U. S. DEPARTMENT OF COMMERCE

BUILDING MATERIALS AND STRUCTURES

REPORT BMS36

Structural Properties of Wood-Frame Wall, Partition, Floor, and Roof Constructions with "Red Stripe" Lath Sponsored by The Weston Paper and Manufacturing Co.

by

HERBERT L. WHITTEMORE

and AMBROSE H. STANG

with the collaboration of

THOMAS R. C. WILSON
Forest Products Laboratory

NATIONAL
BUREAU OF STANDARDS

The program of research on building materials and structures, carried on by the National Bureau of Standards, was undertaken with the assistance of the Central Housing Committee, an informal organization of governmental agencies concerned with housing construction and finance, which is cooperating in the investigations through a subcommittee of principal technical assistants.

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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.

[For list of BMS publications and how to purchase, see cover page III.]

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ISSUED JANUARY 2, 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.

UNITED STATES GOVERNMENT PRINTING OFFICE · WASHINGTON · 1940

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, therefore, is responsible for the description of the specimens and the method of fabrication. The Bureau is responsible for the method of testing and the test data.

This report covers only the load-deformation relations and strength of the structural elements when subjected to compressive, transverse, concentrated, impact, and racking loads by standardized methods simulating the loads to which the elements 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 constructions having 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 Wood-Frame Wall, Partition, Floor, and Roof Constructions with "Red Stripe" Lath Sponsored by The Weston Paper and Manufacturing Co.

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ABSTRACT

For the program on the determination of the structural properties of low-cost house constructions, The Weston Paper and Manufacturing Co. submitted 30 specimens representing wood-frame wall, partition, floor, and roof constructions with "Red Stripe" lath.

The wall specimens were subjected to compressive, transverse, concentrated, impact, and racking loads; the partition specimens to concentrated and impact loads; the floor specimens to transverse, concentrated, and impact loads; and the roof specimens to transverse and concentrated 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, and for each of these loads six 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 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 constructions 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 elements of a house are subjected. In actual service, compressive loads on a wall are produced by the weight of the roof, by second floor and second-story walls, if any, by furniture and occupants, and by snow and wind loads on the roof. Transverse loads on a wall are produced by the wind, concentrated loads by furniture or accidental contact with heavy objects, and racking loads by the action of the wind on adjoining walls. On nonload-bearing partitions, impact loads may be applied accidentally by furniture or by a person falling against a partition, and concentrated loads by furniture or by a ladder or other object leaning against a partition. Transverse loads are applied to floors by furniture and by the 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. Transverse loads are applied to roofs by wind and snow; concentrated loads by persons walking on the roof and by tools and equipment when the roof is constructed and repaired.

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 The Weston Paper and Manufacturing Co., Dayton, Ohio, and represented wood-frame constructions with a fabricated paper-stock lath marketed under the trade name "Red Stripe." The constructions consisted of conventional wood-frame walls, partitions, floors, and roofs, with lath and plaster as one or both faces.

III. SPECIMENS AND TESTS

The specimens represented four elements of a house, which were assigned the following symbols: wall, *BQ;* partition, *BR;* floor, *BS;* and roof, *BT.* The specimens were assigned the designations given in table 1.

TABLE 1.—*Specimen designations*

Element	Construction symbol	Specimen designation	Load	Load applied
Wall	*BQ*	*C1, C2, C3*	Compressive	Upper end.
Do	*BQ*	*T1, T2, T3*	Transverse	Inside face.
Do	*BQ*	*T4, T5, T6*	do	Outside face.
Do	*BQ*	*P1, P2, P3* [a]	Concentrated	Inside face.
Do	*BQ*	*P4, P5, P6* [a]	do	Outside face.
Do	*BQ*	*I1, I2, I3*	Impact	Inside face.
Do	*BQ*	*I4, I5, I6*	do	Outside face.
Do	*BQ*	*R1, R2, R3*	Racking	Upper end.
Partition	*BR*	*P1, P2, P3* [a]	Concentrated	Either face.
Do	*BR*	*I1, I2, I3*	Impact	Do.
Floor	*BS*	*T1, T2, T3*	Transverse	Upper face.
Do	*BS*	*P1, P2, P3* [a]	Concentrated	Do.
Do	*BS*	*I1, I2, I3*	Impact	Do.
Roof	*BT*	*T1, T2, T3*	Transverse	Do.
Do	*BT*	*P1, P2, P3* [b]	Concentrated	Do.

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

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. 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.

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 one-third this thickness from the inside surface of the studs. The shortenings and sets were measured by means of compressometers attached to the steel loading plates through which the load was applied to the specimen, not attached to the specimen as described in BMS2. This was done because in wood-frame constructions under compressive load there is considerable local shortening caused by crushing of the floor plate and top plate at the ends of the studs. Therefore, the shortening of the entire specimen is not proportional to the value obtained from compressometers attached near each end of the specimen.

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 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 in the channel into the top of the specimen. Two dial micrometers were attached to a steel block which was in contact with the floor plate of the specimen at the stop. The spindles of the micrometers were in contact with rigid extensions of the steel angle of the deformeter. The gage length (distance from the top of the specimen to the center of the block) was 7 ft 11¼ in. The micrometers were 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.

Before applying the loads, the speed of the movable head of the testing machine was measured under no load. For compressive loading the speed was 0.072 in./min, for transverse loads on walls the speed was 0.14 in./min, on floors it was 0.173 in./min, and on roofs it was 0.24 in./min. These speeds were recommended by the Forest Products Laboratory.

The specimens were tested on the 28th day following the application of the finish coat of plaster. The tests were begun November 23, 1938 and completed December 9, 1938. The sponsor's representative witnessed the tests.

IV. MATERIALS

1. Sources of Information

Unless otherwise stated the information on materials was obtained from the sponsor and from inspection of the specimens. The Forest Products Laboratory assisted the sponsor by identifying the species of the wood in the framing. The Heat Transfer Section of this Bureau assisted by determining the thermal conductivity of the lath, the Paper Section by determining the other physical properties of the lath, and the Lime and Gypsum Section by determining the properties of the plaster.

2. Wood

(a) *Framing for Walls and Partitions*

Studs, floor plates, top plates, and girts, Douglas-fir, *Pseudotsuga taxifolia*, No. 1 common, S4S (surfaced four sides), 1⅝ by 3⅝ in. (nominal 2 by 4 in.).

(b) *Framing for Floors and Roofs*

Joists, rafters, and end members, longleaf-southern-pine, identified as southern yellow pine, *Pinus sp.*, No. 1 common, S4S, 1⅝ by 7½ in. (nominal 2 by 8 in.).

(c) *Sheathing and Subflooring*

Shortleaf-southern-pine, *Pinus sp.*, No. 2 common, dressed and matched, tongued-and-grooved, 25/32 in. thick by 5¼ in. face width (nominal 1 by 6 in.).

(d) *Bevel Siding*

Red-cypress, *Taxodium distichum*, select, grade *C* or better, 7/16 by 3/16 by 5½ in.

(e) *Bridging*

Shortleaf-southern-pine, *Pinus sp.*, No. 2 common, rough, 1 by 3 in.

(f) *Flooring*

White-oak, *Quercus sp.*, plain-sawed, clear, tongued-and-grooved, end-matched, 13/16 in. thick by 2¼ in. face width, Jackson Lumber Co.'s "Merit Brand."

(g) *Spacers and Grounds*

Shortleaf-southern-pine, *Pinus sp.*, No. 2 common, S4S. Spacers for walls and partitions were 25/32 by 3⅝ in. (nominal 1 by 4 in.), and for floors and roofs 25/32 by 6 23/32 in. (nominal 1 in. thick). Grounds were 25/32 by 1⅝ in. (nominal 1 by 2 in.).

After each specimen was tested, one face was removed to expose the framing members, and photographs were taken showing the knots and failures. Typical frames of each of the constructions are shown in figures 1 to 4, inclusive.

FIGURE 1.—*Wall BQ.*
Typical specimen.

The species of the woods were identified by examination of a sample of the framing of each specimen.

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

An electrical moisture meter was used when determining the moisture content. The moisture meter was graduated for Douglas fir and for longleaf pine. To determine the correction factor of the meter, 21 samples from the wall and partition frames and 9 samples from the floor and roof frames 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 dry,

FIGURE 2.—*Partition BR.*

Typical specimen.

FIGURE 3.—*Floor BS.*

Typical specimen.

