Texas Department of Transportation

Construction & Materials Tips

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Retrofit Bridge Railing

Bridge Railing is designed to contain and redirect errant vehicles. Crash testing of barrier rail is performed to verify the strength of the barrier and to assure that critical failure modes such as vehicular stability (i.e. rollover) and occupant compartment deformation are satisfied. Since September 1986, the Federal Highway Administration (FHWA) has required that new bridge railing placed on the National Highway System be full-scale crash tested in accordance with current national criteria. In accordance with FHWA direction, bridge railing and other barriers are crash tested to minimum test levels using passenger vehicles and pickup trucks (additional crash tests are occasionally performed with light and heavy commercial trucks).

Retrofitting (*) is required by an upgrade to a crash-tested bridge rail and is sometimes necessary after the original construction of the bridge or bridge slab as a requirement of phased construction. In some instances, threaded inserts are cast flush into the bridge slab during construction, to be uncovered later and used to anchor a subsequent cast-in-place bridge rail. The retrofit rail generally increases construction time and costs.

Retrofit rails are required to meet the same crash worthiness as the original tested rail design. The rail anchorage must be re-engineered as a retrofit connection from the slab into the railing and, if properly designed, eliminates the need for additional crash testing. However, impact strength needs to be established when a newly designed retrofit connection is proposed. Crash impacts are simulated by testing a full-scale model of the railing with an 1,800 lb. pendulum.

Retrofit rail anchorages are made by drilling or coring the existing bridge slab, adhering threaded anchors in the holes, and connecting the railing to the anchors. Design of a high-strength anchor is hampered by the thickness of the bridge slab, which is usually only 8 inches (With an 8 in. deck, you can usually go only 6 in. deep and still maintain minimum cover over the end of the bar. The completed hole may be too shallow an embedment to allow ideal impact strength). Anchors are installed in the following ways:

- by drilling or coring a hole in the bridge slab top to produce the proper embedment length for the bar
- by drilling holes, partially filling them with an epoxy, and forcing rebar into the hole
- by coring through the bridge slab and installing a through-bolt from the slab bottom, strengthened by a plate washer.

An adequate design transmits and distributes the impact loads from the rail into the slab, just as in the original cast-in-place construction. To date, retrofit anchors have included proprietary epoxy adhesive anchors from vendors such as HILTI, Simpson, and Epcon. Each of these vendors guarantees a specific

strength for each of their anchor systems based on depth of embedment, compressive strength of the concrete into which the anchor is set, and proximity of the anchor to an edge.
At this time, concrete expansion anchors, sometimes generically called “Red Head Anchors” or wedge anchors, are not used for retrofit rail anchorages because there is not yet enough confidence in the impact performance of expansion anchors. After additional research, this anchor may be considered for such applications. A TxDOT-sponsored project will begin this fall to study this issue.

The Bridge Division has designed many retrofit anchorages for bridge railing. In most cases, these connections prove to be as strong as, or stronger than, the cast-in-place anchorage that was originally crash tested with a test vehicle. However, if the retrofit connections cannot be as strong as the original, they are designed to resist the minimum load specified for high speed impacts.

Standard drawings and working drawings for bridge railing that can be custom designed for almost any connection condition include:

T-6	T502	T4	C411
T101RC	T503	SSTR	CTB
T501R	T201	T203	

Field performance expectations for retrofit bridge railing are generally different from the failure modes noted in cast-in-place bridge railing anchorages. Most observations following field impacts of railing and barriers reveal a tire smudge, a superficial scrape, some bent steel along a steel railing, or a gouge in the concrete surface of a concrete railing. Rarely is a bridge railing, or its connection to the bridge slab, failed by an errant vehicle. When it is, the barrier fails in a predictable manner.

Even when designed using the forces expected for high-speed passenger vehicles and light trucks, retrofit bridge railing (and conventionally placed bridge railing) may be caused to fail by an impacting vehicle in the field. The vehicle that caused the failure was most probably heavier or traveling faster than the test vehicle specified in the crash test.

The failed retrofit bridge rail will probably look different from the failure of a conventionally attached bridge rail. In the case of conventional cast-in-place concrete bridge railing, for example, failures resulting from severe impacts usually occur in the top third to half of the railing. Rarely are failures observed in the connection of the railing to the slab.

However, retrofit railing generally will fail at the connection to the slab, and the anchors may be fully exposed. The expected failure mechanism is the anchor coming free from the bridge slab. Rarely, if ever, will the individual steel retrofit anchor come apart in a tensile failure of the steel cross section. This observation does not mean that the designed anchorage was inadequate, under strength, or improperly installed. The ultimate strength of the anchor was exceeded by the forces of the impacting vehicle because it was much heavier or much faster than the required crash test vehicle. Fortunately, these types of impacts and failures are very rare.

Bridge railing that generally should not be retrofitted because of complexity and strength considerations include:

- Tank Truck Rail, often called Monster Rail
- Heavy Truck Rail
- T101.

For additional information, call Mark Bloschock, P.E., Bridge Division Special Projects Manager, at (512) 416-2178, or Eric Ingamells, P.E., at (512) 416-2280.

* Retrofitting, regarding bridge barrier rail, 1) means that the bridge rail installation occurs at some time after original construction, and 2) usually requires a custom designed anchorage to the slab or other structural member.