October 2, 2003

Refer to: HSA-10/B-122

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor
Midwest Roadside Safety Facility
University of Nebraska-Lincoln
527 Nebraska Hall
Lincoln, Nebraska 68588-0529

Dear Dr. Faller:

In your August 25 letter to Mr. A. George Ostensen, you requested the Federal Highway Administration's formal acceptance of three **non-proprietary** longitudinal barrier systems for use on the National Highway System (NHS). The first design consisted of stacked steel H-Sections connected end-to-end and bolted to a simulated bridge deck. It was developed specifically for use at locations where typical lateral deflections for temporary concrete barrier would be considered excessive. This design was accepted for use on the NHS as a test level 3 barrier in my September 12 letter, B-117. The second design, an F-shape precast concrete barrier bolted to a bridge deck to eliminate most deflection, will be addressed in this letter, and the final system, w-beam guardrail posts embedded in solid rock, will be covered in a third letter.

Each barrier segment used in the test installation of the concrete barrier bolted to a simulated bridge deck was a 3.8-m long F-shape barrier, having a minimum 28-day compressive strength of 34.5 MPa (5,000 psi). All of the steel reinforcement in the barrier was ASTM A615 Grade 60 rebar, except for the loop bars, which were ASTM A706 Grade 60 steel. Barrier reinforcement consisted of three 16M (No. 5) and two 13M (No. 4) longitudinal bars, twelve 13M (No.4) bars for the vertical stirrups, and six 19M (No. 6) bars for the anchor bolt block reinforcement loops. The anchor bolt block loops were 889-mm (35-in.) long and were bent into a U-shape to reinforce the anchor bolt area. The barriers segments were connected by two sets of three separate rebar loops made from ASTM A706 Grade 60 19M (No. 6) bars on each barrier interconnection. Each segment end had one or two upper and one or two lower loops (for a total of three loops) and the adjacent section had one loop that fit between the two-loop connection of the first section, and two loops that fit over and below the adjacent single loop. The vertical pin used in the connection consisted of a 32-mm (1.25-in.) diameter x 711-mm (28-in.) long round bar composed of ASTM A36 steel. Because of the double shear, triple loop configuration, no retaining nut was used on the vertical pin.

The barriers were fastened to the concrete bridge deck with a 29-mm (1.125-in.) diameter ASTM A307 anchor bolts with heavy hex nuts and 76-mm (3-in.) x 76-mm (3-in.) x 13-mm (0.5-in.) thick washers at each anchor bolt location. Each anchor bolt was epoxied into the concrete to an embedment depth of approximately 305 mm (12 in). These bolts were installed only on the traffic side of the barrier in order to reduce the propensity for barrier tipping and subsequent vehicle climbing and vaulting. In separate correspondence, you indicated that alternative anchoring designs, including through-bolting, would be acceptable as long as the full tensile strength of the anchor bolts can be developed. Overall barrier dimensions and reinforcement details are shown in Enclosure 1.

The National Highway Cooperative Research Program (NCHRP) Report 350 test 3-11 was successfully conducted on the final design and is described in the Midwest Roadside Safety Facility's August 22 report entitled, Development and Evaluation of a Tie-Down System for the Redesigned F-Shape Concrete Temporary Barrier." Enclosure 2 is a summary sheet of the test results. All NCHRP Report 350 evaluation criteria were met. The maximum vehicle roll angle was reported to be 34 degrees. Maximum pitch, although relatively high, was not reported. The concrete spalled at all bolt locations on the two barrier segments in the impact zone (segments 8 and 9) and major structural failure was reported near midspan on segment 9. This failure possibly contributed to the relatively high roll and pitch angles noted after impact. Additional longitudinal reinforcing would likely improve barrier performance and reduce future maintenance/replacement costs. Dynamic deflection, including tipping of the top of the barrier, was limited to 287 mm (11.3 inches). Permanent deformation was 89 mm (3.5 inches).

