U.S. Department
of Transportation
Federal Highway Administration

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

March 6, 1998

Refer to: HNG-14

Mr. Don L. Ivey
Research Engineer
Safety Division
Texas Transportation Institute
Texas A&M University System
College Station, Texas 77843-3135

Dear Mr. Ivey:

In your February 25 letter to Messrs. James H. Hatton, Jr., and Richard D. Powers of my staff, you requested the Federal Highway Administration's (FHWA) acceptance of a sloped end treatment for the Low Profile Barrier at the National Cooperative Highway Research Program (NCHRP) Report 350 test level 2 (TL-2). To support this request, you also sent us a copy of TTI Research Report 1403-1S, "Development of an End Treatment for the Low-Profile Concrete Barrier" and a video tape of the certification tests that you ran.

The low-profile end treatment is a reinforced concrete design 6100-mm long. Its approach end is 102-mm high, 356-mm wide at the bottom, and 365-mm wide at the top. From this cross section the end treatment transitions linearly and symmetrically over 4600 mm to match the cross section of the low-profile barrier (510-mm high, 660-mm wide at the bottom, and 710-mm wide at the top). This cross section continues for 1500 mm to the back of the terminal where it is connected with two ASTM A36 steel bolts to the first low-profile barrier segment through bulkheads cast into each end of the barrier segment and the downstream end of the sloped end section. The end section is anchored to the pavement with seven 32-mm diameter steel pins driven through precast holes in the section spaced at 610-mm intervals. The pins are variable lengths and each is set a minimum of 200-mm into the roadway surface in pre-drilled holes. The low-profile barrier segments themselves are not anchored. Enclosure 1 is a drawing of the tested design.

The NCHRP Report 350 recommends up to seven tests to certify a barrier terminal like the low-profile end treatment. You requested that test 2-33 be waived because this test with a pickup truck impacting the nose of the terminal at a 15 degree angle would be less severe than test 2-32, the same test using an 820-kg vehicle. You also requested that tests 2-35 and 2-39 be waived. Test 2-35 involves the 2000-kg pickup truck striking the terminal at 20 degrees at the beginning of the length of need. You defined this location as the connection point between the end treatment and the barrier proper, although we believe it could be the point where the end treatment attains its ultimate height of 510-mm. At either point, the terminal has the same

dimensions as the barrier itself, which was successfully tested previously with a pickup truck at 25 degrees. You recommended that test 2-39, a reverse-direction hit with a pickup truck at a 20 degree angle, be waived because you predicted that the test vehicle would pass "harmlessly" over the end treatment after impacting at its midpoint height of 273-mm. While we do not share your certitude that this would be a benign test, we do believe that, for the prescribed test conditions (height of barrier at impact point, type of test vehicle, and speed and angle of impact), the test results would be acceptable and, in addition, that the type of impacts simulated by this test would be rare. Thus, we are in agreement with you that the three tests you have cited would not be as telling in assessing the acceptability of the end treatment as the tests you have run, and we are willing to waive them.

Summary data on tests 2-30, 2-31, 2-32, and 2-34 are enclosed as Enclosure 2. Appropriate evaluation criteria were met in each of these tests. We noted that the critical impact point test 2-34 was run twice with initial impact points 2000 mm and 910-mm downstream from the nose of the end treatment and that the second test proved more critical in terms of vehicular roll, pitch, and yaw angles. We noted also that for end-on impacts and angle impacts near the nose, the impacting vehicles were not slowed appreciably and continued to travel over 60 meters on top of or behind the barrier. Thus, proper usage and design of specific installations is essential to ensure adequate protection for both motorists and construction workers.

Based on our review of the data submitted, we concur that the end treatment tested meets the evaluation criteria of the NCHRP Report 350 for a TL-2 terminal. It may be used in work zones and other locations on the National Highway System (NHS) when requested by a State or local transportation agency where impact speeds and angles are expected to be comparable to TL-2 conditions. Since both the low-profile barrier and its terminal are proprietary, the guidance contained in Title 23, Code of Federal Regulations, Section 635.411, remains applicable to the use of such items on all Federal-Aid projects, except those on exempt, non-NHS routes.

