THE TOP TO BOTTOM COMPRESSION STRENGTH OF A CORRUGATED CONTAINER AS A FUNCTION OF FLUTE SIZE AND RELATIVE HUMIDITY DETERMINED BY A DEAD LOAD

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AN ABSTRACT

This investigation was made to determine the effect of relative humidity, flute size and load on the compression strength of corrugated containers. In addition, a new test procedure was used to evaluate the previously mentioned variables.

The variables consisted of four relative humidities (30%, 50%, 70%, 90%), three flute sizes (A, B, C), and varying loads. All tests were controlled within the conditions specified by the listed references.

The test results showed that relative humidities 70% and 90% effected the strength of a corrugated container. C flute board seemed to provide the stronger board for container construction.

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I. INTRODUCTION

The Problem

Along with the tremendous increase in use of the corrugated fibreboard shipping containers, has come the problem of toppling of columns of containers during storage. This may be due, in part, to the atmosphere surrounding the boxes, overloading of the containers, types of board used in the container or a combination of these factors.

Objectives

The objectives of this study were to determine the effects of humidity and flute size on the top-load compression strength of a corrugated container and to possibly find a more realistic compression test for corrugated containers. A test that would: 1.) more closely approximate the conditions of long duration dead loads; 2.) not require a large number of samples; 3.) be easy to analyze statistically.

The standard ASTM compression test requires that the load be applied with a continuous motion of the movable head of the testing machine, at a speed of 0.5 in. per min., until failure and maximum load or either has been reached (1). This static loading of the container does not take into account the effects of creep or fatigue encountered in compressive loads of longer duration, such as occur in warehouse stacking (3). The test procedure developed for this study, was designed to include the effect of fatigue that occurs over a long period of time. Fatigue of this type, is defined as stress variations that occur continuously over a relatively long period of time (5). For the purposes of this study, it can be pictured as a ratio of a load to the strength of the container. As time passes, this ratio will increase. In other words, the effect of time and load decreases the strength of the container and therefore this effect will increase with a longer period of time. In many cases, the fatigue strength of a container is less than the dynamic yield strength. It can be assumed, that the omission of the effect of fatigue will give a somewhat false impression of the corrugated container.

The test method used in this study is original, incorporating a series of dead loads which are applied to a corrugated container for a specified length of time. The data that is obtained from such a test is simply the deflection, at a dead load, over a specified period of time. Dividing the deflection by the time, produces a value in inches per minute. Therefore, for a specified load, flute size and humidity, a rate of deflection is obtained. This can be used as the criteria for judging the strength of the corrugated container. In other words, a high rate of deflection would indicate a container of low compression strength and a low rate of deflection would show a high compression strength.

Previous Work

A study was made, at the Forest Products Laboratory, to determine the safe stacking life of corrugated containers. This study involved a dead load, various controlled atmospheres and two different kinds of corrugated board. The load was applied by using weights and was left until the container failed. The following is quoted from this study:

"The behavior of the corrugated boxes subjected to various dead loads appeared to follow a general pattern that may be described by the reactions during three distinct periods of time. The first period, in which there was a rapid compression of the boxes, resulted from the initial application of the load and started the instant the load contacted the box. Some of the rapid compression can be attributed to flattening of the rounded portion of the score along the horizontal edges of the box, together with a general leveling of the surfaces. The rapid compression continued but at a decreasing rate, for a comparatively short period of a few seconds to 1 to 2 hours, with a rather abrupt transition into the second period. The compression during the second period continued at a uniform but much slower rate. It had been observed that when in the third period the rate of compression again increased, failure was imminent and occurred as compression in creased more and more rapidily"(3).

Although the last two periods of reaction were experienced in this experiment, the first period was not noticed. It probably occurred while attaining the initial load and hence was not detected.

Two significant conclusions came out of the study made by the Forest Products Laboratory. These were: 1.) for the conditions considered in the study, increases of moisture content reduced the time a box could sustain a dead load, and for it to remain in a stack for a specific period would necessitate a reduction in the magnitude of the dead load; 2.) the influence of moisture content on the compressive strength of corrugated fibreboard boxes was found to be about the same for the different kinds of board included in this study.

