U. S. DEPARTMENT OF COMMERCE

BUILDING MATERIALS AND STRUCTURES

REPORT BMS72

Structural Properties of "Precision-Built, Jr." Prefabricated Wood-Frame Wall Construction Sponsored by the Homasote Co.

by

ARCHIE H. EASTON

and MAHLON F. PECK

with the collaboration of

R. F. Luxford

Forest Products Laboratory

NATIONAL BUREAU OF STANDARDS

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Forest Products Laboratory
Forest Service, United States Department of Agriculture

ISSUED APRIL 14, 1941

The National Bureau of Standards is a fact-finding organization; it does not "approve" any particular material or method of construction. The technical findings in this series of reports are to be construed accordingly.

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Foreword

This report is one of a series issued by the National Bureau of Standards on the structural properties of constructions intended for low-cost houses and apartments. These constructions were sponsored by organizations within the building industry advocating and promoting their use. The sponsor built and submitted the specimens described in this report for participation in the program outlined in BMS2, Methods of Determining the Structural Properties of Low-cost House Constructions. The sponsor, therefore, is responsible for the design of the constructions and for the description of materials and method of fabrication. The Bureau is responsible for the testing of the specimens and the preparation of the report.

This report covers only the load-deformation relations and strength of the structural element submitted when subjected to compressive, transverse, concentrated, impact, and racking loads by standardized methods simulating the loads to which the element would be subjected in actual service.

The Forest Products Laboratory, Forest Service, United States Department of Agriculture, collaborated in the tests of those constructions which had wood structural members.

The National Bureau of Standards does not "approve" a construction, nor does it express an opinion as to its merits for reasons given in reports BMS1 and BMS2. The technical facts presented in this series provide the basic data from which architects and engineers can determine whether a construction meets desired performance requirements.

Lyman J. Briggs, *Director.*

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ABSTRACT

For the program on the determination of the structural properties of low-cost house constructions, the Homasote Co., Trenton, N. J., submitted 12 specimens representing a wall construction consisting of a wood frame with "Homasote" insulating fiberboard on both faces.

The specimens were subjected to compressive, transverse, concentrated, impact, and racking loads; for each load three like specimens were tested. The deformation under load and the set after the load was removed were measured for uniform increments of load. The results are presented in graphs and in a table.

I. INTRODUCTION

To provide technical facts on the performance of constructions for low-cost houses, to discover promising new constructions, and ultimately to determine the properties necessary for acceptable performance in actual service, the National Bureau of Standards has invited the cooperation of the building industry in a program of research on building materials and structures suitable for low-cost houses and apartments. The objectives of this program are described in BMS1, Research on Building Materials and Structures for Use in Low-Cost Housing.

To determine the strength of house constructions in the laboratory, standardized methods were developed for applying loads simulating the loads to which a completed house is subjected. Included in this study were masonry and wood constructions of types which have been extensively used in this country for houses and whose behavior under widely different service conditions is well known to builders and the public. The reports on these constructions are BMS5, Structural Properties of Six Masonry Wall Constructions, and BMS25, Structural Properties of Conventional Wood-Frame Constructions for Walls, Partitions, Floors, and Roofs. The masonry specimens were built by the Masonry Construction Section of this Bureau, and the wood-frame specimens were built and tested by the Forest Products Laboratory at Madison, Wis.

The present report describes the structural properties of one element of a house sponsored by one of the manufacturers in the building industry. The wall specimens were subjected to compressive, transverse, concentrated, impact, and racking loads, simulating the loads to which the walls of a house are subjected. In actual service compressive loads on the walls of a one-story house are produced by the weight of the roof and by snow and wind loads; transverse loads are produced by wind, concentrated and impact loads by accidental contact with heavy objects, and racking loads by the action of the wind on the adjoining walls.

The deflection and set under each increment of load were measured, because the suitability of a construction depends not only on its resistance to deformation when loads are applied but also on its ability to return to its original size and shape when the loads are removed.

II. SPONSOR AND PRODUCT

BMS48, Structural Properties of "Precision-Built" Frame Wall and Partition Constructions Sponsored by the Homasote Co., reports the results on its Standard "Precision-Built" construction. The present report gives the results on the "Precision-Built, Jr." construction sponsored by the same organization.

The wall construction consists of a lightweight wood frame with "Homasote" insulating fiberboard fastened to each face by glue and nails.

III. SPECIMENS AND TESTS

The wall construction was assigned the symbol *DK* and the individual specimens were assigned the designations given in table 1.

TABLE 1.—*Specimen designations, wall DK*

Specimen designation	Load	Load applied
C1, C2, C3	Compressive	Upper end.
T1, T2, T3	Transverse	Either face.
P1, P2, P3	Concentrated [a]	Do.
I1, I2, I3	Impact	Do.
R1, R2, R3	Racking	Near upper end.

[a] The concentrated and impact loads were applied to the same specimens, the concentrated loads first.

Except as mentioned below, the specimens were tested in accordance with BMS2, which report also gives the requirements for the specimens and describes the presentation of the results of the tests, particularly the load-deformation graphs.

For the transverse and impact loads there were only three specimens, not six as stated in BMS2, because the specimens were symmetrical about a vertical plane midway between the faces, and the results for transverse and impact loads applied to one face should be identical with those applied to the other face. For the same reason the concentrated load was applied to only three specimens. The differences in the nails in the inside face and the outside face were so small that the constructions were considered symmetrical.

Under compressive load, the shortening of the entire specimen may not be proportional to the value obtained from the compressometers attached to the specimen over only a portion of its height; therefore, the shortenings and the sets were measured with compressometers attached to the plates through which the load was applied, not attached to the specimen as described in BMS2.

