U.S. Department
of Transportation
Federal Highway Administration

May 9, 2006

400 Seventh St., S.W.
Washington, D.C. 20590

In Reply Refer To:
HSA-10/B82-B1

Mr. Derek W. Muir
Group Managing Director
Hill & Smith Ltd.
Springvale Business and Industrial Park
Bilston, Wolverhampton, West Midlands, WV14 0QL

Dear Mr. Muir:

In your April 11, 2006, letter, you requested the Federal Highway Administration's (FHWA's) concurrence that your TL-4 four-rope Brifen Wire Rope Safety Fence (WRSF) would be acceptable as a National Cooperative Highway Research Program (NCHRP) Report 350 test level 3 (TL-3) traffic barrier when placed as described below on a side slope as steep as 1V: 4H.

On that same date, your representatives, Dr. Richard McGinnis and Mr. Jerry Emerson, met with Messrs. Artimovich and Powers of my staff and provided them copies of three test reports prepared by the Southwest Research Institute (SwRI) entitled "NCHRP Report 350, "Modified" Test 3-11 Full-Scale Crash Evaluation of a 111-Meter TL-4 (4-Rope) Wire Rope Safety Fence Installed on a 1V: 4H Sloped Median," (SwRI test no. BCR-2); "NCHRP Report 350, Test 3-10 Full-Scale Crash Evaluation of a 111-Meter TL-4 (4-Rope) Wire Rope Safety Fence Installed on a 1V: 4H Sloped Median," (SwRI test no. BCR-5); and "NCHRP Report 350, Test 3-10 Full-Scale Crash Evaluation of a 111-Meter TL-4 (4-Rope) Wire Rope Safety Fence Installed on a 1V: 4H Sloped Median," (SwRI test no. BCR-4).

In my March 27, 2005, letter to you (acceptance letter B-82B), the FHWA accepted the Brifen 4-rope TL-4 WRSF as a NCHRP Report 350 TL-4 traffic barrier. This TL-4 design consists of four separate cables, the bottom three of which are interwoven between posts and the top cable is set in a 101-mm deep x 22-mm wide slot cut into the top of each post. Cable heights measured from the ground directly beneath the cables were 480 mm, 630 mm, 780 mm, and 930 mm, respectively. The S-shape posts, 100-mm x 55-mm x 4.55-mm thick, manufactured from ASTM A-36 steel, were spaced on 3.2-m centers.

Three tests were conducted with the TL-4 WRSF installed in a 9.8-m (32-feet) wide depressed median with 1V: 4H side slopes. For the first test, the barrier was located 3.7 m (12 feet) up the slope from the ditch bottom and the test vehicle crossed the ditch bottom and started up the

backslope before impacting the barrier. For the second and third tests (NCHRP Report 350 tests 3-10 and 3-11) the barrier was located down the foreslope, 1.2 m (4 feet) from the edge of pavement.

The first test was a modified 3-11 test in which a 1998 Ford Crown Victoria weighing 1,750 kg (3,859 lb) was directed into the median at a 25° angle and 103.1 km/hr (64.1 mph), went down the slope, across the ditch bottom [located 4.9 m (16 ft) from edge of pavement] and 3.7 m (12 feet) up the far side of the ditch where it then impacted the backside of the WRSF [located 8.5 m (28 ft) from edge of pavement] at a 26.5° angle at 95.6 km/hr (59.4 mph). The vehicle deflected the barrier 2.2 m (7.3 ft) laterally and was safely contained and redirected by the WRSF. Cables were tensioned to 20.0 kN (4500 lb) based on the ambient temperature of 29 degrees Celsius (84 degrees Fahrenheit). Although the barrier in this test was located 3.7 m (12 feet) beyond the ditch bottom, a subsequent analysis prepared by Dr. McGinnis and based on additional data obtained from the SwRI test indicated that the Crown Victoria would have been captured by the WRSF if the barrier had been installed closer to the ditch bottom. After reviewing the bumper trajectory data and the crash test video, my staff agreed that the barrier would likely perform satisfactorily with a minimum 3.0-m (10-foot) offset from the ditch bottom. Enclosure 1 is the test summary sheet for the first test.

