THE INFLUENCE OF VIBRATION ON THE COMPRESSIVE STRENGTH AND DEFLECTION AT MAXIMUM COMPRESSION OF U. S. AND JAPANESE B-FLUTE CORRUGATED CONTAINERS

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Sukehisa Nada

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AN ABSTRACT

Submitted to the College of Agriculture, Michigan State
University of Agriculture and Applied Science in
partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Forest Products
School of Packaging

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Approved: ______________________

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This investigation was made to determine the effect of vibration on the compressive strength of corrugated containers and on the degree of deflection at maximum compression. Another purpose was to compare the strength of U. S. and Japanese containers.

The factors studied consisted of seven vibration periods: no vibration, 0.5 hour, 1.0 hour, 1.5 hours, 2.0 hours, 2.5 hours, and 3.0 hours. Four types of B-flute board were used: U. S. Kraft board, U. S. Jute board, and two kinds of Japanese Jute boards.

The test results indicated that a vibration period of three hours affected the compressive strength the most. In the case of deflection, the three hours vibration period again showed the most effect.

Of the containers tested, the Japanese Jute board containers appeared to be stronger than the U. S. Jute and Kraft containers. However, due to the small number of samples tested and the wide degree of variation in test results with the Japanese containers, the validity of these results is questionable.

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I. INTRODUCTION

The use of corrugated fiberboard shipping containers is increasing tremendously all over the world. For example, the production of corrugated board in the United States in 1960 was over 107 billion square feet, which is twice as much as that produced in 1941[1]. In Japan, whose production rate before World War II was limited, 10 billion square feet were produced in 1960[2]. This is almost twenty times the amount produced in 1952. This means that more and more corrugated containers are handled today than ever before. At the same time, the seriousness of damage to the products packed in corrugated containers, by transportational hazards and by storage period loading, becomes more important.

In the regular shipment and handling of commodities, the compressive strength of the container is important because it may be required to sustain the load of several containers placed on the top of it. Also, it may be required to protect the contents from the endthrust of other containers in a truck that stops suddenly or from the force resulting when freight cars are humped and handled in switching operations.

Vibration shocks caused by resonance, flat car wheels, rail joints, rough road beds, or roadways give the product a shaky, jarring, damaging ride. A container for the product also loses its inherent compressive strength due to these shocks. In other words, the strength of corrugated containers shows fatigue by vibration.

"Today, more and more manufacturing plants throughout the country are using vibration test equipment to investigate the damaging vibrations of transportation and how they affect packages and their products."[3]

In this study the author concentrated his efforts on the compressive strength and deflection of corrugated containers. A comparison of the containers made in the United States and Japan was done because of the Author's interest.

The author hopes that this study will be helpful to those who design or plan to utilize corrugated containers, by presenting them with certain ideas on the degree of reduction of the compressive strength of a corrugated container caused by the hazard of vibration.

II. THE PROBLEMS AND TESTS USED

PROBLEMS

It was the purpose of this study: (1) to determine the effects of vibration on the top-to-bottom compressive strength of a corrugated container; (2) to point out the degree of deflection from the original dimension at the point of maximum compression; and (3) possibly to find any difference in the strength of containers which were made in the United States and Japan.

TESTS USED

The test methods used in this study were a combination of the vibration test and the top-to-bottom compression test.

The vibration test, ASTM Standard D 999-48T[4], simulates the steady pounding and vibration that occurs in most methods of transportation. The standard test requires that the test be continued for a pre-determined period of time, or until failure occurs. This test determines that strength of a corrugated container necessary to provide sufficient protection of the contents when subjected to the vibration. In order to determine this, containers are vibrated for various periods of time with a constant frequency.

The compression test, ASTM Standard D 642-47[5], subjects the container to the load that it will encounter while being stacked in warehouses, freight cars, and other types of transportation. The standard test requires that the load be applied with a continuous motion of the movable head of the testing machine at a speed of $\frac{1}{2} \pm \frac{1}{4}$ inch per minute until failure and the maximum load or either has been reached. In order to find the maximum compressive strength of a container, a gradually increasing load is applied. This static loading measures the resistance of the container which is required for compressive loads of longer periods. The data obtained from such a test are the points of compression strength and deflection from initial load to failure of the container. Therefore, for a specific load and period of vibration, the compressive strength and degree of deflection of the container are obtained. This was used as the criteria for judging the strength of the container. A high degree of reduction of compressive strength would show a container to have been vibrated for a longer period and a lesser amount of reduction would show a container to have been vibrated for a shorter period.

III. PREVIOUS STUDIES

Some related studies concerning the compressive strength of a corrugated container have been made by a few packaging engineers.

A study involving a dead load, various controlled atmospheres and two different kinds of corrugated containers, has been done at the Forest Products Laboratory. In the report two significant conclusions were made:[6]

1. For the conditions considered in the study, increase of moisture content reduced the time a box could sustain a dead load; and

2. The influence of moisture content on the compressive strength of corrugated fiberboard boxes was found to be about the same for the different kinds of board included in this study.

In attempting to explain the top-load compression behavior of a corrugated container in terms of its several structural elements, i.e., flaps, flap score-line, panels, and panel score-line. McKee and Gander[7] found that: (1) the evaluation of the suitability of a container for use with a specific commodity may require a consideration of the entire compression load-deformation curve, not solely the maximum load and corresponding deflection and (2) the top-load compression behavior of a filled container may be expected to depend upon the initial clearance between commodities and flaps, and flap assembly.