The lateral deflections under compressive loads were measured with a deflectometer of fixed gage length, which consisted of a light (duralumin) tubular frame having a leg at one end and a hinged plate at the other. The deflectometer in a vertical position was attached to the specimen by clamping the hinged plate near the upper end to one of the faces. The gage length (distance between the points of support) was 7 ft. 6 in. A dial micrometer was mounted on the frame at midlength, with the spindle in contact with the wall specimen. The dial was graduated to 0.001 in., and the readings were recorded to the nearest division. There were two deflectometers on the specimen, one near each outer stud. This method of measurement was used instead of the taut-wire mirror-scale method described in BMS2.

The indentation under concentrated load and the set after the load was removed were measured, not the set only as described in BMS2. The apparatus is shown in figure 1.

The load was applied to the steel disk, *A*, to which the crossbar, *B*, was rigidly attached. The load was measured by means of the spring dynamometer, *C*. Two stands, *D*, rested on the face of the specimen, each supporting a dial micrometer, *E*, the spindle of which was in contact with the crossbar 8 in. from the center of the disk. The micrometers were graduated to 0.001 in., and readings were recorded to the

FIGURE 1.—*Apparatus for concentrated-load test.*

A, steel disk; *B*, crossbar; *C*, spring dynamometer; *D*, stand; *E*, dial micrometer.

nearest division. The initial reading (average of the micrometer readings) was observed under the initial load, which included the weight of the disk and dynamometer. A load was applied to the disk, and the average of these micrometer readings minus the initial reading was taken as the depth of the indentation under load.

The deflections and sets under the impact loads were measured by means of two deflectometers and two set gages, not one of each as described in BMS2. The deflectometers were placed in contact with the unloaded face of the specimen at midspan, one under each outside stud, and the set gages rested on the loaded face, one over each outside stud. The readings, therefore, were not affected by local deformation of the fiberboard.

The deformations under racking load were measured with a right-angle deformeter, consisting of a steel channel and a steel angle braced to form a rigid connection. In use, the channel of the deformeter supported by two steel blocks, ½ in. thick, 4 in. square, rested along the top of the specimen, with the steel angle extending downward in the plane of the specimen. Two pins passed snugly through the web of the channel into the top plate of the specimen. The floor plate was in contact with a steel stop. A dial micrometer was attached to the steel stop and the spindle was in contact with the steel angle of the deformeter. The gage length (distance from the top of the specimen to the center of the steel stop) was 7 ft. 10¼ in. The micrometer was graduated to 0.001 in., and readings were recorded to the nearest division. The deformeter was used instead of the taut-wire mirror-scale device described in BMS2.

The tests were begun July 30, 1940 and completed August 2, 1940. The sponsor's representative witnessed the tests.

IV. MATERIALS

Unless otherwise stated, the information on materials was obtained from the sponsor and from inspection of the specimens. The Forest Products Laboratory identified the species of the wood in the framing. The Paper Section of this Bureau determined the physical properties of the fiberboard, and the Engineering Mechanics Section determined the moisture content of the wood and fiberboard.

1. Wood

Framing.—The framing was identified as Douglas fir, *Pseudotsuga taxifolia*, No. 1 common. Sizes, 1⅝ by 1⅝ in. (nominal 2 by 2 in), S2S1E (surfaced two sides and one edge), and 1⅝ by 2⅝ in. (nominal 2 by 3 in), S4S (surfaced four sides).

Spacer blocks.—Identified as ponderosa pine, *Pinus ponderosa*, No. 2 common, 25/32 by 1⅝ in. (nominal 1 by 2 in), S4S.

After each specimen was tested, one face was removed to expose the framing and a sample cut from the studs for identification of the species. Photographs were made of each specimen showing the quality of the wood. Figures 2 and 3 are typical specimens.

Figure 2.—*Wall DK.*

Typical 4-ft wall specimen.

For each specimen, readings were taken with an electric moisture meter on each piece of framing and on two spacer blocks. To calibrate the moisture meter, moisture determinations were made on two pieces of framing and one spacer block from each specimen by drying them to constant weight at 212° F. From these determinations the correction to be added algebraically to the meter readings was −1.0 for framing and +0.4 for spacer blocks. Values of the moisture content given in table 2 were obtained by applying these corrections to the average of the meter readings and rounding the results to the nearest whole percent.

Table 2.—*Moisture content of the wood*

[Determined the day the wall specimen was tested]

Material	Moisture content [a]		
	Minimum	Maximum	Average
	Percent	*Percent*	*Percent*
Framing, Douglas fir	10	14	12
Spacer blocks, ponderosa pine	7	11	9

[a] Based on the weight when oven-dry.

2. Insulating Fiberboard

The insulating fiberboard was "Homasote", 15/32 in. thick, made from vegetable fibers derived largely from waste paper. The fibers are sized with rosin and waxes to increase water resistance and then felted into boards.

The physical properties, given in table 3, were determined on undamaged samples taken from the wall specimens after testing. The linear expansion, tensile strength, transverse strength and deflection, and water absorption were determined in accordance with Federal Specification LLL–F–321a, Fiberboard; Insulating. For these properties the board complied with the requirements for class A. The thermal conductivity failed to comply with the requirements for class A, for which the maximum value is 0.36 (Btu/hr ft^2)/(°F/in).

Figure 3.—*Wall DK.*

Typical 8-ft wall specimen.

Table 3.—*Physical properties of insulating board, 15/32 in. thick*

[The samples were taken from the specimens after they had been tested]

Property	Value
Tensile strength:	
Machine direction ... lb/in.²	643
Cross direction ... lb/in.²	627
Transverse strength: [a]	
Machine direction ... lb	33
Cross direction ... lb	33
Deflection at rupture:	
Machine direction ... in	0.85
Cross direction ... in	.72
Linear expansion for 45 percent change in relative humidity ... percent	.20
Nail-holding strength: Lateral ... lb	143
Density, after drying 24 hours at 160° F ... lb/ft³	25.6
Moisture content, based on weight when oven-dry ... percent	9
Air permeability ... (ft³/hr. ft.²)/(lb./in.²)	25
Water absorption, by volume ... percent	4.1
Thermal conductivity ... (Btu./hr. ft.²)/(°F/in.)	[b] 0.41

[a] Span, 12 in.; width of specimens, 3 in.
[b] Value given by sponsor.