The use of a non-standard test vehicle for the first test was intended to replicate the FHWA-sponsored crash test of a Ford Crown Victoria sedan into a standard 3-rope US cable barrier that was conducted on April 23, 2004 at the Federal Outdoor Impact Laboratory by the National Crash Analysis Center (NCAC). In that test, the cable barrier was located 1.2 m (4 feet) up from the ditch bottom in a median with 1V: 6H side slopes. The test vehicle's front suspension compressed when it struck the backslope, allowing the bumper to slide underneath the bottom cable. The vehicle then underrode the barrier and continued up the slope with no redirection. A second test conducted by NCAC with a Crown Victoria impacting at the same speed and angle but with the generic cable barrier offset from the ditch bottom by only 0.3 m (one foot) was successful.

The second Brifen test was a standard NCHRP Report 350 3-10 test with the TL-4 WRSF located 1.2 m (4 ft) down the 1V: 4H slope from the edge of pavement. A 1998 Suzuki Swift weighing 907 kg (2,000 lb) impacted the WRSF at a 21.1-degree angle at 101.3 km/hr (62.9mph). The maximum dynamic deflection of the barrier was 1.2 m (4.0 ft), and the vehicle was safely contained and redirected by the WRSF. Cables were tensioned to 18.7 kN (4200 lb) based on the ambient temperature of 32 degrees Celsius (90 degrees Fahrenheit). Enclosure 2 is the test summary sheet for this second test.

The third Brifen test was a standard NCHRP Report 350 3-11 test with the WRSF again located 1.2 m (4 ft) down the 1V: 4H slope from the edge of pavement. A 1998 Chevrolet C2500 3/4-ton pickup truck weighing 2,139 kg (4,717 lb) impacted the WRSF at a 24.1 degree angle at 101.4 km/hr (63.0 mph). The maximum dynamic deflection of the barrier was 2.7 m (9.0 ft) caused by the rear of the vehicle rotating into the barrier while the vehicle was airborne. The maximum deflection of the barrier caused by the front of the vehicle was 2.3 m (7.6 ft). The vehicle was contained and safely redirected by the barrier. Cables were tensioned to 24.7 kN (5550 lb). The ambient temperature immediately prior to this test was 14 degrees Celsius (48 degrees Fahrenheit). Enclosure 3 is the test summary sheet for the third test.

Based on the test results summarized above, your TL-4 Brifen WRSF is acceptable as a TL-3 traffic barrier when placed no farther than 1.2 m (4 feet) down a 1V: 4H slope (for adjacent traffic impacts) and no closer than 10 feet from the ditch bottom for opposite-side impacts. Although the WRSF tested above was the Brifen WRSF TL-4 four-rope system which was successfully tested with the single unit truck on a flat slope, transportation agencies using this design on a 1V: 4H slope should understand that only TL-3 vehicles were used in the crash tests. On such slopes, it is possible that TL-4 vehicles and larger may not be captured or contained by the barrier.

I strongly agree with your recommendation that usage be closely monitored through in-service evaluation, since three crash tests alone cannot predict the performance of any traffic barrier for every conceivable combination of barrier type, site conditions, vehicle size, shape, weight, and impact angle and speed. Because the NCHRP Report 350 testing was developed to address a **worst practical case** scenario, there is always a possibility that some vehicular penetrations will occur when anything less than a high-performance TL-5 or TL-6 barrier is used.

