U. S. DEPARTMENT OF COMMERCE

BUILDING MATERIALS AND STRUCTURES

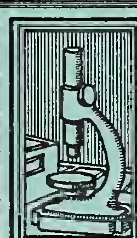
REPORT BMS27

Structural Properties of "Bender Steel Home" Wall Construction Sponsored by The Bender Body Company

by

HERBERT L. WHITTEMORE,
AMBROSE H. STANG, *and*
VINCENT B. PHELAN

NATIONAL
BUREAU OF STANDARDS



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NATIONAL BUREAU OF STANDARDS · Lyman J. Briggs, Director

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ISSUED OCTOBER 13, 1939

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.

UNITED STATES GOVERNMENT PRINTING OFFICE · WASHINGTON · 1939
FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, WASHINGTON, D. C. · PRICE 10 CENTS

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. Practically all of these constructions were sponsored by groups within the building industry which advocate and promote the use of such constructions and which have built and submitted representative specimens as outlined in report BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions. The sponsor is responsible for the representative character of the specimens and for the description given in each report. The Bureau is responsible for the test data.

This report covers only the load-deformation relations and strength of the wall of a house when subjected to compressive, transverse, concentrated, impact, and racking loads by standardized methods simulating the loads to which the wall would be subjected in actual service. It may be feasible later to determine the heat transmission at ordinary temperatures and the fire resistance of this construction and perhaps other properties.

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 on this and other constructions 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 Bender Body Co. submitted 21 specimens representing their "Bender Steel Home" construction for walls.

The specimens were subjected to compressive, transverse, concentrated, impact, and racking loads. The transverse, concentrated, and impact loads were applied to both faces of the specimens. For each of these loads three like specimens were tested. The deformation under load and the set after the load was removed were measured for uniform increments of load, except for concentrated loads, for which the set only was determined. The results are presented in graphs and in a table.

I. INTRODUCTION

In order to provide technical facts on the performance of constructions which might be used in low-cost houses, to discover promising constructions, and ultimately to determine the properties necessary for acceptable performance, the National Bureau of Standards has invited the building industry to cooperate in a program of research on building materials and structures for use in 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 the structural properties in report BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions.

As a part of the research on structural properties, six masonry wall constructions have been subjected to a series of standardized laboratory tests to provide data on the properties of some constructions for which the behavior in service is generally known. These data are given in report BMS5, Structural Properties of Six Masonry Wall Constructions. The results of similar tests made on wood-frame constructions by the Forest Products Laboratory of the United States Department of Agriculture are given in BMS25, Structural Properties of Conventional Wood-Frame Constructions for Walls, Partitions, Floors, and Roofs.

This present report describes the structural properties of a wall construction sponsored by one of the manufacturers in the building industry. The 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 are produced by the weight of the roof, second floor and second-story walls if any, furniture and

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occupants, and snow and wind loads on the roof. Transverse loads on a wall are produced by the wind, concentrated and impact loads by furniture or accidental contact with heavy objects, and racking loads by the action of the wind on adjoining walls.

The deflection and set under each increment of load were measured because the suitability of a wall construction depends in part on its resistance to deformation under load and whether it returns to its original size and shape when the load is removed.

II. SPONSOR AND PRODUCT

The specimens were submitted by The Bender Body Co., Elyria, Ohio, and represented a wall construction marketed under the trade name "Bender Steel Home." This construction consisted of sheet-steel studs and outside face, and fiber insulating board inside face, with additional fiberboard insulation between the faces.

III. SPECIMENS AND TESTS

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

TABLE 1.—*Specimen designations, wall AV*

Specimen designation	Load	Load applied
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	Upper end.
R4, R5, R6 [b]	do	Do.

[a] These specimens were undamaged portions of the transverse specimens.
[b] These three specimens had diagonal braces in one-half of the specimen.

The specimens were tested in accordance with 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.

For the compressive test the thickness of the wall was taken as the thickness of the structural portion only, that is, the thickness from the outside face of the wall to the inside edge of the studs. The compressive load was applied one-third this thickness from the inside edge of the studs.

The tests were begun March 24, 1938, and completed April 5, 1938. The sponsor's representative witnessed the tests.

IV. WALL *AV*

1. SPONSOR'S STATEMENT

(*a*) *Materials*

Steel.—Nickel-copper alloy sheets; tensile strength, 79,000 lb/in^2; yield point, 66,000 lb/in^2; elongation in 2 in., 27 percent. The Youngstown Sheet and Tube Co.'s "Yoloy."

The chemical composition of the steel is given in table 2. The steel was prepared for paint by the "Metal Prep" process.

TABLE 2.—*Chemical composition of the steel, wall AV*

Element	Content	
	Minimum	Maximum
	Percent	*Percent*
Carbon		0.12
Manganese		.60
Phosphorus		.04
Sulfur		.05
Nickel	1.50	2.00
Copper	0.90	1.10

Bolts.

Machine, ⅜ in., 16 threads per in., 1 in. long, hexagon head, "Yoloy" steel, cadmium plated; with hexagon nut and SAE standard lock washer, cadmium plated.

Machine, ⅜ in., 16 threads per in., 2½ in. long, hexagon head, "Yoloy" steel, cadmium plated; with hexagon nut and SAE standard lock washer, cadmium plated.

Stove, ⅛ in., 40 threads per in., ⅜ in. long, round head, "Yoloy" steel, cadmium plated; with No. 8 SAE standard lock washer, cadmium plated.

Rivets.

¼-in. diam, ¾ in. long, button head, "Yoloy" steel.

¼-in. diam, 1⅜ in. long, button head, "Yoloy" steel.

⅜-in. diam, ⅝ in. long, countersunk head, "Yoloy" steel.

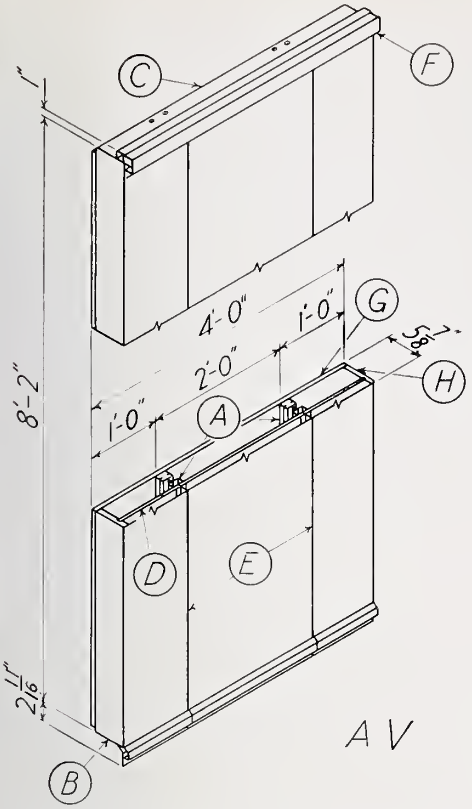


FIGURE 1.—*Four-foot wall specimen AV.*

A, studs; *B*, sill; *C*, wall plate; *D*, insulation; *E*, outside face; *F*, fascia; *G*, inside face; *H*, filler.