Sincerely yours,

Dwight A. Horne

Dwight A. Horne
Chief, Federal-Aid and Design Division

2 Enclosures

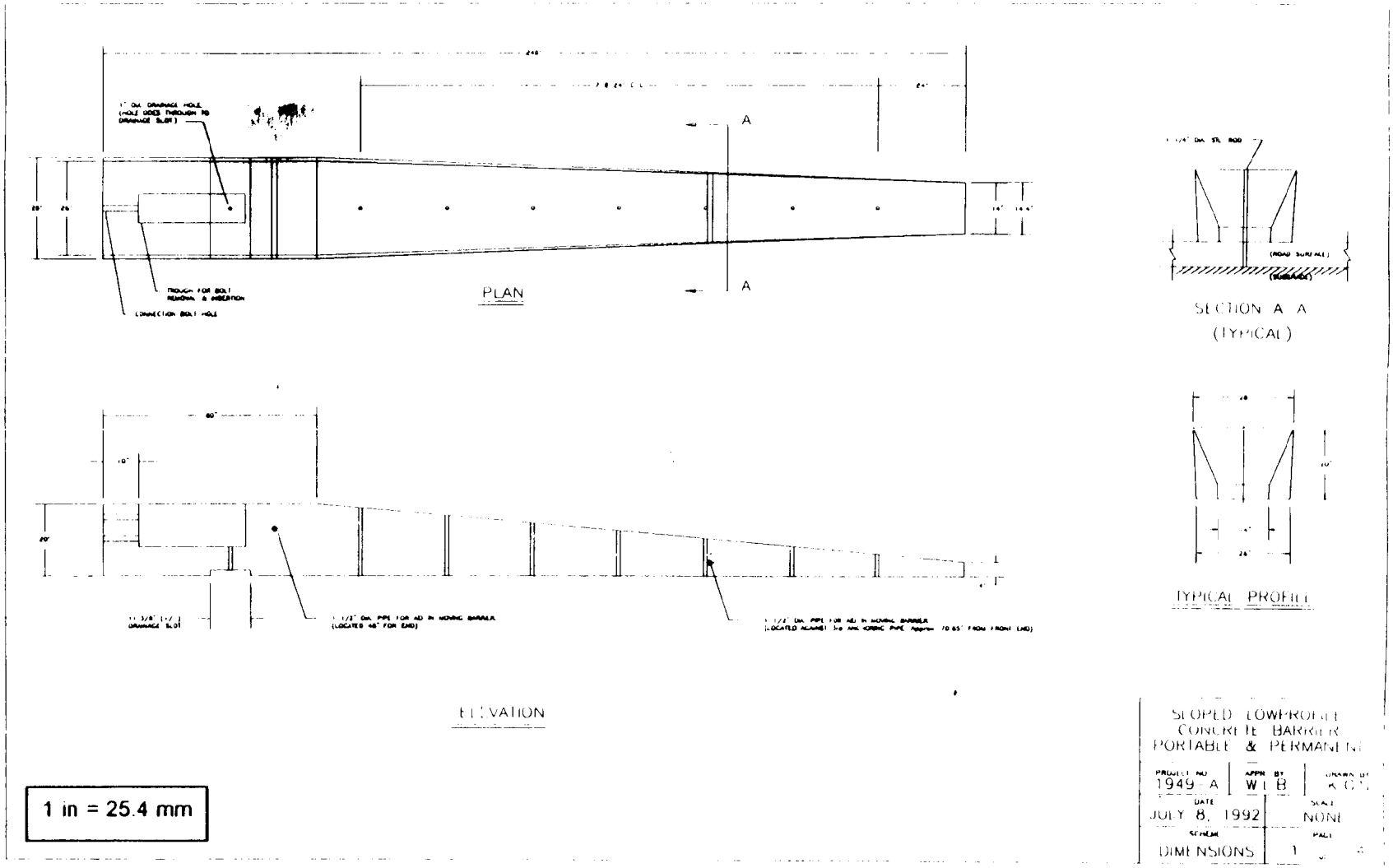
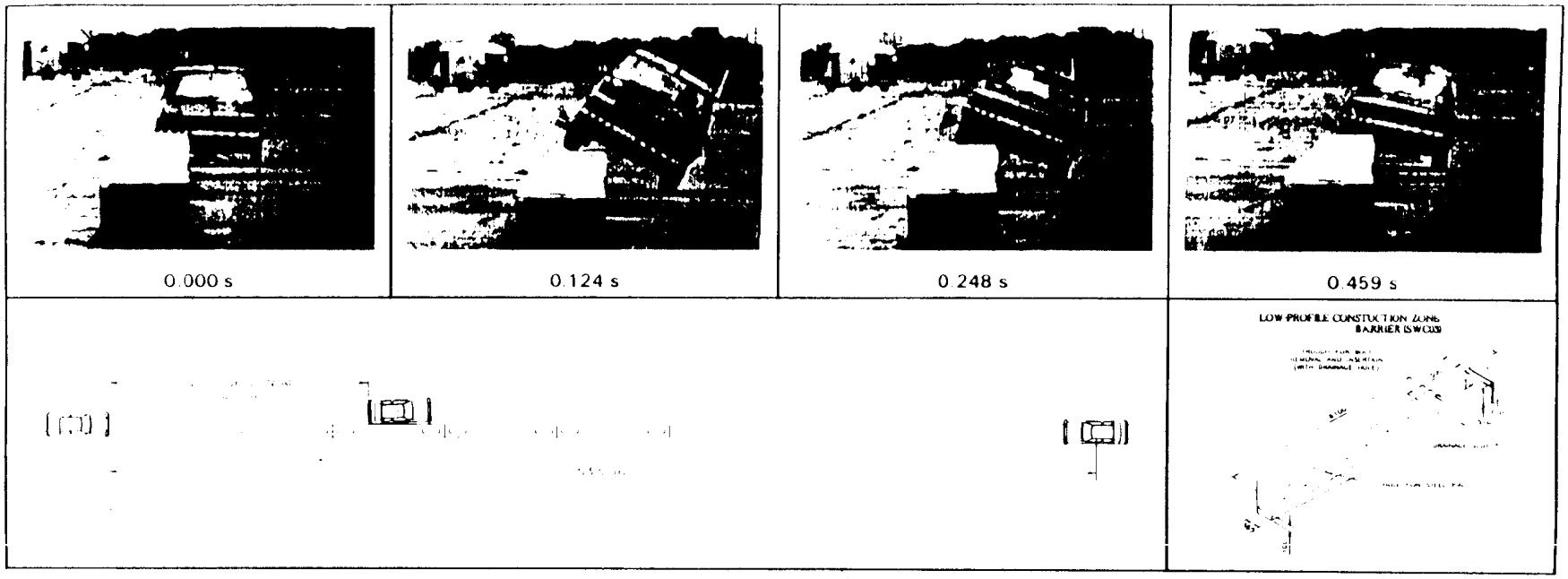