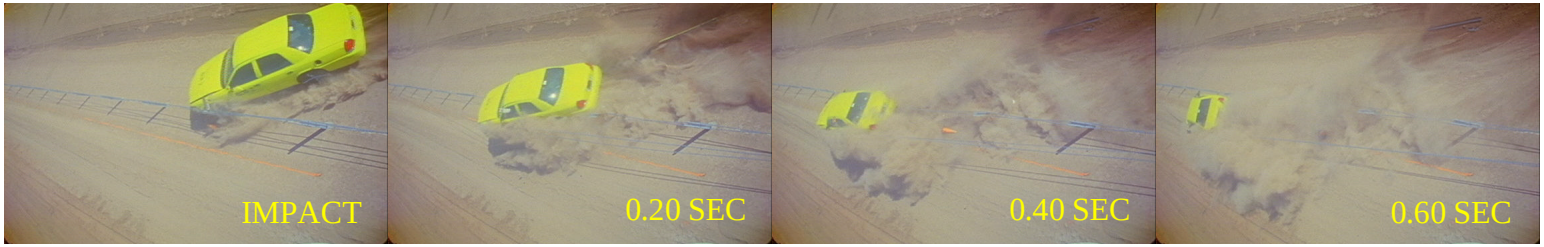
Sincerely yours,

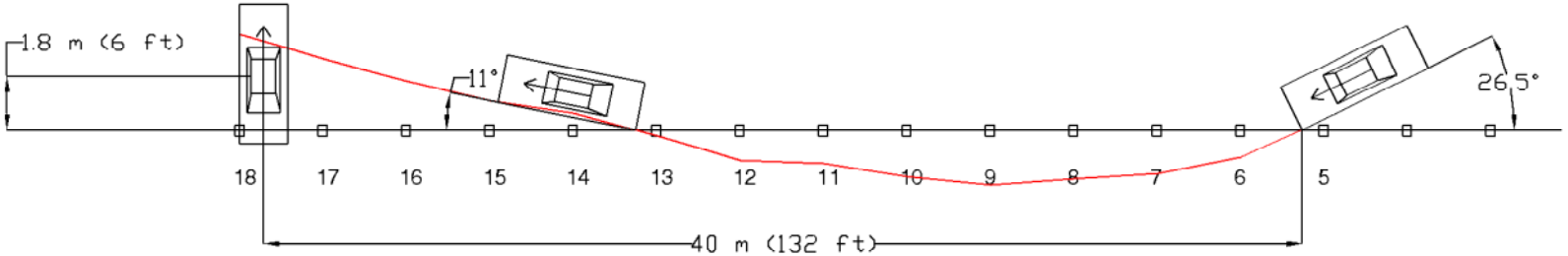
/original signed by/

John R. Baxter, P.E.
Director, Office of Safety Design
Office of Safety

3 Enclosures

Table 4.1 – Summary of Test Results and Conditions





General Information
- Test Agency.....Southwest Research Institute
- Test Number.....BCR-2
- Test Date.....02/28/2006
- Test Category.....3-11

Test Article
- Type.....Longitudinal Barrier
- Installation Length.....111 m (365 ft)
- Nom. Barrier Height.....930 mm (36.5 in)
- Type of Primary Barrier.....Wire Rope Safety Fence, 4-Rope

Soil Stable, Dry – Highly Compacted

Test Vehicle
- Type.....Special
- Designation.....Special
- Model.....1998 Ford Crown Victoria
- Mass (kg).....1750
- Inertial Mass(kg).....1750
- Dummy Mass (kg).....NA
- Gross Static Mass (kg).....1750

Impact Conditions
- Speed (km/hr).....95.6
- Angle (degrees).....26.5

Exit Conditions
- Speed (km/hr).....59 (calculated)
- Angle (degrees).....11

Occupant Risk Values
- Impact Velocity (m/s)
  - x-direction.....3.6
  - y-direction.....-0.7
- Ridedown Accelerations (g's)
  - x-direction.....-5.8
  - y-direction.....6.7

Post Impact Vehicular Behavior (limited to events <2.000 seconds)
- Maximum Roll Angle (degrees).....-34.9 @ 1.212 sec.
- Maximum Pitch Angle (degrees).....-14.3 @ 0.435 sec.
- Maximum Yaw Angle (degrees).....38.6 @ 2.000 sec.

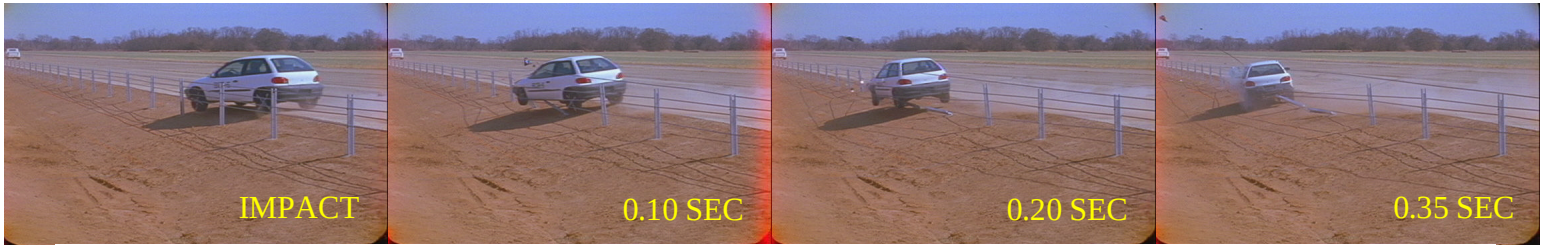
Test Article Deflection
- Dynamic.....2.2 m (7.3 ft)
- Permanent.....0 m (0 ft)

