National Transportation Safety Board

Highway Accident Brief

Passenger Vehicle/School Bus Collision and Roadway Departure

Accident Number:	HWY15FH010
Accident Type:	Passenger vehicle/school bus collision and roadway departure
Location:	Eastbound Interstate 610 (I-610) overpass above Telephone Road, Houston, Harris County, Texas
Date and Time:	September 15, 2015; about 7:03 a.m.
Vehicles:	47-passenger 2009 International school bus 2004 Buick LeSabre passenger vehicle
Fatalities:	2
Injuries:	3

Crash Description

On Tuesday, September 15, 2015, about 7:03 a.m. local time, a 47-passenger 2009 International school bus, operated by the Houston Independent School District (HISD) and occupied by a 44-year-old female driver and four HISD students aged 14 to 17, was traveling eastbound on South Loop East Freeway (I-610) in lane 3 of the four-lane limited access highway at an estimated speed of 55 mph.[1] The school bus had entered eastbound I-610 at South Wayside Drive and was en route to Furr High School. (See figure 1.) After traveling approximately 1 mile on eastbound I-610, the school bus approached the overpass above Telephone Road. About the same time, a 2004 Buick LeSabre passenger vehicle, driven by a 29-year-old female, was traveling eastbound in lane 2 on I-610 at an estimated speed of 69 mph.[2] As the Buick overtook the school bus, it departed lane 2 to the right and collided with the school bus in lane 3. The Buick struck the school bus near the bus's left front wheel. The school bus moved to the right, departed lane 3, traversed lane 4 and the right shoulder, and struck the bridge rail at an approximate 28-degree angle.[3] The bus overrode the concrete portion of the bridge rail and breached the metal railing along the top of the concrete parapet, leaving an approximately

[1] (a) For the purposes of this brief, the four eastbound lanes are considered lanes 1 through 4, with the leftmost lane in the direction of travel being lane 1 and the rightmost lane being lane 4. (b) The 55-mph speed estimate for the school bus was determined through an NTSB analysis of the HISD school bus video.

[2] The 69-mph speed estimate for the Buick LeSabre was determined through an NTSB analysis of the HISD school bus video.

[3] (a) The bridge rail was described as a Type C4 (modified) railing. (b) The 28-degree angle is turned from a line parallel with the bridge rail to a line parallel with the tire friction marks. The tire friction marks left by the HISD school bus were found on the right shoulder.

3-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 I-610 beyond the overpass.

