

December 24, 1998

Refer to: HNG-14

Mr. Darryl E. Durgin
Deputy Commissioner
Chief Engineer
Minnesota Department of Transportation
395 John Ireland Boulevard
Saint Paul, Minnesota 55155-1890

Dear Mr. Durgin:

In your November 5 letter to Mr. Henry Rentz, you requested the Federal Highway Administration's (FHWA) acceptance of the Eccentric Loader Terminal (ELT) as an National Cooperative Highway Research Program (NCHRP) Report 350 Test Level 3 (TL-3) terminal for W-beam guardrail. To support your request, you also sent copies of a Texas Transportation Institute report, "Crash Testing and Evaluation of the Eccentric Loader Terminal (ELT)," by Mak, Bligh, and Menges, dated October 1998.

Our review indicated that the ELT that was tested to the NCHRP Report 350 criteria is essentially the same design as the ELT that was developed and tested in the late 1980's under NCHRP Report 230 criteria. The only changes made were the replacement of post number 7 (originally a standard line post) with a fifth wooden CRT post, and a 25 mm extension in the offset distance (from 635 mm to 660 mm) at post number 2. The latter change is reflected in the enclosed drawings (Enclosure 1), and we suggest that the drawings be updated to show clearly the use of CRT posts at post locations 3 through 7.

The NCHRP Report 350 recommends up to seven tests for a gating, redirective terminal. We agreed prior to testing that the angle hits on the nose of the ELT (tests 3-32 and 3-33) and the reverse direction test (3-39) could be waived as they have been with similarly flared terminal designs. We also agreed that earlier tests run on the Report 230 ELT, RBCT-13 (test 3-30) and RBCT-19 (test 3-34), need not be repeated if they met the test parameters now required in the NCHRP Report 350. The researchers reviewed the earlier tests and we concur in their finding that both of these small car tests essentially conformed to the current NCHRP Report 350 tests and that neither test need be repeated.

The summary results of the new tests that were run, tests 3-31 and 3-35, are enclosed as Enclosure 2.

Based on our review of the information you submitted, we find that the ELT, with the modifications listed above, meets the acceptance criteria for an NCHRP Report 350 Test Level 3 (TL-3) W-beam guardrail terminal and is acceptable for use on the National Highway System (NHS) if requested by a transportation agency. However, since the pickup truck rode on the rail for approximately 45 m in the end-on test, each barrier installation terminated with an ELT should have a length of need sufficiently long to prevent an impacting vehicle from reaching a shielded fixed-object hazard that is directly behind the guardrail. This recommendation is also noted in the research report. Because all of the line posts in the test installation were timber posts and the W-beam was near its breaking point, the ELT should not be used with steel line posts without an additional test. Because several of the line posts failed at the ground line as the truck slid on top of the rail, the ELT and the guardrail installation it anchors should be installed in a strong soil, as tested. We noted also that the ELT was installed and tested using straight sections of W-beam rail that are forced against the posts resulting in some kinking of the rail elements. We believe this kinking is beneficial in that it allows the rail to collapse more readily in an end-on hit. Consequently, shop-curved sections should not be used without further testing.

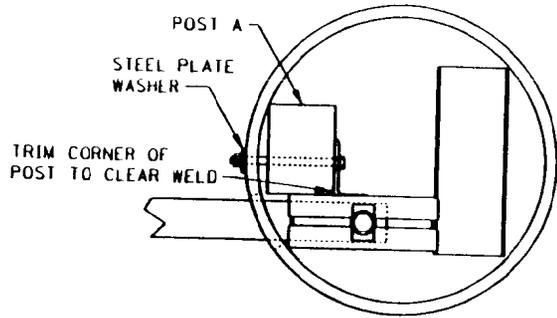
Finally, we wish to emphasize the necessity and importance of the grading around the terminal that is shown in your standard drawing. As with all gating terminals, impacting vehicles may travel some distance behind and beyond the ELT in an end-on hit so this area needs to be clear of hazards and relatively traversable. You may also wish to revise your standard drawing to show appropriate reflectorization on the nose of the ELT and, as noted above, to show that posts 3 through 7 are CRT posts and post 8 and all downstream posts must be standard timber line posts.