"It may be shown that corrugated containers have the most resistance and exhibit the greatest amount of stiffness when their moisture content is at the lowest level."[8] This idea was comfirmed by Bjornseth at the School of Packaging, Michigan State University in 1959.[9]

These three studies which pointed out the effects on compressive strength of a corrugated container from the various factors which cause the reduction, should give the reader an idea of the characteristics of the compressive strength of a corrugated container.

Because of the difficulty involved in summarizing the test results, any summary concerning the reduction of the compressive strength of a corrugated container as a result of vibration hazard has not previously appeared. This study which does summarize the test results, is entirely new for this reason.

IV. EXPERIMENTAL PROCEDURE

As previously mentioned, the test procedures used were a combination of the Vibration test and the Compression test. A total of 112 corrugated containers were tested. The tests were run in seven series; each series representing a vibration period. Each series consisted of four groups containing four samples each of: (1) the U. S. Kraft board; (2) the U. S. Jute board; (3) Japanese Jute board I; and (4) Japanese Jute board II. Kraft board is made from 100 % virgin sulphate pulp; Jute board consists of a combination of waste papers, including old corrugated containers and newprint, and a small amount of virging Kraft pulp. The exact amount of these materials varies widely from mill to mill. Thus it is extremely difficult to compare one Jute board with another. The seven series consisted of tweleve samples at (A) no vibration; (B) 0.5 hour; (C) 1.0 hour; (D) 1.5 hours; (E) 2.0 hours; (F) 2.5 hours; and (G) 3.0 hours of vibration.

STRUCTURE OF THE CONTAINERS

The containers used for the test were regular slotted containers made of B-flute board. The inside dimensions were 7" x 7" x 7". There was a practical reason for using a container of this size. A corrugated box of shallow depth shows a high structural strength[10], and therefore the difference between the test variables would be less.

These corrugated containerd were made from boards consisting of 50 lb. liners and 26 lb. corrugated medium. They were of balanced construction; that is a liner of the same weight was used on both sides.

The horizontal and the vertical scores for all containers were made on a sample table.

A three inch asphalt laminated, reinforced gummed tape was used for the manufacturer's joint. A tow inch 60 lb. gummed tape was used for sealing the flaps.

The U. S. Kraft board was obtained from Packaging Corporation of America in Grand Rapids, Michigan. The U. S. Jute board was obtained from Consolidated Paper Company in Monroe, Michigan. Two kinds of Japanese Jute boards were supplied by Chiyoda Paper Industrial Company of Osaka, Japan.

TEST PROCEDURES

All the samples were kept in a conditioning room* for 72 hours or more before testing. After proper conditioning they were subjected to vibration. After the vibration test the samples were placed in the compression tester and load was applied. The maximum load sustained by each sample was recorded for later analysis.

The Vibration Test

The standard ASTM D 999-48T, Vibration Test for Shipping Containers (Tentative), was followed. The apparatus

* Conditioning Room: A room accurately controlled to a Relative Humidity of 50 2 per cent and a Temparature of $73.4 \pm 3.6^{o}F$ ($23 \pm 2^{o}C$).

used for the test was Vibrating Table and Strobotac (see Figures I and II). The amount of vibration to which each container was subjected, is contained in Table I. The reason for the variation in the amount of vibration was to show the relationship of damage recieved as a function of the vibration period. The frequency was held constant at 3.5 cycles per second which falls within the range[11] predominantly responsible for damage in real shipment.

The samples were placed on the vibrating table (see Figure I) without fastening. Two fences were fastened to the table with 7½ inches between them, which left the sample free to move ¼ inch. The two fences represented the sides of containers placed next to the sample in a practical shipping situation.

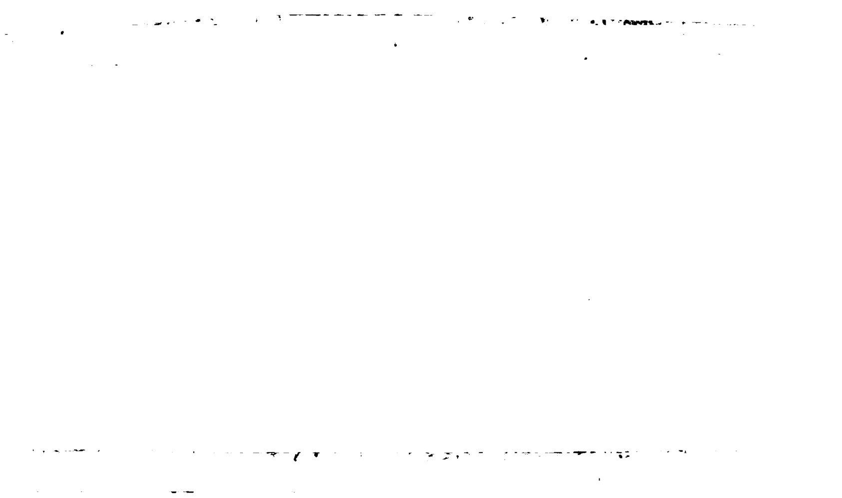
The machine was operated for a pre-determined time as Table I shows. This test was performed immediately after removing the sample from the conditioning room.

Four fruit juice cans (308 x 700), weighing 2.5 pounds each, were used as the packaged product. The total weight of product for each container was 10 pounds.

The containers were stapled on the bottom and sealed with gummed tape on the top as Figure III shows.