The moisture content of the fiberboard was determined on one sample from each wall specimen by drying at 212° F until the weight was constant.

3. Nails

Steel.—A description of the steel-wire nails is given in table 4.

Table 4.—*Description of steel-wire nails*

Type	Size	Length	Steel-Wire Gage	Diameter	Finish	Nails per pound
	Penny	*in*	*No.*	*in.*		
Common	10	3	9	0.1483	Bright	69
Do	20	4	6	.192	do	31
Box	4	1½	14	.080	Zinc-coated	403

Monel metal.—The monel-metal nails, $1\frac{3}{4}$ in. long, were made from monel-metal wire, 0.083-in. diam; finish, bright; number of nails per pound, 330. To increase the force required to pull the nails from the wood, there were 24 annular barbs per inch of length between the head and the diamond point.

4. Glue

Casein glue, grade A, ground. Formula: casein, 65 percent; lime, 15 percent; and dispersing agents and secret ingredients. One part of glue was mixed with one part of water, by volume, to which were added 2 ounces of kerosene per pound of dry glue. The glue complied with United States Army Specification 3–152–A and United States Navy Specification 52G8b. I. F. Laucks, Inc., "Lauxein 888."

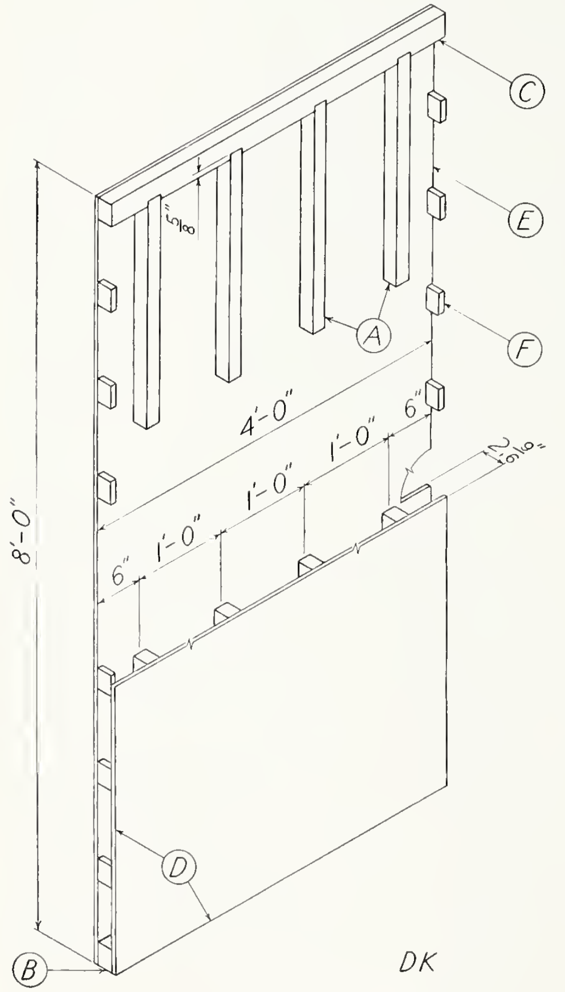

FIGURE 4.—*Four-foot wall specimen DK.*

A, studs; *B*, floor plate; *C*, top plate; *D*, outside face; *E*, inside face; *F*, spacer block.

V. WALL *DK*

1. Sponsor's Statement

Wall *DK* was a wood-frame construction having insulating fiberboard on both faces, fastened by glue and nails. The specimens were not painted.

The price of this construction in Washington, D. C., as of July 1937, was $0.17/ft^2.

(*a*) *Four-Foot Wall Specimens*

The 4-ft wall specimens, shown in figure 4, were 8 ft 0 in. high, 4 ft 0 in. wide, and $2\frac{9}{16}$ in. thick. Each was a wood frame to which the faces were fastened. The frame consisted of four studs, *A*, fastened to floor plate, *B*, and top plate, *C*. Both the outside face, *D*, and the inside face, *E*, consisted of one sheet of insulating fiberboard. The edges of the faces were connected by spacer blocks, *F*.

Studs.—The studs, *A*, were Douglas fir, $1\frac{5}{8}$ by $1\frac{5}{8}$ in. (nominal 2 by 2 in), 7 ft 8 in. long, spaced 1 ft 0 in. Except in specimens *DK–T3* and *DK–I2*, each stud was fastened to the floor plate and top plate by one 20d common nail through the plates into the stud (not toenailed). In specimens *DK–T3* and *DK–I2* the studs were fastened to the floor plate and top plate by two 10d common nails, one through each edge of the stud and into the plates (toenailed). In houses of this construction there is one 16d common nail through the plate and into the stud.

Floor plate and top plate.—Both floor plate, *B*, and top plate, *C*, were Douglas fir, $1\frac{5}{8}$ by $2\frac{5}{8}$ in. (nominal 2 by 3 in), 4 ft 0 in. long. The upper surface of the floor plate and the lower surface of the top plate were dadoed (notched) $\frac{5}{8}$ by $1\frac{5}{8}$ in., 12 in. on centers. The ends of the studs fitted into the notches.