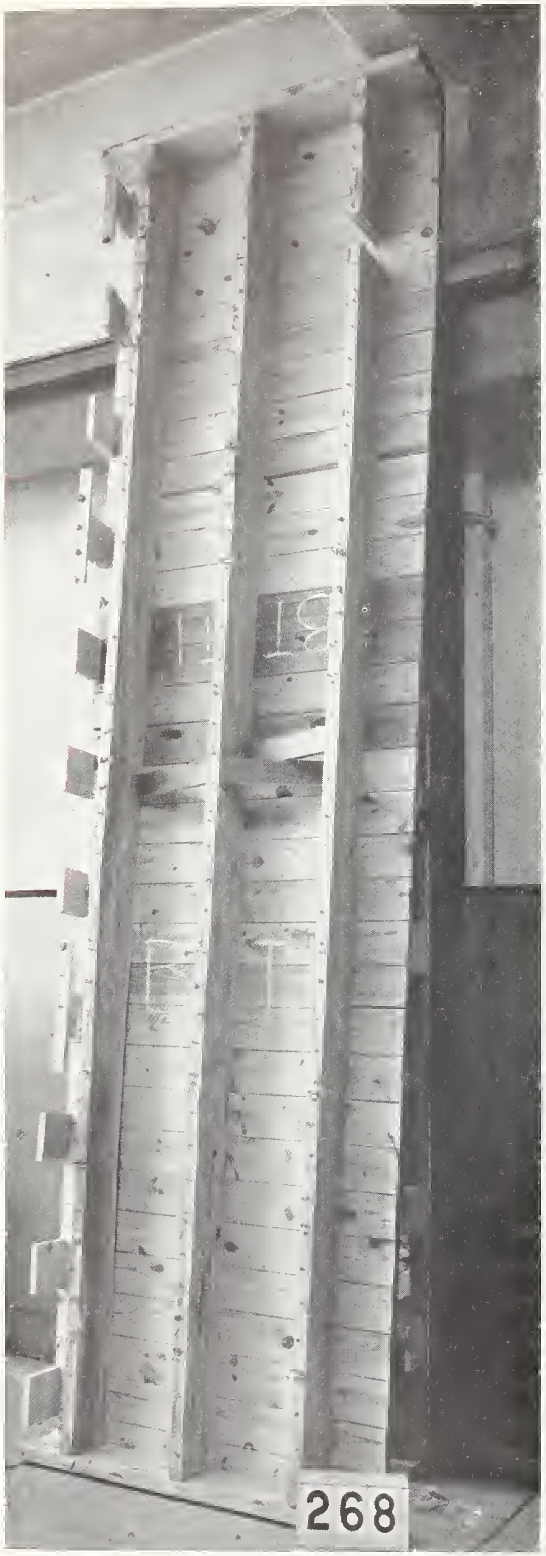

FIGURE 4.—*Roof BT.*

Typical specimen.

divided by the weight when dry. The average value for the Douglas fir (wall and partition) samples was 1.0 less than the average of the meter readings, and the average value of the longleaf-pine (floor and roof) samples was 1.0 greater than the average of the meter readings. Therefore, the moisture content of the Douglas fir was obtained by subtracting 1.0 from the meter readings, and the moisture content of the longleaf pine was obtained by adding 1.0 to the meter readings. The results were rounded to the nearest whole number.

TABLE 2.—*Moisture content of the wood*

[Determined on the day the specimen was tested]

Wood	Construction symbol	Moisture content [a]		
		Minimum	Maximum	Average
		Percent	*Percent*	*Percent*
Framing, Douglas fir	*BQ*	9	23	15
	BR	12	18	15
Framing, longleaf-southern-pine	*BS*	12	25	19
	BT	13	25	19
Sheathing, shortleaf-southern-pine	*BQ*	12	19	16
	BT	17	24	20
Subflooring, shortleaf-southern-pine	*BS*	16	23	19
Bevel siding, red-cypress	*BQ*	9	13	11
Flooring, white-oak	*BS*	8	13	10

[a] Based on the weight when dry.

The moisture content of the wood in each specimen was determined on each stud or joist. The moisture content was determined on about one-half of the pieces of sheathing, subflooring, and bevel siding, and on about 10 pieces of the flooring. The meter reading, corrected according to the manufacturer's recommendations, was taken as the moisture content.

3. "RED STRIPE" LATH

(*a*) *Description*

Fiberboards, corrugated, double-wall, 4 ft 0 in. by 1 ft 4 in., ⅜ in. thick. The boards consisted of a flat filler at midthickness, a corrugated sheet on each side of the filler, and a flat facing on each corrugated sheet.

The filler was "Auglaise" chipboard, 0.020 in. thick, weight 60 to 65 lb/1,000 ft^2. The corrugated sheets were built up of two sheets of strawboard, 0.009 in. thick, combined (duplexed) with an asphalt-base compound, weight 17.4 lb/1,000 ft^2, and then corrugated with class *A* flutes, 5/16 in. high, 32 corrugations per foot. The corrugations were parallel to the 4-ft edges of the lath. The facings were gray news liner, 0.025 in. thick, weight 78 to 80 lb/1,000 ft^2. Each facing sheet consisted of two plies; the inner ply was sized in the beater with rosin and starch to increase the moisture resistance, the outer ply was unsized to increase the adhesion of the plaster.

The corrugated sheets were combined with the filler by tapioca starch applied to the inner tips of the corrugations. The facings were combined with the corrugated sheets by sodium silicate, 42° Baumé, applied to the outer tips of the corrugations at a temperature of 75° F. Each edge of the lath was beveled from both sides by rollers and then coated with a patented bituminous compound to increase the moisture resistance.

(b) *Physical Properties*

The thermal conductivity at 86° F mean temperature was 0.49 (Btu/hr ft^2)/(°F/in).

TABLE 3.—*Moisture content of "Red Stripe" lath*

[Determined on the day the specimen was tested]

Construction symbol	Moisture content [a]		
	Minimum	Maximum	Average
	Percent	*Percent*	*Percent*
BQ	7	10	8
BR	8	10	9
BS	8	11	9
BT	7	11	8
Average			8

[a] Based on the weight when dry.

The water absorption, measured in accordance with Federal Specification LLL–F–321a, Fiber-Board; Insulating, was 32 percent, based on the apparent volume. Therefore, the lath did not comply with the requirement for water absorption (maximum, 5 percent) for class *B*, Lath (for plaster base). Corrected for the 50-percent air space, the water absorption was almost 70 percent. The lath was tested for water penetration by the method developed by F. T. Carson and described in BMS4, Accelerated Aging of Fiber Building Boards. After 3 weeks there was no evidence that water had penetrated the lath. The water-vapor permeability was determined on a circular sample of the lath sealed with wax over the mouth of a 95-mm petri culture dish containing 50 g of anhydrous $CaCl_2$ as a desiccant. The assembly was placed in a room maintained at 71° F and 65-percent relative humidity and was weighed periodically. The steady rate of penetration of water vapor was 5.4 g/m^2 per day.

The moisture content of the lath, determined by drying in an oven at 212° F until the weight was constant, is given in table 3.

4. NAILS

The nails were made from steel wire, with the exception of the flooring nails. The description is given in table 4.

TABLE 4.—*Description of nails*

Type	Size	Length	Steel wire gage	Diameter	U. S. Standard gage	Thickness	Head diam	Finish
	Penny	*in.*	*No.*	*in.*	*No.*	*in.*	*in.*	
Box	6	1⅞	13½	0.0858				Cement-coated.
Do	6	2	12½	.0985				Bright.
Do	8	2⅜	12½	.0985				Cement-coated.
Common	16	3½	8	.162				Bright.
Do	20	4	6	.192				Do.
Finishing	6	2	13	.0915				Do.
Do	8	2½	12½	.0985				Do.
Flooring, cut	8	2½			11½	0.1148		
Plasterboard		1¼	11	.1205			7/16	Blued.
Roofing, barbed		1	11½	.113			⅜	Galvanized.

5. PLASTER

The plaster was applied in two coats. The base coat was approximately 1 part of neat gypsum plaster and 2 parts of dry Potomac River building sand, by weight. The finish coat was 1 part of gaging plaster and 3 parts of hydrated finishing lime, by volume. The neat gypsum plaster, the gaging plaster, and the finishing lime were United States Gypsum Co.'s "Red Top." The plastering contractor was instructed to apply the plaster to the specimens as he would to the walls and ceilings of a house.

The following properties of the plaster were determined in accordance with Federal Specification SS–P–401, Plaster; Gypsum. The time of set of the neat gypsum plaster was 15 hr and the average tensile strength of six samples was 270 lb/in^2. The neat gypsum plaster complied with the requirements of the Federal specification for time of set and tensile strength.

A sample consisting of 1 part of neat gypsum plaster and 2 parts of sand, by weight, at a

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consistency of 18 (18 g of water to 100 g of sanded mixture at ½-in. slump), had a time of set of 8 hr and a tensile strength of 155 lb/in^2. Accelerator was added to the sanded plaster by the contractor to decrease the time of set to 4 hr. The tensile strength of the sanded plaster for some of the specimens was determined on samples taken on the job from some of the batches of the wet plaster. The plaster was cast in briquet molds and cured in accordance with paragraph F–2f(1), Federal Specification SS–P–401. The tensile strength of the sanded plaster is given in table 5.

TABLE 5.—*Tensile strength of sanded plaster*

[Determined when weight was constant within 0.1 percent]

Batch No.	Specimens	Tensile strength
		lb/in.
1	*BQ–C1, C2, T1*	120
2	*BQ–C3, T2, T3*	155
3	*BQ–T4, T5, R1*	165
4	*BQ–T6, I4, I5*	115
5	*BQ–R2, R3; BR–I3, P3*	115
6	*BQ–I3, P3; BS–T1, T2, T3, I1, I2, I3*	175

The tensile strength of the different batches of the sanded plaster varied principally with the quantity of water in the plaster mix. There are no requirements in the Federal specification for the tensile strength of sanded plaster which has been sanded on the job. The tensile strength of each batch tested exceeded the specified minimum tensile strength for ready-sanded, scratch-coat plaster.

