2003

PERFORMANCE ANALYSIS OF WELCH PRODUCTS RECYCLED RUBBER SPACER BLOCK

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Submitted by

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University of Nebraska-Lincoln
527 Nebraska Hall
Lincoln, Nebraska 68588-0529
(402) 472-6864

Submitted to

MIDWEST STATE'S REGIONAL POOLED FUND
Nebraska Department of Roads
1500 Nebraska Highway 2
Lincoln, NE 68502

MwRSF Research Report No. TRP-03-132-03

March 16, 2003

March 13, 2003

Mr. Howard Block
Welch Products, Inc.
205 S. Garfield
Carlisle, Iowa 50047
Phone - 515-989-0829
Fax - 515-989-0344

Subject: Summary Report on the Performance Analysis of Welch Products Recycled Rubber Spacer Block

Dear Mr. Block:

The Midwest Roadside Safety Facility was contracted by Will Stein of the Iowa Department of Transportation to conduct dynamic bogie testing of a recyclable rubber guardrail spacer block manufactured by Welch Products, Inc. The scope of the work included the setup of both a standard, wood guardrail post blockout and the Welch Products recycled rubber blockout on a standard W150x13.5 steel post, as well as two component tests using a bogie vehicle. The bogie tests were conducted in accordance with previously accepted procedures to evaluate the performance of guardrail post blockouts made of non-standard materials.

On February 28, 2003, MwRSF performed two dynamic bogie tests on two spacer blocks, a routed, wood spacer block and a recycled rubber spacer block.

Wood Routed W-beam Spacer Block

Bogie test no. WB-1 was performed at 32.2 km/h and 0 degrees on a routed, wood spacer block mounted on a W150x13.5 steel post at a mounting height of 550 mm. A 305-mm long piece of W-beam guardrail was mounted on the front of the spacer block. The system description, design details, and test results for the routed, wood spacer block are included in Attachment No. 1.

Recycled Rubber Routed W-beam Spacer Block

Bogie test no. WB-2 was performed at 31.9 km/h and 0 degrees on a routed, recycled rubber spacer block mounted on a W150x13.5 steel post at a mounting height of 550 mm. A 305-mm long piece of W-beam guardrail was mounted on the front of the spacer block. The system description, design details, and test results for the routed, recycled rubber spacer block are included in Attachment No. 1.

Discussion

Based on the results of the crash tests, obvious differences were observed in the performance of the wood and recycled rubber blockouts. While both blockouts displayed similar levels of permanent damage after impact, the recycled rubber blockout was observed to be much less stiff than the wood blockout during the impact. Analysis of the high speed film showed that the recycled rubber blockout crushed approximately 76 mm during the impact, thereby reducing the effective depth of the spacer block to 127 mm. The reduced depth of the spacer block causes an increased potential for wheel snag because the guardrail would no longer be spaced 203 mm in front of the post as in standard W-beam guardrail systems. It is believed that the increased potential for wheel snag may pose a hazard if the recycled rubber blockout were installed on a standard W-beam guardrail.

A second area of concern with the recycled rubber blockout design pertained to installation. Due to the lower relative stiffness of the recycled rubber blockout and the offset post bolt on the W150x13.5 post used in the testing, tightening of the post bolt to secure the W-beam to the post and blockout caused one side of the blockout to compress. This prevented the W-beam from being mounted on the system perpendicular to the post. It is believed that this phenomena could cause some problems installing the blockout on W-beam installations in the field.

In light of the comparison of the crash test results, the researchers recommend that the Welch Products recycled rubber blockout be subjected to full-scale crash testing on a standard W-beam system to alleviate the previously mentioned concerns with stiffness and construction. The bogie tests detailed herein demonstrated that the performance of the recycled rubber blockout was substantially different under load than the standard wooden blockout. As such, it is not possible to accurately predict the performance of the blockout when installed in a full-scale system without further testing.

If you have any questions regarding this information, please feel free to contact me at (402) 472-9064.

Sincerely,

Bob Bielenberg, M.S.M.E., E.I.T.
Research Associate Engineer

Enclosures: (1) One CD-ROM containing digital still photographs, slow-speed footage, and high-speed footage of the two bogie tests.

Attachment: (1) Performance Analysis of Welch Products Recycled Rubber Spacer Block

x.c. - Ronald Faller, Ph.D., P.E., Research Assistant Professor

ATTACHMENT NO. 1

PERFORMANCE ANALYSIS OF WELCH PRODUCTS RECYCLED RUBBER SPACER BLOCK

Bogie Test WB-1 (Wood Spacer Block Baseline Test)

1. System:
   - Wood spacer block for steel post W-beam system
   - 200-mm x 150-mm x 360-mm spacer block with 10-mm x 100-mm x 360-mm router on back face
   - Southern Yellow Pine
   - Mounted on W150x13.5 steel post in rigid foundation with a 305-mm long section of 12 gauge W-beam guardrail on the front face
   - Standard mounting height (550 mm to post bolt)

2. Bogie Vehicle Weight: 992 kg

3. Impact speed: 32.2 km/hr
   Impact orientation: 0 degrees
   Bogie Impact Height: 550 mm

4. System performance – The wood spacer block displayed minor damage due to the impact of the bogie vehicle. Some cracking and chipping of the wood on the front face of the block was observed. A portion of the routed edge on the rear of the block was disengaged as to bogie rolled over the post. No crushing or change in the depth of the spacer block was observed during the impact. The spacer block remained attached to the post.

Bogie Test WB-2 (Recycled Rubber Spacer Block Test)

1. System:
   - Recycled rubber spacer block for steel post W-beam system
   - 213-mm x 140-mm x 360-mm spacer block with 10-mm x 111-mm x 360-mm router on back face
   - Recycled Rubber (rubber material and resin compound)
   - Mounted on W150x13.5 steel post in rigid foundation with a 305-mm long section of 12 gauge W-beam guardrail on the front face
   - Standard mounting height (550 mm to post bolt)

2. Bogie Vehicle Weight: 992 kg

3. Impact speed: 31.9 km/hr
   Impact orientation: 0 degrees
   Bogie Impact Height: 550 mm

4. System performance – The recycled rubber spacer block displayed minor damage due to the impact of the bogie vehicle. The front face displayed slices near the top and bottom of the block where the W-beam guardrail penetrated into the rubber during impact. An approximately 76 mm x 76 mm section of the block near the top-left corner on the rear of the block was disengaged as the bogie vehicle rolled over the post. Significant crushing of the spacer block was observed during the impact. The depth of the spacer block was reduced a maximum of approximately 76 mm. The spacer block remained attached to the post.

