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Preliminary Evaluation of the Paper Engineering Paper
Pallet Design

By

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1 Introduction

Paper Engineering is studying the feasibility of an innovative stringer style, corrugated pallet design.

2 Objectives

- Evaluate the preliminary stiffness and strength of the Paper Engineering pallet design.

3 Test Materials

Paper Engineering supplied 8 prototype 48x40-inch, non-reversible, partial 4-way, stringer style, double wing, corrugated paper pallets for testing. A typical pallet is shown in Figure 1.

4 Test Methods

The pallets were tested for static strength and stiffness according to two predetermined test procedures: fork tine support and floor stacking. All pallets were tested according to the protocol of ASTM D1185-98 “Standard Test Methods for Pallets and Related Structures Employed in Materials Handling and Shipping”¹.

4.1 Fork Tine Support Static Strength and Stiffness

The fork tine support strength and stiffness tests were performed according to ASTM D1185-98 Section 8.4 “Pallet Bending.” The pallets were tested with two simulated fork tines penetrating the open 40-inch end of the pallet and supporting bottom side of the top deck. Each fork tine was centered between stringers with a 12-inch span between tines (edge to edge). Figure 2 is a photograph of the test setup. A uniform load applicator (airbag) was used to supply the test load. The load was applied and the deflection monitored during a 2-hour creep test. After a relaxation period of 60-minutes, an

¹ American Society for Testing Materials, West Conshohocken, PA, Vol 15.09, pgs 181-191

increasing load was applied until pallet failure occurred. Three replicate tests were performed.

4.2 Floor Stack Static Strength and Stiffness

The floor stack strength and stiffness tests were performed according to ASTM D1185-98 Section 8.4 “Pallet Bending.” The test apparatus was setup to fully support the entire surface area of a pallet base. A uniform load applicator (airbag) was used to supply the load. Figure 3 shows the floor stacking test setup. One pallet was tested to failure to determine the rated load. Based on failure load and deflection, the creep load was determined at 2000-pounds which is 1.25 times the rated load of 1600-pounds. For each pallet, the load was applied and the deflection monitored during a 2-hour creep test. After a relaxation period of 60-minutes, an increasing load was applied until pallet failure occurred. Three replicate tests were performed.

5 Results

5.1. Fork Tine Support Static Strength and Stiffness

The results of the fork tine support tests are shown in Table 1. Using one pallet and testing to failure, the test load was determined to be 2000-pounds which is 1.25 times the rated load of 1600-pounds. After testing the remaining three pallets, the results indicate this prototype pallet passed the ASTM strength and stiffness requirements to safely support a 1600-pound rated load. The deflection limits are based on a 1.9% maximum across the free span. Deflection results were measured for the free span between fork tines (13-inches) and for the two 9.5-inch spans located outside each edge of the fork tines. Although pallet deflections outside the fork tines marginally exceeded the ASTM criteria, it was not enough to fail the pallets in this test. Figure 4 and 5 show Paper Engineering pallets in the test apparatus, as well as the mode of failure at the location outside the fork tine, when tested to failure.

*Table 1: Paper Engineering Pallet: Fork Tine Support with Flexible Load
ASTM D-1185 - Creep Test at 2000 pounds and Test to Failure*

Replicate	Max Deflection Center (inches) Creep	Max Deflection Outside (inches) Creep	Max Deflection Center (inches) Relax	Max Deflection Outside (inches) Relax	MAX LOAD (lbs)	Max Deflection Center (inches) Fail	Max Deflection Outside (inches) Fail
1	-	-	-	-	5503	0.32	1.84
2	0.12	0.22	0.03	0.07	6063	0.26	0.61
3	0.14	0.24	0.04	0.07	6708	0.37	1.85
4	0.10	0.20	0.03	0.05	5388	0.20	0.97
AVE	0.12	0.22	0.03	0.06	5915	0.29	1.32
ASTM Criteria	0.24	0.18	0.09	0.06	4000		
Results	Pass	Pass	Pass	Pass	Pass	NA	NA

5.2 Floor Stack Static Strength and Stiffness

The results of the floor stack static tests are shown in Table 2. Based on the results of this test, the prototype pallet is rated for 4,800 pounds. The creep deflection between stringers was smaller than expected for the 2000 pound rated load. Due to the low creep deflection, this pallet is failure limited. Using the average load at failure, the rated load is 4800-pounds using a 2.5 times safety factor. The expected deflection at this load level is below the 0.32-inch maximum allowance.

*Table 2: Pallet Engineering Pallet: Results of Floor Stack Test with Flexible Load -
ASTM D-1185 - Creep Test at 2000 pounds and Test to Failure*

Replicate	Deflection after 2 hrs at creep load (inches)	Residual Deflection after 1 hr recovery (inches)	Load at Failure (lbs)	Deflection at failure (inches)
1	-	-	12283	0.63
2	0.12	0.03	13129	0.89
3	0.13	0.06	10612	0.91
4	0.14	0.03	12058	0.99
Average	0.13	0.04	12021	0.86
ASTM Criteria	0.32	0.12	12000	
Results	Pass	Pass	Pass	

6 Conclusions

- The prototype Paper Engineering corrugated paper pallet is strong and stiff enough to safely support 1600 pounds when supported by a forklift.
- The prototype Paper Engineering corrugated paper pallet is strong and stiff enough to safely support a uniform load of 4,800 pounds when floor stacked.



Figure 1: Prototype Paper Engineering 48x40-inch, non-reversible, partial 4-way, stringer style, double wing, corrugated paper pallet.



Figure 2: Photograph of the Fork Tine Test Setup.
This pallet has been tested to failure.



Figure 3: Test setup for floor stacking test.



Figure 4: Fork tine support test showing the condition of pallets after testing to failure.



Figure 5: Failure of the Pallet Engineering pallet occurring outside the edge of the fork tine when tested to failure.