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Effect of Cushion Placed on Wooden Pallets

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Abstract Wooden pallets are commonly dropped vertically and hit horizontally during distribution. To reduce the impact, it seems logical to place cushioning materials on a pallet. In this study an anti-vibration pad was used in free-fall vertical drop tests and horizontal impact tests of softwood pallets. Results indicate that placing cushioning materials on a pallet does in fact increase impact acceleration significantly due to the uneven surface of the top board of the pallet in the free-fall drop case and due to the additional friction force from the cushioning materials in the horizontal impact case. Thus, placing cushioning materials on wooden pallets is not recommended.
Keywords *Wooden Pallets; Free-Fall Drop; Side Impact; Cushion*

1. Introduction

Wooden pallets are used widely in carrying goods during the distribution stage. They are normally handled by forklifts. A pallet could be dropped vertically or hit horizontally by a forklift. Merchandises on the pallet feel the shock from a drop or a hit. Cushioning materials have been used in containers to absorb shock, resulting in the reduction of potential damages to the merchandise. Thus, it would be logical to place cushioning materials on a pallet to absorb the shock, even though this is not common due to the added cost of the cushion. The purpose of this study is to determine if the addition of cushion reduces the shock received from a vertical drop or a horizontal impact.

2. Materials and Methods

2.1. Free-Fall Vertical Drop

A full pallet was dropped vertically from a drop tester (Figure 1a) with a shock recorder mounted at the center of the pallet (Figures 1a and 1b). The pallet was then lifted up 8 inches and dropped to the steel base of the tester. About twenty drops were made for two setups; (1) no cushion and (2) with cushion between the pallet's top board and shock recorder. An anti-vibration pad (Figure 1c), used for reducing vibration from machinery transmitted to the floor, was used as a cushioning material in this study.

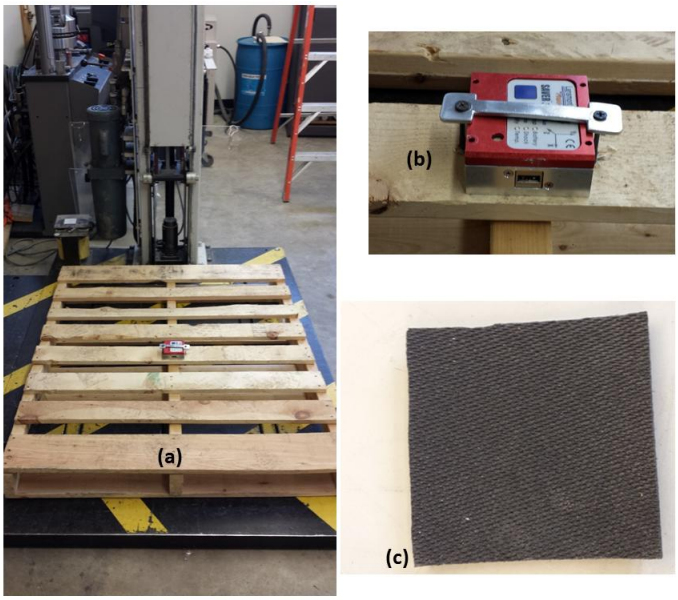

***Figure 1**: (a) Pallet on Drop Tester, (b) Shock Recorder, and (c) Anti-Vibration Pad*

2.2. Incline Impact

A specimen was cut from a softwood pallet stringer and one end clamped to a custom-built incline impact tester's back panel (Figure 2a). The other end of the specimen was hit by the sliding plate to simulate the impact experienced from a forklift. A piece of the pallet's top board was attached to the specimen with a shock recorder mounted to the top (Figure 2b). About twenty hits were made for two setups; (1) no cushion and (2) with cushion between the pallet's top board and shock recorder. An aluminum plate shown in Figure 2b was later added (to be discussed later in this article). A steel bent (shown in Figure 2b but not shown in Figure 2a) was used to cover the end of the specimen to protect damages from repeated hits received by the sliding panel. The same anti-vibration pad (Figure 2c) used in the vertical drop test was utilized. The tri-axial recorder was set to align with the direction of impact so impact acceleration is independent of the incline angle. This setup for impact study yields more consistent results than the free-fall drop test [1] and is a better simulation of horizontal hits obtained from a forklift.

