

A Comparative Performance Evaluation of Recycled HDPE, 48x48 Pallets (Skids) For Heavy-Duty Application



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FINAL

Prepared for:

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The William H. Sardo Pallet & Container Research Laboratory at Virginia Polytechnic Institute and State University conducted the testing on the pallet/skids.

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1.0 INTRODUCTION

The All Service All Packaging (ASAP) company of Green Acres, Washington, has designed the second generation of their skid specifically for the “heavy capacity” shipment of aluminum and steel coil. The skid is made from a proprietary formulation, primarily made from recycled, natural (unpigmented), high-density polyethylene (HDPE).

The purpose of this project was to test the strength and durability performance characteristics of this recycled-content skid for use in the “heavy capacity” skid market. ASAP contracted the William H. Sardo Pallet & Container Research Laboratory at Virginia Tech to conduct the evaluation. The test objectives were:

- ?? To determine the joint compression strength for load capacity;
- ?? To determine the leading deck edge impact resistance; and
- ?? To determine the drop resistance at the corners of the skids.

This test is a follow-on to a previous project “Performance Evaluation of 48x48 Coil Pallets Made From 100% Recycled Plastic”, funded by CWC, and primarily written by the authors of this report in partnership with Keith Adkins of ASAP and John Dacquisto of Dacquisto Engineering and Administrative Services. The original report was published September 1997 and can be found at this web address:

<http://cwc.org/PET-HDPEpubs.htm>. The purpose of this set of tests was to acquire independent verification of ASAP’s in-house evaluation and testing of their coil pallets (skids).

2.0 MATERIALS

ASAP supplied Virginia Tech with nine newly designed, recycled HDPE, 48x48 coil skids. The skids have three stringers at 3-7/16" wide x 3-7/16" wide by 48-1/4" long. The skids have five top deckboards at 5-1/4" wide x 1-1/2" high by 48" long. The skids have no bottom deckboards. The stringers and deckboards are a proprietary mix of recycled HDPE. The average weight of each skid was 118 pounds.

3.0 TEST METHODS

3.1 Joint Compression Tests of Pallet Stringer and Deckboard Joints

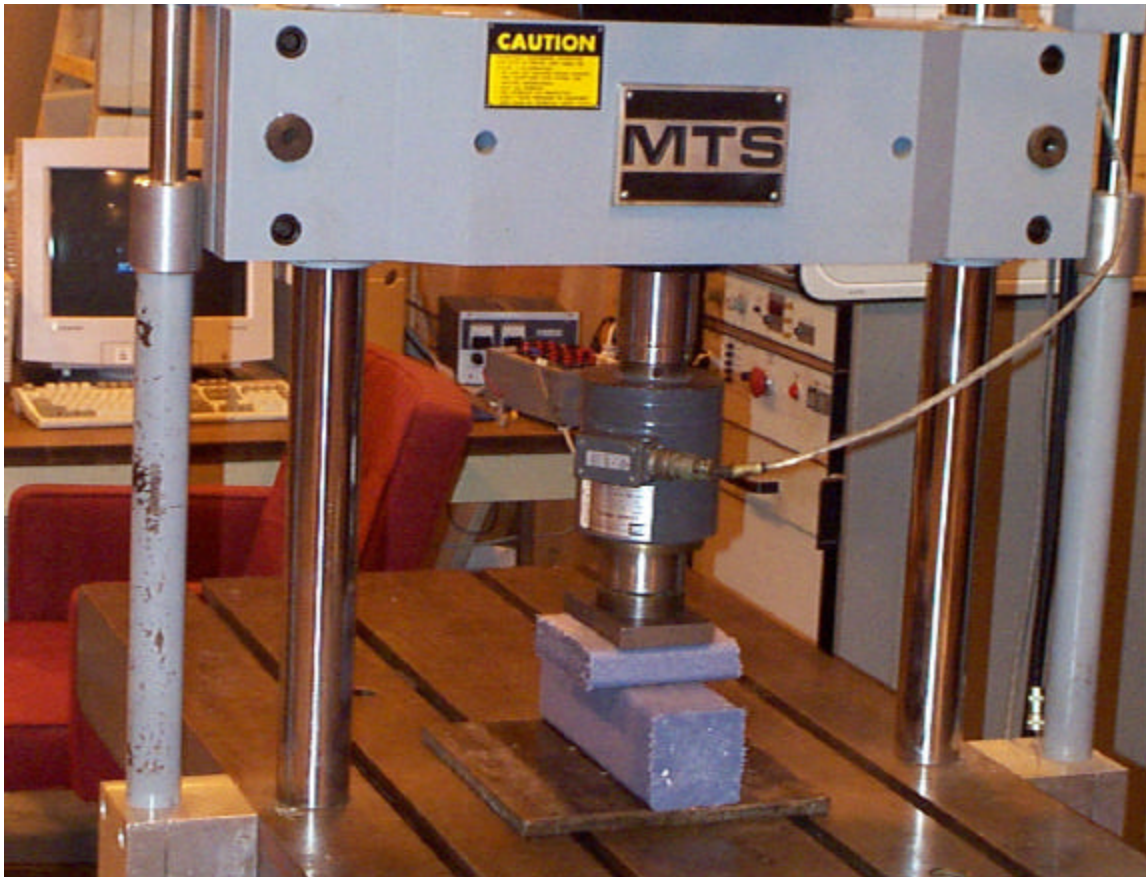
The joint compression test determines load capacity of the coil skids. The method used for this is different than the 1997 study. During the testing for the original report in 1997, ASAP supplied Virginia Tech with 48" diameter simulated metal coils weighing 10,000 pounds each. The steel coils were not available during year 2000 testing, so an alternate test method was used.

