

EFFECT OF SIZE AND SHAPE OF SPECIMEN ON THE TENSILE STRENGTH OF FIBERBOARDS

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EFFECT OF SIZE AND SHAPE OF SPECIMEN
ON THE TENSILE STRENGTH OF FIBERBOARDS

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Summary

Tension-parallel-to-surface tests were made on six different building boards using four specimens of different shapes for each board to obtain a comparison of results of test for the different specimens with the intent of arriving at a recommended standard specimen for this strength property. One type of specimen had a uniform cross section, as presently required by Federal Specification, and the other three types were "necked down" specimens. One conformed to American Society for Testing Materials Tentative Standard C209-46T, and the other two types were variations of the A.S.T.M. Standard.

These tests showed that, in general, the strength values obtained from the specimens of uniform section (type A, fig. 1) were lower than the values obtained from the other types of specimens because concentrations of stress or crushing at the grips caused most of the failures to occur in the area adjacent to the grips. The strength values obtained from the other types of test specimen were essentially the same indicating that the most satisfactory specimen would be the one with the largest area in tension consistent with good testing techniques and limited by commercially available testing equipment.

Therefore the specimen recommended, a variation of the present A.S.T.M. standard, is 10 inches long, 2 inches wide at the grips, and has a reduced center section 1-1/2 inches wide and 2 inches long. It is designated Type D and is detailed in figure 1. Since it is only 2 inches

¹Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

wide, it has the advantage of being adaptable to test with standard self-aligning grips commonly available in this width. Self-aligning grips 3 inches wide, as required in the A.S.T.M. Tentative Standard C209-46T, are considered special and can be obtained only at high cost. The 2-inch wide specimen, referred to as type D in figure 1, is recommended for adoption as a standard for evaluating the tensile strength of building boards.

Introduction

Federal Specifications UU-W-101a "Wallboard, Composition," and LLL-F-321b "Fiberboard; Insulating," have governed the type of test specimen for obtaining tensile strengths of building boards. These specifications require a rectangular specimen at least 10 inches long and 2 inches wide with at least 6 inches between the grips at test. They further require that any test value should be disregarded if the failure of the specimen was within 1/2 inch of the grips. As a result, it has been necessary to "throw out" the values obtained from a majority of tests because of the adverse influence of the grips.

Practically, it has meant that when tests have conformed to the Federal specifications, the tests were of the grips as much as of the material because, unless the material happened to be weaker in the center section than at the grips, the failures of the lower density boards were at the grips. Often the average of the tensile strengths of a group of specimens was higher if the values for the specimens that failed at or near the grips were not culled than if they were culled and the average represented only those specimens that failed in the area away from the grips.

In order to obtain a more representative value and reduce the number of throw outs, the American Society for Testing Materials in a tentative standard "Testing Structural Insulating Board Made from Vegetable Fibers," A.S.T.M. Designation C209-46T, recommended the use of a specimen² 3 inches wide at the grips with a 2-inch long reduced section 2 inches wide.

For the series of tests herein reported, four different types or variations of specimens were selected. The tests were divided into two groups. The first group was composed of specimens from six different boards and three types of specimens were tested as follows:

²This specimen is type C detailed in figure 1.

- (1) Federal Standard, rectangular specimen 2 inches wide and 10 inches long.
- (2) A.S.T.M. tentative standard, 10 inches long, 3 inches wide at the grips with a reduced section 2 inches wide and 2 inches long.
- (3) Variation of A.S.T.M. tentative standard, 10 inches long, 2 inches wide at the grips, with a reduced section 1 inch wide and 2 inches long.

The second group was composed of specimens from four representative building boards.. Two types of specimens were tested as follows:

- (1) A.S.T.M. tentative standard, described in preceding paragraph.
- (2) Variation of A.S.T.M. tentative standard, 10 inches long, 2 inches wide at the grips, with a reduced section 1-1/2 inches wide and 2 inches long.