Faces.—Each face was one piece of fiberboard, $\frac{15}{32}$ in. thick, 8 ft 0 in. high, and 4 ft 0 in. wide, fastened to the floor plate, top plate, and studs by both glue and nails. The glue was liberally applied to the studs and the plates by a roller continuously supplied with glue. The nails were spaced 6 in. along the floor plate and top

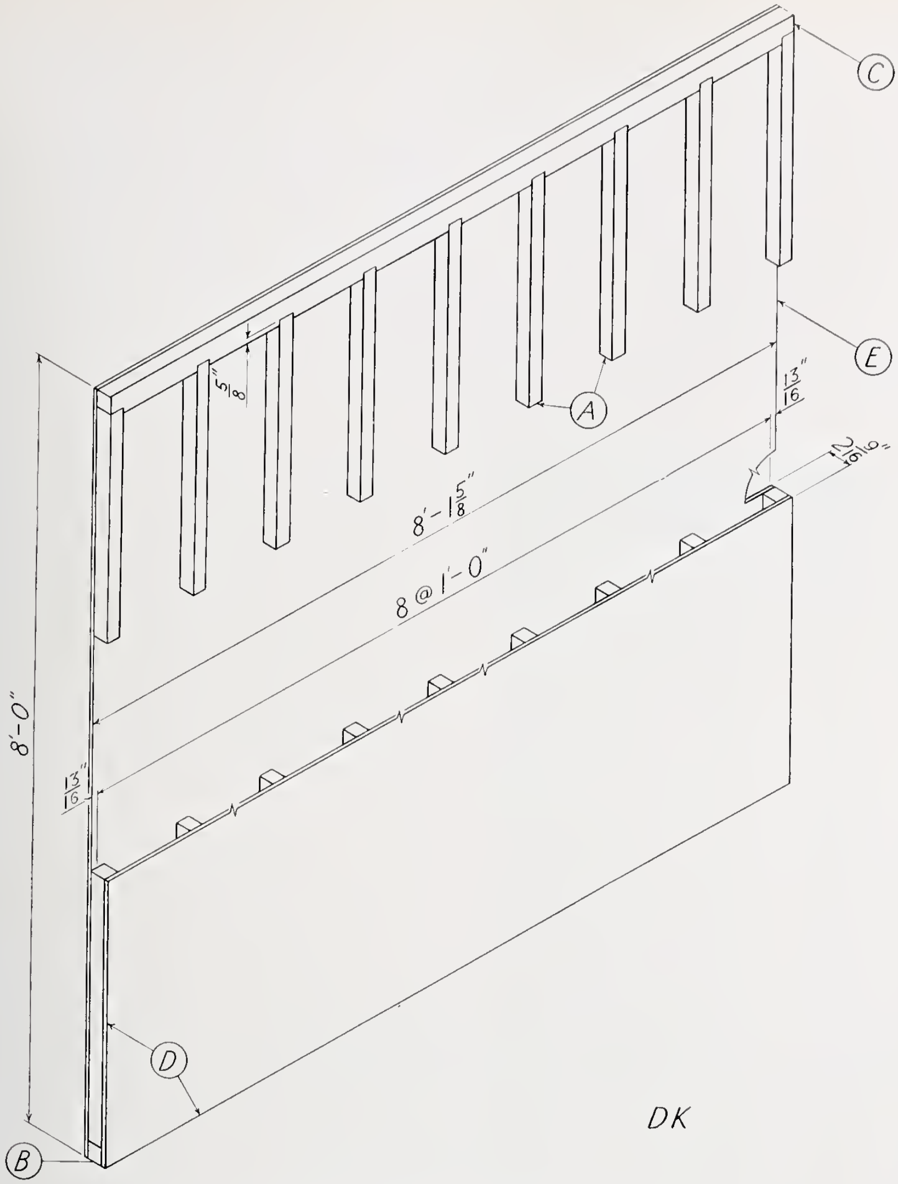

FIGURE 5.—*Eight-foot wall specimen DK.*

A, studs; *B*, floor plate; *C*, top plate; *D*, outside face; *E*, inside face.

plate and from 6 to 10 in. along each stud. The nails fastening the inside face were monel metal, 1¾ in. long, 0.083-in. diam. and those fastening the outside face were 4d zinc-coated box nails. The nails along the plates were from ½ in. to 1 in. from the ends of the board.

Spacer blocks.—The spacer blocks, *F*, were ponderosa pine, 25/32 by 1⅝ in., 2¾ in. long, spaced 1 ft 0 in. Each block was fastened to each face by two 4d zinc-coated nails through the fiberboard and into the block.

(*b*) *Eight-Foot Wall Specimens*

The 8-ft wall specimens, shown in figure 5, were 8 ft 0 in. high, 8 ft 1⅝ in. wide, and 2 9/16 in. thick. The specimens were similar to the 4-ft specimens except that there were nine studs spaced 1 ft 0 in. on centers and no spacer blocks.

Faces.—Each face was one piece of fiberboard, 15/32 in. thick, 8 ft 0 in. high, 8 ft 1⅝ in. wide, fastened to the floor plate, top plate, and

TABLE 5.—*Structural properties of wall DK*

[Weight, based on face area: 3.13 lb/ft²]

Compressive load [a]		Transverse load; span 7 ft 6 in.		Concentrated load [b]		Impact load; [c] span 7 ft 6 in.		Racking load	
Specimen	Maximum load	Specimen	Maximum load	Specimen	Maximum load	Specimen	Maximum height of drop	Specimen	Maximum load
	[d] *Kips/ft*		*lb/ft²*		*lb*		*ft*		[d] *Kips/ft*
C1	2.82	*T1*	124	*P1*	267	*I1*	5.0	*R1*	1.15
C2	3.06	*T2*	113	*P2*	260	*I2*	5.5	*R2*	1.72
C3	2.70	*T3*	118	*P3*	269	*I3*	5.0	*R3*	1.40
Average	2.86	Average	118	Average	265	Average	5.2	Average	1.42

[a] The compressive loads were applied 0.54 in. (one-third the thickness of the frame) from the face of the studs nearer the load line.
[b] Diameter of steel disk, 1 in.
[c] Weight of sandbag, 60 lb.
[d] A kip is 1,000 lb.