Sincerely yours,

(original signed by Dwight A. Horne)

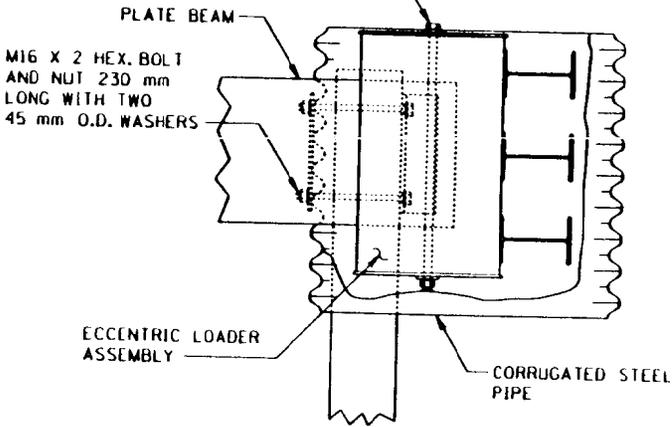
Dwight A. Horne
Chief, Federal-Aid and Design Division

2 Enclosures
Acceptance Letter CC-56



TOP VIEW

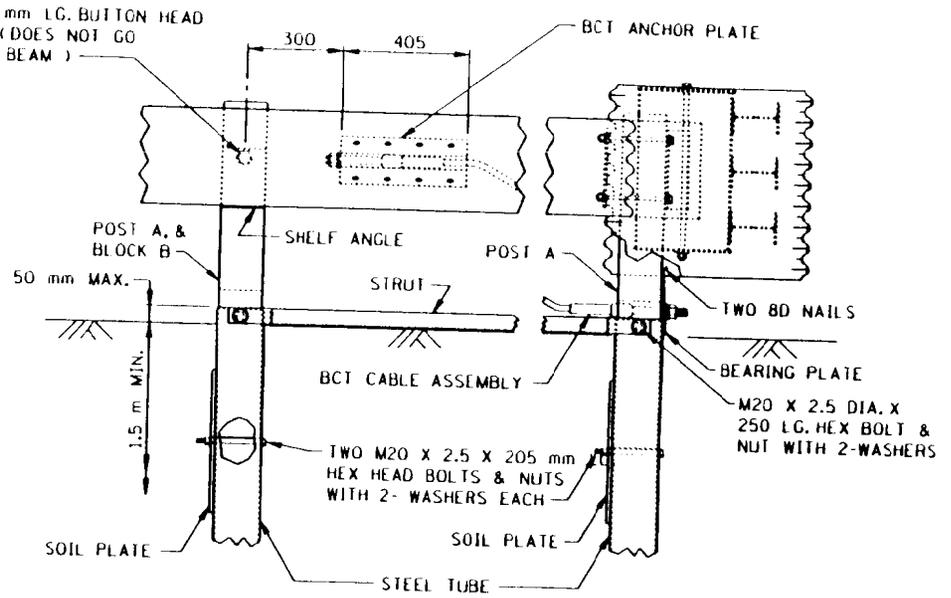
M16 X 2 HEX BOLT AND NUT 560 mm LONG WHICH PASSES THRU END SPLICE BOLT SLOTS OF PLATE BEAM. 45 mm X 75 mm RECTANGULAR WASHER AND 45 mm O.D. WASHERS ON TOP AND BOTTOM



