Rubber Buffings for Bridge Approach Expansion Joints

Final Report
For
MLR-01-1

October 2001

Highway Division

Iowa Department of Transportation

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for
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8. ABSTRACT

Many of the bridges in the state of Iowa have type ‘CF’, ‘EE’, or ‘EF’ expansion joints installed in the bridge approach slabs. These joints, which are typically 4” wide, are currently filled with a foam expansion joint material that is covered with a sealant. Over time the sealant begins to pull off of the walls of the joint and it ultimately fails. The joint, which is now exposed to the weather, is then filled with water and solids. The foam joint material, which is lighter than water, floats out of the joint onto the highway. This foam resembles a large 4” X 6” plank and poses a threat to motorists. A possible solution to this problem would be to replace the foam material with rubber buffings. Rubber buffings are a by-product of the tire retread industry.

9. KEY WORDS	10. NO. OF PAGES
Expansion Joints Rubber Buffings Rubber	21

Table of Contents

DISCLAIMER

INTRODUCTION

Many of the bridges in the state of Iowa have type 'CF', 'EE', or 'EF' expansion joints installed in the bridge approach slabs (see Appendix A). These joints, which are typically 4" wide, are currently filled with a foam expansion joint material that is covered with a sealant. Over time the sealant begins to pull off of the walls of the joint and it ultimately fails. The joint, which is then exposed to the weather, is filled with water, and/or solids. The foam joint material, which is lighter than water, floats out of the joint onto the highway. This foam resembles a large 4" X 6" plank and poses a threat to motorists. A possible solution to this problem would be to replace the foam material with rubber buffings. Rubber buffings are heavier than water, a recycled material, and a by-product of the tire retread industry.

OBJECTIVE

The objective of this research is to develop a technique for the use of rubber buffings as a replacement for the foam material that is currently used in expansion joints. This research will also determine whether a cold applied 1 component, cold applied 2 component, or hot pour sealant should be used. The research will also determine if a mixture of buffings that have a large amount of fine particles, coarse particles, or mixture of both is better suited for the expansion joint material.

PROJECT DESCRIPTION

Four different samples of rubber buffings were used in this research. Two samples were taken from each of the four suppliers and sieved over a ¼" box sieve with a mechanical shaker for 15 seconds. The amount passing and retained was recorded for each sample and recorded in table 1 in Appendix B. Two 1000 gram samples of each supplier's product were carefully sifted through and inspected for any wires and cords. The results for this test can be found in table 2 in Appendix B. The samples that would be used in the following tests were selected from the results of this test.

Once the samples were selected, preparations for the next set of tests were made. A set of forms was constructed to hold a given amount of the rubber buffings so that various sealants could be applied for comparison. There were eight individual forms and each form was divided into a 2" and 10" section. The 2" section would later be used in a compression test and the 10" section would be used for various tests described later in this report.

Two supplier's rubber buffings, and 5 different types of sealants from 2 different manufacturers were selected for the tests. A set of combinations for each rubber and sealant were selected for each mold. The list of each mold's rubber supplier and sealant manufacturer is listed on the next page.

Form 1:
- Sealant: WR Meadows, 2 component
- Rubber: Baur Built Tire, Cedar Rapids

Form 2:
- Sealant: WR Meadows, 2 component
- Rubber: Interstate Tire, Atlantic

Form 3:
- Sealant: WR Meadows, 1 component
- Rubber: Baur Built Tire, Cedar Rapids

Form 4:
- Sealant: WR Meadows, 1 component
- Rubber: Interstate Tire, Atlantic

Form 5:
- Sealant: WR Meadows 3405, 1 component
- Rubber: Baur Built Tire, Cedar Rapids

Form 6:
- Sealant: WR Meadows 3405, 1 component
- Rubber: Interstate Tire, Atlantic

Form 7:
- Sealant: WR Meadows, Sof Seal (Hot Pour)
- Rubber: Baur Built Tire, Cedar Rapids

Form 8:
- Sealant: Craftco, Road Saver 231 (Hot Pour)
- Rubber: Baur Built Tire, Cedar Rapids

After the combinations for each mold were selected each one was lined with aluminum foil. Each 2” and 10” section was then filled with 115 grams and 600 grams respectively with the appropriate supplier’s buffings. After being placed in the form each was stirred to evenly distribute the particles and then they were gently tamped to level off the surface. Each form was covered with ½” of joint sealant from the manufacturer that was designated to be used for that form. Each sealant was applied following the manufacturer’s directions for use.

TESTING

After the sealants had cured overnight the finished samples were subjected to several tests. The first test was for water permeability. Each 10” sample had 1 teaspoon of water placed on it in two locations and the amount of water that permeated through the sealant was recorded after 2 minutes. The results and photos for this test are located in Appendix C.