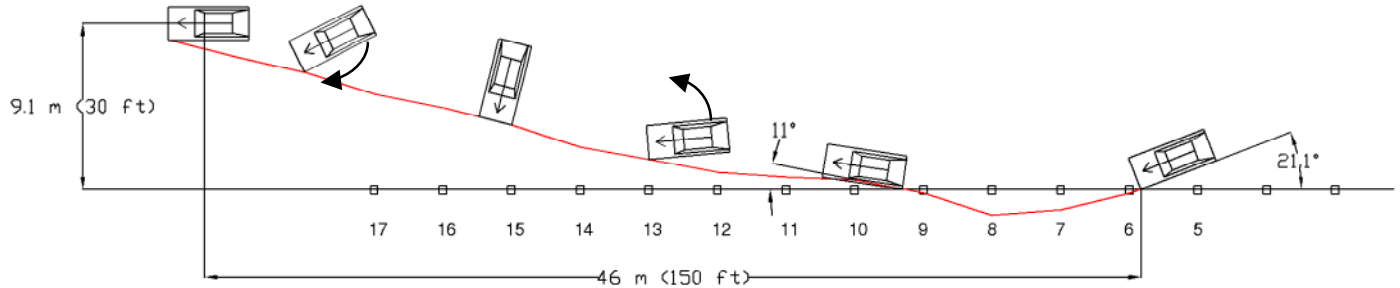
Vehicle Damage

Exterior
- CDC.....11LFEW5
- VDS.....11-LFQ-3

Interior
- OCDI.....LF0000000
- Max. Deform. (mm).....0

Table 4.1 – Summary of Test Results and Conditions





General Information
- Test Agency.....Southwest Research Institute
- Test Number.....BCR-5
- Test Date.....03/01/2006
- Test Category.....3-10

Test Article
- Type.....Longitudinal Barrier
- Installation Length.....111 m (365 ft)
- Nom. Barrier Height.....930 mm (36.5 in)
- Type of Primary Barrier.....Wire Rope Safety Fence, 4-Rope

Soil Stable, Dry– Highly Compacted

Test Vehicle
- Type.....Small car
- Designation.....820C
- Model.....1998 Suzuki Swift
- Mass (kg).....907
- Inertial Mass(kg).....907
- Dummy Mass (kg).....75
- Gross Static Mass (kg).....982

Impact Conditions
- Speed (km/hr).....101.3
- Angle (degrees)....21.1

Exit Conditions
- Speed (km/hr).....74 (calculated)
- Angle (degrees)....11

Occupant Risk Values
- Impact Velocity (m/s)
  - x-direction.....3.5
  - y-direction.....-3.7
- Ridedown Accelerations (g's)
  - x-direction.....-9.0
  - y-direction.....10.3

Post Impact Vehicular Behavior (limited to events <2.000 seconds)
- Maximum Roll Angle (degrees).....-8.2 @ 1.705 sec.
- Maximum Pitch Angle (degrees).....-4.0 @ 0.376 sec.
- Maximum Yaw Angle (degrees).....-99.3 @ 2.000 sec.