These two conclusions and the three reaction periods seem to be the only basis for comparing the results of the procedure used in the present study with those obtained by the standard test methods. Of course, this will not show which is a better compression test, if there is a better test, but it should give enough information to make a comparison of the two.

II. EXPERIMENTAL PROCEDURE

Sample Containers

Size. The container size was held constant at 10" x 8" x 8". The reason for using a container of this size was to assimilate a size structure that is practical. A corrugated container with a depth less than eight inches shows a high structural strength and therefore the differences between the tested variables would be less (4). Other reasons, were to facilitate use of the testing machine, the humidity cabinet and also the available gluing blocks.

Material. The corrugated containers were made from double-face 200 pound test boxard, with the board varying in flute size. The A and B flute board was obtained from Twin Cities Container Corporation and the C flute from the M. S. U. Packaging Laboratory. The manufacturers joint was taped using a four inch fibreglass reinforced kraft tape. A casein adhesive was used for sealing the top and bottom flaps. The material makeup was the same for all types of board tested. This board was 42# - 26# - 42#.

Preparation

The corrugated containers were sealed in accordance with the method described in the ASTM standards. The face of the box was sealed as follows: A board similiar in size to that used for the first closure was suspended in the opening of the box. A carriage bolt was then placed so that it extended upward through the center of the board. Next, the short or inner flaps were flexed first outward and then inward, and finally brought to rest on the board and given a coating of glue. Then the longer or outer flaps were flexed outward and inward and brought to rest on the glued surfaces. Pressure was applied by slipping a second board down over the bolt, and tightening the nut to draw the two boards together, thus holding the glued joint until it set (1).

The A and B flute container blanks were cut by the supplying company. The C flute container blanks were made on the department sample table using the normal sample making procedure. The style of the container was of the regular slotted type.

Test Method.

Design. A total of 36 corrugated containers were tested. The tests were run in four series. Each series consisted of nine test containers, conditioned at a particular relative humidity. The nine samples consisted of three containers each of A, B and C flute board. The four series consisted of nine samples at 30%, 50%, 70% and 90% relative humidities respectively.

Humidity Control. The relative humidities of 30%, 70% and 90% were obtained by using the Blue - M Counter Flow Relative Humidity Cabinet (Model CP770H) in the Forest Products building which is located about a block away from the testing apparatus. Because of this, the test specimen had to be placed in a polyethylene bag to preserve the desired humidity. The sample was also tested in the polyethylene bag so as to insure a constant humidity over the period of time required for the test. The polyethylene bag was conditioned along with the test specimens. The Packaging Laboratory conditioning room was used for the tests at standard conditions (50% relative humidity and 73° F). The specimens were placed on a fluted piece of corrugated board so they would be properly conditioned.

The four humidities were controlled within plus or minus two percent. The length of time that the specimens were exposed was approximately 20 hours.

Transfer of Samples. Each sample was taken from the humidity cabinet and placed in a pre-conditioned polyethylene bag. The seal on the bag was made by twisting and doubling over the polyethylene and securing with a rubber band. The enclosed sample was then moved to the compression testing machine. The approximate time of transfer was about two minutes. The time of transfer plus the time required to run the tests was approximately 45 minutes. All the testing was done in a room conditioned at 50% relative humidity and 73°F. Therefore, the outside conditions for testing were always 50% relative humidity. However, the outside conditions during the time of transfer varied from 30% to 95% relative humidity. It would seem that this would be sufficient time for the sample to gain or lose moisture. A weight check was made on three samples from each series. The results showed there was not a significant loss or gain of moisture.

Compression Tests. The apparatus used for the dead load compression tests was the Baldwin - Emery SR-4 Testing Machine (Model FGT) and the attached stress - strain recorder which is shown in Figures 1 and 2. As stated previously, the tests were run in four series, with each series containing nine samples. The nine samples were run in succession until completion of the series.