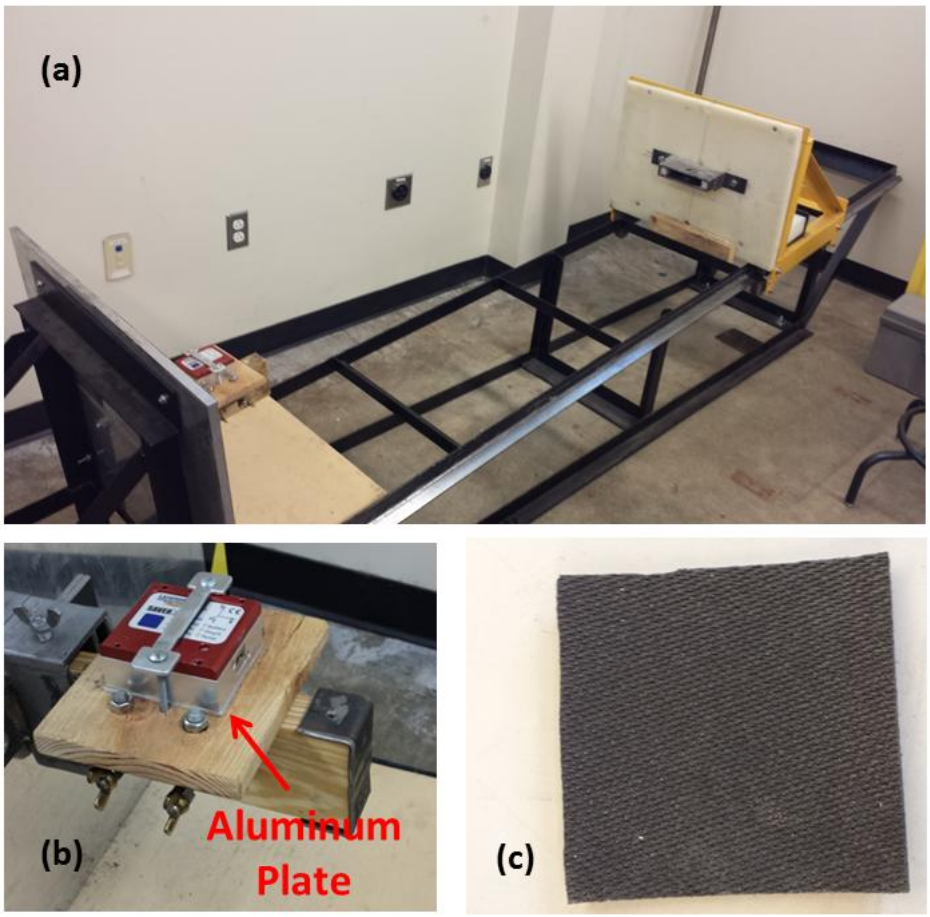

Figure 2: *(a) Specimen Setup for Incline Impact Test, (b) Shock Recorder, and (c) Anti-Vibration Pad*

3. Results and Discussion

3.1. Free-Fall Vertical Drop

Impact accelerations from about twenty drops at an 8-inch drop height were attained by a shock recorder. They are shown in Cases 1 and 2 of Table 1, where the recorder was placed directly on the pallet's top board with and without an anti-vibration pad between the top board and shock recorder. Sketches of the two cases are shown in Figure 3. The shock recorder with the anti-vibration pad underneath felt about 14% more impact than without the pad. Thus, the pad does not help in reducing the shock from a drop, which is counter intuitive.

Table 1: *Drop Test Data & Results*

	Impact Acceleration (g) at 8-inch Drop Height			
	Case 1 Wood + Recorder	**Case 2** Wood + Cushion + Recorder	**Case 3** Wood + Aluminum Plate + Recorder	**Case 4** Wood + Aluminum Plate + Cushion + Recorder
1	25.20	40.60	40.34	32.15
2	33.51	46.30	36.95	33.59
3	26.90	43.18	32.8	20.72
4	31.81	32.83	36.89	36.96
5	27.58	38.95	44.47	27.45
6	25.75	30.65	42.07	31.64
7	21.41	38.51	34.81	40.93
8	31.76	33.15	30.39	37.34
9	35.61	24.11	44.06	19.82
10	31.48	39.46	34.91	31.38
11	27.80	24.61	39.8	34.18
12	25.74	31.10	42.5	36.99
13	28.63	31.90	40.93	29.45
14	34.56	27.91	37.06	32.81
15	30.45	37.50	33.13	38.16
16	37.66	35.53	18.93	19.56
17	33.06	21.97	21.89	19.22
18	34.86	39.40	42.11	41.2
19				27.73
AVG (g) =	**30.21**	**34.31**	**36.34**	**31.12**
SD (g) =	**4.33**	**6.82**	**7.09**	**7.12**
SD (% of AVG) =	**14.35**	**19.86**	**19.51**	**22.89**
Change (%) =		**13.59** (Change from Case 1)		**-14.35** (Change from Case 3)

Typically, the surface of a pallet's top board is not smooth. The contact area between the shock recorder and wood surface when no pad was used (Figure 4a) is less than when a pad was used (Figure 4b). The pad was quite flexible and elastic, thus it was pushed to fill in the uneven wood surface. More contact area allows more shock to transmit from the bottom of the pallet up toward the shock recorder located on the top. To prove this explanation, an aluminum plate was placed above the pallet's top board (Figure 5). Impact accelerations captured by the shock recorder were read for cases with and without the anti-vibration pad between the aluminum plate and shock recorder and summarized in Cases 3 and 4 of Table 1. Sketches of these two new cases are shown in Figure 3. Both cases were based on the same contact area between the aluminum plate and wood surface. It turned out that the pad reduced about 14% of the impact.

