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Michigan Department of Transportation Materials & Technology Division P.O. Box 30049 Lansing, Michigan 48909	14. Sponsoring Agency Code

15. Supplementary Notes

This study was conducted in cooperation with the United States Department of Transportation, Federal Highway Administration.

16. Abstract

The intent of the study was to determine if recycled plastic posts could be used as an alternate product in guardrail installations. The contract was setup in two phases. In Phase I, pendulum tests were performed on individual guardrail posts of wood, steel, and recycled plastic. Phase II would involve a full scale crash test of a complete guardrail installation using the recycled plastic posts. The results of the testing showed that all recycled plastic posts failed at a fracture energy level below the required 5.5 foot-kips. Based on the data generated during this testing program, no post currently made from purely recycled plastic consistently achieved the required fracture energy value. Therefore, Phase II testing was not done. Development of recycled plastic posts as an alternative guardrail post will not be pursued further by the department because of the expense of developmental testing and the variability of the product.

17. Key Words	18. Distribution Statement
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ACTION PLAN

1. Materials and Technology Division

   A. Transmit report to Design, Traffic and Safety, Construction, Maintenance and Engineering Services Divisions, and Districts.

2. R. A. Welke, Deputy Director, Bureau of Highways

   A. Transmit report to the Federal Highway Administration.

3. Engineering Operations Committee

   A. No action necessary upon approval of this report.

EXECUTIVE SUMMARY

EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTIC

A contract with Southwest Research Institute (SwRI) was initiated to determine the dynamic performance properties of wood, steel, and recycled plastic posts. The intent of the study was to determine if recycled plastic posts could be used as an alternate product in guardrail installations.

The contract was setup in two phases. In Phase I, pendulum tests were performed on individual guardrail posts of wood, steel, and recycled plastic. Pendulum testing imparts a dynamic, horizontal force that closely simulates loading of a highway guardrail post when the guardrail installation is impacted by an errant vehicle. If Phase I was successful, Phase II would involve a full scale crash test of a complete guardrail installation using the recycled plastic posts.

Phase I began with testing eighteen 6" x 8" wood posts and eleven W6 x 9 steel posts. These posts were tested under various temperature conditions to establish baseline fracture energy levels. The tests confirmed that the 5.5 foot-kips fracture energy level for wood and steel posts are not significantly affected by -20/+120 degree Fahrenheit temperatures.

Nine recycled plastic posts from two manufacturers were then tested at ambient temperature. If the posts passed the required fracture energy level, further pendulum testing would take place with posts at various temperature extremes. The manufacturers were Hammer Plastic Recycling Corporation of Iowa Falls, Iowa and Trimax Plastic Lumber of Ronkonkoma, New York.

The results of the testing showed that all recycled plastic posts failed at a fracture energy level below the required 5.5 foot-kips. The fracture energy of Hammer Plastic Recycling posts displayed a wide variance in values and many of these posts were observed with voids in the center section of the post, while the Trimax Plastic Lumber posts were uniform in appearance and fracture energy values.

Based on the data generated during this testing program, no post currently made from purely recycled plastic consistently achieved the required fracture energy value. Therefore, Phase II testing was not done.

Development of recycled plastic posts as an alternative guardrail post will not be pursued further by the department because of the expense of developmental testing and the variability of the product. The recycled plastic industry will be expected to furnish independent test results meeting national standards for crash testing before such products will be considered for use on Michigan's highways.

FINAL REPORT

EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTIC

Southwest Research Institute
Project No. 06-3906

Prepared for

MICHIGAN DEPARTMENT OF TRANSPORTATION
P. O. Box 30049
Lansing, Michigan 48909

By

Joe B. Mayer, Jr.
Engineering Technologist
Southwest Research Institute
San Antonio, Texas

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SOUTHWEST RESEARCH INSTITUTE

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SOUTHWEST RESEARCH INSTITUTE

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1.0 INTRODUCTION

Waste plastics contribute a significant amount of non biodegradable waste to solid waste disposal sites. One method of making use of this waste plastic is development of large-volume, permanent end use by recycling. Several recycled plastic manufacturers currently make non structural lumber and landscape timbers from waste plastic. This program involved taking the lumber concept a step further by investigating the fitness-for-use of recycled plastic as substitute for wood or steel posts in highway guardrail systems. Although calculations and static strength tests provide information on physical properties of a new material, only dynamic evaluation will provide information necessary for determining suitability for the intended use as a guardrail post. Pendulum testing in a controlled environment is an efficient and accurate method of evaluation. In a 1974 study for the USDA Forest Service [1] numerous dynamic pendulum tests were performed on various sizes of and species of wood posts and steel posts and several full-scale crash tests were performed to verify the results of the pendulum tests. Based on pendulum tests supported by full-scale crash testing, a fracture energy value of 5.5 ft-kips and above for strong post guardrail systems was established in the study.

2.0 PROGRAM OBJECTIVE

The objective of this program was to experimentally determine the dynamic performance properties of wood, steel, and selected posts made from recycled plastic. The pendulum imparts a dynamic, horizontal force which closely simulates loading of a highway guardrail post when the guardrail installation is impacted by an errant vehicle.

3.0 SPECIMEN DOCUMENTATION AND PREPARATION

A Specimen/Test Data Sheet was generated for each post which contained the following information:

- Test date
- Specimen number
- Sketch of post with dimensions and locations of measurement
- Mass weight
- Mass impact velocity
- Mass velocity change
- Ambient temperature
- Specimen temperature - before test
- Specimen temperature - after test
- Moisture content - after test (if applicable)
- Fracture energy
- Post displacement during impact
- Peak force
- Average force during impact
- Comments if necessary

3.1 Wood Posts

The wood posts were placed in a controlled temperature/humidity environment in which the temperature was maintained at 70^{+}_{-} 2 degrees and 50+/- 5% relative humidity. The 20 Douglas Fir posts were numbered, measured and graded. Appendix A contains a post data sheets and grading data.

3.2 Steel Posts

The steel posts were numbered, measured, weighed and placed in a secure area for test.

3.3 Recycled Plastic Posts

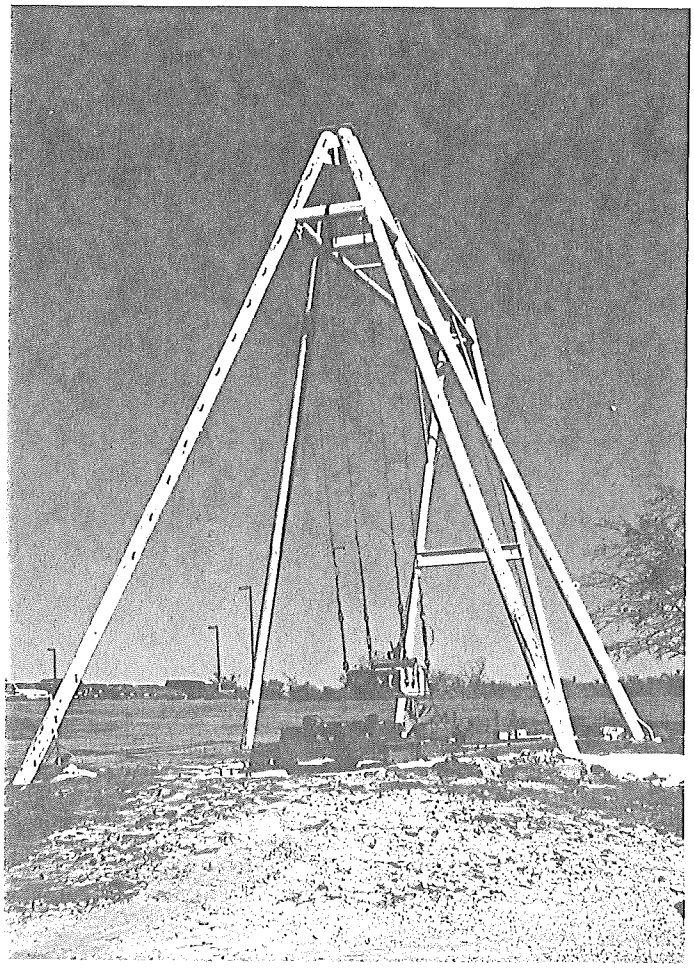
The Hammer's recycled plastic posts were received in 8 foot lengths and had to be cut to length to fit the test fixture. The posts were numbered, measured and placed in a controlled environment. The TRIMAX posts (received much later in the program) were also numbered, measured and placed in a controlled environment.

4.0 TEST PROCEDURES

The tests were performed using the SwRI Pendulum Impact Facility. The SwRI Pendulum Impact Facility is designed specifically for large scale impact tests of materials, structures, and vehicle components. The pendulum test procedure for guardrail posts was developed in a 1970 study for the Highway Research Board (2) and has been used as an economic evaluation tool prior to expensive full-scale testing. The impacting medium for tests is a steel-reinforced, concrete mass which may have either a hard unyielding impact face or be fitted with a staged aluminum honeycomb nose which crushes to simulate a collision between two deformable bodies. Masses up to 10,000-lb can be accommodated by the pendulum facility. A 4000-lb pendulum mass was used in all the tests reported herein. The impact nose of the pendulum was equipped with a 4-in radius rigid half-cylinder equipped with a one-half inch rubber impact face. Figure 1 presents photographs of the SwRI Pendulum Impact Facility and the post restraint mounting fixture.

Testing was conducted by raising the mass to a drop height which resulted in the desired impact velocity. A quick-release system was then activated to release the mass which allowed the mass to swing down and strike the test specimen installed in a fixture at the bottom of the pendulum arc. The drop height for all reported tests was 7.6-ft which resulted in an impact speed of 22 fps.

Test data were recorded by both electronic and photographic equipment. Signals from accelerometers mounted on the mass were continually monitored during the impact event. These data were stored in digital form on a data acquisition system connected to a PC. A high-speed 16-mm movie camera was trained on the impact area to record the event at a frame-rate of 500 frames per second.



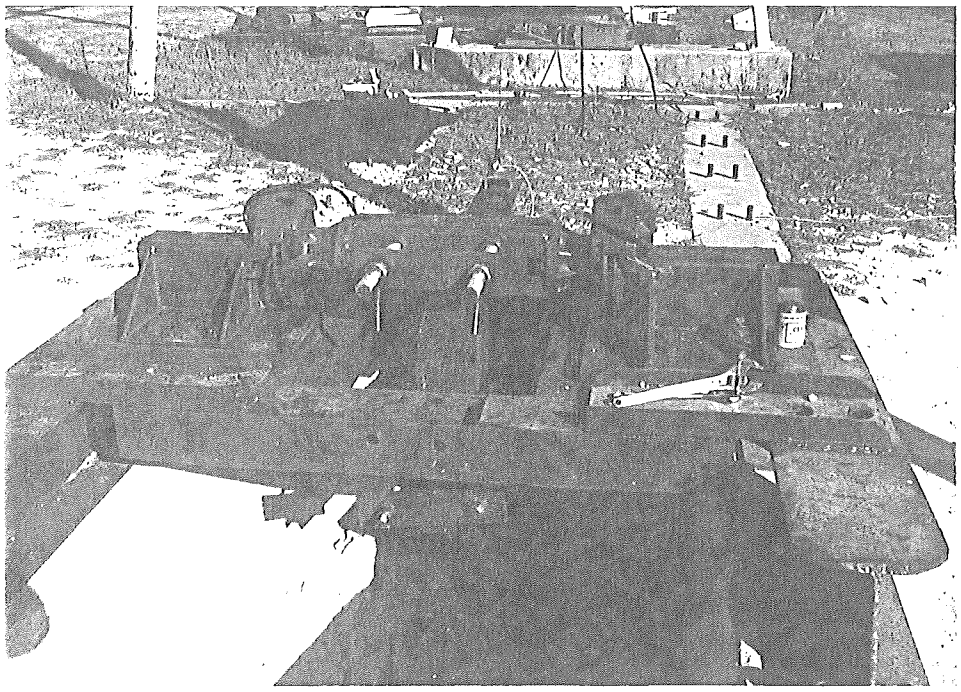


Figure 1. Pendulum Impact Test Facility

The test articles were mounted in a rigid fixture attached to the foundation of the pendulum facility. The mass was positioned to impact the test article at 18 inches above grade.

4.1 Specimen Conditioning

The specimens were cooled/heated in a laboratory remote from the test facility, therefore the specimens were placed in a specially constructed insulated container for transportation to the impact test facility. The posts were wrapped with an insulated blanket and the insulated container was pre-heated or pre-cooled to minimize temperature loss during transport. Numerous preliminary calibration tests were conducted to determine the cold/hot chamber temperature required to attain correct test temperature of the test specimen at the time of test. This procedure was repeated for each of the different types of test specimens. It was found the wood and plastic posts required about a 15 to 20 degree temperature excess to allow for 15 minutes working time. The steel posts required supplemental heat/cold to maintain sufficient time to transport and install the posts in the fixture for test. It was found that dry ice would hold cold temperature while "dummy" plastic posts maintained heat for the steel posts in transport.

4.2 Temperature Measurement

In order to accurately measure the true temperature of the wood and plastic specimens, a 1/8 inch hole was drilled in the lower portion of the post to a depth of approximately 1 inch. A thermocouple probe was inserted into the hole and sealed with duct seal compound. The thermocouple was connected to a digital readout for temperature record. Because of the thin section of the steel posts, a surface thermistor was used to measure the temperature of the steel posts.

4.3 Moisture Content Measurement

The moisture content of the wood posts was measured just prior to tests using a Delmhorst Instruments Model RC-IC moisture meter.

4.4 Impact Tests

The following scenario was accomplished for each impact test:

- The post data sheet was reviewed to ensure all pre-test data was recorded.
- The high speed movie camera was positioned to view the impact event.
- The properly conditioned post was installed in the test fixture.
- Pre-test photographs and documentary video were taken of the test specimen.
- The instrumentation was armed to record the event.
- Moisture content and temperature were measured and recorded if necessary.
- The pendulum mass was elevated to the proper height.
- The mass was released and the high-speed camera was started.

- Moisture content and temperature were measured and recorded if necessary.
- Post-test photographs and documentary video were taken of the test specimen.
- The tested specimen was removed from the fixture and visually inspected for anomalies.

Figures 2,3, and 4 present photographs of typical before and after tests of wood, steel, and plastic posts.

5.0 TEST RESULTS

A total of thirty-eight (38) pendulum tests were performed during this program; 18 wood posts, 11 steel posts, and 9 recycled plastic posts from two different manufacturers. Table 1 presents a summary of average values derived from the tests. Table 2 presents a summary of test results from each individual test. As a matter of review, previous research (1) indicates the better strong post provides a lower peak resistance force and a lower average resistance force while at the same time maintaining an adequate fracture energy. Peak and averages forces relate to the "g" forces acting on vehicle occupants while fracture energy relates to the ability of a guardrail system to absorb the energy of impact. For comparing guardrail post sizes and materials, analysis of data to the point of major failure is more precise than considerations of total effects. After major failure, it is difficult to compare wood and steel posts, because wood posts sustain a major material failure while steel posts suffer a major structural failure. The subsequent force on a steel post after initial failure is used to bend the post around the base and is not considered significant to affect guardrail performance. Post displacement is calculated for initial fracture energy and is based on linear velocity change with time to end of event. Appendix B presents test data sheets and calculations of all test data obtained during the program.

5.1 Discussion of Test Results

A review of the data indicates the wood and steel posts are not significantly affected by -20/+120 degree temperatures. The results of the tests are within the spread of the average values for ambient temperatures. While the steel post-test results showed predictable and close fracture energy values, the wood post values ranged from 3.3 ft-kips to 11 ft-kips throughout the temperature ranges. Since splits and knots were not considered a major factor (no significant flaws in the fracture area), it appears the most obvious difference is the density of the wood; the lightest weight (56-lb) post fractured at the lowest value while the heaviest (77-lb) post fractured at the highest value. Moisture content is not considered a determining factor since the major and minor fracture energies indicated a moisture content difference of only 0.5%.