After testing for water permeability each 10” sample was tested for sealant penetration. When the sealant was applied the majority of it ran down into the rubber buffings below. This test was to determine if this penetration was uniformly distributed across the sample, or if there was more penetration along the sides than in the center. To perform this test the sample was removed from the form, turned upside down, the aluminum foil was removed from the bottom, and the loose material was shaken off. The highest and the lowest depth of the remaining material was then measured and recorded (see Appendix D).

Each 2” sample was subjected to a compression test. This test was used to determine the amount of load that was required to compress each sample to half of its original thickness, and to also determine if after the sample was compressed it would return to its original thickness. To perform this test each sample was placed in a special box that has a separate top to allow the load to be applied (see Appendix E). A sample was placed in the box and loaded at a rate of 0.25”/minute. The load and the deflection were recorded at 30 second intervals until 1” of deflection had been reached. After compression the samples were allowed to expand to a point of equilibrium. After 4 hours the amount that the sample expanded was determined as a percent of the original thickness. The results of these tests are located in Appendix E.

COSTS

Of the sealants tested the WR Meadows 2 component was the most expensive to use at the current approximate price of $22 to $26 per gallon. Both of the 1 component cold applied sealants have a current approximate price range of $10 to $13 per gallon, and the hot pour sealants from both manufacturers were the lowest priced of all at a current price range of $0.35 to $0.45 per pound or around $4.00 per gallon. The cost for the rubber buffings was around $0.06 to $0.08 per pound.

The products required for a joint 4 inches wide, 11 inches deep and 40 feet long would be approximately 11.3 ft^3 or 247 pounds of rubber buffings, and 8.5 gallons or 77 pounds of sealant. These quantities were calculated assuming that there is ½” of free space at the top of the joint, a 1” thick layer of sealant allowing for ½” on top of the buffings and the remainder to penetrate into the joint, and 10” deep of rubber buffings. A cost comparison between the conventional and the proposed method of filling this type of joint is shown in the table below.

Material	Sealant	Approximate Cost
Rubber	2 Component	$ 218.88
Rubber	1 Component	$ 113.88
Rubber	Hot Pour	$ 48.00
Foam	2 Component	$ 500.80
Foam	1 Component	$ 448.30
Foam	Hot Pour	$ 415.36

Table 1: Cost Comparison

RESULTS

Of the 8 samples tested the results show that for the most part the Baur Built buffings offered more resistance to compression than the Interstate buffings. This is probably due to the large amount of finer particles in the Baur tire sample. Of the 5 sealants tried the WR Meadows 3405 and the Craftco hot pour sealants penetrated the least, and the 2 component and the two 1 component sealants penetrated the most. The results show that the 2 component and the hot pour sealants have the greatest recovery after being compressed to half of their original thickness. Both the 2 component and the hot pour sealants also offered the most resistance to water penetration. Both of the 1 component sealants had lower resistance to compression and the lowest percentage of recovery. Each of these samples also offered the least resistance to the penetration of water.

The results of the compression and percent recovery testing were also compared to the results of tests done on some of the materials that are currently in use for these joints (see Appendix F). The majority of the samples exhibited a higher compressive strength than the manufacturers and for the most part the percent recovery was lower than the manufacturers.

CONCLUSION

The materials that were tested for use in the type ‘CF’, ‘EE’, or ‘EF’ expansion joints for bridge abutments look promising. The rubber buffings are heavier than water and therefore will not float. They also have the advantage of being a recycled material. Of the two samples that were tested the Interstate Tire appears to be the better choice for the material to fill the joint. It has a lower resistance to compression, which means that as the adjoining pavement expands less of the load will be transferred to the bridge. The best combination of rubber and sealants for use in these joints would be Interstate Tire buffings and either of the hot pour sealants. The finished joint closely resembles what is currently being constructed in the field, however, it has the disadvantage of needing a melting kettle to melt the sealant. The next best combination would be Interstate Tire and WR Meadows 2 component cold applied sealant. It had the lowest compressive strength of all of the samples tested and has the advantage that it recovers to its original thickness when compressed. Another advantage is that no heating is required to apply the sealant. There was some evidence of water penetration in this combination but that can be solved by the application of another or thicker coat of sealant. The application of a thicker coat would also give the finished product a smooth surface. The use of the cold applied 1 component sealants would be discouraged in this application because any of the sealant that runs down through the buffings and collects at the bottom of the joint may not cure due to a lack of exposure to air. Laboratory tests have shown that the sealant may not cure for a number of days if it has penetrated and settled deep into or at the bottom of the joint.