It should be noted that the field crew noticed that the W-beam rail would not mount perpendicular to the W150x13.5 post. The relatively low stiffness of the spacer block, combined with the offset post bolt location on the steel post, caused one side of the spacer block to compress more than the other. This prevented installation of the W-beam at the correct angle.

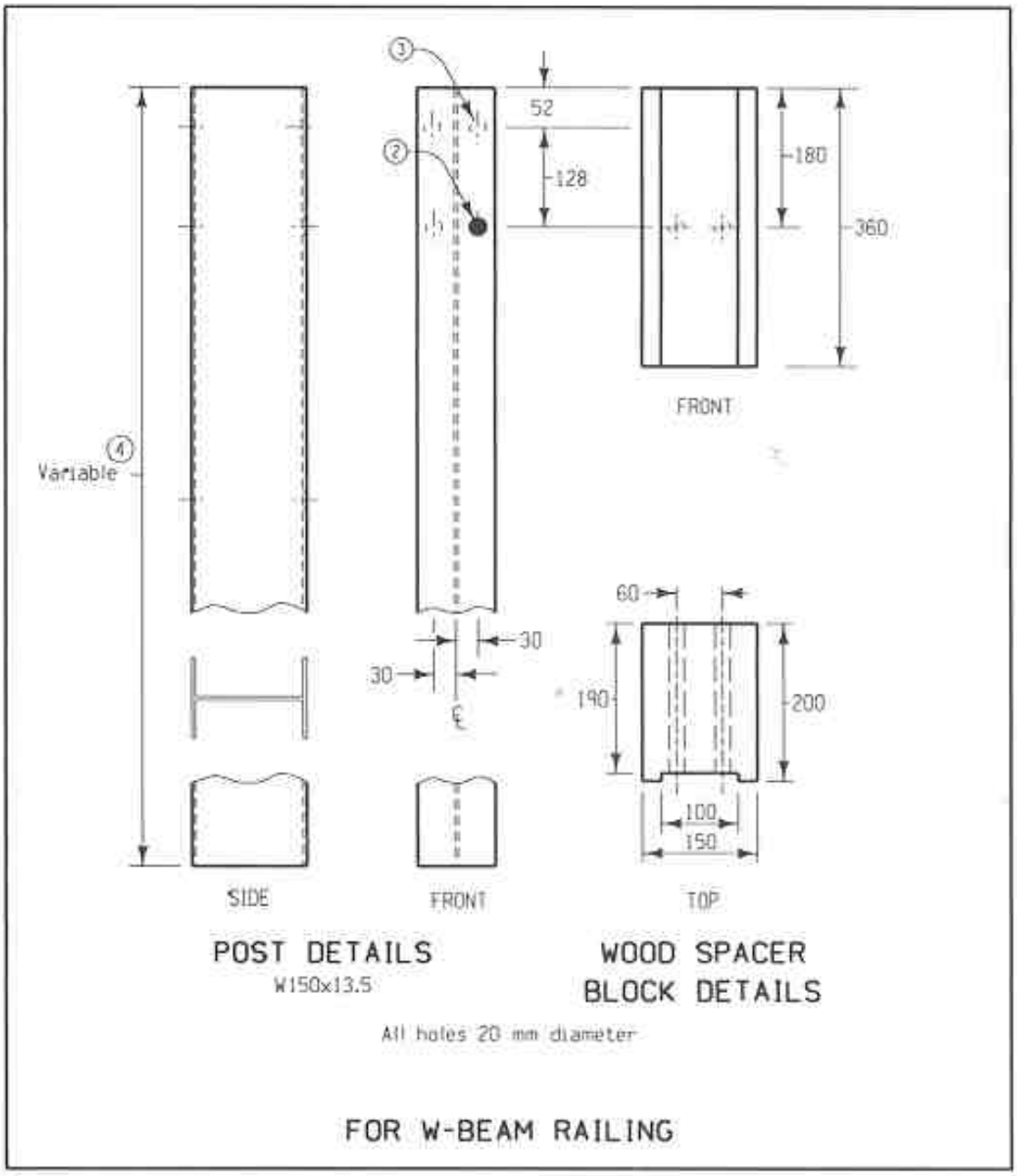
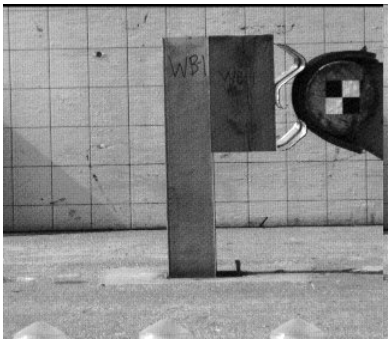


Figure 1. Wooden Spacer Block Details, Test WB-1

Figure 2. Wooden Spacer Block, Test WB-1

Figure 3. Wooden Spacer Block Impact Location, Test WB-1

Figure 4. System Damage, Bogie Test WB-1



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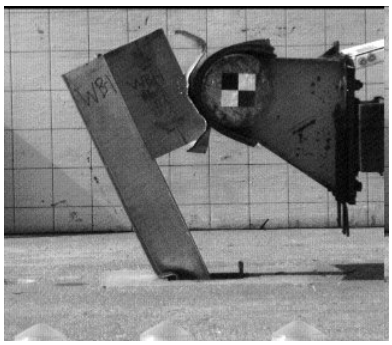

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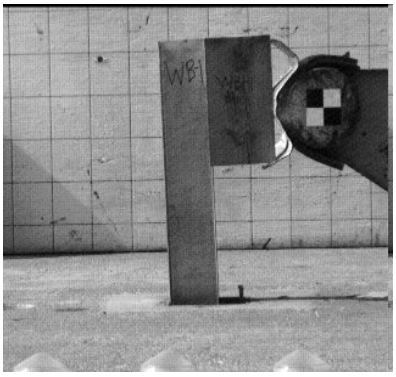

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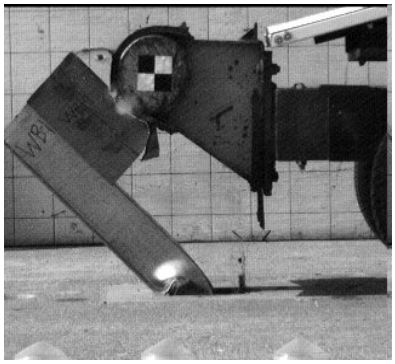