The test method described in ASTM D1185-98A section 8.3.2.2, "Standard Test Method for Pallets and Related Structures Employed in Materials Handling and Shipping" was used, with a loading rate from ASTM D695-91 section 9, "Standard Test Method for Compressive Properties of Rigid Plastics." The loading rate of 5/100" per minute was chosen because the loading rate of the ASTM D1185-98A was too fast and high loads accumulated in just a few seconds. A servo-hydraulic testing machine was used to compress the joints at a rate of 5/100" per minute. Figure 1 depicts the joint compression test setup. Load and deflection were measured during each test.

The skids were cut into stringer/deckboard joint sections. Fifteen of these sections were tested in compression past the load at the proportional limit, but not to failure.

The load causing failure was much higher than the 20,000 pound capacity of the machine.

Figure 1: Joint Compression Test Setup



3.2 Leading Deck Edge Inclined Impact Tests

The purpose of this test is to determine the durability of the leader board under simulated industrial incidence of fork-tine impact from forklifts. The top deck leading edge impact test was performed according to ASTM D-1185-94, section 9.4. The skids were conditioned to -13° F prior to testing. The skid was positioned so that the leading edge deckboards would be impacted on the center span of each deckboard between stringers.

A 700 pound cargo load was applied throughout the test. The impact distance began at 12" and progressed through 24", 48", 72", 96", and 120". Ten (10) impacts were

performed at each energy level. The tests are normally terminated when a deckboard is removed or broken from the stringer. The test was stopped when machine capacity was reached.

3.3 Corner Drop Tests

The purpose of this test was to determine the resistance of the coil pallet to determine racking or skewing, e.g. bending or deforming out of its original shape. Corner drop tests were performed according to ASTM method described in ASTM D-1185. Empty skids were dropped on corner from a height of 1 meter and 2 meter. Skids were dropped 10 times from each height starting at 1m until failure affecting safety or functionality was compromised. Figure 2 shows the corner drop test.