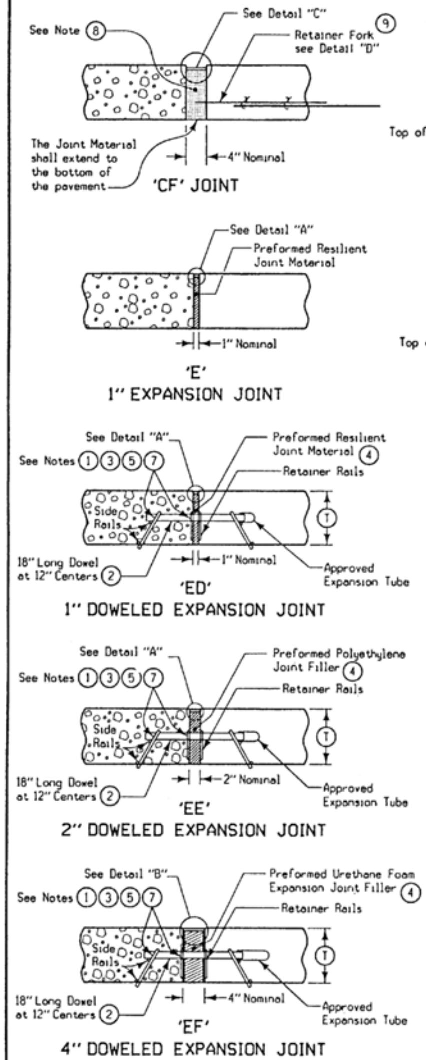
FURTHER TESTING

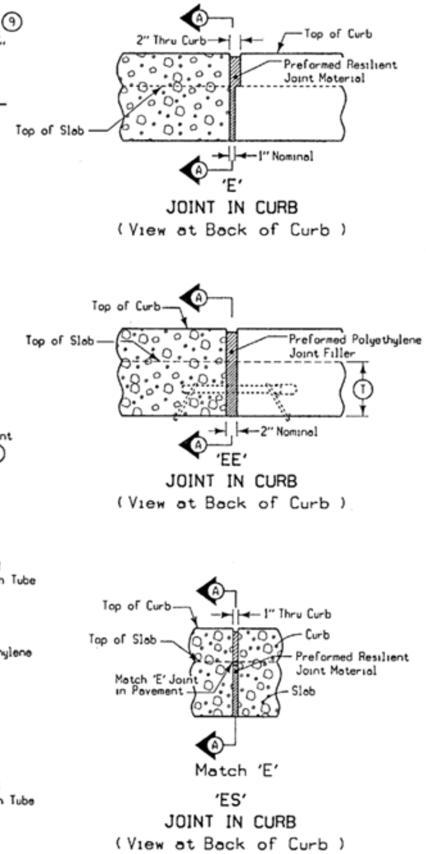
Further testing may be necessary to determine if the rubber buffing samples obtained from the suppliers are fairly constant in particle size or if it varies greatly during production. Another set of test specimens using the 2 component sealant applied in 2 layers would show if there is a gain in compressive strength, if the recovery after a load application would be affected, and if a decrease in water penetration would occur. It would also be advisable to test a combination of Interstate Tire and the 2 hot pour sealant manufacturers to see if the results are similar to the Baur Built Tire and the 2 hot pour sealants.

ACKNOWLEDGEMENT

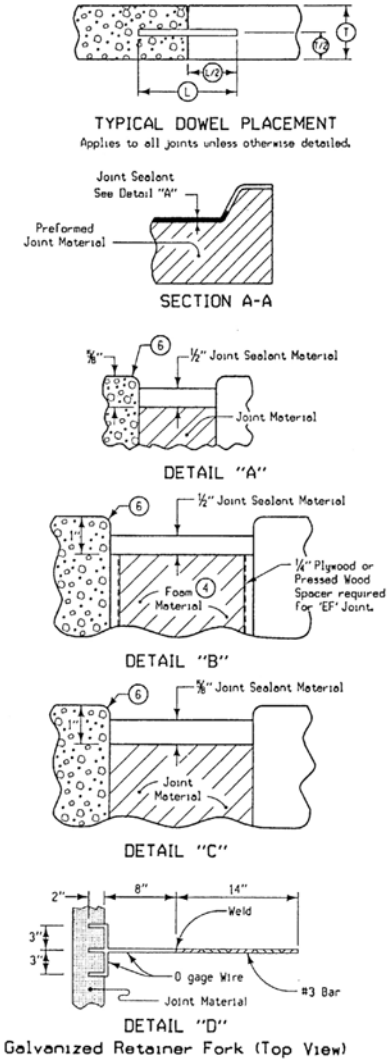
Sincere thanks and appreciation goes Mark Carter for initiating the use of rubber buffings for bridge approach expansion joints, to the General Testing personnel for their support in specimen testing and preparing the hot pour sealants, to Physico Chemical personnel for the use of lab space, and to the Aggregate Testing personnel for their support in the sieve analysis.

