



U.S. Department
of Transportation
**Federal Highway
Administration**

February 10, 2000

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

HMHS-B66

Alexander K. Bardow, P.E.
Bridge Engineer
Massachusetts Highway Department
Ten Park Plaza
Boston, Massachusetts 02116-3973

Dear Mr. Bardow:

In your January 28 letter, you requested formal Federal Highway Administration acceptance of your Massachusetts Type S3 Bridge Railing at the National Cooperative Highway Research Program (NCHRP) Report 350 test level 4 (TL-4). To support your request, you also sent me a copy of a Texas Transportation Institute report dated December 1999, entitled "Testing and Evaluation of the Massachusetts Type S3-TL4 Bridge Railing," by Buth, Menges, and Williams.

You developed and tested two versions of the basic design - one mounted behind a 1550-mm wide sidewalk and one mounted directly on a 200-mm high concrete curb. Both designs consist of a TS127x102x6.4 upper rail and two TS127x127x6.4 lower rails mounted on W150x37 posts on 2000 mm centers. The posts on the curb-mounted design are 200 mm shorter than the posts on the sidewalk design, thus making the total rail height above the roadway and sidewalk surfaces, respectively, 1070 mm in both instances. To give the rail an aesthetic appearance, 38 mm x 38 mm x 1.6-mm thick steel "pickets" are bolted vertically to the field side of the horizontal rail elements. These and other design details are shown in Enclosure 1.

Three full-scale tests (NCHRP Report 350 tests 4-10, 4-11, and 4-12) were run on the sidewalk design using an 820-kg car, a 2000-kg pickup truck, and a 8000-kg single unit truck, thereby demonstrating TL-4 performance. The same tests were run on the curb-mounted design, except that the small car test (test 4-10) was omitted based on its satisfactory performance in the earlier test of the sidewalk design. Summary sheets for each of the five tests are shown in Enclosure 2.

Based on staff review of the information you presented, I agree that the Massachusetts S3-TL4 Bridge Railing meets NCHRP Report 350 evaluation criteria for a TL-4 bridge railing and it may be used on the National Highway System on bridges with sidewalk widths of 1550 mm or greater and on bridges with 200-mm high curbs without sidewalks when requested by a transportation

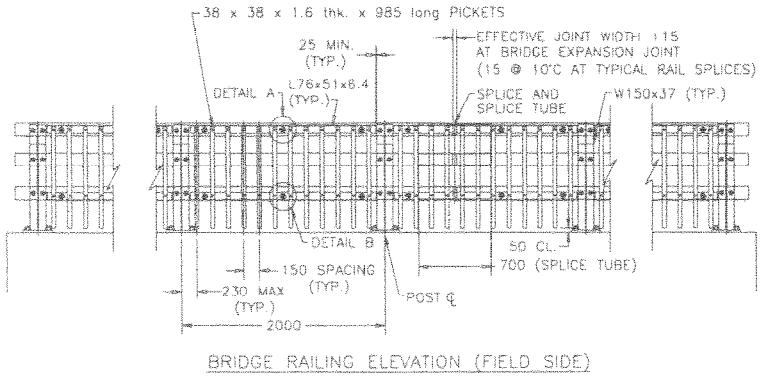
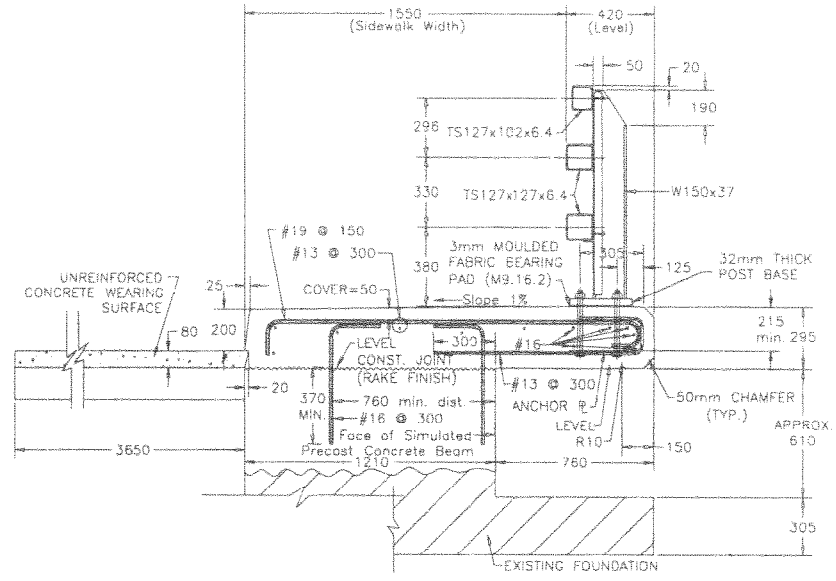
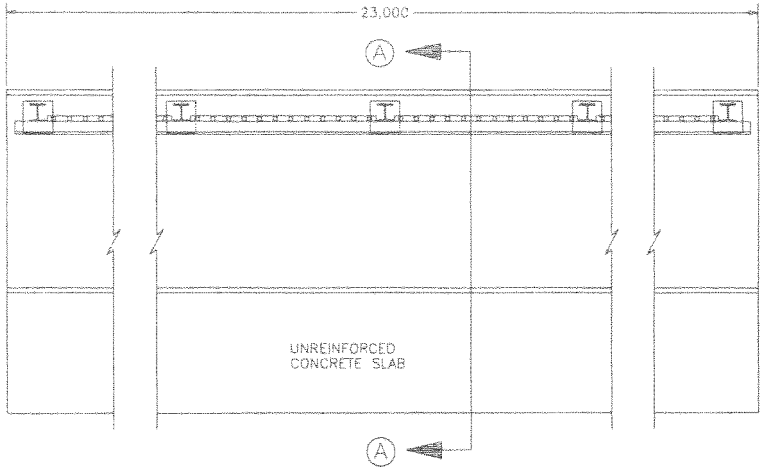
agency. As noted in your letter, the Massachusetts S3 railing has generated a good deal of interest because of its open, aesthetic design and its demonstrated crash test performance at TL-4. I understand that the design is nonproprietary and that anyone seeking detailed drawings and specifications may obtain these by contacting you directly at (617) 973-7570.