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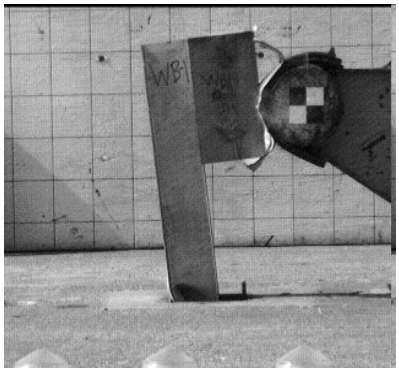

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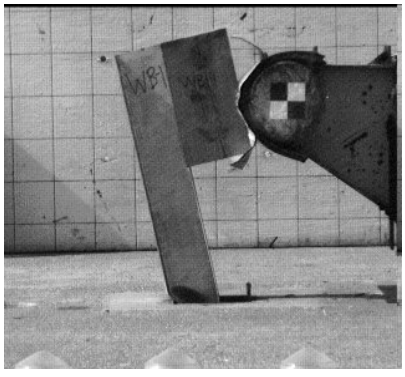

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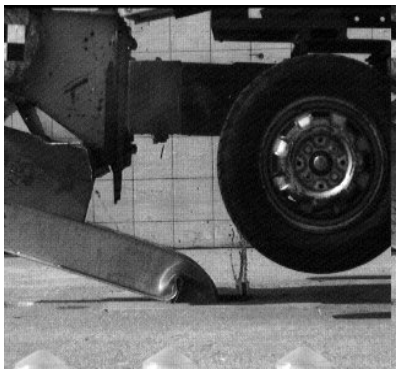

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Figure 5. Sequential Photographs, Test WB-1