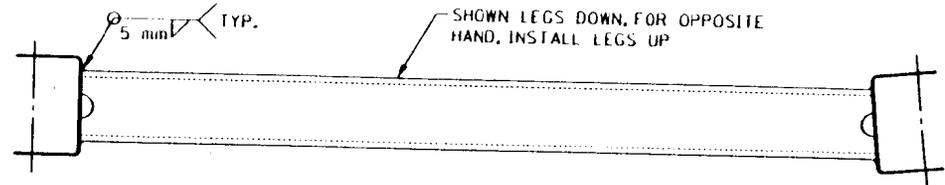
SIDE VIEW

NOSE DETAILS

M16 X 2 X 455 mm LG. BUTTON HEAD BOLT AND NUT (DOES NOT GO THROUGH PLATE BEAM)



ELEVATION - NOSE ASSEMBLY



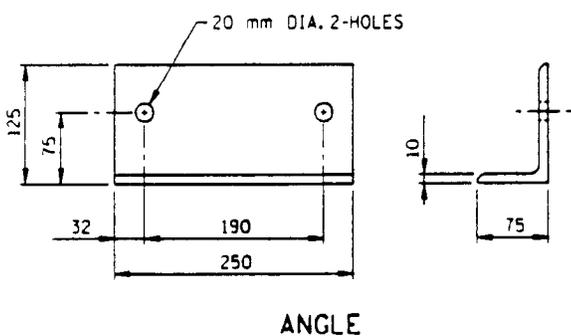
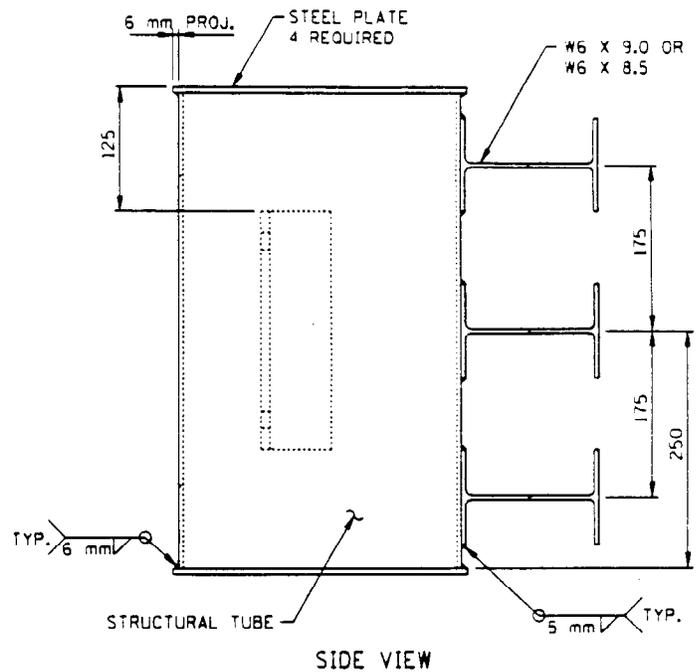
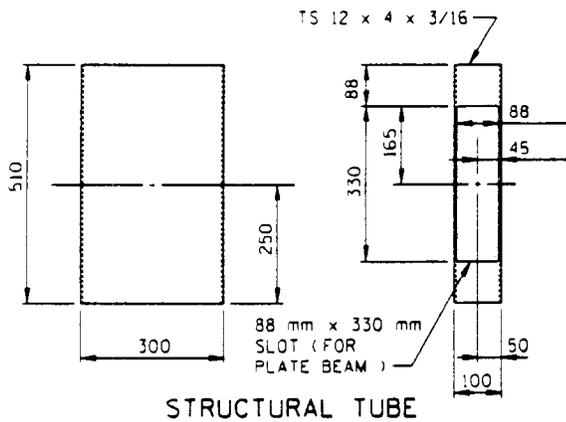
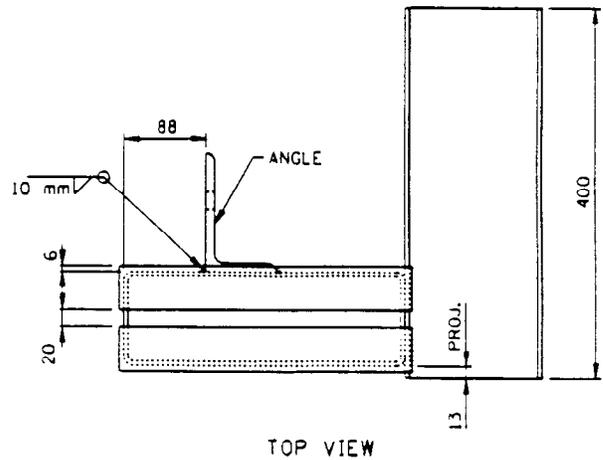
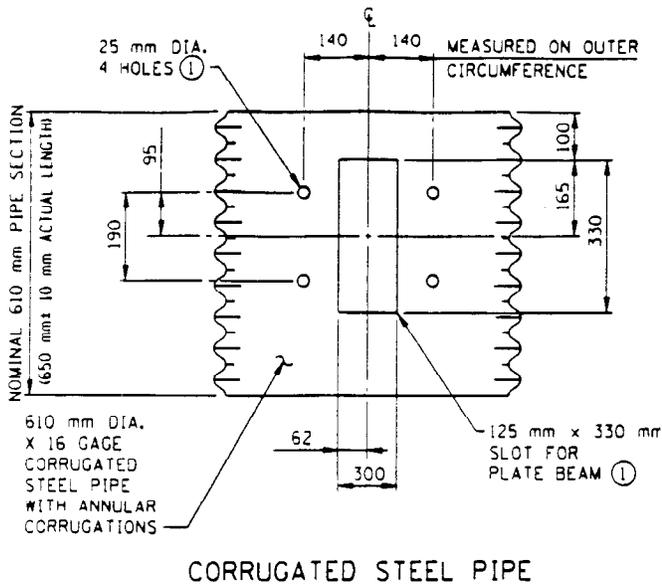
PLAN VIEW