The fracture energy of the Hammer's posts showed a wide variance in values. The difference in post weight was only 5-lb and, although the lightest post fractured at the lowest value and the heaviest fractured at the highest value, it is suspected the fracture energy variance is caused by material voids and impurities in the fracture area. As a general comment, of the 54 Hammer's

Table 1. Summary of Test Results

Post Designation	Size-Inches	Moisture Content	Test Temp. Deg.-F	Fracture Energy ft-kips	Peak Force kips	Average Force kips	Displacement inches
Douglas Fir	6x8	16.8	70	5.7	20.6	8.7	7.7
Douglas Fir	6x8	15.3	-20	5.3	19.8	8.2	6.9
Douglas Fir	6x8	11.5	120	5.6	20.1	8.1	8.2
W6x9 Steel	4x6	NA	-20	10.8	22.6	14.8	8.8
W6x9 Steel	4x6	NA	120	10.5	22.2	14.2	9.1
Hammer Plastic	6x10	NA	70	3.8	19.4	7.4	6.4
Hammer Plastic*	6x8	NA	70	2.7	18	6.3	5.2
Trimax plastic	6x8	NA	70	2.5	22.1	5.4	5.2

*Only one post tested at this size

Table 2. Pendulum Test Results

Post No.	Post Material	Moisture Content (%)	Impact Vel. (ft/sec)	Final Vel. (ft/sec)	Fracture Energy (ft/kips)	Post Displacement(in)	Peak Force (kips)	Average Force (kips)	Specimen Temp. (deg.F)
W1	6X8 WOOD	21.0	22	20.02	5.2	8.8	19.2	7.0	66.5
W2	6X8 W00D	13.5	22	20.65	3.6	6.4	16.8	6.7	70.6
W3	6X8 WOOD	14.5	22	19.58	6.3	10.0	18.0	7.5	69.8
W4	6X8 WOOD	18.0	22	20.20	4.7	8.8	20.0	6.4	71.3
W5	6X8 WOOD	17.0	22	17.52	11.0	8.3	32.0	15.9	71.4
W6	6X8 WOOD	16.8	22	20.65	3.3	8.4	17.6	8.4	72.0
W7	6X8 WOOD	12.6	22	19.35	6.8	6.2	21.2	13.2	118.0
W8	6X8 WOOD	11.3	22	20.15	4.8	7.6	20.0	7.7	120.0
W9	6X8 WOOD	10.7	22	20.55	3.8	5.1	19.2	9.0	119.0
W10	6X8 WOOD	10.1	22	20.40	4.2	8.9	20.4	5.7	121.0
W11	6X8 WOOD	10.5	22	18.50	8.8	10.9	19.2	9.7	118.0
W12	6X8 WOOD	13.4	22	20.10	5.0	11.4	20.4	5.2	116.0
W13	6X8 WOOD	16.5	22	20.15	4.8	6.3	19.6	9.2	-18.0
W14	6X8 WOOD	14.8	22	19.90	5.5	7.8	20.0	7.4	-20.0
W15	6X8 WOOD	15.4	22	19.95	5.3	8.8	20.8	7.4	-17.0
W16	6X8 WOOD	14.9	22	18.90	7.9	7.4	21.6	12.8	-21.0
W17	6X8 WOOD	14.6	22	20.25	4.6	5.1	19.2	10.9	-16.0
W18	6X8 WOOD	16.2	22	20.50	4.0	5.1	18.0	9.3	-19.0
S1	W6X9 STEEL	NA	22	17.03	12.1	9.4	23.2	15.4	-19.5
S2	W6X9 STEEL	NA	22	18.23	9.4	8.4	22.3	13.4	-21.0
S3	W6X9 STEEL	NA	22	17.64	10.7	8.3	22.0	15.5	-20.0
S4	W6X9 STEEL	NA	22	17.92	10.1	9.6	22.8	12.7	-23.5
S5	W6X9 STEEL	NA	22	17.22	11.6	8.2	22.4	17.0	-20.5
S6	W6X9 STEEL	NA	22	17.65	10.7	8.2	21.6	15.6	122.5
S7	W6X9 STEEL	NA	22	18.35	9.2	9.4	23.4	11.7	117.5
S8	W6X9 STEEL	NA	22	17.44	11.2	8.2	23.2	16.3	126.0
S9	W6X9 STEEL	NA	22	18.93	7.8	8.2	19.2	11.4	122.0
S10	W6X9 STEEL	NA	22	17.88	10.2	9.4	20.4	13.0	117.0
S11	W6X9 STEEL	NA	22	18.45	8.9	9.3	20.0	11.4	120.0
PC1	6X10 HAMMER	NA	22	19.94	5.4	8.8	19.6	7.3	70.0
PC2	6X10 HAMMER	NA	22	20.45	4.1	7.6	18.0	6.4	70.6
PC3	6X10 HAMMER	NA	22	20.72	3.4	3.8	20.1	10.6	71.0
PC4	6X10 HAMMER	NA	22	20.72	3.4	5.1	18.0	8.0	71.0
PC5	6X10 HAMMER	NA	22	20.46	4.1	10.2	21.2	4.8	70.2
PA1	6X8 HAMMER	NA	22	20.99	2.7	5.2	18.0	6.3	70.1
TA1	6X8 TRIMAX	NA	22	21.05	2.5	9	21.2	3.4	69.0
TA2	6X8 TRIMAX	NA	22	21.10	2.4	3.9	22.4	7.5	69.6
TA3	6X8 TRIMAX	NA	22	21.02	2.6	2.6	22.8	12.2	68.5

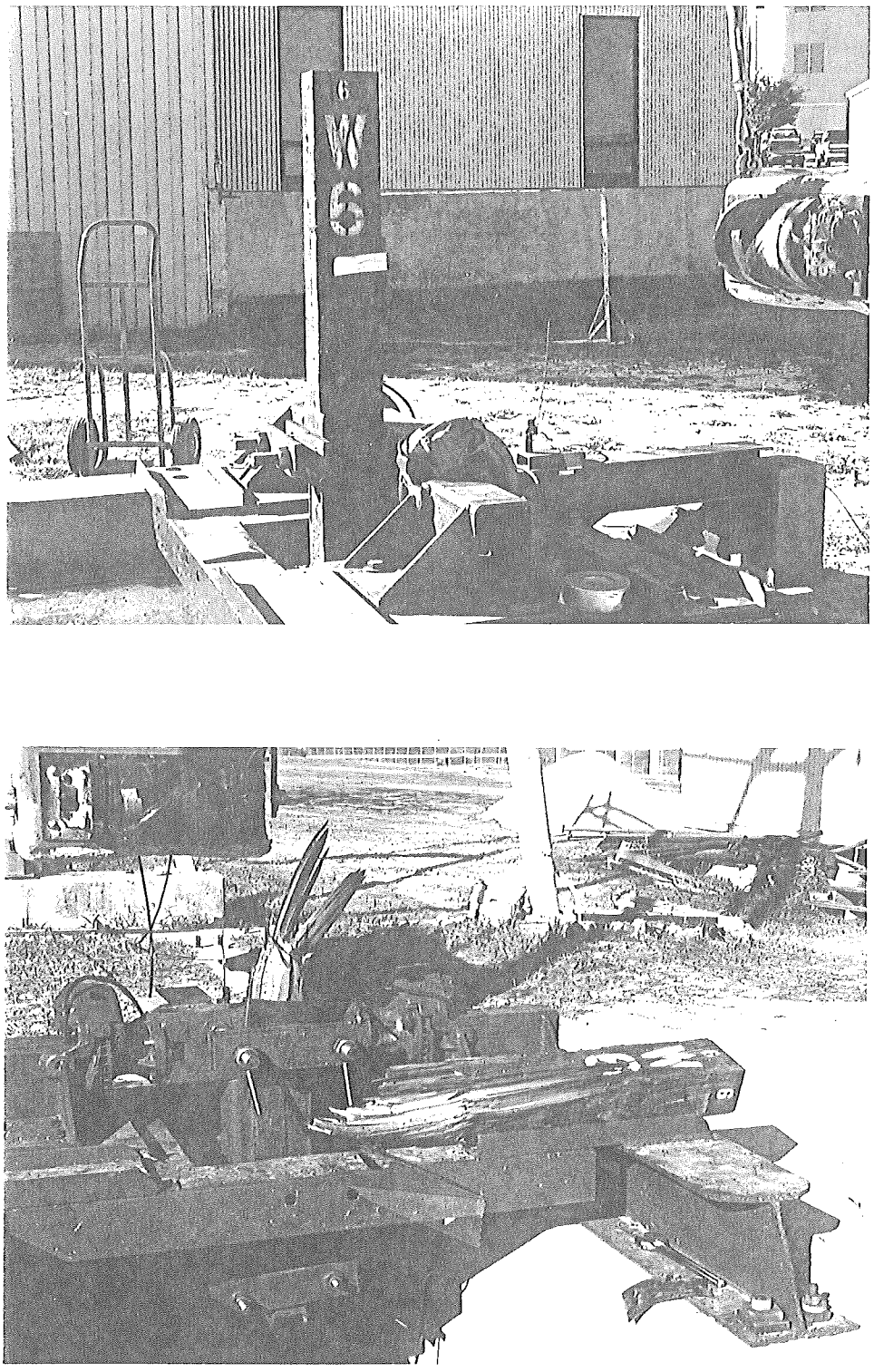


Figure 2. Typical Wood Post Before and After Test Photographs

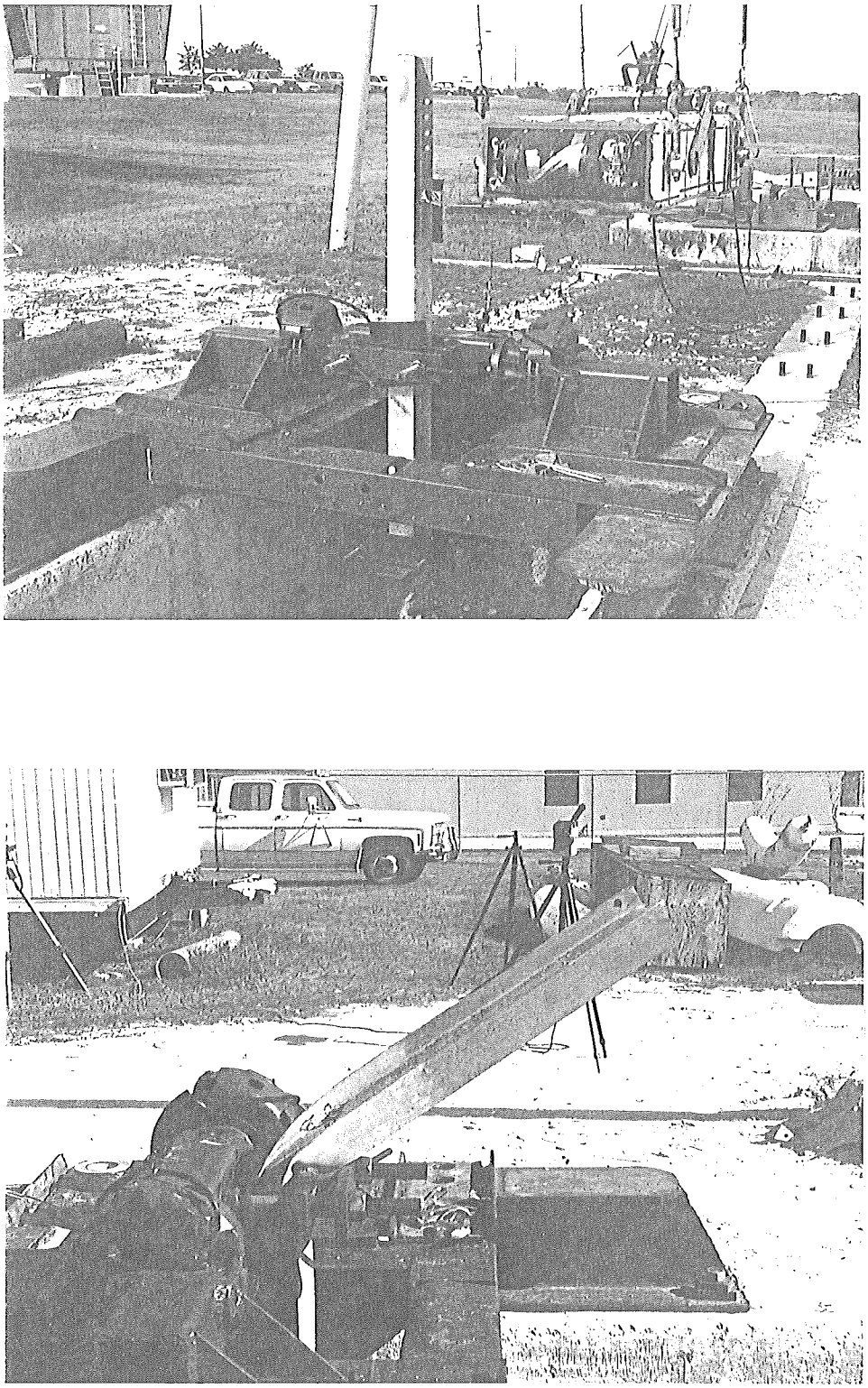


Figure 3. Typical Steel Post Before and After Test Photographs

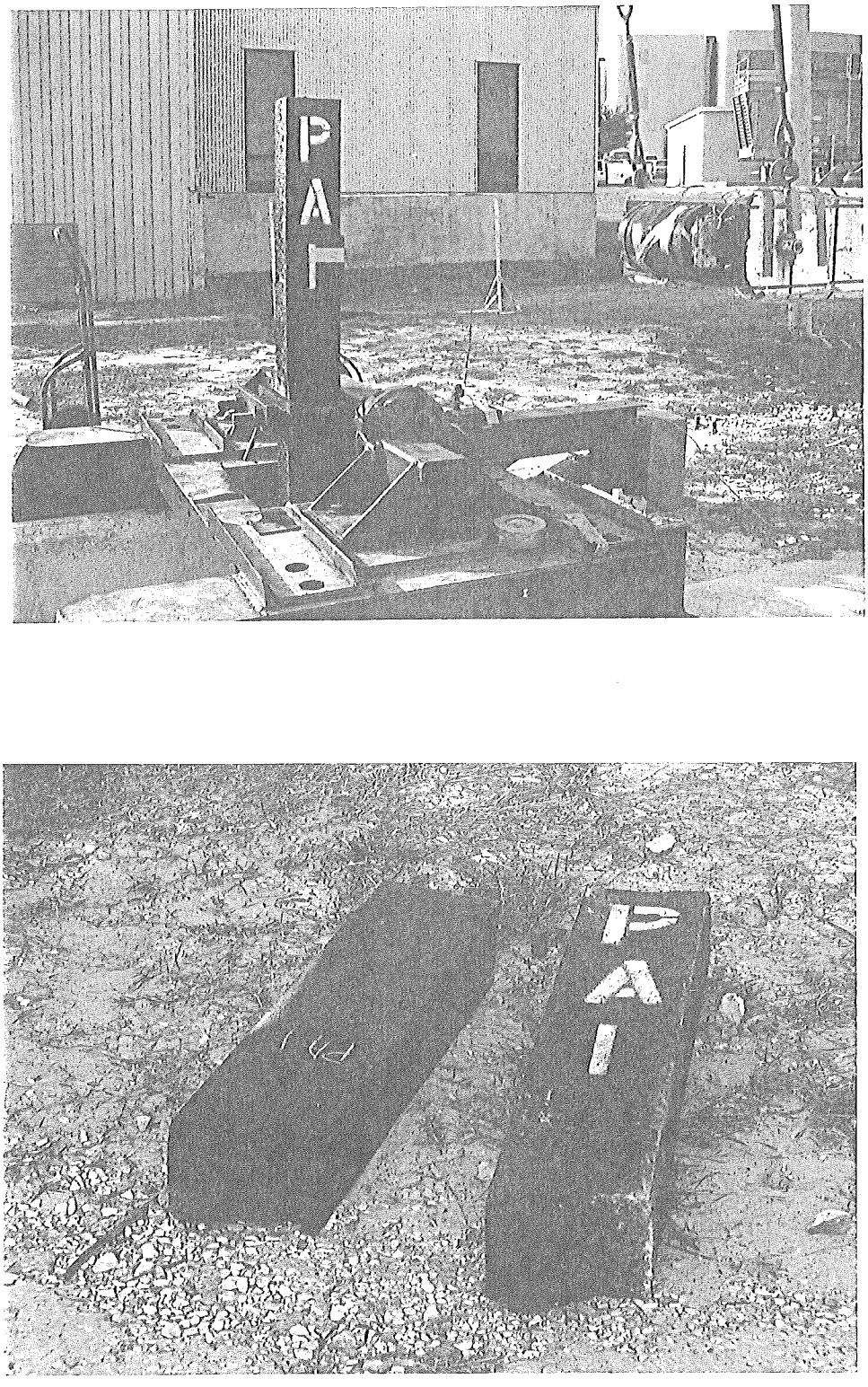


Figure 4. Typical Plastic Post Before and After Test Photographs

posts cut to length prior to initiation of testing, many were observed with voids in the center section of the post. While the outer 1-inch of the perimeter of the section was quite uniform in density, while the inner section exhibited considerable honeycomb. The TRIMAX posts were very uniform in appearance and fracture energy values, but comparison of fracture energy values from tests with similar size Hammer's posts and posts from two other manufacturers, indicated fracture energy values well below the desired 5.5 ft-kips.