The proportions of plaster and sand in the set plaster were determined in accordance with the proposed revision of C26–33,[1] Standard Method of Testing Gypsum and Gypsum Products. The proportions for sanded plaster, by weight, were 1 part of plaster to 1.79 parts of sand for batch 5, and 1 part of plaster to 1.93 parts of sand for batch 6.

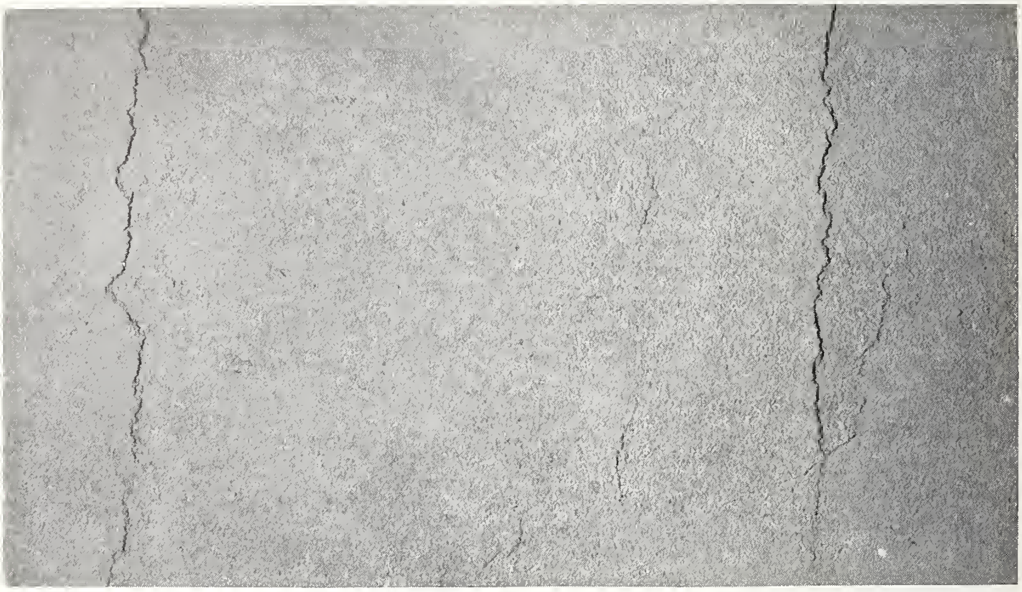

FIGURE 5.—*Typical cracks in the base coat of the plaster.*

Before the finish coat of plaster was applied, it was observed that the base coat was cracked along most of the bituminous-coated edges of the lath. Since the plaster did not adhere well to this bituminous coating, there was also a tendency for the plaster to bulge outward prior to the cracking at the joints. This was especially noticeable in the floor and roof specimens. Because these specimens were horizontal and the plaster was applied to the lower face, the force of gravity accentuated the bulging of the plaster. Typical cracks in the base coat of the plaster are shown in figure 5. Although the finish coat of plaster concealed the cracks, the bulges at the edges of the lath were still noticeable.

[1] Proc. Am. Soc. Testing Materials **38**, pt. 1, 1323 (1938).

6. Sheathing Paper

Red-rosin paper, weight 40 lb/108 ft^2, 36 in. width of roll. Bird & Son, Inc.

7. Tacks

Bill-poster tacks, ½ in. long, diam of head ¼ in., size No. 6.

8. Size

Decorator's size, alum-treated animal glue and mineral fillers. Recommended mixture for plaster, 1 lb to 6 qt of water. M. Ewing Fox Co.'s "Fox Decorator's Size."

9. Paints

(a) *Outside*

E. I. du Pont de Nemours and Co.'s "Dupont Outside White No. 40."

The outside paints were prepared as follows:

Primer—a mixture of 1 gal of outside white, 3 pt of raw linseed oil, and 1 pt of turpentine.

Undercoat—a mixture of 1 gal of outside white and 1 pt of turpentine.

Finish—a mixture of 1 gal of outside white and 1 pt of linseed oil.

The formula for the outside white paint is given in table 6.

Table 6.—*Formula for paint: outside white*

[Composition, by weight: pigment, 63 percent; vehicle, 37 percent]

Pigment		Vehicle	
Ingredient	Content, by weight	Ingredient	Content, by weight
	Percent		*Percent*
Titanium magnesium[a]	32	Linseed oil	89
White lead[b]	33	Japan drier	5
Zinc oxide	30	Mineral spirits	6
Titanium dioxide	5		
Total	100	Total	100

[a] Mixture of 30 percent of titanium dioxide, 70 percent of magnesium sulfate

[b] Basic carbonate, 51 percent: basic sulfate, 49 percent.

(b) *Inside*

E. I. du Pont de Nemours and Co.'s "Dupont Interior, Semi-Gloss, Ivory." The formula is given in table 7.

Table 7.—*Formula for paint: interior, semigloss, ivory*

[Composition, by weight: pigment, 45 percent; vehicle, 55 percent]

Pigment		Vehicle	
Ingredient	Content, by weight	Ingredient	Content, by weight
	Percent		*Percent*
Titanium calcium pigment	77	Resin	3
Titanium oxide	19	Processed linseed and china-wood oils	51
Tinting colors (zinc yellow; french ocher)	4	Drier	10
		Mineral spirits	36
Total	100	Total	100

10. Shellac Varnish

White shellac, a mixture of 4 lb of gum shellac and 1 gal of alcohol. A. L. Webb and Sons' "Webb."

11. Roofing

(a) *Asphalt*

Asphalt-saturated rag felt 36 in. wide; two weights, 30 lb/100 ft^2 and 15 lb/100 ft^2. The Barrett Co.

(b) *Caps*

Sheet-steel, No. 31 U. S. Std. Gage (0.0109 in. thick), 1$\frac{7}{16}$-in. diam, tinned and lacquered.

V. WALL *BQ*

1. Description, Sponsor's Statement

Wall *BQ* was a conventional wood frame with diagonal sheathing, sheathing paper, and wood bevel siding as the outside face, and lath and plaster as the inside face.

The price of this construction in Washington, D. C., as of July 1937, was \$0.37/ft^2.

(a) *Four-Foot Wall Specimens*

The 4-ft wall specimens were 8 ft 0 in. high, 4 ft 0 in. wide, and 5⅝ in. thick, as shown in figure 6. Each specimen consisted of a wood frame to which the faces were fastened. The frame consisted of three studs, *A*, fastened to a floor plate, *B*, and a top plate, *C*, by nails. The outside face consisted of wood sheathing, *D*, sheathing paper, *E*, and wood bevel siding, *F*. The inside face consisted of lath, *G*, and plaster, *H*. The overhanging edges of the lath were supported by spacer blocks, *I*. The faces were covered with paint.

Studs.—The studs, *A*, were Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in), 7 ft 7⅛ in. long, spaced 1 ft 4 in., on centers. The lower end of each stud was fastened to the floor plate by two 16d common nails driven from the bottom of the plate (not toenailed), and the upper end of each stud was fastened to the top plate by

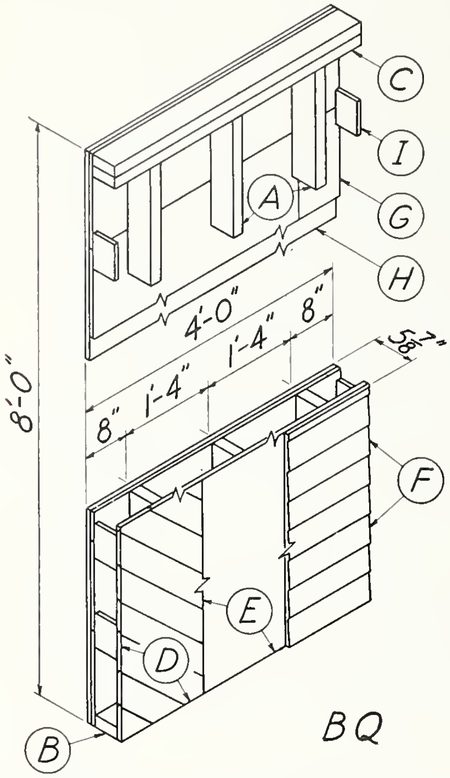

FIGURE 6.—*Four-foot wall specimen BQ.*

A, studs; *B*, floor plate; *C*, top plate; *D*, sheathing; *E*, sheathing paper; *F*, bevel siding; *G*, lath; *H*, plaster; *I*, spacer block.

two 16d common nails driven from the top of the lower member of the plate.

Floor plate.—The floor plate, *B*, was Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in), 4 ft 0 in. long.

Top plate.—The top plate, *C*, consisted of two pieces of Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in), 4 ft 0 in. long, fastened by three 16d common nails, one in each stud, driven from the top of the upper member of the plate.

Sheathing.—The sheathing, *D*, was shortleaf southern pine, 25/32 in. thick by 5¼ in. face width (nominal 1 by 6 in), tongued-and-grooved, fastened at an angle of 48° to the studs by 6d cement-coated box nails, two nails through each piece into each stud and into the top plate and floor plate for those pieces which were in contact with them.

Sheathing paper.—The sheathing paper, *E*, was laid transversely (across the specimen) over the sheathing and consisted of two sheets 3 ft 0 in. wide and one sheet 2 ft 6 in. wide, having two laps with the upper sheets lapping 3 in. over the lower sheets. The paper was fastened by one tack at each corner of each sheet, one tack serving for two sheets at overlapping corners.