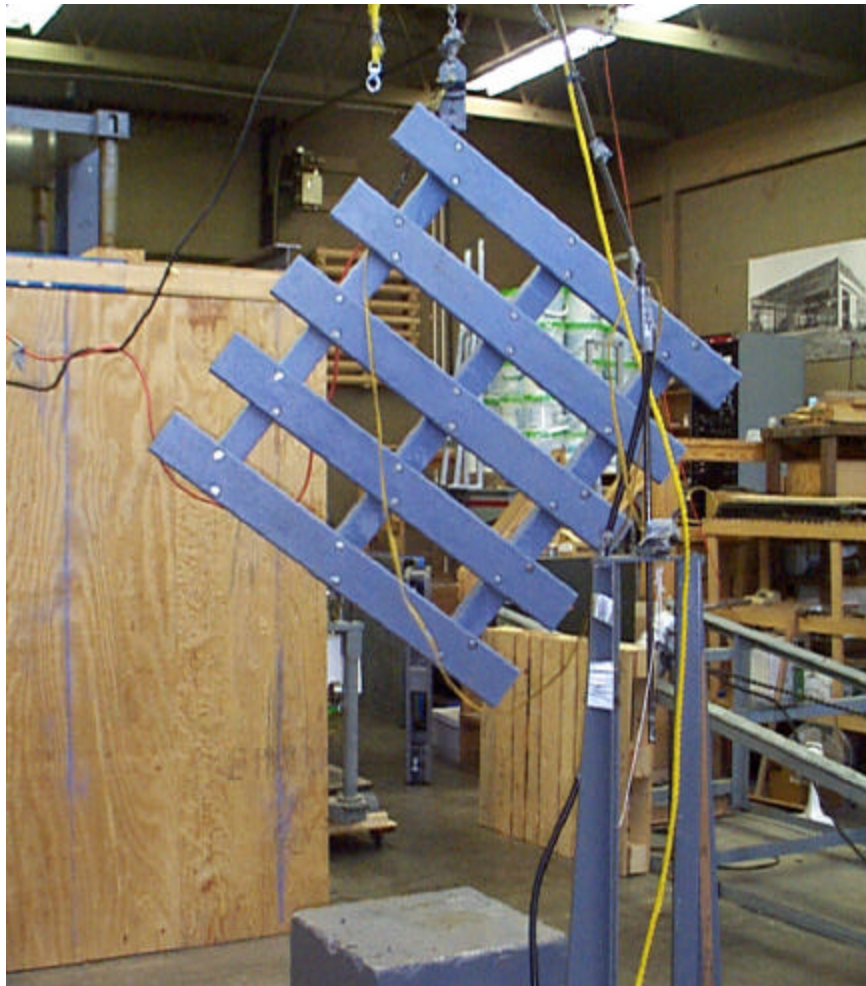


Figure2: Corner Drop Test

4.0 RESULTS

4.1 Joint Compression Tests of Pallet Stringer and Deckboard Joints

Table 1 presents the summarized results from the ASTM D 1185-98A stringer/joint compression tests.

**Table 1:
Summary of ASTM D1185-98A Joint Compression Tests
of Stringer/Deckboard Joints**

Average Joint Area (in ²)	Average Proportional Limit Stress of Joints Tested (psi)	Pallet Compressive Area with a 48" Diameter Coil (in ²)		
		Floor/stringer interface	Top deck/stringer interface	Bottom deck second pallet interface with top of bottom coil
17.92	514.83	497.6 in ²	198.5 in ²	404.6 in ²
Safe rigid load per interface area (lbs) = interface area (in ²) x average proportional limit stress (lbs/in ²)		256, 179 lbs	102,194 lbs	208,300 lbs

The average proportional limit of the joints tested is a conservative estimate of joint compression strength. This is the point at which the compression of the sample begins to occur at a faster rate when equal load increments are applied. No visible damage to the skid joint can be seen at this level of deformation.

The average compressive areas of the skid have been calculated and the top deck/stringer joint has the lowest compressive area with a 48" diameter metal coil load (198.5 in²). Using the proportional limit stress and multiplying that by the compressive area, the safe load per skid is calculated. The safe load per skid with a rigid coil load is 102,194 lbs. This load is very large and is certainly many times greater than the actual loads placed on the skids. The skids tested in the original study "Performance Evaluation of 48x48 Coil Pallets Made From Recycled Plastic", September 1997, safely supported a dead load of 30,000 lbs in a two-high stack with no skid damage.

4.2 Leading Deck Edge Inclined Impact Tests

The impact force subjected to the new skids was 21,250 pounds per skid. The average impact force per skid tested in September 1997 was 6,993 pounds. The force of each impact was calculated by the following formula:

$$\begin{aligned} \text{Force} &= \frac{1}{2} (\text{pallet} + \text{load weight}) \times (\text{velocity})^2 \\ &= \frac{1}{2} (\text{pallet} + \text{cargo load weight}) \times (\text{velocity})^2 \end{aligned}$$

Table 2 contains a summary and comparison of results from the inclined impact tests.

Table 2:
Results of ASTM D 1185 Inclined Plane Impact Tests on Coil Pallets (Skids)
and
Comparisons to Previously Tested Coil Skids

Number of Impacts to Leading Edge Failure (700 Pound Cargo)						
Pallet ID	12'' Distance	24'' Distance	48'' Distance	72'' Distance	96'' Distance	120'' Distance
New No.1	10	10	10	10	10	10
New No. 2	10	10	10	10	10	10
New No. 3	10	10	10	10	10	10
Average of New Coil Skids	10	10	10	10	10	10*
<i>Average for Skids Tested in September 1997</i>	<i>10</i>	<i>10</i>	<i>9.3</i>	<i>2</i>	<i>Not Tested</i>	<i>Not Tested</i>

* The pallets (skids) did not fail after 10 impacts at the 120'' distance; the capacity of the test device.

The new skids received over three times the impact force of the previous design and had not failed. Although, no failures occurred, the leading edge deckboard was forced back ¼'' on the center stringer. This is a result of the lag bolts bending from repeated impacts at high energy levels.

