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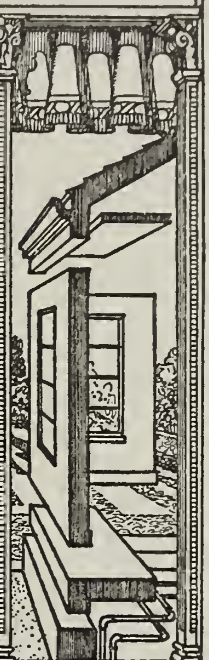


BUILDING MATERIALS AND STRUCTURES

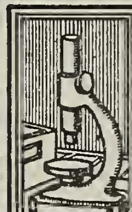
REPORT BMS47

Structural Properties of Prefabricated Wood-Frame Constructions for Walls, Partitions, and Floors

Sponsored by American Houses, Inc.

by

HERBERT L. WHITTEMORE
and AMBROSE H. STANG
with the collaboration of
THOMAS R. C. WILSON
Forest Products Laboratory



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The Forest Products Laboratory of the United States Department of Agriculture is cooperating with both committees on investigations of wood constructions.

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Forest Service, United States Department of Agriculture

ISSUED JUNE 3, 1940

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 the description of materials and methods used in their fabrication. The Bureau is responsible for the method of testing and for the test results.

This report covers only the load-deformation relations and strength of the structural elements of a house 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. It may be feasible later to determine the heat transmission at ordinary temperatures and the fire resistance of these same constructions.

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 the merits of a construction, for the 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.*

Structural Properties of Prefabricated Wood-Frame Constructions for Walls, Partitions, and Floors Sponsored by American Houses, Inc.

by HERBERT L. WHITTEMORE *and* AMBROSE H. STANG

with the collaboration of

Thomas R. C. Wilson, Forest Products Laboratory, Forest Service, United States Department of Agriculture

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ABSTRACT

For the program on the determination of the structural properties of low-cost house constructions, American Houses, Inc., New York, N. Y., submitted 39 specimens representing wood-frame wall, partition, and floor constructions.

The wall and load-bearing partition specimens were subjected to compressive, transverse, concentrated, impact, and racking loads; the nonload-bearing partition specimens to concentrated and impact loads; the floor specimens to transverse, concentrated, and impact loads. For each of the loads, three like specimens were tested. The transverse, concentrated, and impact loads were applied to both faces of the wall specimens. 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 tables.

I. INTRODUCTION

To provide technical facts on the performance of constructions which might be used in 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 report BMS1, Research on Building Materials and Structures for Use in Low-Cost Housing, and that part of the program relating to structural properties in report BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions.

Masonry constructions and wood constructions of types which have been extensively used in this country for houses were included in the program because their behavior under widely different service conditions is 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 four elements of a house sponsored by one of the manufacturers in the building industry. The wall and load-bearing partition specimens were subjected to compressive, transverse, concentrated, impact, and racking loads, simulating loads to which the walls of a house are subjected. In actual service compressive loads on a wall or load-bearing partition are produced by the weight of the roof, by second floor and second-story walls or partitions, if any, by furniture and occupants, and by snow and wind loads on the roof. Transverse loads on a wall and load-bearing partition are produced by the wind, concentrated and impact loads by accidental contact with heavy objects, and racking loads by the action of the wind on adjoining walls. For non-load-bearing partitions, impact loads may be applied accidentally by furniture or by a person falling against a partition, and concentrated loads by a ladder or other object leaning against a partition. Transverse loads are applied to floors by furniture and by occupants; concentrated loads by furniture, for example, the legs of a piano; and impact loads by objects falling on the floor or by persons jumping on the floor.

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

II. SPONSOR AND PRODUCT

The specimens were submitted by American Houses, Inc., New York, N. Y.

The constructions consisted of wood-frame wall, load-bearing partition, non-load-bearing partition, and floor sections, prefabricated in a shop and assembled at the building site to form the house.

III. SPECIMENS AND TESTS

The specimens represented four elements of a house which were assigned the following symbols: Wall, *CI*; load-bearing partition, *CJ;* non-load-bearing partition, *CK;* and floor, *CL.* The individual specimens were assigned the designations given in table 1.

TABLE 1.—*Specimen designations, wall CI, load-bearing partition CJ, non-load-bearing partition CK, and floor CL*

Element	Specimen designation	Load	Load applied
Wall	*C1, C2, C3*	Compressive	Upper end.
	T1, T2, T3	Transverse	Inside face.
	T4, T5, T6	do	Outside face.
	P1, P2, P3 [a]	Concentrated	Inside face.
	P4, P5, P6 [a]	do	Outside face.
	I1, I2, I3	Impact	Inside face.
	I4, I5, I6	do	Outside face.
	R1, R2, R3	Racking	Top plate.
Load-bearing partition	*C1, C2, C3*	Compressive	Upper end.
	T1, T2, T3	Transverse	Either face.
	P1, P2, P3 [a]	Concentrated	Do.
	I1, I2, I3	Impact	Do.
	R1, R2, R3	Racking	Top plate.
Non-load-bearing partition.	*P1, P2, P3* [a]	Concentrated	Either face.
	I1, I2, I3	Impact	Do.
Floor	*T1, T2, T3*	Transverse	Upper face.
	P1, P2, P3 [a]	Concentrated	Do.
	I1, I2, I3	Impact	Do.

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

The specimens were tested in accordance with the procedure outlined in BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions, which also gives the requirements for the specimens and describes the presentation of the results of the tests, particularly the load-deformation graphs.

Only three load-bearing partition specimens were tested under the transverse, concentrated, and impact loads, not six specimens, as required by BMS2. Inasmuch as the load-bearing partition construction was symmetrical about a plane midway between the faces, the results for these loads applied to one face of the specimens should be identical with those obtained by applying the loads to the other face.

For the compressive load the thickness of the wall was taken as the thickness of the structural portion, that is, the distance from the inside surface of the studs to the outside surface of the studs. The compressive load was applied along a line parallel to the inside face and at a distance from the inside surface of the studs of one-third the thickness of the wall. Also, the thickness of the load-bearing partition was taken as the thickness of the structural portion, that is, the distance from one surface of the studs to the other surface. The load was applied one-third this thickness from one surface of the studs.

Since the faces of the wall and partition specimens were not flush with the ends of the specimens, the steel-loading plates were not in contact with the faces, and therefore the compressive load was applied only to the top and floor plates. Wood-frame constructions under compressive load show considerable local shortening, caused by crushing of the floor plate and top plate at the ends of the studs. As a result, the shortening of the entire specimen is not proportional to the value obtained from compressometers attached to the specimen over only a portion of its height. Therefore, the shortenings and sets were measured with compressometers attached to the steel plates through which the load was applied, not attached to the specimen as 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.

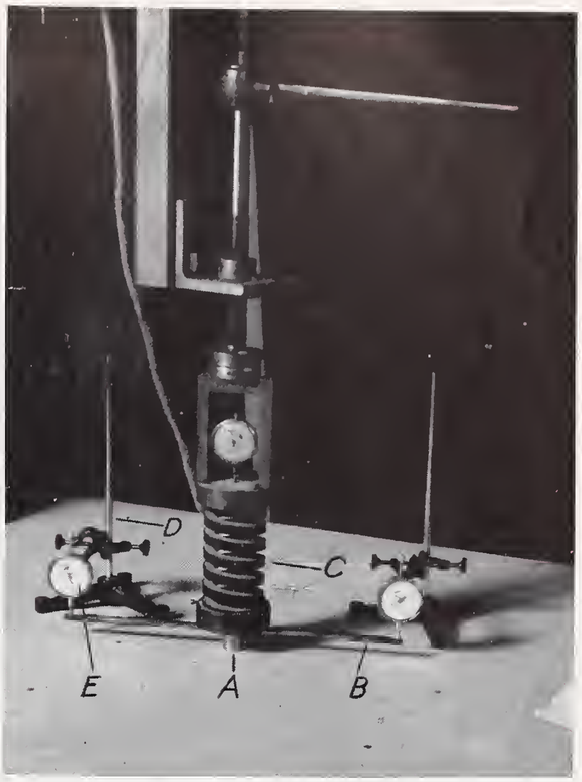

Figure 1.—*Apparatus for concentrated-load test.*

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

The load was measured by means of the 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 disk. The micrometers were graduated to 0.001 in., and readings were recorded to the 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 the micrometer readings minus the initial reading was taken as the depth of the indentation under load.

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 plates, 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 holes

FIGURE 2.—*Wall CI.*

Typical specimen.

in the channel and into the top of the specimen. A dial micrometer was attached to a steel block which was in contact with the floor plate of the specimen at the stop. The spindle of the micrometer was against the steel angle of the deformeter. The gage length (distance from the top of the specimen to the center of the steel block) was 8 ft ½ in. The micrometer was graduated to 0.001 in., and readings were recorded to the nearest division. This deformeter was used instead of the taut-wire mirror-scale device described in BMS2.

Thomas R. C. Wilson, of the Forest Products Laboratory, Madison, Wis., cooperated with the Bureau staff in this work by giving advice and making suggestions on the technique of testing wood structures.

The tests were begun April 10, 1939, and completed April 20, 1939, The sponsor's representative witnessed the tests.

IV. MATERIALS

The information on materials was obtained from the sponsor and from inspection of the specimens, except that the Forest Products Laboratory assisted by identifying the species of wood in the framing, and the Engineering Mechanics Section of the National Bureau of Standards assisted by determining the moisture content of the wood and the weight and transverse strength of the gypsum wall board.

1. WOOD

Framing.—The wood for the framing was identified as Douglas fir, *Pseudotsuga taxifolia.*

No. 1 common, S4S (surfaced four sides), in sizes ⅝ by 3⅝ in. 1$\frac{1}{16}$ by 2⅝ in. (nominal 1¼ by 3 in), 1⅝ by 2⅝ in. (nominal 2 by 3 in), 1⅝ by 3⅝ in. (nominal 2 by 4 in), and 1⅝ by 7½ in. (nominal 2 by 8 in).

Ribbons.—Plywood, Douglas fir, ⅝ in. thick, five-ply bonded with water-resistant glue. Douglas Fir Plywood Association "Plyscord" grade. Washington Veneer Co., "Westboard."

Sheathing.—Plywood, Douglas fir, $\frac{5}{16}$ in. thick, three-ply, bonded with water-resistant glue. Douglas Fir Plywood Association "Plyscord" grade. Washington Veneer Co., "Westboard."

Subflooring.—Plywood, Douglas fir, ⅝ in. thick, five-ply, bonded with water-resistant glue. Douglas Fir Plywood Association "Plyscord" grade. Washington Veneer Co., "Westboard."

Flooring.—Red oak, $\frac{13}{16}$ by 2¼ in., plain-sawed, select, tongue-and-grooved and end-matched.

Shingles.—Red cedar, 18 in. long, 5 butts in 2¼ in., No. 1 "Certigrade" of the Red Cedar Shingle Bureau.

After each specimen was tested, one face was removed to expose the framing, and a sample of the wood was taken from either a joist or a stud. Photographs were made showing the character of the wood in the framing, and also in the flooring on each floor specimen. Figures 2, 3, and 4 represent typical frames.

The moisture content of the wood (except bridging and spacers) is given in table 2.

TABLE 2.—*Moisture content of the wood*

[Determined on the day the wall, partition, or floor specimen was tested]

Wood	Construction symbol	Moisture content [a]		
		Minimum	Maximum	Average
		Percent	*Percent*	*Percent*
Framing, Douglas fir	*CI*	8	19	12
	CJ	7	16	11
	CK	8	14	11
	CL	9	19	13
Average				12
Sheathing, Douglas fir plywood	*CI*	6	10	7
Subflooring, Douglas fir plywood	*CL*	7	8	8
Shingles, red cedar	*CI*	[b] <7	7	[b] <7
Flooring, red oak	*CL*	6	13	9

[a] Based on weight when dry.
[b] "Less than" (<) symbol.

An electric moisture meter was used for determining the moisture content. To calibrate the meter for Douglas fir and red oak, 39 samples from the wall, partition, and floor frames and 6 samples of the flooring were dried in an oven at 212° F. until the weight was constant. The moisture content was the difference between the initial weight and the weight when ovendry, expressed as a precentage of the weight when ovendry. The average value for the Douglas fir (framing) samples was 0.8 less than the average of the meter readings on the same samples. The average value of the red-oak (flooring) samples was 0.6 less than the

FIGURE 3.—*Load-bearing partition CJ.*

Typical specimen.

average meter readings on the same samples. Therefore, the moisture content of the Douglas fir was obtained by subtracting 0.8 and the moisture content of the red oak by subtracting 0.6 from the average of the meter readings. The results were rounded to the nearest whole number. The moisture content was determined on each piece of framing and on six pieces of flooring from each specimen.