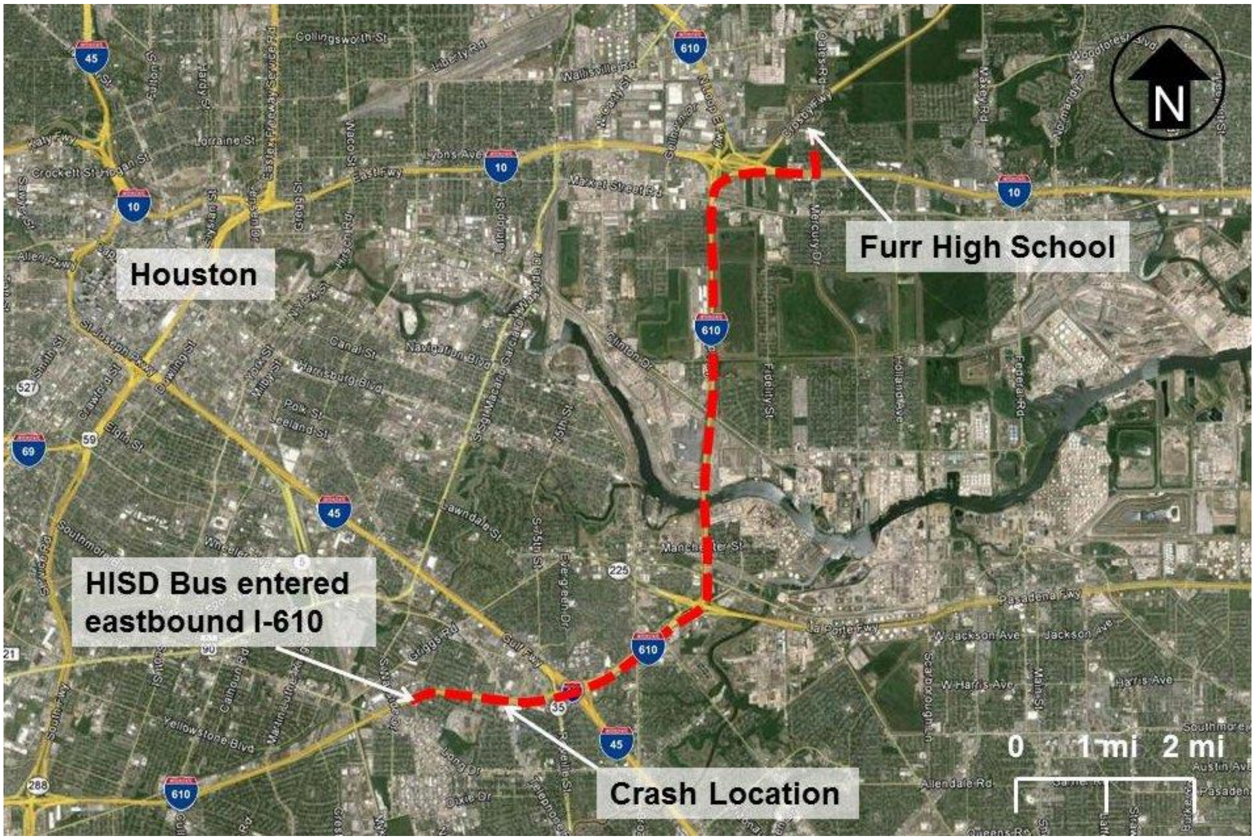

Figure 1. Route of HISD school bus (Source: Google Earth modified)

As a result of the crash, two student passengers on the bus died, and the remaining two students received serious injuries. The driver of the HISD school bus received serious injuries. The driver of the Buick was not injured.

The weather was clear, there was no precipitation at the time of the crash, and the road surface was dry. Winds were reported light, at 4 mph. Civil twilight began at 6:42 a.m., and sunrise occurred at 7:06 a.m. At the time of the crash, the sun was approximately 1.5 degrees below the horizon.

Highway Information

The crash occurred on the eastbound I-610 overpass above Telephone Road near mile marker 33 in Houston. The crash site is about 6 miles southeast of downtown Houston. Eastbound I-610 consists of four travel lanes and left and right paved shoulders. The total width of the four travel lanes is approximately 51 feet, and the total width of the left and right paved shoulders is approximately 17 feet. The posted speed limit for eastbound I-610 in the vicinity of the crash is 60 mph. On October 27, 2015, the Texas Department of Transportation (TxDOT) Houston District conducted a 24-hour traffic count in the vicinity of the crash that revealed that 72,338 vehicles traveled on eastbound I-610, including 66,928 (92.5 percent) passenger cars and other two-axle, four-tire, single-unit vehicles; 5,104 (7 percent) heavy vehicles; 184 (0.3 percent) buses; and 122 (0.2 percent) motorcycles.[4] The TxDOT Houston District conducted a speed study on October 21, 2015, on eastbound I-610 in the vicinity of the crash that revealed an 85th percentile speed of 64 mph.[5] According to the TxDOT Houston District, from 2010 to 2015, one fatal crash occurred in the vicinity on December 14, 2012, which involved a vehicle overturning while traveling westbound on I-610.[6]

Figure 2 is a crash scene diagram showing the following features of this crash: approximate area of impact between the Buick LeSabre and the HISD school bus; approximate point of the school bus's impact with the bridge rail; and final rest positions of the school bus and the Buick.