Screw nails.—1¼ in., hardened, cadmium plated.

Wood.—Nailing strips, fillers, western hemlock, S4S (surfaced four sides).

Fiber insulating board.—Cane-fiber, ¾ in. thick. Celotex Corporation's "Celotex Building Board."

Asphalt mastic.

Nails.

Casing, 1¼ in. long, No. 14 steel wire (0.080-in. diam).

Common, 7d, cut to ⅞ in. long, No. 11½ steel wire (0.113-in. diam).

Filler strip.—Wood-fiber, ⅛ in. thick. Masonite Corporation's "Masonite Tempered Presdwood."

Roofing felt.—Rag-base, saturated with asphalt; weight, 30 lb/100 ft².

Calking compound.

Paint.

Oil, priming, red oxide.

Oil, undercoater, gray. E. I. du Pont de Nemours & Co., Inc.

Aluminum, baked at 180° F.

Casein, light-tinted.

Welds.—Arc, manual.

(*b*) *Description*

(1) *Four-foot wall specimens.*—The 4-ft wall specimens were 8 ft 2 in. high, 4 ft 0 in. wide, and 5⅞ in. thick. Each specimen had two sheet-steel studs, *A*, shown in figures 1 and 2, fastened to a sheet-steel sill, *B*, and to a sheet-steel wall plate, *C*, by clip angles. Fiberboard insulation, *D*, was set in grooves in the sides of the studs, with an air space between it and the outside face. The outside face consisted of channel-shaped sheet-steel panels, *E*, one full panel in the center and two half panels at the edges of the specimen. The half panels were cut from full panels. The flanges of the panels were fastened in grooves in the outside edges of

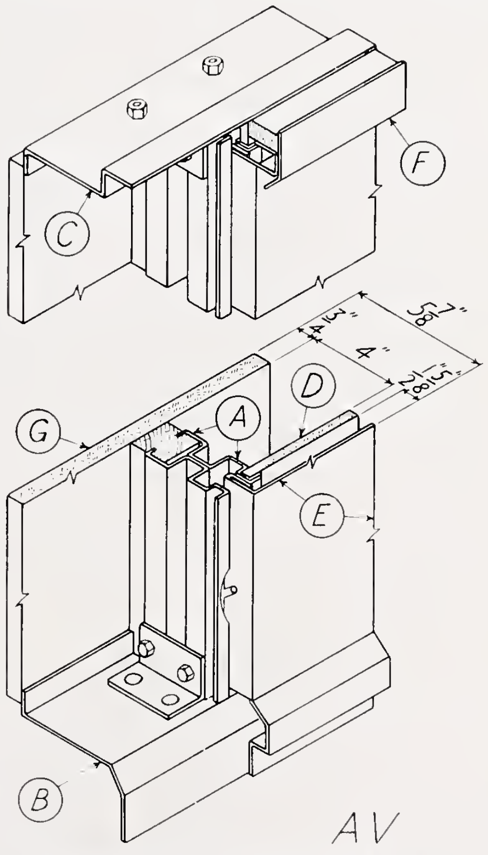


FIGURE 2.—*Details of wall specimen AV.*

A, stud; *B*, sill; *C*, wall plate; *D*, insulation; *E*, outside face; *F*, fascia; *G*, inside face.

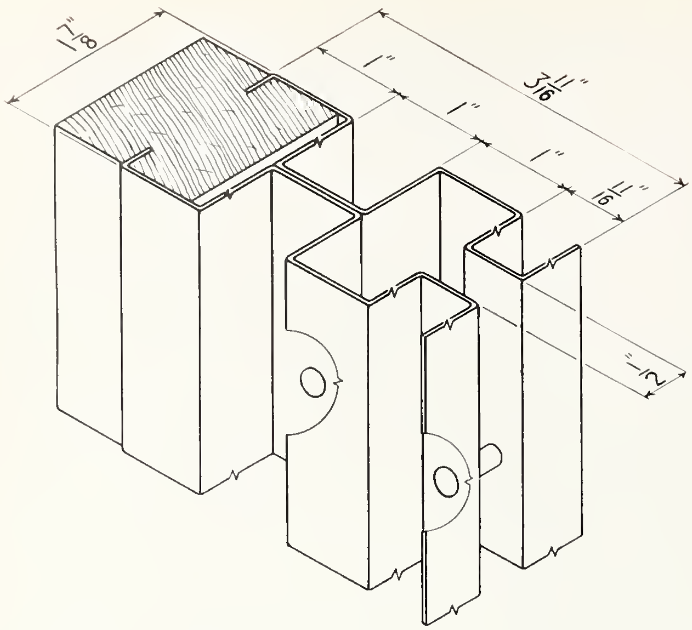


FIGURE 3.—*Stud.*

the studs. A sheet-steel fascia, *F*, was fastened by screw nails to a wood nailing strip which was in turn fastened to the wall plate by screw nails. The inside face, *G*, was fiber insulating board fastened by 1¼-in. casing nails to wood nailing strips in the studs. The faces and insulation were supported at the edges of the specimen by wood fillers, *H*. The edges of the outside face were fastened to the fillers by screw nails and the edges of the inside face by 1¼-in. casing nails. The edges of the insulation fitted into grooves in the fillers.

All steel parts were covered with one coat of oil priming paint and one coat of oil undercoater applied by dipping. The studs, sill, and wall plate were given an additional coat of aluminum paint applied by dipping and then baking at 180° F. The inside face was covered with one coat of casein paint applied with a brush.

The price of this construction in Washington, D. C., as of July 1937 was $0.60/ft^2.