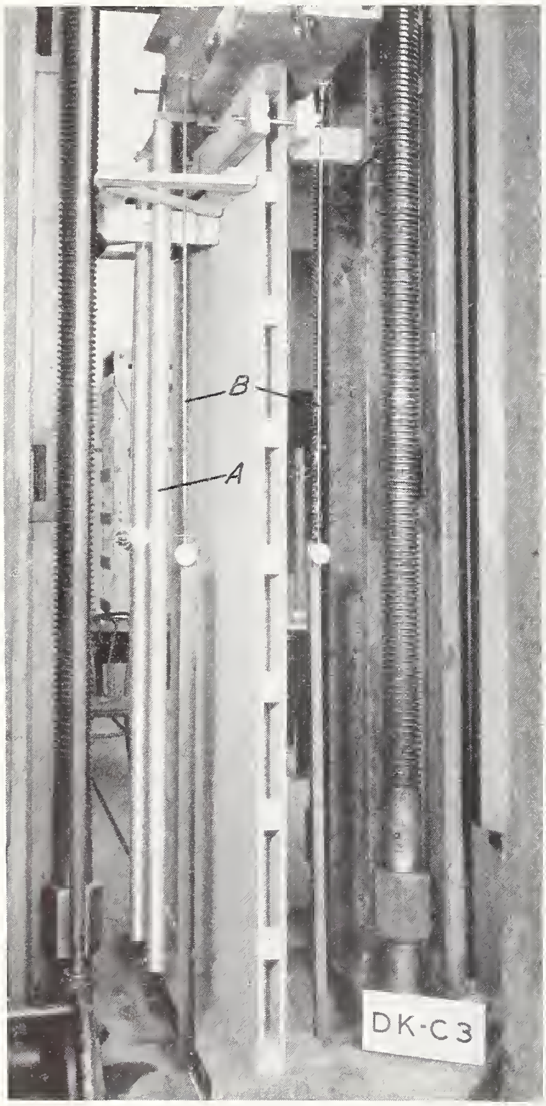

FIGURE 6.—*Wall specimen DK–C3 under compressive load.*

A, deflectometer; *B*, compressometers.

studs by both glue and nails. On the inside face the nails into the studs were monel metal, 1¾ in. long, 0.083–in. diam, spaced from 6 to 10 in., and those into the plates 4d zinc-coated box nails spaced 6 in. On the outside face the nails were 4d zinc-coated box nails spaced from 6 to 10 in. in the studs and 6 in. in the plates. All nails in the floor plate, top plate, and edge studs were from ½ to 1 in. from the edge of the fiberboard.

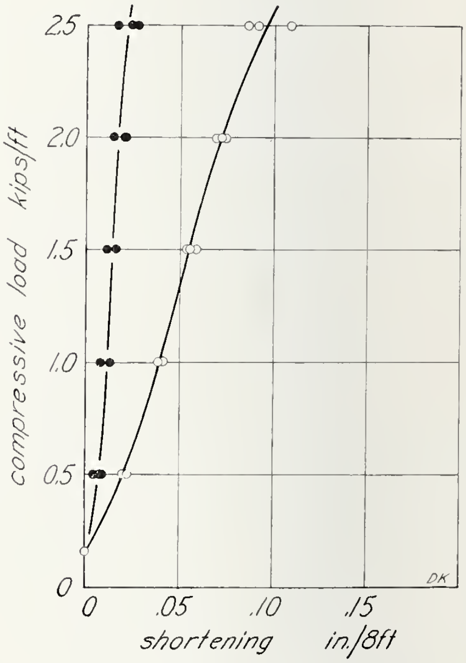

FIGURE 7.—*Compressive load on wall DK.*

Load-shortening (open circles) and load-set (solid circles) results for specimens *DK–C1, C2,* and *C3*. Load applied 0.54 in. (one-third the thickness of the frame) from the face of the studs nearer the load line. The loads are in kips per foot of actual width of specimen.

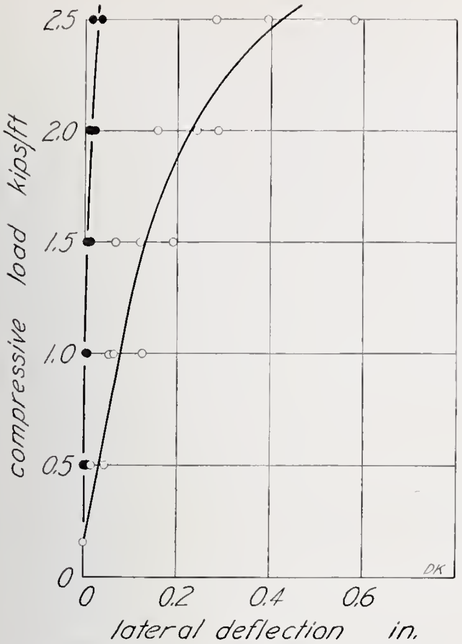

FIGURE 8.—*Compressive load on wall DK.*

Load-lateral deflection (open circles) and load-lateral set (solid circles) results for specimens *DK–C1*, *C2*, and *C3*. Load applied 0.54 in. (one-third the thickness of the frame) from the face of the studs nearer the load line. The loads are in kips per foot of actual width of specimen. The deflections and sets are for a gage length of 7 ft 6 in., the gage length of the deflectometers.

(c) *Comments*

Walls are built in sections, one section for each side of the room. The maximum width of section available is 20 ft; however, there should be no width greater than 16 ft unsupported by a partition. If the room dimensions are greater than 14 ft (the maximum width of Homasote fiberboard), a strip of Vehisote fiberboard, ¼ in. thick, is nailed or glued over the joints in the inside face.

The studs and plates are precut and then assembled on a jig table.