Figure 37. Fabrication Details for the Low-Profile End Treatment.



General Information
- Test Agency: Texas Transportation Institute
- Test No.: 1949A-2
- Date: 06/26/92

Test Article
- Type: End Treatment
- Name: Low-Profile End Treatment
- Installation Length (m): 30.5
- Size and/or dimension and material of key elements: 102-mm to 510-mm High Constant Slope Concrete End Treatment, 6.1 m Long
- Soil Type and Condition: Concrete Pavement, Dry

Test Vehicle
- Type: Production
- Designation: 820C
- Model: 1988 Yugo GVL
- Mass (kg) Curb: 819
- Test Inertial: 817
- Dummy: 76
- Gross Static: 893

Impact Conditions
- Speed (km/h): 72.6
- Angle (deg): 0 - rt qtr

Exit Conditions
- Speed (km/h): 65.3
- Angle (deg): 2.0

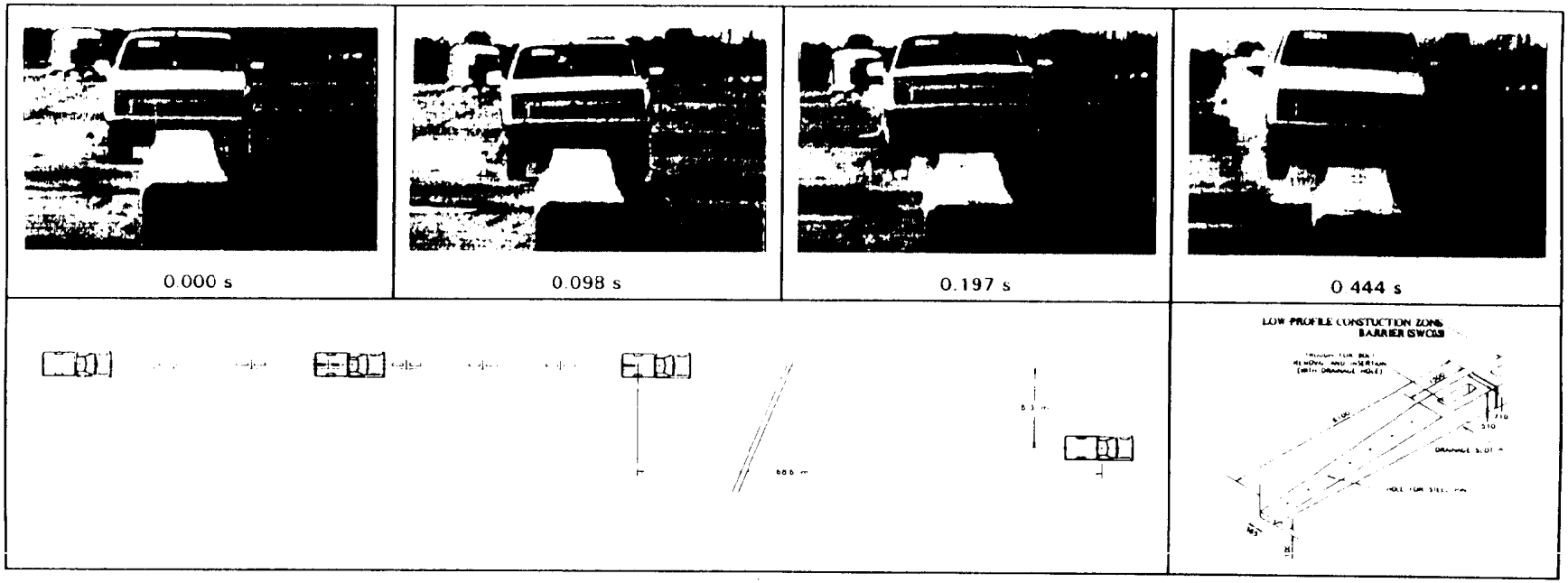
Occupant Risk Values
- Impact Velocity (m/s)
  - x-direction: 1.9
  - y-direction: No contact
- Ridedown Accelerations (g's)
  - x-direction: -0.6
  - y-direction: N/A
- Max. 0.050 s Average (g's)
  - x direction: -0.6
  - y direction: 1.0
  - z direction: 3.3

Test Article Deflections (m)
- Dynamic: nil
- Permanent: nil

Vehicle Damage
- Exterior
  - VDS: N/A
  - CDC: 12FRWU1
- Maximum Exterior Vehicle Crush (mm): 0
- Interior
  - OCDI: RF0000000
- Max. Occ. Compart. Deformation (mm): 0

Post-Impact Behavior (during 1.0 s after impact)
- Max. Roll Angle (deg): -27
- Max. Pitch Angle (deg): 5
- Max. Yaw Angle (deg): 20

Figure 11. Summary of Results for Test 1949A-2.