Studs.—The studs, *A*, were 8 ft $1\frac{13}{16}$ in. long, and spaced 2 ft 0 in. on centers. The details of the studs are shown in figure 3. Each stud was formed from two like pieces of sheet steel, No. 18 U. S. Std. Gage (0.049 in. thick), fastened by six rivets, ¼-in. diam, ¾ in. long, spaced 1 ft

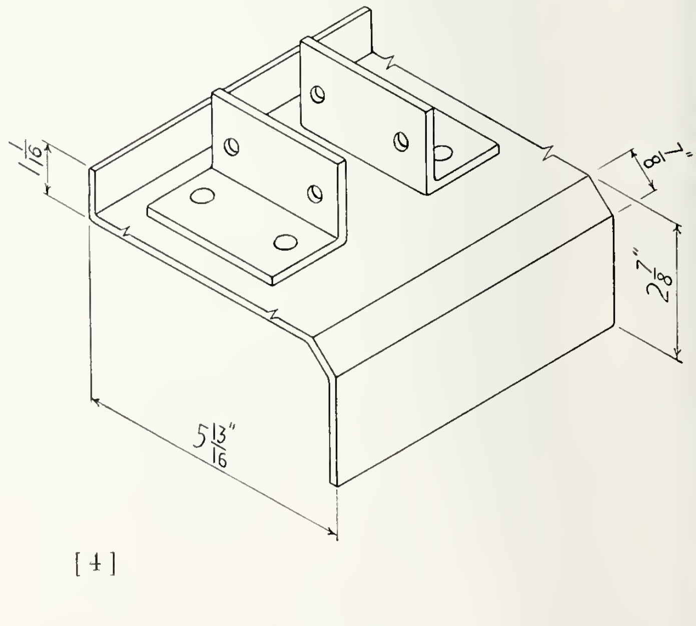


FIGURE 4.—*Sill and clip angles.*

6 in. along the center line of the web. There were six additional rivets, ¼-in. diam, 1⅜ in. long, spaced 1 ft 6 in. on centers, to receive slots in the flanges of panels, *E*. A grooved-wood nailing strip engaged the turned-in edges of the inside flanges of the studs and was fastened by 7d common nails, spaced 10 in., and driven through the sides of the flanges.

Sill.—The sill, *B*, was formed from sheet steel, No. 12 U. S. Std. Gage (0.1072 in. thick). The dimensions are given in figure 4. The sill was fastened to each stud by two clip angles, 1¾ by 1¾ in., 3 in. long, formed from sheet steel, No. 8 U. S. Std. Gage (0.1685 in. thick). Both angles were fastened to the stud by two ⅜-in. bolts, 2½ in. long, with nuts and lock washers. Each clip angle was fastened to the sill by two rivets, ⅜-in. diam, with the countersunk heads on the underside of the sill.

Wall plate.—The wall plate, *C*, was formed from sheet steel, No. 18 U. S. Std. Gage (0.049 in. thick). The dimensions are given in figure 5. The wall plate was fastened to each stud by two clip angles. The clip angles were like those which fastened the sill and were fastened to the studs in the same manner. Each clip angle was fastened to the wall plate by two ⅜-in. bolts, 1 in. long. Only one of the two bolts (or holes) for each clip appears in figures 1, 2, 5, and 6, because the other is hidden by the vertical portion of the wall plate nearest the reader.

Insulation.—The insulation, *D*, was three fiber insulating boards, ½ in. thick. The center board between the studs was 8 ft 2⁹⁄₁₆ in. by 1 ft 11⅛ in. The two outer boards were each 8 ft 2⁹⁄₁₆ in. by 11⅟₁₆ in. The edges and the faces of the board were covered with asphalt mastic for a distance of ½ in. from the edges. The lower edges of the boards were protected by sheet-steel channels ⁹⁄₁₆ by ⅝ in., No. 20 U. S. Std. Gage (0.0368 in. thick), resting on the sill. The vertical edges of the boards fitted into grooves in the studs and in the wood fillers. The upper edges fitted into a groove between the wall plate and the wood strip back of the fascia.

Outside face.—The outside face, *E*, was formed from sheet-steel channel-shaped panels, No. 18 U. S. Std. Gage (0.049 in. thick). The center panel, between the studs, was 1 ft 11⅞ in. by 1½ in., 8 ft 5⁹⁄₁₆ in. long, with upper and lower ends molded, and with the flanges doubled back on themselves for 1⅟₁₆ in. Each flange had six ⅜-in. diagonal slots, spaced 1 ft 6 in. on centers. The half panels were made from standard panels by cutting along the vertical center line. The flanges of the panel and of the two half panels fitted into the grooves in the outside edges of the studs, the diagonal slots engaging the shanks of the rivets which extended through the studs. The panels were insulated from the studs by strips of roofing felt, 8 ft 2 in. by 1⅜ in., bent around the edges and protected by sheet-steel angles, 1 by ½ in., 8 ft 2 in. long, No. 20 U. S. Std. Gage (0.0368 in. thick). A fiberboard filler strip, 1¼ by ⅛ in., 8 ft 2 in. long, was wedged between the flanges to make a tight joint. This joint was pointed with calking compound. The panels were fastened to the sill, *B*, by seven ⅛-in. stove bolts, spaced about 7½ in. The outer edges of the half panels were fastened to

