

# METHODS OF TEST FOR EVALUATING THE PROPERTIES OF FIBER BUILDING BOARDS

Revised May 1949



(Report)

No. R1712



UNITED STATES DEPARTMENT OF AGRICULTURE  
FOREST SERVICE  
FOREST PRODUCTS LABORATORY  
Madison 5, Wisconsin  
In Cooperation with the University of Wisconsin

# METHODS OF TEST FOR EVALUATING

## THE PROPERTIES OF FIBER BUILDING BOARDS

By Forest Products Laboratory<sup>1</sup>, Forest Service  
U. S. Department of Agriculture

----

### Foreword

1. Of the methods of test presented here, some have been in generally accepted use for many years for the evaluation of structural fiber building boards; others are modifications of previous methods or more recent developments. The methods have been extensively used in studies of building boards during the past several years.

### Scope

2. These methods cover procedures for determining the following properties of building boards:

<u>Property</u>	<u>Sections</u>
(a) Size and appearance of boards	7 to 10
(b) Strength properties	
(1) Static bending	11 to 20
(2) Tensile strength parallel to surface	21 to 27
(3) Tensile strength perpendicular to surface	28 to 33
(4) Nail holding --	
Lateral resistance	34 to 39
Direct withdrawal	40 to 46
(c) Moisture tests	
(1) Water absorption	47 to 52
(2) Linear expansion	53 to 56
(d) Accelerated aging	57 to 61
(e) Moisture content and specific gravity	62

### Selection of Test

3. Not all the methods of test herein outlined may be necessary to evaluate any particular board for any specified use. In each instance, therefore, it will be necessary to determine which tests shall be made.

---

<sup>1</sup>Maintained at Madison 5, Wisconsin, in cooperation with the University of Wisconsin.

## Test Specimens

4. The number of specimens to be chosen for test and the method of their selection depend on the purpose of the particular tests under consideration, so that no general rule can be given to cover all instances. With the exception of the nail tests, however, a minimum of three specimens should be tested for each phase of the investigation. For example, a minimum of three specimens shall be prepared with the long dimension parallel to the long dimension of the sheet, and a minimum of three specimens shall be prepared with the long dimension perpendicular to the long dimension of the sheet for test in static bending both in the dry and in the soaked condition. A minimum of six nail-withdrawal tests shall be made for each phase.

## Control of Moisture Content and Temperature

5. The strength properties of building boards depend on the moisture content at time of test. Therefore, when possible, material for test in the dry condition should be conditioned to approximately constant weight and moisture content before test. No tests shall be made when the specimens are undergoing a decided change in moisture content. A temperature of 70° F. with a relative humidity of 65 percent is recommended for conditioning specimens for test in the dry state. This condition corresponds to the standards for wood and wood-base materials. If there is any departure from the above-recommended condition, it shall be so stated.

## Report

6. The report of each test shall include a complete description of the material. The origin, kind, type of test, and any details that might have affected the test shall be noted. When specimens have received any special conditioning prior to test, this shall be stated. Dimensions of the finished specimens shall be given.

## Size and Appearance of Boards

### Size of Finished Board

7. The width of each finished board shall be obtained by measuring the width at each end and at midlength to the nearest 1/16 inch. Likewise, three measurements of the length shall be made, one near each edge and one at midwidth.

### Variation in Thickness

8. For the determination of variations in thickness, specimens at least 8 inches square shall be used. The thickness of each specimen shall be measured

at five points, near each corner and near the center, and the average thickness and the variation in thickness be noted. These measurements preferably shall be made to the nearest 0.001 inch, but in no instance shall they be made to less than the nearest 0.01 inch.

### Specific Gravity

9. Specific-gravity and moisture-content determinations are required on coupons taken from the static-bending test, and the average specific gravity for the bending specimens tested in the dry condition shall be used as the specific gravity of the board. The maximum and minimum values for specific gravity (based on volume at test and weight when oven-dry) shall also be noted.

Note: When it is desired to make specific-gravity determinations independent of any other test, specimens of any convenient size may be selected. These shall be measured, weighed, and dried as outlined in section 62.

### Surface Finish

10. The finish of both surfaces shall be described. A photograph of each surface shall be taken to show the texture of the board. This photograph shall show suitable numbering so that the building board may be properly identified.

## Static Bending

### Scope

11. Static-bending tests shall be made on specimens both in the dry and in the soaked condition. One-half of the test specimens shall be prepared with the long dimension parallel and the other half with the long dimension perpendicular to the long dimension of the board in order to evaluate directional properties.

### Test Specimen

12. Each test specimen shall be 3 inches wide if the thickness is greater than 1/4 inch, and 2 inches wide if the thickness is 1/4 inch or less. The depth (thickness) shall be the thickness of the material. The length of each specimen shall be 2 inches plus 24 times the depth (note). The width and length of each specimen shall be measured to the nearest 0.01 inch and the thickness measured to the nearest 0.001 inch.

Note: Long-span specimens are desired for tests in bending so that the effects of deflections due to shear deformations will be minimized and the values of moduli of elasticity obtained from the bending tests will approximate the true moduli of the materials.

### Specimens Soaked Before Test

13. The specimens to be tested in the soaked condition shall be submerged in water at room temperature for 24 hours before test and shall be tested immediately upon removal from the water.

### Span and Supports

14. The span for each test shall be 24 times the nominal thickness (depth) of the specimen (note 1). The supports shall be such that no appreciable crushing of the specimen will occur at these points during the test. The supports either shall be rounded or shall be knife edges provided with rollers and plates under the specimen at these points. When rounded supports, such as those shown in figure 1, are used, the radius of the rounded portion shall be at least 1-1/2 times the thickness of the material being tested. If the material under test deviates from a plane (note 2), laterally adjustable supports<sup>1</sup> shall be provided.

Note 1: A constant span-depth ratio is required to allow an accurate comparison of test values for materials of different thicknesses.

Note 2: The laterally adjustable knife edges may be necessary for the specimens tested in the soaked condition because of warping or twisting that may occur due to soaking.

### Center Loading

15. The specimens shall be loaded at the center of span with the load applied to the finished face at a uniform rate through a bearing block rounded as is shown in figure 1. The bearing block shall be at least 3 inches wide and shall have a length (parallel to span) equal to twice the radius of curvature of the rounded portion of the loading block. The radius of the rounded portion shall be approximately equal to 1-1/2 times the thickness of the specimen.