The average uncorrected meter reading on six shingles per specimen was taken as the moisture content of the shingles. On the plywood sheathing and subflooring the determination was made by drying one sample from each specimen in an oven until the weight was constant.

2. Wallboard

Gypsum wallboard, 12 ft 0 in. long, 4 ft 0 in. wide, ½ in. thick, weight 2,000 lb/1,000 ft². The wallboard was gypsum plaster containing graded cork and reinforced on each face by a sheet of paper. The plaster was 93 percent of gypsum plaster and 7 percent of graded cork, by weight. On one face the paper was manila, buff, 0.021 in. thick, weight 85 lb/1,000 ft²; on the other face, gray, 0.021 in. thick, weight 75 lb/1,000 ft². The longitudinal edges of the buff face were rabbeted 1½ in. wide and 0.025 in. deep.

The transverse strength of the wallboard, determined in accordance with Federal Specification SS–W–51a, Wallboard; Gypsum, was 189 lb loaded across the surface fibers of the paper, and 50 lb loaded parallel to the surface fibers. The wallboard complied with the requirements of the specification for weight and strength. Kelley Plasterboard Co., "Kelley Cork-Gypsum Wallboard."

3. Nails

All the nails except the cut flooring nails were made from steel wire. The description is given in table 3.

4. Sheathing Paper

Asphalted paper.—Felt, asphalt-saturated, weight 15 lb/100 ft²; rolls, width 3 ft 0 in., area 432 ft². Lloyd A. Fry & Co.

Rosin paper.—Red paper, rosin-sized, weight 4 lb/100 ft²; rolls, width 3 ft 0 in., area 500 ft². Sears, Roebuck & Co., Catalog No. 48 H M 3007.

TABLE 3.—*Description of nails*

Type	Size	Length	Steel Wire Gage	Diameter	U. S. Std. Gage	Thickness	Finish
	Penny	*in.*	*No.*	*in.*	*No.*	*in.*	
Common	6	1⅞	13	0.0915			Cement-coated.
Do	8	2⅜	11½	.113			Do.
Do	10	2⅞	11	.1205			Do.
Do	16	3¼	9	.1483			Do.
Do	20	3¾	7	.177			Do.
Flooring	8	2½			12	0.1072	
Plasterboard.[a]		1⅛	13	.0915			Blued.
Shingle		1½	12	.1055			Zinc-coated.

[a] Head diameter 5/16 in.

5. Staples

Tacker staples, formed of sheet steel, No. 25 U. S. Std. Gage (0.0214 in. thick), 0.05 in. wide; staple, 7/16 in. wide, 5/16 in. long, tinned.

6. Glue

Water-resistant glue, I. F. Laucks, Inc., No. 888.

7. Joint Filler

The filler was a mixture of casein glue, clay, and mica; casein, minimum 10 percent, by weight. Kelley Plasterboard Co., Inc., "Kelley Joint Filler."

8. Tape

Cotton tape, 2 in. wide, approximately 0.006 in. thick, thread count 44 by 40. Kelley Plasterboard Co., Inc., "Kelley Cloth Tape."

V. WALL *CI*

1. Sponsor's Statement

Wall *CI* was a prefabricated wood frame having plywood sheathing, sheathing paper, and wood shingles as the outside face and gypsum wallboard as the inside face. The specimens were not painted.

The price of this construction in Washington, D. C., as of July 1937, was $0.335/ft².

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

The 4-ft wall specimens shown in figure 5 were 8 ft 1 5/16 in. high, 4 ft 0 in. wide, and 5¼ in. thick. Each specimen was a wood frame to which the faces were fastened. The frame consisted of three full-sized studs, *A*, and one half-sized stud, *B*, fastened to a floor plate, *C*, and

FIGURE 4.—*Floor CL.*

Typical specimen.

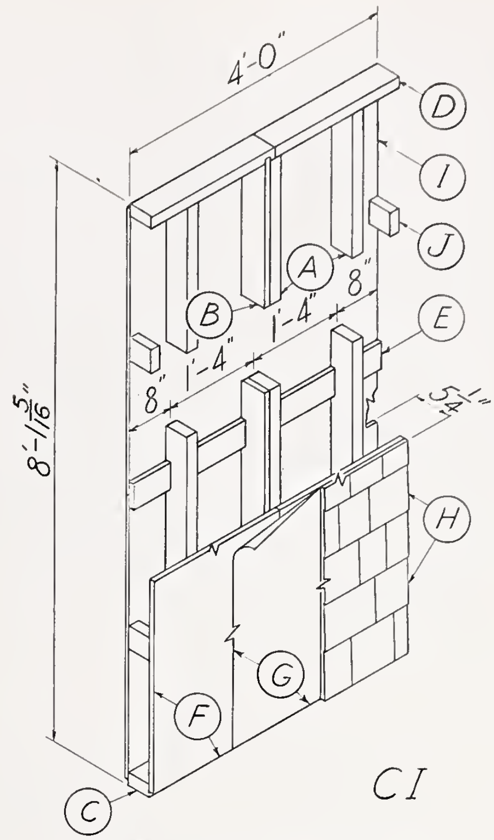

FIGURE 5.—*Four-foot wall specimen CI.*

A, full-sized studs; *B*, half-sized stud; *C*, floor plate; *D*, top plate; *E*, plywood ribbon; *F*, plywood sheathing; *G*, sheathing paper; H, wood shingles; *I*, wallboard; *J*, spacers.

a top plate, *D*, by nails. The joint between the center stud and the half-sized stud represented the joint between two adjacent prefabricated sections when erected in a house. A plywood ribbon, *E*, was fastened to the studs at midheight. The outside face consisted of plywood sheathing, *F*, sheathing paper, *G*, and wood shingles, *H*. The inside face consisted of two sheets of gypsum wallboard, *I*. The overhanging edges of the faces were supported by spacers, *J*.

Full-sized studs.—The full-sized studs, *A*, were Douglas fir, 1⅝ by 3⅝ in., 7 ft 10 1/16 in. long, spaced 1 ft 4 in. on centers. The inside edges of the studs were dadoed (notched) ⅝ by 3⅝ in. at midheight.

Half-sized stud.—The half-sized stud, *B*, was Douglas fir, ⅝ by 3⅝ in., 7 ft 11 1/16 in. long, dadoed ⅝ by 3⅝ in. at midheight, and fastened to the center stud by 8d common nails spaced about 1 ft 0 in.

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Floor plate and top plate.—The floor plate, *C*, and the top plate, *D*, each consisted of two pieces of Douglas fir, 1⅝ by 3⅝ in., 2 ft 0 in. long, with a joint on the center full-sized stud. Each piece was fastened to an outer stud by two 20d common nails driven through the plate into the stud (not toenailed). One piece was notched ⅝ in. wide by ½ in. deep, fitting over the half-sized stud, to which it was fastened by two 10d common nails through the piece into the half-sized stud. The other piece was fastened to the center full-sized stud by two 16d common nails through the piece into the stud (not toenailed).

Plywood ribbon.—The plywood ribbon, *E*, consisted of two pieces of ⅝-in. Douglas fir plywood, 3⅝ in. wide and 2 ft 0 in. long, with a joint on the center full-sized stud. The grain of the outer plies was longitudinal. The ribbon fitted flush into the dadoes in the studs and was fastened to each stud by two 6d common nails.

Sheathing.—The sheathing, *F*, was two pieces of 5/16-in. Douglas fir plywood, 1 ft 11 15/16 in. wide and 8 ft 0 in. long, the grain of the outer plies being longitudinal (vertical). There was a vertical joint on the center stud with ⅛ in. clearance between the edges. The plywood was fastened to the outer studs, the floor plate, and the top plate by 6d common nails spaced 6 in. One piece of sheathing was fastened to the center full-sized stud by 6d common nails spaced 4 in. and to the half-sized stud by 6d common nails spaced 6 in. The other piece was fastened to the center stud by 6d common nails spaced 6 in.

Sheathing paper.—The sheathing paper, *G*, consisted of three sheets of asphalted paper, 3 ft 0 in. by 4 ft 0 in. The sheets were laid transversely over the sheathing with two 6-in. laps and were fastened to the sheathing along the laps and at the ends of the specimen by staples, spaced about 8 in., which were driven through both sheets at the laps.

Shingles.—The shingles, *H*, were red cedar, 18 in. long, exposed 8 in. to the weather, and fastened at midlength to the sheathing by 1½-in. shingle nails, two nails through each shingle.

Wallboard.—The wallboard, *I*, was two sheets of gypsum wallboard, ½ in. thick, 4 ft 0 in. square, with a transverse joint between the rabbeted edges on the plywood ribbon. The wallboard was fastened to the ribbon by glue and by 1⅛-in. plasterboard nails spaced 6 in., to the full-sized studs by 1⅛-in. plasterboard nails spaced 8 in., and to the top plate and floor plate by 1⅛-in. plasterboard nails ½ in. from the edge of the board, spaced 6 in. The wallboard was not fastened to the half-sized stud. The joint was calked with filler, covered with 2-in. tape, and allowed to set. More filler was then applied over the tape, bringing the surface flush with the wallboard.

Spacers.—The spacers, *J*, along the overhanging edges of the faces, were Douglas fir, 1⅝ by 3⅝ in., 4 in. long, and each was fastened to the wallboard by two 1⅛-in. plasterboard nails and to the sheathing by two 6d common nails passing through the wallboard and sheathing into the spacer. Spacers are not used in a house.

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

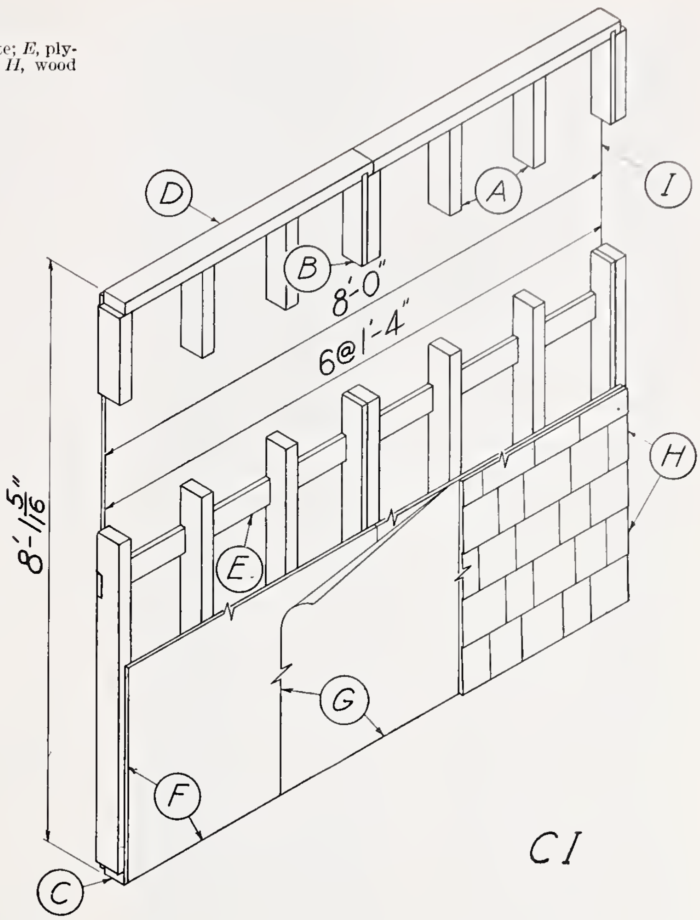
The 8-ft wall specimens shown in figure 6 were 8 ft 1 5/16 in. high, 8 ft 0 in. face width, and 5¼ in. thick. The specimens were similar to the 4-ft specimens, except there were seven full-sized studs spaced 1 ft 4 in. on centers, and two half-sized studs, one fastened to the center stud and one to an edge stud. A full-sized stud at each edge extended one-half its thickness beyond the faces. The width overall was 8 ft 1⅝ in.

Sheathing.—The sheathing was two pieces of plywood, 8 ft 0 in. by 4 ft 0 in., the grain of the outer plies being longitudinal (vertical). There was a vertical joint on the center stud. The plywood was fastened to the outer studs, the floor plate, and the top plate by 6d common nails spaced 6 in. One piece of sheathing was fastened to the center full-sized stud by 6d common nails spaced 4 in. and to the half-sized stud by 6d nails spaced 6 in.; and the other piece to the center stud by 6d nails spaced 6 in.