Sincerely yours,



Dwight A. Home
Director, Office of Highway Safety Infrastructure

2 Enclosures



- NOTES:
1. FOR DETAILS NOT SHOWN, SEE MASS. STANDARD DRAWING DATED JUNE 27, 1997.
 2. MIN. COMPRESSIVE STRENGTH OF CONCRETE SHALL BE 5000 PSI.
 3. MAX. SIZE OF AGGREGATE SHALL BE 19mm.
 4. MIN. YIELD STRENGTH OF REINFORCEMENT SHALL BE 60KSI.

Revisions				The Texas A&M University System			
No.	Date	By		TEXAS TRANSPORTATION INSTITUTE COLLEGE STATION, TEXAS 77843			
1				Project No.	Date	Drawn By	Scale
2				404251	10/97	TDD	
3				Title MASS BRIDGE RAIL			
4							

Figure 1. Details of the Massachusetts Type S3-TL4 Bridge Railing mounted on sidewalk with curb for tests 404251-1 through 3.

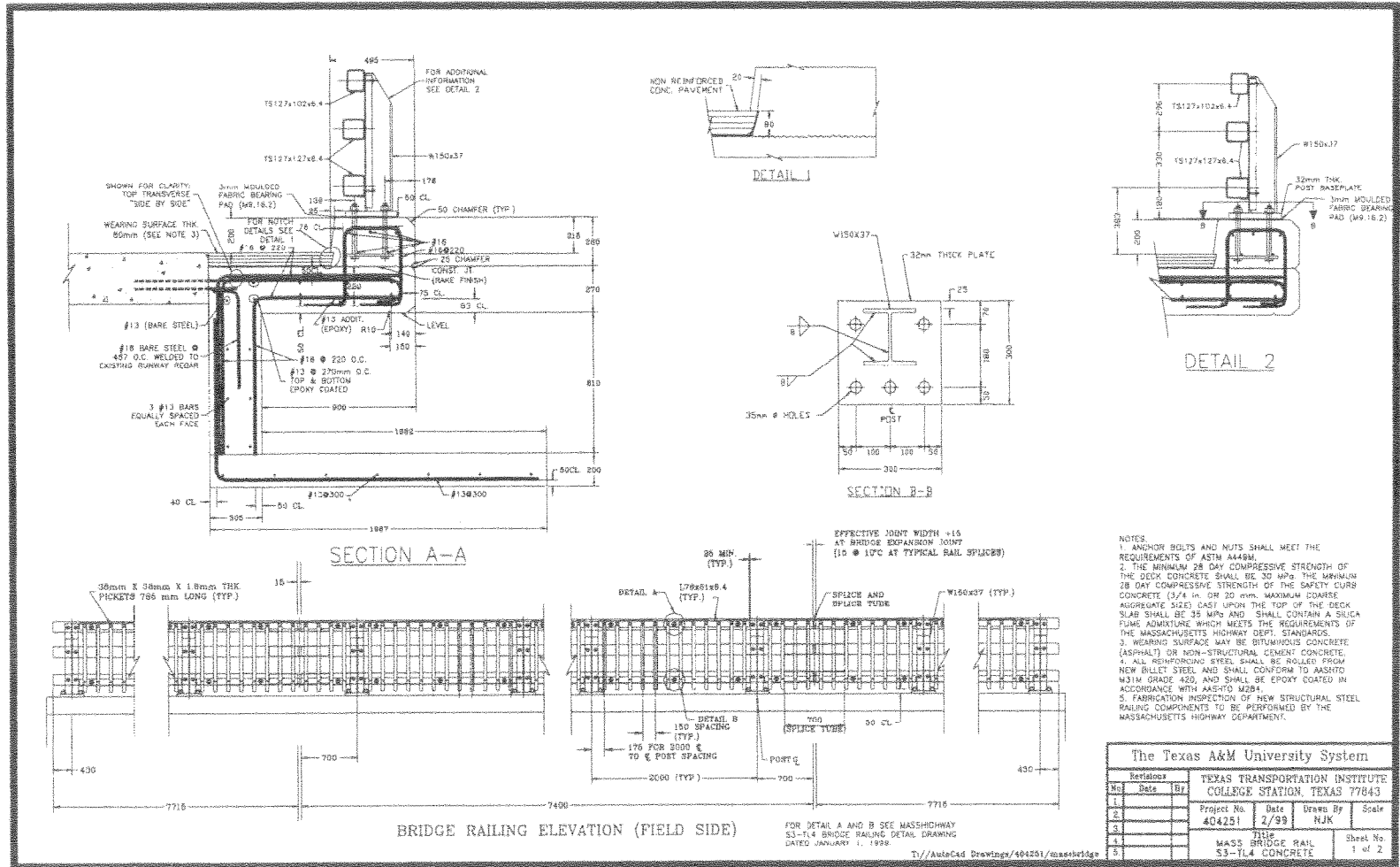
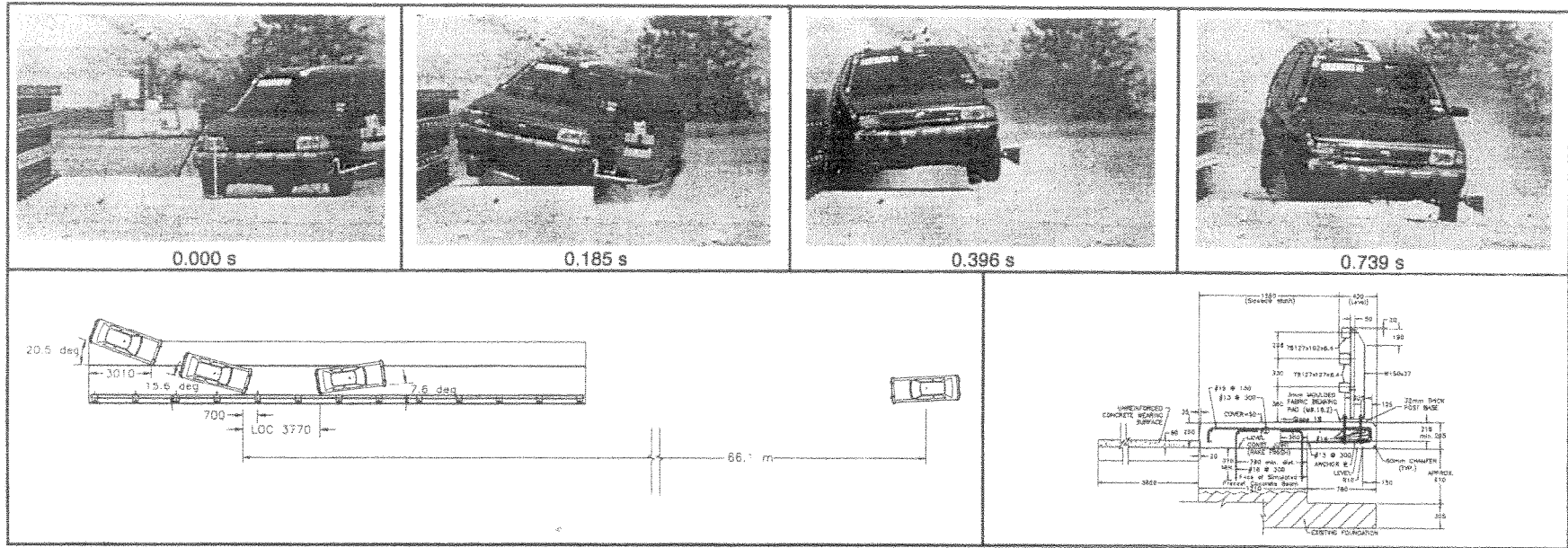