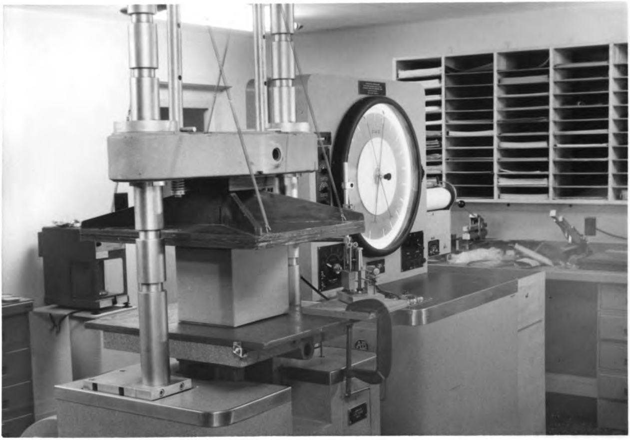

Figure 1

Baldwin-Emery SR-4 - Testing Machine (Model FGT)

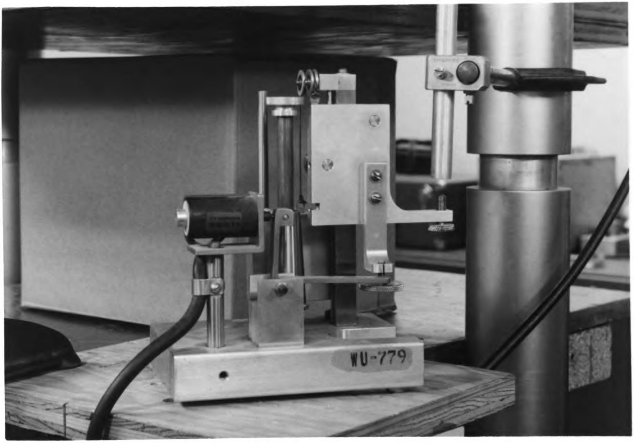

Figure 2

Baldwin Stress-Strain Recorder (Model MA1B)

The machine settings, used for these tests, are as follows:

Load Range..........1000 lbs.

Upper Limit...95% Lower Limit...-10%

Platen Speed........0.008 to 0.8 in./min.

Deflectometer x Magnifier...200 magnification

Recorder Range..........half range

Rate of Loading.........50 lbs./min.

Platen Stops..........1 in. and 12 in.

The sample was placed between the two auxiliary wooden platens and a load was applied at a rate of 50 pounds per minute until 400 pounds was reached. The rate of loading was determined by a load pacer built in the compression machine. When 400 pounds was reached, the recorder pen was engaged and the load was held at 400 pounds for a period of 5 minutes. The timing was done by manual operation of the speed control. The manual operation of the testing machine required varying the speed of the machine so that a load could be held as the deflection per minute of the sample varied. The load was held within plus or minus 2 pounds which is a one-half percent error at 400 pounds. At the end of the five minute interval, the load was increased to 450 pounds and again held for five minutes. This procedure

was repeated by adding increments of 50 pounds until a 500 pound load was reached. Then 25 pound increments were used until the sample failed. However, for the higher relative humidities the range of dead loads had to be changed to facilitate the use of the defectometer. For example, at 90% relative humidity the loads started at 200 lbs. and not at 400 lbs. If the sample failed before the five minute interval was completed, the failure was indicated on the load dial and the stopwatch was stopped, noting the elapsed time. From this an inches per minute deflection can be calculated for the failure point. After testing, the sample was coded for flute size, humidity and replication. For example, A-90-2 would mean the second A flute container tested at 90% relative humidity.

The test procedure just described was not based on the failure of the container. Rather, it was based on a rate of deflection at a given load. By using this method, it was hoped that a more definite picture of the effect of compression on a corrugated container could be obtained. A series of 9 containers, similiar to the ones used in this experiment, were also tested by the Standard ASTM Compression Method. The failure point of these containers varied as much as 250 pounds using the ASTM test. The variations, resulting from the test method developed for the present study, ranged from a maximum of 75 lbs. to zero at failure. This certainly doesn't mean that one test is better than the other as the number of samples tested using the ASTM method was not statistically large enough. However, this may be indicative of further work in comparing the two methods.