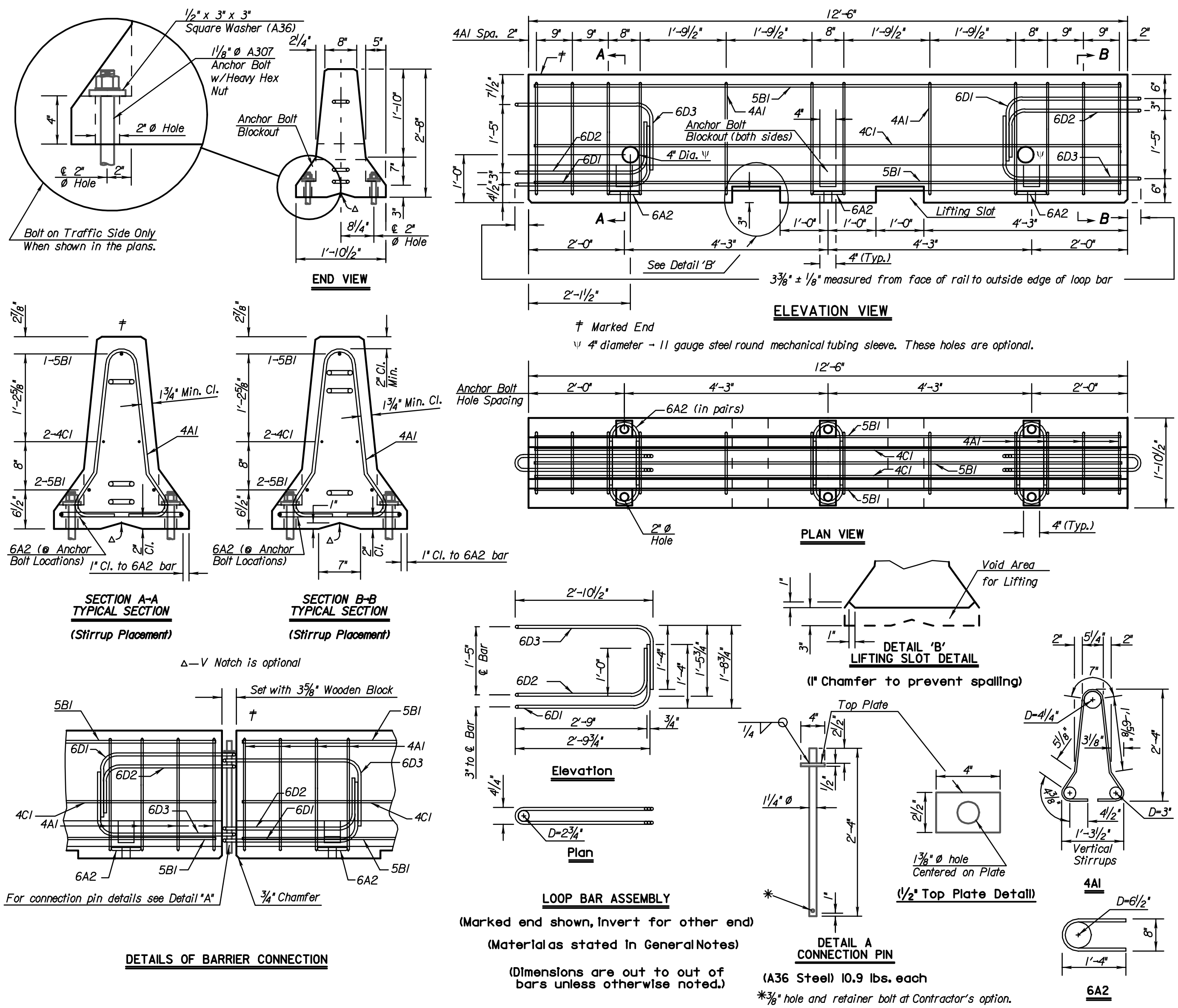
I agree with your conclusion that this design met all NCHRP Report 350 evaluation criteria for a test level 3 barrier and conclude that it can be used as a temporary barrier on concrete bridge decks on the NHS when its use is acceptable to the contracting agency.

Sincerely yours,

(original signed by John R. Baxter)
John R. Baxter, P.E.
Director, Office of Safety Design

2 Enclosures

| STATE | PROJECT NO. | YEAR | SHEET NO. | TOTAL SHEETS |
|---|---|---|---|---|
| KANSAS | | | | |




GENERAL NOTES:

MATERIAL: Use ASTM A615, Grade 60 reinforcing bars, except for the loop bars (6D1, 6D2 and 6D3).