FIGURE I

VIBRATION TEST MACHINE (I)



VIBRATING TABLE
PACKAGE TESTER SELVMCH 35
Type No. 400, Serial 3600 - 27

FIGURE II

VIBRATION TEST MACHINE (II)

STROBOTAC
Type No. 631-BL, Serial No. 15947

FIGURE III

STRUCTURE AND DIMENSIONS OF
CONTAINERS

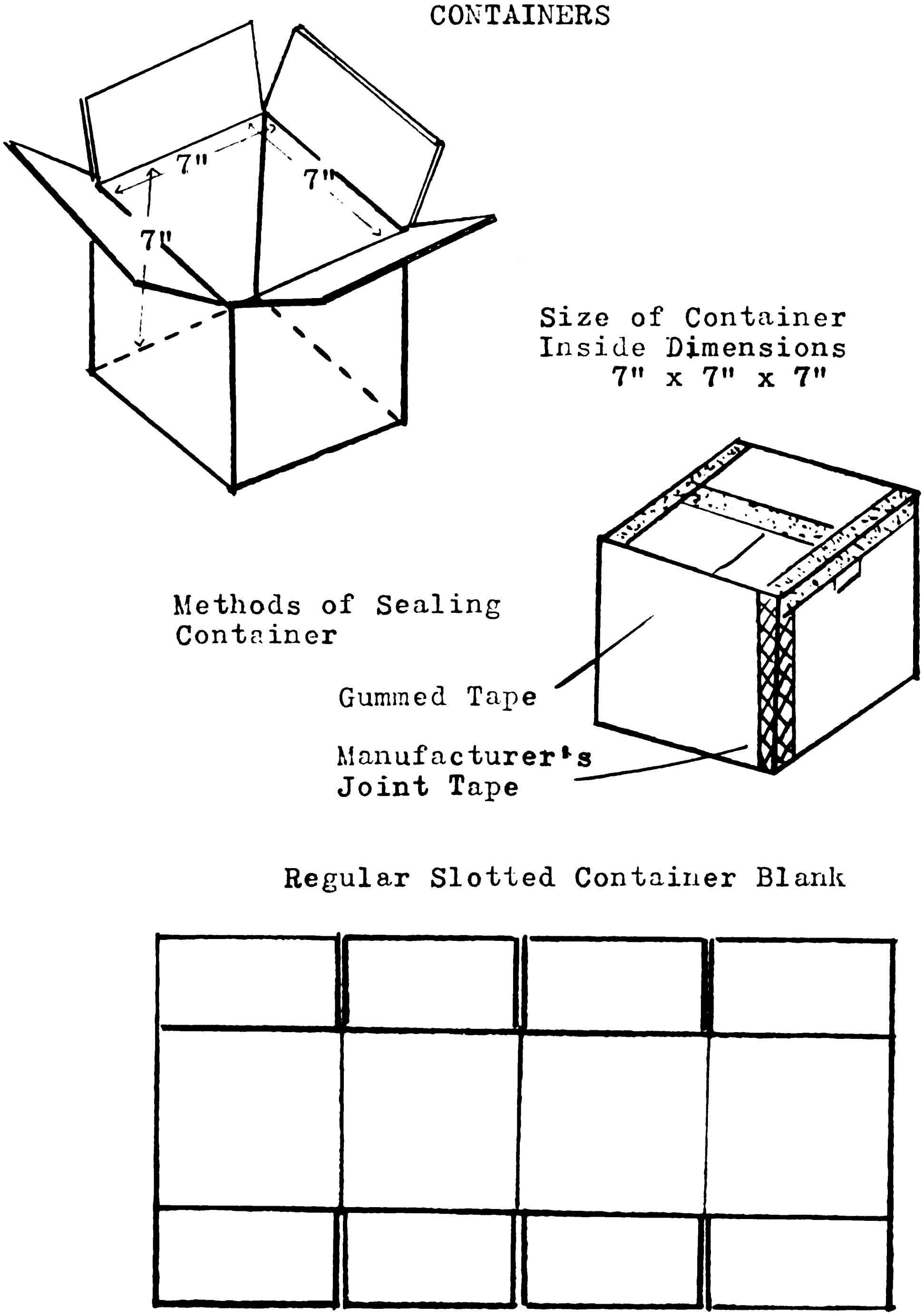


TABLE I

THE NUMBER OF SAMPLES
FROM EACH PRODUCT FOR VIBRATION
TEST

PRODUCTS	VIBRATION (HOUR)						
	A (No)	B (0.5)	C (1.0)	D (1.5)	E (2.0)	F (2.5)	G (3.0)
1 U. S. Kraft Board	4	4	4	4	4	4	4
2 U. S. Jute Board	4	4	4	4	4	4	4
3 Japanese Jute Board I	4	4	4	4	4	4	4
4 Japanese Jute Board II	4	4	4	4	4	4	4
Total	16	16	16	16	16	16	16
Grand Total	112						

The Compression Test

The standard ASTM D 642-47, Compression Test for Shipping Containers, was followed. The apparatus used for the top-to-bottom compression test was the Baldwin Emery SR-4 Testing Machine and attached stress-strain recorder. This equipment is shown in Figures IV and V.

In order to have a precise record of vibrational influence on the compressive strength of the container, the compression test was run immediately after the container had been subjected to the pre-determined amount of vibration.

The machine setting used for the test was as follows:

Load Range	0-2500 lb./unit area
Platen Speed	0.4 in./min.
Deflectometer and Magnifier	200 Magnification.
Recording Range	Half Range

The sample was placed between the two auxiliary wooden platens. An initial load of 50 pounds was applied to insure a definite area of contace between the specimen and the platen. The distance between the platens at this time was recorded as zero deflection. With this 50 pounds load on the sample, the automatic stress and strain recorder pen was set at zero deflection. The machine was operated at a speed of 0.4 inch per minute until failure occured. This procedure was repeated for all the samples. The machine recorded the load and the deflection (see Figure VI).