2. Compressive Load

Wall specimen *DK–C3* under compressive load is shown in figure 6. The results for specimens *DK–C1*, *C2*, and *C3* are given in table 5 and in figures 7 and 8.

The speed of the movable head of the testing machine was adjusted to 0.072 in./min. The gage length of the compressometers was 8 ft 0 in.

Under the maximum load on each specimen, the studs buckled laterally toward the outside face (the face farther from the load line). No other effects were observed except that one outer stud in specimen *C3* split longitudinally near one end.

3. Transverse Load

Specimen *DK–T2* under transverse load is shown in figure 9. The results are presented in table 5 and figure 10.

The transverse loads were applied to the outside face (fastened with glue and 4d box nails)

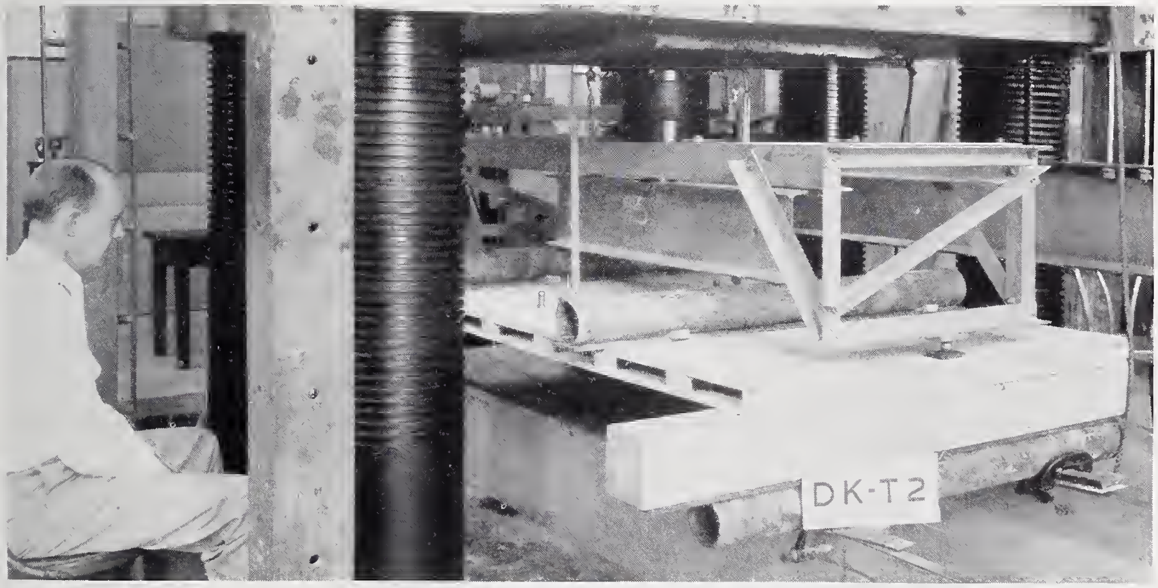

FIGURE 9.—*Wall specimen DK–T2 under transverse load.*

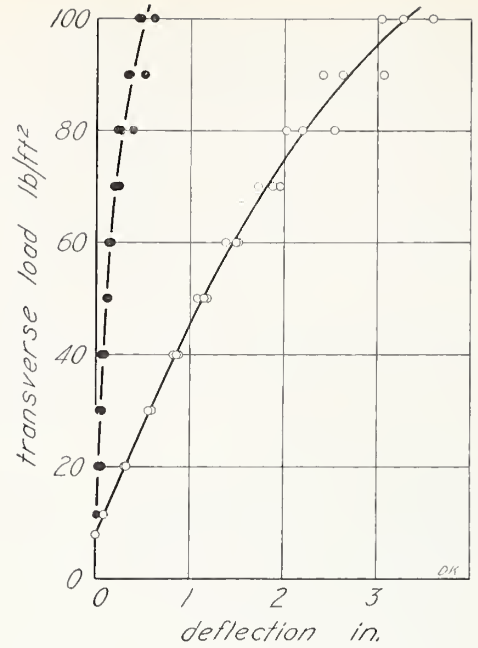

Figure 10.—*Transverse load on wall DK.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *DK–T1*, *T2*, and *T3* on the span 7 ft 6 in. The load (pounds per square foot) is the total load divided by the product of the span and the width of specimen.

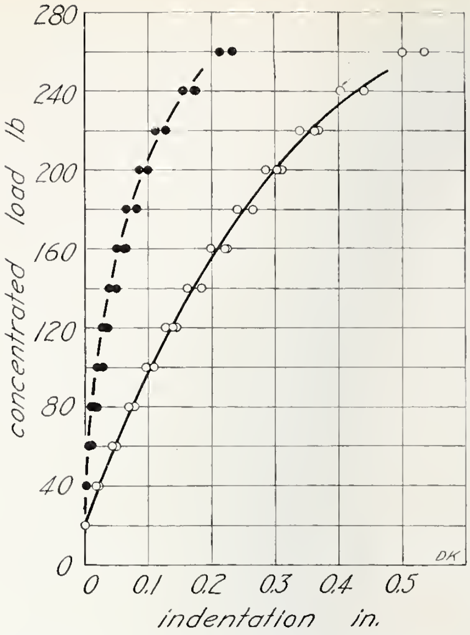

Figure 11.—*Concentrated load on wall DK.*

Load-indentation (open circles) and load-set (solid circles) results for specimens *DK–P1*, *P2*, and *P3*.

Figure 12.—*Wall specimen DK–I2 during the impact tests.*

A, deflectometer; *B*, set gage.