The second group of tests was made after inquiry to a reliable manufacturer of testing equipment indicated that self-aligning grips 3 inches wide were not a standard size and that grips of this width would cost from \$1,500 to \$2,000 to make on special order. This cost was considered to be almost prohibitive so that it appeared that the most suitable specimen should be 2 inches wide at the grips with a reduced center section as wide as possible but enough smaller than the width at the grips so that the failure was in the center section in practically all instances. The specimen, type D of figure 1, appeared to be the best compromise.

Test Specimens and Method of Matching

The four types of specimens are detailed in figure 1. Type A is required by Federal specifications; type C is the A.S.T.M. recommendation; and types B and D are two modifications of the A.S.T.M. tentative standard with widths at the grips of 2 inches.

In the first group of tests, specimens of types A, B, and C were tested. All specimens from each material were cut from a single piece. The specimens were oriented side by side in each piece with first a type A specimen, next a type B specimen, and then a type C specimen. This order was repeated three times for each material until blanks were prepared for a total of nine specimens (three of each type).

In the second group, specimens of types C and D were prepared and tested. Like the first group all specimens of each material were obtained from the same piece of material. In this group, a total of 12 specimens of each type (C and D) of each material were prepared. The specimens were oriented so that types C and D alternated in the sheets of building boards. Thus close matching of the two types of specimens was accomplished and any errors due to matching were small.

The reduced center section in the specimens was cut with a bandsaw. A sharp saw with limited set to the teeth was used and a satisfactorily smooth edge was obtained. Figure 2 of typical failures shows the type of edge obtained on the different materials.

Method of Test

The specimens were tested in a hydraulic testing machine equipped with Templin type self-aligning grips. Loads were applied to the specimens at a uniform rate of head movement of the testing machine of 0.15³ inch per minute. Maximum loads only were determined, and when divided by the net area gave the unit stress at failure.

Specimens were tested in the prevailing laboratory temperature and humidity. All specimens of each group were stored together until time of test; so the moisture content could not have differed appreciably among specimens from a given material.

Figure 3 shows a typical test set-up for the tension tests of building boards. The self-aligning grips that were used to transmit loads from the testing machine to the specimens are shown.

³A.S.T.M. "Tentative Methods of Testing Plywood, Veneer, and Other Wood and Wood-base Materials" (D805-47) recommends a testing speed of 0.035 inch per minute for plywood and Federal specifications and the aforementioned ASTM C209-46T require 2 inches per minute. The first is too slow; it may require as much as 25 minutes to perform a single test. The second is too fast to obtain an accurate measurement of maximum load for most testing machines, tests being completed in 6 to 9 seconds. A testing machine speed of 0.15 inch per minute required from 2 to 6 minutes, depending on the thickness and density of the board, to complete a test. This amount of time is reasonable and compares favorably with the time required for tensile tests of wood.

Presentation and Analysis of Data

The results for the first group of tests are presented in table 1. Only a single moisture content and specific gravity determination was made for each material. These are presented in columns 3 and 4 and are to be considered indicative only. The ultimate tensile strengths as obtained from tests of specimens of types A, B, and C are presented in columns 6, 8, and 10, respectively.

With two exceptions, considerably greater average tensile strengths were obtained from tests of the specimens with a reduced center section than from the tests of the specimens with straight sides (required by Federal Specification). One of these exceptions was the hardboard that had sufficient hardness to resist crushing at the grips. The other exception was insulating board D, where all of the straight-sided specimens failed in the center portion. Whether or not this particular group of specimens was proportionately weaker in the center than nearer the ends is not known. Also the unit stresses for each material as obtained from the tests of specimen types B and C were essentially equal.

Further, nine of the straight-sided specimens failed within 1/2 inch of the grips, which would necessitate the rejection of 50 percent of the test values for the straight-sided specimens in order to conform to Federal specifications. It has been observed also that sometimes the average tensile strengths obtained from this specimen are lower if the test values for specimens failing near the grips are culled than if they are included in the average. Tests in this series also confirm this observation and indicate that some other type than the straight-sided specimen is preferred. Because twice as much material is represented in specimen type C as in specimen type B, more uniform results would ordinarily be expected, and one would naturally recommend specimen type C. Economics and good testing techniques, however, further complicate the decision because of the prohibitively high cost of 3-inch wide self-aligning grips.