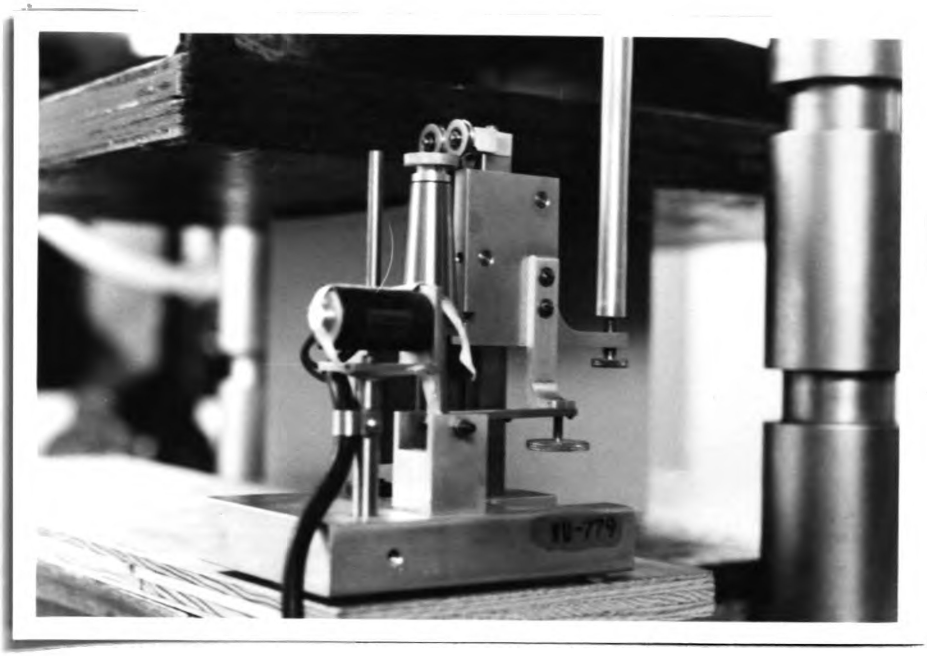
FIGURE IV

COMPRESSION TEST MACHINE (I)

COMPRESSION TEST MACHINE
BALDWIN—EMERY SR-4
Testing Machine (Model FCT)

FIGURE V

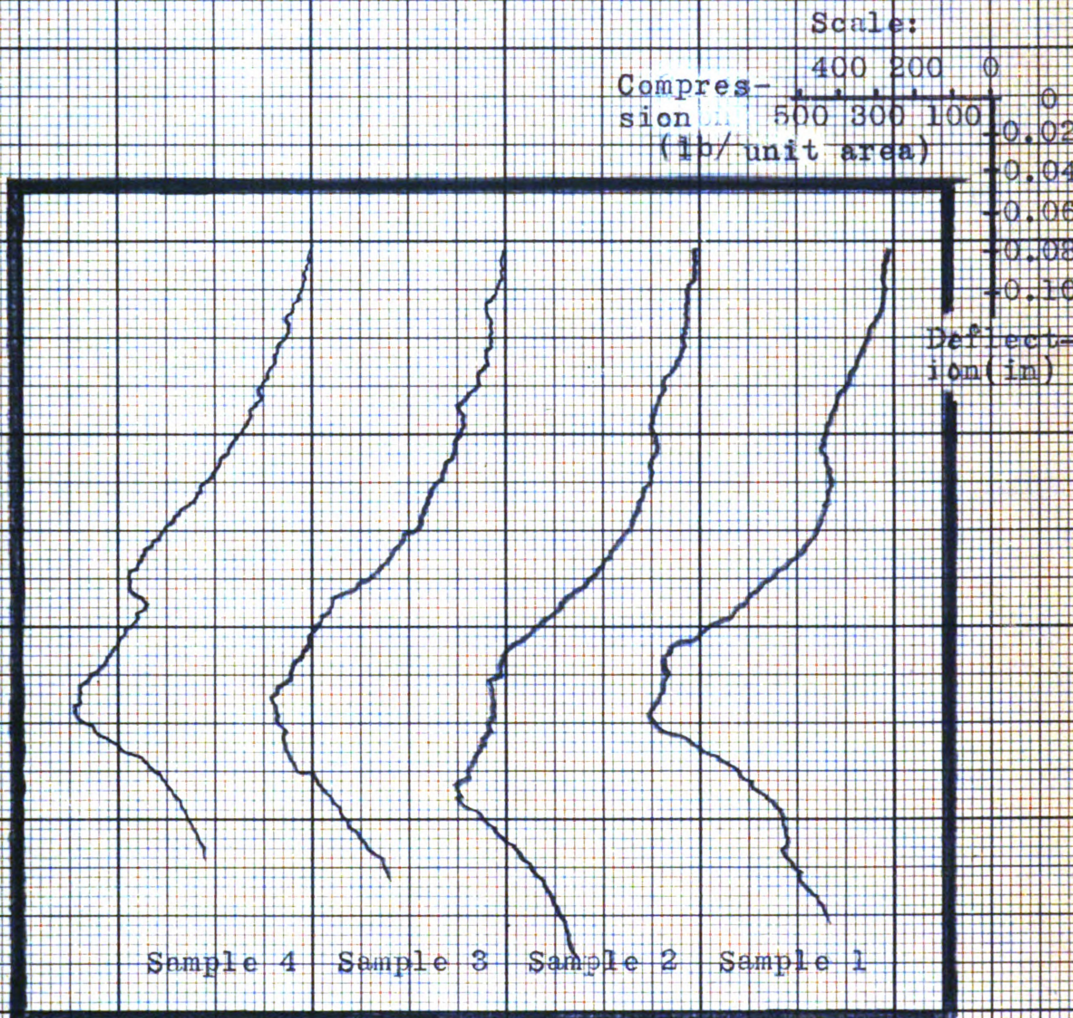
COMPRESSION TEST MACHINE (II)