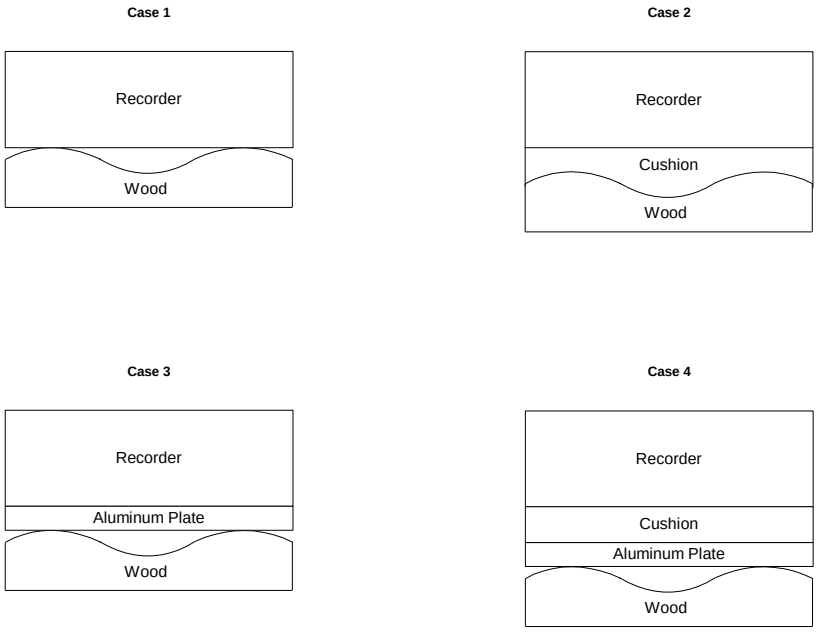

Figure 3: *Four Setup Cases*

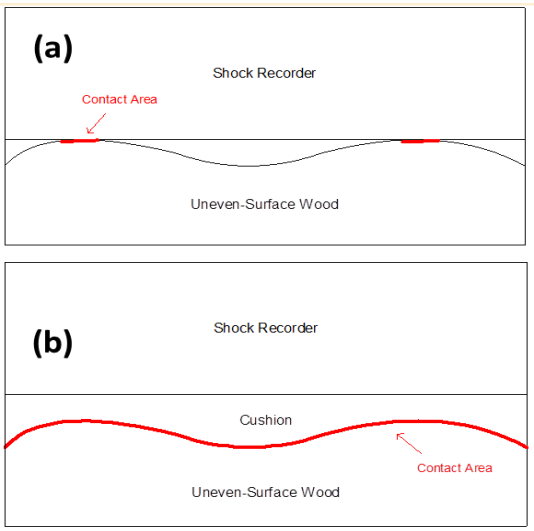

Figure 4: *(a) Shock Recorder Placed on Pallet Top Board without Cushion; (b) Shock Recorder Placed on Pallet Top Board with Cushion*

Figure 5: *Aluminum Plate Placed on the Pallet Top Board with Cushion above (Case 4)*

3.2. Incline Impact

Impact accelerations of about twenty side impacts were captured by a shock recorder. They are shown in Cases 1 and 2 of Table 2, where the recorder was placed directly on pallet's top board with and without anti-vibration pad between the top board and shock recorder. These are the same cases used previously in Table 1 and Figure 3. The shock recorder with anti-vibration pad underneath felt about 3% more impact than without the pad. Thus, the pad does not help in reducing the shock from a side impact, which is counter intuitive.