Therefore, a compromise specimen (type D) with a reduced section 1-1/2 inches wide and a width at the grips of 2 inches was designed. The series of tests in the second group was made on the two types (C and D) to determine whether or not comparable values would be obtained. The results of the tests in this group are presented in table 2. The ultimate tensile strengths as obtained by these two types of specimens are presented in columns 5 and 7. Examination of these values will show that almost exactly the same values were obtained by either type of specimen. Further, what little difference there was cannot be considered significant.

The coefficients of variation calculated for each set of data indicate that average values obtained from either type of specimen are of comparable quality. These coefficients are tabulated below:

<u>Material</u>	<u>Coefficients of Variation</u>	
	<u>Type C</u>	<u>Type D</u>
	<u>Percent</u>	<u>Percent</u>
Hardboard	5.6	6.8
Insulating board A	6.4	5.3
Insulating board C	8.7	8.1
Insulating board E	3.0	2.7

Only one specimen of type D failed in the area adjacent to the grips, which indicates that the specimen has enough reduction in cross section to induce failure to occur elsewhere than at the grips in practically all cases; so it should be satisfactory.

Conclusions

Because a substantial portion of the straight-sided specimens (prescribed in Federal specifications for fiberboards) failed within 1/2 inch of the grips, and because the ultimate strength values obtained from the use of this type of specimen were generally considerably lower than those obtained from tests of specimens with a reduced section, it appears that a specimen with a reduced center section should be used for the determination of tensile strengths of building boards.

Comparative tests of the three different types of specimen with a reduced center section indicated that comparable values could be obtained from any of the specimens. Judgment indicated that the most satisfactory specimen would be the one with the greatest width in the reduced section but with sufficiently greater width at the grips so that failure would not occur in the area adjacent to or at the grips.

Standard grips are limited to 1 or 2 inches in width. Grips wider than 2 inches would have to be made on special order and would have almost a prohibitively high cost; so it appeared desirable to have a width of specimen of 2 inches. Therefore specimen type D, 2 inches wide at the grips with a reduced section 1-1/2 inches wide and 2 inches long, seemed to be the best compromise. The comparative tests between this specimen and the one presently recommended by A.S.T.M. (type C, 3 inches wide at the grips with a reduced section 2 inches wide and 2 inches long) on four representative boards showed almost identical ultimate strengths. Specimen type D, therefore, is recommended for adoption as a standard for obtaining tensile strengths parallel to the surface of building boards.

Table 1.-Comparison of tensile strengths of specimen types A, B, and C for building boards¹

Material ²	Nominal thickness	Approximate moisture content ³	Approximate specific gravity ⁴	Type "A" specimens ⁵		Type "B" specimens ⁵		Type "C" specimens ⁵		Remarks
				Specimen number	Ultimate tensile strength	Specimen number	Ultimate tensile strength	Specimen number	Ultimate tensile strength	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Hardboard	1/4	4.4	2.04	M-A-1 4 7	3,800 3,860 3,890	M-B-2 5 8	3,680 3,540 4,410	M-C-3 6 9	3,890 3,890 4,400	Type "A" specimen failed 3/4 inch from grip. Type "A" specimen failed at grip. (Type "A" specimen failed at grip. (Type "C" specimen failed in transition section.
Average					3,850		3,680		4,040	
Insulating board A	3/4	8.0	.27	P-A-1 4 7	234 229 219	P-B-2 5 8	253 266 267	P-C-3 6 9	277 279 274	Type "A" specimen failed 1/2 inch from grip. Type "A" specimen failed at grip. Type "A" specimen failed 1/2 inch from grip.
Average					227		269		277	
Insulating board B	1/2	9.4	.34	P-A-1 4 7	252 204 268	P-B-2 5 8	282 274 283	P-C-3 6 9	291 275 285	Type "A" specimen failed 1 inch from grip. Type "A" specimen failed at grip. Type "A" specimen failed 1/2 inch from grip.
Average					268		273		284	
Insulating board C	1/2	6.5	.42	E-A-1 4 7	460 475 457	E-B-2 5 8	492 516 498	E-C-3 6 9	494 520 497	Type "A" specimen failed 1/2 inch from grip.
Average					464		502		504	
Insulating board D	1/2	5.5	.27	O-A-1 4 7	214 193 172	O-B-2 5 8	225 164 205	O-C-3 6 9	206 168 210	Type "A" specimen failed at grip. (Type "C" specimen failed in transition section.
Average					193		195		195	
Wood-mastic board	3/4	6.1	.44	PL-A-1 4 7	170 201 304	PL-B-2 5 8	205 355 350	PL-C-3 6 9	297 338 337	(Type "A" specimen failed at grip. (Type "C" specimen failed in transition section. Type "C" specimen failed at grip.
Average					255		297		324	