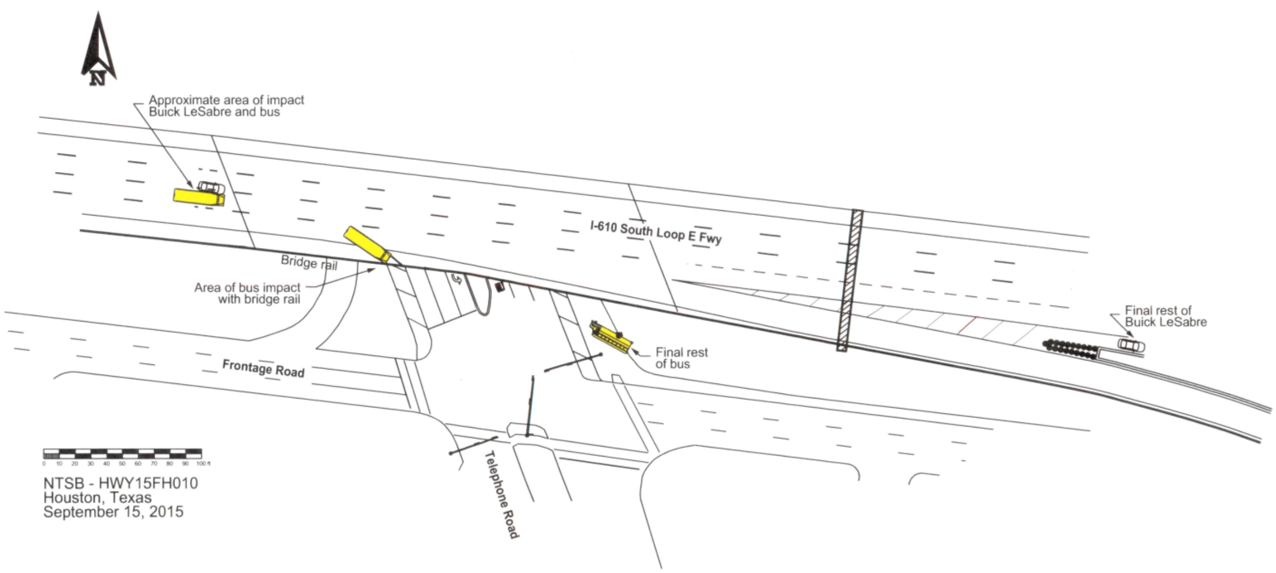

Figure 2. Diagram showing the crash events that involved the school bus (in yellow) and Buick LeSabre.

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[4] Heavy vehicles are considered Class 5 (two-axle, six-tire, single-unit trucks) through Class 13 (seven or more axle multi-trailer trucks).

[5] The 85th percentile speed is the speed at which 85 percent of the vehicle traffic is traveling either at or below.

[6] According to TxDOT, a contributing cause to the 2012 crash was the driver's failure to drive in a single lane due to the influence of alcohol or drugs.

Bridge Rail Information

The I-610 overpass above Telephone Road was constructed in 1970, and it consisted of four spans. The Type C4 (modified) bridge railing consisted of a 1-foot 6-inch high concrete parapet with metal posts and rail, which brought the total design height to 3 feet. A 3-inch bonded overlay had been applied to the bridge deck in 1987, reducing the effective height of the concrete parapet to 1 foot 3 inches and the total bridge rail height to 2 feet 9 inches.

The typical spacing of the metal rail posts was 10 feet. The rail posts were attached to the concrete parapets via base plates with slotted holes; they were anchored using U-bolts attached by hexagonal nuts and steel washers. The posts were seated on elastomeric pads; in some locations, only one pad was used, but in others, up to three pads were used.[7] The design plans required that all the metal components of the rail be galvanized, including the anchor bolts.

National Transportation Safety Board (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. The FHWA's response was documented in an e-mail 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 [American Association of State Highway and Transportation Officials] 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 [National Cooperative Highway Research Program] 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 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.

The crash test criteria referenced in this e-mail are Test Level 3 (TL-3) requirements. TL-3 in NCHRP Report 350 is summarized below: [8]

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[7] An elastomeric pad is used to eliminate concrete spalling (a type of surface failure) by compensating for construction irregularities such as rotation and non-parallel load-bearing surfaces.

[8] 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, DC, 1993.