Wallboard.—The wallboard consisted of three sheets of gypsum wallboard: one piece, 8 ft 0 in. by 4 ft 0 in., extending over the entire width; and two pieces, 5 ft 4 in. by 4 ft 0 in. and 2 ft 8 in. by 4 ft 0 in., with a longitudinal (vertical) joint over a stud 2 ft 8 in. from the edge of the face. The full-width piece covered the upper half of one specimen and the lower half of the others.

FIGURE 6.—*Eight-foot wall specimen CI.*

A, full-sized studs; *B*, half-sized stud; *C*, floor plate; *D*, top plate; *E*, plywood ribbon; *F*, plywood sheathing; *G*, sheathing paper; *H*, wood shingles; *I*, wallboard.



There was a horizontal joint at midheight over the ribbon. The wallboard was fastened to the floor plate, the top plate, and the edge studs by 1⅝-in. plasterboard, nails ½ in. from the edge of the boards, spaced 6 in. It was fastened to the ribbon by glue and by 1⅝-in. plasterboard nails spaced 6 in., to the stud at the vertical joint by 1⅝-in. nails spaced 6 in., and to the remaining full-sized studs by 1⅝-in. nails spaced 8 in. It was not fastened to the half-sized studs. Both joints were calked with filler and covered with tape.

(c) *Comments*

Wall sections are manufactured in widths which are multiples of 1 ft 4 in. The actual width depends on the size and location of openings and on the location of partitions. Usually the joints are at the edges of openings and at intersecting partitions. The sections are full story height, the usual ceiling height being 8 ft.

The prefabricated sections consist of the wood frame, plywood sheathing, and ribbon. They are assembled without the use of power equipment by raising into a vertical position on the subfloor and then sliding into place. They are fastened to the floor by two 16d nails between each pair of studs, driven through the floor plate into the headers in the floor. At a joint, the edge stud, the top plate, the ribbon, and the sheathing are nailed to the edge stud of the adjacent section. The wall sections are joined at corners by a special unit.

At the intersection of a wall and a partition a half-sized stud is nailed to a stud in the wall and the partition is fastened to the half-sized stud.

Openings are framed for conventional sizes of doors and windows, which are put in place after the sections are assembled.

Exterior and interior finishes are applied after the frames for the openings are in place. Exterior finishes may be wood siding, shingles,

FIGURE 7.—*Wall specimen CI–C1 under compressive load.*

stucco, or brick veneer. The interior finish is usually wallpaper or paint on gypsum wallboard. Thermal insulation may be placed between the studs. This space can also be used for pipes, ducts, and conduits.

2. Compressive Load

Wall specimen *CI–C1* under compressive load is shown in figure 7. The results for specimens *CI–C1*, *C2*, and *C3* are given in table 4 and in figures 8 and 9.

The speed of the movable head of the testing machine under no load was adjusted to 0.072 in./min. The lateral deflections shown in figure

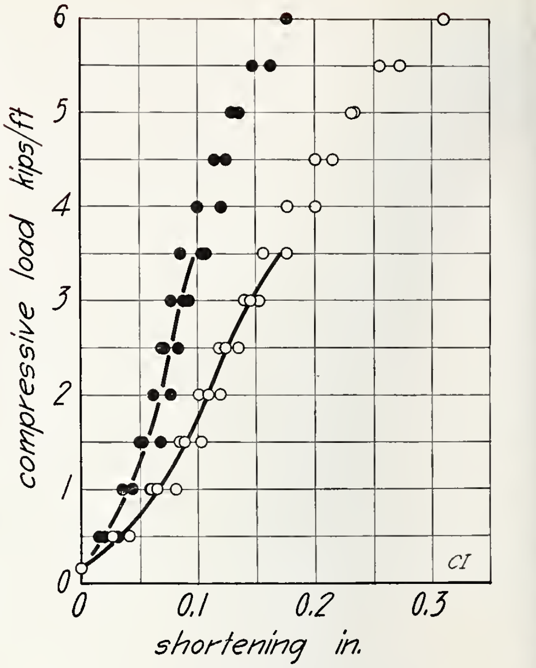


FIGURE 8.—*Compressive load on wall CI.*

Load-shortening (open circles) and load-set (solid circles) results for specimens *CI–C1*, *C2*, and *C3*. The load was applied 1.21 in. (one third the thickness of the frame) from the inside surface of the studs. The loads are in kips per foot of actual width of specimen.

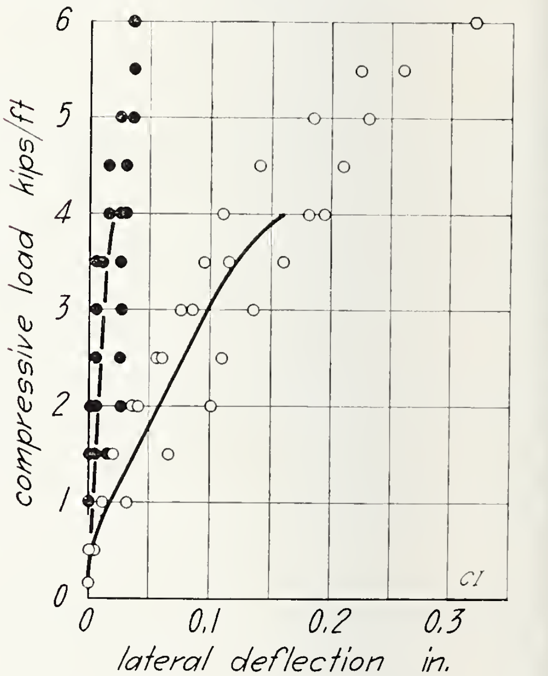


FIGURE 9.—*Compressive load on wall CI.*

Load-lateral deflection (open circles) and load-lateral set (solid circles) results for specimens *CI–C1*, *C2*, and *C3*. The load was applied 1.21 in. (one-third the thickness of the frame) from the inside surface of the studs. The loads are in kips per foot of actual width of specimen. The deflections and sets are for a gage length of 8 ft 0 in., the gage length of the deflectometers.

Table 4.—*Structural properties of wall CI and load-bearing partition CJ*

[Weight: Wall *CI*, 5.46 lb/ft²; load-bearing partition *CJ*, 5.42 lb/ft²]

Construction symbol	Load									
	Compressive [a]		Transverse [b]		Concentrated		Impact [b]		Racking	
	Specimen	Maximum load	Specimen	Maximum load	Specimen	Maximum load	Specimen	Maximum height of drop	Specimen	Maximum load
		[c] *Kips/ft*		*lb/ft²*		*lb*		*ft*		[c] *Kips/ft*
CI	*C1*	4.22	*T1*	345	*P1*	192	*I1*	[d] 10.0	*R1*	1.37
	C2	7.57	*T2*	272	*P2*	186	*I2*	[d] 10.0	*R2*	1.20
	C3	5.98	*T3*	342	*P3*	192	*I3*	[d] 10.0	*R3*	1.18
Average		5.92		320		190		[d] 10.0		1.25
CI			*T4*	237	*P4*	[e] 1,000	*I4*	[f] 10.0		
			T5	225	*P5*	[e] 1,000	*I5*	9.0		
			T6	169	*P6*	950	*I6*	[f] 10.0		
Average				210						
CJ	*C1*	4.90	*T1*	167	*P1*	181	*I1*	8.0	*R1*	0.80
	C2	6.00	*T2*	125	*P2*	175	*I2*	6.5	*R2*	.80
	C3	5.65	*T3*	122	*P3*	210	*I3*	6.0	*R3*	.83
Average		5.52		138		189		6.8		0.81

[a] The compressive loads were applied 1.21 in. (one-third the thickness of the frame) from the inside surface of the studs.
[b] Span 7 ft 6 in.
[c] A kip is 1,000 lb.
[d] Test discontinued. Specimen did not fail. No studs broken.
[e] Test discontinued. Specimen did not fail, the shingle split.
[f] Test discontinued. One or more studs ruptured.

9 were plotted to the right of the vertical axis for deflections of the specimen toward the outside face.

Under a load of 4.0 kips/ft on specimen *C1* the studs crushed into the top plate at the inside surface of the wood frame. The studs crushed into the plate in specimen *C2* under a load of 3.5 kips/ft. and in specimen *C3* under a load of 5.5 kips/ft. Under loads of 4.0, 7.0, and 5.5 kips/ft, respectively, the gypsum wallboard separated at the top of the studs. Under the maximum load on each specimen the top plate split along the grain and crushed at the inside surface of the studs.

3. Transverse Load

The transverse-load test results are shown in table 4 and in figure 10 for wall specimens *CI–T1*, *T2*, and *T3*, loaded on the inside face, and in figure 11 for wall specimens *CI–T4*, *T5*, and *T6*, loaded on the outside face.

The speed of the movable head of the testing machine under no load was adjusted to 0.14 in./min.

As the load was increased the nails tilted under the shearing forces exerted by the gypsum wallboard, and small circular cracks appeared around the head of each nail. This was particularly pronounced near the ends of the specimen. These cracks were observed at a load of 300 lb/ft² on specimen *T1*, 200 lb/ft² on specimen *T2*, and 175 lb/ft² on specimen *T3*. The deflections of the specimens under these loads were 2.03, 1.25, and 1.04 in., respectively. Under the maximum load the center stud of specimen *T1* ruptured at midspan, and as the deflection increased without an increase in load both outer studs ruptured. In specimens *T2* and *T3* under the maximum loads two studs ruptured near midspan and the top plate and floor plate separated from the studs and sheathing.

In specimen *T4* under a load of 148 lb/ft², in *T5* under 194 lb/ft², and in *T6* under the maximum load, all the studs split along the grain, beginning at the dadoes at midheight. The force exerted by the split studs ruptured the gypsum wallboard at the transverse joint. Under the maximum load on each specimen all the studs ruptured either partially or completely. In each stud the rupture began at the dado.

4. Concentrated Load

Concentrated-load test results are presented in table 4 and in figure 12 for wall specimens *CI–P1*, *P2*, and *P3*, loaded on the inside face, and in figure 13 for specimens *CI–P4*, *P5*, and *P6*, loaded on the outside face.

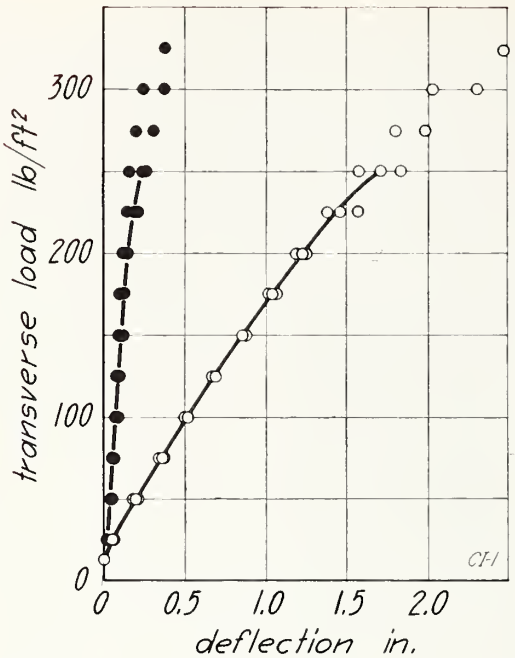


FIGURE 10.—*Transverse load on wall CI, load applied to inside face.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *CI–T1, T2,* and *T3* on the span 7 ft 6 in.