APPENDIX A
Expansion Joint Standard Plan





BAR SIZE TABLE			
T	<8"	8" and <10"	≥10" or >10"
DOWEL SIZE	¾"	1¼"	1½"



GENERAL NOTES:

All materials and construction features used in the construction of pavement joints shall conform to the requirements of current Standard and Supplemental Specifications. Refer to other appropriate Standard Road Plans and project plans for additional information. Alternate methods for construction of joints may be submitted to the Engineer for consideration.

Dowels for the 'ED', 'EE', and 'EF' joints shall be properly positioned by the use of an approved support assembly.

Epoxy coat all bars, see "Pavement Reinforcement" in the current Standard Specifications.

All preformed joint material shall be installed perpendicular to the pavement surface and care shall be exercised throughout the construction of the pavement to ensure that such joint material remains in proper position upon completion of paving operation.

The joints as detailed hereon shall not be measured for payment. The construction detailed hereon including the furnishing of the dowels, dowel assemblies, and joint filler material shall be considered incidental to PCC paving, unless noted otherwise.

1. The free moving ends of dowel support assembly shall be placed alternately across joints.
2. Refer to Bar Size Table
3. The free end of dowel bar shall be coated as directed by the Engineer prior to placement of second slab to prevent bond with that portion of pavement.
4. Holes for Joint Material shall be predrilled or preformed for appropriate dowel size. Material shall meet requirements of the current Standard Specifications for Joint Material.
5. Bars in Transverse Joints shall be placed so that no bar will be closer than 6" to any Longitudinal Joint (centerline or laneline). The distance to the first bar from edge of pavement will vary from 6" to 12" depending upon pavement width.
6. Edge with 1/4" tool for length of joint indicated in formed; edging not required when cut with diamond blade saw.
7. Weld side opposite Expansion Tube.
8. Preformed Joint Material 4" nominal width x pavement thickness – 1" deep. See Materials I.M. 436.05 for list of approved materials.
9. Place 'CF' Joint material 1" lower than top of pavement. Anchor with galvanized retainer forks at 24" centers; tie forks to reinforcing mat or place on support chairs.

Iowa Department of Transportation
Project Development Division

STANDARD ROAD PLAN	RH-52
REVISION: Update notes on joint details.	REVISION NO. 7
4-15-96 APPROVED BY DESIGN METHODS ENGINEER	REVISION DATE 08-20-96

JOINTS
(EXPANSION)

APPENDIX B
Rubber Buffings Analysis

Rubber Buffings Sieve Results

	Sample 1	Sample 2	Sample 3	Sample 4
Supplier	Baur Built Tire	Jack's OK Tire	Interstate Tire	Baur Built Tire
Location	Des Moines, IA	Algona, IA	Atlantic, IA	Cedar Rapids, IA
Test 1				
Sample weight (g)	1013.7	1013.7	1013.7	1013.7
Weight Passing (g)	713.4	726.0	607.6	741.5
Weight Retained (g)	300.3	287.7	406.1	272.2
Passing - Retained (g)	413.1	438.3	201.5	469.3
Test 2				
Sample weight (g)	1013.7	1013.7	1013.7	1013.7
Weight Passing (g)	718.8	687.6	589.9	710.9
Weight Retained (g)	294.9	326.1	423.8	302.8
Passing - Retained (g)	423.9	361.5	166.1	408.1
Average Passing - Retained Run 1 & 2 (g)	418.5	399.9	183.8	438.7

Note: All samples were evaluated using a $^1/_4$ inch box sieve with a mechanical shaker timed for 15 seconds.

Table 1: Sieve analysis results

Wire and Cord Results

	Sample 1	Sample 2	Sample 3	Sample 4
Supplier	Baur Built Tire	Jack's OK Tire	Interstate Tire	Baur Built Tire
Location	Des Moines	Algona	Atlantic	Cedar Rapids
Test 1				
Sample weight (g)	1000	1000	1000	1000
Steel Wires	Trace	None	Trace	None
Cords	None	None	None	Trace
Test 2				
Sample weight (g)	1000	1000	1000	1000
Steel Wires	None	None	None	None
Cords	None	None	None	None

Note: 1000g approximately equal to $0.1ft^3$ bulk volume

Maximum particle size: 2" X $^1/_4$" X $^1/_8$"