5.2 Discussion of Program Objectives

The primary objective of this program was to determine the optimum size recycled plastic post which could replace the standard 6"x8" wood or w6x9 steel guardrail post. Based on the data generated during this program and test results from other developmental programs initiated after the start of this program, no posts made from purely recycled plastic are currently available which can be substituted as a direct replacement for conventional wood or steel posts. It has been determined in other developmental programs for commercial sponsors, mechanical reinforcement can be implemented which will produce a post that will meet the criteria. Unfortunately, the cost to manufacture such a post would be prohibitive.

List of references

1. Gatchel, Charles J. and Michie, Jarvis D., "PENDULUM IMPACT TESTS OF WOODEN AND STEEL HIGHWAY GUARDRAIL POSTS," USDA Forest Service Research Paper NE-311, 1974.

2. HAMMER Plastic Recycling, Inc., Rural Route 3 Box 182, Iowa Falls, IA 50126.

3. TRIMAX Plastic Lumber, 2076 Fifth Avenue, Ronkonoma, NY 11779

4. Michie, Jarvis D., Gatchel, Charles J. and Duke, Theodore J., "DYNAMIC EVALUATION OF TIMBER POSTS FOR HIGHWAY GUARDRAIL,"
Highway Research Board, Division of Engineering, National Research Council, National Academy of Science, National Academy of Engineering, August 1970.

APPENDIX A

Post Grading Data Sheets

Proj. #: 06-3906-001 By: Doug McKee Page #: 1

POST ID	SPLITS		CHECKS					SHAKES	STAINS	SPLITS CHECKS & STAINS	SLOPE OF GRAIN	WANE	KNOTS				
	LENGTH	PLANE OF BOLT	DEPTH (A)	WIDTH	LENGTH	SINGLE (B)	OPPOSITE (C)		.	(D)	(E)		SOUND	TIGHT	GRAIN DISTORTION (F)	SUM OF L. D.* (G)	LENGTH IN L. D.* (H)
#	in	Y or N	in	in	in	Y or N	#	in	% of piece	Y or N	in / in	% of face	Y or N	Y or N	in	in / 6 in	in
1	11	N			4	N	1-2				0:0		1 Y	Y	0"		7/8"
	30	N			2								2 Y	Y	12"		1"
	28	Y											3 Y	Y	2 1/2"		1 1/2"
													4 Y	Y	1"		1 1/4"
2	37"	N			3		1-2				0:0		1 Y	Y	1"		1"
	28"	N			3								2 Y	Y	1 1/2"		1 1/2"
	9"	N			4								3 Y	Y	2"		2"
	22"	N			3		4-5						4 Y	Y	1/2"		1"
	14"	N			4								5 Y	Y	2"		1"
	17"	Y											6 Y	Y	1/2"		1"
	13"	Y											7 Y	Y	1"		1"
	12"	Y															
	16"	Y															
	13"	Y															
3	11"	Y			1"			1 1/2"			0:0		Y	Y	20"		2"
	5"	N			1"								Y	Y	11"		2 1/4"
													Y	Y	5"		2"
4	22	Y			3/4"			1"			0:0	Y	Y	Y	1"		2"
	11	Y											Y	Y	2"		1 1/2"
	27	Y											Y	Y	1"		2 1/2"
	26	Y			1"								Y	Y	1"		1 3/4"
													Y	Y	1 1/2"		1 1/2"

(A) If two or more checks appear on one face, note the deepest. If two checks are opposite each other, note the sum of their depths

(B) Note whether checks are single or not

(C) Note checks that are directly opposite each other by number; i.e.; 1 - 1, 2 - 2, etc.

(D) Note whether splits, checks, and stains are in such a combination that could cause the post to separate into several pieces

(E) See attached diagram - enter the ratio

(F) Length of grain distortion caused by knot clusters

(G) Greatest sum of the least dimensions of all knots in any 6-inch of post (all faces)

(H) Length of the least dimension of the largest apparent knot

* Least Dimension

Proj. #: 66-3906-001 By: Doug McKee Page #: 2

POST ID	SPLITS		CHECKS					SHAKES	STAINS	SPLITS CHECKS & STAINS	SLOPE OF GRAIN	WANE	KNOTS				
	LENGTH	PLANE OF BOLT	DEPTH (A)	WIDTH	LENGTH	SINGLE (B)	OPPOSITE (C)			(D)	(E)		SOUND	TIGHT	GRAIN DISTORTION (F)	SUM OF L.D.* (G)	LENGTH IN L.D.* (H)
#	in	Y or N	in	in	in	Y or N	#	in	% of piece	Y or N	in / in	% of face	Y or N	Y or N	in	in / 6 in	in
4 (cont'd)													Y	Y	2		1 1/4
5	20	N			1/2	Y					0:0		Y	Y	1 1/2		1 1/2
	31	N			1/2	Y							Y	N	1 1/2		3/4"
													Y	N	1 1/2		1 1/8"
													Y	N	1 1/2		1"
6	72	Y			1 1/2	Y					0:0		Y	Y	3/4		1"
													Y	Y	2		2 1/4
													Y	Y	1		1 1/2
													Y	Y	1 1/2		1 1/2
													Y	Y	1 1/2		1 1/2
7	24	N			1 1/2	Y					0:0		Y	Y	1		1 1/2
													Y	Y	1		1 1/2
													Y	Y	2 1/2		1 1/4
8											0:0		Y	Y	3"		2 1/2
													Y	Y	1 1/2		2
													Y	Y	1"		1 3/4
													Y	Y	1"		1 3/4

(A) If two or more checks appear on one face, note the deepest. If two checks are opposite each other, note the sum of their depths

(B) Note whether checks are single or not

(C) Note checks that are directly opposite each other by number; i.e.; 1 - 1, 2 - 2, etc.

(D) Note whether splits, checks, and stains are in such a combination that could cause the post to separate into several pieces

(E) See attached diagram - enter the ratio

(F) Length of grain distortion caused by knot clusters

(G) Greatest sum of the least dimensions of all knots in any 6-inch of post (all faces)

(H) Length of the least dimension of the largest apparent knot

* Least Dimension

Proj. #: 06-3906-001 By: Doug McKee Page #: 3

POST ID	SPLITS		CHECKS					SHAKES	STAINS	SPLITS CHECKS & STAINS	SLOPE OF GRAIN	WANE	KNOTS				
	LENGTH	PLANE OF BOLT	DEPTH (A)	WIDTH	LENGTH	SINGLE (B)	OPPOSITE (C)			(D)	(E)		SOUND	TIGHT	GRAIN DISTORTION (F)	SUM OF L.D.* (G)	LENGTH IN L.D.* (H)
#	in	Y or N	in	in	in	Y or N	#	in	% of piece	Y or N	in / in	% of face	Y or N	Y or N	in	in / 6 in	in
9	15	Y			2 1/2			1/2			0:0		Y	Y	1"		1 1/2
	10	Y			1/4"								Y	Y	1"		1"
													Y	Y	2"		1 1/2"
10											0:0						
11	72	N			1 3/4						0:0		Y	Y	2 1/2		1"
													Y	Y	1 1/2		1 1/2
													Y	Y	1"		1 1/2
12	32	N									0:0		Y	Y	1 1/2		1 3/8
	14	N															
	72	N			9(3/4)				YES								
13											0:0		Y	Y	1/2		1 1/2"
													Y	Y	1"		2 3/4"
													Y	Y	2"		1 1/2"

(A) If two or more checks appear on one face, note the deepest. If two checks are opposite each other, note the sum of their depths

(B) Note whether checks are single or not

(C) Note checks that are directly opposite each other by number; i.e.; 1 - 1, 2 - 2, etc.

(D) Note whether splits, checks, and stains are in such a combination that could cause the post to separate into several pieces

(E) See attached diagram - enter the ratio

(F) Length of grain distortion caused by knot clusters

(G) Greatest sum of the least dimensions of all knots in any 6-inch of post (all faces)

(H) Length of the least dimension of the largest apparent knot

* Least Dimension

Proj. #: 66-3906-001 By: Doug McKee Page #: 4

POST ID	SPLITS		CHECKS					SHAKES	STAINS	SPLITS CHECKS & STAINS	SLOPE OF GRAIN	WANE	KNOTS				
	LENGTH	PLANE OF BOLT	DEPTH (A)	WIDTH	LENGTH	SINGLE (B)	OPPOSITE (C)			(D)	(E)		SOUND	TIGHT	GRAIN DISTORTION (F)	SUM OF L.D.* (G)	LENGTH IN L.D.* (H)
#	in	Y or N	in	in	in	Y or N	#	in	% of piece	Y or N	in / in	% of face	Y or N	Y or N	in	in / 6 in	in
14	27	Y									0:0		Y	Y	2"		2 3/4
15	50	Y									0:0	YES	Y	Y	3"		2"
													Y	Y	1 1/2"		1 1/2"
													Y	Y	1 1/2"		1 1/4"
													Y	Y	2"		1"
16	56	Y									0:0	YES	Y	Y	2"		2 1/2"
													Y	Y	1 1/2"		2 1/2"
17	48	N			2						0:0		Y	Y	1 1/2		1/2
													Y	Y	1"		1 1/2
													Y	Y	2"		1 1/2
													Y	Y	1"		1"
18	8	N			3/4												
	31	Y						3"									

(A) If two or more checks appear on one face, note the deepest. If two checks are opposite each other, note the sum of their depths

(B) Note whether checks are single or not

(C) Note checks that are directly opposite each other by number; i.e.; 1 - 1, 2 - 2, etc.

(D) Note whether splits, checks, and stains are in such a combination that could cause the post to separate into several pieces

(E) See attached diagram - enter the ratio

(F) Length of grain distortion caused by knot clusters

(G) Greatest sum of the least dimensions of all knots in any 6-inch of post (all faces)

(H) Length of the least dimension of the largest apparent knot

* Least Dimension

Proj. #: 06-3906-001

By: Doug McKee

POST ID	SPLITS		CHECKS					SHAKES	STAINS	SPLITS CHECKS & STAINS	SLOPE OF GRAIN	WANE	KNOTS				
	LENGTH	PLANE OF BOLT	DEPTH	WIDTH	LENGTH	SINGLE	OPPOSITE						SOUND	TIGHT	GRAIN DISTORTION	SUM OF L. D.*	LENGTH IN L. D.*
#	in	Y or N	(A) in	in	in	(B) Y or N	(C) #	in	% of piece	(D) Y or N	(E) in / in	% of face	Y or N	Y or N	(F) in	(G) in / 6 in	(H) in
19	39	N			1"		1-2				0:0		Y	Y	1"		1½"
	42	N			2½								Y	Y	1"		1"
	7	Y			1		3-4										
	15	Y			2												
20											0:0		Y	Y	1½"		1½"
													Y	Y	2"		2½"

(A) If two or more checks appear on one face, note the deepest. If two checks are opposite each other, note the sum of their depths
(B) Note whether checks are single or not
(C) Note checks that are directly opposite each other by number; i.e.; 1 - 1, 2 - 2, etc.
(D) Note whether splits, checks, and stains are in such a combination that could cause the post to separate into several pieces
(E) See attached diagram - enter the ratio
(F) Length of grain distortion caused by knot clusters
(G) Greatest sum of the least dimensions of all knots in any 6-inch of post (all faces)
(H) Length of the least dimension of the largest apparent knot

* Least Dimension

Page #: 5

APPENDIX B

Test Data Sheets and Calculations

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

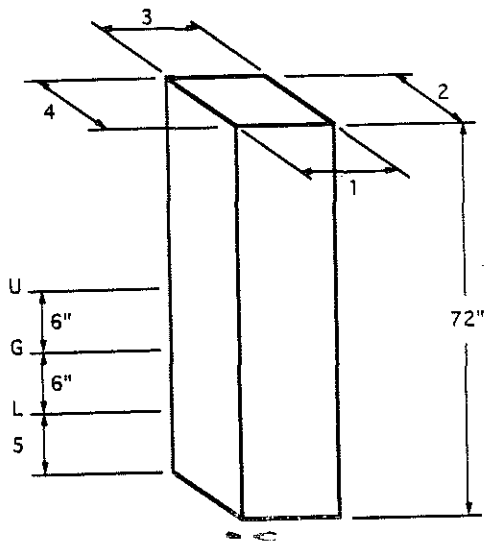
Test Date: 2 Dec 92 Testing Official: J. Mayer

SPECIMEN DATA

Specimen Number: W1 Material Type: Wood

Specimen Weight: 64 lbs

Moisture Content after test: 21% %



MASS DATA

Mass Weight:	4000	pounds
Mass Impact Velocity:	22	ft/sec
Mass Velocity Change:	2.0	ft/sec

TEMPERATURE EFFECTS

Ambient Temperature:	54	degrees F
Specimen Temperature - before test:	67.8	degrees F
Specimen Temperature - after test:	66.5	degrees F

TEST RESULTS

Fracture Energy:	5.2	~~lb-ft~~ FT-KIPS
Post Displacment During Impact:	8.8	in
Peak Force:	19.2	~~lbs~~ KIPS
Average Force During Impact:	7.0	~~lbs~~ KIPS

WOOD & PLASTICS

U: 1 5 7/8" 2 7 3/4" 3 5 7/8" 4 7 1/2"

G: 1 5 3/4" 2 7 5/8" 3 5 7/8" 4 7 1/2"

L: 1 5 3/4" 2 7 5/8" 3 5 7/8" 4 7 1/2

5: 26"

COMMENTS: Drop Height 7'6"

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: [signature] DATE: 12/2/92

TEST No. W-1

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	20.02	
FE=	5167.5272 FT-LB	5.17 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	4.8	
PF=	19200 LB	19.2 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00	
Vf =	20.02	
Ti =	0.00	
Tf =	0.035	
d =	0.73535 FT	8.8242 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	5.17	
d =	0.74	
Favg =	7.03 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

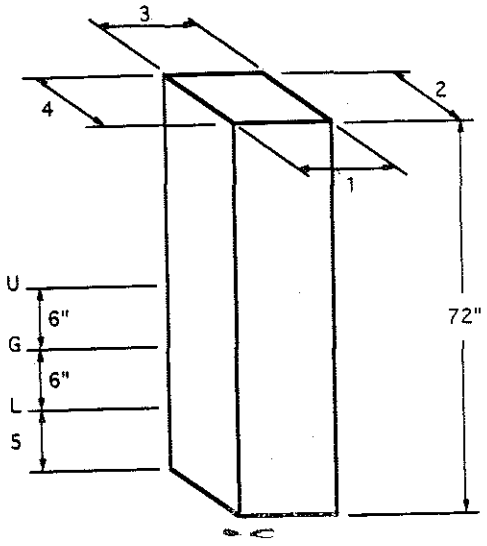
Test Date: 2 Dec 92 Testing Official: J. Mayer

SPECIMEN DATA

Specimen Number: W2 Material Type: WOOD

Specimen Weight: 57 lbs

Moisture Content after test: 13,5 %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 1,4 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 71.8 degrees F
Specimen Temperature - before test: 70.2 degrees F
Specimen Temperature - after test: 70,6 degrees F