Using the new method allows one to obtain a significant amount of data from a relatively small number of test samples and this data easily lends itself to statistical interpretation. However, the time required for testing is quite lengthy and the machine must be continually watched so as to hold the load. It was also necessary to alter the speed control so that the moveable platen could be stopped using this control; this was necessary to hold the load.

III. ANALYSIS OF DATA

Dead Load Compression Test Results

Tables I thru XII show the results in deflection per minute of the various static loads. Also noted, is the static load at which the container failed. Of course, not all the specimens will show a failure load simply because the load at failure occurred above the range that was used for the statistical analysis.

Where the load at failure was below the maximum value in the analysis range, a maximum deflection value was entered in the table for this sample. It can be assumed that after failure the deflection of the container is infinite. Therefore, if the deflection value obtained at failure is used, it represents the minimum deflection value at the load in question. For example, the static loads used for statistical analysis ranged from 400 lbs. to 550 lbs. at 30% and 50% relative humidity. This would include static loads at 400, 450, 500, 525, and 550 pounds for each sample. Suppose the deflection readings went as follows:

	400 lbs..........0.0010 in/min.
	450 lbs..........0.0025 in/min.
Failure	500 lbs..........0.0080 in/min.

It can be seen that the container failed before the desired static loads were reached. So that a statistical analysis could be made, the following additions to the table were made:

400 lbs..........0.0010 in/min.
450 lbs..........0.0025 in/min.
500 lbs..........0.0080 in/min.
525 lbs..........0.0080 in/min.
550 lbs..........0.0080 in/min.

In other words, the deflection after failure should be at the very least the deflection at failure. Tables XIII and XV give the average values for the three test variables.

TABLE I

Static Compression Results

Load - Deflection

	FLUTE A - HUMIDITY 30		
	Load Applied	Deflection Units *	Deflection In./Min.
Rep. 1	400 450 500 525 550	12 14 23 20 25	0.0012 0.0014 0.0023 0.0020 0.0025
Rep. 2	400 450 500 525 550	20 22 29 11 17	0.0020 0.0022 0.0029 0.0011 0.0017
Rep. 3	400 450 500 525 550	19 11 13 10 13	0.0019 0.0011 0.0013 0.0010 0.0013

* Units in .0005 inch

TABLE II

Static Compression Results

Load - Deflection

	FLUTE B - HUMIDITY 30		
	Load Applied	Deflection Units *	Deflection In./Min.
Rep. 1	400	19	0.0019
	450	15	0.0015
	500	19	0.0019
	525	25	0.0025
	500	19	0.0019
Rep. 2	400	14	0.0014
	450	12	0.0012
	500	14	0.0014
	525	9	0.0009
	F - 550	82	0.0098
Rep. 3	400	18	0.0018
	450	10	0.0010
	500	10	0.0010
	525	6	0.0006
	550	6	0.0006

F Indicates failure

* Units in .0005 inch

TABLE III

Static Compression Results

Load - Deflection

	FLUTE C - HUMIDITY 30		
	Load Applied	Deflection Units *	Deflection In./Min.
Rep. 1	400	19	0.0019
	450	15	0.0015
	500	14	0.0014
	525	10	0.0010
	550	80	0.0080
Rep. 2	400	18	0.0018
	450	14	0.0014
	500	24	0.0024
	525	12	0.0012
	550	12	0.0012
Rep. 3	400	11	0.0011
	450	10	0.0010
	500	13	0.0013
	525	9	0.0009
	550	9	0.0009

* Units in .0005 inch

TABLE IV

Static Compression Results

Load - Deflection

	FLUTE A - HUMIDITY 50		
	Load Applied	Deflection Units *	Deflection In./Min.
Rep. 1	400 450 500 525 500	12 16 25 27 18	0.0012 0.0016 0.0025 0.0027 0.0018
Rep. 2	400 450 500 525 500	11 9 30 38 26	0.0011 0.0009 0.0030 0.0038 0.0026
Rep. 3	400 450 500 525 500	11 15 24 16 18	0.0011 0.0015 0.0024 0.0016 0.0018