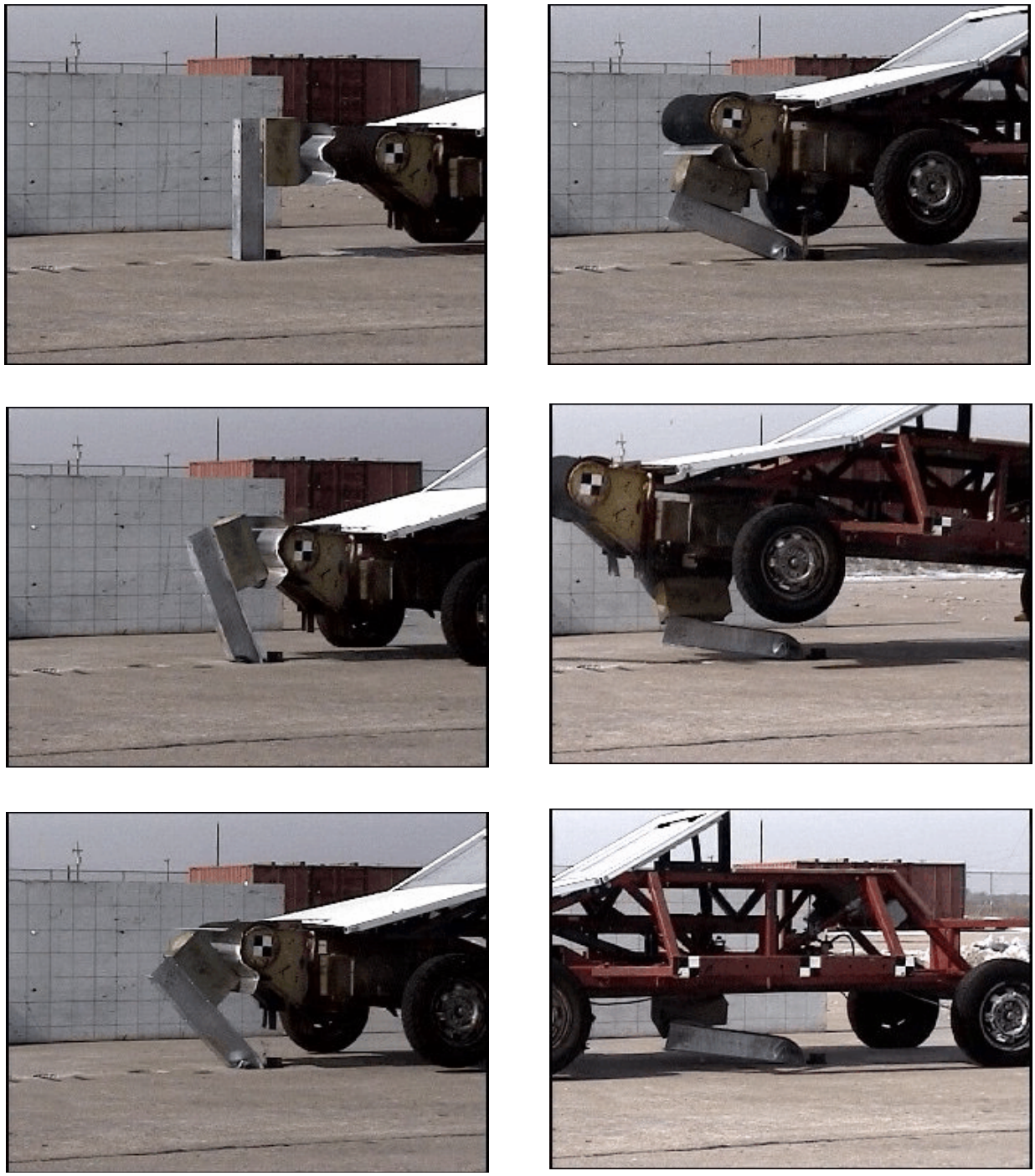


Figure 6. Documentary Photographs, Test WB-1

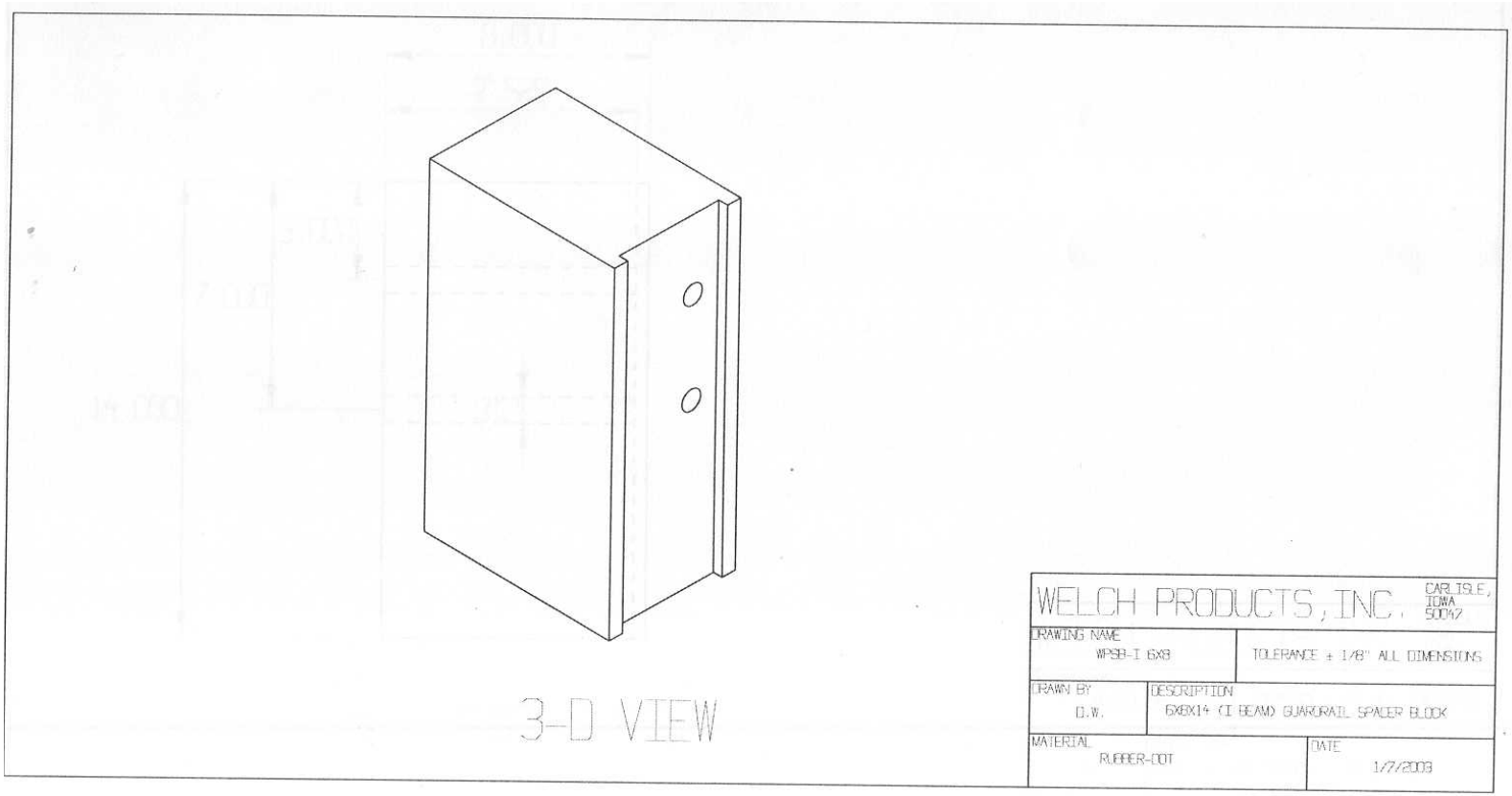


Figure 7. Recycled Rubber Spacer Block Details, Test WB-2

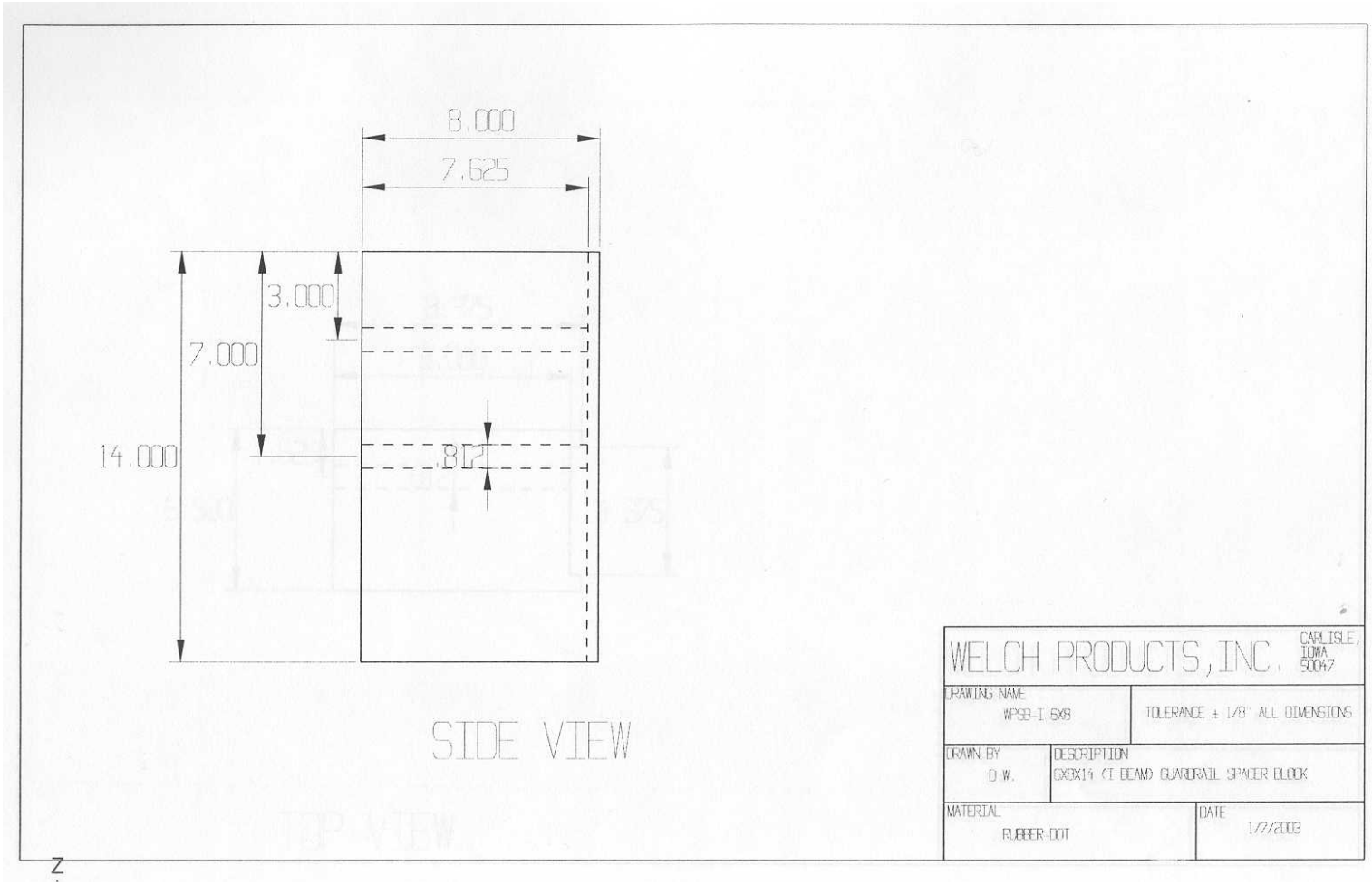


Figure 8. Recycled Rubber Spacer Block Details, Test WB-2

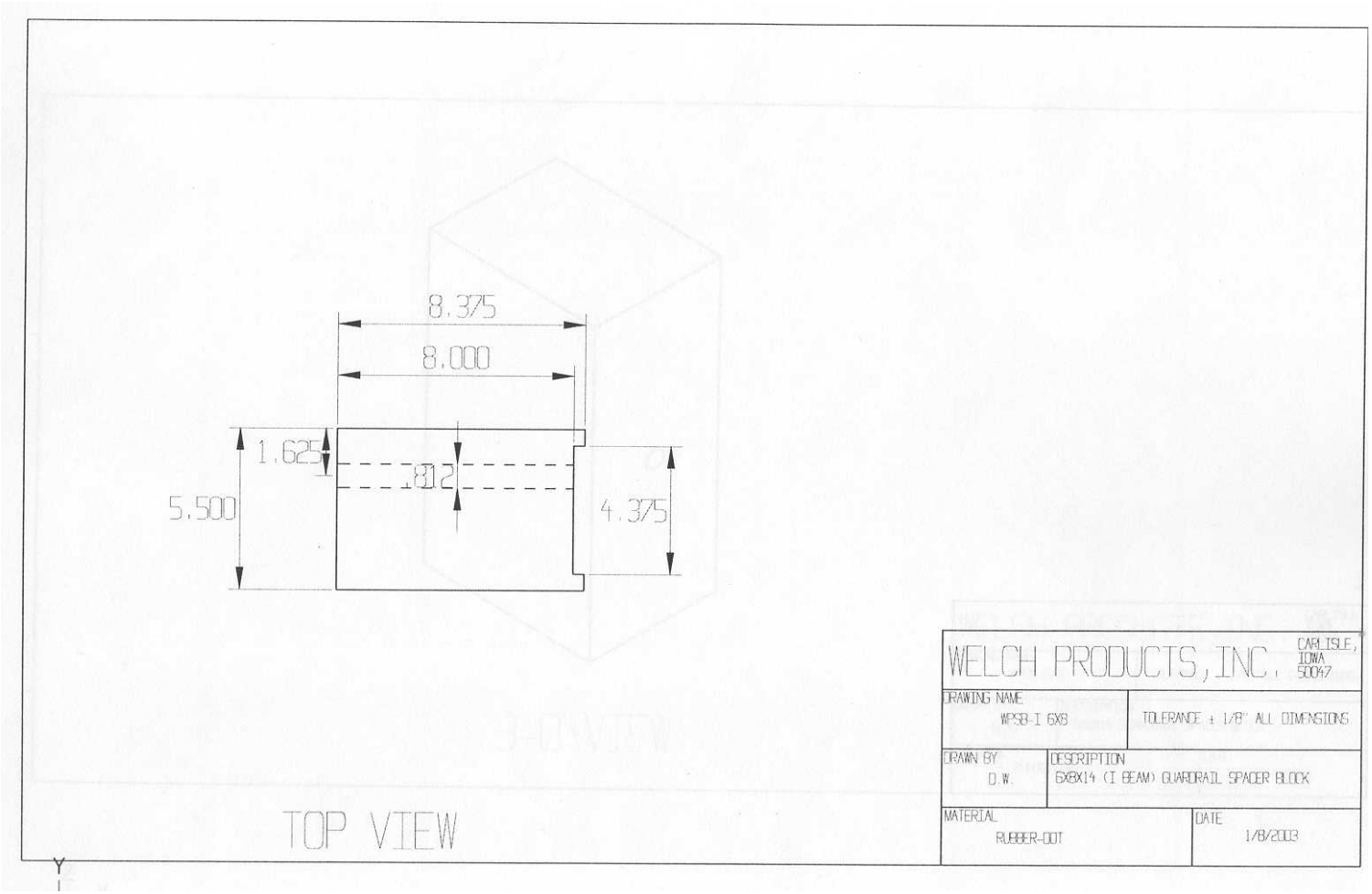


Figure 9. Recycled Rubber Spacer Block Details, Test WB-2

MATERIAL SAFETY DATA SHEET

SECTION I: **PRODUCT IDENTIFICATION**

PRODUCT NAME: **Guardrail Spacer Block(s)**

MANUFACTURER: Welch Products, Inc.
205 S. Garfield
PO Box Z
Carlisle, Iowa 50047

CHEMICAL NAME: The Guardrail Spacer Block(s) are derived from the tread of used automobile and truck tires as well as buffings and other vulcanized rubber having the following approximate composition:

Natural and Synthetic Rubber	40%
Carbon Black	35%
Volatiles	11%
Zinc Oxide	5%
Ash	4%
Stearic Acid	3%
Sulfur	3%
Water	0.3%

The volatiles are composed primarily of the following:

Aromatic processing oil	4%
Refined paraffin wax	4%
t-Octylphenol/formaldehyde resin	1%
Various alkyl and aryl *p*-Phenylenediamines	1%
Various alkyl phthalate plasticizers	1%

CHEMICAL FAMILY: Hydrocarbon Polymer

EMERGENCY TELEPHONE NUMBERS: (515)-989-0829 (660) 385-7156 (Days)
(660) 385-5389 (Nights)

SALES AND PRODUCT INFORMATION: (515)-989-0829 (660) 385-7156

DATE PREPARED: Updated January 9, 2003

Figure 10. Recycled Rubber Spacer Block Material Specifications

SECTION II: HAZARDOUS INGREDIENTS/IDENTITY INFORMATION

Hazardous Components	CAS No.	OSHA PEL	ACGIH-TLV	%
Naphthenic/ Aromatic Oil	64742-04-7	-	5 mg/m³	10%
Zinc oxide	1314-13-2	-	5 mg/m³	5%
Carbon black	1333-86-4	-	3.5 mg/m³	35%
Dibutyl phthalate	84-74-2	-	5 mg/m³	< 1%
Dimethyl phthalate	131-11-3	-	5 mg/m³	< 1%
Di-*sec*-octyl phthalate	117-81-7	-	5 mg/m³	< 1%
Heptane	142-82-5	500 ppm	2000 mg/m³	< 1%
Hexane	110-54-3	500 ppm	1800 mg/m³	< 1%