TEST RESULTS

Fracture Energy: 3,6 ~~lb-ft~~ AT-KIPS
Post Displacment During Impact: 6,4 in
Peak Force: 16,8 ~~lbs~~ KIPS
Average Force During Impact: 6,7 ~~lbs~~ KIPS

WOOD & PLASTICS

U: 1 5 5/8" 2 8" 3 5 3/4" 4 7 7/8"
G: 1 5 5/8" 2 8" 3 5 3/4" 4 7 7/8"
L: 1 5 5/8" 2 8" 3 5 5/8" 4 7 7/8"
S: 26"

COMMENTS:

Drop Height 7'6"
Tape switch failed

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: Joe Mayo DATE: 12/2/92

TEST No. W-2

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	20.65		
FE=	3576.1385	FT-LB	3.58 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	4.2		
PF=	16800	LB	16.8 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	20.65		
Ti =	0.00		
Tf =	0.025		
d =	0.533125	FT	6.3975 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	3.58	
d =	0.53	
Favg =	6.71	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

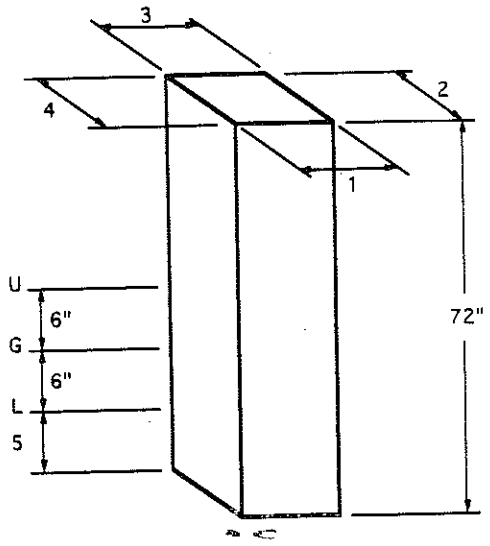
Test Date: 2 Dec 92 Testing Official: J. Mayer

SPECIMEN DATA

Specimen Number: W3 Material Type: Wood

Specimen Weight: 68 lbs

Moisture Content after test: 14.5 %



MASS DATA

Mass Weight: 4,000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 2.4 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 71.6 degrees F
Specimen Temperature - before test: 70.1 degrees F
Specimen Temperature - after test: 69.8 degrees F

TEST RESULTS

Fracture Energy: 6.25 ~~lb-ft~~ ft-Kips
Post Displacment During Impact: 10 in
Peak Force: 18 ~~lbs~~ Kips
Average Force During Impact: 7.5 ~~lbs~~ Kips

WOOD & PLASTICS

U: 1 5 7/8" 2 8" 3 5 7/8" 4 7 3/4"
G: 1 5 7/8" 2 8" 3 5 7/8" 4 7 3/4"
L: 1 5 7/8" 2 8" 3 5 3/4" 4 7 3/4"
S: 26"

COMMENTS: Drop Height 7'6"

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: Joe Walker DATE: 12/2/92

TEST No. W-3

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	19.58		
FE=	6249.7318	FT-LB	6.25 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	4.5		
PF=	18000	LB	18 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	19.58		
Ti =	0.00		
Tf =	0.040		
d =	0.8316	FT	9.9792 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	6.25	
d =	0.83	
Favg =	7.52	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

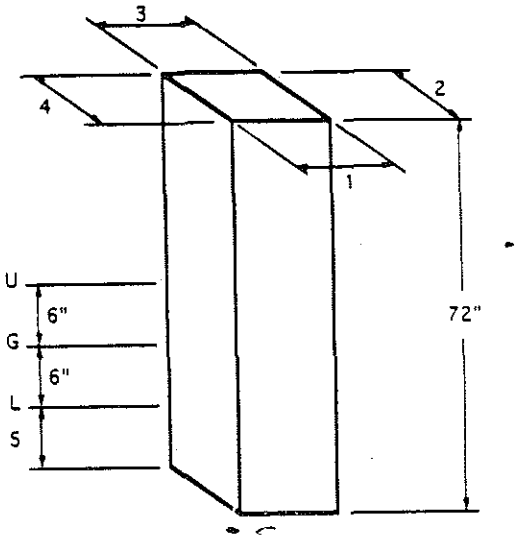
Test Date: 12-9-92 Testing Official: Joe McGee

SPECIMEN DATA

Specimen Number: W4 Material Type: _____

Specimen Weight: 68 lbs

Moisture Content after test: 18 %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 1.8 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 71.2 degrees F
Specimen Temperature - before test: 71.3 degrees F
Specimen Temperature - after test: 71.3 degrees F

TEST RESULTS

Fracture Energy: 4.7 lb-ft ft-kips
Post Displacment During Impact: 8.8 in
Peak Force: 20 lbs kips
Average Force During Impact: 6.4 lbs kips

WOOD & PLASTICS

U: 1 6¼ 2 7⅜ 3 6 4 7¾
G: 1 5⅞ 2 7¾ 3 6 4 7¾
L: 1 6¼ 2 7¾ 3 5⅞ 4 7¾
S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: Joe McCarthy DATE: 12/9/93
TEST No. W-4

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	20.20	
FE=	4717.8756 FT-LB	4.72 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	5.0	
PF=	20000 LB	20 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00	
Vf =	20.20	
Ti =	0.00	
Tf =	0.035	
d =	0.7385 FT	8.862 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	4.72	
d =	0.74	
Favg =	6.39 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

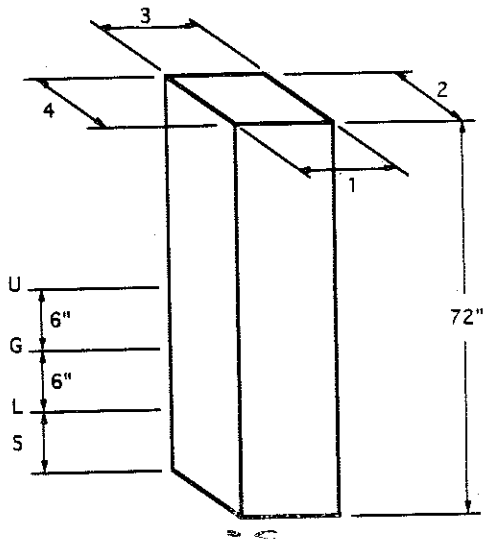
Test Date: 9 Dec 92 Testing Official: J. Mayer

SPECIMEN DATA

Specimen Number: W5 Material Type: WOOD

Specimen Weight: 77 1/2 lbs

Moisture Content after test: 17 %



MASS DATA

Mass Weight: 4,000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 4.5 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 71.4 degrees F
Specimen Temperature - before test: 71.3 degrees F
Specimen Temperature - after test: 71.4 degrees F

TEST RESULTS

Fracture Energy: 11.0 ~~lb-ft~~ ft-kips
Post Displacment During Impact: 8.3 in
Peak Force: 32 ~~lbs~~ kips
Average Force During Impact: 15.9 lbs

WOOD & PLASTICS

U: 1 6 1/4" 2 8 3 6" 4 8"
G: 1 6 1/8" 2 8" 3 6" 4 8"
L: 1 6 1/4" 2 7 7/8" 3 6" 4 8"
S: 26"

COMMENTS: Good Post

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: [illegible] DATE: 12/9/92
TEST No. W-5

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	17.52	
FE=	10996.551 FT-LB	11.00 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	8	
PF=	32000 LB	32 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00	
Vf =	17.52	
Ti =	0.00	
Tf =	0.035	
d =	0.6916 FT	8.2992 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	11.00	
d =	0.69	
Favg =	15.90 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

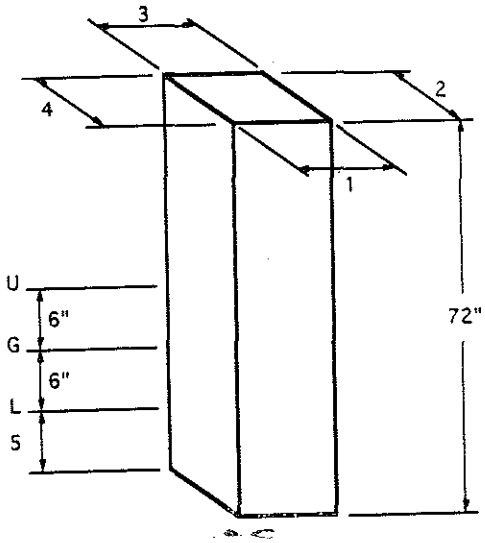
Test Date: 10 Dec 92 Testing Official: J. Mayer

SPECIMEN DATA

Specimen Number: W6 Material Type: Wood

Specimen Weight: 56 lbs

Moisture Content after test: 16.75 %



MASS DATA

Mass Weight: 4,000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 1.4 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 73 degrees F
Specimen Temperature - before test: 71.6 degrees F
Specimen Temperature - after test: 72 degrees F

TEST RESULTS

Fracture Energy: 3.3 lb-ft ft-Kips
Post Displacment During Impact: 3.8 in
Peak Force: 17.6 lbs Kips
Average Force During Impact: 2.7 lbs Kips

WOOD & PLASTICS

U: 1 $5\frac{3}{4}$" 2 $7\frac{3}{4}$" 3 6" 4 $7\frac{3}{4}$"
G: 1 $5\frac{3}{4}$" 2 $7\frac{3}{4}$" 3 6" 4 $7\frac{3}{4}$"
L: 1 $5\frac{3}{4}$" 2 $7\frac{3}{4}$" 3 6" 4 $7\frac{3}{4}$"
S: 26"

COMMENTS: Drop Height 7'6"

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: _____ DATE: 12/10/92

TEST No. W-6

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	20.65		
FE=	3576.1385	FT-LB	3.58 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	4.4		
PF=	17600	LB	17.6 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	20.65		
Ti =	0.00		
Tf =	0.020		
d =	0.4265	FT	5.118 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	3.58	
d =	0.43	
Favg =	8.38	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

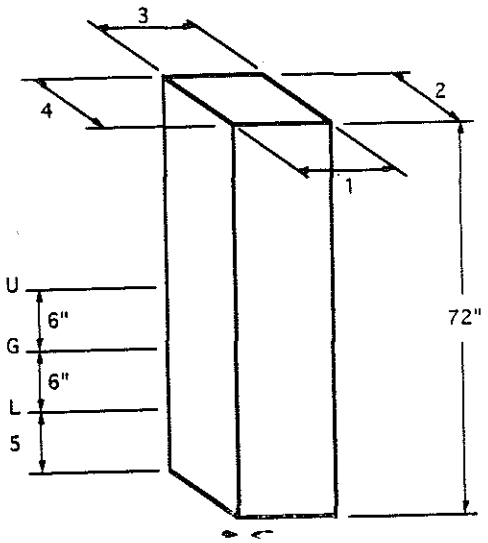
Test Date: 11 DEC 92 Testing Official: Joe Mayer

SPECIMEN DATA

Specimen Number: W7 Material Type: Wood

Specimen Weight: 68 lbs

Moisture Content after test: 12.4 %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 2.7 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 71 degrees F
Specimen Temperature - before test: 137 degrees F
Specimen Temperature - after test: 118 degrees F

TEST RESULTS

Fracture Energy: 6.8 ~~lb-ft~~ FT-KIPS
Post Displacment During Impact: 6.2 in
Peak Force: 21.2 ~~lbs~~ KIPS
Average Force During Impact: 13.2 ~~lbs~~ KIPS

WOOD & PLASTICS

U: 1 6" 2 7 3/4" 3 6" 4 7 7/8"
G: 1 6" 2 7 3/4" 3 6" 4 7 7/8"
L: 1 6" 2 7 3/4" 3 6" 4 7 7/8"
S: 26"

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: JMM DATE: 11 Dec 92
TEST No. W-7

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	19.35	
FE=	6805.8585 FT-LB	6.81 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	5.3	
PF=	21200 LB	21.2 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00	
Vf =	19.35	
Ti =	0.00	
Tf =	0.025	
d =	0.516875 FT	6.2025 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	6.81	
d =	0.52	
Favg =	13.17 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

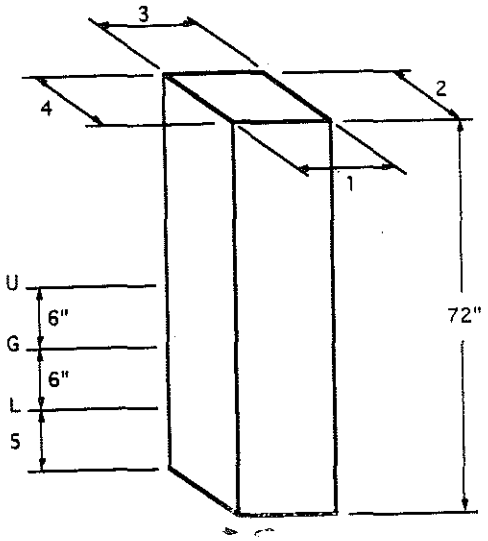
Test Date: 11 DEC 92 Testing Official: Jon Mayer

SPECIMEN DATA

Specimen Number: W8 Material Type: Wood

Specimen Weight: 65 lbs

Moisture Content after test: 11.3 %



MASS DATA

Mass Weight:	4000	pounds
Mass Impact Velocity:	22	ft/sec
Mass Velocity Change:	1.9	ft/sec

TEMPERATURE EFFECTS

Ambient Temperature:	71	degrees F
Specimen Temperature - before test:	141	degrees F
Specimen Temperature - after test:	120	degrees F

TEST RESULTS

Fracture Energy:	4.8	lb-ft AT-KIPS
Post Displacment During Impact:	7.6	in
Peak Force:	20.0	lbs KIPS
Average Force During Impact:	7.7	lbs KIPS

WOOD & PLASTICS

U: 1 5 3/4" 2 7 3/4" 3 5 3/4 4 7 7/8"

G: 1 5 3/4" 2 7 3/4" 3 5 3/4 4 7 7/8"

L: 1 5 3/4" 2 7 3/4" 3 5 3/4 4 7 7/8"

5: 26"

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: JMH DATE: 11 DEC 92
TEST No. W-8

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	20.15		
FE=	4843.1825	FT-LB	4.84 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5		
PF=	20000	LB	20 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00		
Vf =	20.15		
Ti =	0.00		
Tf =	0.030		
d =	0.63225	FT	7.587 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	4.84	
d =	0.63	
Favg =	7.66	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

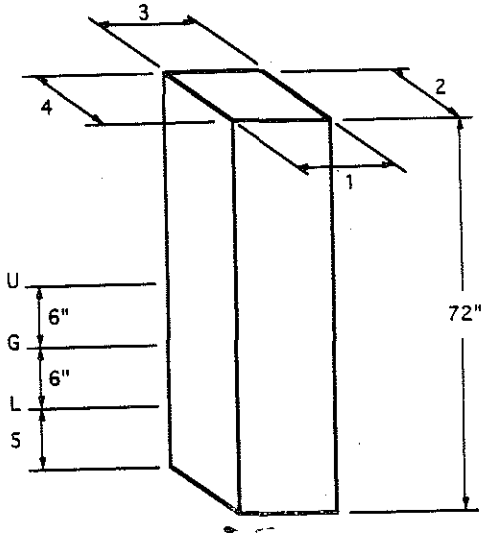
Test Date: 11 DEC 92 Testing Official: Joe Mongan

SPECIMEN DATA

Specimen Number: W9 Material Type: WOOD

Specimen Weight: 64 lbs

Moisture Content after test: 10,7 %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 1.5 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 73 degrees F
Specimen Temperature - before test: 136 degrees F
Specimen Temperature - after test: 119 degrees F

TEST RESULTS

Fracture Energy: 3,8 lb-ft FT-KIPS
Post Displacment During Impact: 5,1 in
Peak Force: 19,2 lbs KIPS
Average Force During Impact: 9,0 lbs KIPS

WOOD & PLASTICS

U: 1 5 3/4" 2 7 3/4" 3 5 5/8" 4 7 3/4"
G: 1 5 5/8" 2 7 3/4" 3 5 5/8" 4 7 3/4"
L: 1 5 5/8" 2 7 3/4" 3 5 5/8" 4 7 3/4"
S: 26"

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: _____ DATE: 11 DEC 92
TEST No. W-9