STRUT AND YOKE ASSEMBLY

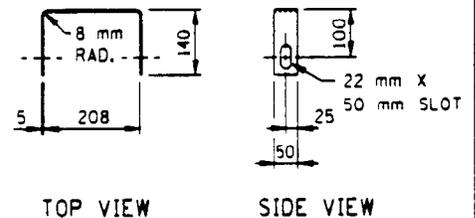
NOTES:

CORRUGATED STEEL PIPE AS PER SPEC. 3226.
STRUCTURAL STEEL AS PER SPEC. 3306, UNLESS OTHERWISE NOTED.
GALVANIZE STRUCTURAL STEEL AS PER SPEC. 3392 & 3394 AFTER FABRICATION, UNLESS OTHERWISE NOTED.

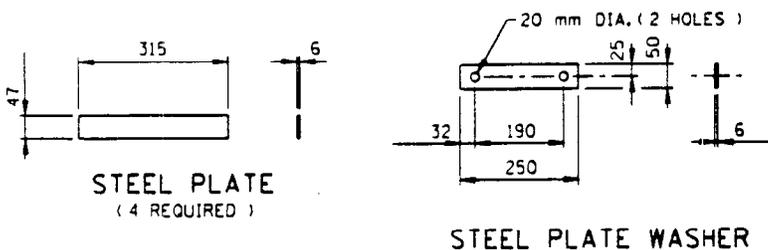
NOTE: ALL DIMENSIONS ARE IN MILLIMETERS, EXCEPT AS NOTED.



ECCENTRIC LOADER ASSEMBLY



YOKE (2 REQUIRED)



① DO NOT USE FLAME CUTTING FOR THESE OPENINGS.

NOTE:
 ALL DIMENSIONS ARE IN MILLIMETERS, EXCEPT AS NOTED.