¹The three types of specimens used in this comparison are detailed in figure 1. Load was applied to the specimens at a uniform rate of bend movement of the testing machine of 0.15 inch per minute.

²Only a single sample of each material was used; hence, the test values are not to be considered representative of all material of each type. They were chosen merely to evaluate the test method.

³Only one moisture content and specific gravity determination was made for each material; hence, these values are only approximate.

⁴Type "A" specimens had a uniform cross section (2 inches wide) and conformed to that required by Federal Specifications.

⁵Type "B" specimens had a reduced cross section 1 inch wide and 2 inches long. The width at the grips was 2 inches.

⁶Type "C" specimens had a reduced cross section 2 inches wide and 2 inches long. The width at the grips was 3 inches, and conformed to that required by A.S.T.M. standard C209-46g.

Table 2.--Comparison of tensile strengths of specimen types C and D for building boards¹

Material ²	Nominal thickness	Approximate moisture content	Type "C" specimens ³		Type "D" specimens ⁴		Remarks	
			Specimen number	Ultimate tensile strength	Specimen number	Ultimate tensile strength		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
	Inch	Percent		P.s.i.		P.s.i.		
Hardboard	1/4	3.4	M-C-10	4,780	M-D-11	4,740		
			12	4,650	13	4,790		
			14	4,850	15	5,020		
			3.4	16	4,270	17	4,730	
				18	4,910	19	4,350	
				20	4,260	21	3,800	
			3.8	23	4,220	22	4,800	
				25	4,540	24	4,660	
			3.3	27	4,660	26	4,240	
				29	4,620	28	4,390	
			3.8	31	4,780	30	4,600	
				33	4,270	32	4,820	
	Average.....		3.5		4,570		4,580	
Insulating board A	3/4	5.7	B-C-10	294	B-D-11	292		
			12	297	13	264		
			14	283	15	282		
			5.5	16	264	17	243	
				18	281	19	263	
				20	255	21	251	
			5.3	23	297	22	281	
				25	266	24	270	Specimen type D failed at grip.
			5.8	27	285	26	269	
				29	256	28	278	
				31	280	30	276	
				33	246	32	255	
	Average.....		5.6		275		269	
Insulating board C	1/2	7.0	H-C-10	517	H-D-11	458		
			12	429	13	452		
			14	462	15	510		
			6.6	16	522	17	518	
				18	528	19	515	
				20	528	21	498	
			7.0	23	435	22	486	
				25	418	24	418	
			6.7	27	455	26	446	
				29	449	28	441	
				31	455	30	457	
				33	452	32	406	
	Average.....		6.8		471		467	
Insulating board B	1/2	6.2	O-C-10	208	O-D-11	202		
			12	194	13	204		
			14	198	15	205		
			6.2	16	207	17	196	
				18	205	19	198	
				20	201	21	193	
			6.0	23	199	22	196	
				25	205	24	204	
			5.9	27	191	26	208	
				29	209	28	213	
				31	206	30	199	
				33	210	32	202	
	Average.....		6.1		203		202	

¹The two types of specimens used in this comparison are detailed in figure 1. Load was applied to the specimens at a uniform rate of head movement of the testing machine of 0.15 inch per minute.