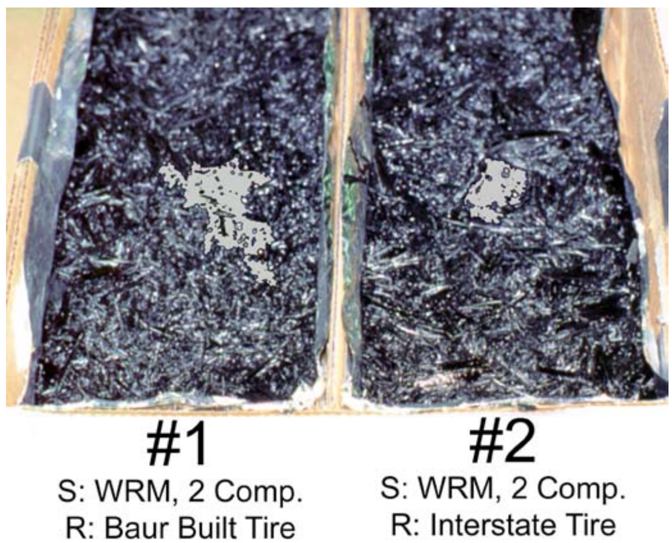
Minimum particle size: dust

Table 2: Wire and cord analysis results

APPENDIX C
Water Penetration Test

Water Penetration			
Sample	Volume	Time	% Loss
1	1 Teaspoon	2 Min.	0
2	1 Teaspoon	2 Min.	10
3	1 Teaspoon	2 Min.	95
4	1 Teaspoon	2 Min.	50
5	1 Teaspoon	2 Min.	90
6	1 Teaspoon	2 Min.	90
7	1 Teaspoon	2 Min.	0
8	1 Teaspoon	2 Min.	0

Table 1: Water penetration test results



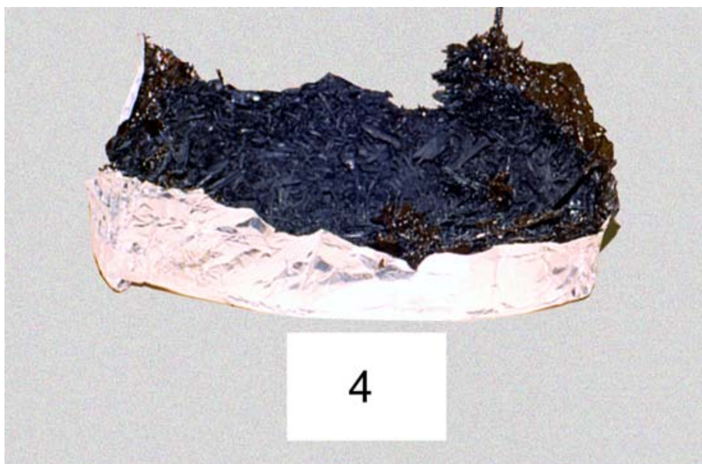
Photograph of test samples 1 & 2 undergoing water penetration test.
Note: photograph altered to show water as gray area.

Photograph of test samples 7 & 8 undergoing water penetration test.
Note: photograph altered to show water as gray area.

APPENDIX D
Sealant Penetration Test

Sealant Penetration		
Sample	Minimum (in.)	Maximum (in.)
1	3/4	3
2	3/4	3
3	3/4	2
4	3/4	2 1/2
5	3/8	3
6	1/2	2 1/4
7	1/2	1
8	3/4	1

Table 1: Sealant penetration test results



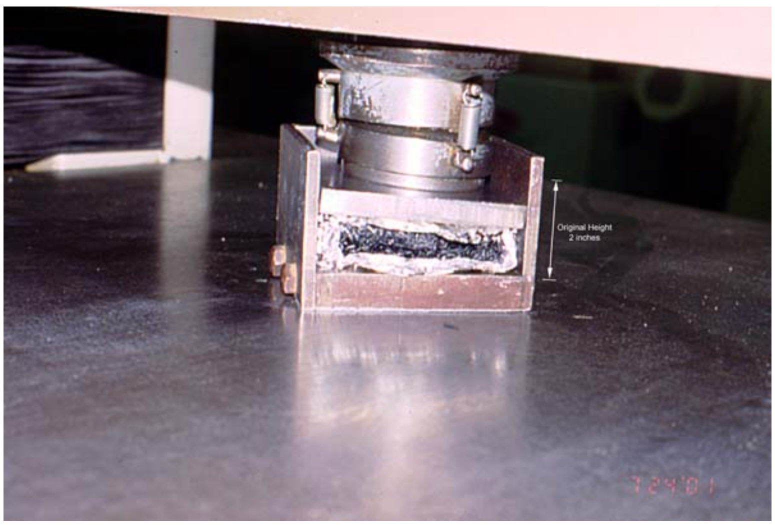
Photograph of sample 4 after removing the foil to determine the depth of sealant penetration.

Photograph of sample 5 after removing the foil to determine the depth of sealant penetration.