The loop bars (6D1, 6D2 and 6D3) shall be ¾" smooth steel bars with a minimum yield of 60 ksi, a tensile strength of not less than 1.25 times the yield strength but a minimum of 80 ksi, a minimum 14% elongation in 8 inches, and passing a 180 degree bend test using a 3.5D pin bend diameter. The loops shall be installed within ⅛" of the plan dimensions.

Use air-entrained concrete with f'c = 5,000 p.s.i.

Use 1⅛" ø A307 Anchor Bolts with heavy hex nut & washer (A36). Use ASTM A36 material for the Connection Pin.

SECTION: The section furnished must generally comply with dimensions shown. Requests for minor variations in section geometry and attachments may be submitted to the Engineer for approval.

LIFTING SLOTS: Lifting slots shall be constructed where specified on the plans to facilitate the drainage of water after installation on the roadway.

TEMPORARY CONCRETE SAFETY BARRIER: Furnishing and placing of all materials when required and all labor and equipment required to position the temporary barrier shall be included in the Contract unit price bid for "Concrete Safety Barrier (Type F3)(Temporary)". Any relocation of the barrier required for the project shall be paid in accordance with the Special Provisions under the bid item "Concrete Safety Barrier (Type F3)(Temporary-Relocate)". Unless otherwise noted on the Plans, the Temporary Concrete Safety Barrier shall become the property of the Contractor and shall be removed from the site upon acceptance of the completed project. Approximate weight of one unit equals 2.7 tons.

SURFACE PREPARATION: Barrier shall be placed on a paved surface. All loose dirt and sand shall be removed from the roadway surface just prior to placement of the barrier.

DELINEATION: See Standard Drawing RD622B for delineator notes and details.

MARKING: The left end (†) of each barrier shall be permanently marked by stamping or forming into the barrier the following information:

- Type F3
- Manufacturer code (as specified by KDOT Bureau of Const. & Maint.)
- Date manufactured (month and year)

**At no time shall the barriers be lifted, moved, etc by use of the loop bars: 6D1, 6D2 or 6D3.**

Per 12'-6" Barrier Section

| REINFORCING A615 Gr. 60 | | | | | |
|---|---|---|---|---|---|
| Bar | Bar Size | Shape | No. of Bars | Length Ft. | Weight Lbs. |
| 4A1 | 4 | ⎍ | 12 | 6'-0" | 48.1 |
| 6A2 | 6 | ⊂ | 6 | 2'-11" | 26.3 |
| 5B1 | 5 | —— | 3 | 12'-2" | 38.1 |
| 4C1 | 4 | —— | 2 | 12'-2" | 16.3 |
| LOOP ASSEMBLY | | | | | |
| 6D1 | 6 | ⌐ | 2 | 8'-5" | 25.3 |
| 6D2 | 6 | ⌐ | 2 | 7'-7" | 22.8 |
| 6D3 | 6 | ⌐ | 2 | 8'-6" | 25.5 |

Concrete Quantity = 1.3 C.Y.

| NO. | DATE | REVISIONS | BY | APP'D |
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| 3 | | | | |
| 2 | | | | |
| 1 | | | | |

KANSAS DEPARTMENT OF TRANSPORTATION

TEMPORARY
CONCRETE SAFETY BARRIER
TYPE F3

RD622

| | | | |
|---|---|---|---|
| FHWA APPROVAL 9-25-02 | APP'D James O. Brewer | | |
| DESIGNED | DETAILED | QUANTITIES | CADD M.R.R. |
| DESIGN CK. | DETAIL CK. | QUAN. CK. | CADD CK. |