²Only a single sample of each material was used; hence, the test values are not to be considered representative of all material of each type. They were chosen merely to evaluate the test method.

³Type C specimen had a reduced cross section 2 inches wide and 2 inches long. The width at the grips was 3 inches.

⁴Type D specimen had a reduced cross section 1-1/2 inches wide and 2 inches long. The width at the grips was 2 inches.

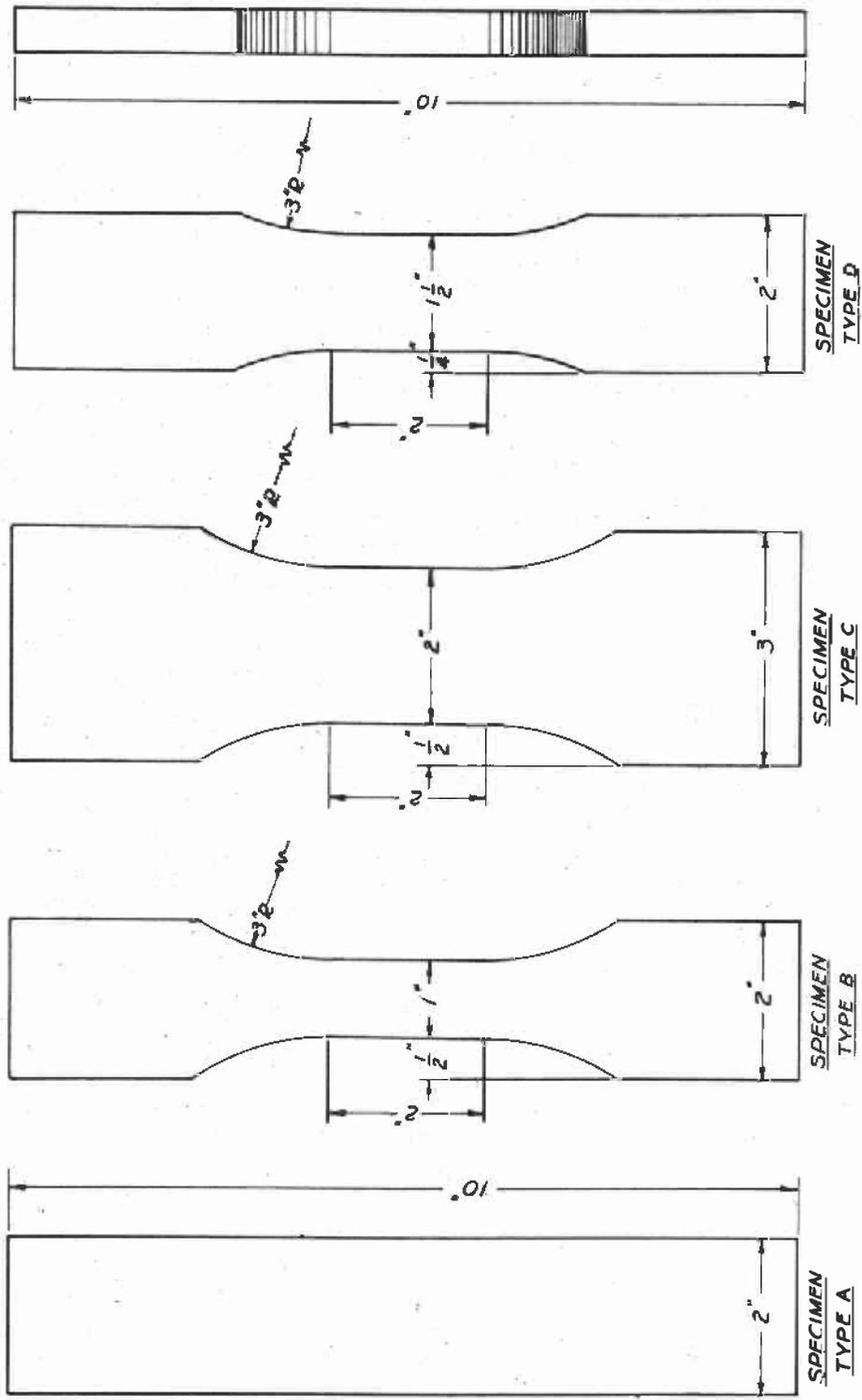


Figure 1.--Detail of specimens for comparative tests of building boards in tension parallel to surface.

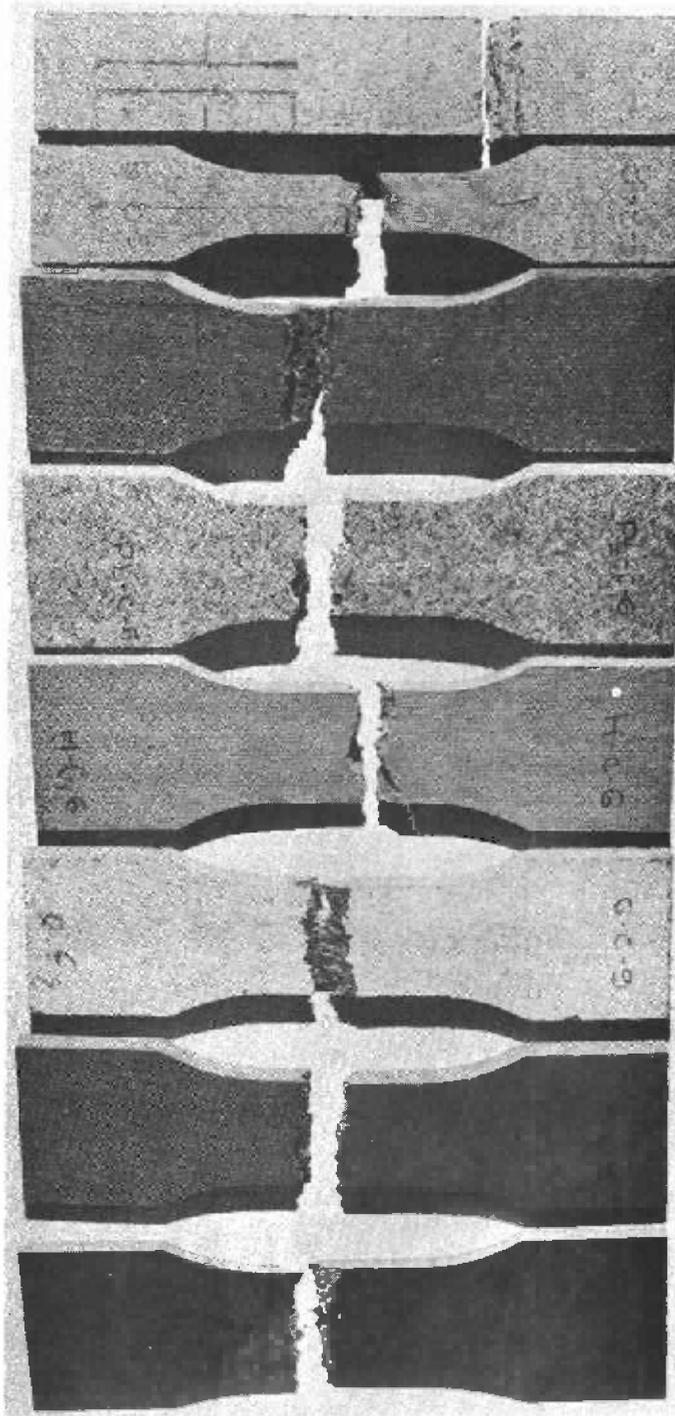


Figure 2.--Typical failures of tensile specimens for building board, showing character of failures and quality of the band-saw cut for the reduced center section for the materials tested.