### Speed of Testing

16. The load shall be applied continuously throughout test at a uniform rate of motion of the movable cross head of the testing machine as calculated by the following formula (notes 1 and 2).

$$N = \frac{zL^2}{6d}$$

where

N = rate of motion of moving head, in inches per minute

z = unit rate of fiber strain, in inches per inch of outer fiber length per minute

---

<sup>1</sup>Details of laterally adjustable supports may be found in figure 4 of "Methods of Testing Plywood, Veneer, and Other Wood and Wood Base Materials," American Society for Testing Materials Designation D805-47.

= 0.005  
L = span, in inches  
d = depth (thickness) of specimen, in inches

Note 1: The testing-machine speed used shall not vary by more than  $\pm 50$  percent from that specified for a given test. The testing-machine speed used shall be recorded on the data sheet. The cross-head speed shall mean the free-running, or no-load, cross-head speed for testing machines of the mechanical-drive type, and the loaded cross-head speed for testing machines of the hydraulic-loading type.

Note 2: The calculated rates of head descent are, therefore, 0.12 inch per minute for the 1/4-inch-thick specimens, 0.24 inch per minute for the 1/2-inch-thick specimens, 0.36 inch per minute for the 3/4-inch-thick specimens, and 0.48 inch per minute for the 1-inch-thick specimens.

### Load-deflection Curves

17. Load-deflection curves shall be obtained to maximum load for all bending tests. The deflection of the center of the specimen shall be obtained by measuring the deflection of the bottom of the specimen at the center by means of an indicating dial (note) attached to the base of the testing jig, with the dial plunger in contact with the bottom of the specimen at the center. This arrangement is shown in figure 1. The load and deflection at first failure and at maximum load shall be noted. Readings of deflection shall be taken to at least the nearest 0.005 inch. Figure 2 shows a typical load-deflection curve.

Note: The range of standard 0.001-inch indicating dials is 1 inch. The total deflection of some thicknesses of building boards may exceed 1 inch at failure. When this happens, either a 2-inch total-travel indicating dial or a suitable 2:1 reducing lever in conjunction with a 1-inch-travel dial should be used so that maximum deflections can be obtained.

### Description of Failure

18. The character of the failure shall be noted. The report shall include the sequence of failure and note whether or not the initial failure was in compression or tension. Photographs of typical failures will be helpful.

### Moisture Content and Specific Gravity

19. The specimen shall be weighed immediately before test, and after test a moisture section 1 inch by the width of specimen shall be cut from the body of the specimen. The moisture content and specific gravity of each specimen shall be determined as outlined in section 62.

## Calculations and Report

20. (a) The modulus of rupture shall be calculated for each specimen by the following formula, and the values determined thereby shall be presented in the report.

$$R = \frac{3PL}{2bd^2}$$

where

P = maximum load, in pounds  
L = length of span, in inches  
b = width of specimen, in inches  
d = thickness (depth) of specimen, in inches  
R = modulus of rupture, in pounds per square inch

(b) The stiffness (apparent modulus of elasticity) shall be calculated for each specimen by the following formula, and the values determined shall be presented in the report.

$$E = \frac{P_1 L^3}{4bd^3 y_1}$$

where

P<sub>1</sub> = some load below proportional limit, in pounds  
y<sub>1</sub> = center deflection at that load, in inches  
L = length of span, in inches  
b = width of specimen, in inches  
d = thickness (depth) of specimen, in inches  
E = stiffness (apparent modulus of elasticity), in pounds per square inch

## Tensile Strength Parallel to Surface

### Scope

21. The test of tensile strength parallel to the surface shall be made on specimens both in the dry and in the soaked condition. Tests shall be made of specimens both with the long dimension parallel and perpendicular to the long dimension of the board to determine whether or not the material has directional properties.

Note: This method of test may be applied to material 1 inch or less in thickness. When the material exceeds 1 inch in thickness, crushing at the grips during test is likely to affect adversely the test values obtained. It is recommended that for material greater than 1 inch in thickness, the material be resawed to 1/2-inch thickness. Test values obtained from resawed specimens may be only approximate, because strengths of material near the surface may vary from the remainder.

### Test Specimen

22. Each test specimen shall be fabricated as shown in figure 3. The reduced section shall be cut to the size shown with a band saw. A sharp saw shall be used to insure a smooth surface in the center section. The thickness of the board in the net section shall be carefully measured to the nearest 0.001 inch. The minimum width of the reduced section shall be determined to at least the nearest 0.01 inch. These two dimensions shall be used to determine the net cross-sectional area for determining maximum stress.

### Specimens Soaked Before Test

23. Specimens to be tested in the soaked condition shall be prepared as specified in section 13.

### Method of Loading

24. Self-aligning, self-tightening grips with serrated gripping surfaces at least 2 inches wide and at least 2 inches long shall be used to transmit load from the testing machine to the specimen. Figure 4 shows a typical test set-up for the tension test of building boards.

### Speed of Testing

25. The load shall be applied continuously throughout test at a uniform rate of motion of the movable cross head of the testing machine of 0.15 inch per minute (see note 1, sec. 16).

### Test Data and Report

26. Maximum loads shall be obtained from which the stress shall be calculated. If the failure is within 1/2 inch of either grip, the test value shall be disregarded. The report shall show maximum loads and the location and description of the failures.

### Moisture Content

27. The moisture content of each specimen shall be determined as specified in section 62.

### Tensile Strength Perpendicular to Surface

#### Scope

28. The test of tensile strength perpendicular to surface shall be made on specimens in the dry condition when the strength of the material under test



is less than the bond between the material and the blocks that are used to apply the load.

Note: This test is included because of the increased use of fiberboards of lower density as core stock for constructions where wood, plywood, or other more dense materials are glued to the faces of the fiberboard. Tests in the soaked condition shall be made if the material is to be used under severe weather conditions.

#### Test Specimen

29. The test specimen shall be 2 inches square by the thickness of the finished board. Loading blocks of steel or aluminum alloy 2 inches square and 1 inch thick shall be bonded with steam-refined roofing pitch or other suitable adhesive (note) to the 2-inch-square faces of the specimen as shown in figure 5, which is a detail of the specimen and loading fixtures. Cross-sectional dimensions of the specimen shall be measured to the nearest 0.01 inch.

Note: A suitable technique for applying the blocks to the specimen is as follows:

- (1) The specimen is cut to size with a sharp, circular, woodworking saw.
- (2) The pitch is melted, with care being taken that it will not ignite.
- (3) The metal blocks are heated to approximately the same temperature as the pitch.
- (4) The surface of the block that is to be in contact with the specimen is coated with pitch.
- (5) The blocks and specimen are assembled in a jig, and approximately 20 pounds per square inch of pressure are applied until the blocks have cooled. The residual heat in the blocks keeps the pitch fluid until a satisfactory bond with a good squeeze-out is effected. The load blocks may be cleaned after test and reused.