BALDWIN Stress-Strain
Recorder (Model MA1B)

FIGURE VI

A SAMPLE FROM AUTOMATIC
STRESS AND STRAIN MACHINE RECORD



Products: Product (1), U.S. Kraft board
Vibration: Vibration (D), 1.5 hours

TABLE II

COMPRESSIVE STRENGTH AND DEFLECTION

No Vibration

PRODUCTS		COMPRESSIVE STRENGTH (lb./unit area) VALUE	AVERAGE	DEFLECTION (inch) VALUE	AVERAGE
U.S. Kraft	1	745	743.7	0.63	0.575
	2	760		0.57	
	3	725		0.56	
	4	745		0.54	
U.S. Jute	1	600	603.7	0.63	0.620
	2	590		0.59	
	3	620		0.64	
	4	605		0.62	
Japanese Jute I	1	685	681.2	0.68	0.680
	2	655		0.60	
	3	710		0.76	
	4	675		0.68	
Japanese Jute II	1	960	813.7	0.78	0.690
	2	800		0.71	
	3	750		0.64	
	4	745		0.63	

TABLE III

COMPRESSIVE STRENGTH AND DEFLECTION

0.5 Hour Vibration

PRODUCTS		COMPRESSIVE STRENGTH (lb./unit area) VALUE	AVERAGE	DEFLECTION (inch) VALUE	AVERAGE
U.S. Kraft	1	675	713.7	0.49	0.530
	2	720		0.52	
	3	740		0.58	
	4	720		0.53	
U.S. Jute	1	625	596.2	0.69	0.605
	2	570		0.67	
	3	590		0.56	
	4	600		0.50	
Japanese Jute I	1	655	638.7	0.66	0.655
	2	625		0.63	
	3	640		0.67	
	4	640		0.66	
Japanese Jute II	1	745	801.2	0.70	0.622
	2	810		0.65	
	3	830		0.48	
	4	820		0.66	

TABLE IV

COMPRESSIVE STRENGTH AND DEFLECTION

1.0 Hour Vibration

PRODUCTS		COMPRESSIVE STRENGTH (lb./unit area) VALUE	COMPRESSIVE STRENGTH (lb./unit area) AVERAGE	DEFLECTION (inch) VALUE	DEFLECTION (inch) AVERAGE
U. S. Kraft	1	720	710.0	0.49	0.530
	2	715		0.52	
	3	670		0.58	
	4	715		0.53	
U.S. Jute	1	565	576.2	0.56	0.557
	2	560		0.58	
	3	600		0.58	
	4	580		0.51	
Japanese Jute I	1	580	591.2	0.61	0.645
	2	645		0.62	
	3	560		0.69	
	4	580		0.66	
Japanese Jute II	1	740	793.7	0.60	0.635
	2	750		0.70	
	3	850		0.65	
	4	835		0.59	

TABLE V

COMPRESSIVE STRENGTH AND DEFLECTION

1.5 Hours Vibration

PRODUCTS		COMPRESSIVE STRENGTH (lb./ unit area)		DEFLECTION (inch)	
		VALUE	AVERAGE	VALUE	AVERAGE
U.S. Kraft	1	680	645.0	0.49	0.507
	2	670		0.57	
	3	725		0.49	
	4	505		0.48	
U.S. Jute	1	560	547.5	0.54	0.533
	2	570		0.57	
	3	525		0.52	
	4	535		0.50	
Japanese Jute I	1	600	580.0	0.73	0.647
	2	580		0.60	
	3	560		0.60	
	4	580		0.66	
Japanese Jute II	1	820	770.0	0.61	0.632
	2	775		0.60	
	3	740		0.70	
		745		0.62	

TABLE VI

COMPRESSIVE STRENGTH AND DEFLECTION

2.0 Hours Vibration

PRODUCTS		COMPRESSIVE STRENGTH (lb./unit area)		DEFLECTION (inch)	
		VALUE	AVERAGE	VALUE	AVERAGE
U.S. Kraft	1	695	678.7	0.44	0.447
	2	645		0.42	
	3	670		0.47	
	4	705		0.46	
U.S. Jute	1	530	516.2	0.54	0.532
	2	470		0.57	
	3	530		0.52	
	4	535		0.50	
Japanese Jute I	1	530	525.2	0.57	0.580
	2	500		0.58	
	3	545		0.62	
	4	525		0.55	
Japanese Jute II	1	780	740.0	0.48	0.597
	2	770		0.59	
	3	755		0.61	
	4	655		0.70	