Bevel siding.—The bevel siding, *F*, was 22 pieces of red cypress, 7/16 by 3/16 by 5½ in., 4 ft 0 in. long, laid 4⅜ in. to the weather, and fastened through the overlapping edges by 6d bright box nails, one at each stud.

Lath.—The lath, *G*, consisted of six courses of "Red Stripe" lath, each course 1 ft 4 in. high, with a small clearance between courses. There was a vertical joint in most courses, centered on a stud, with no clearance between boards at the joint. The lath was fastened to the studs by 1¼-in. plasterboard nails, five nails to each piece of lath at each stud; and to each plate by five nails, one at each stud and one at each end of the plate.

Spacer blocks.—The spacer blocks, *I*, were shortleaf southern pine, 25/32 by 3⅝ in., 6 in. long, and supported the overhanging edges of the lath. Each block was centered at a joint between lath courses and was fastened to the sheathing by one 6d finishing nail driven from the sheathing into the block and to the lath by four 1¼-in. plasterboard nails driven through the lath into the block. These spacer blocks are not used in a house.

Plaster.—The plaster, *H*, was ⅝ in. thick and consisted of a base coat and a finish coat. The lath was dry when the plaster was applied.

Paint.—The outside face was painted with one primer coat, one under coat, and one finish coat of outside paint. The inside face was prepared for painting by the application of one coat of size and finished with one coat of inside paint. Paint and size were applied with a brush.

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

The 8-ft wall specimens were 8 ft 0 in. high, 8 ft 0 in. face width, and 5⅞ in. thick. The specimens were similar to the 4-ft. specimens except that there were seven studs, spaced 1 ft 4 in. on centers, and no spacer blocks. There was a stud at each edge extending one-half its thickness beyond the faces, width over-all 8 ft 1⅝ in.

2. Compressive Load

The results for wall specimens *BQ-C1*, *C2*, and *C3* are shown in table 8 and in figures 7 and 8.

Table 8.—*Structural properties of wall BQ*

[Weight, 8.94 lb/ft²]

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*	[a] *Kips/ft*
Compressive	Upper end, one-third the thickness (1.21 in.) from the inside surface of the studs (see section III).	*C1*				10.87
		C2				9.02
		C3				7.55
	Average					9.15
						lb/ft ²
Transverse	Inside face; span, 7 ft 6 in.	*T1*				227
		T2				230
		T3				205
	Average					221
Do	Outside face; span, 7 ft 6 in.	*T4*				240
		T5				233
		T6				167
	Average					213
						lb
Concentrated	Inside face	*P1*				275
		P2				275
		P3				300
	Average					283
Do	Outside face	*P4*				[b] 1,000
		P5				[b] 1,000
		P6				[b] 1,000
	Average					[b] 1,000
Impact	Inside face; span, 7 ft 6 in.	*I1*	4.5	(c)	[d] 10.0	
		I2	5.5	(c)	[d] 10.0	
		I3	4.0	(c)	[d] 10.0	
	Average		4.7	(c)	[d] 10.0	
Do	Outside face; span, 7 ft 6 in.	*I4*	(c)	4.0	[d] 10.0	
		I5	(c)	5.5	[d] 10.0	
		I6	(c)	4.5	[d] 10.0	
	Average		(c)	4.7	[d] 10.0	
						[a] *Kips/ft*
Racking	Upper end	*R1*				2.12
		R2				1.38
		R3				1.58
	Average					1.69

[a] A kip is 1,000 lb.
[b] Test discontinued. Specimen did not fail.
[c] Face did not fail.
[d] Test discontinued. Specimen damaged.

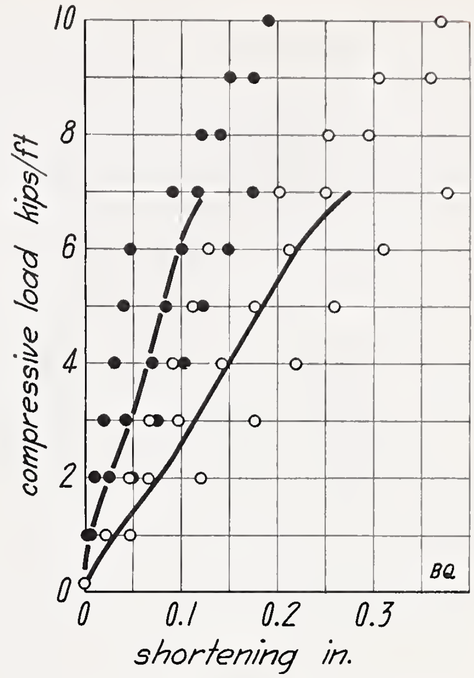

Figure 7.—*Compressive load on wall BQ.*

Load-shortening (open circles) and load-set (solid circles) results for specimens *BQ-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.

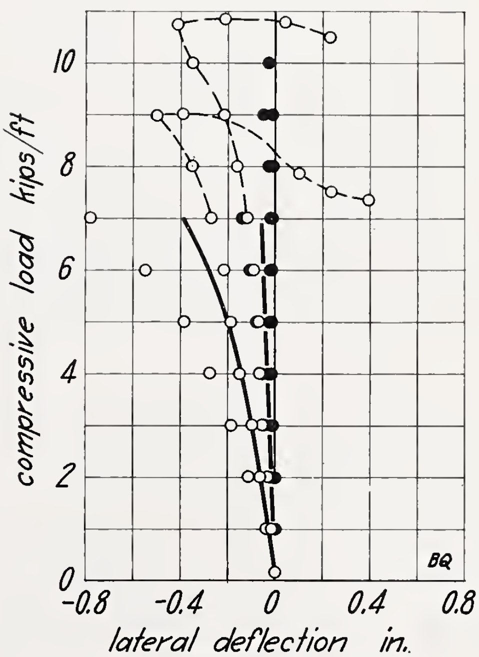

Figure 8.—*Compressive load on wall BQ.*

Load-lateral deflection (open circles) and load-lateral set (solid circles) results for specimens *BQ-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 7 ft 10 in., the gage length of the deflectometers.

Although the load was eccentric toward the inside face, each of the specimens deflected toward the inside face under loads up to the maximum load, probably because the stiffness of the plaster counteracted the effect of the eccentric load. After the maximum had been reached, specimens *C1* and *C2* deflected in the

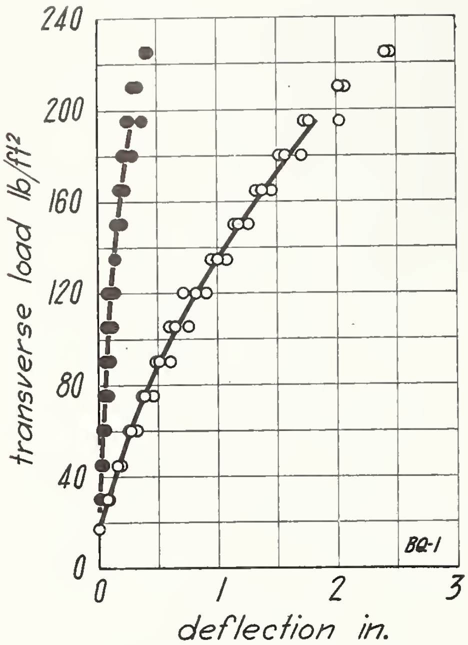

FIGURE 9.—*Transverse load on wall BQ, load applied to inside face.*

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

opposite direction, that is, toward the outside face, whereas specimen *C3* continued to deflect toward the inside face. The change of direction of the deflection curves of specimens *C1* and *C2* indicated local failure of the inside faces.

At loads of 6.2 and 4.0 kips/ft on specimens *C1* and *C2*, respectively, the plaster at the bottom of the inside face began to crush. At the maximum loads on these two specimens the top plate crushed locally at the inside edge of the studs, the lath at the bottom of the specimen separated from the floor plate, and the plaster continued to crush. In specimen *C3* at a load of 7.0 kips/ft the lath separated from the studs near the floor plate; at the maximum load the sheathing boards separated from each other and the top plate crushed locally at the outside edge of the studs, whereas the floor plate crushed at the inside edge. After the maximum load had been reached, the studs cracked near midheight and continued to crush into both top plate and floor plate, the plaster cracked transversely and diagonally, and the joints in the sheathing boards opened wider.

3. Transverse Load

The results are shown in table 8 and in figure 9 for wall specimens *BQ–T1, T2,* and *T3*, loaded on the inside (plastered) face, and in figure 10 for wall specimens *BQ–T4, T5,* and *T6*, loaded on the outside face.