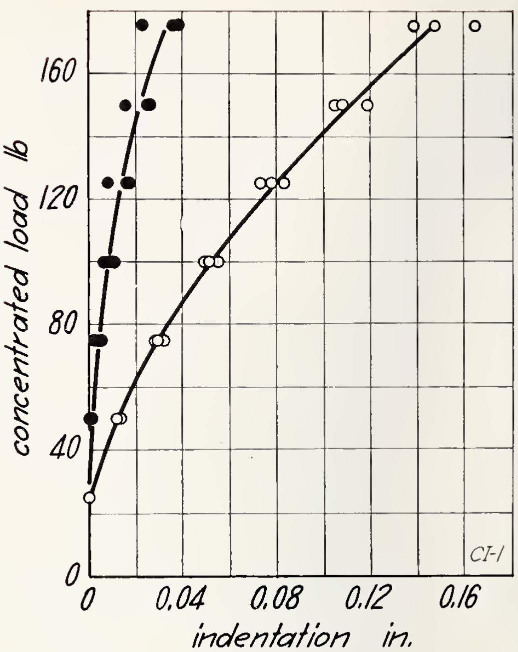


FIGURE 12.—*Concentrated load on wall CI, load applied to inside face.*

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

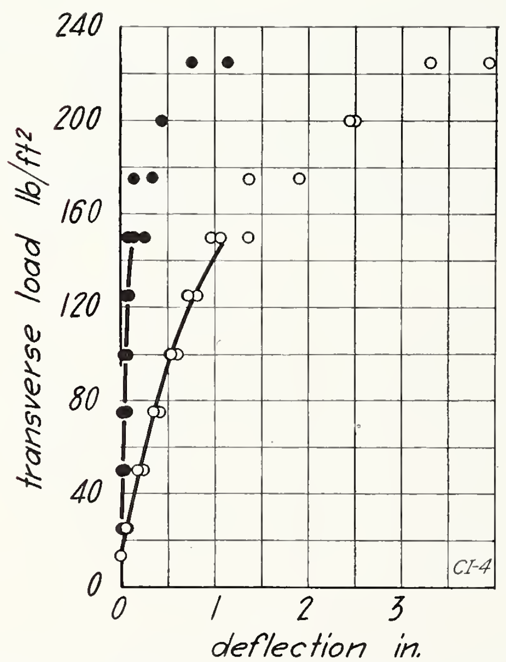


FIGURE 11.—*Transverse load on wall CI, load applied to outside face.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *CI–T4, T5,* and *T6* on the span 7 ft 6 in.

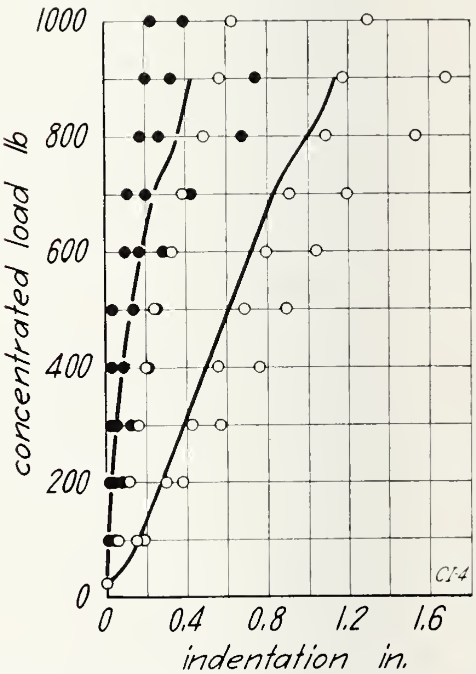


FIGURE 13.—*Concentrated load on wall CI, load applied to outside face.*

Load-indentation (open circles) and load-set (solid circles) results for specimens *CI–P4, P5,* and *P6.*

The concentrated loads were applied to the inside face of specimens *CI–P1*, *P2*, and *P3* on the gypsum wallboard midway between two studs and about 1½ ft from one end of the specimen. Under the maximum load on each specimen the disk punched through the wallboard.

The concentrated loads were applied to the outside face of specimens *CI–P4*, *P5*, and *P6* on a shingle about 1½ ft from an end of the specimen. The load was applied midway between studs on specimens *P4* and *P6* and 1½ in. from a stud on specimen *P5*. In specimen *P4* the shingle split along the grain at one edge of the disk under a load of 800 lb, and in specimens *P5* and *P6* under a load of 750 lb. Under the maximum load on specimen *P6* the disk punched through the shingle and the plywood sheathing. In specimens *P4* and *P5* the sets after a load of 1,000 lb were 0.39 and 0.23 in., respectively.

5. Impact Load

Impact-test results are shown in table 4 and in figure 14 for wall specimens *CI–I1*, *I2*, and *I3*, loaded on the inside face, and in figure 15 for wall specimens *CI–I4*, *I5*, and *I6*, loaded on the outside face.

The impact loads were applied to the center of the inside face of specimens *CI–I1*, *I2*, and *I3*, the sandbag striking the gypsum wallboard directly over the plywood ribbon and the center stud. The effects are given in table 5.

Table 5.—*Effects of impact load on wall CI, load applied to the inside face*

Description of effects on loaded (gypsum wallboard) face	Specimen *I1*		Specimen *I2*		Specimen *I3*	
	Height of drop	Deflection	Height of drop	Deflection	Height of drop	Deflection
	ft	*in.*	*ft*	*in.*	*ft*	*in.*
Nails began to pull from studs	2.0	0.82	1.0	0.51	1.0	0.58
Wallboard cracked where the sandbag struck	6.0	1.62	6.5	1.71	6.5	1.81
Wallboard ruptured longitudinally between studs	8.5	2.10	8.5	2.07		
Wallboard ruptured transversely along the joint at midspan			8.5	2.07	8.5	2.31

After the 10-ft drop on specimens *I1*, *I2*, and *I3* the sets were 0.16, 0.14, and 0.19 in., respectively. No studs were broken, and the face not loaded (shingles) was undamaged.

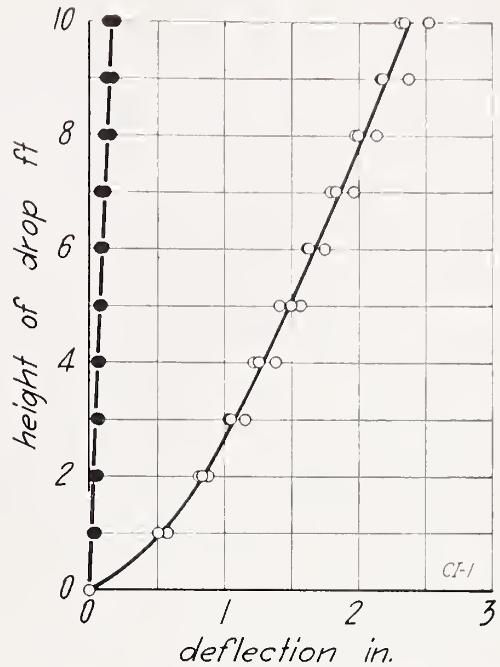


Figure 14.—*Impact load on wall CI, load applied to inside face.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *CI-I1*, *I2*, and *I3* on the span 7 ft 6 in.

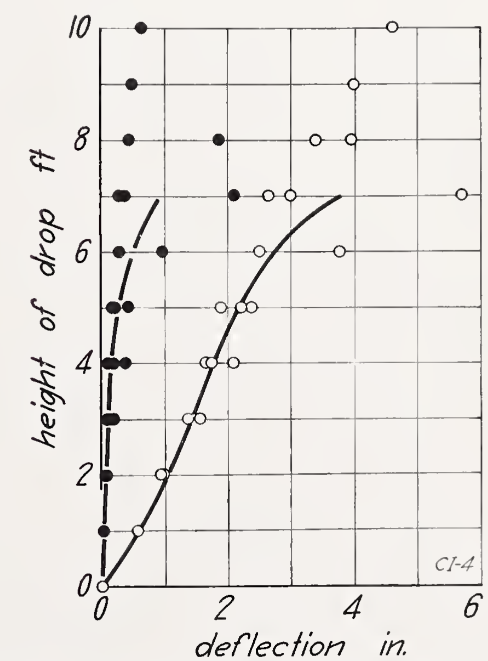


Figure 15.—*Impact load on wall CI, load applied to outside face.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *CI-I4*, *I5*, and *I6* on the span 7 ft 6 in.

The impact loads were applied to the center of the outside face of specimens *CI–I4*, *I5*, and *I6*, the sandbag striking the shingles directly over the center stud. The effects are given in table 6.

TABLE 6.—*Effects of impact load on wall CI, load applied to the outside face*

Description of effects	Specimen *I4*		Specimen *I5*		Specimen *I6*	
	Height of drop	Deflection	Height of drop	Deflection	Height of drop	Deflection
Face not loaded (gypsum wallboard):						
Longitudinal crack along center stud at midspan	*ft* 1.5	*in.* 0.75	*ft* 2.5	*in.* 1.13	*ft* 2.0	*in.* 0.94
Nails began to pull from studs	2.0	.92	2.5	1.13	2.5	1.12
Wallboard ruptured longitudinally along center stud at midspan	3.5	1.50				
Wallboard separated 3 in. or more from studs at midspan			4.0	2.09	5.0	1.90
Face loaded: Shingles split longitudinally along a stud	7.0	2.65	7.0	5.70	9.0	3.98
Studs:						
Center full-sized stud and half-sized stud split along the grain, beginning at the dado	4.0	1.66	5.0	2.37	5.5	2.20
Rupture of either one or two studs	8.0	3.95	6.0	3.78		
Rupture of all studs, sandbag passed through specimen			9.0			

The maximum height of drop on specimen *CI–I5* was 9.0 ft. After the 10-ft drop on specimens *CI–I4* and *I6* the sets were 2.50 and 0.62 in., respectively.

6. Racking Load

The racking-load test results for wall specimens *CI–R1*, *R2*, and *R3* are shown in table 4 and in figure 16.

Racking loads were applied by means of a hand-driven pump, and the speed could not be closely controlled. The load was applied only to the top plate, and the stop was in contact only with the floor plate at the diagonally opposite corner of the specimen.

Under a load of 1.0 kip/ft on specimens *CI–R1* and *R2* there was noticeable tearing of the plasterboard nails through the edges of the gypsum wallboard along the top plate, along the upper portion of the stud at the unloaded edge, and along the lower portion of the stud at the loaded edge of the specimen. Under a load of 0.8 kip/ft on specimen *R3* the nails began

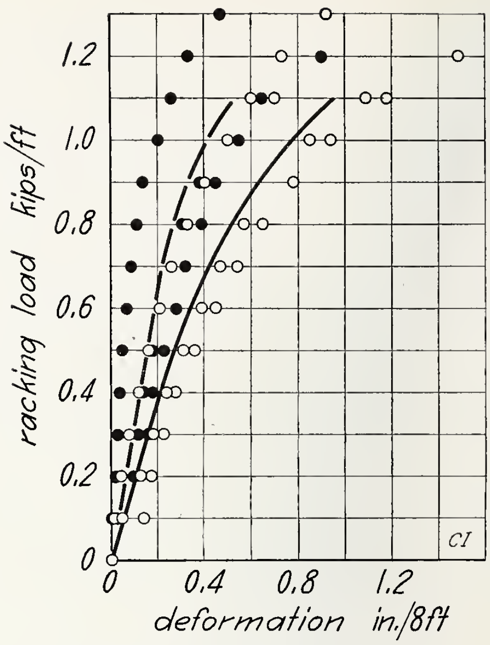


FIGURE 16.—*Racking load on wall CI.*

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

to tear through the edges of the wallboard along the top plate and the edge studs. Under the maximum loads the wallboard separated from the edge studs and the top plate, and the nails in the plywood sheathing bent, some pulling from the studs and the top plate. There was about ½-in. vertical displacement between the pieces of sheathing at the joints. The wallboard on specimens *R2* and *R3* cracked near the center of the specimen and the vertical joint ruptured, tearing the tape.

VI. LOAD-BEARING PARTITION *CJ*

1. Sponsor's Statement

Load-bearing partition *CJ* was a wood frame with faces of gypsum wallboard. It was similar to wall *CI* except that both faces were wallboard, not one face. The specimens were not painted.

The price of this construction in Washington, D. C., as of July 1937, was \$0.252/ft^2.