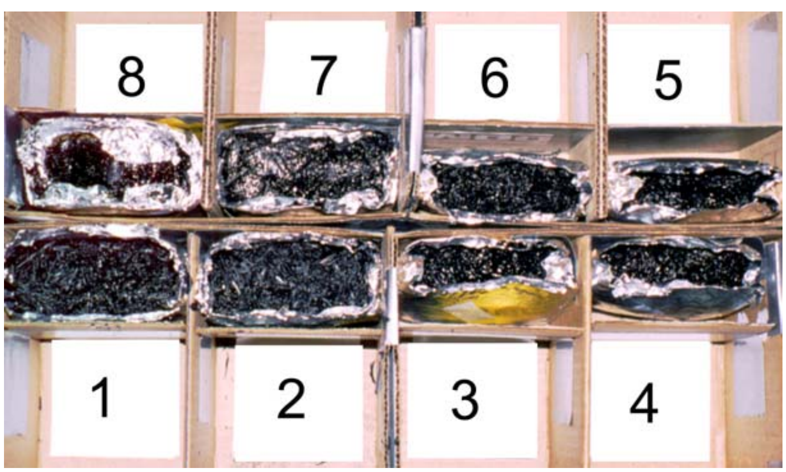
APPENDIX E
Compression
and
Recovery Testing

Sample/Manufacturer	Material	Load (psi)	% Recovery
1	Rubber	26.3	100
2	Rubber	18.3	100
3	Rubber	19.8	70
4	Rubber	18.8	60
5	Rubber	22.7	70
6	Rubber	23.9	70
7	Rubber	29.1	90
8	Rubber	31.4	95

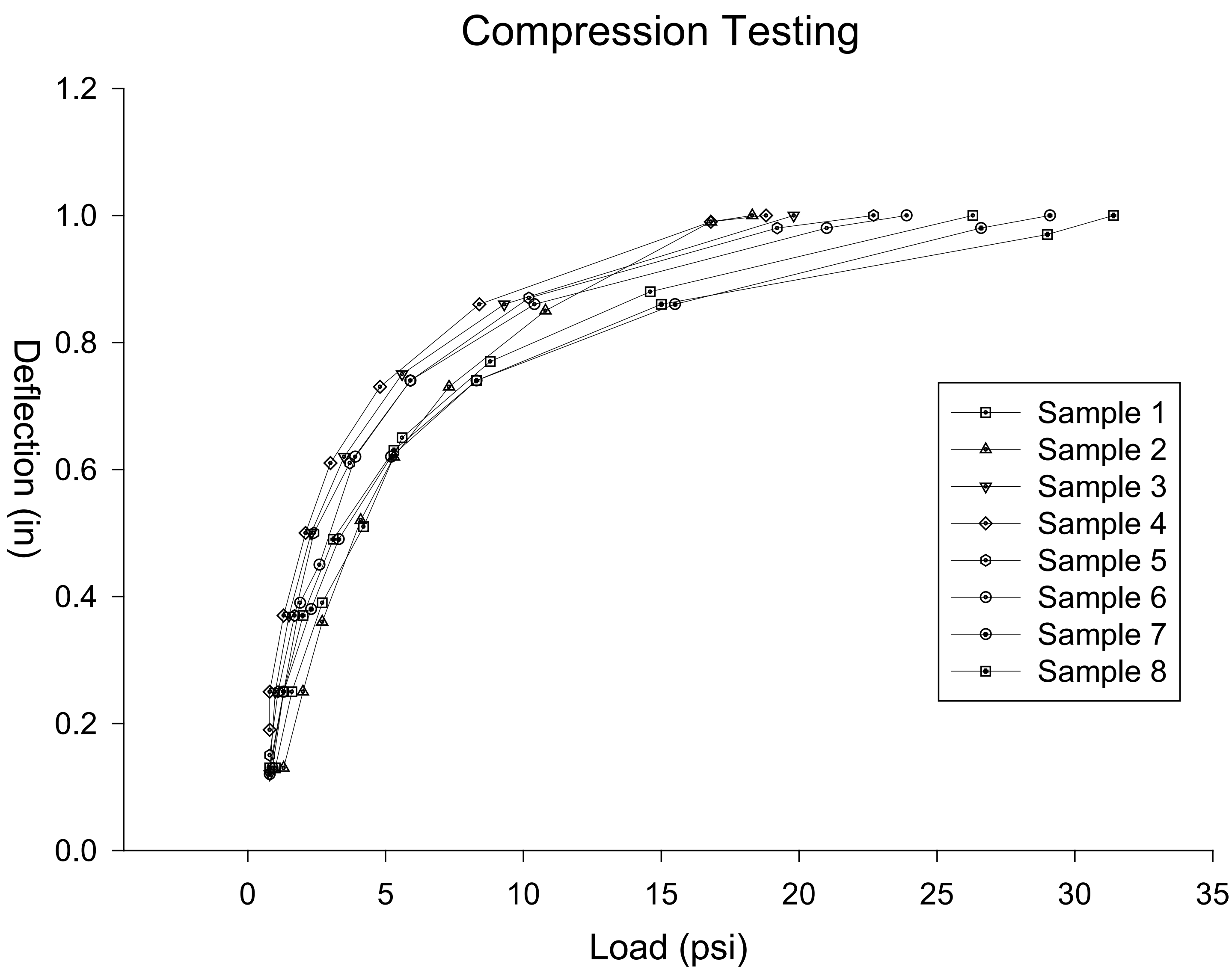
Table 1: Compression and recovery test results



Photograph showing 2 inch thick specimen undergoing compression test.