In specimens *T1, T2,* and *T3* the plaster cracked longitudinally along each outer stud

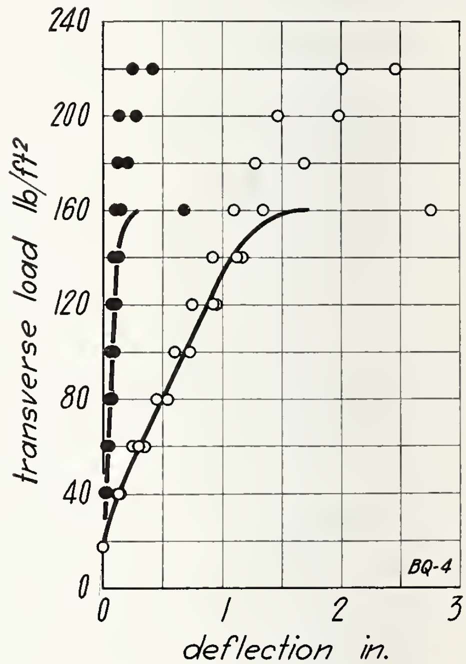

FIGURE 10.—*Transverse load on wall BQ, load applied to outside face.*

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

and transversely across the specimen in several places. The first longitudinal cracks occurred at loads of 120, 120, and 90 lb/ft^2 and deflections of 0.82, 0.71, and 0.61 in., respectively. The first transverse cracks occurred at lath joints at or near midspan at loads of 180, 195, and 195 lb/ft^2 and deflections of 1.57, 1.73, and 2.03 in., respectively. At loads of 195 and 135 lb/ft^2 for specimens *T1* and *T2*, respectively, one outer stud of each specimen ruptured under a loading roller. At the maximum load specimen *T1* failed by rupture of the two remaining studs between loading rollers, the plaster was broken in several places, but the lath, the sheathing, and the siding were undamaged. Specimen *T2* failed by rupture of the center stud and partial rupture of the remaining outer stud under a loading roller. The plaster was broken in several places, one siding strip was split near midspan, and the siding and sheathing were separated from the studs under the ruptured outer stud. Specimen *T3* failed by rupture of the center and one outer stud, and by partial rupture of the other outer stud between loading rollers. The plaster was broken in several places, but the lath, sheathing, and siding were undamaged.

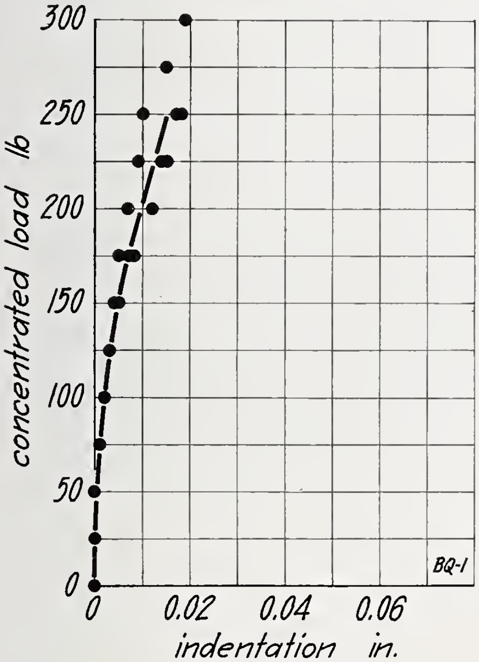

Figure 11.—*Concentrated load on wall BQ, load applied to inside face.*

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

In specimens *T4*, *T5*, and *T6*, loaded on the siding, the plaster cracked transversely in several places, about half the cracks occurring at lath joints. The first transverse cracks occurred between the loading rollers at loads of 60, 58, and 50 lb/ft ^{2} and deflections of 0.24, 0.28, and 0.24 in., respectively. At loads of 217 and 157 lb/ft ^{2} on specimens *T4* and *T6*, respectively, one outer stud of each specimen ruptured between the loading rollers. At the maximum load specimen *T4* failed by rupture of the two remaining studs between the loading rollers, specimen *T5* failed by rupture of all the studs between the loading rollers, and specimen *T6* failed by rupture of the center stud and partial rupture of the remaining outer stud between loading rollers. The plaster was severely cracked, but the lath, sheathing, and siding were undamaged.

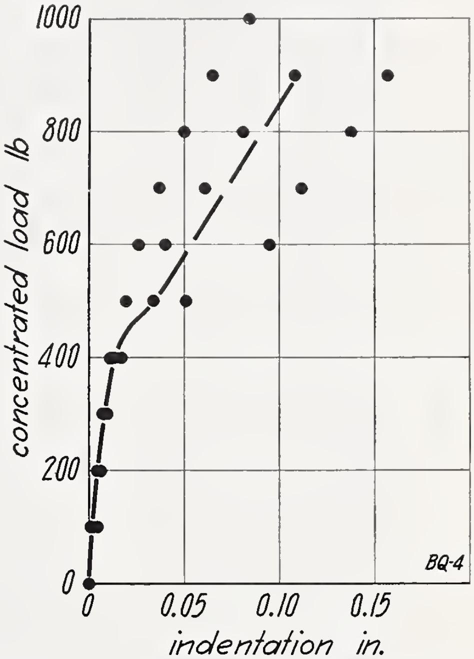

Figure 12.—*Concentrated load on wall BQ, load applied to outside face.*

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

4. Concentrated Load

The results are shown in table 8 and in figure 11 for wall specimens *BQ–P1*, *P2*, and *P3*, loaded on the inside face, and in figure 12 for wall specimens *BQ–P4*, *P5*, and *P6*, loaded on the outside face.

The concentrated loads were applied to the inside face of specimens *P1*, *P2*, and *P3* on the plaster midway between two studs, over a lath joint 2 ft. 8 in. from one end. Each of the specimens failed by punching of the disk through the plaster into the lath. Also, in specimens *P1* and *P2* the plaster over the two adjacent studs cracked for about 1 ft along the studs on each side of the disk.

The concentrated loads were applied to the outside face of specimens $P4$, $P5$, and $P6$ on the wood bevel siding midway between studs and from 3 to 4 ft from one end. At loads of 900, 400, and 529 lb on specimens $P4$, $P5$, and $P6$, respectively, the siding split along the grain

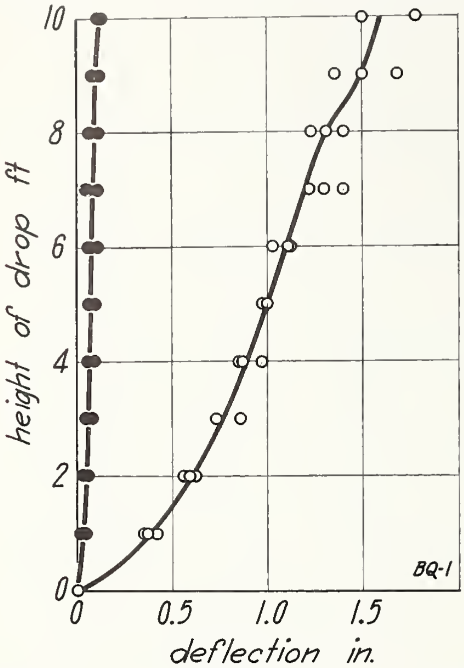

Figure 13.—*Impact load on wall BQ, load applied to inside face.*

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

at one edge of the disk. For specimen $P4$ at a load of 1,000 lb the indentation was 0.084 in., and no other effect was observed. For specimens $P5$ and $P6$ at a load of 900 lb the wood crushed locally under the disk, and at the maximum load the specimens failed by punching of the disk through the siding strip.

5. Impact Load

The results are shown in table 8 and in figure 13 for wall specimens *BQ–I1, I2*, and *I3*, loaded on the inside face, and in figure 14 for wall specimens *BQ–I4, I5*, and *I6*, loaded on the outside face.

The impact loads were applied to the center of the inside face of specimens *I1, I2*, and *I3*, the sandbag striking the plaster directly over the center stud. In each specimen at the 3.5-ft drop, the plaster cracked locally under the bag. The plaster cracked longitudinally over an outer stud in each specimen at drops of 4.5, 1.5, and 7.5 ft, and deflections of 0.97, 0.48, and 1.30 in., respectively; it also cracked transversely over a lath joint near midspan at drops of 4.5, 3.5, and 2 ft, and deflections of 0.97, 0.80, and 0.59 in., respectively. At drops of 4.5, 5.5, and 4 ft, respectively, the inside face of each specimen failed and the plaster crushed locally where the sandbag struck. After a drop of 10 ft the sets were 0.118, 0.111, and 0.136 in., respectively; the plaster and lath were broken where the sandbag struck; and one of the outer studs of specimens *I1* and *I2* cracked, but the outside faces had not failed.

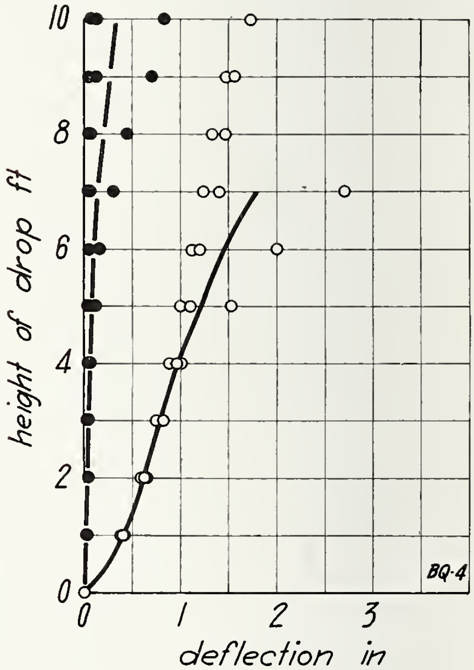

Figure 14.—*Impact load on wall BQ, load applied to outside face.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *BQ–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 *I4, I5*, and *I6*, the sandbag striking the wood bevel siding directly over the center stud. In each specimen at drops of 1.5, 0.5, 1.5 ft and deflections of 0.51, 0.24, and 0.52 in., respectively, the plaster cracked transversely at a lath joint near midspan. At drops of 4, 5.5, and 4.5 ft, respectively, the inside face of each specimen failed by further cracking of the plaster. In specimen *I4* the center stud ruptured at a drop of 5 ft, and at a drop of 6 ft one outer stud ruptured. At a drop of 6.5 ft there was noticeable separation of the lath from the studs, and after the 8.5-ft drop there was noticeable separation of the siding strips at midspan. After the 10-ft drop the set was 0.835 in. and several sections of lath had fallen from the specimen. In specimen *I5* at a drop of 8.5 ft there was noticeable separation of the lath from the studs and at a drop of 9.5 ft the center stud cracked at midspan. After the 10-ft drop the set was 0.067 in. and most of the sections of lath had fallen from the specimen. In specimen *I6* the lath separated noticeably from the studs at a drop of 8 ft and one outer stud ruptured at midspan at a drop of 9 ft. After the 10-ft drop the set was 0.133 in. and two sections of lath had fallen from the specimen near midspan.

