CONSTRUCTION OF FRANGIBLE-TUBE, ENERGY-ABSORBING BRIDGE BARRIER SYSTEM

Michael M. Kasinskas, Materials Testing Laboratory, and
Charles E. Dougan, Bureau of Planning and Research,
Connecticut Department of Transportation

ABRIDGMENT

The Connecticut Department of Transportation in cooperation with the Federal Highway Administration installed a frangible-tube, energy-absorbing bridge barrier system. The experimental barrier absorbs the impact forces of a colliding vehicle by using fragmenting aluminum tubes. This paper details the construction of the experimental barrier on a Connecticut bridge having concrete parapet walls.

•THE Connecticut Department of Transportation, in conjunction with the Federal Highway Administration, completed installation of a newly developed energy-absorbing bridge barrier system in July 1974. The basic concept of the barrier was conceived by the National Aeronautics and Space Administration for absorbing the impact experienced by space craft during lunar landings. FHWA, realizing the potential that NASA's energy-absorbing system had for highway-safety applications, contracted Southwest Research Institute (SwRI) of San Antonio, Texas, to investigate possible uses of this concept. Using the NASA concept, SwRI subsequently designed the energy-absorbing bridge guardrail discussed.

OPERATION OF ENERGY-ABSORBING SYSTEM

The operating principal of the SwRI design is based on the fragmentation of a series of aluminum tubes secured between a rigid bridge railing and a movable box beam. On impact between a vehicle and the box beam, the kinetic energy is absorbed in the fragmenting tubes at a rate that prevents the development of reaction force and that thereby reduces the possibility of the vehicle rebounding back into the traffic stream (1).

DESCRIPTION OF CONNECTICUT BRIDGES

In Connecticut, most bridges have concrete parapet walls 3.08 ft (0.94 m) high and 15 in. (38 cm) wide. At the base of the parapets, there is either a 6-in.-wide (15-cm) by 10-in.-high (25-cm) granite curb or an 18-in. (46-cm) sidewalk with the granite curb; at the top there is a steel railing 1.6 ft (0.49 m) high. Shoulders between the outside edge of the travelway and the approximate base of the parapet vary from 2 to 10 ft (0.6 to 3 m). The parapet ends are usually protected by a 1-ft (0.3-m) W-beam guiderail.

MODIFICATION OF INITIAL FRANGIBLE-TUBE BARRIER

There were substantial differences between the parapet-rail system used in the SwRI study (1) and the typical system currently used on Connecticut bridges. These differences required basic modification of the SwRI design (Figure 1). Some of these modifications were as follows:

1. Replacement of the rectangular guide with a standard 3-in. (7.6-cm) internal-diameter steel pipe of increased length to clear the 1.25-ft (0.38-m) concrete parapet;
2. Replacement of the 4-in. (10-cm) square sleeves with 4-in. (10-cm) round holes cored in the parapet;
3. Replacement of steel shims with wooden shims or spacers to minimize damage at lower levels, if the shims should become dislodged and drop; and
4. Deletion of the rub rail recommended by SwRI, since the existing granite curbing would serve as one.

TEST SITE DESCRIPTION

The structure chosen for the test installation is in the eastbound roadway of I-84 in the towns of Plainville and New Britain. The geometry of the bridge is as follows: L = 852.8 ft (260 m), R = 1,375 ft (419 m), and D = 4 deg 10 min. The concrete deck has a superelevated cross slope of ¾ in./ft (6.25 cm/m). The installation is on the high side of the road. The shoulder along the outside lane is 10 ft (3 m) wide with 6-in.-wide (15-cm) curbing at the parapet base.

CONSTRUCTION DETAILS

The contractor accomplished the work in two phases: core drilling and installation of the barrier system.

Core Drilling

The 4-in. (10-cm) core holes were drilled by using two conventional portable coring rigs with manual feed. The baseplate of each rig had a vacuum chamber on its underside for securing the rig in the desired position. A screw at each of the four corners of the baseplate permitted a small amount of adjustment when the bit was leveled. The guide on which the drill was mounted was attached to the baseplate at 90 deg in all directions.

The drilling operation required 10 working days to core 141 holes with a cumulative length of 176.25 linear ft (53.7 m); thus, drilling efficiency amounted to 17.625 linear ft (5.37 m)/day or 8.86 ft (2.7 m)/day/rig.

Figure 1. Top view of section through centerline of tubes.