General Information
- Test Agency . . . . . Texas Transportation Institute
- Test No. 1949A-3
- Date 06/30/92

Test Article
- Type . . . . . End Treatment
- Name . . . . . Low-Profile End Treatment
- Installation Length (m) 30.5
- Size and/or dimension and material of key elements . . . . . 102-mm to 510 mm-High Constant Slope Concrete End Treatment, 6.1-m Long
- Soil Type and Condition . . . . . Concrete Pavement, Dry

Test Vehicle
- Type . . . . . Production
- Designation 2000P
- Model . . . . . 1984 Chevrolet C-20
- Mass (kg) Gross 2121
  - Test Inertial 2043
  - Dummy . . . . . No dummy
  - Gross Static 2043

Impact Conditions
- Speed (km/h) 74.8
- Angle (deg) . . . . . 0 -cntr/cntr

Exit Conditions
- Speed (km/h) 70.6
- Angle (deg) . . . . . approx. 0

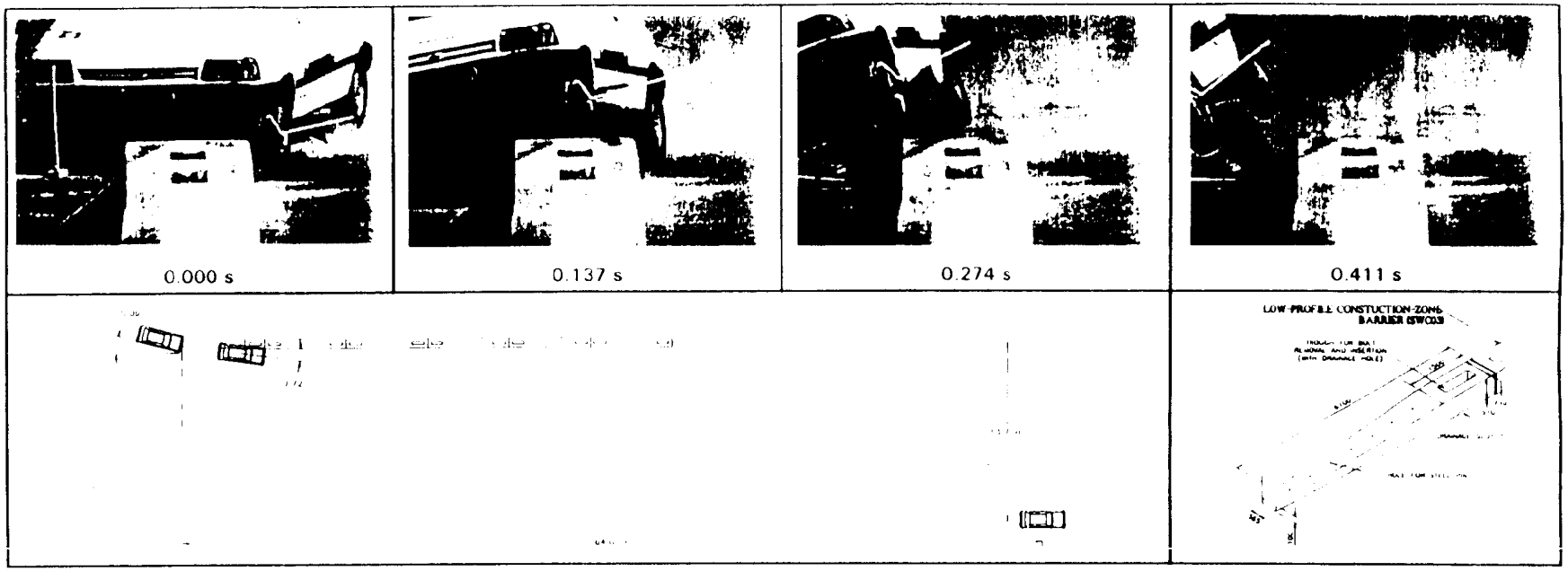
Occupant Risk Values
- Impact Velocity (m/s)
  - x-direction 1.9
  - y-direction 0.4
- Ridedown Accelerations (g's)
  - x-direction 4.1
  - y-direction 2.1
- Max. 0.050-s Average (g's)
  - x-direction 1.8
  - y direction 1.2
  - z-direction 3.3