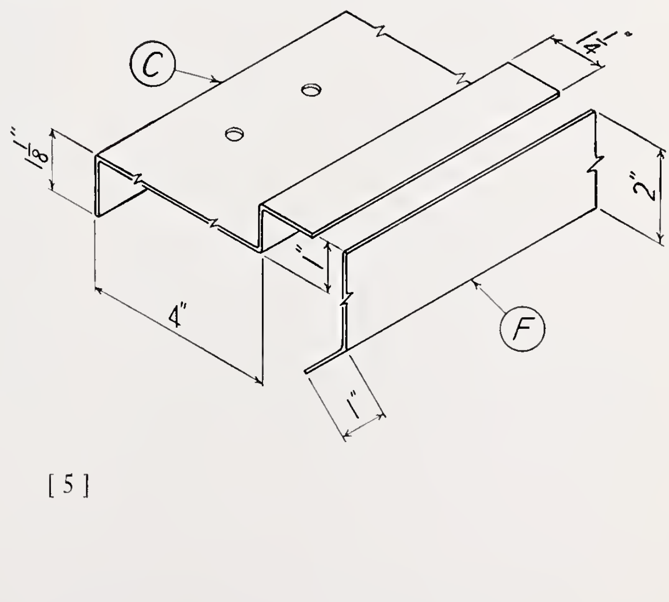


FIGURE 5.—*Wall plate, C, and fascia, F.*

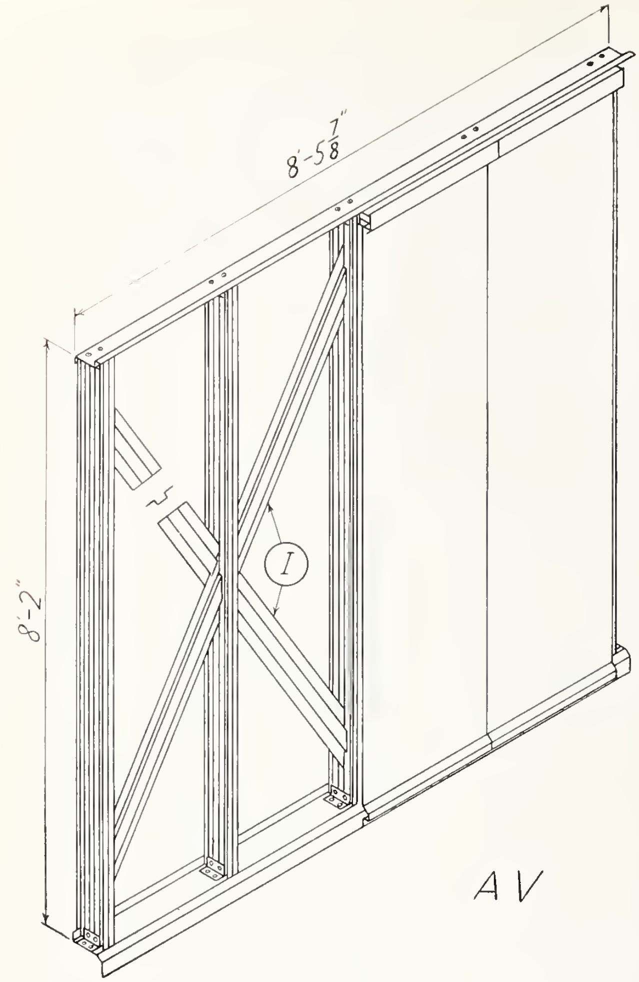


FIGURE 6.—*Eight-foot braced wall specimen AV. I, diagonal brace.*

the wood fillers, *H*, by screw nails, spaced 4 in. The underside of the upper and lower molded ends had ½-in. breather holes, two in each full-size panel, to ventilate the air space between the insulation and the outside face.

Fascia.—The fascia, *F*, was an angle, as shown in figure 5, 4 ft 0 in. long formed from sheet steel, No. 18 U. S. Std. Gage (0.049 in. thick). The angle between the flanges was about 135°. The fascia was fastened to a wood strip, ¾ by 1½ in., 4 ft 0 in. long, by screw nails, spaced 4 in. The wood strip was fastened in the same manner to the wall plate.

Inside face.—The inside face, *G*, was a fiber insulating board, 8 ft 1 in. by 4 ft 0 in. by ¾ in., fastened by 1¼-in. casing nails, spaced 6 in., to the wood nailing strips in the studs.

Fillers.—The wood fillers, *H*, were ¾ by 5⅛ in., 8 ft 1¹³⁄₁₆ in. long, with ½- by ¼-in. grooves to support the edges of the insulation, *D*. The fillers supported the overhanging edges of the specimens but are not used in a house.

(2) *Eight-foot wall specimens.*—The 8-ft wall specimens were 8 ft 2 in. high, 8 ft 2 in. wide, and 5⅝ in. thick. The specimens were similar to the 4-ft specimens except for the following details. In each specimen there were five studs, spaced 2 ft 0 in. on centers, fastened to a continuous sill and a continuous wall plate, each 8 ft 5⅞ in. long. The outside face consisted of four sheet-steel panels. The insulation was four fiber insulating boards, 8 ft 2⁹⁄₁₆ in. by 1 ft 11⅛ in. The inside face was two fiber insulating boards, 8 ft 1 in. by 4 ft 0 in., having a vertical joint on the center stud. There were no wood fillers because there was a stud at each edge. Specimens *R4*, *R5*, and *R6* each had two diagonal braces, *I*, shown in figure 6, in one half

of the specimen. The braces were 6 in. wide and were formed from sheet steel, No. 20 U. S. Std. Gage (0.0368 in. thick). Each brace had a rib, 2 in. wide and 1 in. deep, along the center line. The braces were fastened to the studs by arc welds. There were no braces in specimens *R1*, *R2*, and *R3*

(c) *Comments*

The "Bender Steel Home" is designed to be erected on a concrete-block foundation wall on a concrete spread footing. The top of the foundation wall is first covered with asphalt mastic and then the sills are fastened to it by ⅝-in. anchor bolts, spaced about 8 ft. The studs, wall plates, insulation, and faces of the walls are assembled during erection, except that the frames having diagonal braces are fabricated at the factory. One braced frame is placed in each wall at each corner. Corner panels project 1 in. from the wall panels.

Figure 7.—*Wall specimen AV-C1 under compressive load.*

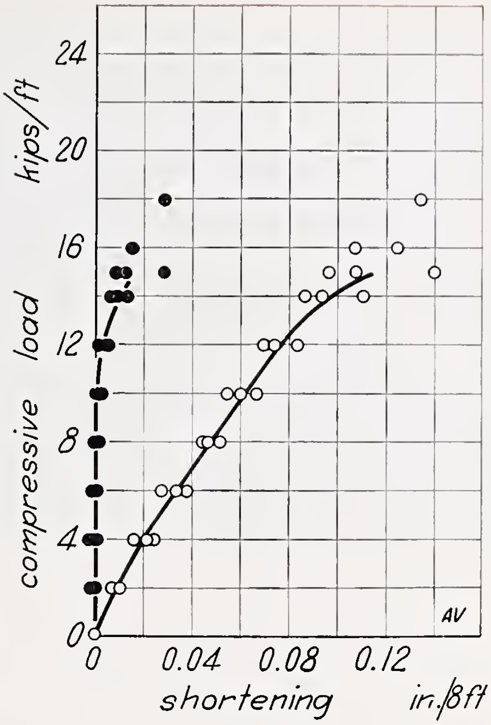


Figure 8.—*Compressive load on wall AV.*

Load-shortening (open circles) and load-set (solid circles) results for specimens *AV-C1, C2,* and *C3*. The load was applied 2.46 in. from the inside face. The loads are in kips per foot of actual width of specimen.

Openings for standard door and window frames are cased with sill and lintel zees fastened to the studs by clip angles. Sheet-steel trim is fastened to the frames with screw nails.

The floors are sheet-steel panels resting on the foundation wall. Partitions, roofs, and ceilings are conventional wood-frame construction. The ceiling joists and roof rafters are supported by brackets fastened to the wall plate directly above the studs by the same bolts fastening the plate to the clip angles. These brackets are 7⅛ by 1¾ by 3¾ in., formed from sheet steel, No. 8 U. S. Std. Gage (0.1685 in. thick). The roof is covered with composition roofing. Ceilings are insulated by 4-in. rock-wool batts placed between the joists. The inside faces of the walls and both faces of partitions are fiber insulating boards

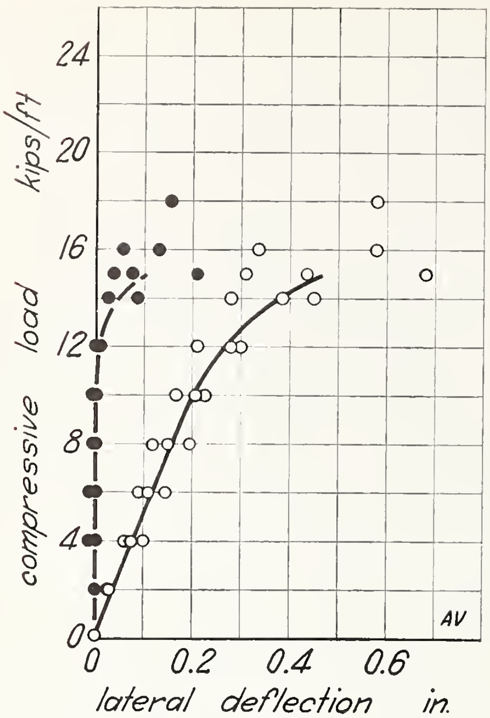


FIGURE 9.—*Compressive load on wall AV.*

Load-lateral deflection (open circles) and load-lateral set (solid circles) results for specimens *AV-C1*, *C2*, and *C3*. The load was applied 2.46 in. from the inside face. 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.

finished with casein paint. The outside faces of the walls are finished with oil paint.