TABLE VII

COMPRESSIVE STRENGTH AND DEFLECTION

2.5 Hours Vibration

PRODUCTS		COMPRESSIVE STRENGTH (lb./unit area) VALUE	COMPRESSIVE STRENGTH (lb./unit area) AVERAGE	DEFLECTION (inch) VALUE	DEFLECTION (inch) AVERAGE
U.S. Kraft	1	710	658.7	0.47	0.442
	2	640		0.44	
	3	620		0.41	
	4	665		0.45	
U.S. Jute	1	530	488.7	0.40	0.420
	2	470		0.42	
	3	480		0.43	
	4	475		0.43	
Japanese Jute I	1	515	496.2	0.56	0.492
	2	490		0.48	
	3	505		0.49	
	4	475		0.44	
Japanese Jute II	1	770	698.7	0.50	0.507
	2	645		0.49	
	3	745		0.52	
	4	630		0.52	

TABLE VIII

COMPRESSIVE STRENGTH AND DEFLECTION

3.0 Hours Vibration

PRODUCTS		COMPRESSIVE STRENGTH (lb./unit area)		DEFLECTION (inch)	
		VALUE	AVERAGE	VALUE	AVERAGE
U.S. Kraft	1	635	607.5	0.37	0.430
	2	630		0.46	
	3	580		0.46	
	4	585		0.43	
U.S. Jute	1	440	461.2	0.35	0.415
	2	490		0.42	
	3	460		0.46	
	4	455		0.43	
Japanese Jute I	1	490	481.2	0.46	0.485
	2	485		0.56	
	3	470		0.48	
	4	480		0.44	
Japanese Jute II	1	610	650.0	0.50	0.447
	2	690		0.44	
		680		0.43	
		620		0.42	