APPROVED February 19, 1992
B.M. Hill
 DIRECTOR

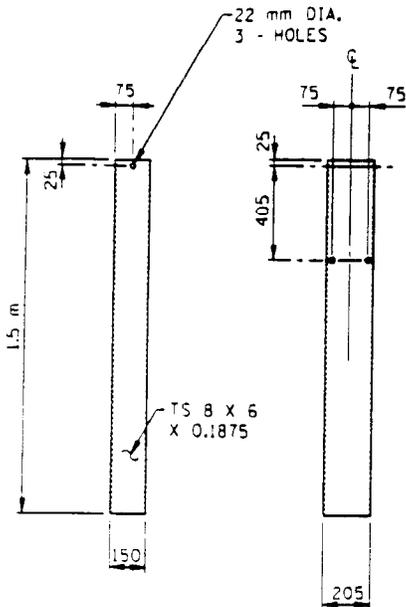
STATE OF MINNESOTA
 DEPARTMENT OF TRANSPORTATION
**ECCENTRIC LOADER
 BREAKAWAY CABLE TERMINAL (ELT)**

SPECIFICATION
 REFERENCE

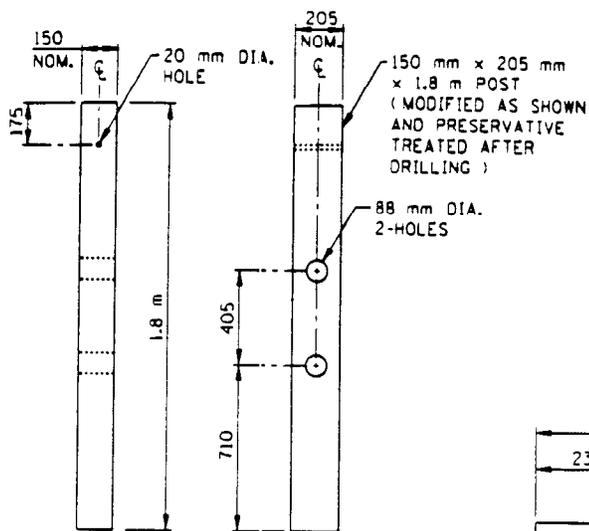
2554

STANDARD
 PLATE
 NO.

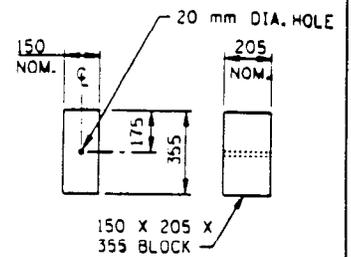
M8329F



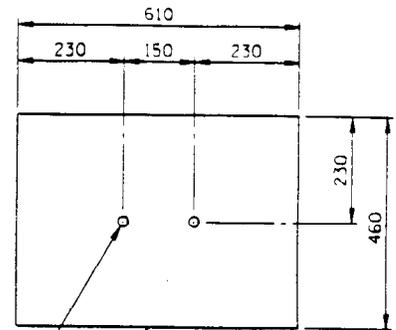
STEEL TUBE (POST A)



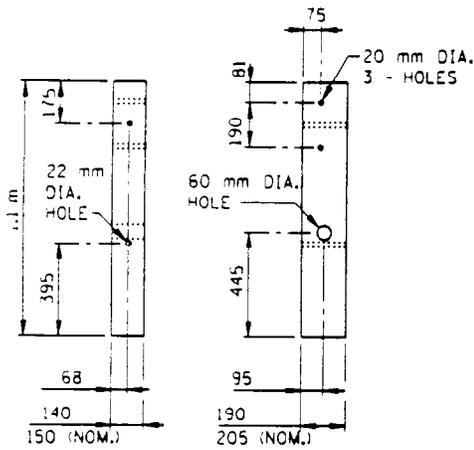
WOOD BREAKAWAY POST B



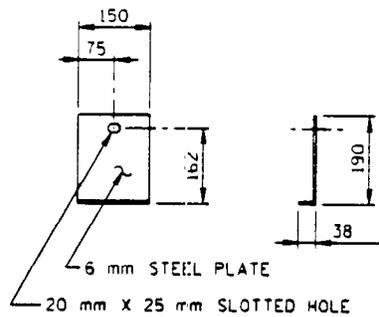
WOOD BLOCK B
(STANDARD BLOCKOUT)