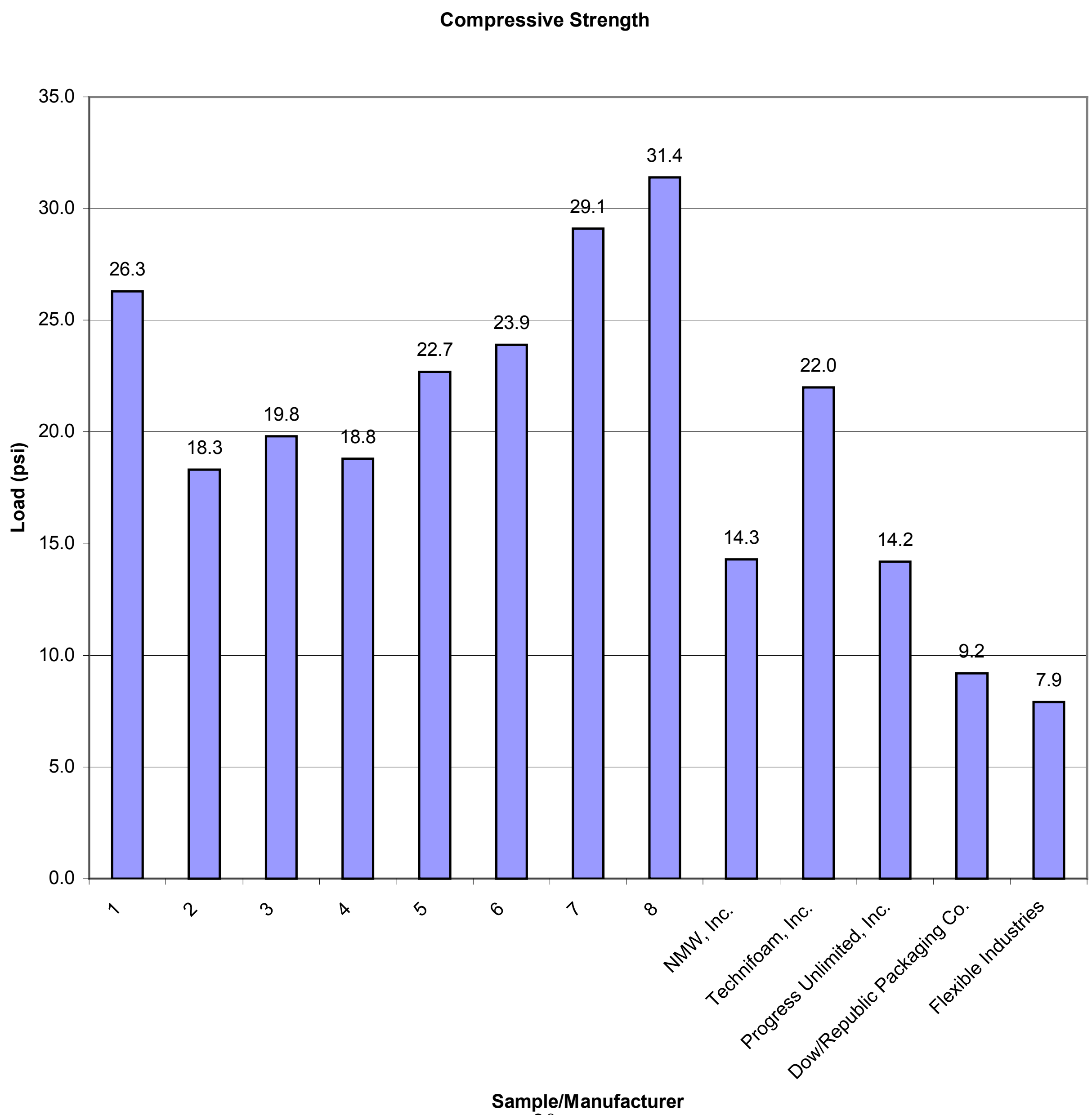
Photograph showing all of the compression test samples after compressing to ½ original thickness.