6. Racking Load

Wall specimen *BQ-R1* under racking load is shown in figure 15. The results for wall specimens *BQ-R1*, *R2*, and *R3* are shown in table 8 and figure 16.

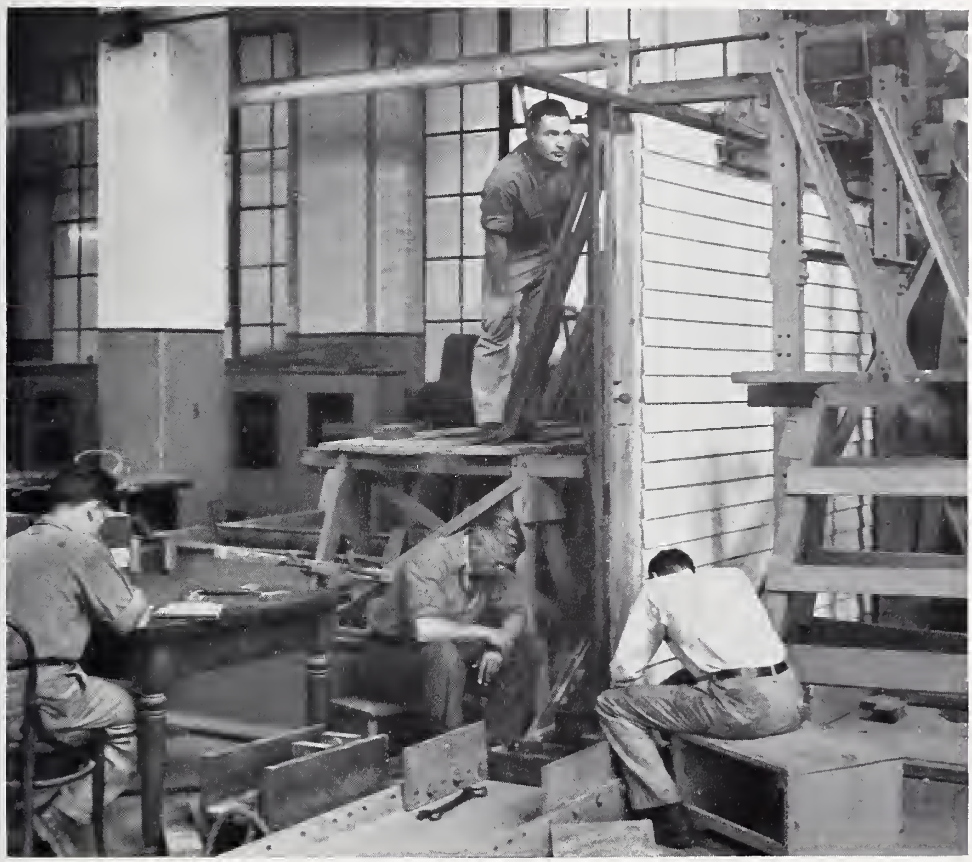

Figure 15.—*Wall specimen BQ-R1 under racking load.*

The racking load was applied to the top plate only, and the stop was in contact only with the floor plate at the diagonally opposite corner of the specimen. The specimens were loaded so that the diagonal sheathing was approximately at right angles to a line from the load to the stop. In each of the specimens the plaster cracked in one or in several places, either diagonally parallel to the line from load to stop, or vertically and horizontally along lath joints. The first significant cracks occurred at loads of 1.12, 1.12, and 1.50 kips/ft and deformations of 0.38, 1.03, and 2.17 in./8 ft in specimens *R1*, *R2*, and *R3*, respectively. At loads of 1.62, 1.00, and 1.00 kips/ft, respectively, there was noticeable displacement of the top plate with respect to the sheathing and the lath, the nails pulling through the edges of the sheathing and the lath. At the maximum load each of the specimens failed by shearing of the top plate and studs from the sheathing and lath and by displacement of the top plate horizontally with respect to the studs, the nails

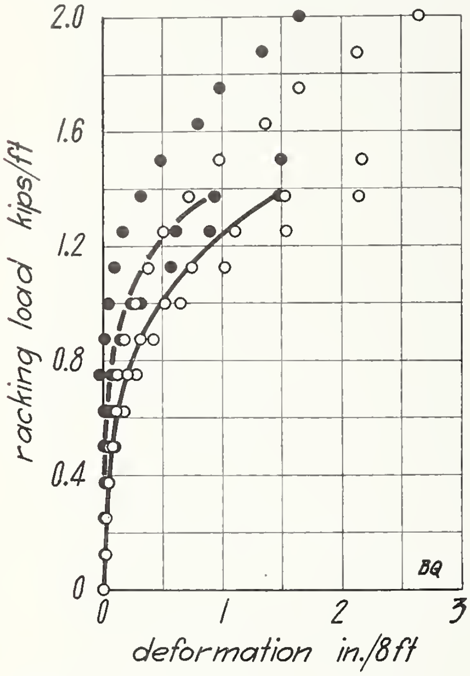

FIGURE 16.—*Racking load on wall BQ.*

Load-deformation (open circles) and load-set (solid circles) results for specimens *BQ-R1*, *R2*, and *R3*. The loads are in kips per foot of the face width of specimen (8 ft 0 in).

pulling from the studs and splitting some of the studs at the upper end.

VI. PARTITION *BR*

1. Description, Sponsor's Statement

Partition *BR* was a conventional wood frame with lath and plaster as both faces. The frame was similar to that of wall *BQ*, with the exception that there were girts at midheight and both faces were like the inside face of wall *BQ*.

The price of this construction in Washington, D. C., as of July 1937, was \$0.29/ft².

The partition specimens were 8 ft 0 in. high, 4 ft 0 in. wide, and 5⅛ in. thick. Each specimen consisted of a wood frame to which two like faces were fastened. The frame consisted of three studs, *A*, shown in figure 17, fastened to a floor plate, *B*, a top plate, *C*, and girts, *D*, by nails. Both faces consisted of lath, *E*, and plaster, *F*. The overhanging edges of the lath were supported by spacer blocks, *G*. Both faces were coated with paint.

Studs.—The studs, *A*, were Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in), 7 ft 7⅛ in. long, spaced 1 ft 4 in. on centers. The lower end of each stud was fastened to the floor plate by two 20d common nails driven from the bottom of the plate (not toenailed), and the upper end of each stud was fastened to the top plate

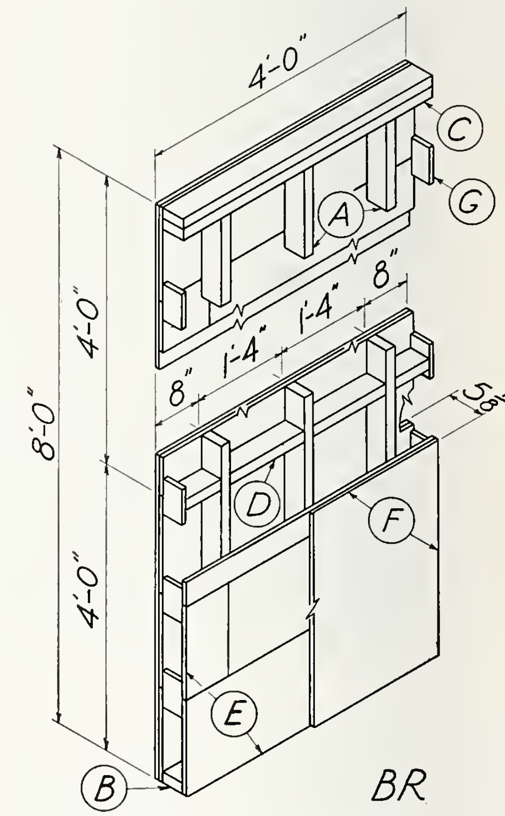

FIGURE 17.—*Partition specimen BR.*

A, studs; *B*, floor plate; *C*, top plate; *D*, girt; *E*, lath; *F*, plaster; *G*, spacer block.

by two 20d common nails driven from the top of the lower member of the plate.

Floor plate.—The floor plate, *B*, was Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in), 4 ft 0 in. long.

Top plate.—The top plate, *C*, consisted of two pieces of Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in), 4 ft 0 in. long, fastened by three

20d common nails, one in each stud, driven from the top of the top plate.