SECTION III: PHYSICAL/CHEMICAL CHARACTERISTICS

The volatiles listed above will all vaporize and leave the crumb rubber at temperatures below 3008C. The vapor pressures of those volatiles at room temperature and pressure are negligible, given that those amenable to evaporation have done so in the useful life of the original tire and during the mechanical and ambient heating involved in the crumbing process. The following data refer to the rubber:

BOILING POINT:	~5008C
VAPOR PRESSURE:	Negligible
VAPOR DENSITY:	N/A
SOLUBILITY IN WATER:	Negligible (hydrophobic)
APPEARANCE:	Black, granular flexible solid
ODOR:	Slight
SPECIFIC GRAVITY:	1.02 g/cm³
MELTING POINT:	~3008C
EVAPORATION RATE:	Below 1508C, negligible

SECTION IV: FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:	3878C (solid plus volatiles) 3208C (dust)
FLAMMABLE LIMITS(%):	Dust @ 0.025 oz./cu. ft
EXTINGUISHING MEDIA:	Carbon dioxide or dry chemical preferred. Water will extinguish a small rubber fire. Do not use high pressure water.
SPECIAL FIRE FIGHTING PROCEDURES:	Due to the large quantity of unburned hydrocarbons (typically radicals) released in a rubber fire, a self-contained breathing apparatus should be worn.
UNUSUAL FIRE & EXPLOSION HAZARDS:	In the presence of an ignition source a dust explosion may occur if the dust is mixed with air in concentrated levels.

Figure 11. Recycled Rubber Spacer Block Material Specifications

SECTION V: **REACTIVITY DATA**

STABILITY: Stable below 2508C. Will smolder but not ignite at that temperature.
INCOMPATIBILITY: Should not be stored with strong oxidizers. Rubber is a high BTU fuel.
HAZARDOUS DECOMPOSITION OR BYPRODUCTS:

Hazardous decomposition occurs upon combustion. Due to the high oxygen demand of rubber under combustion, many unburned hydrocarbons in the form of radicals are produced. These are highly reactive and may cause serious lung damage. This oxygen deficient combustion also promotes the formation of carbon monoxide. Further, the sulfur content of rubber causes the release of sulfur dioxide during combustion.

HAZARDOUS POLYMERIZATION: None.

SECTION VI: **HEALTH HAZARD DATA**

ROUTES OF ENTRY

INHALATION:	None
SKIN:	None
INGESTION:	Protect food and drink from dust.

HEALTH HAZARDS (ACUTE AND CHRONIC):

CARCINOGENICITY:	None known
SIGNS AND SYMPTOMS OF EXPOSURE:	Not applicable
MEDICAL CONDITIONS:	None known
EMERGENCY AND FIRST AID PROCEDURES:	Not applicable

SECTION VII: **PRECAUTIONS FOR SAFE HANDLING**

RELEASE OR SPILL RESPONSE MEASURES:	No special precautions necessary
WASTE DISPOSAL METHOD:	Dispose according to Federal/State/Local regulations.
PRECAUTIONS IN HANDLING AND STORAGE:	None
OTHER PRECAUTIONS:	None

SECTION VIII: **CONTROL MEASURES**

RESPIRATORY PROTECTION:	None required
VENTILATION:	None required
PROTECTIVE GLOVES:	Yes--Recommended
EYE PROTECTION:	Safety goggles recommended
OTHER PROTECTIVE CLOTHING/EQUIPMENT:	None
WORK/HYGIENIC PRACTICES:	Wash hands before handling food

Figure 12. Recycled Rubber Spacer Block Material Specifications

RESIN TECHNICAL DATA

In addition to the ground tire rubber identified above, the other element in the composite finished product is a polyurethane resin which "binds" the particles together.
The resin technical data:

Properties	ASTM Method	Results
Solids Content	D-1353	80%
Temp Service Range	D-1349	-65 to200F
Tear Resistance	D-624	150
Tensile Strength	D-412	1050
Ultimate Elongation	D-412	350%
Hardness Shore A	D-2240	60
Water Absorption	D-543	5% by wt

Figure 13. Recycled Rubber Spacer Block Material Specifications

Welch Products Inc. -- Durotrim™ Spacer Block(s) Material
Test Summary and Preliminary Report

Welch Products Inc.-- Durotrim™ and Spacer Block rubber composition material was evaluated for the following:

Tensile Strength*
Tear Strength*
Puncture Resistance*
Flammibility*
Coefficient of Friction
Weatherometer (Xenon Arc)
Thermocycling (Freeze/ Thaw Wet)
Thermocycling (Freeze/ Thaw Dry)

* Before and after accelerated aging by thermocycling.

Conclusion: The results indicate the material appears to be strong and durable and would be suitable for its intended use.

RESULTS

TENSILE STRENGTH — **ASTM D882**

Description: Load to break a 2" wide by 1" thick specimen. Results reflect the average of 3 replicates.

Tensile	Pounds	PSI
As Received	87	36.6
After Accelerated Aging	155	70.2
% Diff.	+ 78%	+ 78%

Seam	Pounds	PSI
As Received	57	22.8
After Accelerated Aging	42	17.6
% Diff.	- 26%	- 23%

TEAR STRENGTH — **ASTM D624**

Description: Load to tear 0.5" specimen.

	Pounds	PSI
As Received	5	9.1
After Accelerated Aging	7	11.2
% Diff.	+ 40%	+ 23%

PUNCTURE RESISTANCE

Description: Load to force a 0.25" and a 0.5 rod through the material.

	Rod	Pounds	Rod	Pounds
As Received	0.25"	51	0.5"	87
After Accelerated Aging		119		173
% Diff.		+ 135%		100%

COEFFICIENT OF FRICTION — **ASTM C1028**

Description: Load to move a rubber heel skid

Figure 14. Recycled Rubber Spacer Block Material Specifications

Welch Products Inc. -- Durotrim™ Spacer Block(s) Material
Test Summary and Preliminary Report

	Load to move a rubber heel skid across dry and wet tiles (Avg. of 12	
	Pounds	Dry Static Coefficient of Friction
Dry	41	1.45
	Pounds	Wet Static Coefficient of Friction
Wet	41	1.48

FLAMMABILITY **ASTM D4804**

The tile did not burn when subjected to flame and cigarette on the surface. It could be ignited if a direct flame was applied to the bottom edge of the material. After accelerated aging, the tile still could not be ignited with surface burning. The direct flame burned longer after the aging cycle.