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	20.55		
FE=	3832.0317	FT-LB	3.83 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	4.8		
PF=	19200	LB	19.2 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00		
Vf =	20.55		
Ti =	0.00		
Tf =	0.020		
d =	0.4255	FT	5.106 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	3.83	
d =	0.43	
Favg =	9.01	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

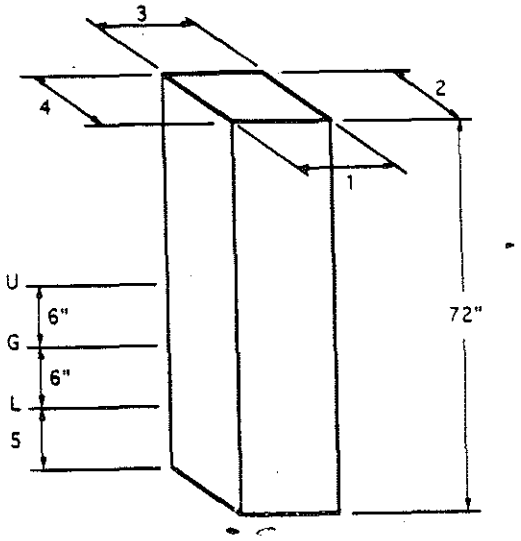
Test Date: 11 DEC 92 Testing Official: Joe Wekezer

SPECIMEN DATA

Specimen Number: W10 Material Type: WOOD

Specimen Weight: 66 lbs

Moisture Content after test: 10.1 %



MASS DATA

Mass Weight:	4000	pounds
Mass Impact Velocity:	22	ft/sec
Mass Velocity Change:	1.6	ft/sec

TEMPERATURE EFFECTS

Ambient Temperature:	74	degrees F
Specimen Temperature - before test:	140	degrees F
Specimen Temperature - after test:	121	degrees F

WOOD & PLASTICS

U: 1 5 3/4 2 7 3/4 3 5 3/4 4 7 3/4

G: 1 5 3/4 2 7 3/4 3 5 3/4 4 7 3/4

L: 1 5 3/4 2 7 3/4 3 5 3/4 4 7 3/4

5: 26

TEST RESULTS

Fracture Energy:	4.2	~~lb-ft~~ FT-Kips
Post Displacment During Impact:	8.9	in
Peak Force:	20.4	~~lbs~~ Kips
Average Force During Impact:	5.7	~~lbs~~ Kips

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: Jale DATE: 11 Dec 2

TEST No. W-10

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	20.40	
FE=	4213.5424 FT-LB	4.21 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	5.1	
PF=	20400 LB	20.4 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00	
Vf =	20.40	
Ti =	0.00	
Tf =	0.035	
d =	0.742 FT	8.904 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	4.21	
d =	0.74	
Favg =	5.68 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

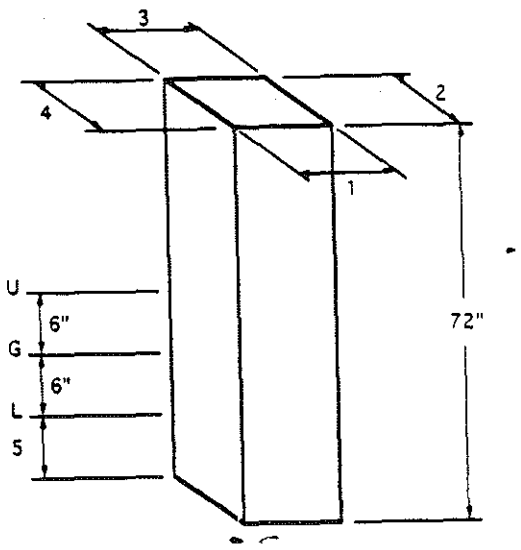
Test Date: 11 DEC 92 Testing Official: [signature]

SPECIMEN DATA

Specimen Number: W-11 Material Type: WOOD

Specimen Weight: 65 lbs

Moisture Content after test: 10.5 %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 3.5 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 74 degrees F
Specimen Temperature - before test: 138 degrees F
Specimen Temperature - after test: 118 degrees F

TEST RESULTS

Fracture Energy: 8.8 lb-ft
Post Displacment During Impact: 10.9 in
Peak Force: 19.2 lbs
Average Force During Impact: 9.7 lbs

WOOD & PLASTICS

U: 1 5 3/4 2 7 3/4 3 5 7/8 4 7 7/8
G: 1 5 3/4 2 7 3/4 3 5 3/4 4 7 3/4
L: 1 5 3/4 2 7 3/4 3 5 7/8 4 7 7/8
S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: JLM DATE: 11 DEC 92

TEST No. W-11

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	18.50		
FE=	8804.0925	FT-LB	8.80 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	4.8		
PF=	19200	LB	19.2 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	18.50		
Ti =	0.00		
Tf =	0.045		
d =	0.91125	FT	10.935 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	8.80	
d =	0.91	
Favg =	9.66	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

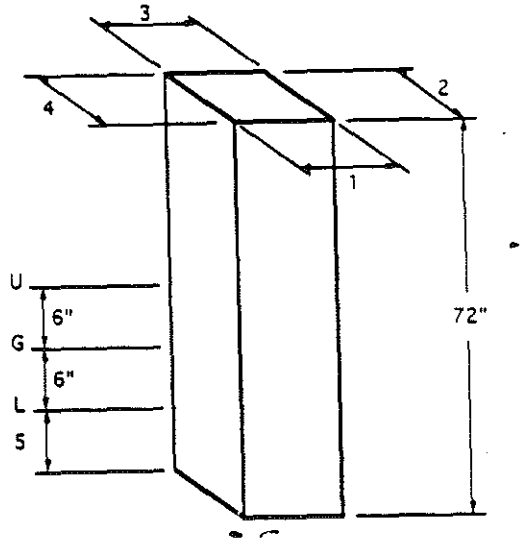
Test Date: 11 DEC 92 Testing Official: Joe Wiegand

SPECIMEN DATA

Specimen Number: W12 Material Type: WOOD

Specimen Weight: 67 lbs

Moisture Content after test: 13.4 %



MASS DATA

Mass Weight:	4000	pounds
Mass Impact Velocity:	22	ft/sec
Mass Velocity Change:	1.9	ft/sec

TEMPERATURE EFFECTS

Ambient Temperature:	74 ~~132~~	degrees F
Specimen Temperature - before test:	132	degrees F
Specimen Temperature - after test:	116	degrees F

TEST RESULTS

Fracture Energy:	5.0	~~lb-ft~~ ft-kips
Post Displacment During Impact:	11.4	in
Peak Force:	20.4	~~lbs~~ kips
Average Force During Impact:	5.2	~~lbs~~ kips

WOOD & PLASTICS

U: 1 5 3/4 2 7 7/8 3 5 7/8 4 7 3/4

G: 1 5 3/4 2 7 7/8 3 5 3/4 4 7 3/4

L: 1 5 3/4 2 7 3/4 3 5 3/4 4 7 3/4

S: ____

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: JM DATE: 11 DEC 92

TEST No. W-12

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	20.10		
FE=	4968.1789	FT-LB	4.97 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5.1		
PF=	20400	LB	20.4 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	20.10		
Ti =	0.00		
Tf =	0.045		
d =	0.94725	FT	11.367 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	4.97	
d =	0.95	
Favg =	5.24	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

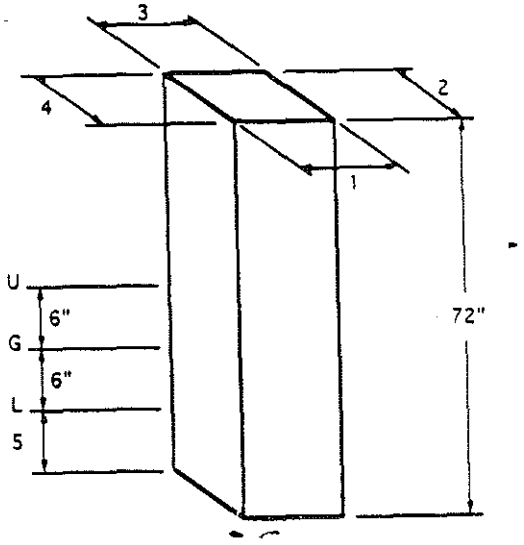
Test Date: 12-15-92 Testing Official: [signature]

SPECIMEN DATA

Specimen Number: W13 Material Type: WOOD

Specimen Weight: 64 lbs

Moisture Content after test: 16.5 %



MASS DATA

Mass Weight:	4000	pounds
Mass Impact Velocity:	22	ft/sec
Mass Velocity Change:	1.9	ft/sec

TEMPERATURE EFFECTS

Ambient Temperature:	61	degrees F
Specimen Temperature - before test:	-35	degrees F
Specimen Temperature - after test:	-18	degrees F

TEST RESULTS

Fracture Energy:	4.8	lb-ft ~~FT-KIPS~~
Post Displacment During Impact:	6.3	in
Peak Force:	19.6	lbs ~~KIPS~~
Average Force During Impact:	9.2	lbs ~~KIPS~~

WOOD & PLASTICS

U: 1 5 3/4 2 7 3/4 3 5 7/8 4 7 3/4

G: 1 5 3/4 2 7 3/4 3 5 3/4 4 7 3/4

L: 1 5 3/4 2 7 3/4 3 5 3/4 4 7 3/4

S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: _____ DATE: 12-15-92

TEST No. W-13

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	20.15		
FE=	4843.1825	FT-LB	4.84 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	4.9		
PF=	19600	LB	19.6 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	20.15		
Ti =	0.00		
Tf =	0.025		
d =	0.526875	FT	6.3225 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	4.84	
d =	0.53	
Favg =	9.19	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

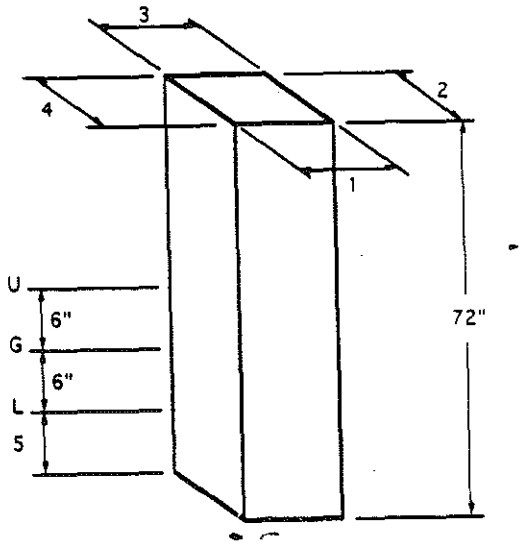
Test Date: 12-15-92 Testing Official: [signature]

SPECIMEN DATA

Specimen Number: W14 Material Type: Wood

Specimen Weight: 63 lbs

Moisture Content after test: 14.8 %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 2.1 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 61 degrees F
Specimen Temperature - before test: -39 degrees F
Specimen Temperature - after test: -20 degrees F

TEST RESULTS

Fracture Energy: 5.5 lb-ft ft-kips
Post Displacment During Impact: 7.8 in
Peak Force: 20.0 lbs-kips
Average Force During Impact: 7.4 lbs-kips

WOOD & PLASTICS

U: 1 5 3/4 2 7 3/4 3 5 3/4 4 7 3/4
G: 1 5 3/4 2 7 3/4 3 5 5/8 4 7 3/4
L: 1 5 3/4 2 7 3/4 3 5 3/4 4 7 3/4
S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: JWM DATE: 12-15-92
TEST No. W-14

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	19.90	
FE=	5465.0589 FT-LB	5.47 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	5	
PF=	20000 LB	20 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00	
Vf =	19.90	
Ti =	0.00	
Tf =	0.035	
d =	0.73325 FT	8.799 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	5.47	
d =	0.73	
Favg =	7.45 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

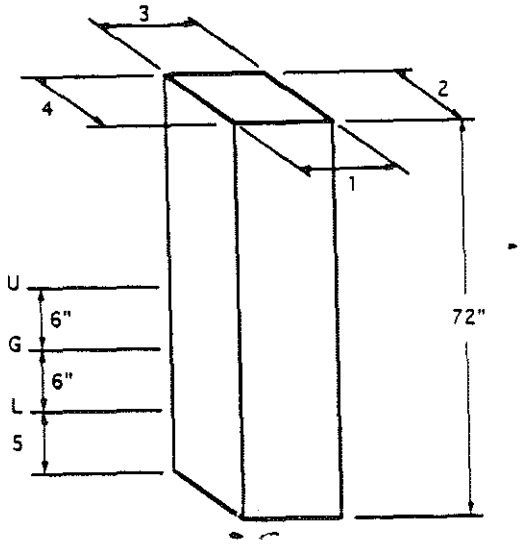
Test Date: 12-15-92 Testing Official: [signature]

SPECIMEN DATA

Specimen Number: W15 Material Type: Wood

Specimen Weight: 66 lbs

Moisture Content after test: 15,4 %



MASS DATA

Mass Weight:	4000	pounds
Mass Impact Velocity:	22	ft/sec
Mass Velocity Change:	2,05	ft/sec

TEMPERATURE EFFECTS

Ambient Temperature:	62	degrees F
Specimen Temperature - before test:	-35	degrees F
Specimen Temperature - after test:	-17	degrees F

TEST RESULTS

Fracture Energy:	5,3	lb-ft
Post Displacment During Impact:	8,8	in
Peak Force:	20,8	lbs
Average Force During Impact:	7,3	lbs

WOOD & PLASTICS

U: 1 5 7/8 2 7 3/4 3 5 3/4 4 7 3/4

G: 1 5 7/8 2 7 3/4 3 5 3/4 4 7 3/4

L: 1 5 3/4 2 7 3/4 3 5 3/4 4 7 7/8

5: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: JLH DATE: 12-15-92
TEST No. W-15

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	19.95	
FE=	5341.3047 FT-LB	5.34 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	5.2	
PF=	20800 LB	20.8 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00	
Vf =	19.95	
Ti =	0.00	
Tf =	0.035	
d =	0.734125 FT	8.8095 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	5.34	
d =	0.73	
Favg =	7.28 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

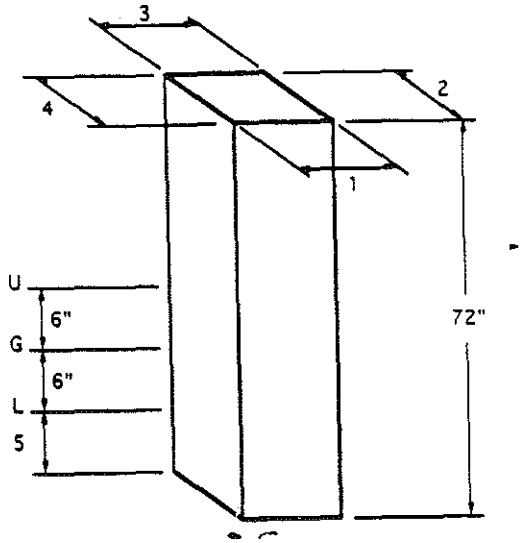
Test Date: 12-15-92 Testing Official: [signature]

SPECIMEN DATA

Specimen Number: W16 Material Type: Wood

Specimen Weight: 64 lbs

Moisture Content after test: 14.9 %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 3.1 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 62 degrees F
Specimen Temperature - before test: -40 degrees F
Specimen Temperature - after test: -21 degrees F

TEST RESULTS

Fracture Energy: 7.9 ~~lb-ft~~ ft-kips
Post Displacment During Impact: 7.4 in
Peak Force: 2160 ~~lbs~~ kips
Average Force During Impact: 12.8 ~~lbs~~ kips

WOOD & PLASTICS

U: 1 5¾ 2 7¾ 3 5¾ 4 7¾
G: 1 5¾ 2 7¾ 3 5¾ 4 7¾
L: 1 5¾ 2 7¾ 3 5¾ 4 7¾
S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: JMM DATE: 12-15-92
TEST No. W-16

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	18.90		
FE=	7874.9269	FT-LB	7.87 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5.4		
PF=	21600	LB	21.6 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00		
Vf =	18.90		
Ti =	0.00		
Tf =	0.030		
d =	0.6135	FT	7.362 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	7.87	
d =	0.61	
Favg =	12.84	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