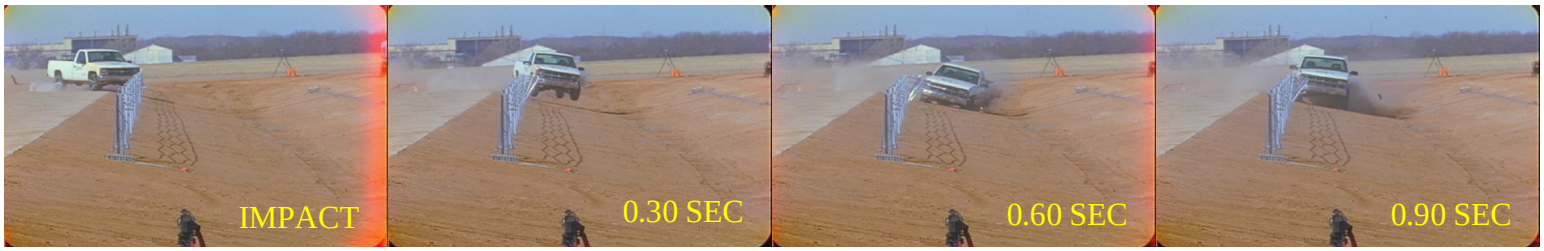
Test Article Deflection
- Dynamic.....1.2 m (4.0 ft)
- Permanent.....0 in (0 m)

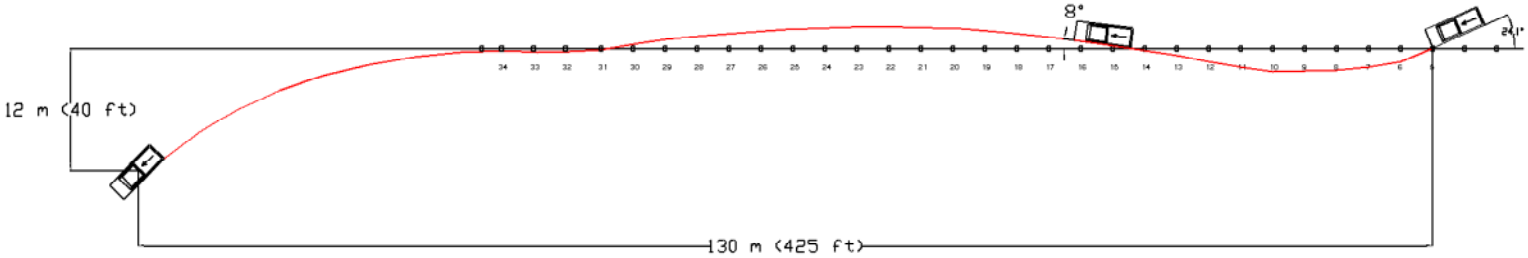
Vehicle Damage

Exterior
- CDC.....11LFEW5
- VDS.....11-LFQ-2

Interior
- OCDI.....LF0000000
- Max. Deform. (mm).....0

Table 4.1 – Summary of Test Results and Conditions





General Information
- Test Agency.....Southwest Research Institute
- Test Number.....BCR-4
- Test Date.....03/01/2006
- Test Category 3-11

Test Article
- Type .....Longitudinal Barrier
- Installation Length .....111 m (365 ft)
- Nom. Barrier Height.....930 mm (36.5 in)
- Type of Primary Barrier .....Wire Rope Safety Fence, 4-Rope

Soil Stable, Dry – Highly Compacted

Test Vehicle
- Type .....¾ Ton Pickup
- Designation.....2000P
- Model.....1998 Chevy C2500
- Mass (kg).....2139
- Inertial Mass(kg) 2139
- Dummy Mass (kg) .....NA
- Gross Static Mass (kg).....2139

Impact Conditions
- Speed (km/hr) 101.4
- Angle (degrees).....24.1

Exit Conditions
- Speed (km/hr) .....71 (calculated)
- Angle (degrees).....8

Occupant Risk Values
- Impact Velocity (m/s)
  - x-direction.....2.7
  - y-direction.....-2.8
- Ridedown Accelerations (g's)
  - x-direction.....-5.9
  - y-direction.....8.2

Test Article Deflection
- Dynamic .....2.7 m (9.0 ft)
- Permanent .....0 m (0 ft)

Vehicle Damage

Exterior
- CDC 11LFEW4
- VDS 11-LFQ-2

Interior
- OCDI LF0000000
- Max. Deform. (mm) 0

Post Impact Vehicular Behavior (limited to events <2.000 seconds)
- Maximum Roll Angle (degrees).....16.8 @ 0.679 sec.
- Maximum Pitch Angle (degrees).....-3.2 @ 1.983 sec.
- Maximum Yaw Angle (degrees) .....32.9 @ 0.592 sec.