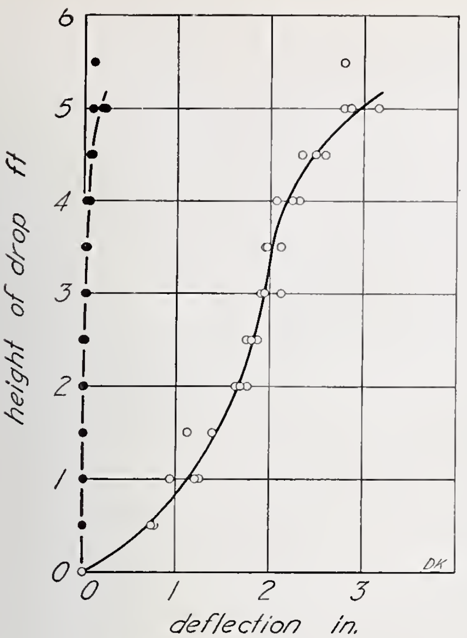

FIGURE 13.—*Impact load on wall DK.*
Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *DK–I1*, *I2*, and *I3* on the span 7 ft 6 in.

of specimen *DK–T1* and the inside face (fastened with glue and monel-metal nails) of specimens *T2* and *T3*. The speed of the movable head of the testing machine was adjusted to 0.31 in./min.

In specimen *T1* under a load of 121 lb/ft^2 an outer stud cracked at a knot near midspan. Under the maximum load this stud broke, rupturing the fiberboard locally; also an inner stud and the other outer stud ruptured near a loading roller. In specimens *T2* and *T3* at loads of 102 and 109 lb/ft^2, respectively, the glue bond ruptured on the loaded face between the loading rollers; at 106 and 117 lb/ft^2, respectively, a crack appeared in an outer stud under a loading roller. Under the maximum load on *T2*, an inner stud cracked under a loading roller. Under the maximum load on *T3*, all studs either cracked or ruptured.

4. Concentrated Load

Specimen *DK–P1* under concentrated load is shown in figure 1. The results for specimens *DK–P1*, *P2*, and *P3* are given in table 5 and in figure 11.

The concentrated loads were applied to the fiberboard midway between two adjacent studs, 1 ft 6 in. from the end of the specimen. The diameter of the disk was 1 in. Under the maximum load on each specimen, the disk punched through the fiberboard.

5. Impact Load

Specimen *DK–I2* during the impact load is shown in figure 12. The results for specimens *DK–I1*, *I2*, and *I3* are given in table 5 and in figure 13.

The impact loads were applied to the outside face (fastened with glue and 4d box nails) of *DK–I1* and to the inside face (fastened with glue and monel-metal nails) of specimens *I2* and *I3*, the sandbag (weight, 60 lb) striking the center of the specimen on the fiberboard between two studs.

In specimens *I1* and *I2* the fiberboard on the face struck cracked under the sandbag at a drop of 3.0 ft. At a drop of 3.5 ft the sandbag broke through the fiberboard on the face struck of both specimens. After a drop of 4.5 ft on *I1*, the fiberboard separated from the inner studs on the face not struck. At the maximum drop the sandbag went through the face not struck and one outer stud broke at midspan. After the maximum drop on *I2*, the fiberboard on the face not struck was broken and some of the 4d box nails had pulled out of the studs. After a drop of 3.0 ft on *I3*, the fiberboard was broken under the bag on the face struck. At a drop of 4.0 ft the box nails began to pull out of the studs on the face not struck. At the maximum drop the bag broke the fiberboard and separated it from two of the studs on the face not struck.

6. Racking Load

Specimen *DK–R2* under racking load is shown in figure 14. The results on specimens *DK–R1*, *R2*, and *R3* are given in table 5 and figure 15.

The racking loads were applied to the top plate, and the stop was in contact with the floor plate at the diagonally opposite corner.

Under the maximum load on specimen *R1*, the top plate crushed under the steel plate restrained by the vertical tie rods. Under the maximum load on *R2*, the specimen deflected laterally 2½ in. at the edge not loaded. In specimen *R3* under the maximum load, the top

FIGURE 14.—*Wall specimen DK–R2 under racking load.*

A, deformeter; *B*, dial micrometer; *C*, stop.

plate crushed under the steel plate restrained by the vertical tie rods and the stud at the loaded edge buckled outward in the plane of the wall.

VI. ADDITIONAL COMMENTS BY SPONSOR

The "Precision-Built, Jr." construction combines the economies derived from a maximum of shop fabrication and the resulting reduction in time of erection. This construction is recommended by the sponsor for one-story buildings having a width up to 24 ft.

The floors, walls, partitions, ceilings, and roofs are fabricated in sections and assembled on the site. When designing a house, it is desirable to use as many sections of the same dimensions as possible.

The framing of a typical house is shown in figure 16.

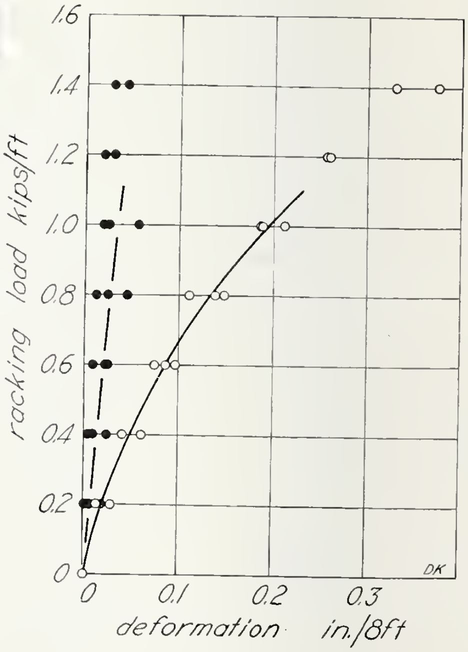

FIGURE 15.—*Racking load on wall DK.*

Load-deformation (open circles) and load-set (solid circles) results for specimens *DK–R1*, *R2*, and *R3*. The loads are in kips per foot of actual width of specimen.