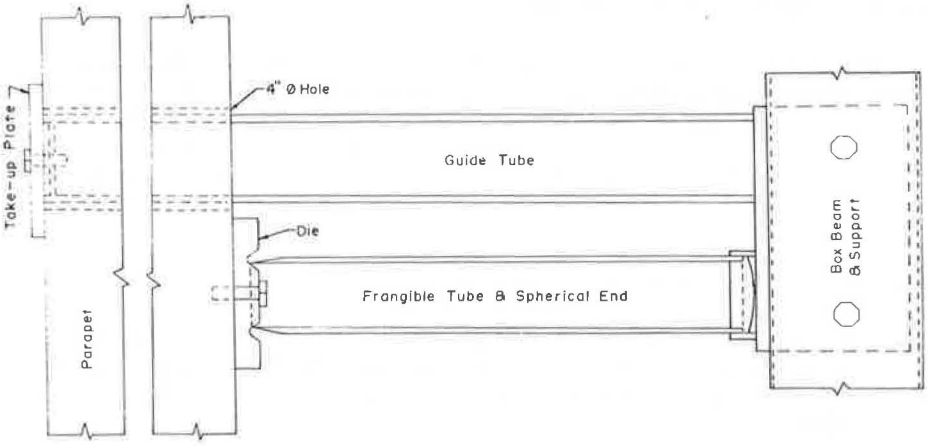

Figure 2. Components of frangible-tube system.

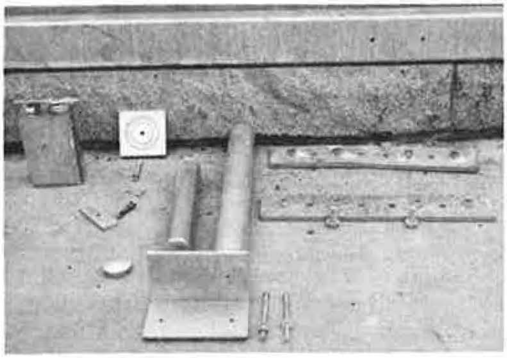

Figure 3. Fully installed unit of system on bridge.

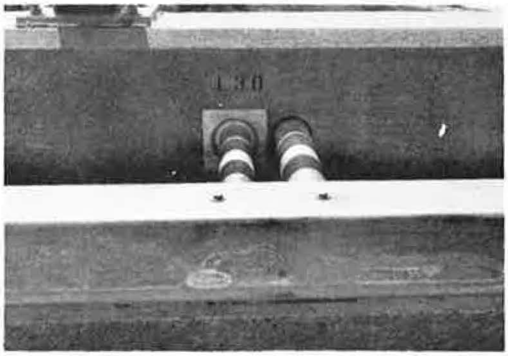

Figure 4. The completed system.

Installation

Before the barrier was installed, a backup system and transition section were installed at the west end of the bridge. The backup system consisted of a reinforced 1-ft (0.3-m) W-beam mounted on 6-in. (15-cm) I-beams driven 3.25 ft (0.99 m) into the embankment.

The radius of the bridge was sufficiently long to allow placement of the entire length of box beam in 18 to 19-ft (5.5 to 5.8-m) chord sections. The chords differed in those areas where twin conduits and junction boxes existed in the parapet. In these cases, the chords varied in length from 20 to 24 ft (6.1 to 7.3 m). The spacing between the frangible-tube units was 6 to 6.8 ft (1.8 to 2.1 m). Spacing differed to avoid expansion joints and electrical conduits.

Sufficient dies and frangible-tube assemblies were mounted on the parapet wall for each day of work. Before the aluminum tubes were mounted onto the die (Figure 2), they were coated with lubricant. The lubricant recommended by a local distributor was Molykote 557. This particular lubricant comes in liquid form and is described as an extreme-pressure lubricant with antiweld properties for cutting and forming metals. When the solvent evaporates, it leaves a thin film on the surfaces. The take-up plates were loosely bolted into position. A section of box beam with predrilled bolt holes was then placed on the mounted assemblies and loosely connected to the preceding section of box beam with a splice plate. Three units were used per section of box beam. After the initial installation, the alignment was corrected. The box beam was then bolted to the frangible-tube assemblies and the splice-plate bolts were secured (Figure 3). When all the units and box beam were in place, the units were leveled by using hydraulic jacks; wooden shims were inserted in the core holes at the top and bottom of the guides. When the units were leveled and the shims were in place, the take-up plates were secured.

SUMMARY

The entire project required 22½ working days to complete. As mentioned, 10 days were required for the drilling operation, and 10 days for the actual installation. The remaining $2\frac{1}{2}$ days were used in laying out the job, excavating and placing the concrete anchor block, and rechecking all the bolts for tightness.

Construction of the frangible-tube barrier system, as designed by SwRI and modified by Connecticut DOT (for Connecticut's needs) indicates that, with minor changes in design, the system can be installed without encountering major problems. In addition, the system has pleasant aesthetic features and blends in well with its environment (Figure 4).

ACKNOWLEDGMENT

The contents of this paper reflect the views of the authors, who are responsible for the facts and accuracy of the data presented. The contents do not necessarily reflect the official views or policies of the state of Connecticut or the Federal Highway Administration. The report does not constitute a standard, specification, or regulation.

REFERENCE

1. An Impact-Energy Attenuating Device Combined With Guardrail-Like Structures. Southwest Research Institute, Final Rept.