- 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 in the crash was approximately 16,300 pounds.[9] In addition to the bus's weight being almost 12,000 pounds above the TL-3 test protocol, the angle of impact with the barrier was slightly above the thresholds for the TL-3 test criteria. Given these factors, the Type C4 (modified) bridge railing, in its designed condition, would not have been expected to redirect a collision by a school bus. (Figure 3 provides a view of the bridge rail after being struck by the HISD school bus.)

Figure 3. Bridge rail after being struck by the HISD school bus (view is to the southeast).

Injury Information

The 47-passenger school bus had eight rows of seats on each side, and all but one seat were designed to carry a maximum of three students. Additionally, a half seat at the back of the bus on the driver's side was capable of carrying a maximum of two students. The school bus was equipped with a standard lap seat belt for each passenger. The driver's seat was equipped with a three-point lap/shoulder belt. At the time of the crash, the four HISD student passengers were seated and not wearing seat belts; the driver was wearing her three-point lap/shoulder belt.

[9] The total weight consists of 15,600 pounds for the bus and 700 pounds for the passengers and driver.

The HISD provided a copy of its seat policy to NTSB investigators, which read in part as follows:

> 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.

In November 2015, the HISD announced that all new school buses purchased by the district would include three-point seat belts. The announcement was in response to new National Highway Traffic Safety Administration guidance suggesting that students should have access to three-point seat belts.[10] About 40 new buses equipped with three-point seat belts, purchased by the HISD following the announcement, are expected to arrive at HISD in summer 2016. The new buses are to be assigned to the district's highest mileage routes.

Figure 4 is a seating chart of the school bus that provides the gender, age, and injury level of the bus occupants. It also indicates the seating locations of the two student passengers who were ejected from the bus; these two students were fatally injured in the crash.

[10] The guidance was posted by the National Highway Traffic Safety Administration on November 8, 2015, at the following link: http://www.nhtsa.gov/About+NHTSA/Speeches,+Press+Events+&+Testimonies/mr-napt-11082015, accessed June 23, 2016.