Conclusion	The tiles did not ignite under normal outdoor usage conditions. As is the case with many materials, the tiles will burn slowly if subjected to a direct flame for an

AGING

Description	The effects of light and temperature on the material.
Weatherometer	10 days exposure to light and moisture. 102 minutes / 18 minutes of light and water spray.
Conclusion	There was no significant difference in the material after exposure. A slight darkening of some of the lighter particles did occur. The material was monitored for fading, checking, pealing and cracking.
Thermocycle (Dry)	9 exposure cycles - 24 hr. @ 212 °F., 4 hr. @ 72 °F., 4 hr. @ -40 °F
Conclusion	There was no significant difference in the material after exposure. A slight darkening of some of the lighter particles did occur. The material was monitored for fading, checking, pealing and cracking.
Thermocycle (Wet)	Freeze/Thaw Cycle

There was no observable deterioration of the material after Freeze/Thaw testing.

Fayette Environmental Services Inc.
120 East Davis St.
Fayette, MO 65248-0021
Phone: 660-248-1911
FAX: 660-248-1921

Figure 15. Recycled Rubber Spacer Block Material Specifications

Figure 16. Recycled Rubber Spacer Block, Test WB-2

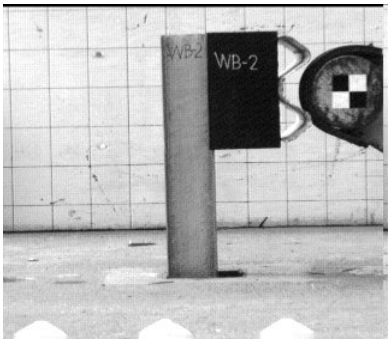
Figure 17. Recycled Rubber Spacer Block Impact Location, Test WB-2

Figure 18. System Damage, Bogie Test WB-2

Figure 19. System Damage, Bogie Test WB-2

Figure 20. System Damage, Bogie Test WB-2

Figure 21. System Damage, Bogie Test WB-2



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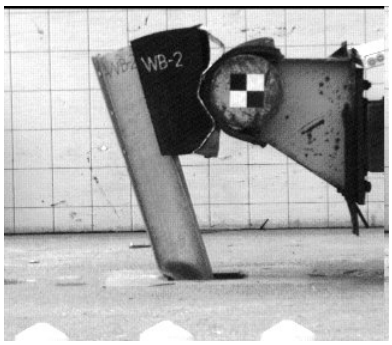

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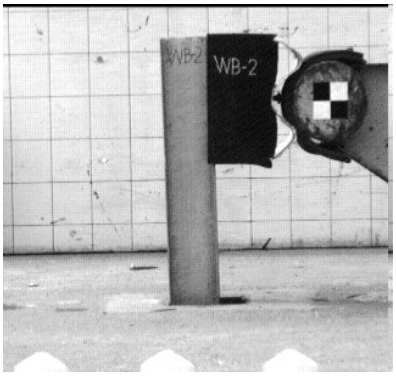

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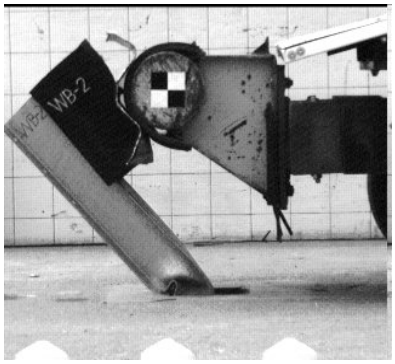

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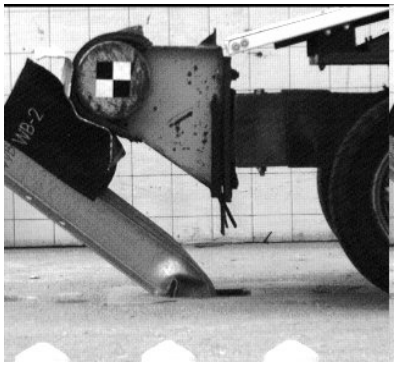

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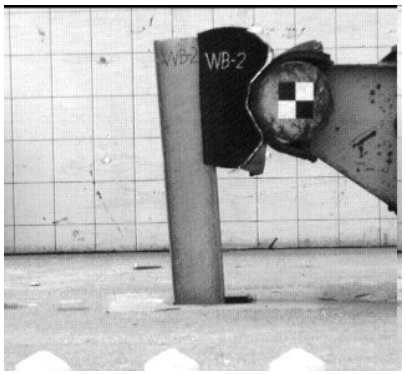

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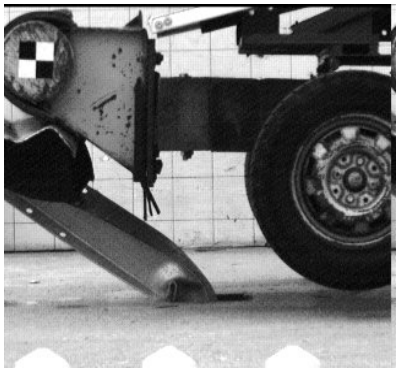

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Figure 22. Sequential Photographs, Test WB-2