Chimneys are heavy-gage enameled iron with 1 in. of asbestos insulation enclosed by galvanized-steel jackets.

2. COMPRESSIVE LOAD

Wall specimen *AV-C1* under compressive load is shown in figure 7. The results for wall specimens *AV-C1*, *C2*, and *C3* are shown in table 3 and in figures 8 and 9.

Specimen *C1* was tested with the wood fillers, *H* (fig. 1), intact. For specimens *C2* and *C3* the fillers were cut transversely in two places about 1 in. apart near midheight, and the pieces of wood between the saw cuts were removed. In addition, for specimen *C3*, the screw nails which held the edges of the outside face to the fillers were removed.

The compressive loads were applied 2.46 in. from the inside face. The shortenings and sets shown in figure 8 for a height of 8 ft were computed from the values obtained from the compressometer readings. The compressometers were on the studs. The gage length of the compressometers was 7 ft 6 in.

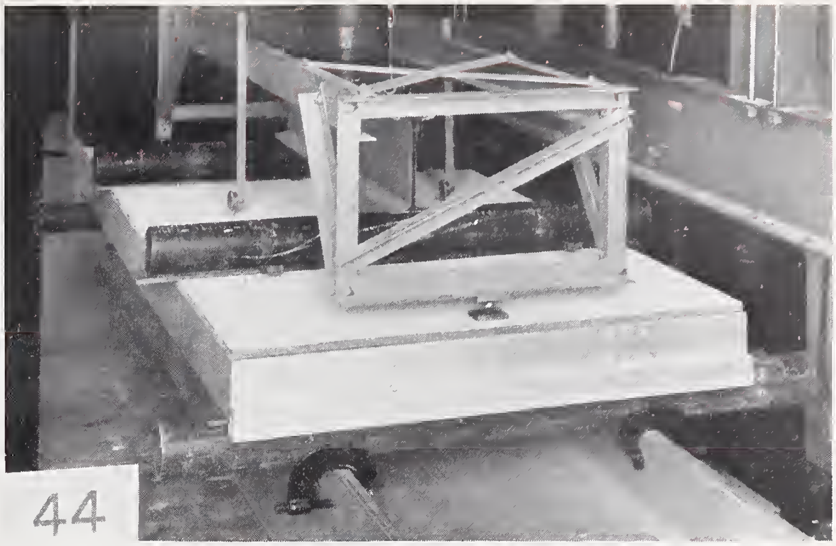
TABLE 3.—*Structural properties, wall AV*

[Weight (without wood fillers), 7.24 lb/ft² for all specimens except *R4*, *R5*, and *R6*; 7.97 lb/ft² for these three specimens]

Load	Load applied	Specimen designation	Failure of loaded face, height of drop	Failure of opposite face, height of drop	Maximum height of drop	Maximum load
			ft	*ft*	*ft*	[b]*Kips/ft*
Compressive	Upper end, 2.46 in. from the inside face.[a]	*C1*	-----	-----	-----	19.2
		C2	-----	-----	-----	16.6
		C3	-----	-----	-----	15.1
	Average	-----	-----	-----	-----	17.0
						lb/ft²
Transverse	Inside face; span, 7 ft 6 in.	*T1*	-----	-----	-----	492
		T2	-----	-----	-----	400
		T3	-----	-----	-----	381
	Average	-----	-----	-----	-----	425
Do	Outside face; span, 7 ft 6 in.	*T4*	-----	-----	-----	350
		T5	-----	-----	-----	355
		T6	-----	-----	-----	338
	Average	-----	-----	-----	-----	348
						lb
Concentrated	Inside face	*P1*	-----	-----	-----	153
		P2	-----	-----	-----	158
		P3	-----	-----	-----	175
	Average	-----	-----	-----	-----	162
Do	Outside face	*P4*	-----	-----	-----	[c]1,000
		P5	-----	-----	-----	[c]1,000
		P6	-----	-----	-----	[c]1,000
	Average	-----	-----	-----	-----	[c]1,000
Impact	Inside face; span, 7 ft 6 in.	*I1*	1.5	[d]10.0	[e]10.0	-----
		I2	1.5	[d]10.0	[e]10.0	-----
		I3	1.5	[d]10.0	[e]10.0	-----
	Average	-----	1.5	[d]10.0	[e]10.0	-----
Do	Outside face; span, 7 ft 6 in.	*I4*	[d]10.0	[d]10.0	[e]10.0	-----
		I5	[d]10.0	10.0	[e]10.0	-----
		I6	[d]10.0	7.0	[e]10.0	-----
	Average	-----	[d]10.0	-----	[e]10.0	-----
						[b]*Kips/ft*
Racking	Near upper end	*R1*	-----	-----	-----	0.59
		R2	-----	-----	-----	.59
		R3	-----	-----	-----	.55
	Average	-----	-----	-----	-----	0.58
Do	Near upper end	*R4*	-----	-----	-----	1.18
		R5	-----	-----	-----	1.33
		R6	-----	-----	-----	1.10
	Average	-----	-----	-----	-----	1.20

[a] For the compressive load the thickness of the specimens was taken as 5⅛ in., that of the structural portion only.
[b] A kip is 1,000 lb.
[c] Test discontinued. Specimen did not fail.
[d] Face did not fail.
[e] Test discontinued. Specimen damaged.

Figure 10.—*Wall specimen AV–T1 under transverse load.*



For specimen *C2* at a load of 13 kips/ft a rivet in the web of one stud sheared. At the maximum loads each of the specimens failed by buckling of both studs near midheight. The joints between the panel and the half panels opened slightly.