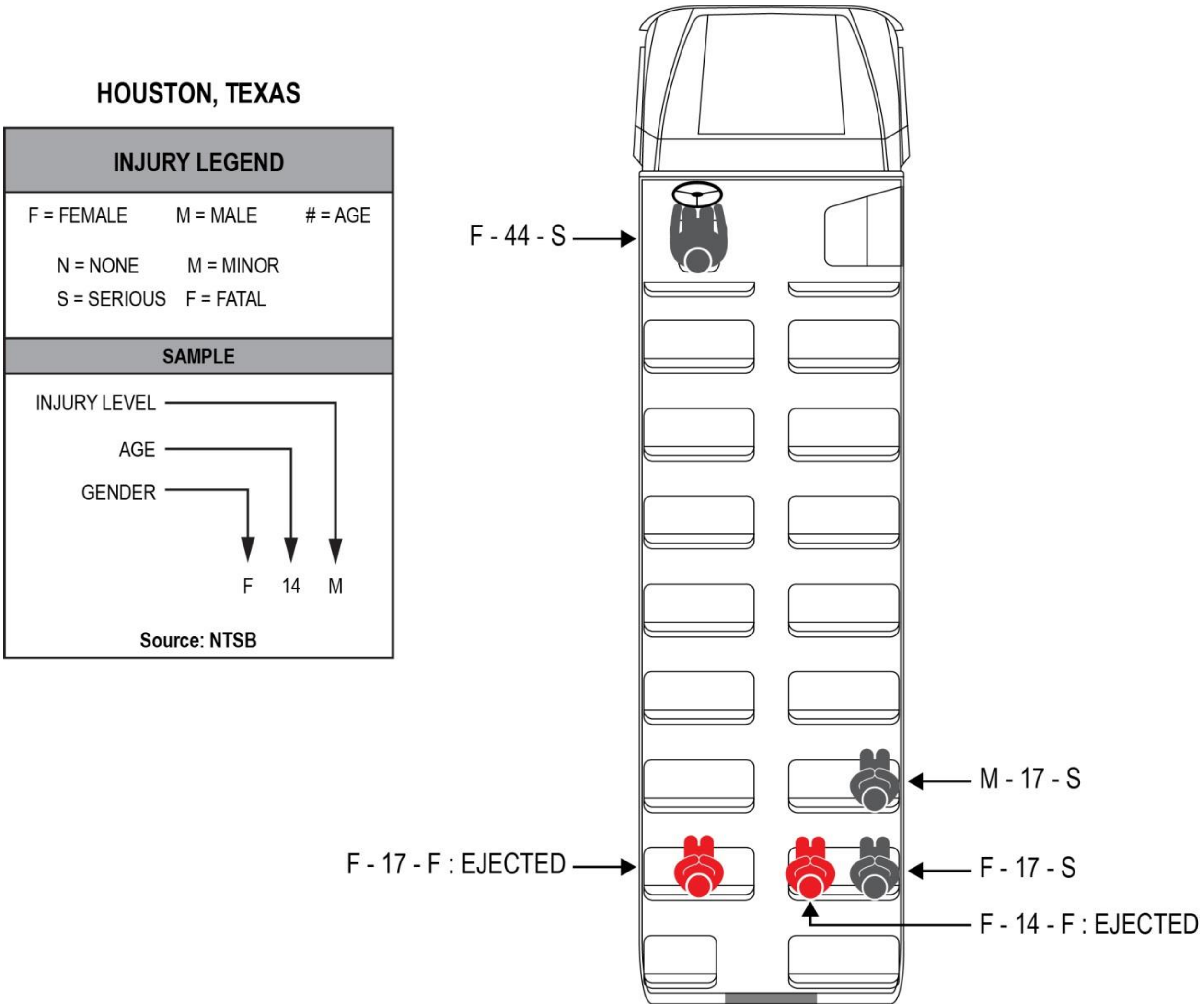

Figure 4. Seating positions, demographic information, and injury and ejection outcomes for school bus occupants. (Persons who received fatal injuries are indicated in red.)

Vehicles

HISD Bus. A postcrash inspection of the school bus was conducted, and all components not damaged by the crash were in good repair. The school bus had received and passed an annual safety-only vehicle inspection by the Texas Department of Public Safety on August 11, 2015.

The front end and left side of the bus had extensive collision contact damage. The hood was completely detached from the vehicle, and the windshield was missing. Numerous components on the left side of the engine were crushed and damaged. The steering components showed significant damage. The steering shaft was hanging from the steering gearbox, which had broken away from the frame rail and was resting on the ground.

The air brake system was inoperable due to crash damage, but a visual inspection of all brake linings and pads indicated that they were within regulatory standards. The left front tire was deflated but still mounted on the damaged rim. There were fresh paint transfer and rub marks on the wheel studs of this tire, consistent with impact from the Buick. The other tires and rims on the bus were damaged, deflated, or detached. All the bus tires had adequate tread depth and were of the size recommended by the bus manufacturer.

The right side of the school bus, from the boarding door rearward, had little damage and all of the windows were intact. The entire body of the bus was shifted to the right due to the impact damage on the left side. The left side of the bus had extensive contact damage, with crush damage concentrated at the left rear corner near the roofline. The roof was crushed to the top of the left side seats, with several seatbacks projecting out of the windows. Crush at the left rear corner measured approximately 48 inches, as well as an additional 24 inches due to the shift of the bus body to the right from impact. (Figure 5 shows the rear of the damaged school bus.) The crush decreased from the rear of the bus to the front, with little crush at the left front roofline. The rightward shift of the bus body at this location measured approximately 12 inches. There was intrusion into the interior of the bus at the firewall and floorboard near the driver's seat.

Figure 5. View of the rear of the HISD bus showing contact damage to the top left corner.

Buick LeSabre. The damage to the Buick LeSabre was limited to the right side of the vehicle. There were pattern scratches in the paint on the right front fender near the wheel well. Portions of the outside flange of the right front wheel rim were broken away. There was a tear measuring approximately 3 x 3 inches in the right front sidewall near the valve stem, and the tire was deflated. The pattern scratches and the tear were caused by contact with the wheel studs on the rotating left front wheel of the bus. Figure 6 shows the damage to the Buick LeSabre caused by the wheel studs. A portion of the steering system's right side control arm was fractured through at a fitting near the frame.