#### Method of Test

30. Loading fixtures, such as are shown in figure 5, attached to the heads of the testing machine shall engage the blocks attached to the specimen. The specimen shall be stressed by separation of the heads of the testing machine until failure occurs. The direction of loading shall be as nearly perpendicular to the faces of the fiberboard as possible, and the center of load shall pass through the center of the specimen.

#### Speed of Testing

31. The load shall be applied continuously throughout test at a uniform rate of motion of the movable cross head of the testing machine of 0.035 inch per minute. (See note 1, sec. 16.)

## Test Data and Report

32. Maximum loads shall be obtained from which the stress at failure shall be calculated. Strength values shall be calculated in pounds per square inch, for which the measured dimensions of the specimen shall be used. The location of the line of failure shall be noted in the report.

## Moisture Content

33. The moisture content of each specimen shall be determined as specified in section 62.

## Nail-holding Tests -- Lateral Resistance

### Scope

34. Nail-holding tests shall be made to measure the resistance of a nail to lateral movement through a fiberboard. One-half of the specimens shall be selected and positioned in test so that the movement of the nail will be parallel, and one-half so that the movement of the nail will be perpendicular to the long dimension of the board for evaluation of directional properties.

Note 1: If this test is performed on some hardboards, the nail may bend and pull out of the stirrup. If this happens, the maximum load will be an apparent and not the true resistance of the board, and will only indicate that the resistance is some figure higher than the apparent value. If this happens it shall be noted.

Note 2: Values obtained from this test are dependent on the thickness of the specimen. Values, however, are not directly proportional to the thickness. For this reason values obtained from tests of different boards can only be compared exactly if the thicknesses are equal.

### Test Specimen

35. Each specimen shall be 3 inches wide and of convenient length, and shall have a sixpenny common nail driven at right angles to the face of the board so that about an equal length of nail projects from each face. The nail shall be centered on the width and located  $1/4$ ,  $1/2$ , or  $3/4$  inch from one end. Tests shall be made for all three end clearances for each material tested.

### Specimens Soaked Before Test

36. Specimens to be tested in the soaked condition shall be prepared as specified in section 13, and the nails shall be driven before the specimens are soaked.

### Method of Loading

37. The end of the specimen opposite to the end with the nail shall be clamped in a position parallel to the movement of the testing machine. Grips such as are suitable for tension tests parallel to the plane of the fiberboard are suitable. The nail is engaged by the stirrup, which is in turn connected to one platen of the testing machine by a rod. Figure 6 shows a typical test set-up for measuring the resistance of a nail in the lateral direction. The stirrup and connections are detailed in figure 7.

### Speed of Testing

38. The specimen shall be loaded continuously throughout test by separation of the heads of the testing machine at a uniform rate of cross-head speed of 0.25 inch per minute (see note 1, sec. 16).

### Test Data and Report

39. The load required to move the nail to the edge of the specimen shall be the measure of the lateral resistance. The maximum load and the nature of failure shall be recorded.

## Nail-holding Tests -- Direct Withdrawal

### Scope

40. Nail-holding tests shall be made on nails driven through the fiberboard from face to face to measure the resistance to withdrawal in a plane normal to the face.

### Test Specimen

41. The test specimen shall be of convenient size (at least 3 inches wide and 6 inches long). Sixpenny common nails shall be driven through the board at right angles to the face, and at least 1/2 inch of the shank portion shall project above the surface of the material.

### Specimens Tested in the Dry Condition

42. When the tests are made in the dry state, the withdrawals shall be made immediately after the nails have been driven.

### Specimens Soaked Before Test

43. Specimens to be tested in the soaked condition shall be prepared as specified in section 13, and the nails shall be driven before the specimens are soaked.

### Method of Loading

44. Figure 8 shows the set-up for the direct-withdrawal test. The specimen-holding fixture shall be attached to the lower platen of the testing machine. The specimen shall be inserted in the fixture with the heads of the nails up, as shown. The heads of the nails shall be engaged by the load-applying fixture equipped with a slot for easy attachment. This loading fixture shall be attached to the upper platen of the testing machine. Loads shall be applied by separation of the platens of the testing machine. The fitting is detailed in figure 9.

### Speed of Testing

45. Load shall be applied to the specimen throughout the test by a uniform motion of the movable head of the testing machine at a rate of 0.06 inch per minute. (See note 1, sec. 16.)

### Test Data and Report

46. The maximum load required to withdraw the nail shall be the measure of resistance of the material to direct nail withdrawal, and shall be recorded.

## Water Absorption

### Scope

47. A test shall be made to determine the water-absorption characteristics of building boards.

### Test Specimen

48. The test specimen should be 12 by 12 inches in area with all four edges trimmed square. When a board is less than 12 inches in one or in both dimensions, the largest piece with edges trimmed square approaching 12 by 12 inches shall be used as the specimen, but this shall be at least 6 by 6 inches.

### Conditioning Prior to Test

49. The test specimen shall be conditioned for at least 24 hours before test under controlled temperature-humidity conditions. A relative humidity of 65 percent and a temperature of 70° F. are recommended.

## Weight and Volume of Test Specimen

50. After conditioning, the specimen shall be weighed and the width, length, and thickness shall be measured to the nearest 0.01 inch. The volume of the specimen shall be computed from these measurements.

## Submersion in Water

51. The specimen shall then be submerged horizontally under 1 inch of distilled water maintained at a temperature of 70° ± 5° F. After a 2-hour submersion (note), the specimen shall be placed on end to drain for 10 minutes, at the end of which time the excess surface water shall be removed by hand with a blotting paper or paper towel and the specimen be immediately weighed.

Note: When testing structural hardboard, the immersion time shall be 24 hours instead of 2 hours.

## Calculation and Report

52. The volume of water absorbed shall be calculated from the increase in weight of the specimen during the submersion, and the water absorption shall be expressed as a percentage by volume based on the volume after conditioning. The specific gravity of the water shall be assumed to be 1.00 for this purpose.

## Linear Expansion

### Scope

53. Linear-expansion tests shall be made to measure the dimensional stability of a fiberboard with change in moisture content.

### Specimen

54. The test specimens shall be 3 by at least 12 inches in area. Two specimens shall be provided, one cut parallel with the long dimension of each board and one from the same board cut at right angles to the long dimension. When a board does not permit obtaining a 12-inch specimen, the maximum length possible shall be used, but it shall be at least 6 inches.