The performance of the lag bolts was strong. No fastener withdrawal was observed and only slight bolt bending at the center stringer was measured. This improvement in impact resistance is enormous and will increase the durability of the skid design.

4.3 Corner Drop Test

Diagonal racking, an indicator of skid durability, is dependent on the bending resistance of the fasteners and the separation resistance of the joint. The corner drop test indicates the extent of diagonal racking.

Table 3 contains the results from the corner drop tests.

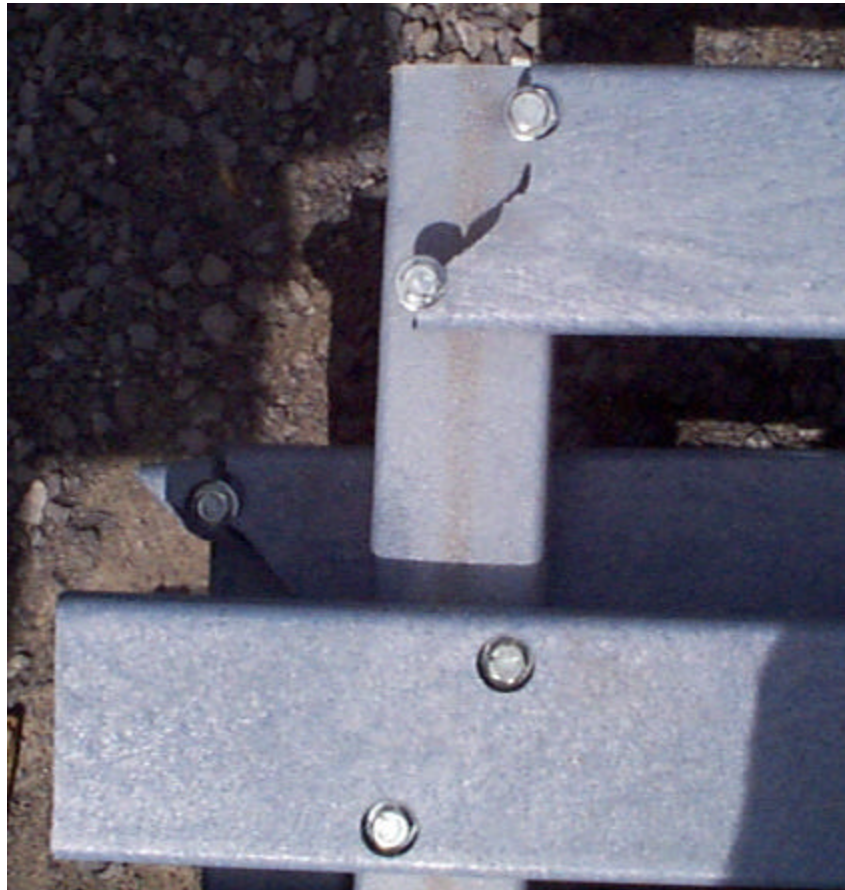
Table 3: Summary of ASTM D-1185 Corner Drop Tests

Pallet No.	Pallet Weight (lbs)	Number of Impacts at 1 meter	Change in Diagonals After 10 Impacts at 1 meter (%)	Number of Impacts at 2 meters	Change in Diagonals Prior to Failure at 2 meters (%)
1	117.26	10	0.29	2	0.58
2	117.50	10	0.10	2	0.30
3	117.95	10	0.29	3	0.86
Average	117.57	10	0.23	2.3	0.58

These results confirm that the lag bolt/HDPE joint is very stiff and also very durable. A 48x40, high quality, block-style skid exhibited an average change in diagonals of 0.86% after ten drops at 1 meter.

The failure mode of the skid from dropping on corner was a fractured corner of the drop edge wing as shown in Figure 3. The wing of this skid is more susceptible to damage than a flush design, because the wing is absorbing most of the impact on this stiff skid design. The impact resistance of this design is high and will likely only be improved by using a material with greater impact resistance.

**Figure 3 Typical Fractured Wing on Impact Corner
(From Corner Drop Tests)**



5.0 CONCLUSIONS

The compression strength of the new skids is very high. Each skid can support a rigid load of over 100,000 pounds. In multiple stacking, the total load should not exceed 100,000 pounds.

The impact resistance of the new skids top deck is over three times the resistance of the skids tested in September 1997.

The corner drop and top deck impact results help predict improved durability of the new design.

?? The enhancement of the lag bolt bending and withdrawal performance improved the new skid durability when compared to the skids tested in September 1997.