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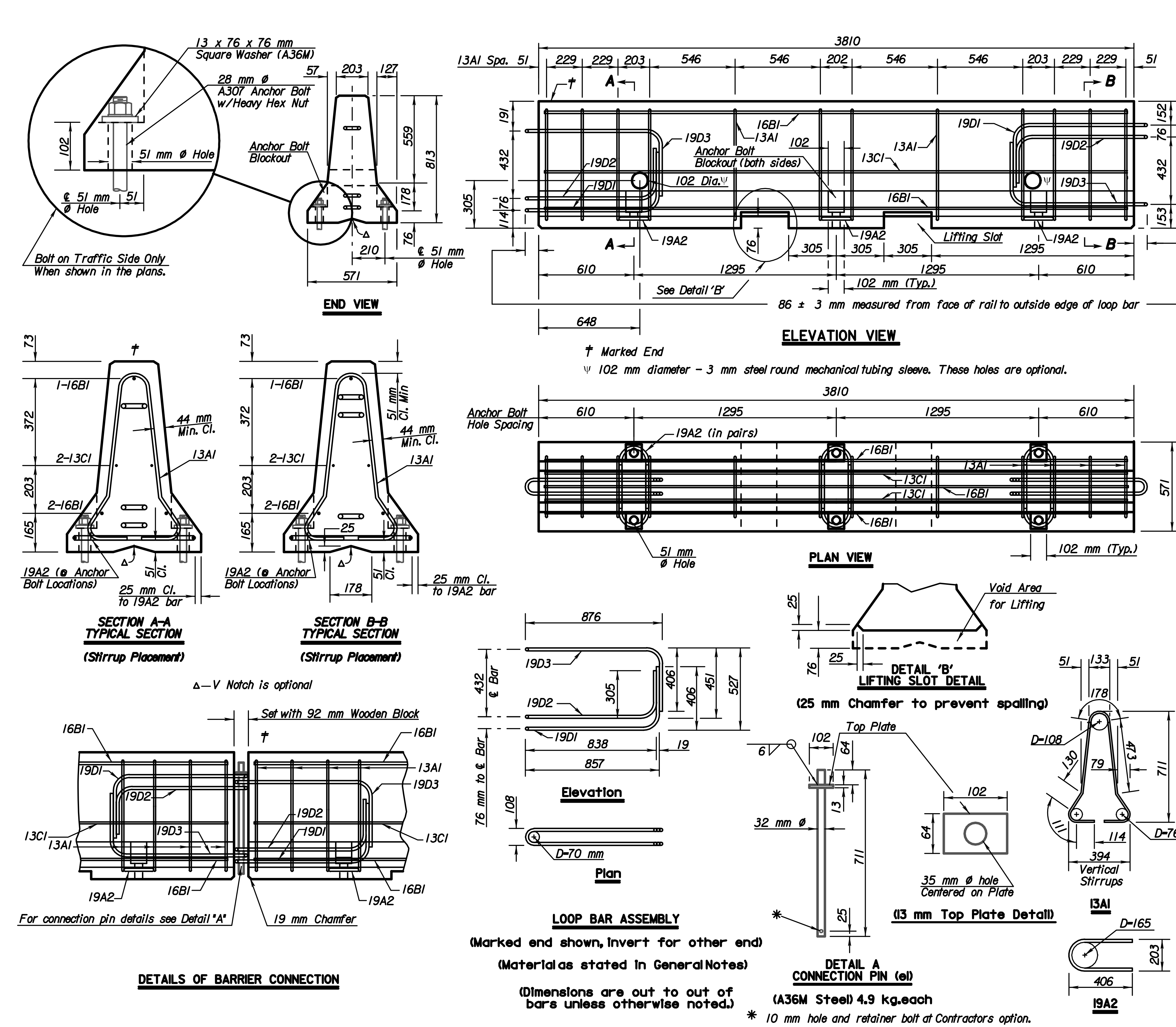


## GENERAL NOTES:

MATERIAL: Use ASTM A615M, Grade 420 reinforcing bars, except for the loop bars (19D1, 19D2 and 19D3).

The loop bars (19D1, 19D2 and 19D3) shall be 19 mm smooth steel bars with a minimum yield of 420 MPa, a tensile strength of not less than 1.25 times the yield strength but a minimum of 550 MPa, a minimum 14% elongation in 203 mm, and passing a 180 degree bend test using a 3.5D pin bend diameter. The loops shall be installed within 3 mm of the plan dimensions.

Use Concrete Grade 35 (AE) throughout.

Use 28 mm ø A307 Anchor Bolts with heavy hex nut & washer (A36M). Use ASTM A36M material for the Connection Pin.

SECTION: The section furnished must generally comply with dimensions shown. Requests for minor variations in section geometry and attachments may be submitted to the Engineer for approval.

