaged rail is to install new anchor bolts as opposed to bending back and re-using damaged bolts.
>
> **TxDOT Response**: TxDOT Bridge Division will include information on the reuse of anchor bolts when repairing damaged concrete bridge rails in the next update of the Concrete Repair Manual. This manual is updated every two years. The next update of this manual is scheduled for spring of 2017. As an interim measure, TxDOT Bridge Division will make a presentation at the next available TxDOT Directors of Maintenance meeting hosted by the Maintenance Division. In conjunction with this meeting, Directors of Maintenance will be provided with materials for distribution to their employees on this issue.
>
> **Issue #2:** Developing a maintenance record that documents bridge railing improvements and cost of repair in all TxDOT Districts.

TxDOT Response: TxDOT Bridge Division is currently working to deploy InspecTech software for collecting bridge inspection data. This will replace the current in-house software, Pontex. The new software is expected to be deployed by the end of calendar year 2016. After the initial roll out, TxDOT will establish procedures for making use of the capabilities for this software for collecting and documenting bridge railing improvement projects. Expected timeframe for this secondary deployment would be one year after the initial deployment. Educational materials will be developed and distributed on the requirement. This will allow TxDOT to capture bridge maintenance activities including railing improvements and associated cost data.

E. DOCKET MATERIAL

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

LIST OF ATTACHMENTS

Highway Attachment 1 – 24-Hour Traffic Count and Vehicle Classification Study conducted by the Texas Department of Transportation (TxDOT) Houston District on October 27, 2015

Highway Attachment 2 – 85th Percentile Radar Motor Vehicle Speed Study conducted by the Texas Department of Transportation (TxDOT) Houston District on October 21, 2015

Highway Attachment 3 – Contract Plans for the Type C4 (modified) Bridge Railing

Highway Attachment 4 – Email from the Federal Highway Administration (FHWA) Office of Safety to NTSB Investigators dated November 6, 2015

Highway Attachment 5 – Photographs taken on December 27, 2012 of the IH-610 Overpass above Telephone Road obtained from the Texas Department of Transportation (TxDOT) Bridge Inspection Reports

Highway Attachment 6 – Contract Plans for the New Single-Sloped Concrete Traffic Rail

Highway Attachment 7 – Texas Department of Transportation (TxDOT) Bridge Damage Assessment Report for the IH-610 Overpass above Telephone Road dated December 15, 2015

Highway Attachment 8 – Email from the Texas Department of Transportation (TxDOT) to NTSB Investigators dated January 28, 2016

LIST OF PHOTOGRAPHS

Highway Photo 1 – View of the bridge rail after impact by the Houston Independent School District (HISD) bus looking to the southeast

Highway Photo 2 – View of the new single-sloped concrete traffic rail installed by the Texas Department of Transportation (TxDOT) Houston District after the crash looking to the southeast (Source: TxDOT Houston District)

Highway Photo 3 – View of approximate 30 foot long opening in the metal rail from the view of Telephone Road looking up to IH-610 looking to the north

Highway Photo 4 – View of the hanging metal post in immediate aftermath of impact at Post 1 of Span 2 on the IH-610 overpass

Highway Photo 5 – View of the U-bolts at Post 2 of Span 2 on the IH-610 overpass

Highway Photo 6 – View of the U-bolts at Post 3 of Span 2 on the IH-610 overpass

Highway Photo 7 – View of the damage to the left front corner and left side of the Houston Independent School District (HISD) bus

Highway Photo 8 – View of the damage to the left rear corner and left side of the Houston Independent School District (HISD) bus

Highway Photo 9 – View of the damage to the right rear corner and right side of the Houston Independent School District (HISD) bus

Highway Photo 10 – View of the damage to the right front corner and right side of the Houston Independent School District (HISD) bus

Highway Photo 11 – View of the damage to the right side of the Buick LeSabre passenger vehicle

END OF REPORT

Dan Walsh, P.E. - Senior Highway Factors Investigator