3. Transverse Load

Wall specimen *AV–T1* under transverse load is shown in figure 10. The results are shown in table 3 and in figure 11 for wall specimens *AV–T1*, *T2*, and *T3*, loaded on the inside face,

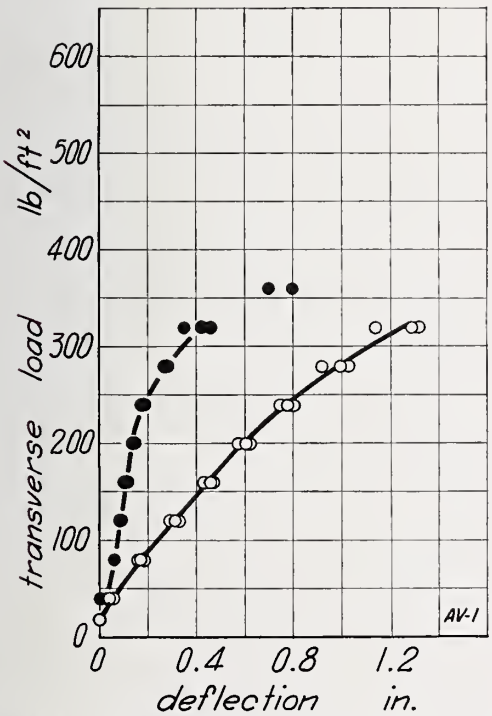


Figure 11.—*Transverse load on wall AV, load applied to inside face.*

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

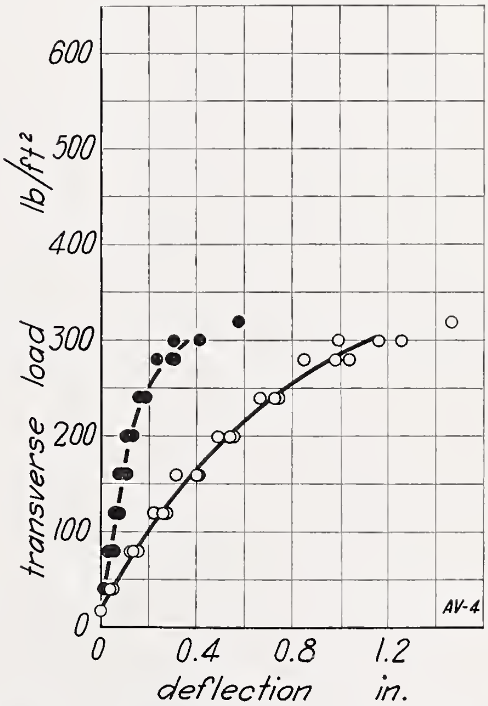


Figure 12.—*Transverse load on wall AV, load applied to outside face.*

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

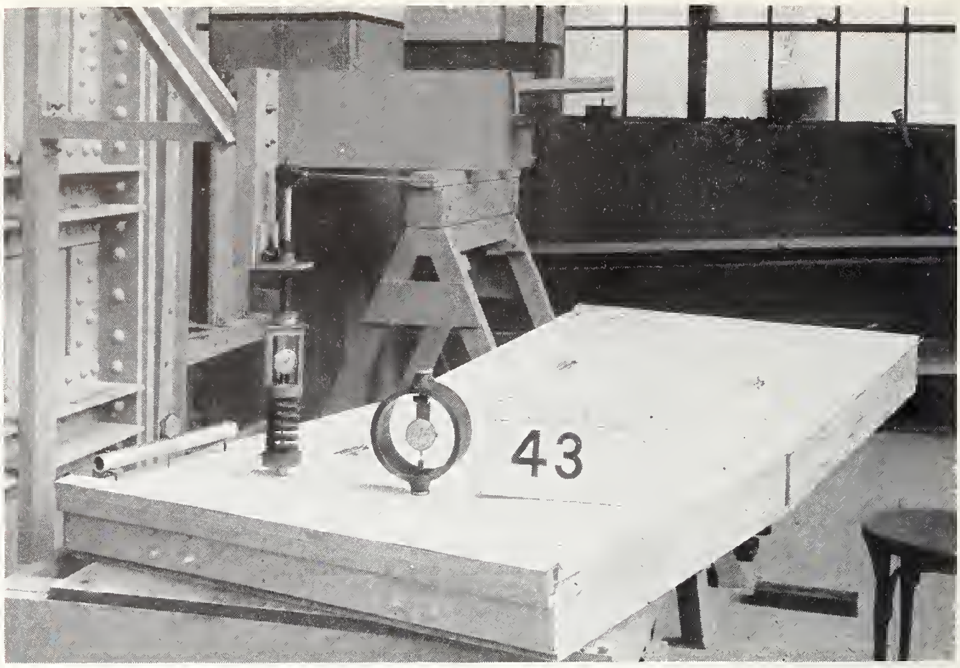


FIGURE 13.—*Wall specimen AV-P6 under concentrated load.*

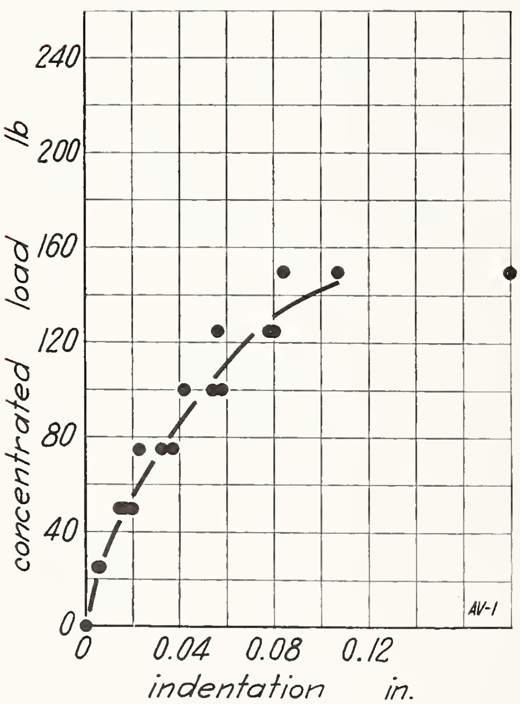


FIGURE 14.—*Concentrated load on wall AV, load applied to inside face.*

Load-indentation results for specimens *AV-P1, P2,* and *P3.*

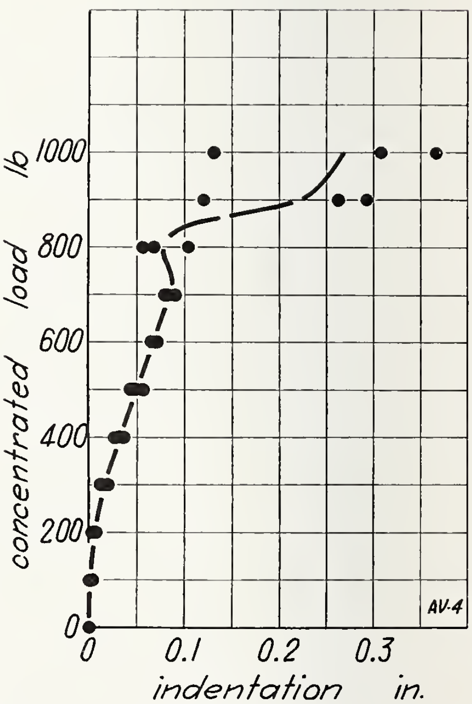


FIGURE 15.—*Concentrated load on wall AV, load applied to outside face.*

Load-indentation results for specimens *AV-P4, P5,* and *P6.*

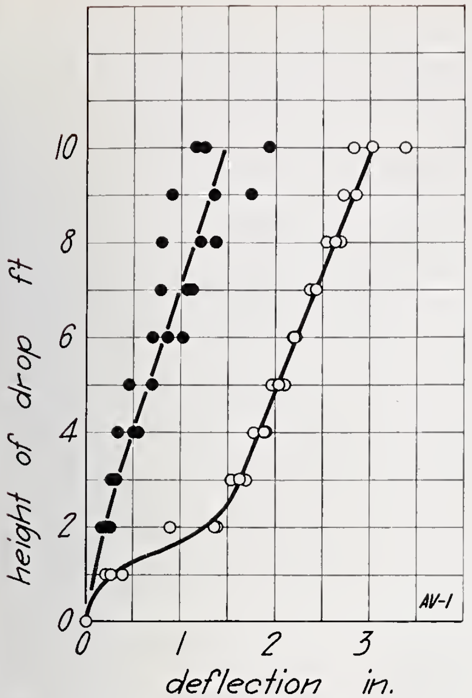


Figure 16.—*Impact load on wall AV, load applied to inside face.*

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

and in figure 12 for wall specimens *AV–T4, T5,* and *T6,* loaded on the outside face.

Specimen *T4* was tested with the wood fillers, *H* (fig. 1), intact. For specimens *T1, T5,* and *T6* the fillers were cut transversely in two places about 1 in. apart at midspan and the pieces of wood between the saw cuts were removed. For specimens *T2* and *T3* the fillers were removed.

Each of the specimens failed by continued bending with no increase in load. For specimens *T2* and *T3* there was slight buckling of the studs. For specimen *T4* one wood filler broke before the maximum load was reached; the other did not fail.

4. Concentrated Load

Wall specimen *AV–P6* under concentrated load is shown in figure 13. The results are shown in table 3 and in figure 14 for wall specimens *AV–P1, P2,* and *P3,* loaded on the inside face, and in figure 15 for wall specimens *AV–P4, P5,* and *P6,* loaded on the outside face.

The concentrated loads were applied to the inside face of specimens *P1, P2,* and *P3* midway between the two studs and about 1 ft from one end of the specimen. Each of the specimens *P1, P2,* and *P3* failed by punching of the disk through the loaded face of the specimen.