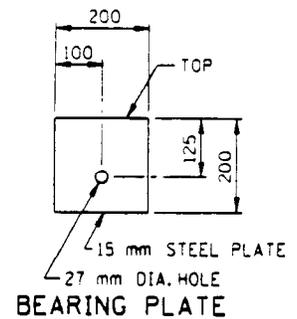
6 mm STEEL PLATE
22 mm DIA. HOLES
SOIL PLATE (POST A)
(2 REQUIRED)



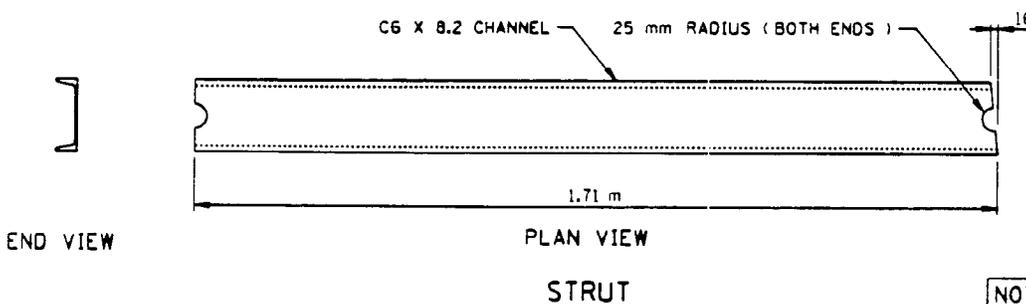
WOOD BREAKAWAY POST A



6 mm STEEL PLATE
20 mm X 25 mm SLOTTED HOLE
SHELF ANGLE
(ONE REQUIRED)