Test Article Deflections (m)
- Dynamic . . . . . nil
- Permanent . . . . . nil

Vehicle Damage
- Exterior
  - VDS . . . . . N/A
  - CDC 00UDCU1
- Maximum Exterior
  - Vehicle Crush (mm) 0
- Interior
  - OCDI RF0000000
- Max. Occ. Compart. Deformation (mm) 0

Post Impact Behavior (during 1.0 s after impact)
- Max. Roll Angle (deg) 20
- Max. Pitch Angle (deg) . . . . -7
- Max. Yaw Angle (deg) . . . . -7

Figure 17. Summary of Results for Test 1949A-3.



General Information
- Test Agency ..... Texas Transportation Institute
- Test No. 414038-2
- Date 09/18/97

Test Article
- Type ..... End Treatment
- Name ..... Low-Profile Barrier
- Installation Length (m) 36.58
- Size and/or dimension and material of key elements ..... 102-mm to 510 mm-High Constant Slope Concrete End Treatment, 6.1-m Long
- Soil Type and Condition ..... Concrete Pavement, Dry

Test Vehicle
- Type ..... Production
- Designation 820C
- Model ..... 1990 Ford Festiva
- Mass (kg) Curb 810
  - Test Inertial 820
  - Dummy 76
  - Gross Static 896

Impact Conditions
- Speed (km/h) 68.91
- Angle (deg) 15.06

Exit Conditions
- Speed (km/h) 63.15
- Angle (deg) 7.72

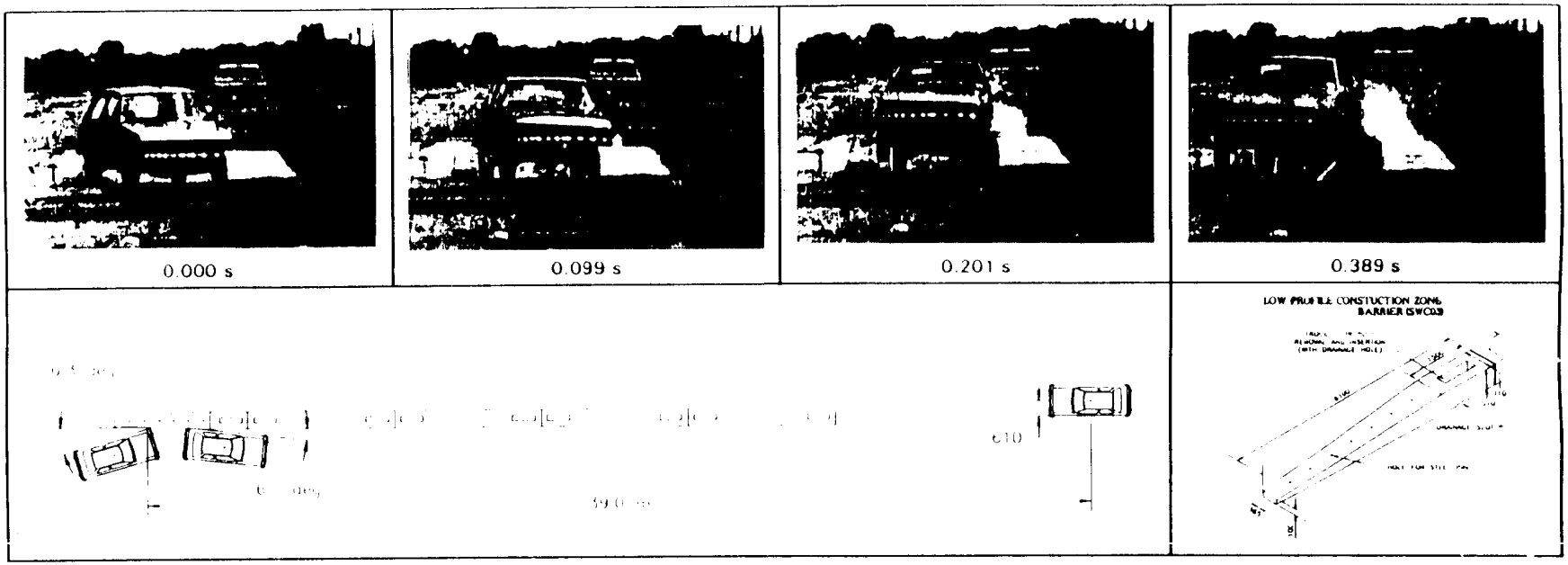
Occupant Risk Values
- Impact Velocity (m/s)
  - x-direction ..... No contact
  - y-direction ..... No contact
- Ridedown Accelerations (g's)
  - x-direction ..... N/A
  - y-direction ..... N/A
- Max. 0.050 s Average (g's)
  - x-direction ..... -0.73
  - y-direction 1.33
  - z-direction 2.54