### Procedure

55. The following or any more accurate procedure shall be followed for measuring specimens. At each of two points approximately 10 inches apart on the center line of each specimen, a small area shall be coated by rubbing with a glass-marking pencil (or wax crayon). When smaller specimens are used, the distance between marks shall be the maximum possible. A fine cross shall be made with a razor blade on the center line in each of these two areas as

reference points for length measurements. The specimens shall then be conditioned for at least 24 hours or until practical equilibrium is obtained at a relative humidity of 50 percent  $\pm$  5 percent and a temperature of 70°  $\pm$  2° F., and measurements shall be made of the distance between the two reference points by means of the scale and magnifying lens. Readings shall be made to the nearest 0.005 inch. The specimens shall next be conditioned for at least 24 hours or until practical equilibrium is obtained at a relative humidity of 97 percent  $\pm$  5 percent and a temperature of 70°  $\pm$  2° F., after which the distance between the two reference points shall again be measured. The measurements shall be made in the conditioned air specified in each case, or as quickly as possible after the specimen is removed therefrom.

Note: In the absence of other facilities, a convenient means of conditioning the specimens at the specified humidity conditions is to expose them in an enclosed space immediately above saturated solutions of suitable salts, sodium dichromate ( $\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$ ) for the 50 percent relative humidity and potassium sulphate ( $\text{K}_2\text{SO}_4$ ) for 97 percent relative humidity.

#### Calculation and Report

56. The linear expansion shall be reported as the percentage increase in length between the reference marks based on the length at 50 percent relative humidity.

#### Accelerated Aging

##### Scope

57. The accelerated-aging test shall be used to obtain a measure of the inherent ability of a material to withstand severe exposure conditions. The cycling exposure to which the material shall be subjected is a simulated condition developed to determine relatively how a material will stand up under weathering conditions. After the specimens are subjected to the cycles of accelerated aging, tests shall be made according to the methods of test outlined as follows:

<u>Test</u>	<u>Section</u>
(1) Static bending	11 to 20
(2) Lateral nail resistance	34 to 39
(3) Nail withdrawal	40 to 46
(4) Water absorption	47 to 52

##### Test Specimens

58. The test specimens shall be fabricated as specified in the pertinent sections listed in section 57.

### Accelerated-aging Cycles

59. Each specimen shall be subjected to six complete cycles of accelerated aging. Each cycle shall consist of the following:

- (1) Immersion in water at  $120^{\circ} \pm 3^{\circ}$  F. for 1 hour
- (2) Sprayed with steam and water vapor at  $200^{\circ} \pm 5^{\circ}$  F. for 3 hours
- (3) Stored at  $10^{\circ} \pm 5^{\circ}$  F. for 20 hours
- (4) Heated at  $210^{\circ} \pm 3^{\circ}$  F. in dry air for 3 hours
- (5) Sprayed again with steam and water vapor at  $200^{\circ} \pm 5^{\circ}$  F. for 3 hours
- (6) Heated in dry air at  $210^{\circ} \pm 3^{\circ}$  F. for 18 hours

After the completion of the six cycles of exposure the material for test shall be further conditioned in the prevailing laboratory temperature and humidity for 48 hours before test.

### Inspection of Material During Cyclic Exposure

60. Frequent inspections of the material shall be made during the aging cycles for any signs of delamination or other disintegration. If there is any apparent damage to the material, it shall be noted, as well as the stage of the cycle in which the damage became apparent.

### Comparisons and Report

61. After the tests following the accelerated-aging treatment are completed, the results shall be computed as specified in the appropriate method of test and compared with the corresponding values obtained from tests made on material that did not have the accelerated-aging treatment.

### Determination of Moisture Content and Specific Gravity

62. (a) The moisture content at time of test and specific gravity shall be determined because of their relation to the strength properties. Values of specific gravity computed from the volume and weight are satisfactory for these materials. When the volume of the fiberboard is changed during test, or when the specimen is otherwise damaged by test, separate coupons for this determination shall be prepared from the same material as is used in preparing the specimen. Otherwise, samples shall be obtained from the specimen as near to the location of the failure as is practical. These coupons shall be kept with the specimen until time of test. Immediately after test the coupon shall be weighed and measured. The thickness of the sample shall be measured to the nearest 0.001 inch and the length and width to at least the nearest 0.01 inch (depending on the size of the sample). The sample shall be dried in an oven at  $100^{\circ}$  C. until approximately constant weight is attained. After drying, the sample shall be weighed immediately. The weight of the sample shall be determined to an accuracy of not less than 0.2 percent.

(b) The moisture content shall be calculated as follows:

$$M = 100 \left( \frac{W - F}{F} \right)$$

where

M = moisture content, in percent

W = initial weight, and

F = final weight when oven-dry

(c) The specific gravity shall be computed as follows (note):