Figure 3. Details of the Massachusetts Type S3-TL4 Bridge Railing mounted on safety curb used for tests 404251-5 and 6.



General Information

Test Agency Texas Transportation Institute
 Test No. 404251-1
 Date 05/21/98

Test Article

Type Bridge Rail
 Name Mass. S3-TL4 on curb/sidewalk
 Installation Length (m) 23.0
 Material or Key Elements Tubular Steel Rail Elements on Steel
 Wide Flange Posts on Sidewalk

Soil Type and Condition Concrete Bridge Deck, Dry

Test Vehicle

Type Production
 Designation 820C
 Model 1993 Ford Festiva
 Mass (kg) Curb 826
 Test Inertial 820
 Dummy 75
 Gross Static 895

Impact Conditions

Speed (km/h) 102.7
 Angle (deg) 20.5

Exit Conditions

Speed (km/h) 83.8
 Angle (deg) 7.6

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 4.1
 y-direction 5.6
 THIV (km/h) 22.5

Ridedown Accelerations (g's)

x-direction -3.3
 y-direction -9.1
 PHD (g's) 9.7
 ASI 1.1
 Max. 0.050-s Average (g's)
 x-direction -4.1
 y-direction -9.1
 z-direction -2.4

Test Article Deflections (m)

Dynamic nil
 Permanent nil

Vehicle Damage

Exterior
 VDS 01RFQ2
 CDC 01FREK1
 &01RDEW3

Maximum Exterior
 Vehicle Crush (mm) 180

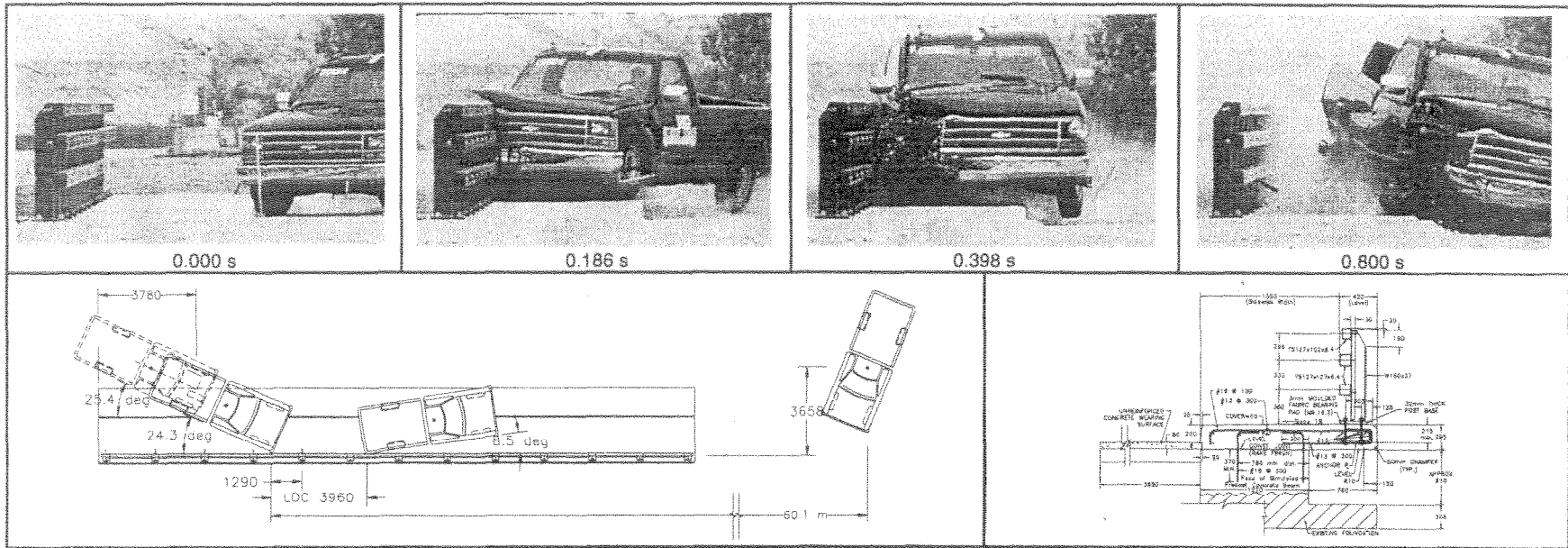
Interior

OCDI RF0000000
 Max. Occ. Comp.
 Deformation (mm) 10

Post-impact Behavior

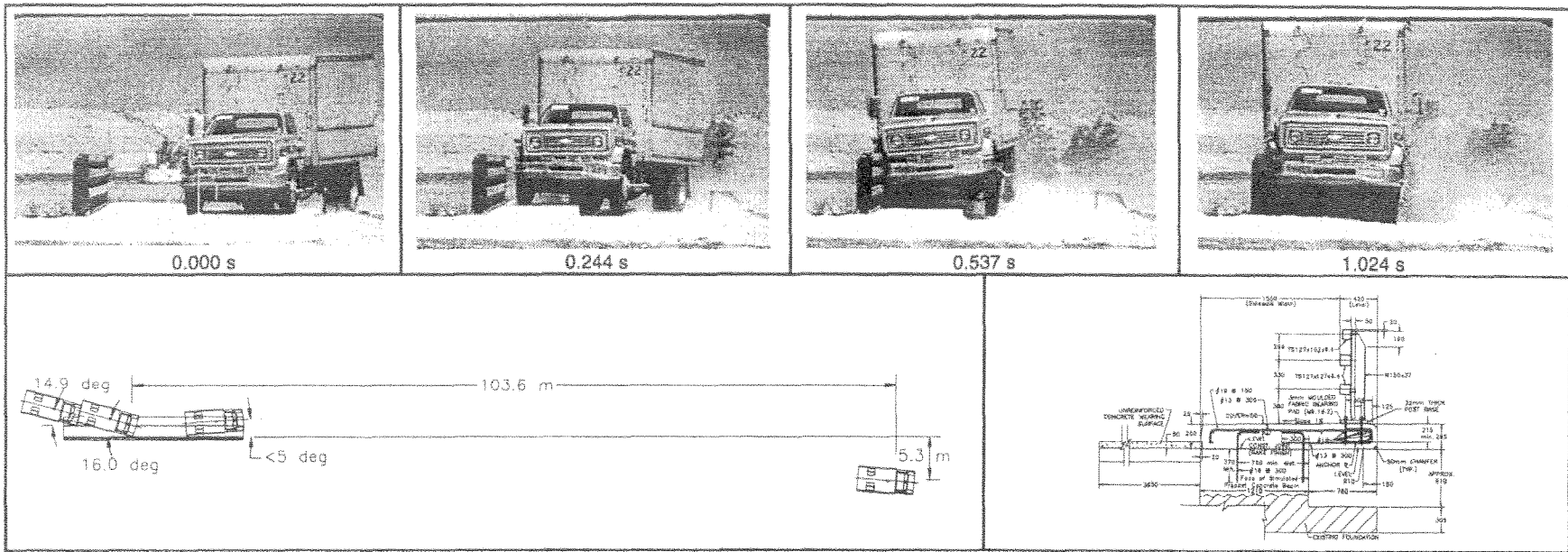
(during 1.0 s after impact)
 Max. Yaw Angle (deg) -23
 Max. Pitch Angle (deg) 10
 Max. Roll Angle (deg) -15

Figure 11. Summary of results for test 404251-1, NCHRP Report 350 test 4-10.