Figure 6. Pattern scratches and damage to the front right tire on the Buick LeSabre from contact with the HISD bus.

The Buick had no interior damage. The driver's seat belt was retracted but not locked. The airbags did not deploy in the collision; however, a non-deployment event was recorded by the Buick's airbag control module. This module was analyzed by Houston Police Department investigators, and the data indicated that the driver's seat belt was buckled at the time of the crash. The vehicle speed recorded by the module was approximately 68 mph (in the 3 seconds prior to the collision). No brake application by the driver was shown in the data until 1 second prior to impact.

HISD School Bus Video

The school bus was equipped with seven video cameras.[11] Two rear-facing cameras were aimed at the occupants. One camera was aimed at the loading door. Two cameras were mounted near the lateral centerline of the bus; one recorded the road ahead and one the road behind the bus. Two externally mounted rear-facing cameras were in position near the front of the bus, about 9 feet above ground level, one on the left side and one on the right side. They recorded traffic in the lanes to the left and right of the school bus.

[11] The video system on the bus was supplied by Safety Vision, LLC. The video frame rate was 10 frames per second.

NTSB investigators examined the HISD school bus video to determine crash variables related to the Buick and to analyze the multiple crash events involving the school bus. Most of the information used in the video analysis was recorded by the externally mounted rear-facing camera on the left side of the school bus, which also captured the Buick's precrash movements.

The location of the school bus was estimated at numerous points over the last 480 feet prior to the impact location, based on the solid white line segments seen in the video frames. Seven locations were considered, corresponding to seven video frames spaced at 1 second intervals. The speed of the school bus, based on the seven estimated locations, was estimated to be about 55 mph.

The Buick was visible in the recorded video for about 10 seconds before it struck the school bus. Its average speed was estimated over a period of 4 seconds prior to impact. The Buick's speed was estimated to be about 69 mph. (This estimated speed closely correlates with the 68 mph speed recorded by the Buick's airbag control module.) Video analysis indicated that the impact angle between the Buick and the school bus was about 1.9 degrees.

Driver of the 2004 Buick LeSabre

Enhancement of the HISD school bus video did not provide sufficient information to determine whether the Buick driver was distracted immediately prior to the collision with the school bus. The Houston Police Department reviewed the Buick driver's cell phone records; the records did not indicate cell phone use immediately prior to the collision.

The Buick driver, through her attorney, declined to be interviewed by NTSB investigators. In a postcrash interview with the Houston Police Department, the Buick driver stated that she "thought a car was coming into my lane so I went to the right." The bus video indicated that no cars were in the immediate vicinity of the Buick at the time of the crash.

The Houston Police Department conducted a drug and alcohol test on the Buick driver, and the results were negative.[12]

U-Bolt Examination

Three U-bolt anchors were removed from the concrete parapet in the approximate location where the HISD school bus surmounted the bridge rail. Figure 7 shows the U-bolt pieces taken from the side facing the outer edge of the traffic rail. The pieces were labeled 10' W, 20' W, and 20' E. The piece labeled 10' W came from the west U-bolt (the first post east of the expansion joint in span 2). The pieces labeled 20' W and 20' E came from the west and east U-bolts, respectively, which anchored the second rail post east of the same expansion joint.

[12] The HISD also conducted a drug and alcohol test on the school bus driver, and those test results were also negative.

Figure 7. Pieces of U-bolt removed from the concrete parapet near where the HISD school bus surmounted the bridge rail.

According to the design plans provided by TxDOT, the U-bolts had a nominal diameter of 0.75 inch. The pieces removed postcrash showed substantial corrosion, including reduced diameter, particularly in the area near the lower end of the threads. Corrosion on the surface of piece 10' W was observed around the circumference up to 4.51 inches from the upper end of the piece. On pieces 20' W and 20' E, corrosion was observed along the entire length of the pieces on the side to the outside of the bend, up to 8.30 inches from the upper end of piece 20' W and 9.04 inches from the upper end of piece 20' E. At the inside of the bend, corrosion was present up to 4.35 inches from the upper end of piece 20' W and up to 2.79 inches from the upper end of piece 20' E.