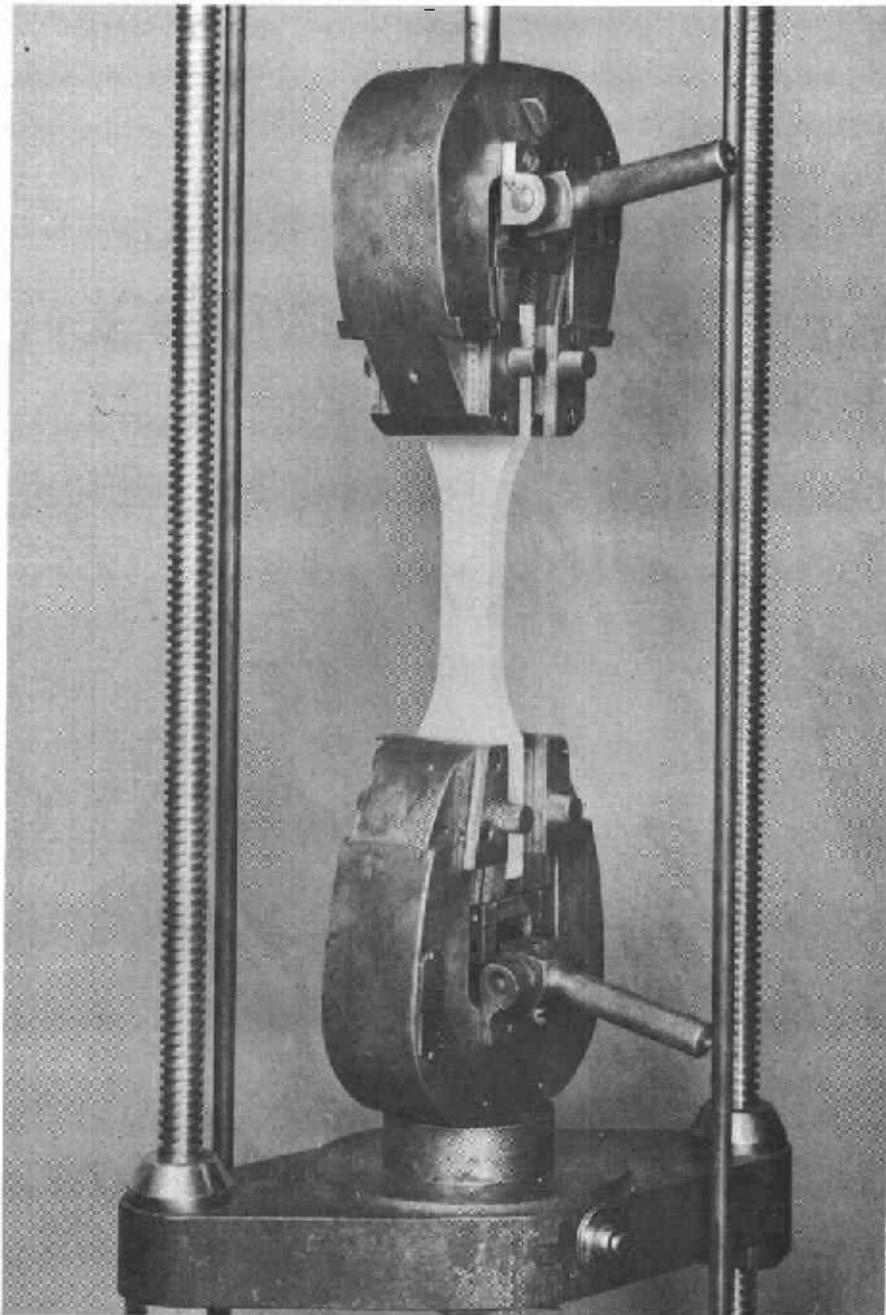


Figure 3.--Test set-up for tensile test of building boards.

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