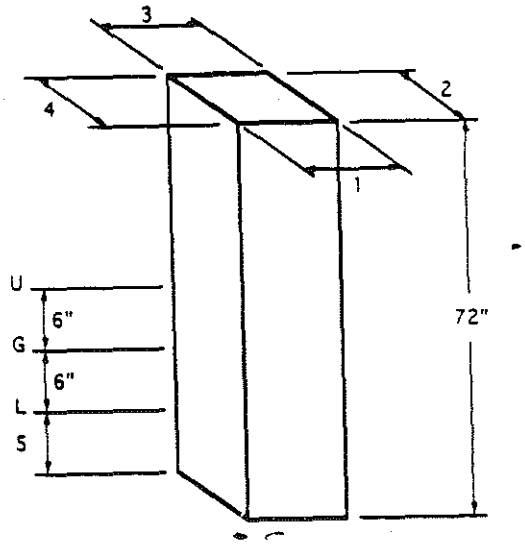
Test Date: 12-16-92 Testing Official: Joe Wang

SPECIMEN DATA

Specimen Number: W-17 Material Type: Wood

Specimen Weight: 63 lbs

Moisture Content after test: 14.6 %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 1.75 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 58 degrees F
Specimen Temperature - before test: -34 degrees F
Specimen Temperature - after test: -16 degrees F

TEST RESULTS

Fracture Energy: 4.6 ~~lb-ft~~ FT-KIPS
Post Displacment During Impact: 5.1 in
Peak Force: 19.2 lbs KIPS
Average Force During Impact: 10.9 lbs KIPS

WOOD & PLASTICS

U: 1 5½ 2 7 5/8 3 5 5/8 4 7 3/4
G: 1 5 5/8 2 7 5/8 3 5 3/4 4 7 5/8
L: 1 5 3/4 2 7 5/8 3 5 3/4 4 7 5/8
S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: _____ DATE: 12-16-92
TEST No. W-17

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	20.25		
FE=	4592.2581	FT-LB	4.59 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	4.8		
PF=	19200	LB	19.2 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00		
Vf =	20.25		
Ti =	0.00		
Tf =	0.020		
d =	0.4225	FT	5.07 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	4.59	
d =	0.42	
Favg =	10.87	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

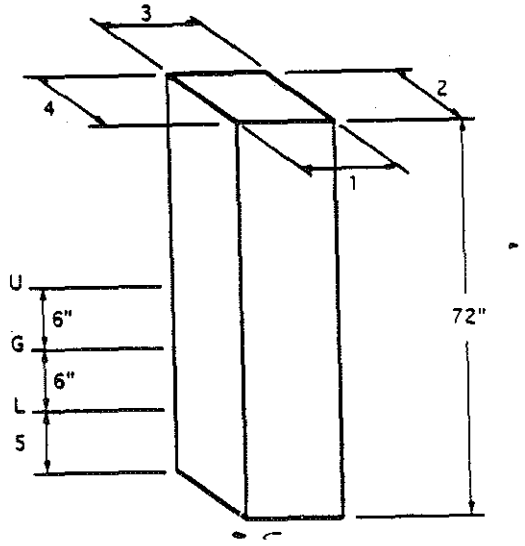
Test Date: 12-16-92 Testing Official: Joe Mayer

SPECIMEN DATA

Specimen Number: W-18 Material Type: Wood

Specimen Weight: 65 lbs

Moisture Content after test: 16.2 %



MASS DATA

Mass Weight:	4000	pounds
Mass Impact Velocity:	22	ft/sec
Mass Velocity Change:	1.5	ft/sec

TEMPERATURE EFFECTS

Ambient Temperature:	60	degrees F
Specimen Temperature - before test:	-41	degrees F
Specimen Temperature - after test:	-19	degrees F

TEST RESULTS

Fracture Energy:	4.0	lb-ft (AT-KIPS)
Post Displacment During Impact:	51	in
Peak Force:	18.0	~~lbs~~ KIPS
Average Force During Impact:	9.3	~~lbs~~ KIPS

WOOD & PLASTICS

U: 1 5 3/4 2 7 3/4 3 5 5/8 4 7 3/8

G: 1 5 3/4 2 7 3/4 3 5 3/4 4 7 3/4

L: 1 5 3/4 2 7 3/4 3 5 3/4 4 7 3/4

S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: [illegible] DATE: 12-16-92

TEST No. W-18

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	20.50		
FE=	3959.5125	FT-LB	3.96 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	4.5		
PF=	18000	LB	18 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	20.50		
Ti =	0.00		
Tf =	0.020		
d =	0.425	FT	5.1 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	3.96	
d =	0.43	
Favg =	9.32	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

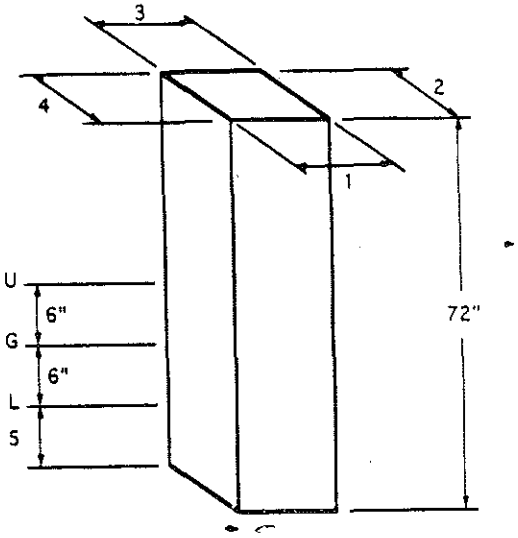
Test Date: 10 DEC 92 Testing Official: D. Mayer ~~PLASTIC~~

SPECIMEN DATA

Specimen Number: PC1 Material Type: PLASTIC

Specimen Weight: 132 lbs

Moisture Content after test: N/A %



MASS DATA

Mass Weight: 4,000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 2.1 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 68 degrees F
Specimen Temperature - before test: 71.3 degrees F
Specimen Temperature - after test: 70 degrees F

TEST RESULTS

Fracture Energy: 5.4 lb-ft FT/KIPS
Post Displacment During Impact: 8.8 in
Peak Force: 19.6 lbs KIPS
Average Force During Impact: 7.3 lbs KIPS

WOOD & PLASTICS

U: 1 5 7/8" 2 9 3/4" 3 5 7/8" 4 9 3/4"
G: 1 5 7/8" 2 9 3/4" 3 5 7/8" 4 9 3/4"
L: 1 5 7/8" 2 9 3/4" 3 5 7/8" 4 9 3/4"
S: 26"

COMMENTS:

Drop Height 7'6"

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY:_____ DATE: _____

TEST No. PC-1

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulul impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	19.94	
FE=	5366.0804 FT-LB	5.37 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	4.9	
PF=	19600 LB	19.6 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00	
Vf =	19.94	
Ti =	0.00	
Tf =	0.035	
d =	0.73395 FT	8.8074 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	5.37	
d =	0.73	
Favg =	7.31 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

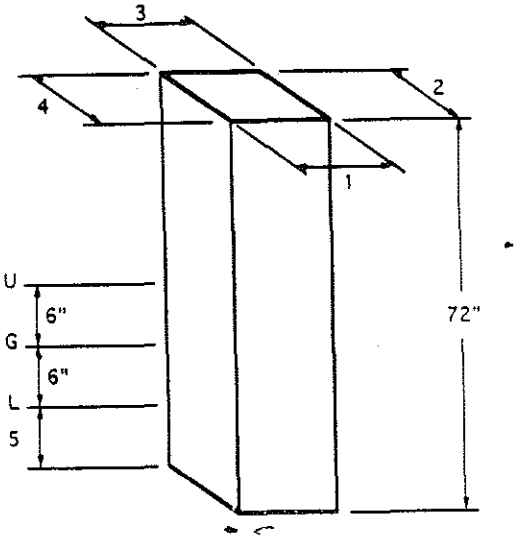
Test Date: 10 DEC 92 Testing Official: J. Mayer

SPECIMEN DATA

Specimen Number: PC 2 Material Type: PLASTIC

Specimen Weight: 125 lbs

Moisture Content after test: N/A %



MASS DATA

Mass Weight: 4,000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 1.6 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 67.4 degrees F
Specimen Temperature - before test: 72.4 degrees F
Specimen Temperature - after test: 70.6 degrees F

TEST RESULTS

Fracture Energy: 4.1 lb-ft FT/Kips
Post Displacment During Impact: 7.6 in
Peak Force: 18 lbs Kips
Average Force During Impact: 6.4 lbs Kips

WOOD & PLASTICS

U: 1 5 3/4" 2 9 5/8" 3 5 3/4" 4 9 5/8"
G: 1 5 3/4" 2 9 5/8" 3 5 3/4" 4 9 5/8"
L: 1 5 7/8" 2 9 5/8" 3 5 3/4" 4 9 5/8"
S: 26"

COMMENTS:

Drop Height 7'6"
Broke 3 pieces : top - half split longitudinally

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: [signature] DATE: 12/10/92

TEST No. PC-2

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulul impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	20.45		
FE=	4086.6827	FT-LB	4.09 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	4.5		
PF=	18000	LB	18 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	20.45		
Ti =	0.00		
Tf =	0.030		
d =	0.63675	FT	7.641 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	4.09	
d =	0.64	
Favg =	6.42	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

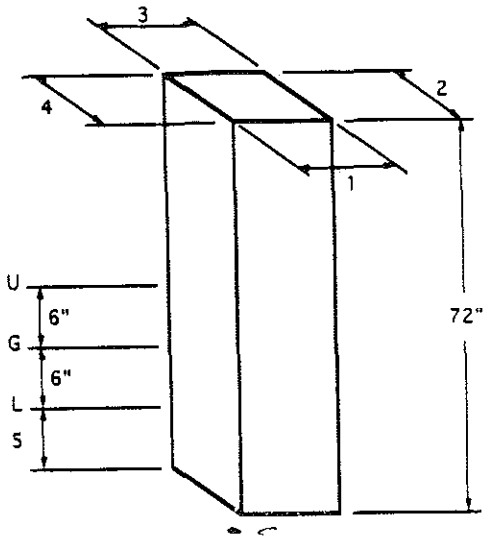
Test Date: 10 DEC 92 Testing Official: J. Mayer

SPECIMEN DATA

Specimen Number: PC 3 Material Type: PLASTIC

Specimen Weight: 132 lbs

Moisture Content after test: N/A %



MASS DATA

Mass Weight:	4,000	pounds
Mass Impact Velocity:	22	ft/sec
Mass Velocity Change:	1.3	ft/sec

TEMPERATURE EFFECTS

Ambient Temperature:	72	degrees F
Specimen Temperature - before test:	69.6	degrees F
Specimen Temperature - after test:	71	degrees F

TEST RESULTS

Fracture Energy:	3.4	~~lb-ft~~ ft. Kips
Post Displacment During Impact:	3.8	in
Peak Force:	20.1	~~lbs~~ Kips
Average Force During Impact:	10.6	~~lbs~~ Kips

WOOD & PLASTICS

U: 1 5 3/4" 2 9 3/4" 3 5 7/8" 4 9 3/4"

G: 1 5 3/4" 2 9 3/4" 3 5 7/8" 4 9 5/8"

L: 1 5 3/4" 2 9 3/8" 3 5 7/8" 4 9 3/8"

S: 26"

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: _____ DATE: 12/10/92

TEST No. PC-3

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulul Impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	20.72		
FE=	3396.2742	FT-LB	3.40 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5.2		
PF=	20800	LB	20.8 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	20.72		
Ti =	0.00		
Tf =	0.015		
d =	0.3204	FT	3.8448 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	3.40	
d =	0.32	
Favg =	10.60	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

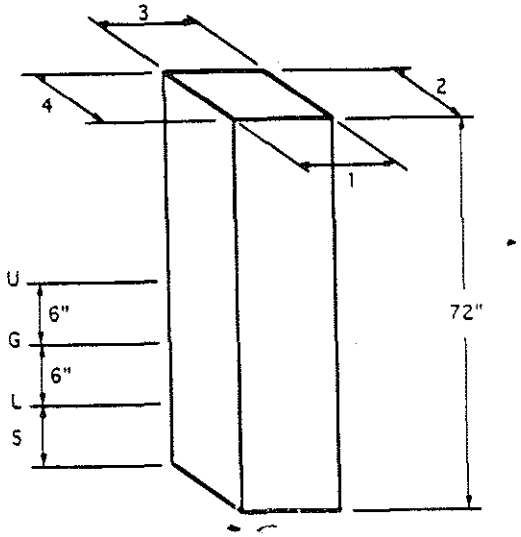
Test Date: 11 Dec 92 Testing Official: J. Mayer

SPECIMEN DATA

Specimen Number: PC 4 Material Type: PLASTIC

Specimen Weight: 127.5 lbs

Moisture Content after test: N/A %



MASS DATA

Mass Weight: 4,000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 1.3 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 67 degrees F
Specimen Temperature - before test: 71.3 degrees F
Specimen Temperature - after test: 71 degrees F

TEST RESULTS

Fracture Energy: 3.4 ~~lb-ft~~ ft-kips
Post Displacment During Impact: 5.1 in
Peak Force: 18 ~~lbs~~ KIPS
Average Force During Impact: 8.0 lbs

WOOD & PLASTICS

U: 1 5 7/8" 2 9 5/8" 3 5 7/8" 4 9 5/8"
G: 1 5 7/8" 2 9 3/4" 3 5 7/8" 4 9 5/8"
L: 1 5 7/8" 2 9 5/8 3 5 3/4" 4 9 5/8"
S: 26

COMMENTS: Drop Height 7'6"

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: [signature] DATE: 12/11/92
TEST No. PC-4

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulul impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	20.72	
FE=	3396.2742 FT-LB	3.40 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	4.5	
PF=	18000 LB	18 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00	
Vf =	20.72	
Ti =	0.00	
Tf =	0.020	
d =	0.4272 FT	5.1264 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	3.40	
d =	0.43	
Favg =	7.95 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

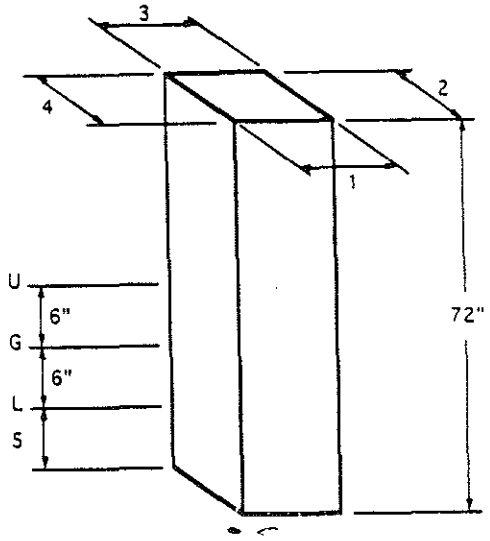
Test Date: 12 / 11 Dec 92 Testing Official: J. Mayer

SPECIMEN DATA

Specimen Number: PC 5 Material Type: PLASTIC

Specimen Weight: 130.5 lbs

Moisture Content after test: N/A %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 1.5 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 67 degrees F
Specimen Temperature - before test: 71.4 degrees F
Specimen Temperature - after test: 70.2 degrees F

TEST RESULTS

Fracture Energy: 4.1 lb-ft Pt-Kips
Post Displacment During Impact: 10.2 in
Peak Force: 21.2 lbs Kips
Average Force During Impact: 4.8 lbs Kips

WOOD & PLASTICS

U: 1 5 3/4" 2 9 5/8" 3 5 3/4" 4 9 3/4"
G: 1 5 3/4" 2 9 5/8" 3 5 3/4" 4 9 3/4"
L: 1 5 3/4" 2 9 5/8" 3 5 3/4" 4 9 5/8"
S: 24"

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: [signature] DATE: 12/11/92
TEST No. PC-5

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	20.46		
FE=	4061.2735	FT-LB	4.06 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5.3		
PF=	21200	LB	21.2 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00		
Vf =	20.46		
Ti =	0.00		
Tf =	0.040		
d =	0.8492	FT	10.1904 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	4.06	
d =	0.85	
Favg =	4.78	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