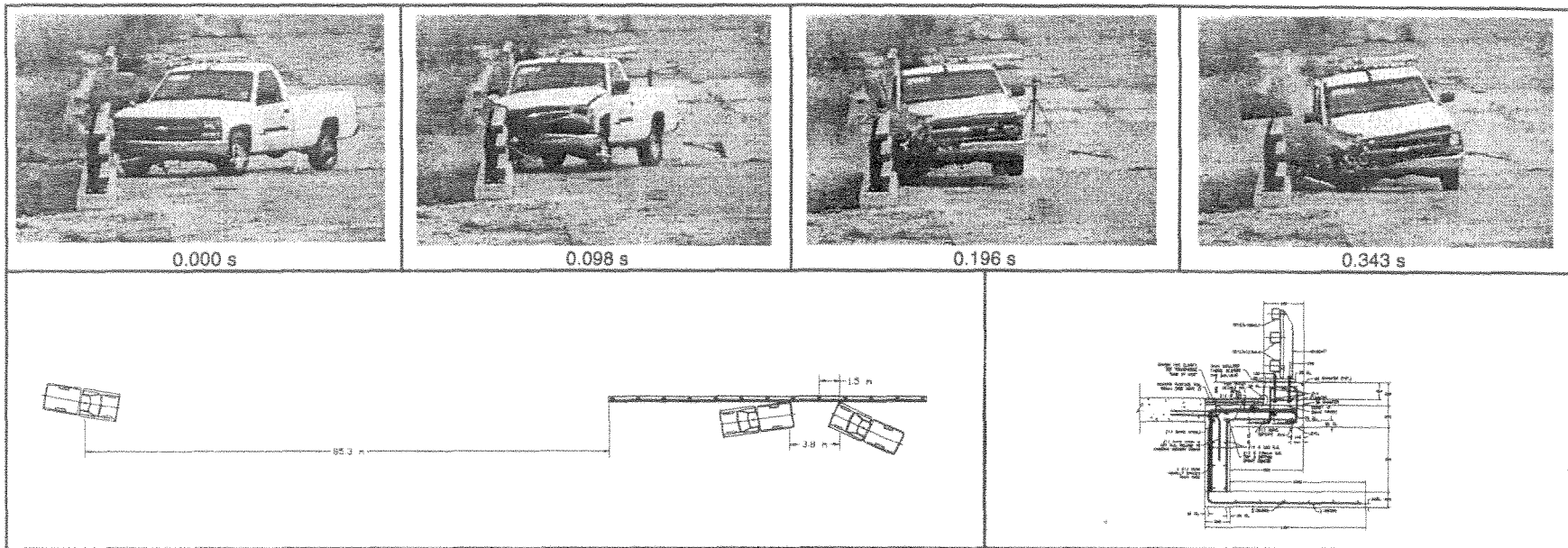
General Information		Impact Conditions		Test Article Deflections (m)	
Test Agency	Texas Transportation Institute	Speed (km/h)	99.4	Dynamic	nil
Test No.	404251-2	Angle (deg)	25.4	Permanent	nil
Date	05/25/98	Exit Conditions		Vehicle Damage	
Test Article		Speed (km/h)	86.0	Exterior	
Type	Bridge Rail	Angle (deg)	8.5	VDS	01RFQ2
Name	Mass. S3-TL4 on curb/sidewalk	Occupant Risk Values		CDC	01FREK1
Installation Length (m)	23.0	Impact Velocity (m/s)		&01RDEW3	
Material or Key Elements	Tubular Steel Rail Elements on Steel Wide Flange Posts on Sidewalk	x-direction	6.2	Maximum Exterior	
Soil Type and Condition		y-direction	7.7	Vehicle Crush (mm)	
Concrete Bridge Deck, Dry		THIV (km/h)	33.0	400	
Test Vehicle		Ridedown Accelerations (g's)		Interior	
Type	Production	x-direction	-7.5	OCDI	
Designation	2000P	y-direction	-9.3	FS1004000	
Model	1993 Chevrolet 2500 pickup	PHD (g's)	11.1	Max. Occ. Compart.	
Mass (kg) Curb	1929	ASI	1.7	Deformation (mm)	
Test Inertial	2000	Max. 0.050-s Average (g's)		48	
Dummy	76	x-direction	-7.8	Post-Impact Behavior	
Gross Static	2076	y-direction	-14.2	(during 1.0 s after impact)	
		z-direction	-7.4	Max. Yaw Angle (deg)	
				-32	
				Max. Pitch Angle (deg)	
				9	
				Max. Roll Angle (deg)	
				-16	