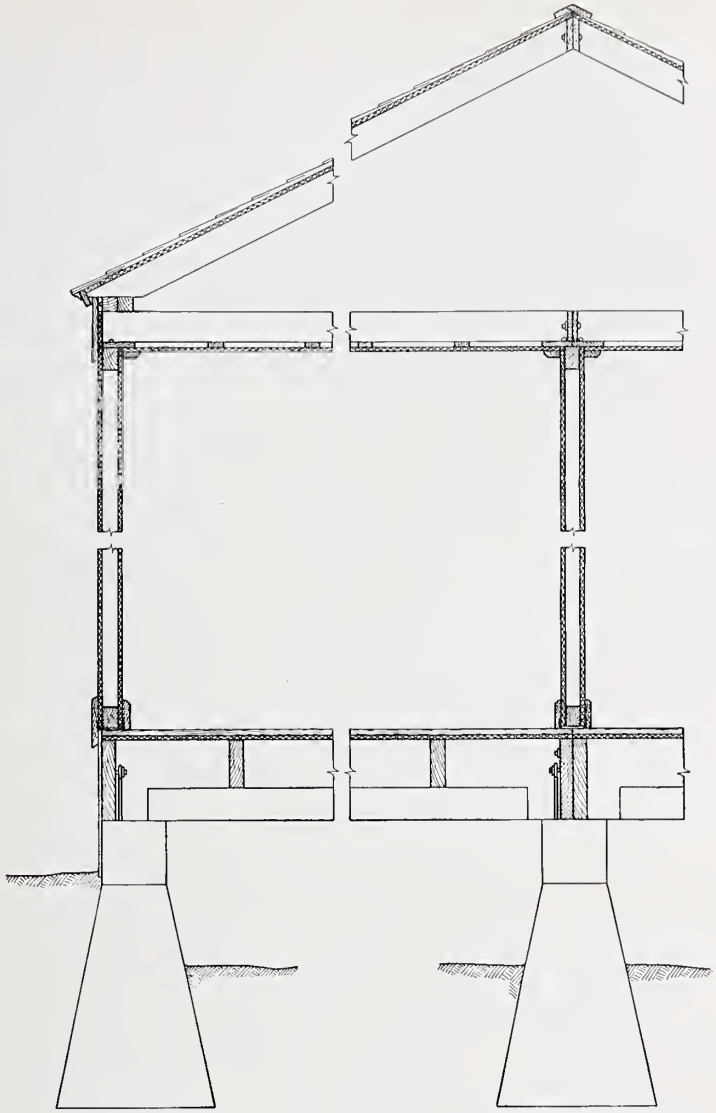

FIGURE 16.—*Section of typical "Precision-Built, Jr." house.*
Junior system of construction.

Any type of foundation can be used for the Junior construction either with or without basement. The precast-pier type of foundation is shown because it is believed to be the least expensive.

Each floor section consists of a wood frame, insulating fiberboard, and finish flooring. The frame has two joists (2 by 10 in) and two end members fastened together to form a rectangle. Parallel to the end members are transverse members (2 by 6 in.) resting on ledger members (2 by 4 in). The largest floor section fabricated is 12 ft long by 7 ft wide.

The floor sections are secured to the foundation by bolts or lag screws through eyebolts embedded in the concrete. Adjacent sections are fastened by bolts, ½-in. diam, spaced 3 ft. This draws complementary edges of the tongue-and-grooved finish floor together, rendering the joint inconspicuous. The finish floor is stained and shellacked in the shop; a final coat of varnish is applied in the field.

The surface of "Homasote" is weather resistant; therefore the exterior need not be painted if low cost is desired. An oil paint mixed with sand passing a No. 20 sieve when applied to the exterior gives the appearance of stucco. The interior may be finished with Rezitex or Plasterez, manufactured by I. F. Laucks, Inc. If exterior and interior finishes are requested, they are applied in the factory. The walls are anchored to the floor by channel clips spaced 3 to 4 ft. Exterior wall sections are joined at the corners by four ⅜ by 3 in. lag screws. Windows are prefitted to the frames and installed at the site.

Partition sections are fabricated and assembled similarly to the exterior-wall sections. Partition sections are fastened to the floor by channel clips and to the walls and other partitions by 20d casing nails at each intersection.

Each ceiling section consists of joists (2 by 4 in) spaced 1 ft, transverse furring strips (1 by 2 in) spaced 1 ft on the lower face of the joists, and insulating fiberboard fastened to the furring strips by glue and nails. The largest sections fabricated are 12 ft long by 8 ft wide.

Ceiling sections are fastened together by carriage bolts, ⅜-in. diam, spaced 2 to 3 ft, and to the wall and partition sections by metal ceiling clips and by lag screws, ⅜-in. diam, 2 in. long, spaced 4 ft.

Each roof section consists of rafters (2 by 6 in.) spaced 1 ft, tied together by a ridge member (1 by 8 in.) and at the eaves by a plate (2 by 4 in), with insulating fiberboard on the upper face. The largest sections fabricated are 16 ft long by 8 ft wide. Roof covering is applied after the sections are assembled.

Roof sections are fastened together along the edge rafters and ridge member by carriage bolts, ⅜-in. diam, spaced 4 ft. At the eaves the roof sections are fastened to the ceiling sections by lag screws.

Gable ends have no inside face and are made in one section in the same way as the walls. The sections are fastened to the joists and rafters by lag screws.

The physical properties of the fiberboard were determined by C. G. Weber of the Paper Section of this Bureau, under the supervision of B. W. Scribner.

The descriptions and drawings were prepared by E. J. Schell and G. W. Shaw of the Building Practice and Specifications Section, under the supervision of V. B. Phelan.

The structural properties were determined by the Engineering Mechanics Section, under the supervision of H. L. Whittemore, with the assistance of the following members of the professional staff: E. S. Cohen, J. S. Noble, J. S. Rimmer, L. R. Sweetman, and H. L. Weiss.

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WASHINGTON, December 18, 1940.

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