(a) *Four-foot Partition Specimens*

The 4-ft partition specimens shown in figure 17 were 8 ft 1$\frac{5}{16}$ in. high, 4 ft 0 in. wide, and 4⅝ in. thick. Each specimen was a wood frame to

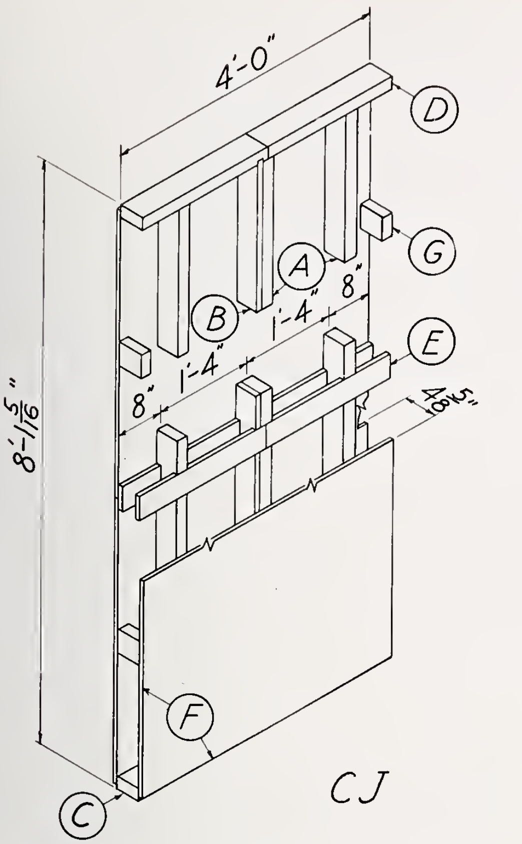


FIGURE 17.—*Four-foot load-bearing partition specimen CJ.*

A, full-sized studs; *B*, half-sized stud; *C*, floor plate; *D*, top plate; *E*, plywood ribbon; *F*, wallboard; *G*, spacers.

which faces were fastened. The frame consisted of three full-sized studs, *A*, and a half-sized stud, *B*, fastened to a floor plate, *C*, and a top plate, *D*, by nails. The joint between the center stud and the half-sized stud represented the joint between two adjacent prefabricated partition sections when erected in a house. Two plywood ribbons, *E*, were fastened to the studs at midheight. Each face consisted of two sheets of gypsum wallboard, *F*. The overhanging edges of the faces were supported by spacers, *G*.

Full-sized studs.—The full-sized studs, *A*, were Douglas fir, $1\frac{5}{8}$ by $3\frac{5}{8}$ in., 7 ft $10\frac{1}{16}$ in. long, spaced 1 ft 4 in. on center. Both edges of the studs were dadoed $\frac{5}{8}$ by $3\frac{5}{8}$ in. at midheight.

Half-sized stud.—The half-sized stud, *B*, was Douglas fir, $\frac{5}{8}$ by $3\frac{5}{8}$ in., 7 ft $11\frac{1}{16}$ in. long, dadoed on both edges $\frac{5}{8}$ by $3\frac{5}{8}$ in., at midheight, and was fastened to the center stud by 8d common nails spaced about 1 ft 0 in.

Floor plate and top plate.—The floor plate, *C*, and the top plate, *D*, each consisted of two pieces of Douglas fir, $1\frac{5}{8}$ by $3\frac{5}{8}$ in., 2 ft 0 in. long, with a joint on the center full-sized stud. Each piece was fastened to an outer stud by two 20d common nails driven through the plate into the stud (not toenailed). One piece was notched $\frac{5}{8}$ in. wide by $\frac{1}{2}$ in. deep, fitting over the half-sized stud, to which it was fastened by two 10d common nails through the piece into the half-sized stud. The other piece was fastened to the center full-sized stud by two 16d common nails through the piece into the stud (not toenailed).

Plywood ribbons.—Each plywood ribbon, *E*, consisted of two pieces of $\frac{5}{8}$-in. Douglas fir plywood $3\frac{5}{8}$ in. wide and 2 ft 0 in. long, with a joint on the center full-sized stud. The grain of the outer plies was longitudinal. The ribbons fitted flush into the dadoes in the studs and were fastened to each stud by two 6d common nails.

Wallboard.—The wallboard, *F*, on each face, was made up of two sheets of gypsum wallboard, $\frac{1}{2}$ in. thick, 4 ft 0 in. square, with a transverse joint between the rabbeted edges on the plywood ribbon. The wallboard was fastened to the ribbon by glue and by $1\frac{1}{8}$-in. plasterboard nails spaced 6 in., and to the full-sized studs by $1\frac{1}{8}$-in. plasterboard nails spaced 8 in. It was fastened to the floor plate and top plate by $1\frac{1}{8}$-in. plasterboard nails spaced 6 in., and $\frac{1}{2}$ to $\frac{3}{4}$ in. from the edge of the board. It was not fastened to the half-sized studs. The joint was calked with filler, covered with 2-in. tape, and allowed to set. More filler was then applied over the tape, bringing the surface flush with the wallboard.

Spacers.—The spacers, *G*, along the overhanging edges of the faces, were Douglas fir, $1\frac{5}{8}$ by $3\frac{5}{8}$ in., 4 in. long, fastened at each side to the wallboard by two $1\frac{1}{8}$-in. plasterboard nails. Spacers are not used in a house.

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

The 8-ft partition specimens shown in figure 18 were 8 ft $1\frac{5}{16}$ in. high, 8 ft 0 in. face width, and $4\frac{5}{8}$ in. thick. The specimens were similar to the 4-ft specimens, except that there were seven full-sized studs 1 ft 4 in. on centers and two half-sized studs, one fastened to the center stud and one to an edge stud. A full-sized stud at each edge extended one-half its thick-

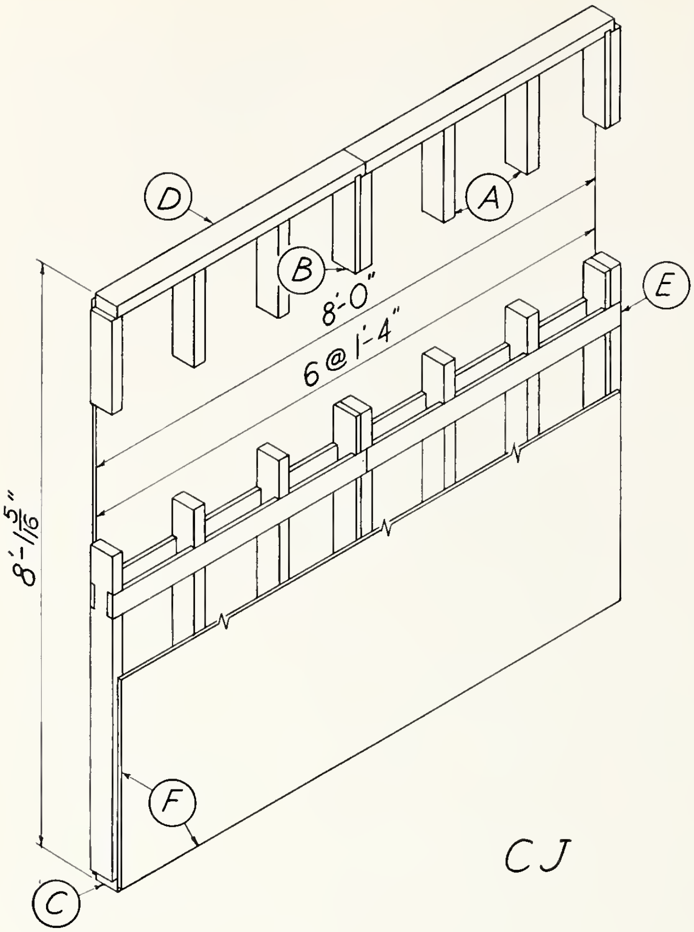


FIGURE 18.—*Eight-foot load-bearing partition specimen CJ.*

A, full-sized studs; *B*, half-sized stud; *C*, floor plate; *D*, top plate; *E*, plywood ribbon; *F*, wallboard.

ness beyond the faces. The width overall was 8 ft 1⅝ in.

Wallboard.—The wallboard on each face consisted of three sheets of gypsum wallboard: one piece, 8 ft 0 in. by 4 ft 0 in., extending over the entire width; and two pieces, 5 ft 4 in. by 4 ft 0 in. and 2 ft 8 in. by 4 ft 0 in., with a longitudinal (vertical) joint over a stud 2 ft 8 in. from the edge of the face. The full-width pieces covered the upper half of one specimen and the lower half of the others. There was a horizontal joint at midheight over the ribbon. The wallboard was fastened to the floor plate, the top plate, and the edge studs by 1⅛-in. plasterboard nails ½ in. from the edge of the board, spaced 6 in. It was fastened to the ribbon by glue and by 1⅛-inch plasterboard nails spaced 6 in., to the stud at the vertical joint by 1⅛-in. nails spaced 6 in., and to the remaining full-sized studs by 1⅛-in. nails spaced 8 in. It was not fastened to the half-sized studs. Both joints were calked with filler and covered with tape.

(c) *Comments*

In a house of this construction the load-bearing partitions are assembled at the same time as the wall sections and in like manner. Adjacent partitions are joined by nailing through the edge studs, the overlapping top plate, and plywood ribbons. The frames for doors are placed and the interior finish is applied after the sections are assembled.

2. COMPRESSIVE LOAD

The results of compressive tests for load-bearing partition specimens *CJ-C1*, *C2*, and *C3* are shown in table 4 and in figures 19 and 20.

The speed of the movable head of the testing machine under no load was adjusted to 0.072

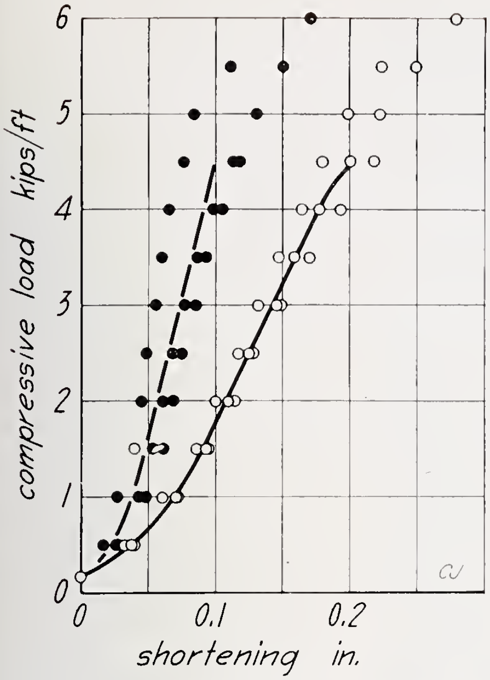


FIGURE 19.—*Compressive load on load-bearing partition CJ.*

Load-shortening (open circles) and load-set (solid circles) results for specimens *CJ-C1, C2*, and *C3*. Load was applied 1.21 in (one-third the thickness of the frame) from the edge of the studs nearer the load line. The loads are in kips per foot of actual width of specimen.

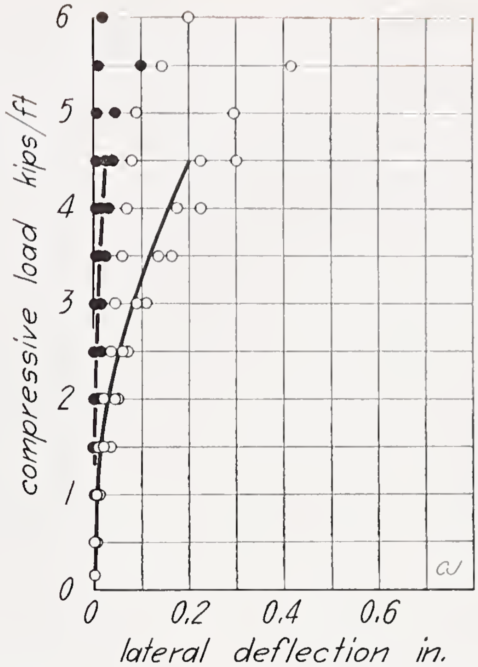


FIGURE 20.—*Compressive load on load-bearing partition CJ.*

Load-lateral deflection (open circles) and load-lateral set (solid circles) results for specimens *CJ-C1, C2*, and *C3*. Load was applied 1.21 in. (one-third the thickness of the frame) from the edge 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 8 ft 0 in., the gage length of the deflectometers.

in./min. The lateral deflections shown in figure 20 were plotted to the right of the vertical axis for deflections of the specimen toward the "outside" face (the face which is the farther from the load line).

Under a load of 4.5 kips/ft on specimen *CJ-C1* the studs crushed into the top plate at the "inside" surface of the wood frame. The studs in specimen *C2* crushed into the top plate under a load of 5.0 kips/ft, and in specimen *C3* under a load of 5.5 kips/ft. Under the maximum load on each specimen there was further local crushing of the top plate at the "inside" edges of the studs, causing the plate to rotate. The gypsum wallboard and the studs were undamaged.

3. Transverse Load

The results of the transverse-load tests are shown in tables 4 and 7 and in figure 21 for load-bearing partition specimens *CJ-T1, T2*, and *T3*.

The speed of the movable head of the testing machine under no load was adjusted to 0.14 in./min.