* Units in .0005 inch

TABLE V

Static Compression Results

Load - Deflection

	FLUTE B - HUMIDITY 50		
	Load Applied	Deflection Units *	Deflection In./Min.
Rep. 1	400	9	0.0009
	450	11	0.0011
	500	27	0.0027
	F - 525	53	0.0086
	500		0.0086
Rep. 2	400	28	0.0028
	450	15	0.0015
	500	66	0.0066
	F - 525	62	0.0182
	550		0.0182
Rep. 3	400	14	0.0014
	450	9	0.0009
	500	10	0.0010
	525	11	0.0011
	F - 550	120	0.0146

F Indicates failure

* Units in .0005 inch

TABLE VI

Static Compression Results

Load - Deflection

	FLUTE C - HUMIDITY 50		
	Load Applied	Deflection Units *	Deflection In./Min.
Rep. 1	400 450 500 525 550	10 10 11 7 12	0.0010 0.0010 0.0011 0.0007 0.0012
Rep. 2	400 450 500 525 550	12 11 13 15 35	0.0012 0.0011 0.0013 0.0015 0.0035
Rep. 3	400 450 500 525 550	22 11 12 9 10	0.0022 0.0011 0.0012 0.0009 0.0010

* Units in .0005 inch

TABLE VII

Static Compression Results

Load - Deflection

	FLUTE A - HUMIDITY 70		
	Load Applied	Deflection Units *	Deflection In./Min.
Rep. 1	400 F - 450 500 525	36 124	0.0036 0.0288 0.0288 0.0288
Rep. 2	400 450 500 F - 525	22 27 59 220	0.0022 0.0027 0.0059 0.0275
Rep. 3	400 450 F - 500 525	34 41 24	0.0034 0.0041 0.0300 0.0300

F Indicates failure

* Units in .0005 inch

TABLE VIII

Static Compression Results

Load - Deflection

	FLUTE B - HUMIDITY 70		
	Load Applied	Deflection Units *	Deflection In./Min.
Rep. 1	400 F- 450 500 525	19 28	0.0019 0.0181 0.0320 0.0320
Rep. 2	400 F- 450 500 525	19 47	0.0019 0.0181 0.0320 0.0320
Rep. 3	400 F- 450 500 525	22 141	0.0022 0.0320 0.0320 0.0320

F Indicates failure

* Units in .0005 inch

TABLE IX

Static Compression Results

Load - Deflection

	FLUTE C - HUMIDITY 70		
	Load Applied	Deflection Units *	Deflection In./Min.
Rep. 1	400	21	0.0021
	450	35	0.0035
	500	84	0.0084
	F- 525	47	0.0261
Rep. 2	400	24	0.0024
	450	25	0.0025
	500	67	0.0067
	F- 525	13	0.0108
Rep. 3	400	17	0.0017
	450	14	0.0014
	500	23	0.0023
	525	46	0.0046

F Indicates failure

* Units in .0005 inch

TABLE X

Static Compression Results

Load - Deflection

	FLUTE A - HUMIDITY 90		
	Load Applied	Deflection Units *	Deflection In./Min.
Rep. 1	250	21	0.0021
	300	19	0.0019
	350	30	0.0030
	400	80	0.0080
Rep. 2	250	29	0.0029
	300	24	0.0024
	350	80	0.0080
	F- 400	30	0.0600
Rep. 3	250	31	0.0031
	300	32	0.0032
	350	102	0.0102
	F- 400	63	0.0630

F Indicates failure

* Units in .0005 inch

TABLE XI

Static Compression Results

Load - Deflection

	FLUTE B - HUMIDITY 90		
	Load Applied	Deflection Units *	Deflection In./Min.
Rep. 1	250 300 F- 350 400	25 31 119	0.0025 0.0031 0.0119 0.0119
Rep. 2	250 300 F - 350 400	21 25 85	0.0021 0.0025 0.0212 0.0212
Rep. 3	250 300 350 F - 400	22 19 136 27	0.0022 0.0019 0.0136 0.0180