15 mm STEEL PLATE
27 mm DIA. HOLE
BEARING PLATE



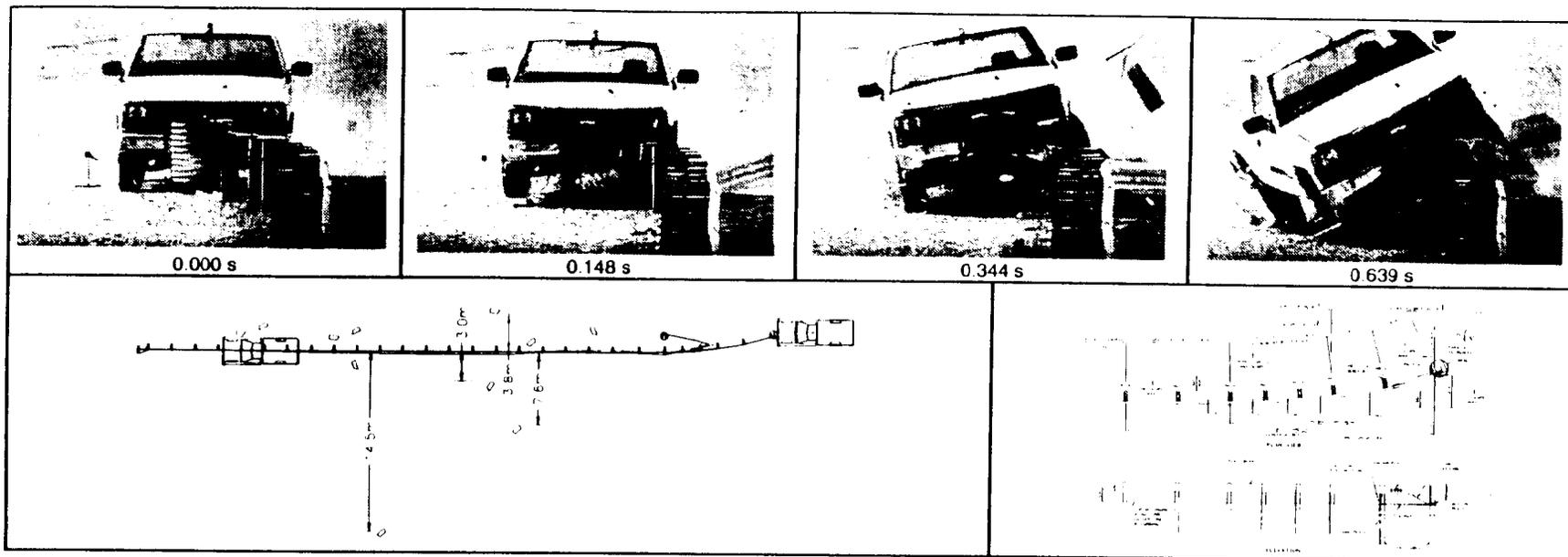
STRUT

NOTE:
ALL DIMENSIONS ARE IN
MILLIMETERS, EXCEPT AS NOTED.

APPROVED February 19, 1992
B.M. Hill
DIRECTOR
OFFICE OF TECHNICAL SUPPORT

STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION
ECCENTRIC LOADER
BREAKAWAY CABLE TERMINAL (ELT)

SPECIFICATION REFERENCE	STANDARD PLATE NO.
2554	M8329F



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General Information

Test Agency Texas Transportation Institute
 Test No. 473390-2
 Date 09/09/88

Test Article

Type Terminal
 Name or Manufacturer Minnesota ELT
 Installation Length (m) 57.1
 Material or Key Elements 1.2 m Flared W-beam Guardrail on
 Wooden Posts Spaced 1.9 m

Soil Type and Condition

Standard Soil, Dry

Test Vehicle

Type Production
 Designation 2000P
 Model 1994 Chevrolet 2500 pickup truck
 Mass (kg)
 Curb 2084
 Test Inertial 2000
 Dummy No dummy
 Gross Static 2000

Impact Conditions

Speed (km/h) 99.7
 Angle (deg) 0

Exit Conditions

Speed (km/h) Stopped
 Angle (deg) N/A

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 5.3
 y-direction 1.9
 THIV (km/h) 18.9
 Ridedown Accelerations (g's)
 x-direction -4.0
 y-direction -4.6
 PHD (g's) 5.3
 ASI 0.73
 Max. 0.050-s Average (g's)
 x-direction -7.1
 y-direction 3.0
 z-direction 3.2

Test Article Deflections (m)