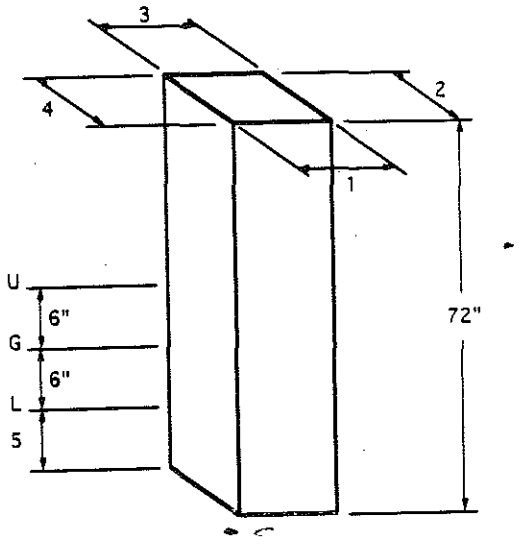
Test Date: 11 Dec 92 Testing Official: J. Mayer

SPECIMEN DATA

Specimen Number: PA1 Material Type: PLASTIC

Specimen Weight: 103 lbs

Moisture Content after test: N/A %



MASS DATA

Mass Weight: 4,000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 1.0 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 67 degrees F
Specimen Temperature - before test: 71.4 degrees F
Specimen Temperature - after test: 70.1 degrees F

TEST RESULTS

Fracture Energy: 2.7 lb-ft FT-KIPS
Post Displacment During Impact: 5.2 in
Peak Force: 1.8 lbs KIPS
Average Force During Impact: 6.3 lbs KIPS

WOOD & PLASTICS

U: 1 5 3/4" 2 7 3/4" 3 5 3/4" 4 7 3/4"
G: 1 5 3/4" 2 7 3/4" 3 5 3/4" 4 7 3/4"
L: 1 5 3/4" 2 7 3/4" 3 5 3/4" 4 7 3/4"
S: 26"

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: Jay Mauger DATE: 12/11/93

TEST No. PA-1

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11			
Vi=	22.00			
Vf=	20.99			
FE=	2696.81	FT-LB	2.70	FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000			
Pa=	4.5			
PF=	18000	LB	18	KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00			
Vf =	20.99			
Ti =	0.00			
Tf =	0.020			
d =	0.4299	FT	5.1588	IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	2.70		
d =	0.43		
Favg =	6.27	KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

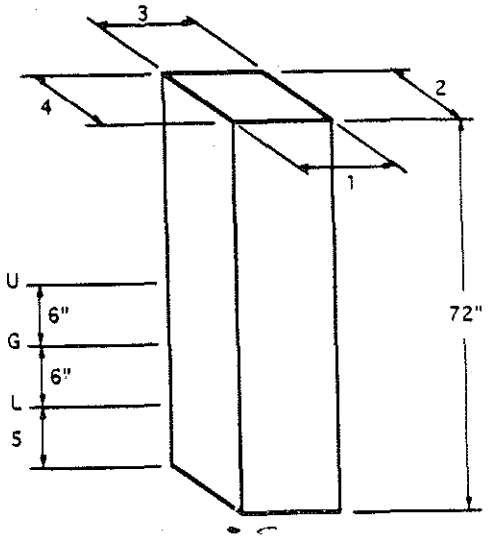
Test Date: 24 Feb 93 Testing Official: J. Mayer

SPECIMEN DATA

Specimen Number: TA-1 Material Type: PLASTIC (TRIMAX)

Specimen Weight: 106 lbs

Moisture Content after test: N/A %



MASS DATA

Mass Weight: 4,050 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 1.0 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 60 degrees F
Specimen Temperature - before test: 70 degrees F
Specimen Temperature - after test: 69 degrees F

TEST RESULTS

Fracture Energy: 2.15 lb-ft ft-kips
Post Displacment During Impact: 9.0 in
Peak Force: 21.2 lbs kips
Average Force During Impact: 3.4 lbs kips

WOOD & PLASTICS

U: 1 6" 2 8" 3 6" 4 7 7/8"
G: 1 6" 2 7 7/8" 3 6" 4 7 7/8
L: 1 6" 2 7 7/8" 3 6" 4 7 7/8
S: 26"

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: Joe Nowak DATE: 3/24/93

TEST No. TA-1

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	21.05	
FE=	2540.1437 FT-LB	2.54 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	5.3	
PF=	21200 LB	21.2 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00	
Vf =	21.05	
Ti =	0.00	
Tf =	0.035	
d =	0.753375 FT	9.0405 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	2.54	
d =	0.75	
Favg =	3.37 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

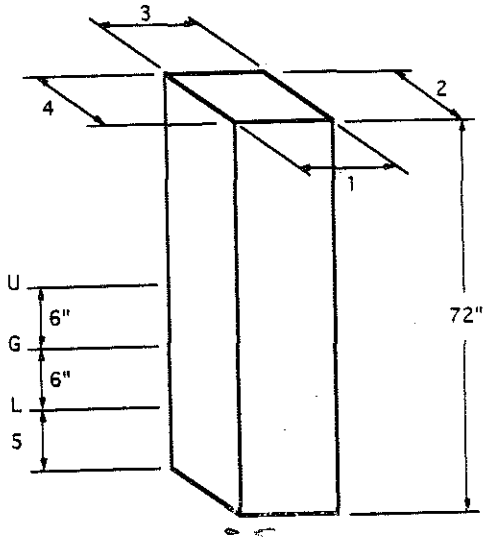
Test Date: 24 FEB 93 Testing Official: J. Mayer

SPECIMEN DATA

Specimen Number: TA-2 Material Type: PLASTIC

Specimen Weight: 104 lbs

Moisture Content after test: N/A %



MASS DATA

Mass Weight: 4,000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 1.0 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 60 degrees F
Specimen Temperature - before test: 70 degrees F
Specimen Temperature - after test: 69.6 degrees F

TEST RESULTS

Fracture Energy: 2,4 lb-ft ft-kips
Post Displacment During Impact: 3,9 in
Peak Force: 22,4 lbs kips
Average Force During Impact: 7,5 lbs kips

WOOD & PLASTICS

U: 1 6" 2 8" 3 6" 4 7 7/8"
G: 1 6" 2 8" 3 6" 4 7 7/8"
L: 1 6" 2 8" 3 6" 4 7 7/8"
S: 26"

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: [illegible] DATE: 2/24/93

TEST No. TA-2

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	21.10		
FE=	2409.2469	FT-LB	2.41 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5.6		
PF=	22400	LB	22.4 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	21.10		
Ti =	0.00		
Tf =	0.015		
d =	0.32325	FT	3.879 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	2.41	
d =	0.32	
Favg =	7.45	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

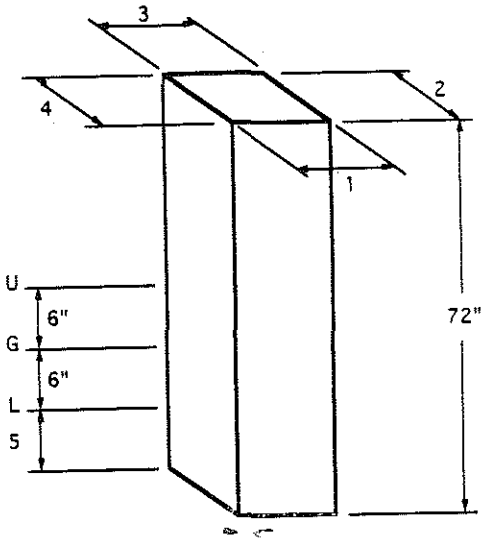
Test Date: 24 Feb 93 Testing Official: J. Mayne

SPECIMEN DATA

Specimen Number: TA-3 Material Type: PLASTIC

Specimen Weight: 106 lbs

Moisture Content after test: N/A %



MASS DATA

Mass Weight: 4,000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 1.0 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 60° degrees F
Specimen Temperature - before test: 70° degrees F
Specimen Temperature - after test: 68.5 degrees F

TEST RESULTS

Fracture Energy: 2.6 ~~lb-ft~~ Ft-Kips
Post Displacment During Impact: 2.6 in
Peak Force: 22.8 ~~lbs~~ Kips
Average Force During Impact: 12.17 ~~lbs~~ Kips

WOOD & PLASTICS

U: 1 6" 2 8" 3 6" 4 7 7/8"
G: 1 6" 2 8" 3 6" 4 7 7/8"
L: 1 6" 2 8" 3 6" 4 7 7/8"
5: 26"

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: [illegible] DATE: 3/24/15

TEST No. TA-3

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	21.02		
FE=	2618.5328	FT-LB	2.62 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5.7		
PF=	22800	LB	22.8 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	21.02		
Ti =	0.00		
Tf =	0.010		
d =	0.2151	FT	2.5812 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	2.62	
d =	0.22	
Favg =	12.17	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

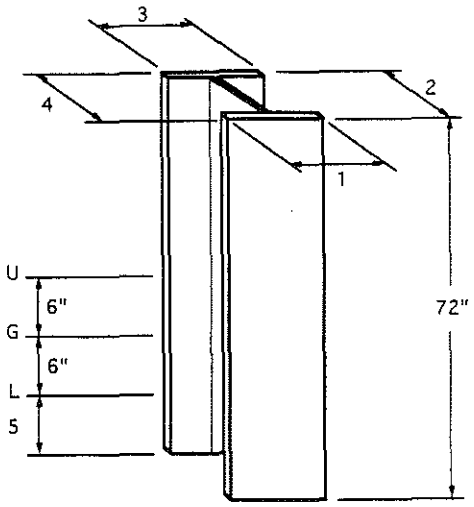
Test Date: Dec 3, 92 Testing Official: [signature]

SPECIMEN DATA

Specimen Number: S1 Material Type: STEEL

Specimen Weight: 54 lbs

Moisture Content after test: NA %



STEEL

MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22.0 ft/sec
Mass Velocity Change: 5.0 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 56 degrees F
Specimen Temperature - before test: -25 degrees F
Specimen Temperature - after test: -14 degrees F

TEST RESULTS

Fracture Energy: 12.1 ~~lb-ft~~ KIPS
Post Displacment During Impact: 9.4 in
Peak Force: 23.2 ~~lbs~~ KIPS
Average Force During Impact: 15.4 ~~lbs~~ KIPS

U: 1 4 2 6 3 4 4 6
G: 1 4 2 6 3 4 4 6
L: 1 4 2 6 3 4 4 6
5: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: Jon Way DATE: 12/3/93

TEST No. S-1

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulul impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	17.03		
FE=	12048.042	FT-LB	12.05 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5.8		
PF=	23200	LB	23.2 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	17.03		
Ti =	0.00		
Tf =	0.04		
d =	0.7806	FT	9.3672 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	12.05	
d =	0.7806	
Favg =	15.43	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

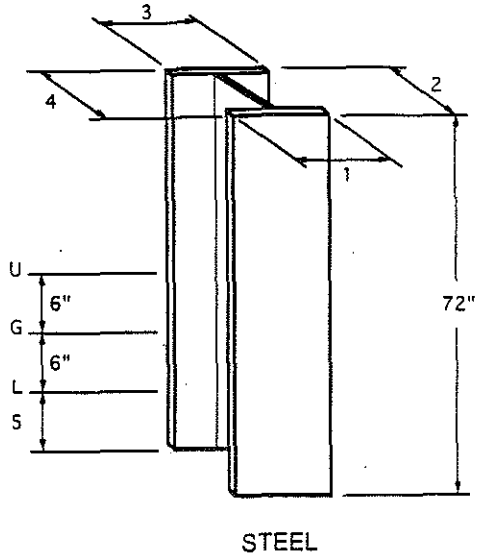
Test Date: 12/03/92 Testing Official: [signature]

SPECIMEN DATA

Specimen Number: S-2 Material Type: STEEL

Specimen Weight: 54 lbs

Moisture Content after test: N/A %



STEEL

MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22.0 ft/sec
Mass Velocity Change: 3.8 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 59 degrees F
Specimen Temperature - before test: -26 degrees F
Specimen Temperature - after test: -16 degrees F

TEST RESULTS

Fracture Energy: 9.4 ~~lb-ft~~ FT-KIPS
Post Displacment During Impact: 8.4 in
Peak Force: 22.4 ~~lbs~~ KIPS
Average Force During Impact: 13.4 ~~lbs~~ KIPS

U: 1 4 2 6 3 4 4 6
G: 1 4 2 6 3 4 4 6
L: 1 4 2 6 3 4 4 6
S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: Joe Mayer DATE: 12/03/92

TEST No. S-2

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulul impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	18.23		
FE=	9420.0436	FT-LB	9.42 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5.6		
PF=	22400	LB	22.4 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	18.23		
Ti =	0.00		
Tf =	0.04		
d =	0.704025	FT	8.4483 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	9.42	
d =	0.70	
Favg =	13.38	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

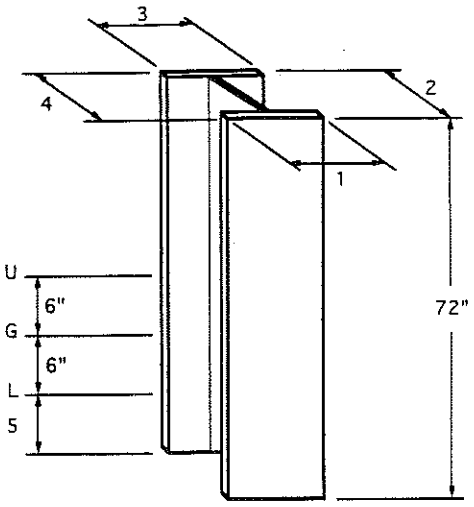
Test Date: Dec 3, 92. Testing Official: [signature]

SPECIMEN DATA

Specimen Number: S3 Material Type: STEEL

Specimen Weight: 54 lbs

Moisture Content after test: N/A %



STEEL

MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22.0 ft/sec
Mass Velocity Change: 4.4 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 57.3 degrees F
Specimen Temperature - before test: -24 degrees F
Specimen Temperature - after test: -16 degrees F

TEST RESULTS

Fracture Energy: 10.7 ~~lb-ft~~ ft-kips
Post Displacment During Impact: 8.3 in
Peak Force: 22.0 ~~lbs~~ kips
Average Force During Impact: 15.47 ~~lbs~~ kips

U: 1 4 2 6 3 4 4 6
G: 1 4 2 6 3 4 4 6
L: 1 4 2 6 3 4 4 6
5: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: [signature] DATE: 12-3-92
TEST No. S-3

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulul impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	17.64		
FE=	10734.496	FT-LB	10.73 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5.5		
PF=	22000	LB	22 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00		
Vf =	17.64		
Ti =	0.00		
Tf =	0.035		
d =	0.6937	FT	8.3244 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	10.73	
d =	0.69	
Favg =	15.47	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

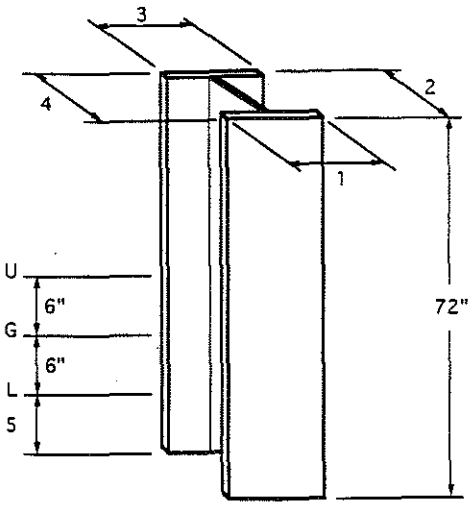
Test Date: 12-3-92 Testing Official: Joe Hayes

SPECIMEN DATA

Specimen Number: S-4 Material Type: STEEL

Specimen Weight: 53.5 lbs

Moisture Content after test: N/A %



STEEL

MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22.0 ft/sec
Mass Velocity Change: 4.1 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 61 degrees F
Specimen Temperature - before test: -30 degrees F
Specimen Temperature - after test: -17 degrees F