LIFTING SLOTS: Lifting slots shall be constructed where specified on the plans to facilitate the drainage of water after installation on the roadway.

TEMPORARY CONCRETE SAFETY BARRIER: Furnishing and placing of all materials when required and all labor and equipment required to position the temporary barrier shall be included in the Contract unit price bid for "Concrete Safety Barrier (Type F3)(Temporary)". Any relocation of the barrier required for the project shall be paid in accordance with the Special Provisions under the bid item "Concrete Safety Barrier (Type F3)(Temporary-Relocate)". Unless otherwise noted on the Plans, the Temporary Concrete Safety Barrier shall become the property of the Contractor and shall be removed from the site upon acceptance of the completed project. Approximate weight of one unit equals 2.45 Mg.

SURFACE PREPARATION: Barrier shall be placed on a paved surface. All loose dirt and sand shall be removed from the roadway surface just prior to placement of the barrier.

DELINEATION: See Standard Drawing RD640 SI for delineator notes and details.

MARKING: The left end (†) of each barrier shall be permanently marked by stamping or forming into the barrier the following information:

- Type F3
- Manufacturer code (as specified by KDOT Bureau of Const. & Maint.)
- Date manufactured (month and year)

**At no time shall the barriers be lifted, moved, etc by use of the loop bars: 19D1, 19D2 or 19D3.**

**Per 3810 mm Barrier Section**

| Bar | Bar Size | Shape | No. of Bars | Length mm | Weight kg |
|---|---|---|---|---|---|
| REINFORCING A615M Gr. 420 | | | | | |
| 13A1 | 13 | | 12 | 1834 | 21.9 |
| 19A2 | 19 | | 6 | 898 | 12.0 |
| 16B1 | 16 | | 3 | 3708 | 17.3 |
| 13C1 | 13 | | 2 | 3708 | 7.4 |
| LOOP ASSEMBLY | | | | | |
| 19D1 | 19 | | 2 | 2565 | 11.5 |
| 19D2 | 19 | | 2 | 2311 | 10.3 |
| 19D3 | 19 | | 2 | 2591 | 11.6 |

Concrete Quantity = 1.0 $m^3$

| STATE | PROJECT NO. | YEAR | SHEET NO. | TOTAL SHEETS |
|---|---|---|---|---|
| KANSAS | | | | |

| NO. | DATE | REVISIONS | BY | APP'D |
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| 3 | | | | |
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KANSAS DEPARTMENT OF TRANSPORTATION

**TEMPORARY CONCRETE SAFETY BARRIER TYPE F3**

RD642 SI

FHWA APPROVAL 9-25-02 | APP'D James O. Brewer
DESIGNED | DETAILED | QUANTITIES | CADD M.R.R.
DESIGN CK. | DETAIL CK. | QUAN. CK. | CADD CK.

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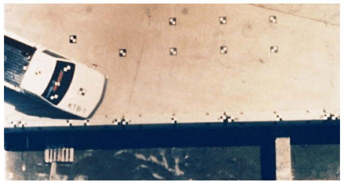

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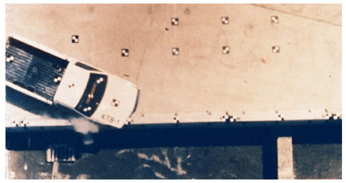

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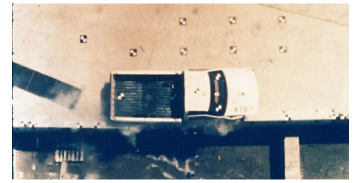

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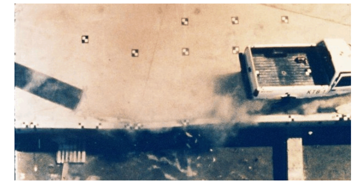