Compression Testing
Deflection (in)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
25
30
35
Load (psi)
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5
Sample 6
Sample 7
Sample 8

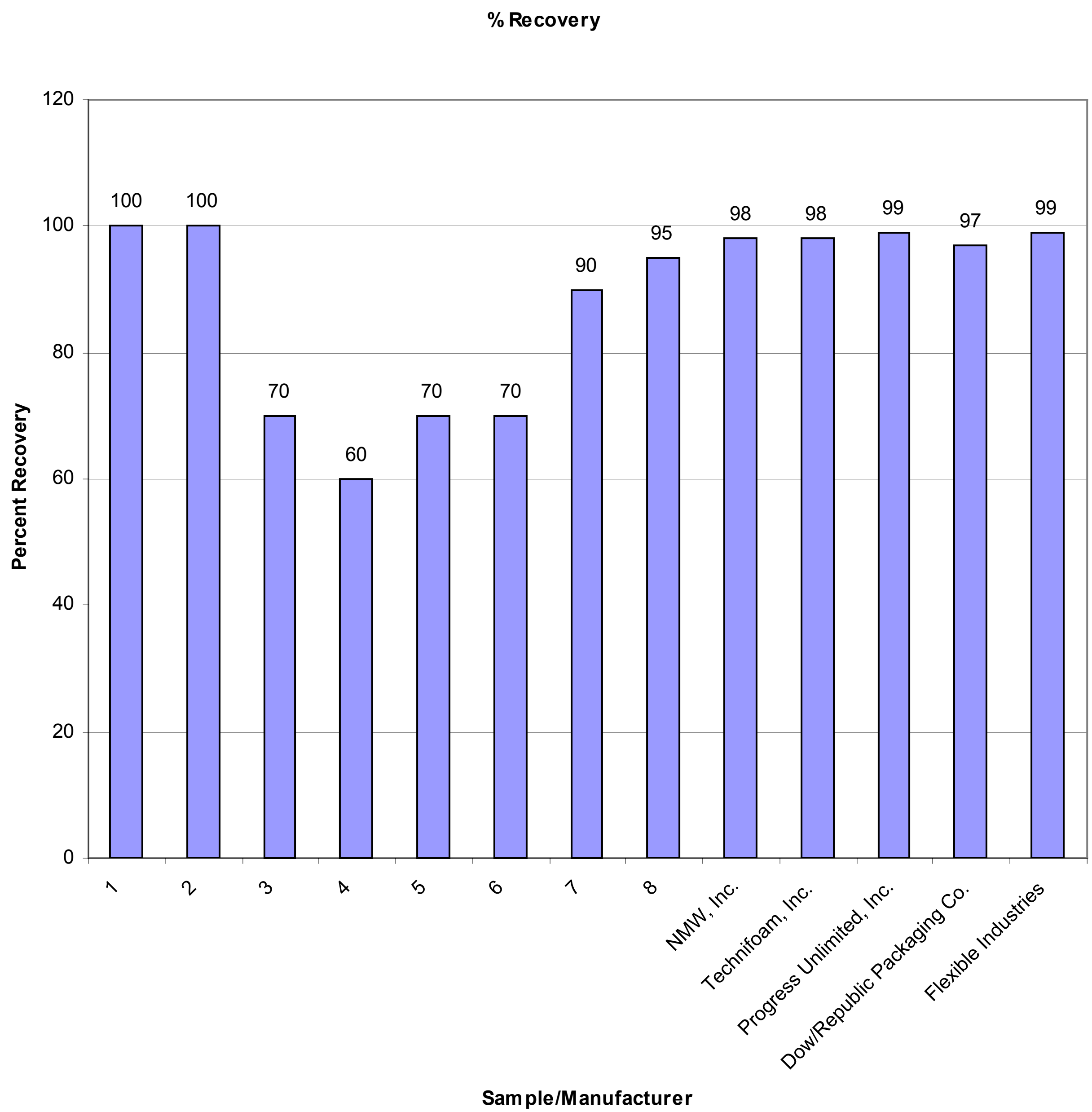
APPENDIX F
Sample and Manufacturer Comparison

Sample/Manufacturer	Material	Load (psi)	% Recovery
1	Rubber	26.3	100
2	Rubber	18.3	100
3	Rubber	19.8	70
4	Rubber	18.8	60
5	Rubber	22.7	70
6	Rubber	23.9	70
7	Rubber	29.1	90
8	Rubber	31.4	95
NMW, Inc.	Foamtech	14.3	98
Technifoam, Inc.	MC 1900	22.0	98
Progress Unlimited, Inc.	FF-7C	14.2	99
Dow/Republic Packaging Co.	EthaFoam 220	9.2	97
Flexible Industries	Flex Loc	7.9	99

Table 1: Compression and recovery comparison



Compressive Strength
Load (psi)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
26.3
18.3
19.8
18.8
22.7
23.9
29.1
31.4
14.3
22.0
14.2
9.2
7.9
1
2
3
4
5
6
7
8
NMW, Inc.
Technifoam, Inc.
Progress Unlimited, Inc.
Dow/Republic Packaging Co.
Flexible Industries
Sample/Manufacturer


% Recovery
Percent Recovery
120
100
80
60
40
20
0
100
100
70
60
70
70
90
95
98
98
99
97
99
1
2
3
4
5
6
7
8
NMW, Inc.
Technifoam, Inc.
Progress Unlimited, Inc.
Dow/Republic Packaging Co.
Flexible Industries
Sample/Manufacturer