Girts.—The girts, *D*, were Douglas fir, 1⅝ by 3⅝ in. (nominal 2 by 4 in). The two inner pieces, 1 ft 2⅜ in. long, were fastened at midheight to the outer studs by either two 16d or two 20d common nails driven through the stud into the girt, and were toenailed to the center stud by two 6d bright box nails. The two outer pieces, 6⁵⁄₁₆ in. long, were placed between the outer studs and the edge of the specimen. They were toenailed to the studs by two 6d bright box nails.

Lath.—The lath, *E*, consisted of six courses of "Red Stripe" lath, each course 1 ft 4 in. high, with a small clearance between courses. There was a vertical joint in most courses, centered on a stud, with no clearance between boards at the joint. The lath was fastened to the studs by 1¼-in. plasterboard nails, five nails to each piece of lath at each stud; and to each plate by five nails, one at each stud and one at each end of the plate.

Spacer blocks.—The spacer blocks, *G*, were shortleaf southern pine, ²⁵⁄₃₂ by 3⅝ in., 6 in. long, and supported the overhanging edges of the lath. Each block was centered at a joint between lath courses, and was fastened to the lath by four 1¼-in. plasterboard nails driven through the lath into the block. These spacer blocks are not used in a house.

Plaster.—The plaster, *F*, was ⅜ in. thick and consisted of a base coat and a finish coat. The lath was dry when the plaster was applied.

Paint.—Both faces were prepared for painting by the application of one coat of size and finished with one coat of interior paint. Paint and size were applied with a brush.

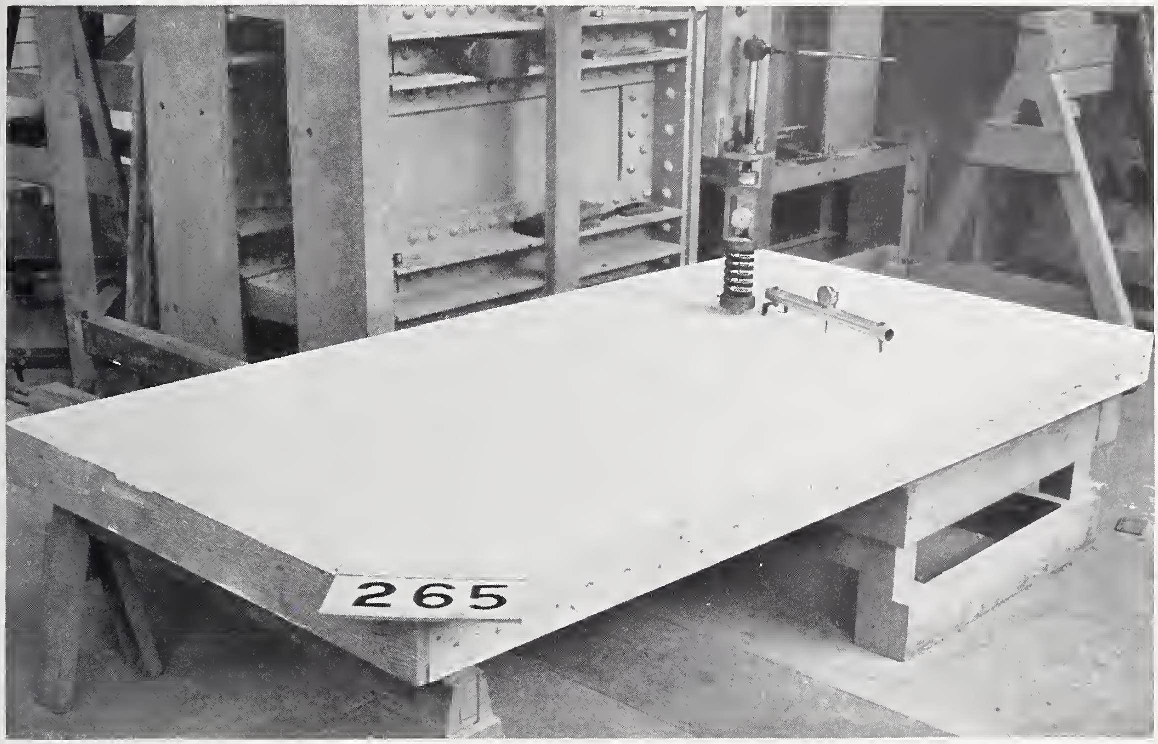

FIGURE 18.—*Partition specimen BR–P2 under concentrated load.*

2. Concentrated Load

A steel disk, 1-in. diam, was placed on the face of the specimen and the concentrated loads applied to the disk. Partition specimen *BR–P2* under concentrated load is shown in figure 18. The results for partition specimens *BR–P1*, *P2*, and *P3* are shown in table 9 and in figure 19.

The concentrated loads were applied to one face of each specimen on the plaster midway between two studs over a lath joint. Each of

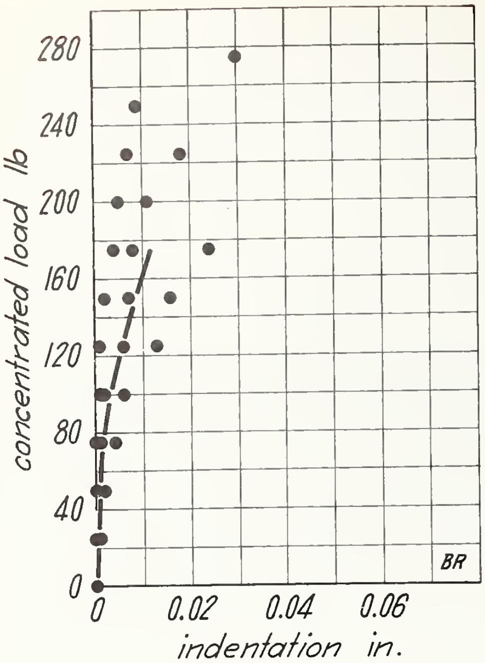

Figure 19.—*Concentrated load on partition BR.*

Load-indentation result for specimens *BR–P1*, *P2*, and *P3*.

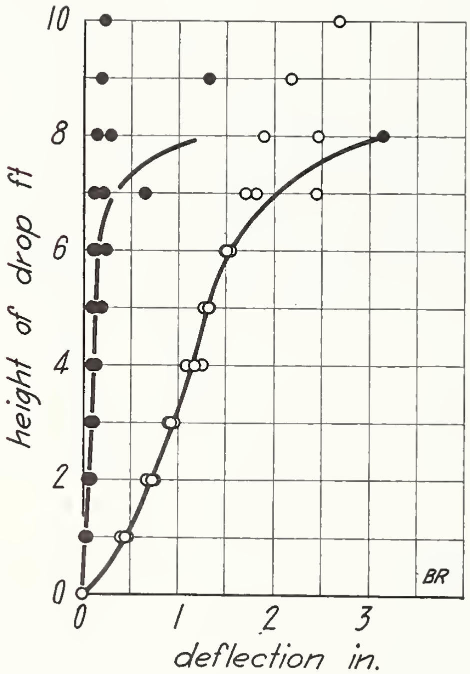

Figure 20.—*Impact load on partition BR.*

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

the specimens failed by punching of the disk through the plaster. Also, on specimen *P3* the plaster over the two adjacent studs cracked for about 1 ft along the studs on each side of the disk.

Table 9.—*Structural properties of partition BR*

[Weight, 9.16 lb/ft²]

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*	*lb*
Concentrated	One face	*P1*				190
		P2				295
		P3				225
	Average					237
Impact	One face; span, 7 ft 6 in	*I1*	6.5	5.5	[a] 10.0	
		I2	6.5	6.5	8.5	
		I3	5.0	5.0	10.0	
	Average		6.0	5.7		

[a] Test discontinued. Specimen damaged.

3. Impact Load

The results for partition specimens *BR–I1*, *I2*, and *I3* are shown in table 9 and in figure 20.

The impact loads were applied to the center of one face of each specimen, the sandbag striking the plaster directly over the center stud. In each of the specimens the plaster on both faces cracked longitudinally along the studs and transversely across each specimen in several places. The first transverse cracks in the face not struck occurred at lath joints near midspan at drops of 0.5, 1.5, and 2.5 ft and deflections of 0.30, 0.52, and 0.86 in. for specimens *I1*, *I2*, and *I3*, respectively. The first transverse cracks in the face struck occurred at lath joints near midspan at drops of 3.5, 4.5, and 4 ft and deflections of 1.02, 1.17, and 1.17 in., respectively. At drops of 6.5 ft for specimens *I1* and *I2* and 5 ft for specimen *I3*, the face struck failed and the plaster crushed where the sandbag struck. At drops of 5.5, 6.5, and 5 ft for specimens *I1*, *I2*, and *I3*, respectively, the opposite face failed and the previous cracks widened. At a drop of 10 ft, the set for specimen *I1* was 0.229 in., and no studs were broken. In specimen *I2* both outer studs ruptured at a drop of 6.5 ft, the center stud ruptured at a drop of 7 ft, and the specimen broke into two pieces at a drop of 8.5 ft. In specimen *I3* the center stud ruptured at a drop of 8.5 ft, and at a drop of 10 ft the sandbag broke completely through the specimen; the two outer studs were undamaged.

VII. FLOOR *BS*

1. Description, Sponsor's Statement

Floor *BS* was a conventional wood frame with diagonal subflooring and finish flooring as the upper face, and with lath and plaster as the lower face. The lower face was similar to the inside face of wall *BQ*.