Dynamic 7.97
 Permanent 7.60

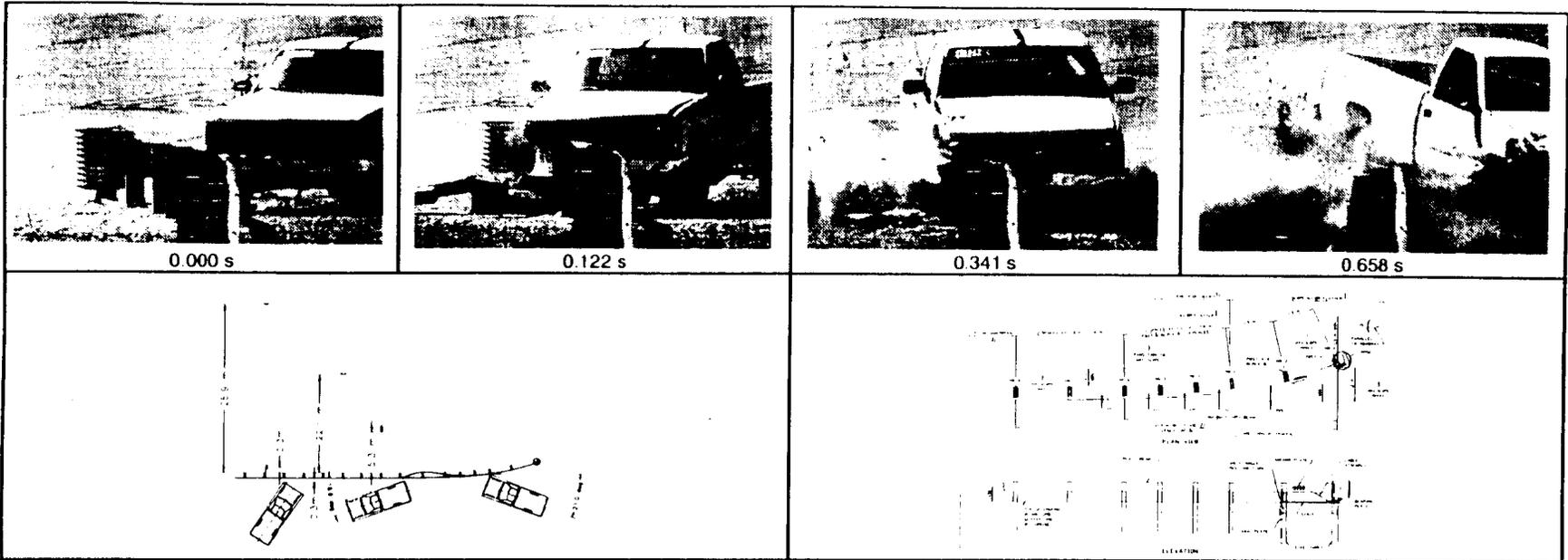
Vehicle Damage

Exterior
 VDS 12FC4
 CDC 12FDEW3
 Maximum Exterior
 Vehicle Crush (mm) 380
 Interior
 OCDI FS0000000
 Max. Occ. Compart.
 Deformation (mm) 0

Post-Impact Behavior

(during 1.0 s after impact)
 Max. Yaw Angle (deg) -24
 Max. Pitch Angle (deg) -7
 Max. Roll Angle (deg) 36

Figure 18. Summary of results for test 473390-2, NCHRP Report 350 test 3-31.



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General Information

Test Agency Texas Transportation Institute
 Test No. 473390-1
 Date 09/07/98

Test Article

Type Terminal
 Name Minnesota ELT
 Installation Length (m) 57.1
 Material or Key Elements 1.2 m Flared W-beam guardrail on wooden posts spaced 1.9 m

Soil Type and Condition

Standard Soil, Dry

Test Vehicle

Type Production
 Designation 2000P
 Model 1994 Chevrolet 2500 pickup truck
 Mass (kg)
 Curb 2071
 Test Inertial 2000
 Dummy No dummy
 Gross Static 2000

Impact Conditions

Speed (km/h) 102.1
 Angle (deg) 21.0

Exit Conditions

Speed (km/h) 35.9
 Angle (deg) 18.8

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 7.3
 y-direction 4.5
 THIV (km/h) 24.4
 Ridedown Accelerations (g's)
 x-direction -9.7
 y-direction -9.0
 PHD (g's) 12.8
 ASI 0.78
 Max. 0.050-s Average (g's)
 x-direction -6.0
 y-direction -5.2
 z-direction 7.5

Test Article Deflections (m)

Dynamic 0.99
 Permanent 0.64

Vehicle Damage

Exterior
 VDS 01RFQ4
 CDC 01FREK2
 &01RFEW3

Maximum Exterior
 Vehicle Crush (mm) 440

Interior
 OCDI RF0104000

Max. Occ. Compart.
 Deformation (mm) 62

Post-Impact Behavior

(during 1.0 s after impact)
 Max. Yaw Angle (deg) -45
 Max. Pitch Angle (deg) -5
 Max. Roll Angle (deg) -6

Figure 10. Summary of results for test 473390-1, NCHRP Report 350 test 3-35.