$$\text{Specific gravity} = \frac{0.061 F}{Lwt}$$

where

F = final weight when oven-dry, in grams

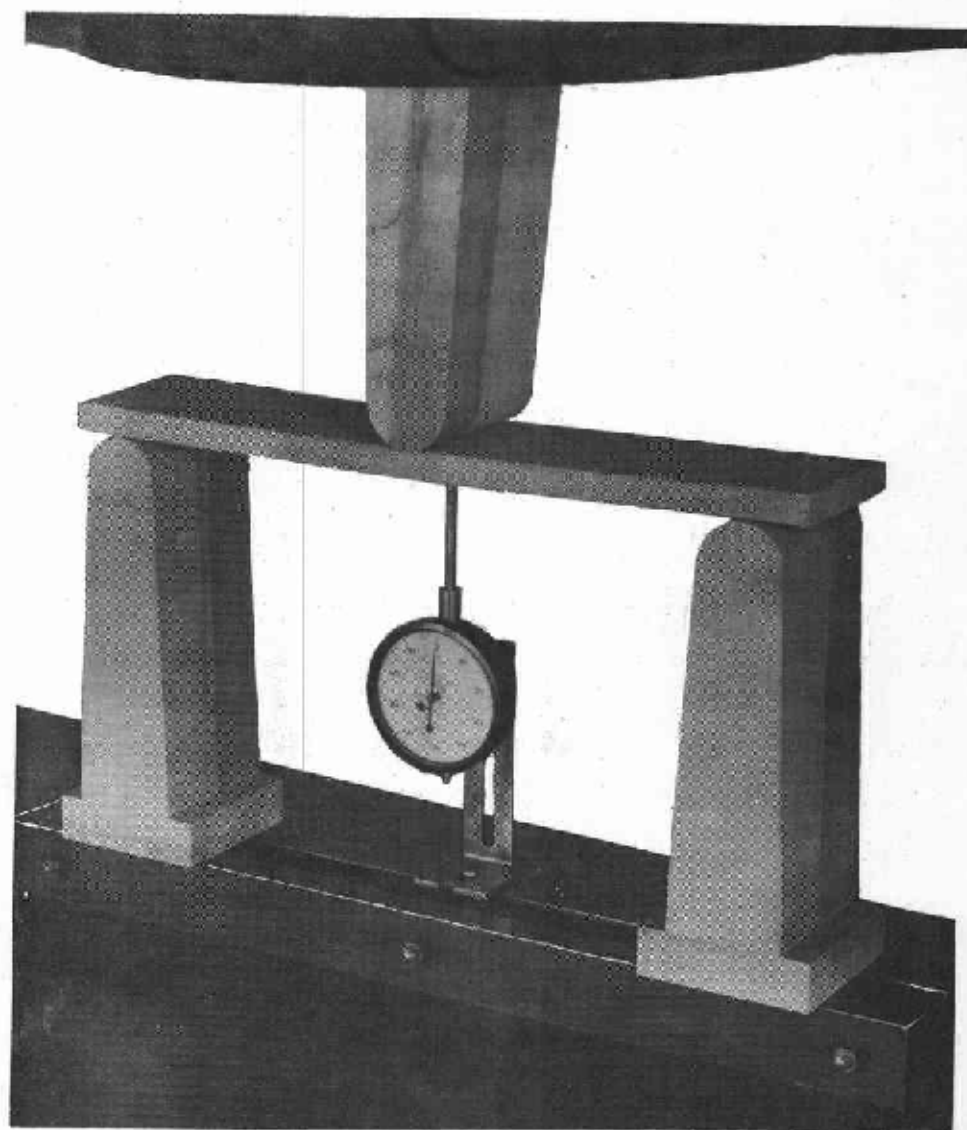
L = length of coupon, in inches

w = width of coupon, in inches, and

t = thickness of coupon, in inches

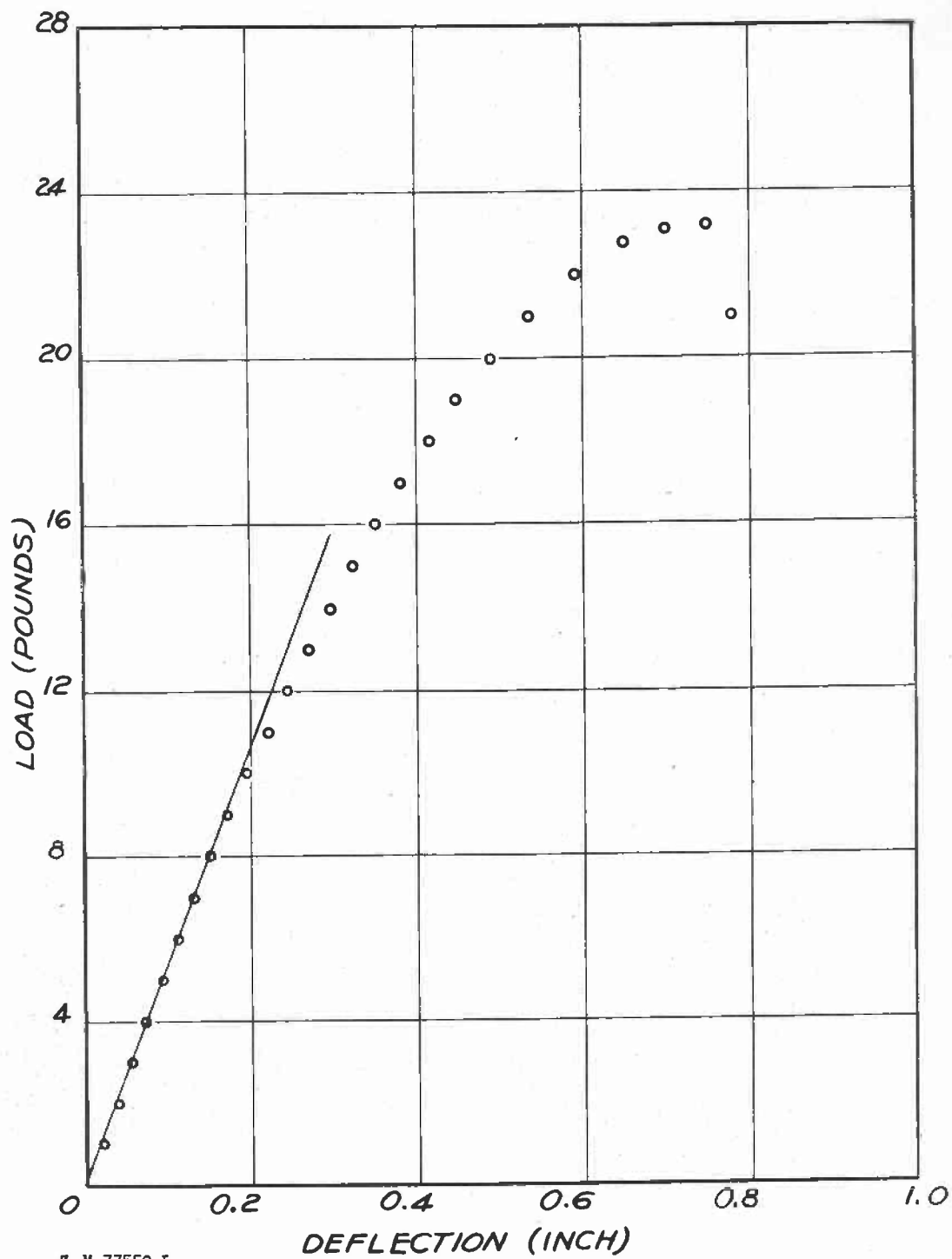
Note: The specific gravity as determined by this equation is based on volume at test and weight when oven-dry.