F Indicates failure

* Units in .0005 inch

TABLE XII

Static Compression Results

Load - Deflection

	FLUTE C - HUMIDITY 90		
	Load Applied	Deflection Units *	Deflection In./Min.
Rep. 1	250	29	0.0029
	300	82	0.0082
	F- 350	90	0.0187
	400		0.0187
Rep. 2	250	27	0.0027
	300	26	0.0026
	350	38	0.0038
	F - 400	78	0.0410
Rep. 3	250	32	0.0032
	300	26	0.0026
	350	57	0.0057
	F- 400	60	0.0273

F Indicates failure

* Units in .0005 inch

TABLE XIII

Summary Of Test Results

Average Deflection In Inches/Minute

30% And 50%

Relative Humidity

Flute Size	A	18.6 *
	B	39.2
	C	15.7
Load	400	15.4
	450	13.9
	500	21.4
	525	27.3
	550	44.5
Humidity	30%	18.3
	50%	30.7

* Times 10^{-4}

TABLE XIV

Summary of Test Results

Average Deflection in Inches/Minute

70% Relative Humidity

Flute Size	A B C	163.2 * 221.8 60.4
Load	400 450 500 525	23.8 123.6 197.7 248.7

* Times 10^{-4}

TABLE XV

Summary Of Test Results

Average Deflection In Inches/Minute

90% Relative Humidity

Flute Size	A	139.8 *
	B	93.3
	C	114.5
Load	250	26.3
	300	31.6
	350	106.8
	400	299.0

* Times 10^{-4}

Techniques and procedures used in the statistical analysis are found in references (2), (7), and (8). Tables XVI thru XVIII show the results of the various analyses.

Three separate analyses of variance were carried out on the test data. The original plan was to make an analysis by using a three-way classification that included all the test data. After reviewing the results, it was decided that the data at 70% and 90% relative humidity, were too large to analyse with the data at 30% and 50% relative humidity. These extremes in values would produce a large error term which in turn would lead to a possible misinterpretation of the data if this error term were used as the basis for an F test. In addition, is the fact that due to the effect of humidity at 70% and 90% relative humidity the dead load had to be lower so as to facilitate the use of the recording devices. For example, the static load range at 90% includes 250 lbs, 300 lbs, 350 lbs, and 400 lbs while the range at 30% and 50% starts at 400 lbs and ends at 550 lbs. Because of these obvious differences in humidities it can be said that the detrimental effect of humidity on a corrugated container is significantly greater at 90% relative humidity than at 70% relative humidity and also significantly greater at 70% relative humidity than at 30% and 50%.

The first analysis of variance was a three way classification that included flute size (A, B and C), humidity (30% R. H. and 50% R. H.) and dead load (400 lbs, 450 lbs, 500 lbs, 525 lbs, and 550 lbs) as the variables. The final analysis of this data showed the three-way interaction of flute size x humidity x load to be significantly different from the error term. Also, there was no significant difference between the three-way interaction and the three two-way interactions; humidity x flute size, humidity x load, and flute size x load. This is an ideal situation because it enables one to test the averages of all the variables using an error term that is basic to each one. However, using the three-way in teraction mean square as the error term did not prove as ideal as was first expected. Testing the variables humidity, flute size, and load, using the three-way interaction, the F test showed no significance within the variables (8). Usually at this point, the problem is not pursued any further because of the non-significant F values. However, on examining the averages of the three deferent flutes, the two humidities and the five dead loads, it was found that there seemed to be an extreme average in each case. For example, the

TABLE XVI

Analysis of Variance
for
30% Humidity and 50% Humidity

All Flute Sizes All Loads

	Sum of Squares	Degrees of Freedom	Mean Square
Total	92278	89	
Humidity	3472	1	3472
Flute Size	9856	2	4928
Load	11012	4	2753
Humidity x Flute	8272	2	4136
Humidity x Load	4050	4	1013
Flute x Load	15427	8	1928
Humidity x Flute x Load	9118	8	1140
Error	31071	60	518