TABLE IX

SUMMARY OF TEST RESULTS
SHOWING AVERAGE COMPRESSIVE STRENGTH
BY MAIN EFFECTS

PRODUCTS	1	679
	2	540
	3	571
	4	751
VIBRATIONS	A	710.6
	B	687.5
	C	668.4
	D	632.5
	E	615.8
	F	585.7
	G	550.0

TABLE X

SUMMARY OF TEST RESULTS
SHOWING AVERAGE DEFLECTION BY MAIN
EFFECTS

PRODUCTS	1	0.603
	2	0.548
	3	0.591
	4	0.590
VIBRATIONS	A	0.641
	B	0.603
	C	0.594
	D	0.580
	E	0.539
	F	0.465
	G	0.444

FIGURE VII

GRAPH OF AVERAGE COMPRESSIVE
STRENGTH VS. VIBRATION EFFECTS

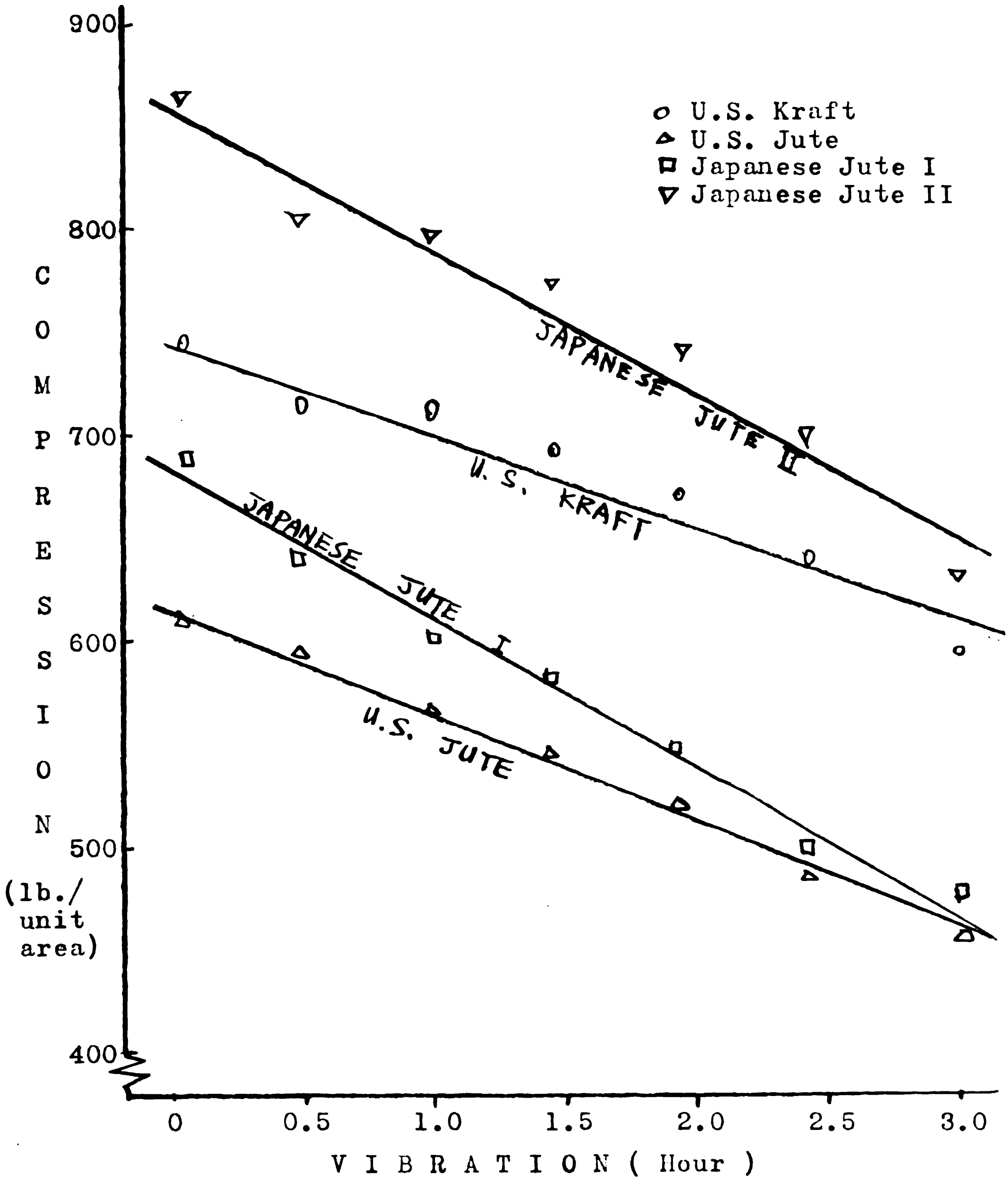
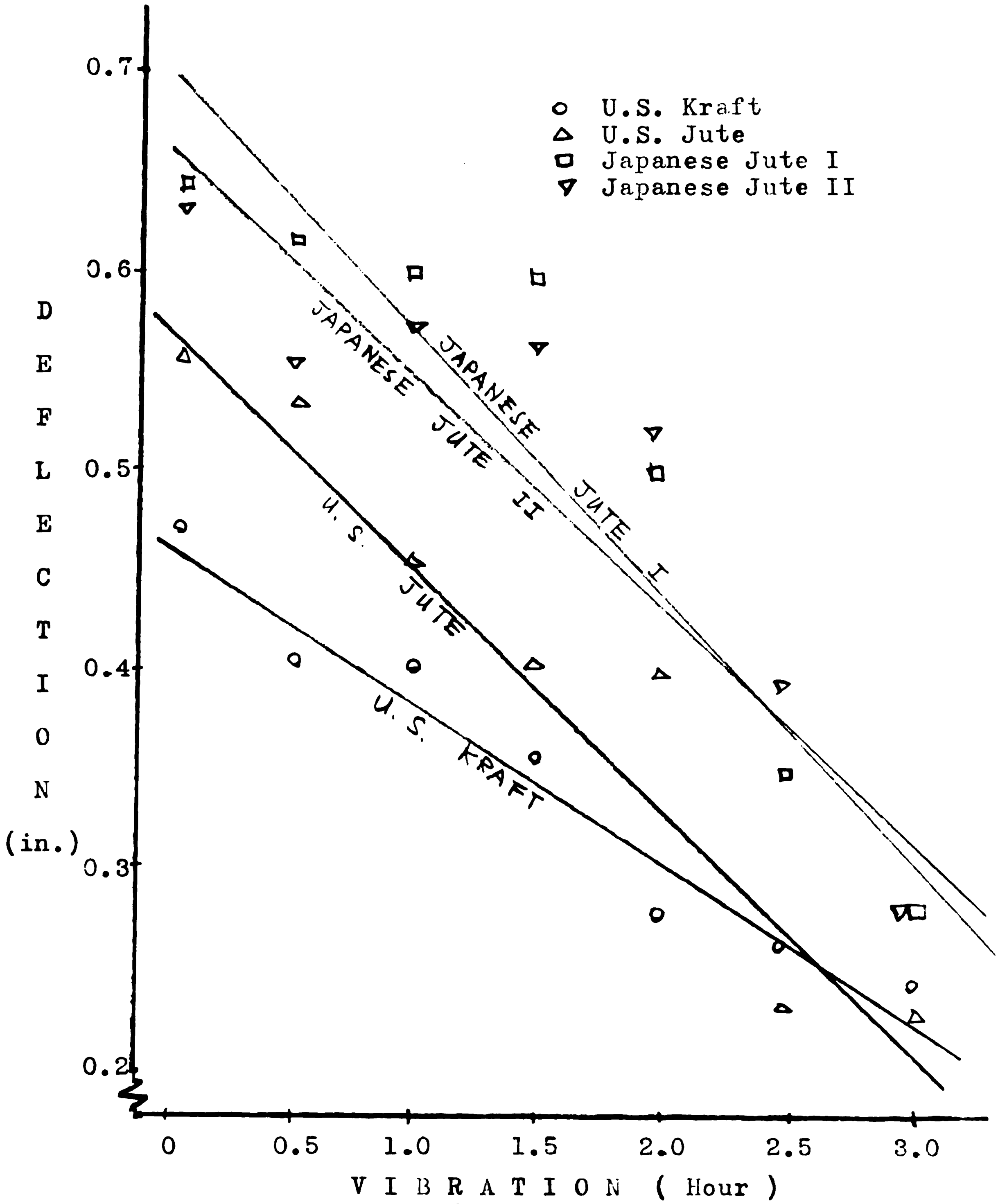


FIGURE VIII

GRAPH OF AVERAGE DEFLECTION
VS. VIBRATION EFFECTS



V. ANALYSIS OF DATA

Tables II through VIII show the test results of compressive strength in pounds per unit area and of deflection in inches at the point of maximum compressive strength. The data present two factors: Products (1, 2, 3, and 4) and Vibrations (A, B, C, D, E, F, and G). The techniques and procedures used in this statistical analysis were taken from Duncan [12]. The results of the analysis are shown in Tables XI and XII.

The analysis of variance revealed that the two-way interaction, product x vibration, was significantly different from the error term. This led to making independent estimates of variance and then running a variance ratio F test.

As a result of this test it was found that the variance of product and vibration had a significant effect on the compressive strength and deflection.