Test Article Deflections (m)
- Dynamic ..... nil
- Permanent ..... nil

Vehicle Damage
- Exterior
  - VDS 01RFQ0
  - CDC 01FRLU0
- Maximum Exterior
  - Vehicle Crush (mm) .... nil
- Interior
  - OCDI RF0000000
- Max. Occ. Compart. Deformation (mm) 0

Post-Impact Behavior (during 1.0 s after impact)
- Max. Roll Angle (deg) .... -17.4
- Max. Pitch Angle (deg) 8.2
- Max. Yaw Angle (deg) .... -7.3

Figure 24. Summary of Results for Test 414038-2.



General Information
- Test Agency . . . . . Texas Transportation Institute
- Test No. 1949A-1
- Date 06/24/92

Test Article
- Type . . . . . End Treatment
- Name . . . . . Low Profile End Treatment
- Installation Length (m) . . . 30.5
- Size and/or dimension and material of key elements . . . . . 102-mm to 510-mm High Constant Slope Concrete End Treatment, 6.1-m Long
- Soil Type and Condition . . . . . Concrete Pavement, Dry

Test Vehicle
- Type . . . . . Production
- Designation 820C
- Model . . . . . 1986 Yugo GVL
- Mass (kg) Curb 824
  - Test Inertial 817
  - Dummy 76
  - Gross Static 893

Impact Conditions
- Speed (km/h) 71.9
- Angle (deg) 16.3

Exit Conditions
- Speed (km/h) 60.2
- Angle (deg) 6.1

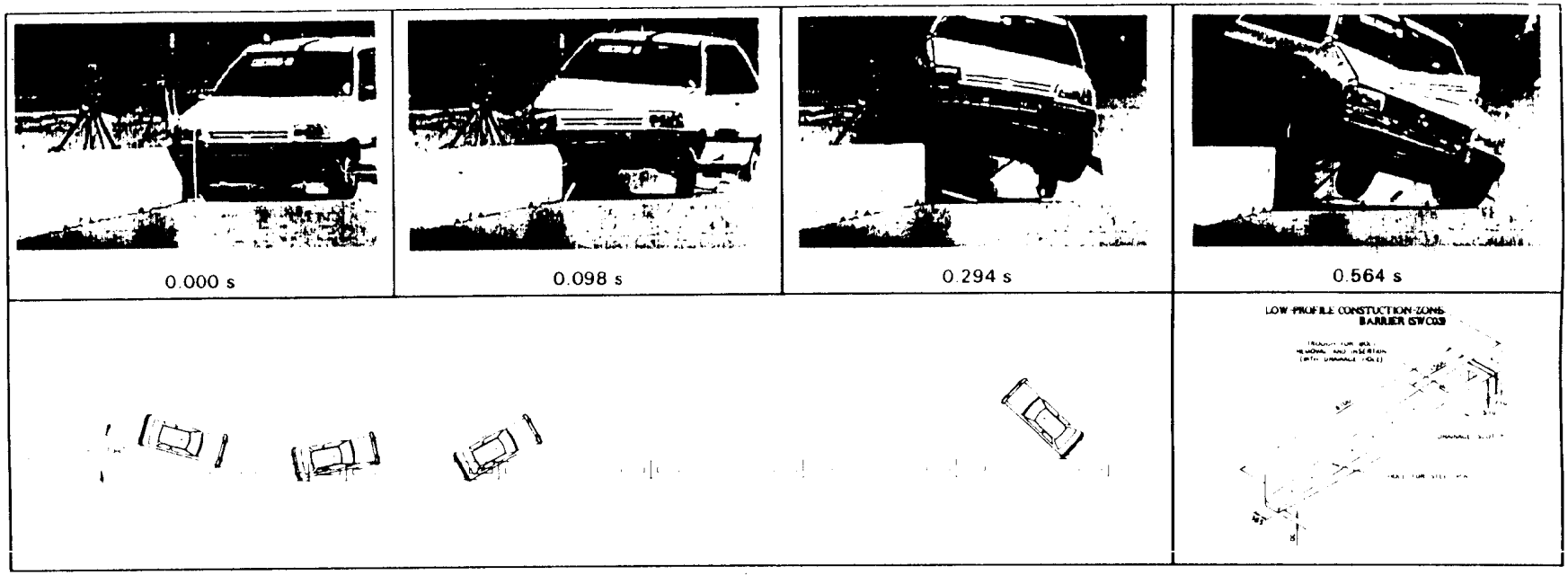
Occupant Risk Values
- Impact Velocity (m/s)
  - x-direction 4.1
  - y-direction 5.5
- Ridedown Accelerations (g's)
  - x-direction . . . . . -1.9
  - y-direction . . . . . -4.5
- Max. 0.050-s Average (g's)
  - x-direction 5.7
  - y-direction 8.3
  - z-direction 3.9