F(8, 60, .05) = 2.10

averages for the flute sizes were: A = 18.63, B = 39.90, and C = 15.67. In this case, the extreme is the B flute average. As was mentioned previously, the F test showed there was no difference between A, B, or C flutes. The averages seemed to indicate there was a significant difference. It was decided to use an accepted test for significance that could be applied to the various averages even though the F test showed no significance. A test developed by Mr. K. R. Nair was used (7). Using the appropriate tables and this test, it was found that there actually was a significant difference in flute size, but there was no difference in loads or humidities.

The second analysis of variance was a two-way classification using the data at 70% relative humidity. The two effects or variables were flute size (A, B, and C) and dead loads (400 lbs, 450 lbs, 500 lbs, and 525 lbs). The error mean square was not significantly different from the two-way interaction flute size x load. Therefore, the two were combined to form a new error term. This combined error mean square was used to test the main effects for significance. Both the flute size and the dead load showed significance. Therefore, the averages of each main effect or variable were tested

TABLE XVII

Analysis of Variance for 70% Humidity

All Flute Sizes All Loads

	Sum of Squares	Degrees of Freedom	Mean Square	F Score
Total	600555	35		
Flute Size	160219	2	80110	13.17**
Load	257854	3	85951	14.13**
Flute x Load	62451	6	10409	
Error	120031	24	5001	
Combined Error	182482	30	6083	

** highly significant

using the studentized range table. It was found that there was a significant difference between C and A flute and C and B flute, but there was no difference between A and B flute. C flute was significantly lower and therefore, exhibited more strength according to this test. The dead loads also showed a difference with the loads 450 lbs, 500 lbs, and 550 lbs being greater than 400 lbs. These same loads showed no difference within themselves.

The third analysis of variance was a two-way classification using the data at 90% relative humidity. The two main effects or variables were flute size (A, B, and C) and dead loads (250 lbs, 300 lbs, 350 lbs, and 400 lbs). As in the analysis at 70% relative humidity, a combined error term was used. Using the combined error mean square as our error term, the F test showed the flute size to be non-significant. The dead load showed significance in that the dead load at 400 lbs was significantly larger than the loads at 250 lbs, 300 lbs, and 350 lbs.

TABLE XVIII

Analysis of Variance for 90% Humidity

All Flute Sizes All Loads

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Score
Total	802021	35		
Flute Size	12963	2	6482	0.56
Load	438705	3	146235	12.52**
Flute x Load	106216	6	17703	
Error	244137	24	10172	
Combined Error	350353	30	11678	

** highly significant

IV. CONCLUSIONS

1. The harmful effect of humidity on the compression strength of a corrugated container is significantly greater at 90% relative humidity than at 70% relative humidity and also significantly greater at 70% relative humidity than at 30% relative humidity and 50% relative humidity. There was not a significant difference between 30% relative humidity and 50% relative humidity. Therefore, at higher humidities, the stacking life of corrugated containers becomes considerably less.
2. Containers of C flute construction statistically proved to be stronger than A and B flute containers when tested at 70% relative humidity. It also should be noted that the trend of the C flute averages show C flute construction to be stronger across all the tests. On the other hand B flute construction was significantly weaker than A flute and C flute construction at 30%, 50%, and 70% relative humidities.
3. As was expected, an increase in the dead load increased the rate of deflection. However, in a few instances, the box shows periods of reinforcement where the rate of deflection actually decreased with an increase in the dead load.

4. Due to the large error terms in the statistical analysis, one set of variables showed non-significant differences when actually they were significant. This is due to the wide range of test values.
5. Using a basis for evaluation previously mentioned, this test procedure seems to compare favorably with previous dead-load compression testing methods.

V. SUGGESTIONS FOR FURTHER WORK

Compare this test procedure with the ASTM method by collating the stress - strain curves obtained from each method. This should show the difference between the effect of the dead load and the static load.

Using the same variables and conditions, find a correlation between an actual long duration dead load test and the test procedure used in this study.

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