TEST RESULTS

Fracture Energy: 10.12 ~~lb-ft~~ ft-KIPS
Post Displacment During Impact: 9.6 in
Peak Force: 22.8 ~~lbs~~ KIPS
Average Force During Impact: 12.7 ~~lbs~~ KIPS

U: 1 4 2 6 3 4 4 6
G: 1 4 2 6 3 4 4 6
L: 1 4 2 6 3 4 4 6
S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: Jon Mc[illegible] DATE: 12/3/92
TEST No. S-4

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	17.92	
FE=	10116.079 FT-LB	10.12 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	5.7	
PF=	22800 LB	22.8 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00	
Vf =	17.92	
Ti =	0.00	
Tf =	0.040	
d =	0.7984 FT	9.5808 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	10.12	
d =	0.80	
Favg =	12.67 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

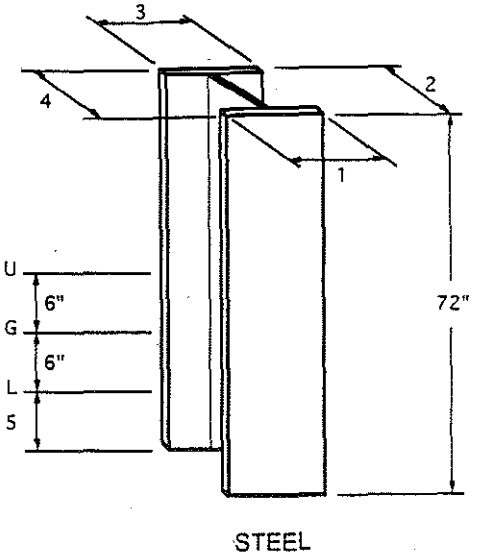
Test Date: 12/3/92 Testing Official: Jon Nguyen

SPECIMEN DATA

Specimen Number: S-5 Material Type: STEEL

Specimen Weight: 5 lbs

Moisture Content after test: N/A %



STEEL

MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 4.8 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 62 degrees F
Specimen Temperature - before test: -28 degrees F
Specimen Temperature - after test: -15 degrees F

TEST RESULTS

Fracture Energy: 11.6 ~~lb-ft~~ Ft-Kips
Post Displacment During Impact: 8.2 in
Peak Force: 22.4 ~~lbs~~ Kips
Average Force During Impact: 17.0 ~~lbs~~ Kips

U: 1 4 2 6 3 4 4 6
G: 1 4 2 6 3 4 4 6
L: 1 4 2 6 3 4 4 6
S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: [signature] DATE: 12/3/92

TEST No. S-5

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	17.22	
FE=	11643.861 FT-LB	11.64 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	5.6	
PF=	22400 LB	22.4 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00	
Vf =	17.22	
Ti =	0.00	
Tf =	0.035	
d =	0.68635 FT	8.2362 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	11.64	
d =	0.69	
Favg =	16.96 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

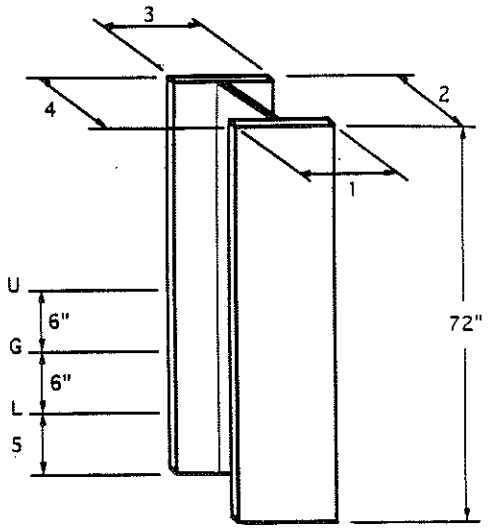
Test Date: 12-7-92 Testing Official: [signature]

SPECIMEN DATA

Specimen Number: S6 Material Type: STEEL

Specimen Weight: 54 lbs

Moisture Content after test: NA %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 4.4 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 58 degrees F
Specimen Temperature - before test: 130 degrees F
Specimen Temperature - after test: 115 degrees F

TEST RESULTS

Fracture Energy: 10.7 ~~lb-ft~~ Ft-KIPS
Post Displacment During Impact: 8.2 in
Peak Force: 21.6 ~~lbs~~ KIPS
Average Force During Impact: 13.6 ~~lbs~~ KIPS

STEEL

U: 1 4 2 6 3 4 4 6
G: 1 4 2 6 3 4 4 6
L: 1 4 2 6 3 4 4 6
5: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: _____ DATE: 12-7-92
TEST No. S-6

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	17.65		
FE=	10712.578	FT-LB	10.71 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5.4		
PF=	21600	LB	21.6 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00		
Vf =	17.22		
Ti =	0.00		
Tf =	0.035		
d =	0.68635	FT	8.2362 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	10.71	
d =	0.69	
Favg =	15.61	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

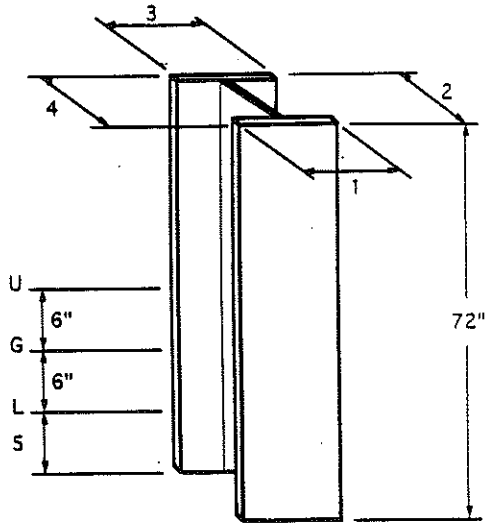
Test Date: 12-7-92 Testing Official: [signature]

SPECIMEN DATA

Specimen Number: S7 Material Type: STEEL

Specimen Weight: 54 lbs

Moisture Content after test: NA %



STEEL

U: 1 4 2 6 3 4 4 6

G: 1 4 2 6 3 4 4 6

L: 1 4 2 6 3 4 4 6

S: 26

MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 3.7 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 58 degrees F
Specimen Temperature - before test: 125 degrees F
Specimen Temperature - after test: 110 degrees F

TEST RESULTS

Fracture Energy: 9.2 lb-ft
Post Displacment During Impact: 9.4 in
Peak Force: 23.4 lbs
Average Force During Impact: 11.7 lbs

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: JMR DATE: 12/7/92

TEST No. S-7

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	18.35		
FE=	9147.4055	FT-LB	9.15 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5.8		
PF=	23200	LB	23.2 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	17.22		
Ti =	0.00		
Tf =	0.040		
d =	0.7844	FT	9.4128 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	9.15	
d =	0.78	
Favg =	11.66	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

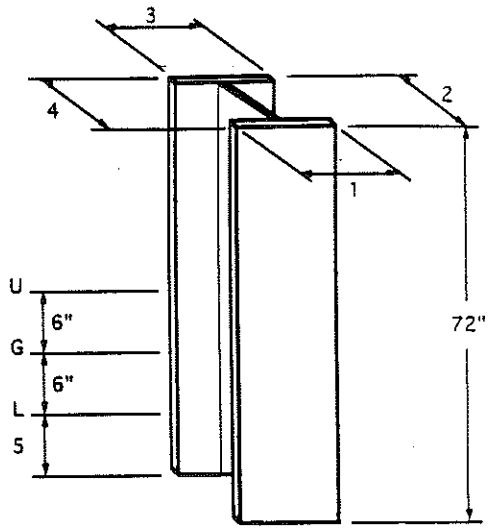
Test Date: 12-7-92 Testing Official: [signature]

SPECIMEN DATA

Specimen Number: S-8 Material Type: STEEL

Specimen Weight: 54 lbs

Moisture Content after test: NA %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 4.6 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 59 degrees F
Specimen Temperature - before test: 130 degrees F
Specimen Temperature - after test: 122 degrees F

TEST RESULTS

Fracture Energy: 11.2 lb-ft
Post Displacment During Impact: 8.2 in
Peak Force: 23.2 lbs
Average Force During Impact: 16.3 lbs

STEEL

U: 1 4 2 6 3 4 4 6
G: 1 4 2 6 3 4 4 6
L: 1 4 2 6 3 4 4 6
5: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: _____ DATE: 12-7-92
TEST No. S-8

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:

m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m=	62.11	
Vi=	22.00	
Vf=	17.44	
FE=	11170.26 FT-LB	11.17 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:

wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt=	4000	
Pa=	5.8	
PF=	23200 LB	23.2 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:

Ti = time at impact in seconds
Tf = time at FE in seconds

Vi =	22.00	
Vf =	17.22	
Ti =	0.00	
Tf =	0.035	
d =	0.68635 FT	8.2362 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	11.17	
d =	0.69	
Favg =	16.27 KIPS	

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

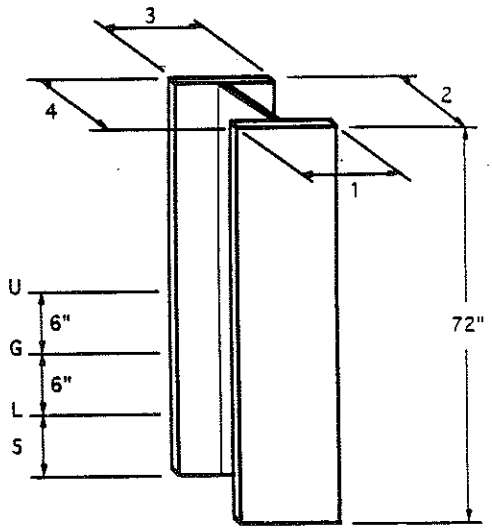
Test Date: 12-7-92 Testing Official: Joe Nelson

SPECIMEN DATA

Specimen Number: S-9 Material Type: STEEL

Specimen Weight: 54 lbs

Moisture Content after test: NA %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 3.1 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 59 degrees F
Specimen Temperature - before test: 135 degrees F
Specimen Temperature - after test: 115 degrees F

TEST RESULTS

Fracture Energy: 7.8 lb-ft
Post Displacment During Impact: 8.2 in
Peak Force: 19.2 lbs
Average Force During Impact: 11.4 lbs

STEEL

U: 1 4 2 6 3 4 4 6
G: 1 4 2 6 3 4 4 6
L: 1 4 2 6 3 4 4 6
S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: JM DATE: 12-7-92

TEST No. S-9

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	18.93		
FE=	7804.4383	FT-LB	7.80 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	4.8		
PF=	19200	LB	19.2 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	17.22		
Ti =	0.00		
Tf =	0.035		
d =	0.68635	FT	8.2362 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	7.80	
d =	0.69	
Favg =	11.37	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

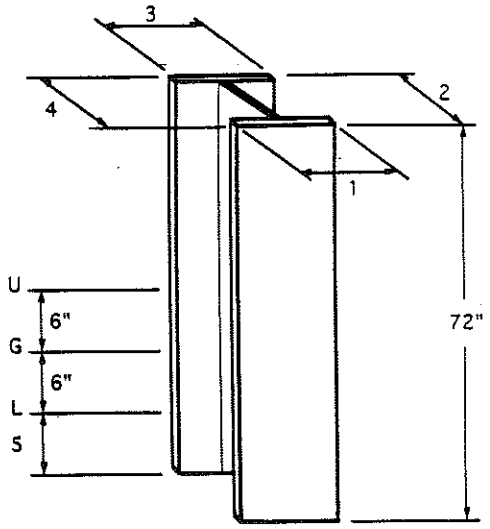
Test Date: 12-7-92 Testing Official: Jon Holloway

SPECIMEN DATA

Specimen Number: S-10 Material Type: STEEL

Specimen Weight: 54 lbs

Moisture Content after test: N/A %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 4.1 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 60 degrees F
Specimen Temperature - before test: 120 degrees F
Specimen Temperature - after test: 114 degrees F

TEST RESULTS

Fracture Energy: 10.2 lb-ft
Post Displacment During Impact: 9.4 in
Peak Force: 20.4 lbs
Average Force During Impact: 13.0 lbs

STEEL

U: 1 4 2 6 3 4 4 6
G: 1 4 2 6 3 4 4 6
L: 1 4 2 6 3 4 4 6
S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION

BY: JHM DATE: 12-7-92

TEST No. S-10

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)

where:

m = weight of pendulum in pounds / 32.2

Vi = pendulum impact velocity in feet per second

Vf = pendulum velocity after fracture

m=	62.11		
Vi=	22.00		
Vf=	17.88		
FE=	10205.021	FT-LB	10.21 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)

where:

wt = weight of pendulum in pounds

g = 32.2

Pa = maximum accelerations attained during fracture

wt=	4000		
Pa=	5.1		
PF=	20400	LB	20.4 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)

where:

Ti = time at impact in seconds

Tf = time at FE in seconds

Vi =	22.00		
Vf =	17.22		
Ti =	0.00		
Tf =	0.040		
d =	0.7844	FT	9.4128 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d

FE =	10.21	
d =	0.78	
Favg =	13.01	KIPS

PROJECT NO.: 06-3906
SPONSOR: MICHIGAN DEPARTMENT OF TRANSPORTATION
PROJECT TITLE: EVALUATION OF THE DYNAMIC STRENGTH OF GUARDRAIL POSTS MADE FROM RECYCLED PLASTICS

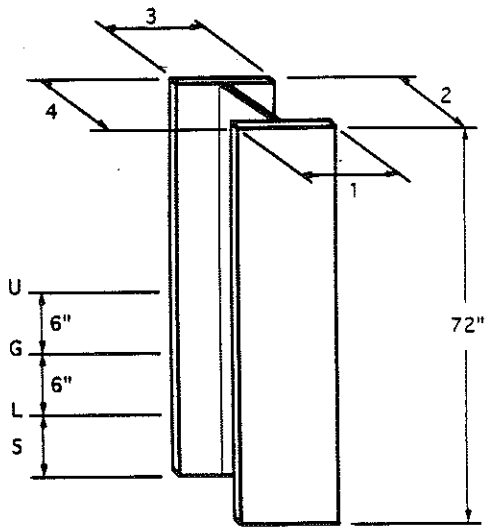
Test Date: 12-7-92 Testing Official: Joe W Sayer

SPECIMEN DATA

Specimen Number: S-11 Material Type: STEEL

Specimen Weight: 54 lbs

Moisture Content after test: NA %



MASS DATA

Mass Weight: 4000 pounds
Mass Impact Velocity: 22 ft/sec
Mass Velocity Change: 3.6 ft/sec

TEMPERATURE EFFECTS

Ambient Temperature: 62 degrees F
Specimen Temperature - before test: 124 degrees F
Specimen Temperature - after test: 116 degrees F

TEST RESULTS

Fracture Energy: 8.9 lb-ft
Post Displacment During Impact: 9.4 in
Peak Force: 20.0 lbs
Average Force During Impact: 11.4 lbs

STEEL

U: 1 4 2 6 3 4 4 6
G: 1 4 2 6 3 4 4 6
L: 1 4 2 6 3 4 4 6
S: 26

COMMENTS:

PENDULUM CALCULATIONS - MICHIGAN DEPARTMENT OF TRANSPORTATION
BY: JMH DATE: 12-7-92
TEST No. S-10

FRACTURE ENERGY (FE) = 1/2m(Vf**-Vi**)
where:
m = weight of pendulum in pounds / 32.2
Vi = pendulum impact velocity in feet per second
Vf = pendulum velocity after fracture

m= 62.11
Vi= 22.00
Vf= 18.45

FE= 8918.8407 FT-LB 8.92 FT-KIPS

==========

PEAK FORCE (PF) =(wt / g)(Pa * g)
where:
wt = weight of pendulum in pounds
g = 32.2
Pa = maximum accelerations attained during fracture

wt= 4000
Pa= 5

PF= 20000 LB 20 KIPS

==========

POST DISPLACEMENT DURING IMPACT (d) = ((Vi+Vf)/2)(Ti-Tf)
where:
Ti = time at impact in seconds
Tf = time at FE in seconds

Vi = 22.00
Vf = 17.22
Ti = 0.00
Tf = 0.040

d = 0.7844 FT 9.4128 IN

==========

AVERAGE FORCE DURING IMPACT (Favg) = FE/d
FE = 8.92
d = 0.78

Favg = 11.37 KIPS