VIBRATION

<u>Compressive Strength</u>

Of the seven periods of vibration tested, all products showed more reduction for longer periods of vibration. In other words, at 3 hours vibration a container lost twenty-nine percent of its inherent compressive strength as compared to fifteen per cent loss at 1.5 hours vibration (see Table

TABLE XI

FINAL ANALYSIS OF VARIANCE
FOR COMPRESSIVE STRENGTH

	Sum of Square	d. f.	Mean Square	F.
PRODUCT	541,212.5	3	108,404.1	110.6
VIBRATION	137,257.4	6	22,876.2	14.0
PRODUCT x VIBRATION	307,389.1	18	17,077.1	10.4
EXPERIMENTAL ERROR	138,587.5	85	1,630.4	
TOTAL	1,124,446.5	112		

* F Test Value:

$F_{.05} = 2.72$ with $n_1 = 3$ and $n_2 = 85$.
$F_{.05} = 2.24$ with $n_1 = 6$ and $n_2 = 85$.
$F_{.05} = 1.76$ with $n_1 = 18$ and $n_2 = 85$.

TABLE XII

FINAL ANALYSIS OF VARIANCE
FOR DEFLECTION

	Sum of Square	d. f.	Mean of Square	F
PRODUCT	0.2064	3	0.0688	17.2
VIBRATION	0.4676	6	0.0779	19.4
PRODUCT x VIBRATION	0.0549	18	0.0031	0.775
EXPERIMENTAL ERROR	0.3368	85	0.0040	
TOTAL	1.0657	112		

* F Test Value:

$F_{.05} = 2.27$ with $n_1 = 3$ and $n_2 = 85$.
$F_{.05} = 2.24$ with $n_1 = 6$ and $n_2 = 85$.
$F_{.05} = 1.76$ with $n_1 = 18$ and $n_2 = 85$.

XIII).

Table IX shows the average compressive strength of all test results by main effects. Figure VII describes average compressive strength of each product by different periods of vibration in graph.

Deflection

Stiffness or the ability of a container to sustain a load shows the lowest value for the longest period of vibration. This means that the longer vibration periods have more effect on compressive strength of a container. In other words, a container which showed failure at 0.641 inch at no vibration, showed failure when it was composed only 0.444 inch after 3 hours vibration. Each product showed a little different behavior as Table X describes. There appeared to be a difference between Kraft board containers and Jute board containers (see Figure VIII).

U. S. AND JAPANESE CONTAINERS

On the basis of the limited number of samples tested, one group of the Japanese Jute board containers appeared to have the highest average compressive strength of all containers used. The other group of Japanese Jute board containers appeared to have a higher compressive strength than U. S. Jute board containers (see Table IX).

The Japanese Jute board containers, which showed the highest compressive strength, had the greatest amount of

TABLE XIII

THE REDUCTION IN COMPRESSIVE STRENGTH
DUE TO VIBRATION, EXPLAINED IN PERCENT

VIBRATION (Hour)	PRODUCTS			
	1 U. S. Kraft	2 U. S. Jute	3 Japanese Jute I	4 Japanese Jute II
A (No)	100	100	100	100
B (0.5)	96	99	94	98
C (1.0)	95	95	87	98
D (1.5)	87	91	85	95
E (2.0)	91	86	77	91
F (2.5)	86	81	73	86
G (3.0)	82	76	71	80

* The Compressive Strength at No Vibration is regarded as 100 percent.

variation in this property as Table XIII shows.

TABLE XIV

VARIATION OF THE VALUE IN
COMPRESSIVE STRENGTH BY MAIN EFFECTS

VIBRATION (Hour)	PRODUCTS			
	1 U. S. Kraft	2 U. S. Jute	3 Japanese Jute I	4 Japanese Jute II
A (No)	15	30	56	215
B (0.5)	65	55	35	85
C (1.0)	50	40	35	85
C (1.5)	55	45	40	80
D (2.0)	50	60	45	125
F (2.5)	70	60	40	140
G (3.0)	55	50	20	80

VI. CONCLUSIONS

1. The amount of reduction of the compressive strength of a corrugated containers is considerably greater at 3.0 hours vibration than at 2.5 hours vibration and, also, at 2.5 hours vibration it is greater than at 2.0 hours vibration. Less difference was found in the reduction of strength between 2.0 hours vibration and 1.5 hours vibration, than was found between 3.0 hours vibration and 2.5 hours vibration. Little difference was noticed between 1.0 hour vibration and 0.5 hour vibration. Therefore, at longer periods of vibration, the compressive strength of corrugated containers becomes considerably less.

2. At longer periods of vibration, corrugated containers show greater fatigue in both stiffness and in ability to sustain loading. The degree of deflection at the point of the maximum compressive strength of a container decreases with increase in the period of vibration. At 3.0 hours vibration a container shows the most fatigue, failing with smallest deflection. At 2.5 hours vibration, the degree of deflection sustained by the container is greater than at 3.0 hours vibration, and at 2.0 hours vibration it is greater than at 2.5 hours vibration.

3. As noted before, the number of samples used and the

number of mills involved was too small to definitely compare the U. S. and Japanese containers. However, the results indicated that the Japanese Jute board containers tested were stronger than the U. S. Jute board containers. Also, although one group of Japanese Jute board containers had a higher average strength than the U. S. Kraft containers, the data obtained from the Japanese Jute board containes varied too much to draw definite conclusions on these two groups.

VII. SUGGESTIONS FOR FURTHER WORK

1. Conduct a similar series of tests to investigate the severity of damage on the compressive strength of different kinds of containers such as A-flute and C-flute boards and compare them with the results of this test.
2. Investigate the severity of damage caused by different frequencies of vibration on the compressive strength of corrugated containers.
3. A detailed investigation of the merits of the U. S. and Japanese containers should be made, involving a large n number of samples from many representative mills in both countries.

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