Table 2: *Side Impact Test Data & Results*

	Impact Acceleration (g) From Side Impact				
	Case 1 Wood + Recorder	**Case 2** Wood + Cushion + Recorder	**Case 3** Wood + Aluminum Plate + Recorder	**Case 4** Wood + Aluminum Plate + Cushion + Recorder	**Case 5** Wood + Aluminum Plate + Cushion + Aluminum Plate + Recorder
1	14.43	12.44	13.86	13.66	14.85
2	12.79	14.37	14.62	17.39	16.81
3	13.09	14.49	14.43	18.74	17.39
4	13.1	14.03	14.15	19.68	17.4
5	13.46	13.62	14.7	20.15	16.02
6	13.67	14.09	14.07	20.5	16.41
7	13.78	13.82	14.04	20.37	15.98
8	13.48	15.01	14.64	20.76	14.09
9	13.82	15.22	14.08	21.79	14.57
10	13.73	14.39	14.1	21.02	14.28
11	13.61	14.98	14.62	20.89	14.46
12	13.86	14.18	14.51	22.26	14.39
13	13.64	14.28	14.97	20.98	15.37
14	14.17	14.31	14.27	20.6	15.61
15	14.5	14.24	15.27	20.25	15.98
16	14.42	14.81	15.63	21.08	16.58
17	14.17	14.01	15.2	21.01	18.1
18	14.23	13.75	15.46	20.97	
19	14.73	14.64	14.96	21	
20	14.38	14	15.83	21.69	
AVG (g) =	**13.85**	**14.23**	**14.67**	**20.24**	**15.78**
SD (g) =	**0.52**	**0.60**	**0.58**	**1.88**	**1.23**
SD (% of AVG) =	**3.77**	**4.24**	**3.93**	**9.28**	**7.78**
Change (%) =		**2.75** (Change from Case 1)		**37.96** (Change from Case 3)	**-22.02** (Change from Case 4)

As in the vertical drop experiment above, an aluminum plate was placed on the pallet's top board and the shock recorder was placed with and without the anti-vibration pad underneath. Data was summarized in Cases 3 and 4 of Table 2 (same as those used previously in Table 1 and Figure 3). Instead of reduction in impact acceleration as in the vertical drop situation, the shock recorder with

anti-vibration pad underneath felt 38% more impact than without the pad. Since the impact force was applied horizontally to the free end of the stringer, the recorder on the top board tended to slide horizontally which was resisted by a friction force. The anti-vibration pad gave a higher coefficient of friction, thus gave more resistance and resulted in more impact. To prove this friction concept, an additional aluminum plate was placed between the anti-vibration pad and recorder (Figure 6). Data was summarized in Case 5 of Table 2. The additional aluminum plate cut down the coefficient of friction significantly. The recorder in Case 5 felt about 22% less impact than that in Case 4. Clamping force had direct effect on this friction force. In this study, clamping force was not accurately controlled, thus the results could be off somewhat. In a real situation clamping force depends on the weight of packages on the cushion. Heavier packages would create more friction force, thus more impact would be felt by the packages.

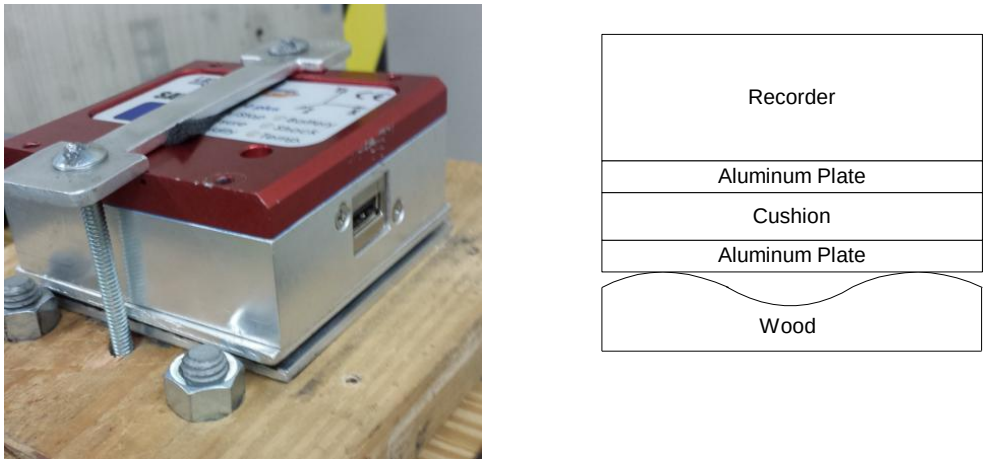

Figure 6: *Anti-vibration Pad Placed Between Two Aluminum Plates (Case 5)*

4. Conclusion

In practice placing a sheet of cushion, such as the anti-vibration pad used in this study, would add cost to the pallet. Manufacturers would be reluctant to add the cost to pallets since most distributions are one way. However, for some expensive merchandise one might attempt to place some cushion to reduce the impact which could reduce product damage potential. This study shows that placing cushion on a wooden pallet would increase damage potential to the product. This is due to the increased contact area in the case of the vertical drop and the increased coefficient of friction in the case of the slide impact.

Reference

[1] Malasri, S., Harvey, M., Moats, R., Aflaki, J., Pourhashemi, A., Martinez, G. M., and Held, P. *Effect of Wet-Dry Cycles on Compressive Strength and Impact Properties of New Softwood Pallets*. International Journal of Advanced Packaging Technology. 2013. 1 (1) 15-21.