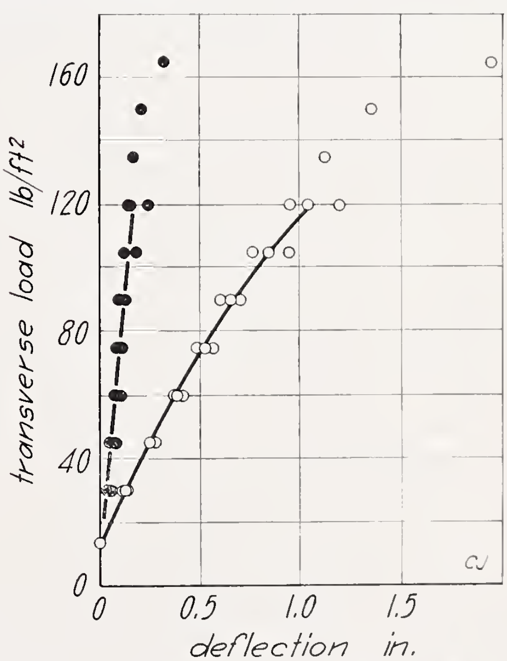


FIGURE 21.—*Transverse load on load-bearing partition CJ.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *CJ-T1, T2*, and *T3* on the span 7 ft 6 in.

Table 7.—*Effects of transverse load on load-bearing partition CJ*

Description of effects	Specimen T1		Specimen T2		Specimen T3	
	Load	Deflection	Load	Deflection	Load	Deflection
	lb/ft ²	*in.*	*lb/ft* ²	*in.*	*lb/ft* ²	*in.*
One or more studs split along the grain, beginning at the dado	105	0.76	97	0.81	105	0.84
Face not loaded, gypsum wallboard ruptured transversely near midspan, splitting the studs further	160	1.75	124	------	120	1.04
All studs either ruptured or split further; maximum load. The wallboard on the loaded face was undamaged	167	------	125	------	122	------

4. Concentrated Load

The concentrated-load test results are shown in table 4 and in figure 22 for load-bearing-partition specimens *CJ–P1*, *P2*, and *P3*.

The concentrated loads were applied to one face of the specimens on the gypsum wallboard midway between studs and about 1½ ft. from one end. Under the maximum load on each specimen the disk punched through the wallboard.

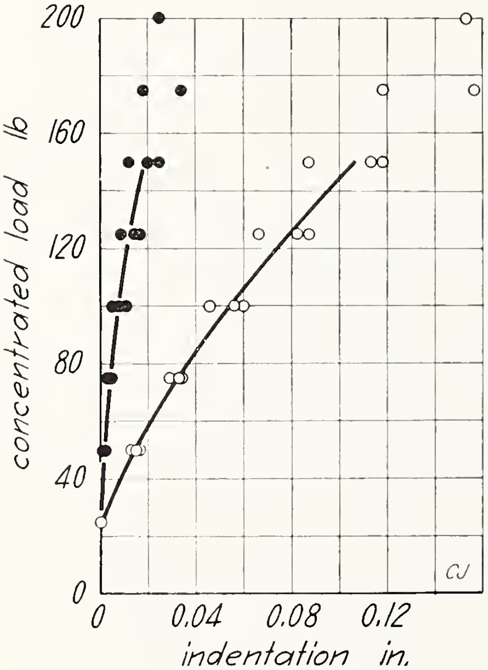


Figure 22.—*Concentrated load on load-bearing partition CJ.*

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

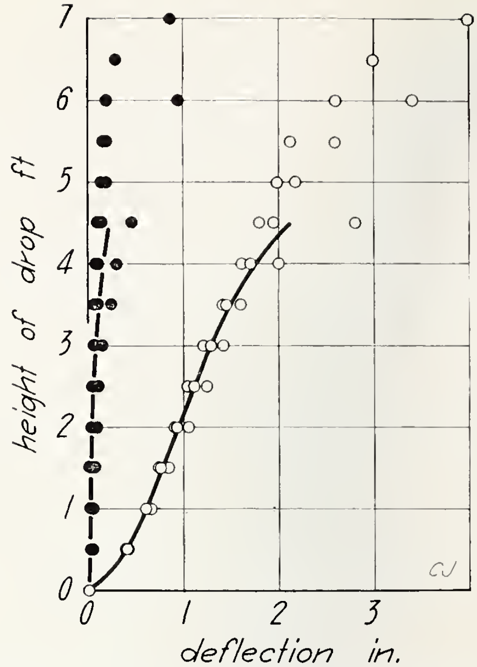


Figure 23.—*Impact load on load-bearing partition CJ.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *CJ–I1*, *I2*, and *I3* on the span 7 ft. 6 in.

5. Impact Load

The impact-test results are shown in table 4 and in figure 23 for load-bearing partition specimens *CJ–I1*, *I2*, and *I3*.

Table 8.—*Effects of impact load on load-bearing partition CJ*

Description of effects	Specimen I1		Specimen I2		Specimen I3	
	Height of drop	Deflection	Height of drop	Deflection	Height of drop	Deflection
	ft.	*in.*	*ft.*	*in.*	*ft.*	*in.*
Both faces: Nails in gypsum wallboard began to pull from the studs	2.0	0.92	1.5	0.74	2.0	1.05
Face not loaded:						
Wallboard cracked along center stud	1.5	.76	3.0	1.21	1.5	0.84
Wallboard separated 3 in. or more from studs at midspan	5.5	2.12	5.0	2.17	3.5	1.61
Face loaded:						
Wallboard cracked where the sandbag struck	5.5	2.12	5.0	2.17	4.5	2.80
Wallboard ruptured where the sandbag struck	6.0	2.59	6.0	3.40	5.0	5.86
Studs:						
One or more studs split along the grain, beginning at the dado	6.0	2.59	5.5	2.58	3.0	1.42
One or more studs ruptured at the dado	7.5	5.61	6.5	------	4.0	2.00
Sandbag passed through specimen; maximum height of drop	8.0	------	6.5	------	6.0	------

The impact loads were applied to the center of one face, the sandbag striking the gypsum

FIGURE 24.—*Load-bearing partition specimen CJ-R2 under racking load.*

wallboard over the plywood ribbon and the center stud. The effects are given in table 8.

6. Racking Load

Load-bearing partition specimen *CJ-R2* under racking load is shown in figure 24. The results for specimens *CJ-R1*, *R2*, and *R3* are presented in table 4 and in figure 25.

The racking loads were applied by means of a hand-driven pump, and the speed could not be closely controlled. The load was applied only to the top plate, and the stop was in contact only with the floor plate at the diagonally opposite corner of the specimen.

Under a load of 0.60 kip/ft on specimen *CJ-R1* the plasterboard nails tore noticeably through the edges of the gypsum wallboard on both faces along the top plate and along the upper portion of the stud at the unloaded edge. In specimen *R2* under a load of 0.70 kip/ft the nails began to tear through the edges of the wallboard along the upper portion of the stud at the unloaded edge and along the lower portion of the stud at the loaded edge. In specimen *R3* under a load of 0.70 kip/ft the nails began to tear through the wallboard along the stud at the unloaded edge.

Under the maximum load on each specimen the nails in the edge studs and top plate tore further through the edges of the wallboard, and the frame had moved 1 to 2 in. relative to the faces.

VII. NON-LOAD-BEARING PARTITION *CK*

1. Sponsor's Statement

Non-load-bearing partition *CK* was a wood frame with gypsum wallboard as both faces. It was similar to load-bearing partition *CJ*, except that there were four 2- by 3-in. studs, not three 2- by 4-in. studs and one half-sized stud. The specimens were not painted.

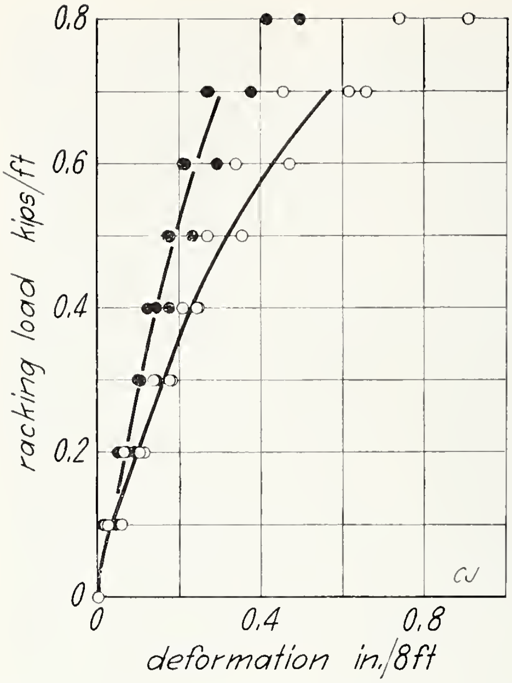


FIGURE 25.—*Racking load on load-bearing partition CJ.*

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

The price of this construction in Washington, D. C., as of July 1937, was \$0.242/ft^2.

These specimens did not represent portions of the partitions from a completed house because, in a representative specimen with studs spaced 16 in., there should be but three studs or the equivalent, as shown in figures 1 and 2 of BMS2.

(*a*) *Description of Specimens*

The partition specimens shown in figure 26 were 8 ft 1$\frac{5}{16}$ in. high, 4 ft 1$\frac{5}{8}$ in. wide, and 3$\frac{5}{8}$ in. thick. Each was a wood frame to which the faces were fastened. The frame consisted of four studs, *A*, a floor plate, *B*, and a top plate, *C*. Two plywood ribbons, *D*, were fastened to the studs at midheight. Each face consisted of two sheets of gypsum wallboard, *E*.

Studs.—The studs, *A*, were Douglas fir, 1$\frac{5}{8}$ by 2$\frac{5}{8}$ in., 7ft 10$\frac{1}{16}$ in. long, spaced 1 ft 4 in. on centers. Both edges of the studs were dadoed $\frac{5}{8}$ by 3$\frac{5}{8}$ in. at midheight.

Floor plate and top plate.—The floor plate, *B*, and the top plate, *C*, were Douglas fir, 1$\frac{5}{8}$ by 2$\frac{5}{8}$ in., 4 ft 1$\frac{5}{8}$ in. long. The plates were fastened to the studs by two 16d common nails driven through the plates into each stud (not toenailed).

Plywood ribbons.—The plywood ribbons, *D*, were $\frac{5}{8}$-in. Douglas fir plywood, 3$\frac{5}{8}$ in. wide, 4 ft 1$\frac{5}{8}$ in. long, fitting flush into the dadoes in the studs and fastened to each stud by two 6d common nails.

Wallboard.—The wallboard, *E*, on each face, was two sheets of gypsum wallboard, $\frac{1}{2}$ in. thick, 4 ft 0 in. square, with a transverse joint between the rabbeted edges on the plywood ribbon. The wallboard was fastened to the ribbon by glue and by 1$\frac{1}{8}$-in. plasterboard nails spaced 6 in., and to the two inner studs by 1$\frac{1}{8}$-in. plasterboard nails spaced 8 in. It was fastened to the floor plate, top plate, and outer studs by 1$\frac{1}{8}$-in. plasterboard nails $\frac{1}{2}$ in. from the edge of the board, spaced 6 in. The joint was calked with filler, covered with 2-in. tape, and allowed to set. More filler was then applied over the tape, bringing the surface flush with the wallboard.

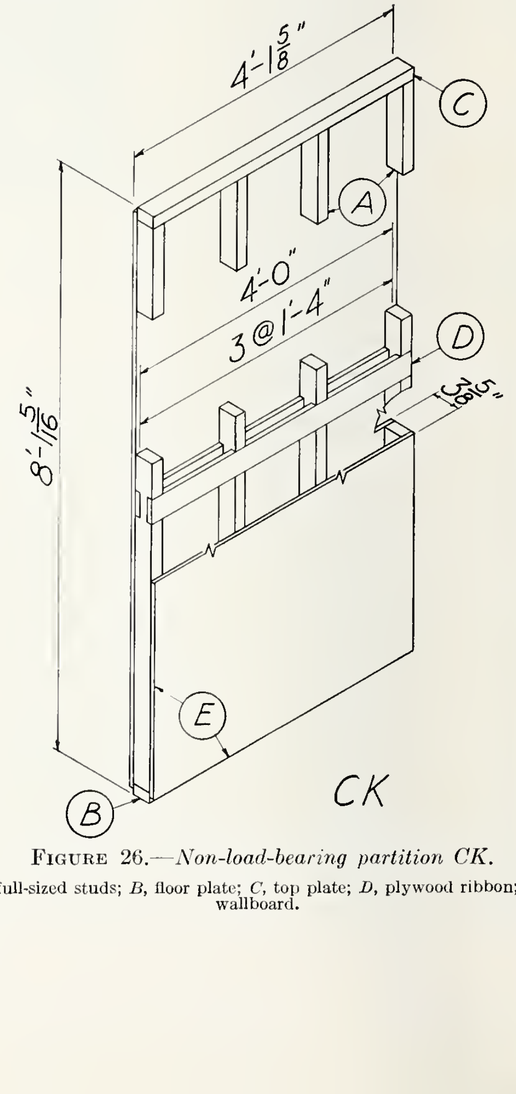


FIGURE 26.—*Non-load-bearing partition CK.*

A, full-sized studs; *B*, floor plate; *C*, top plate; *D*, plywood ribbon; *E*, wallboard.