Test Article Deflections (m)
- Dynamic . . . . . nil
- Permanent . . . . . nil

Vehicle Damage
- Exterior
  - VDS 11LFQ1
  - CDC 11LFEW2
- Maximum Exterior Vehicle Crush (mm) 127
- Interior
  - OCDI LF0000000
- Max. Occ. Compart. Deformation (mm) 0

Post Impact Behavior (during 1.0 s after impact)
- Max. Roll Angle (deg) . . . . -3
- Max. Pitch Angle (deg) . . . . -8
- Max. Yaw Angle (deg) . . . . -34

Figure 30. Summary of Results for Test 1949A-1.



General Information
- Test Agency ..... Texas Transportation Institute
- Test No. 414038-1
- Date 09/16/97

Test Article
- Type ..... End Treatment
- Name ..... Low-Profile Barrier
- Installation Length (m) 36.58
- Size and/or dimension and material of key elements ..... 102-mm to 510-mm High Constant Slope Concrete End Treatment, 6.1-m Long
- Soil Type and Condition ..... Concrete Pavement, Dry

Test Vehicle
- Type ..... Production
- Designation 820C
- Model ..... 1990 Ford Festiva
- Mass (kg) Curb 828
  - Test Inertial 820
  - Dummy 75
  - Gross Static 895

Impact Conditions
- Speed (km/h) 70.91
- Angle (deg) 15.78

Exit Conditions
- Speed (km/h) ..... N/A
- Angle (deg) ..... N/A

Occupant Risk Values
- Impact Velocity (m/s)
  - x-direction 2.94
  - y-direction 3.87
- Ridedown Accelerations (g's)
  - x-direction ..... -2.83
  - y-direction ..... -3.06
- Max. 0.050-s Average (g's)
  - x-direction 3.64
  - y-direction 5.85
  - z direction ..... -3.37

Test Article Deflections (m)
- Dynamic ..... nil
- Permanent ..... nil

Vehicle Damage
- Exterior
  - VDS 01RFQ1
  - CDC 01UDCW1
- Maximum Exterior Vehicle Crush (mm) ..... nil
- Interior
  - OCDI RF0000000
- Max. Occ. Compart. Deformation (mm) 35

Post-Impact Behavior (during 1.0 s after impact)
- Max. Roll Angle (deg) ..... -22.8
- Max. Pitch Angle (deg) 16.9
- Max. Yaw Angle (deg) ..... -68.5

Figure 36. Summary of Results for Test 414038-1.