The concentrated loads were applied to the outside faces of specimens *P4, P5,* and *P6* between the studs and about 1 ft from the lower end of the specimen. For specimens *P4* and *P6,* after a load of 800 lb had been applied, the sheet steel of the outside face buckled upward under the disk giving a smaller set reading than was obtained after the previous increment of load, and resulting in a reversal of the load-set curve, as shown in figure 15. For specimen *P4* the indentation after a load of 1,000 lb had been applied was 0.308 in., and there was a crack in the outside face at a joint near the lower end of the specimen. The indentations after a load of 1,000 lb had been applied were 0.132 and 0.367 in. for specimens *P5* and *P6,* respectively, and no other effect was observed.

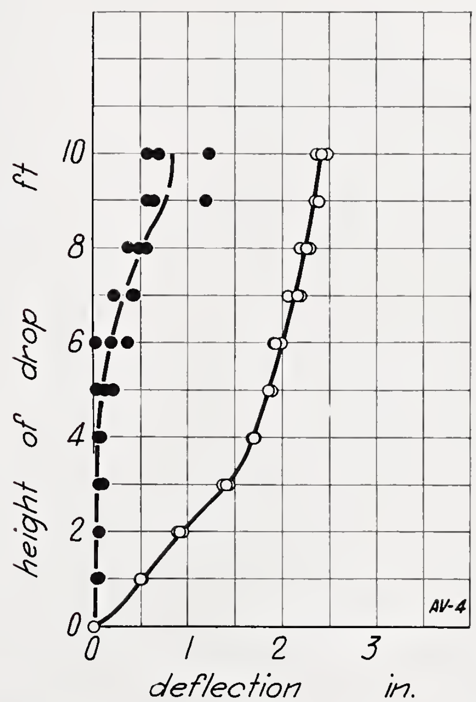


Figure 17.—*Impact load on wall AV, load applied to outside face.*

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

5. Impact Load

The results are shown in table 3 and in figure 16 for wall specimens *AV–I1, I2,* and *I3,* loaded on the inside face, and in figure 17 for wall specimens *AV–I4, I5,* and *I6,* loaded on the outside face.

The specimens were tested with the wood fillers, *H* (fig. 1), intact.

The impact loads were applied to the center of the inside face of specimens *I1, I2,* and *I3,* the sandbag striking midway between the studs. At a drop of 1 ft the inside face of each specimen cracked where the sandbag struck, and at 1.5 ft the inside face failed, the sandbag breaking through the inside face and striking the insulation. Subsequent set readings were taken to the insulation and corrected for the change of datum. The sets after a drop of 10 ft were 1.15, 1.25, and 1.93 in. for specimens *I1, I2,* and *I3,* respectively, and the studs and outside faces did not fail; but for specimens *I1* and *I3* the outside face was slightly buckled, and the calking in the joints was cracked.

The impact loads were applied to the center of the outside face of specimens *I4, I5,* and *I6,* the sandbag striking midway between the studs. For specimen *I4* at a drop of 4 ft the inside face separated noticeably from the studs, and at 5 ft the outside (loaded) face started to buckle. The set after a drop of 10 ft was 0.70 in., and no other effect was observed. For specimens *I5* and *I6* at a drop of 4.5 ft the outside (loaded) face started to buckle; at drops of 6 and 6.5 ft, respectively, the inside face separated about 0.5 in. from the studs; and at 10 and 7 ft, respectively, the inside face failed