(b) *Comments*

Non-load-bearing partition sections are made in one piece. They are placed after the floor, wall, load-bearing partition, and ceiling sections have been assembled and are fastened by nailing through the plates and edge studs.

2. Concentrated Load

The results of the concentrated loads for specimens *CK–P1*, *P2*, and *P3* are shown in table 9 and in figure 27.

Table 9.—*Structural properties of non-load-bearing partition CK*

[Weight, 5.33 lb/ft²]

Concentrated load		Impact load [a]	
Specimen	Maximum load	Specimen	Maximum height of drop
	lb		*ft*
P1	191	*I1*	6.0
P2	183	*I2*	5.5
P3	197	*I3*	6.5
Average	190	Average	6.0

[a] Span 7 ft 6 in.

The concentrated loads were applied to one face of each specimen on the gypsum wallboard midway between studs and 1½ to 2 ft from one end of the specimen. Under the maximum load the disk punched through the wallboard.

The properties of this construction under concentrated load were not affected by the fact that there were four, not three, studs in the specimen.

3. Impact Load

Impact test results for non-load-bearing partition specimens *CK–I1*, *I2*, and *I3* are shown in table 9 and in figure 28.

The impact load was applied to the center of one face of each specimen, the sandbag striking the gypsum wallboard directly over the plywood ribbon and midway between studs.

To prevent misleading results due to local effects on the loaded face of this type of specimen, the deflections and sets were measured with two deflectometers and two set gages, not one, as described in BMS2. The deflectometers were placed in contact with the unloaded face of the specimen at midheight, one at each inner stud; and the set gages rested on the loaded face, one over each of these studs.

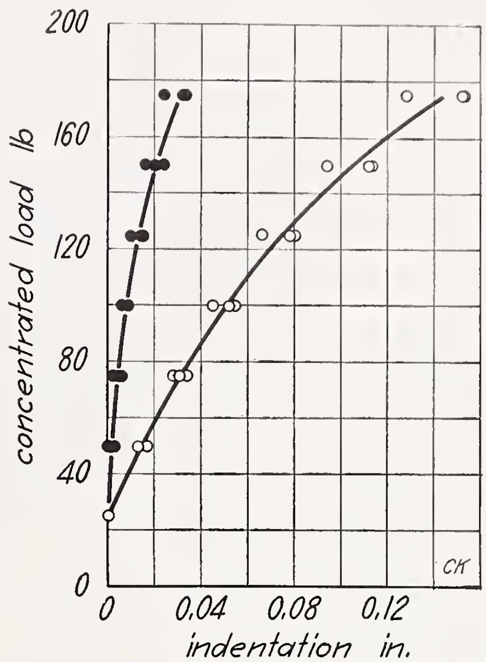


Figure 27.—*Concentrated load on non-load-bearing partition CK.*

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

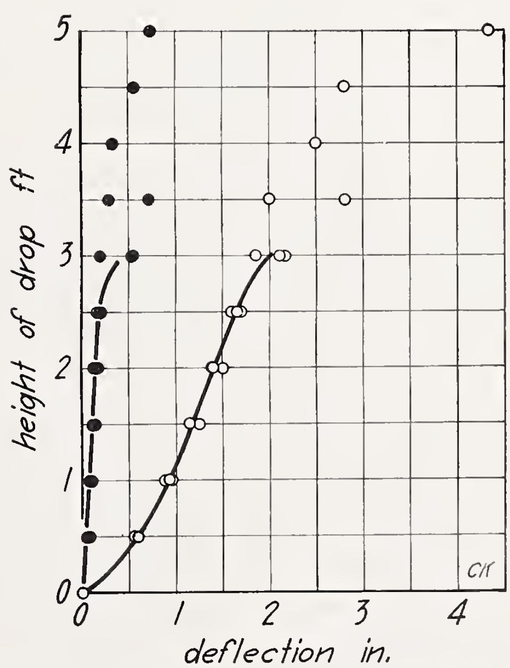


Figure 28.—*Impact load on non-load-bearing partition CK.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *CK–I1*, *I2*, and *I3* on the span 7 ft 6 in.

The effects of the impact load are given in table 10.

TABLE 10.—*Effects of impact load on non-load-bearing partition CK*

Description of effects	Specimen *I1*		Specimen *I2*		Specimen *I3*	
	Height of drop	Deflection	Height of drop	Deflection	Height of drop	Deflection
Face not loaded:						
Gypsum wallboard cracked transversely near midspan	*ft* 2.5	*in.* 1.65	*ft* ------	*in.* ------	*ft* 3.0	*in.* 1.84
Wallboard ruptured transversely	3.0	2.17	3.0	2.11	3.5	2.00
Face loaded:						
Wallboard cracked where sandbag struck	3.0	2.17	------	------	5.0	4.35
Wallboard ruptured where sandbag struck	------	------	4.0	------	5.5	------
Wallboard ruptured 1 ft from one end of the specimen	4.0	------	------	------	------	------
Studs:						
One or more studs either split or ruptured at the dado	3.0	2.17	3.0	2.11	3.5	2.00
All the studs ruptured	5.0	------	5.0	------	5.5	------
Specimen came into contact with the floor. Maximum height of drop	6.0	------	5.5	------	6.5	------

Because there were too many studs in these specimens, the maximum heights of drop were greater and the deflections and sets were less than those of representative specimens.

VIII. FLOOR *CL*

1. SPONSOR'S STATEMENT

Floor *CL* was a wood frame with plywood subflooring, sheathing paper, and finish flooring on the upper face. The lower face was unfinished, and the specimens were not painted.

The price of this construction in Washington, D. C., as of July 1937, was $0.313/ft^2.

(*a*) *Description of Specimens*

The floor specimens shown in figure 29 were 12 ft 7¼ in. long, 4 ft 0 in. wide, and 8^{15}/$_{16}$ in. thick. Each was a wood frame to which the upper face was fastened. The frame consisted of three joists, *A*, two headers, *B*, and bridging, *C*. The upper face was plywood subflooring, *D*, sheathing paper, *E*, and flooring, *F*.

Joists.—The joists, *A*, were Douglas fir, 1⅝ by 7½ in., 12 ft 4 in. long, spaced 1 ft 4 in. on centers. The ends of each joist were fastened to the headers by two 20d common nails through the header into the joist (not toenailed).

Headers.—The headers, *B*, were Douglas fir, 1⅝ by 7½ in., 4 ft 0 in. long.

Bridging.—The bridging, *C*, was Douglas fir, 1^1/$_{16}$ by 2⅝ in., 1 ft 3½ in. long. Two bridging pieces were placed crosswise between the top and bottom edges of adjacent joists at midlength and were fastened to the joists by two 8d common nails, toenailed through each end into the joists.

Subflooring.—The subflooring, *D*, was four pieces of five-ply Douglas fir plywood, ⅝ in. thick. Two pieces were 1 ft 11⅞ in. by 4 ft 7¼ in. and two were 1 ft 11⅞ in. by 8 ft 0 in. The grain of the outer plies was longitudinal. There was a longitudinal joint along the center joist, with ¼-in. clearance, and a transverse joint on each side of the center joist, one joint being 4 ft 7¼ in. from one end of the specimen and the other being 4 ft 7¼ in. from the other end. The subflooring was fastened to the joists and headers by 8d common nails spaced 6 in., and the nails in the two lines along the center joist were staggered.

Sheathing paper.—The sheathing paper, *E*, consisted of two sheets of rosin paper 3 ft 0 in. wide, laid lengthwise over the sheathing with a 2 ft 0 in. longitudinal lap. It was fastened to the subflooring at each end of the specimen by 12 staples.

Flooring.—The flooring was red oak, ^{13}/$_{16}$ by 2¼ in., blind-fastened to each joist by one 8d cut flooring nail through each strip of flooring. The last flooring strip at one end was also fastened by three 8d cut flooring nails driven through the face of the strip into the header.

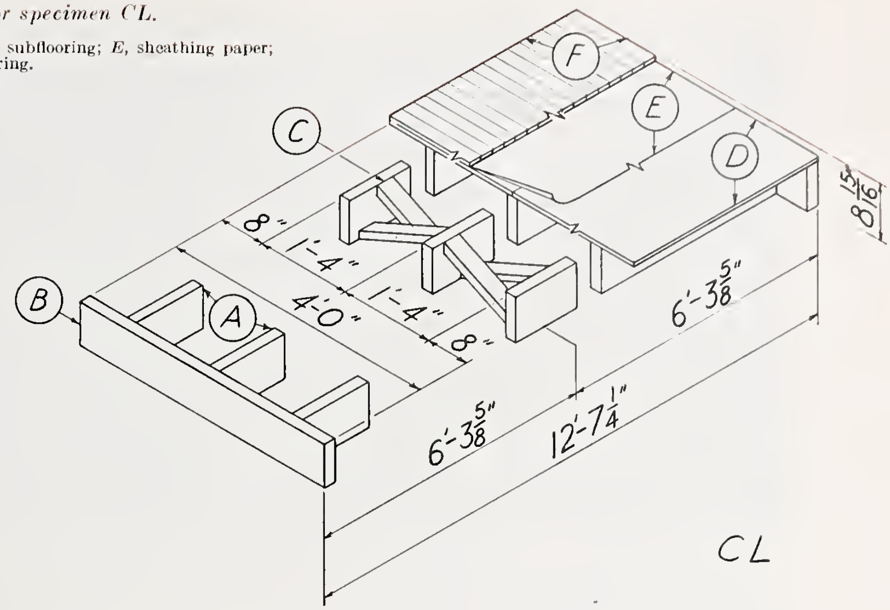
(*b*) *Comments*

Floor sections are made in widths which are multiples of 1 ft 4 in. Lengths are equal to the distance from the outer sill to the center girder. The ends of the floor joists rest on a 2- by 6-in. wood sill and on a ledger strip on the center girder. The joists are toenailed to the sill and girder with two 16d nails at each end. A 2- by 8-in. header is fastened to the outer ends of the joists by two 16d nails at each joist.

The edge of the plywood subflooring of one section overlaps half of the upper surface of the edge joist of the adjacent section. The sections are joined by 8d nails through the edge of

FIGURE 29.—*Floor specimen CL.*

A, joists; *B*, header; *C*, bridging; *D*, subflooring; *E*, sheathing paper; *F*, flooring.



the overlapping subflooring, spaced 6 in. Any conventional type of finish flooring may be applied to the plywood subfloor.

2. Transverse Load

Floor specimen *CL–T1* under transverse load is shown in figure 30. The results for floor specimens *CL–T1*, *T2*, and *T3* are given in table 11 and in figure 31.

TABLE 11.—*Structural properties of floor CL*

[Weight, 7.16 lb/ft²]

Transverse load [a]		Concentrated load		Impact load [a]	
Specimen	Maximum load	Specimen	Maximum load	Specimen	Maximum height of drop
	lb/ft²		*lb*		*ft*
T1	469	*P1*	[b] 1,000	*I1*	[b] 10.0
T2	558	*P2*	[b] 1,000	*I2*	[b] 10.0
T3	320	*P3*	[b] 1,000	*I3*	[b] 10.0
Average	449	Average	[b] 1,000	Average	[b] 10.0

[a] Span 12 ft 0 in.
[b] Test discontinued. Specimen did not fail.

The speed of the movable head of the testing machine under no load was adjusted to 0.17 in./min.

Under loads of 350 and 267 lb/ft² on specimens *T2* and *T3*, respectively, one outer joist split at a knot near midspan. Under the maximum load two or three joists in each specimen either ruptured or split between the loading rollers.

3. Concentrated Load

The concentrated-load test results for floor specimens *CL–P1*, *P2*, and *P3* are shown in table 11 and in figure 32.

The concentrated loads were applied to the upper face between joists over an end-matched joint in the finish flooring 3 to 4½ ft from one end. The sets after a load of 1,000 lb had been applied to specimens *P1*, *P2*, and *P3* were 0.015, 0.036, and 0.027 in., respectively, and no other effects were observed.