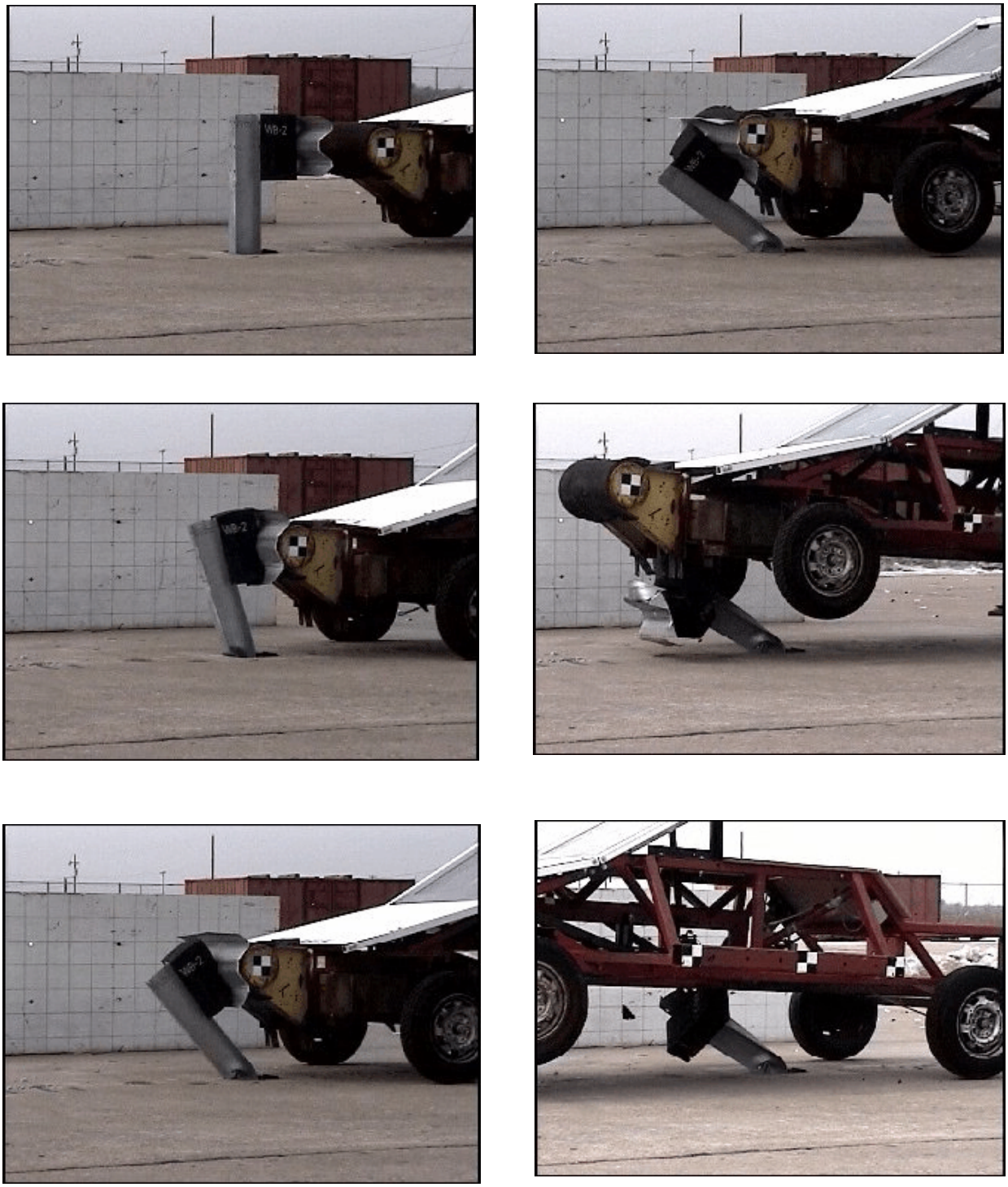

Figure 23. Documentary Photographs, Test WB-2

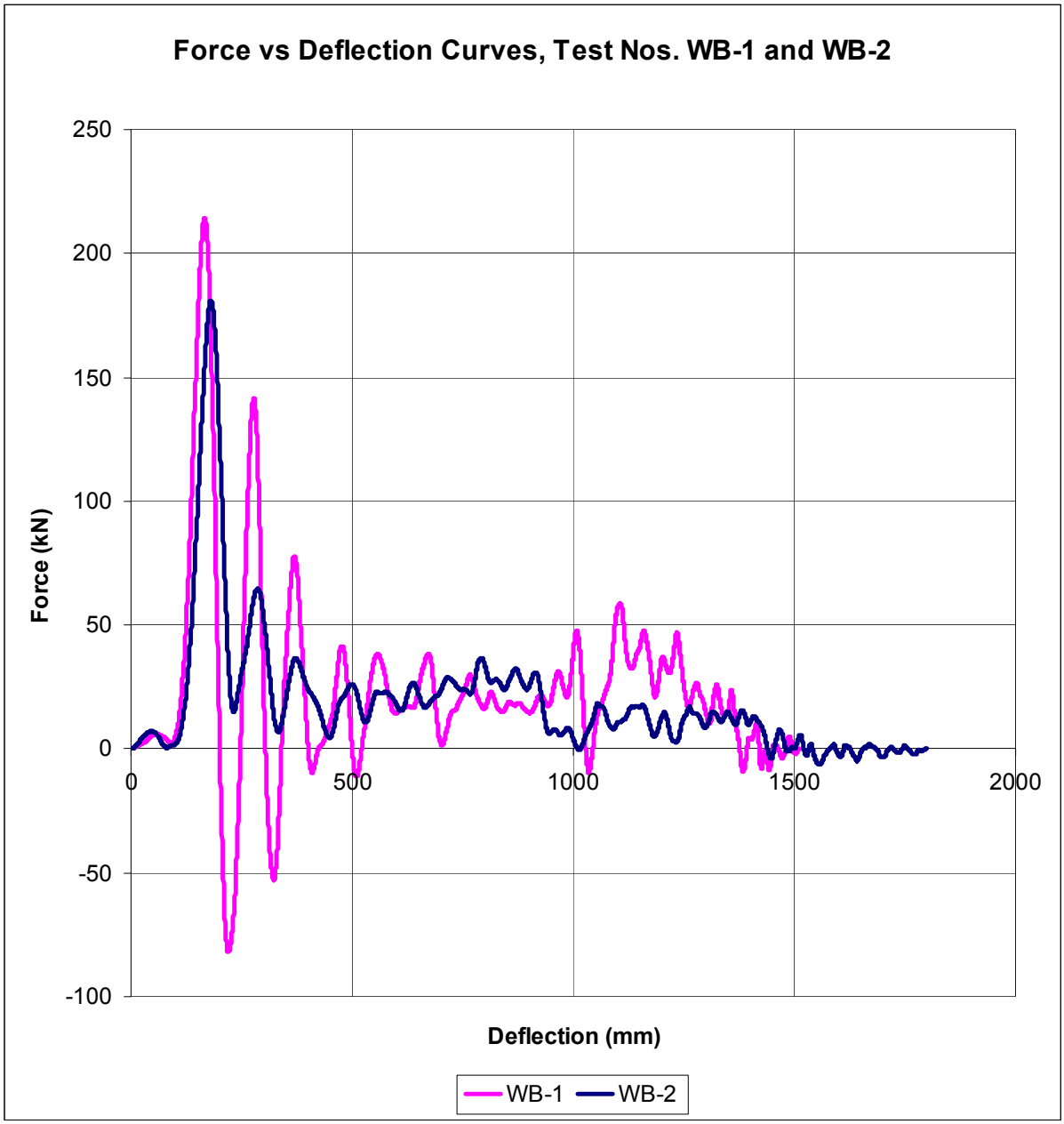

Figure 24. Force vs Deflection, Test Nos. WB-1 and WB-2