Table 1 provides the nominal diameter of each piece, the reduced diameter in the area near the lower end of the threads, and the percent reduction.

Table 1. Diameter measurements of U-bolt pieces.

Piece	Nominal Diameter (inch)	Reduced Diameter (inch)	Percent Reduction (%)
10' W	0.75	0.494	34.1
20' W	0.75	0.466	37.9
20' E	0.75	0.571	23.9

Examination showed that each of the U-bolt pieces had a zinc coating that was compromised, resulting in corrosion and loss of section near the lower ends of the threads. The corrosion and loss of section would have resulted in substantial reduction in the metal strength, particularly in pieces 10’ W and 20’ W. In areas where the thickness of the zinc coating was measured, it varied from 0.005 to 0.048 inch on piece 10’ W, from 0 to 0.042 inch on piece 20’ W, and from 0 to 0.029 inch on piece 20’ E.

TxDOT Postcrash Actions

Following the crash, TxDOT made changes to the existing bridge structure and implemented policies to improve its maintenance operations.

TxDOT Installation of New Single-Sloped Concrete Traffic Rail

TxDOT completed installation of a new rail in the crash area on December 15, 2015. Figure 8 shows the new single-sloped concrete traffic rail installed by TxDOT Houston District after the crash. The new traffic rail has a height of 3 feet, and it was installed along the entire south edge of eastbound I-610 on the overpass above Telephone Road for a distance of about 300 feet.

Figure 8. Looking to the southeast along the new single-sloped concrete traffic rail installed by the TxDOT Houston District after the crash. (Source: TxDOT Houston District)

The new rail was a retrofit, meaning that the existing rail was removed and a new rail was installed in its place; consequently, it could not have the same type of connection to the bridge deck that such a rail would have as an initial installation. For this reason, TxDOT could only certify the new rail to TL-3. (If this same rail had been part of an entirely new bridge construction, TxDOT would have been able to certify it to TL-4.)[13]

TxDOT Bridge Damage Assessment

TxDOT conducted a thorough bridge damage assessment to determine if anchor bolt corrosion constituted a systemic issue. TxDOT also considered whether there were any other widespread deterioration issues with the Type C4 (modified) bridge rail.

TxDOT determined there had been a previous severe impact to the bridge rail in the same location as this crash. However, it could not determine when the previous impact occurred because the TxDOT districts (there are 25 districts statewide) do not keep maintenance records that document prior bridge railing improvements and repair costs. The previous impact resulted in significant damage to the concrete parapet and the anchor bolts. Evidence indicated that the bolts had been bent over by this impact, and then they were bent back and reused rather than being replaced. The previous impact also resulted in significant damage at the posts. Repair mortar had been used to patch spalls at the posts caused by the impact. 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 location where the school bus struck the bridge rail.

TxDOT also examined the remaining bridge rail segments and found no evidence of significant corrosion or reduced capacity from deterioration. Even in areas where previous vehicle impacts caused 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 no systemic deterioration issues were 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 has committed to provide all its 25 districts with an approved procedure for repairing damaged bridge rails.

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

TxDOT Internal Changes

As a result of the crash, TxDOT identified and responded to two issues, as summarized in the following material from an e-mail to NTSB investigators, dated January 28, 2016:

> **Issue #1**: Providing direction to all TxDOT Districts concerning an approved procedure for repairing damaged bridge rail.
>
> **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.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the Houston, Texas, crash was the Buick LeSabre driver's intrusion into a lane occupied by a Houston Independent School District school bus. Contributing to the severity of the crash was the failure of the bridge railing to redirect the school bus because the dynamics of the collision exceeded the design capabilities of the railing.

For more details about this accident, visit http://dms.ntsb.gov/pubdms/ and search for NTSB accident ID HWY15FH010.

Issued: July 20, 2016