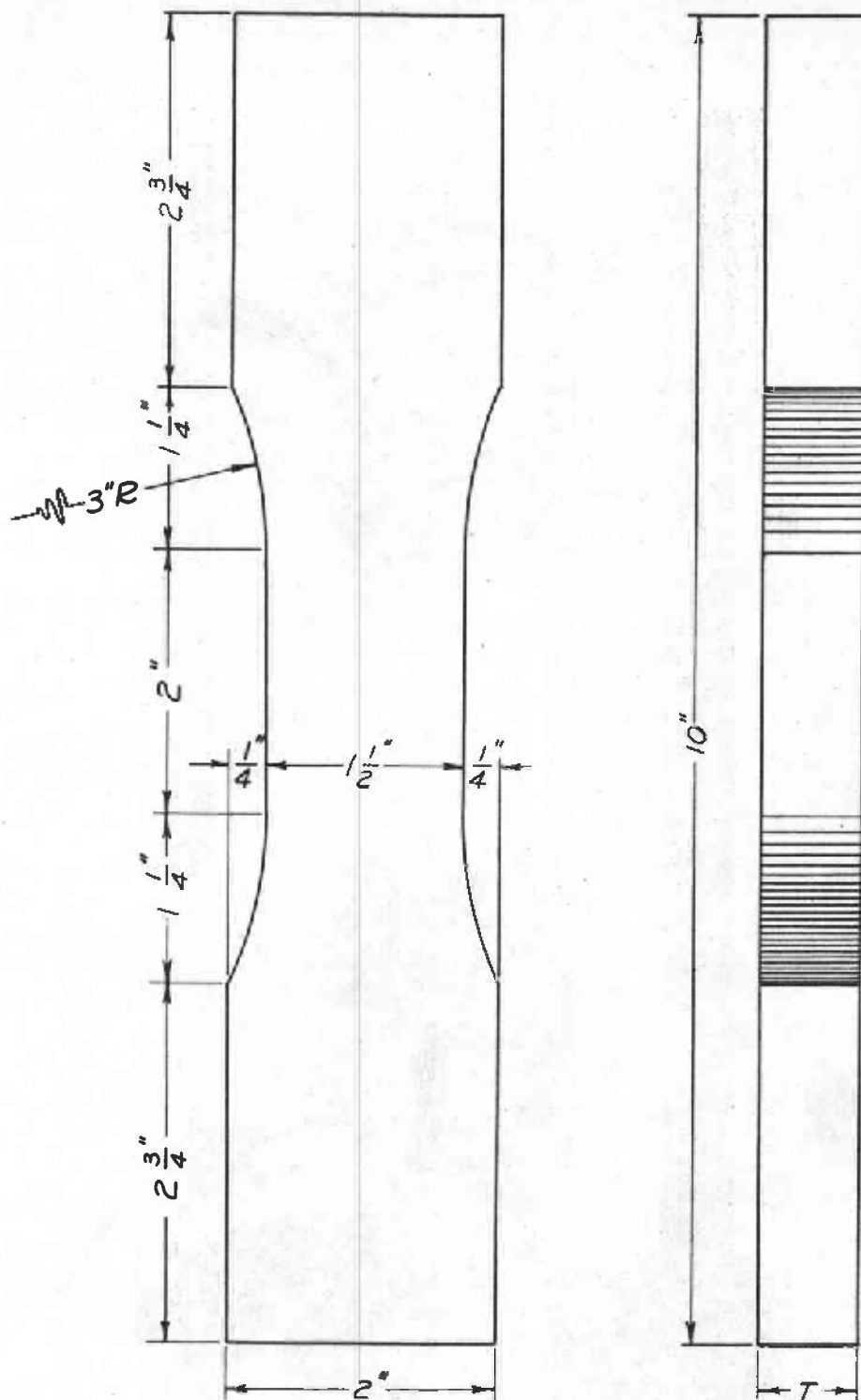
Z N 77557 F

Figure 1.--Test set-up for bending test of fiberboard.



Z M 77550 F

Figure 2.--Typical load-deflection curve for bending test of fiberboard.



$T$  = THICKNESS OF MATERIAL,  
BUT NOT TO EXCEED 1 INCH

Z.M. 77551 F

Figure 3.--Detail of specimen for tension parallel to surface test.

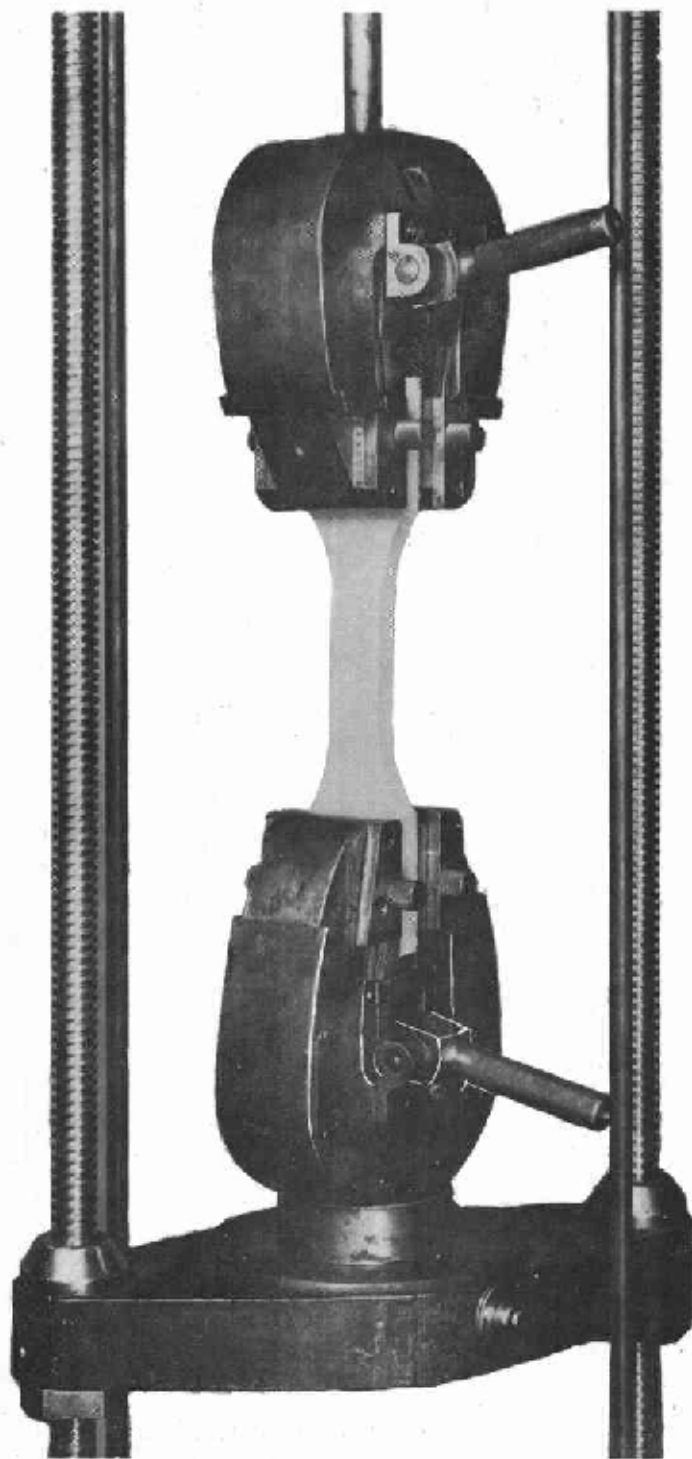


Figure 4.--Test set-up for tension-parallel-to-surface test  
for building boards.