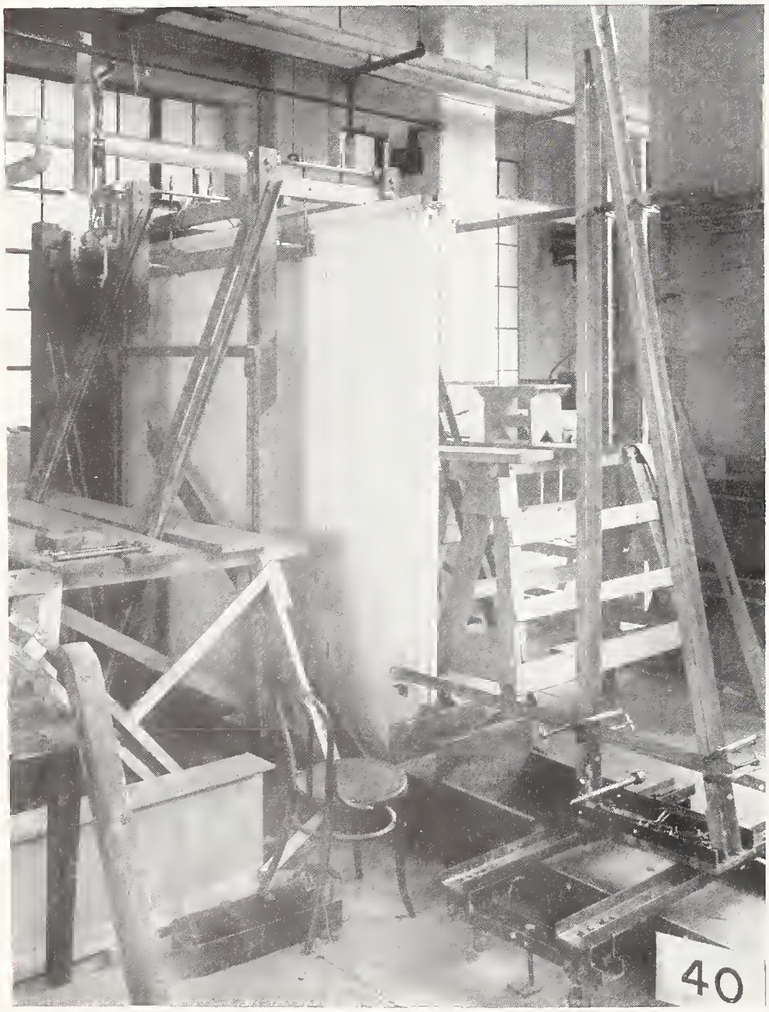


Figure 18.—*Wall specimen AV–R3 under racking load.*

by separating completely from the studs. The sets after a drop of 10 ft were 1.24 and 0.57 in. for specimens *I5* and *I6*, respectively, and the studs and outside face did not fail.

6. Racking Load

Six wall specimens were tested under racking load. Specimens *AV–R1*, *R2*, and *R3* had no braces, whereas specimens *AV–R4*, *R5*, and *R6* had diagonal braces in one-half of each specimen, as shown in figure 6. The load was applied to the upper ends of the specimens at the left edge, as shown in figure 6.

Wall specimen *AV–R3* under racking load is shown in figure 18. The results are shown in table 3 and in figure 19 for wall specimens *AV–R2* and *R3* and in figure 20 for wall specimens *AV–R4*, *R5*, and *R6*. The results for wall specimen *AV–R1* are not shown in figure 19 because the readings were erratic.

The deformations and sets for a height of 8 ft shown in figures 19 and 20 were computed from the values obtained from the measuring-

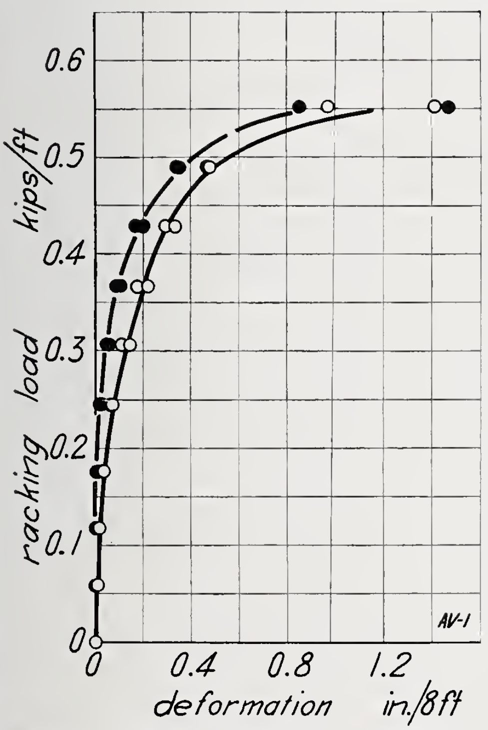


Figure 19.—*Racking load on wall AV, unbraced specimens.*

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

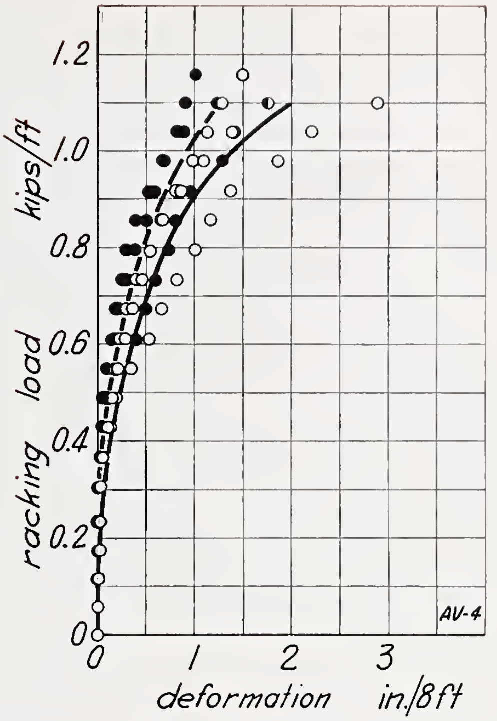


Figure 20.—*Racking load on wall AV, with diagonal braces.*

Load-deformation (open circles) and load-set (solid circles) results for specimens *AV–R4*, *R5*, and *R6*. The loads are in kips per foot of actual width of specimen.

device readings. The gage length of the vertical measuring device was 6 ft 6½ in. The gage length of the horizontal measuring device was 7 ft 7½ in.

Each of the specimens *R1*, *R2*, and *R3* failed by vertical displacement of the panels of the outside face at the joints, and by rupture of some of the bolts which fastened the lower end of the panels to the sill. Nails fastening the inside face to the stud at the stop pulled through the edge of the inside face at the upper end of the specimen.

Each of the specimens *R4*, *R5*, and *R6* failed by vertical displacement of the panels of the outside face at the joint, rupture of some of the bolts which fastened the lower end of the panels to the sill, and buckling of the diagonal braces. Nails fastening the inside face to the stud at the stop pulled through the edge of the inside face at the upper end of the specimen.

The sponsor supplied the information contained in the sponsor's statement. The description and drawings of the specimens were prepared by E. J. Schell and G. W. Shaw of the Bureau's Building Practice and Specifications Section, under the supervision of V. B. Phelan, from this information and from the specimens themselves.

The structural properties were determined 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, R. C. Carter, H. Dollar, M. Dubin, A. H. Easton, A. S. Endler, C. D. Johnson, A. J. Sussman, and L. R. Sweetman.

Washington, May 11, 1939.

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