Figure 18. Summary of results for test 404251-2, NCHRP Report 350 test 4-11



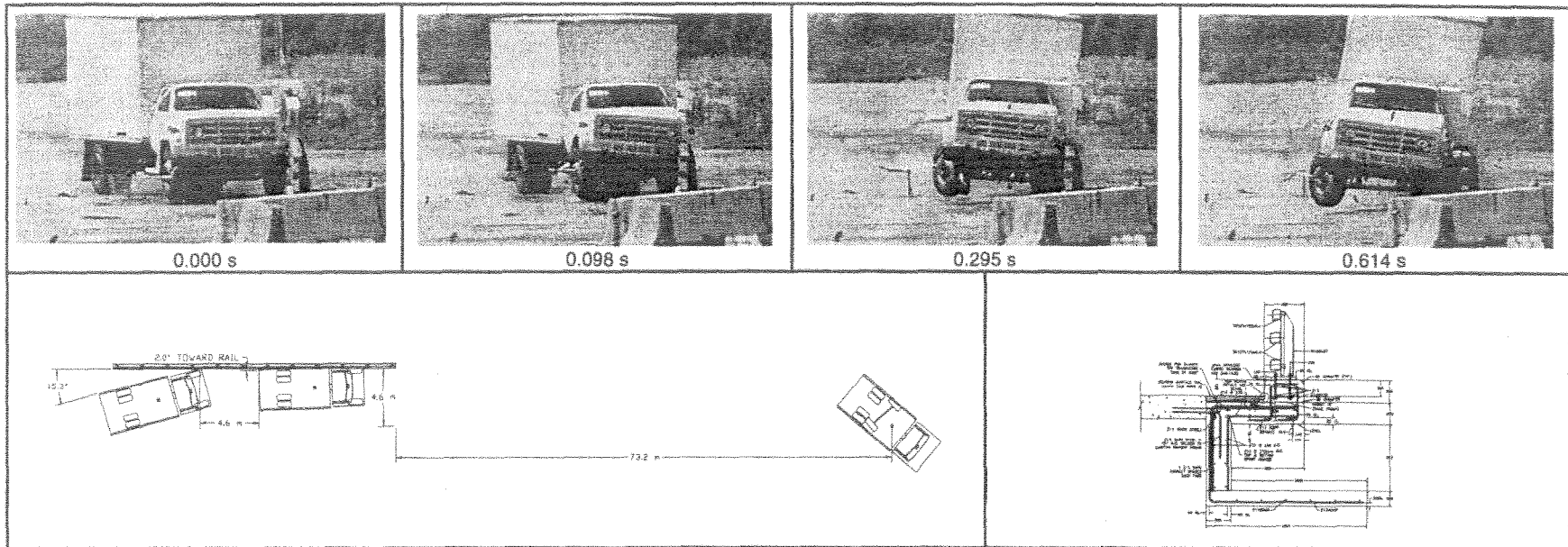
General Information		Impact Conditions		Test Article Deflections (m)	
Test Agency	Texas Transportation Institute	Speed (km/h)	79.6	Dynamic	N/A
Test No.	404251-3	Angle (deg)	14.9	Permanent	0.01
Date	06/19/98	Exit Conditions		Vehicle Damage	
Test Article		Speed (km/h)	N/A	Exterior	
Type	Bridge Rail	Angle (deg)	Approx. 5	VDS	N/A
Name	Mass. S3-TL4 on curb/sidewalk	Occupant Risk Values		CDC	N/A
Installation Length (m)	23.0	Impact Velocity (m/s)		Maximum Exterior	
Material or Key Elements	Tubular Steel Rail Elements on Steel Wide Flange Posts on Sidewalk	x-direction	2.0	Vehicle Crush (mm)	114
Soil Type and Condition	Concrete Bridge Deck, Dry	y-direction	2.6	Interior	
Test Vehicle		THIV (km/h)	10.2	OCDI	FS0000000
Type	Production	Ridedown Accelerations (g's)		Max. Occ. Compart.	
Designation	8000S	x-direction	-1.9	Deformation (mm)	0
Model	1979 Chevrolet C70 single-unit truck	y-direction	-9.6	Post-impact Behavior	
Mass (kg) Curb	5661	PHD (g's)	10.6	(during 1.0 s after impact)	
Test Inertial	8000	ASI	0.5	Max. Yaw Angle (deg)	-13
Dummy	No dummy	Max. 0.050-s Average (g's)		Max. Pitch Angle (deg)	4
Gross Static	8000	x-direction	-1.5	Max. Roll Angle (deg)	5
		y-direction	-4.5		
		z-direction	-2.1		

Figure 25. Summary of results for test 404251-3, NCHRP Report 350 test 4-12.