ZM 77554 F

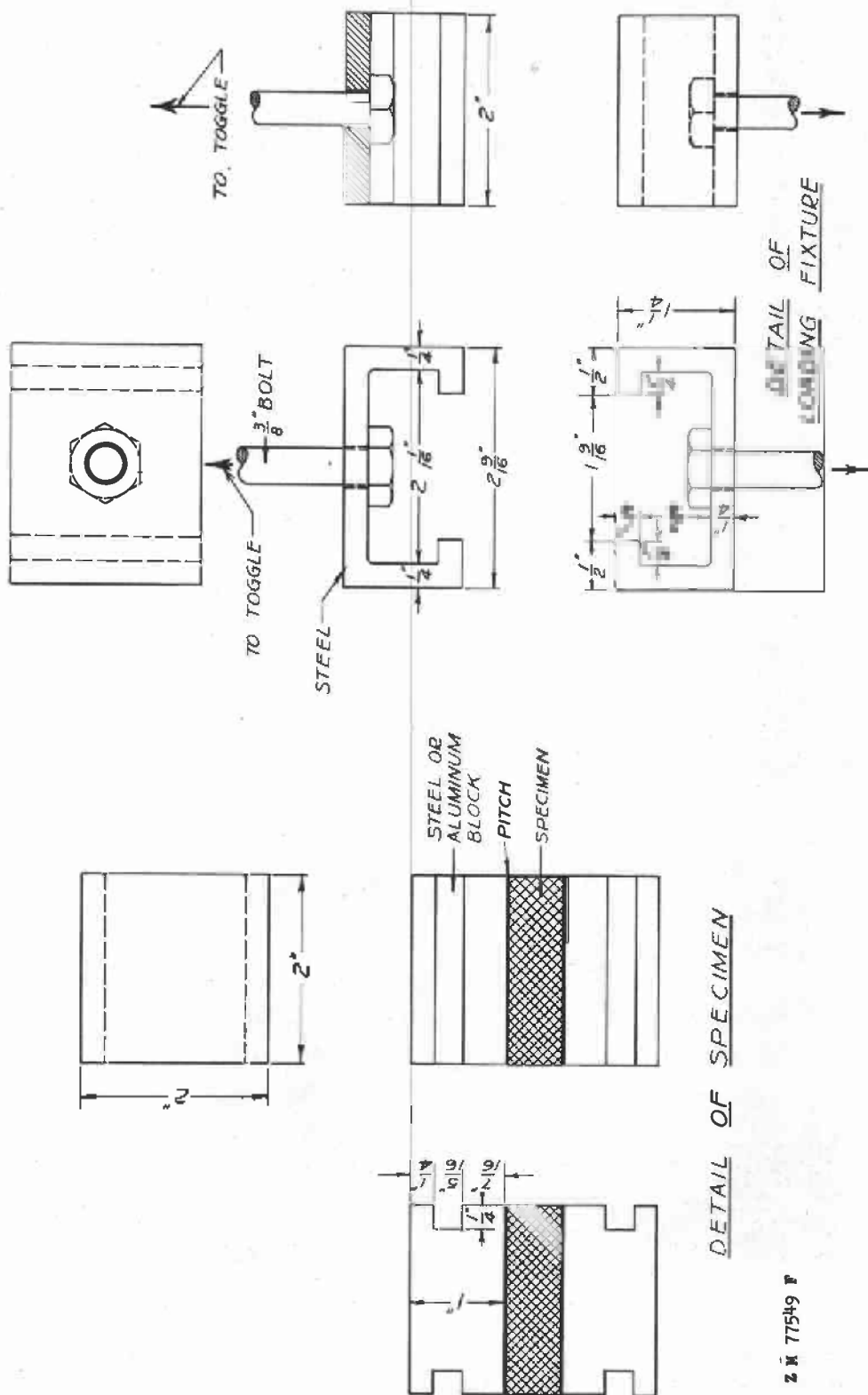


Figure 5.--Detail of specimen and loading fixture for tension-perpendicular-to-surface test for building boards.