4. Impact Load

Floor specimen *CL–I1* during the impact test is shown in figure 33. The results for floor specimens *CL–I1*, *I2*, and *I3* are presented in table 11 and in figure 34.

The impact loads were applied to the center of the upper face, the sandbag striking the finish flooring over the center joist. After a drop of 10 ft the set in specimen *I1* was 0.051 in., in *I2* was 0.078 in., and in *I3* was 0.100 in. No other effect was observed.

IX. ADDITIONAL COMMENTS BY SPONSOR

In structures built of "American Houses" prefabricated sections, the horizontal dimensions are based on multiples of 1 ft 4 in. A section of a typical house is shown in figure 35. Foundations are of various types of conven-

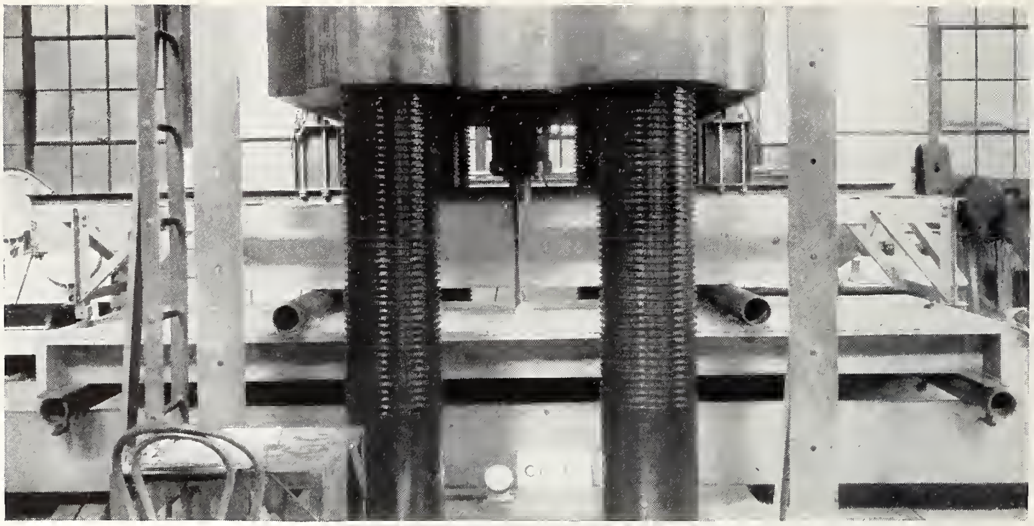


FIGURE 30.—*Floor specimen CL–T1 under transverse load.*

tional masonry construction. Wood sills, 2 by 6 in., are placed on the foundation walls, leveled by means of shims, and secured by anchor bolts, ½ by 8 in., spaced about 8 ft 0 in. The center girder consists of three 2- by 12-in. planks fastened together by 16d nails and supported by the foundation walls and by one column. The upper surface of the girder is leveled to the top of the sills.

The type of framing is similar to the conventional platform or western type of wood-frame construction. Floor sections are placed first, followed by the load-bearing partition and wall sections. The ceiling joists, 2 by

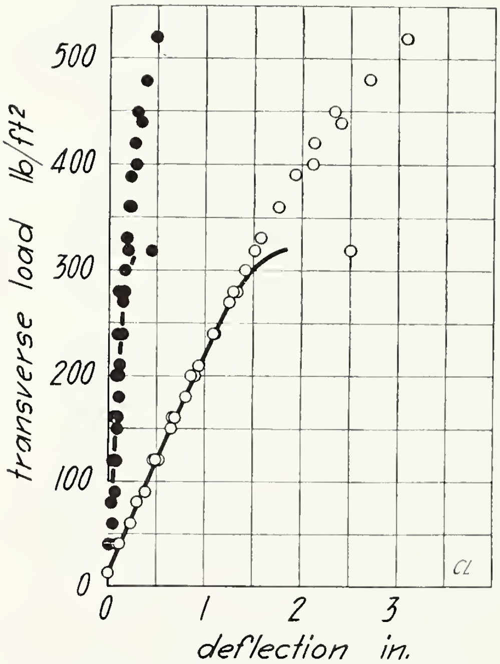


FIGURE 31.—*Transverse load on floor CL.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *CL–T1*, *T2*, and *T3* on the span 12 ft 0 in.

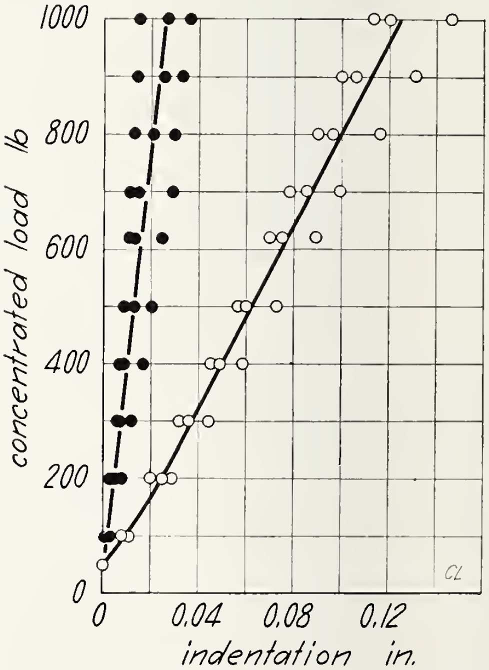


FIGURE 32.—*Concentrated load on floor CL.*

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

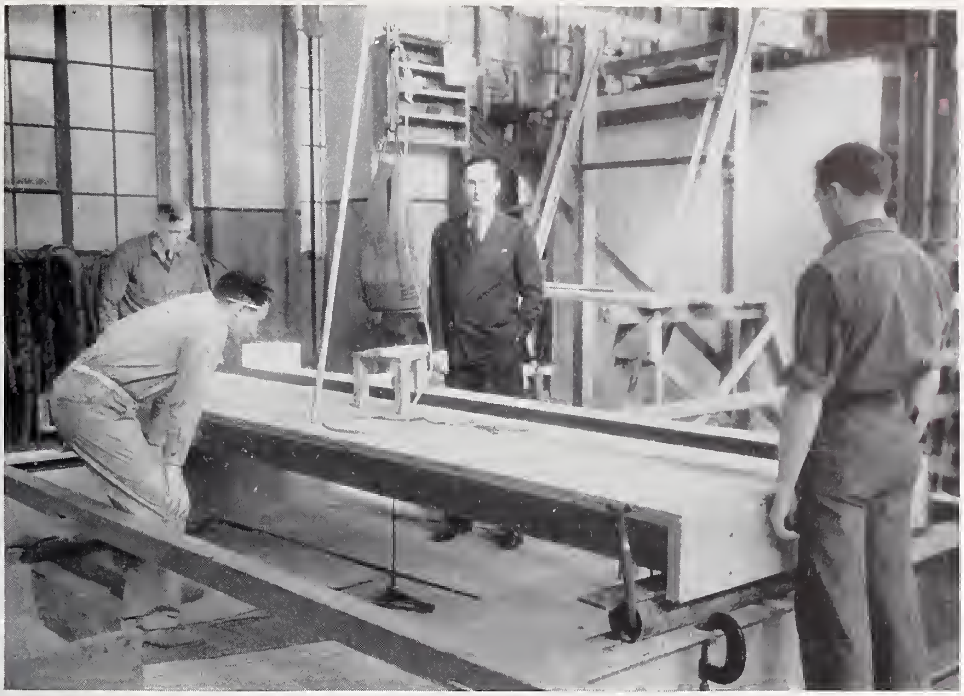


FIGURE 33.—*Floor specimen CL–I1 during the impact test.*

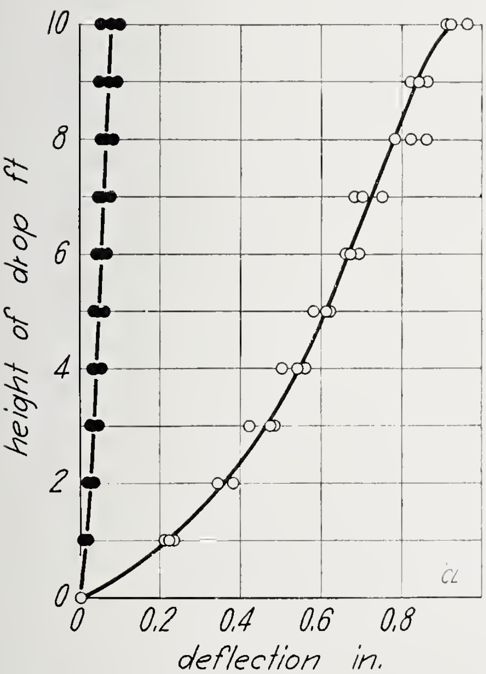


FIGURE 34.—*Impact load on floor CL.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *CL–I1, I2,* and *I3* on the span 12 ft 0 in.

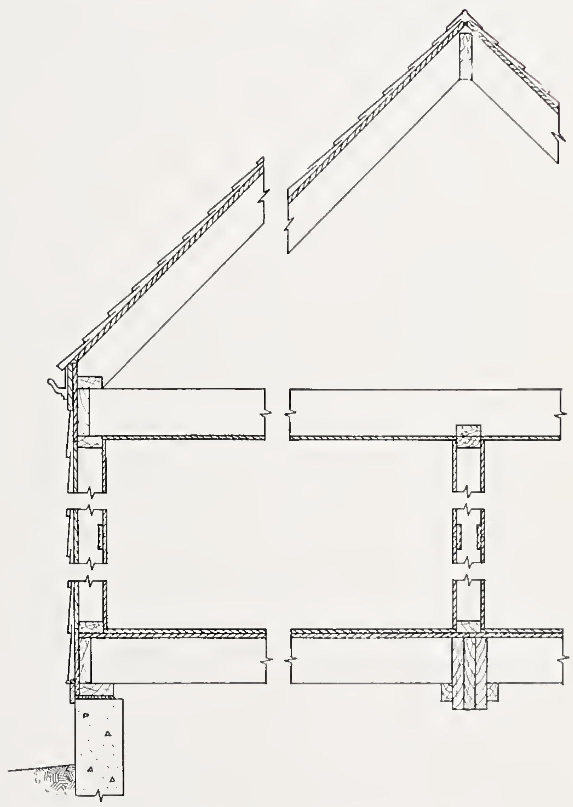


FIGURE 35.—*Section of typical house.*

"American Houses" construction.

8 in., spaced 1 ft 4 in. on centers, are then placed on the top plates of the wall and partition sections, to each of which they are toenailed with two 16d nails. A second plate, 2 by 4 in., is applied to the top plate of the load-bearing partition sections. This plate is dadoed halfway to space and secure the ceiling joists, the bottom edges of which are dadoed to correspond. Ceiling finish is the same as that applied to walls and partitions.

Rafter plates, 2 by 4 in., are fastened to each ceiling joist by two 16d nails. Headers, 2 by 8 in., are attached to the end of each ceiling joist by two 16d nails. Roof sections consist of rafters, 2 by 6 in., spaced 1 ft 4 in. on centers, and plywood sheathing. The sections are assembled in pairs, starting at one end of the house, the ridge rafter (2 by 8 in.) being placed at the same time. The sections are joined by 6d nails passing through the overlapping edges of the sheathing into the rafters, spaced 6 in. The end of each rafter is fastened to the rafter plates by four 10d nails and to the ridge rafter by two 10d nails. Any conventional roofing material, such as shingles, may be applied to the plywood sheathing. Gable end sections are similar in construction to the walls, and the ceiling joists and rafters are fastened to the studs of the end sections by two 16d nails at each stud.

In a two-story house, the floor sections for the second story rest upon the top plates of the first-story wall and partition sections. The bridging is applied to the floor and ceiling joists after the sections are in place.

The description and drawings of the specimens were prepared by E. J. Schell, G. W. Shaw, and T. J. Hanley, of the Bureau's Building Practice and Specifications Section, under the supervision of V. B. Phelan. That section also cooperated in the preparation of the report.

The experimental data were obtained by the Engineering Mechanics Section under the supervision of H. L. Whittemore and A. H. Stang, with the assistance of the following members of the professional staff: F. Cardile, H. Dollar, M. Dubin, A. H. Easton, A. S. Endler, C. D. Johnson, A. B. Lanham, A. J. Sussman, and L. R. Sweetman.

WASHINGTON, October 24, 1939.

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