General information		Impact Conditions		Test Article Deflections (m)	
Test Agency	Texas Transportation Institute	Speed (km/h)	100.9	Dynamic	0.038
Test No.	404251-5	Angle (deg)	25.0	Permanent	0.005
Date	07/13/99	Exit Conditions		Vehicle Damage	
Test Article		Speed (km/h)	84.8	Exterior	
Type	Bridge Rail	Angle (deg)	7.9	VDS	01RFQ2
Name or Manufacturer	Massachusetts S3-TL4 on curb	Occupant Risk Values		CDC	01FREK1
Installation Length (m)	23.0	Impact Velocity (m/s)			&01RDEW2
Material or Key Elements	Tubular Steel Rail Elements on Steel Wide Flange Posts on Safety Curb	x-direction	6.5	Maximum Exterior	
Soil Type and Condition		y-direction	7.8	Vehicle Crush (mm)	
Concrete Bridge Deck, Dry		THIV (km/h)	33.1	460	
Test Vehicle		Ridedown Accelerations (g's)		Interior	
Type	Production	x-direction	-5.9	OCDI	
Designation	2000P	y-direction	-12.2	FS01150001	
Model	1994 Chevrolet 2500 pickup truck	PHD (g's)	13.4	Max. Occ. Compart.	
Mass (kg)		ASI	1.70	Deformation (mm)	
Curb	1925	Max. 0.050-s Average (g's)		77	
Test Inertial	2000	x-direction	-8.8	Post-impact Behavior	
Dummy	No Dummy	y-direction	-13.7	(during 1.0 s after impact)	
Gross Static	2000	z-direction	-4.6	Max. Yaw Angle (deg)	
				-30	
				Max. Pitch Angle (deg)	
				-6	
				Max. Roll Angle (deg)	
				6	

Figure 33. Summary of results for test 404251-5, NCHRP Report 350 test 4-11.



General Information		Impact Conditions		Test Article Deflections (m)	
Test Agency	Texas Transportation Institute	Speed (km/h)	79.1	Dynamic	N/A
Test No.	404251-6	Angle (deg)	15.3	Permanent	0.055
Date	07/22/99	Exit Conditions		Vehicle Damage	
Test Article		Speed (km/h)	69.3	Exterior	
Type	Bridge Rail	Angle (deg)	2.0	VDS	N/A
Name or Manufacturer	Massachusetts S3-TL4 on Curb	Occupant Risk Values		CDC	N/A
Installation Length (m)	23.0	Impact Velocity (m/s)		Maximum Exterior	
Material or Key Elements	Tubular Steel Rail Elements on Steel Wide Flange Posts on Safety Curb	x-direction	2.5	Vehicle Crush (mm)	nil
Soil Type and Condition		y-direction	3.4	Interior	
Concrete Bridge Deck, Dry		THIV (km/h)	12.8	OCDI	N/A
Test Vehicle		Ridedown Accelerations (g's)		Max. Occ. Compart.	
Type	Production	x-direction	-2.5	Deformation (mm)	N/A
Designation	8000S	y-direction	7.5	Post-Impact Behavior	
Model	1987 GMC 7000 Single-Unit Truck	PHD (g's)	7.8	(during 1.0 s after impact)	
Mass (kg)		ASI	0.53	Max. Yaw Angle (deg)	17
Curb	5153	Max. 0.050-s Average (g's)		Max. Pitch Angle (deg)	6
Test Inertial	8000	x-direction	-1.4	Max. Roll Angle (deg)	-8
Dummy	No Dummy	y-direction	4.6		
Gross Static	8000	z-direction	2.2		

Figure 40. Summary of results for test 404251-6, NCHRP Report 350 test 4-12.