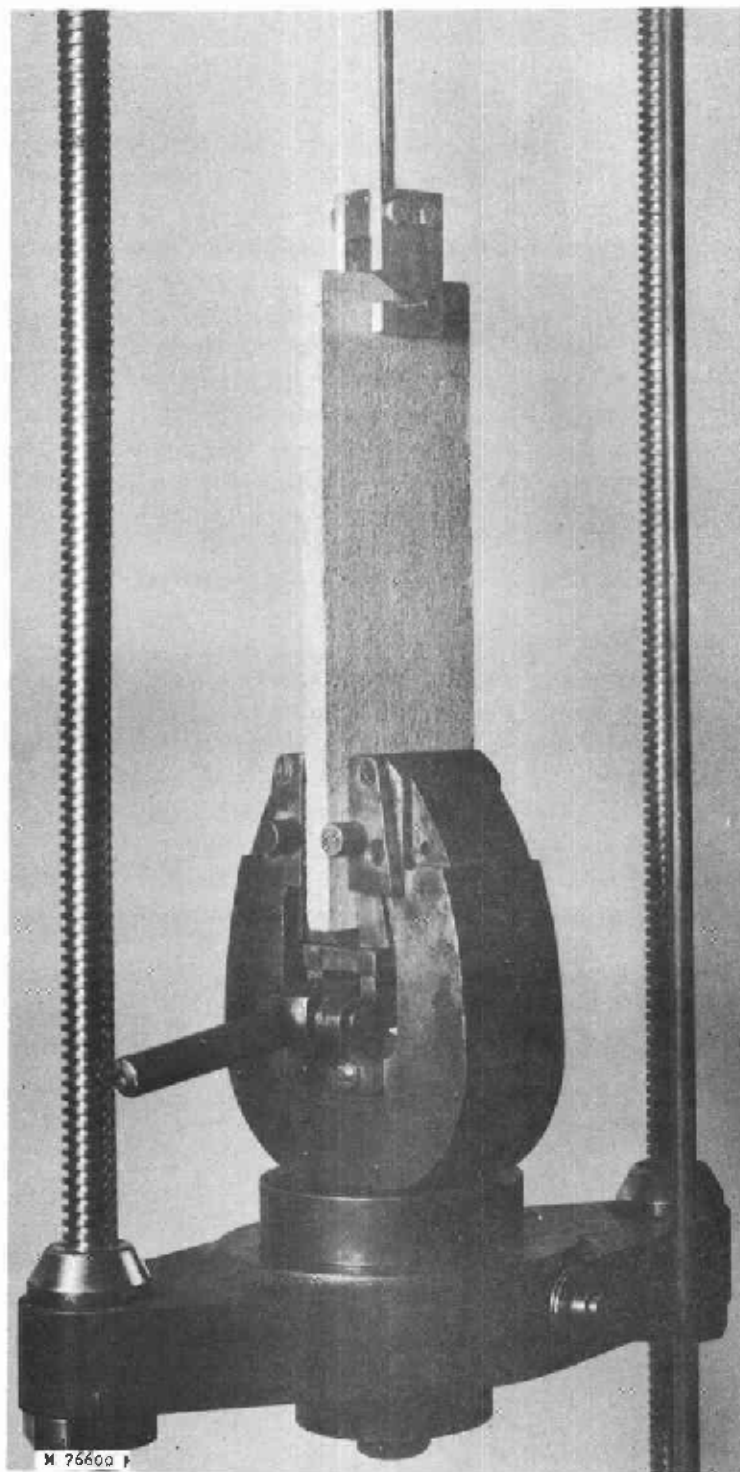
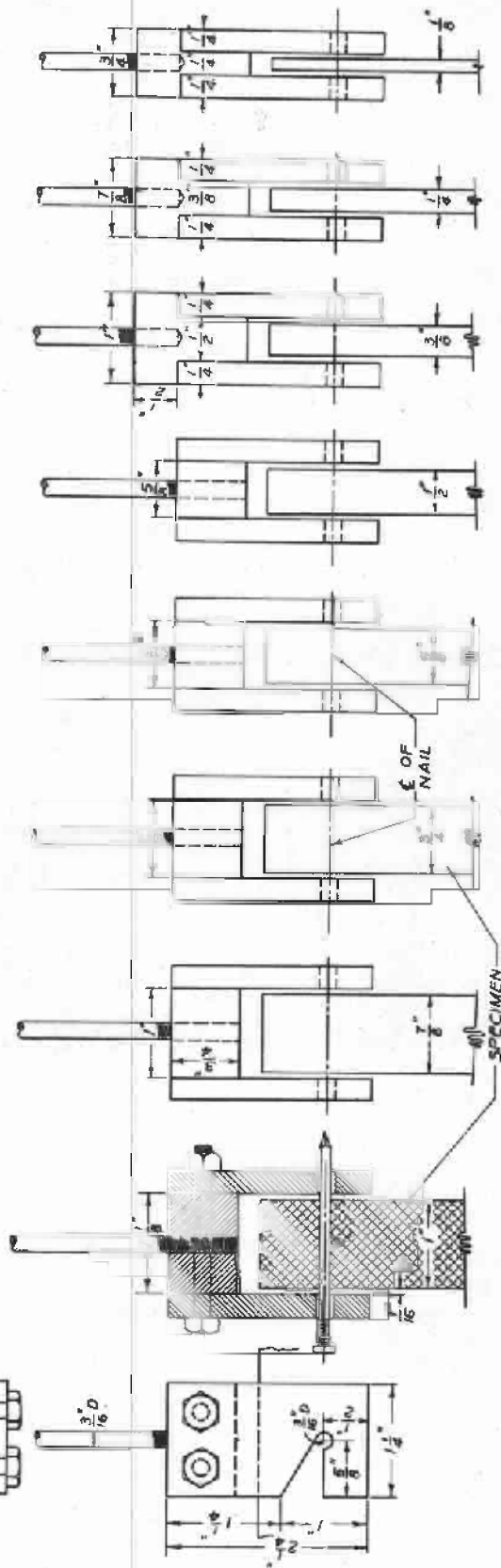


Figure 6.--Test set-up for measuring the resistance  
of nails to lateral movement in building boards.  
Z M 77556 F

$\frac{3}{16}$ " D. AIRCRAFT BOLTS

USE SAME SIDE PLATES WITH ALL THICKNESSES OF SPECIMENS



2X 77552 P

Figure 7.--Stirrups and connections for lateral nail resistance test for building boards.

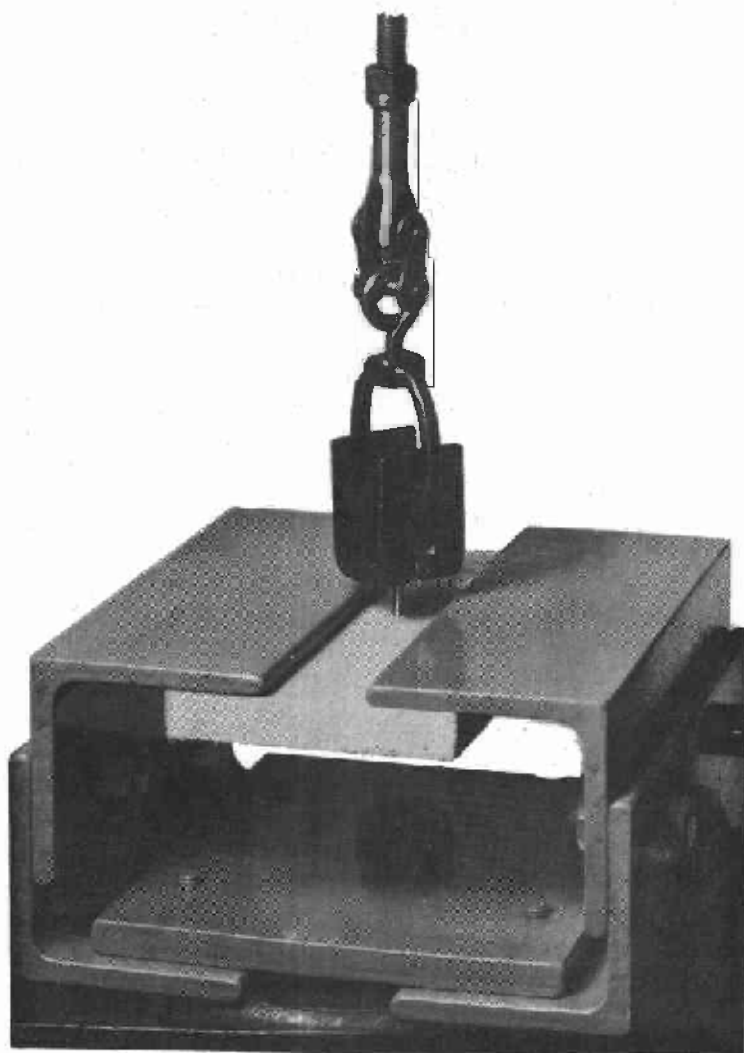


Figure 8.--Test set-up for measuring the resistance of nails to direct withdrawal from building boards.

2 N 77555 F