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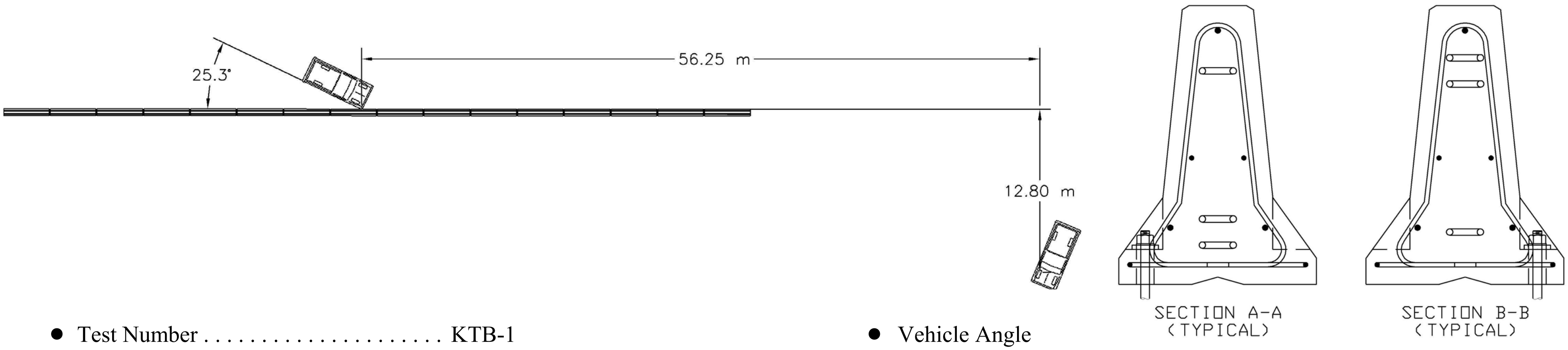




- Test Number . . . . . . . . . . KTB-1
- Date . . . . . . . . . . 7/31/02
- Appurtenance . . . . . . . . . . Kansas Temporary Barrier Tie Down System
- Total Length . . . . . . . . . . 62.23 m
- Placement . . . . . . . . . . 25 mm from concrete bridge deck edge
- Key Elements . . . . . . . . . . Nine 3,810-mm long Kansas Temporary Barriers
  Seven 3,810-mm long Iowa F-Shape Temporary Barriers
- Barrier Joint Pin Connections . . . . . . . 32-mm diameter by 712-mm long A36 steel rod with 64x102x132-mm plate
- Tie-Down Anchors . . . . . . . . . . 28.575 mm ASTM A307 Threaded Dowels
  - Number per Barrier . . . . . . . . . . 3
  - Embedment into Concrete . . . . . . . 305 mm
  - Placement . . . . . . . . . . Traffic side only
- Vehicle Model . . . . . . . . . . 1997 Chevrolet 2500 ¾-ton pickup
  - Curb . . . . . . . . . . 1,991 kg
  - Test Inertial . . . . . . . . . . 2,018 kg
  - Gross Static . . . . . . . . . . 2,018 kg
- Vehicle Speed
  - Impact . . . . . . . . . . 99.8 km/hr
  - Exit (resultant) . . . . . . . . . . 81.5 km/hr
- Vehicle Angle
  - Impact (orientation) . . . . . . . . . . 25.3 deg
  - Exit (trajectory) . . . . . . . . . . 14.4 deg
- Vehicle Snagging . . . . . . . . . . None
- Vehicle Pocketing . . . . . . . . . . None
- Vehicle Stability . . . . . . . . . . Satisfactory
- Occupant Ridedown Deceleration (10 msec avg.)
  - Longitudinal . . . . . . . . . . 10.98 G's< 20 G's
  - Lateral (not required) . . . . . . . . . . 10.60 G's
- Occupant Impact Velocity
  - Longitudinal . . . . . . . . . . 5.68 m/s < 12 m/s
  - Lateral (not required) . . . . . . . . . . 7.01 m/s
- Vehicle Damage . . . . . . . . . . Moderate
  - TAD[14] . . . . . . . . . . 1-RFQ-3
  - SAE[15] . . . . . . . . . . 1-RFAW3
- Vehicle Stopping Distance . . . . . . . . . . 56.25 m downstream
  12.80 m laterally behind
- Barrier Damage . . . . . . . . . . Moderate
- Maximum Rail Deflections
  - Permanent Set . . . . . . . . . . 89 mm
  - Dynamic . . . . . . . . . . 287 mm
- Working Width . . . . . . . . . . 534 mm

Figure 16. Summary of Test Results and Sequential Photographs, Test KTB-1