Joists.—The joists, *A*, were longleaf southern pine, 1⅝ by 7½ in. (nominal 2 by 8 in.), 12 ft 2¾ in. long, spaced 1 ft 4 in. on centers. The ends of each joist were fastened to the end members, *B*, by four 16d common nails driven through the member into the joist.

End members.—The end members, *B*, were longleaf southern pine, 1⅝ by 7½ in. (nominal 2 by 8 in.), 4 ft 0 in. long.

Bridging.—The bridging, *C*, was shortleaf southern pine, 1 by 3 in., 1 ft 5¼ in. long. Two pieces were placed crosswise, diagonally between the top and the bottom of adjacent joists at midlength, and fastened to the joists by three 8d box nails toenailed through the bridging into the joist.

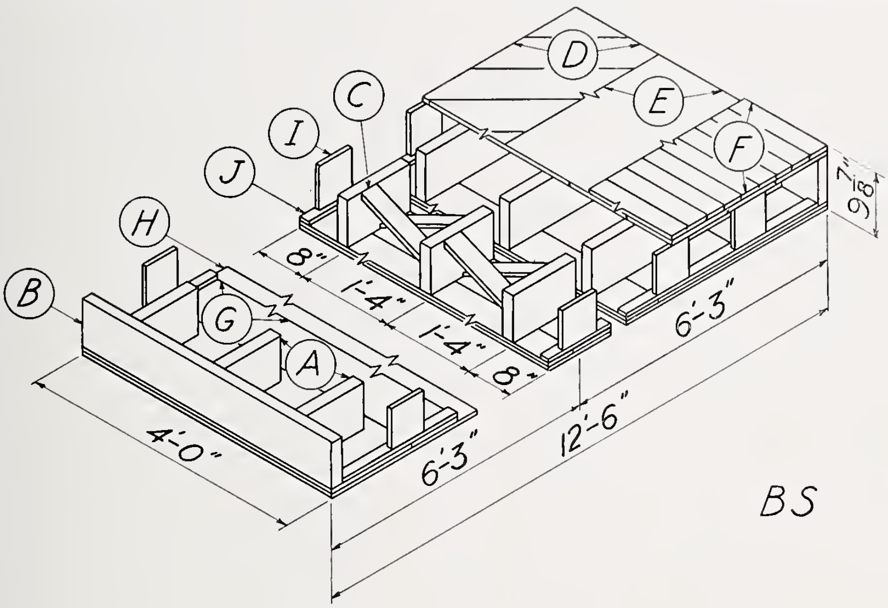

Figure 21.—*Floor specimen BS.*

A, joist; *B*, end member; *C*, bridging; *D*, subflooring; *E*, sheathing paper; *F*, finish floor; *G*, lath; *H*, plaster; *I*, spacer block; *J*, ground strip.

The price of this construction in Washington, D. C., as of July 1937, was \$0.43/ft^2.

The floor specimens were 12 ft 6 in. long, 4 ft 0 in. wide, and 9⅞ in. thick, as shown in figure 21. Each specimen consisted of a wood frame to which the faces were fastened. The frame consisted of three joists, *A*, fastened to end members, *B*, at each end by nails and braced at midlength by bridging, *C*. The upper face consisted of diagonal wood subflooring, *D*, sheathing paper, *E*, and finish flooring, *F*. The lower face consisted of lath, *G*, and plaster, *H*. The overhanging edges of the lath were supported by spacer blocks, *I*, and ground strips, *J*. The upper face was covered with shellac varnish. The lower face was covered with paint.

Subflooring.—The subflooring, *D*, was shortleaf southern pine, $^{25}/_{32}$ in. thick by 5¼ in. face width (nominal 1 by 6 in.), tongued and grooved, and fastened at an angle of 48° to the joists by 8d box nails; either one or two nails were driven through each piece into each joist and into the end members for those pieces which were in contact with them.

Sheathing paper.—The sheathing paper, *E*, consisted of two sheets, 3 ft 0 in. wide and 1 ft 7 in. wide, laid longitudinally to the specimen over the subflooring with a 7-in. lap, and fastened to the subflooring at each end of the specimen by nine tacks.

Finish flooring.—The finish flooring, *F*, was white oak, 13/16 in. thick by 2¼ in. face width, tongued-and-grooved, blind-fastened to each joist by one 8d cut flooring nail driven into each piece through the subflooring and into the joist. The flooring strip at one end of the specimen was also fastened by three 8d finishing nails driven from the face of the strip into the end member. At the other end of the specimen a half strip was used to cover the exposed tongue of the preceding strip, and was fastened to the subflooring by three 6d cement-coated box nails toenailed from the exposed edge of the strip into the subflooring.

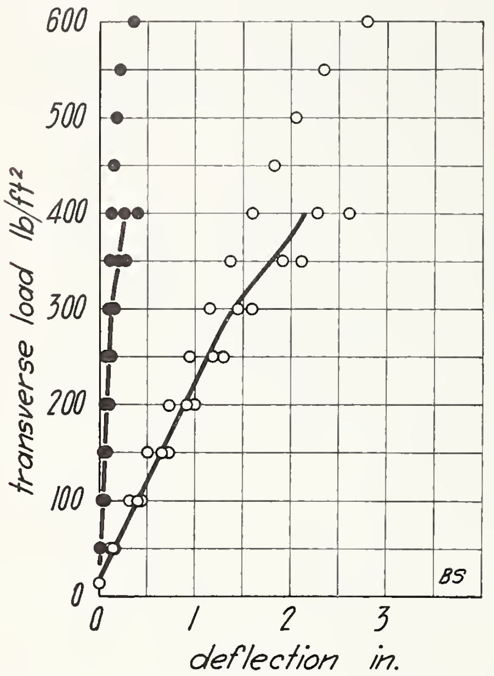

FIGURE 22.—*Transverse load on floor BS.*

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

Lath.—The lath, *G*, consisted of "Red Stripe" lath, nine full courses and one course cut to 6 in. The lath was applied with a small clearance between courses and with a longitudinal joint in most courses, centered on a joist, with no clearance between lath boards at the joint. The lath was fastened to the joists by 1¼-in. plasterboard nails, five nails to each piece of lath at each joist; and to each end member by five nails, one at each joist and one at each end of the member.

Spacer blocks.—The spacer blocks, *I*, were shortleaf southern pine, 25/32 by 6 23/32 in., 6 in. long, and supported the overhanging edges of the lath. The blocks were centered at the joints between lath courses, and rested on ground strips. The blocks were fastened to the ground strips and subflooring by 6d cement-coated box nails, two nails toenailed through each block into the subflooring and two nails driven through the ground strip into the block.

Ground strips.—The ground strips, *J*, were shortleaf southern pine, 25/32 by 1⅝ in., 12 ft 2¾ in. long. The lath was fastened to the ground strips by 1¼-in. plasterboard nails, five nails for each course driven through the lath into the strip. The ground strips were cut at each lath course just before the specimen was tested, so that they did not affect the strength of the specimen. These ground strips and spacer blocks are not used in a house.

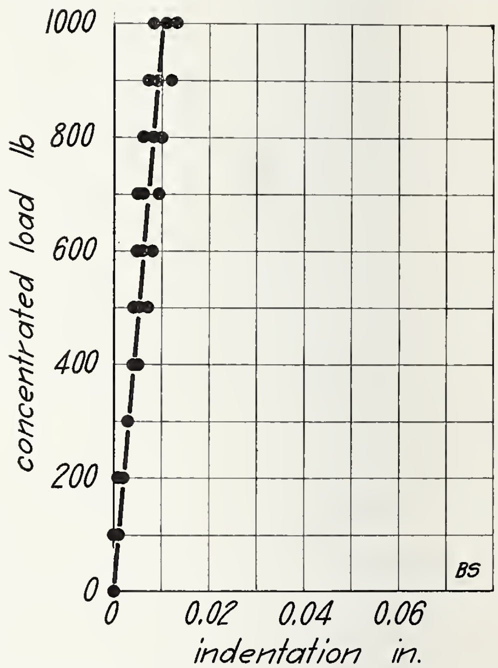

FIGURE 23.—*Concentrated load on floor BS.*

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

Plaster.—The plaster, *H*, was ⅜ in. thick and consisted of a base coat and a finish coat. The lath was dry when the plaster was applied.

Paint and varnish.—The upper face was finished with one coat of shellac varnish. The lower face was prepared for painting by the application of one coat of size and finished with one coat of inside paint. Varnish, size, and paint were applied with a brush.

2. Transverse Load

The results for floor specimens *BS–T1*, *T2*, and *T3* are shown in table 10 and in figure 22.

Table 10.—*Structural properties of floor BS*

[Weight, 13.0 lb/ft²]

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*	*lb/ft²*
Transverse	Upper face; span, 12 ft 0 in.	*T1*				640
		T2				412
		T3				448
	Average					500
						lb
Concentrated	Upper face	*P1*				[a] 1,000
		P2				[a] 1,000
		P3				[a] 1,000
	Average					[a] 1,000
Impact	Upper face; span, 12 ft 0 in.	*I1*	([b])	10.0	[a] 10.0	
		I2	([b])	6.0	[a] 10.0	
		I3	([b])	8.5	[a] 10.0	
	Average		([b])	8.2	[a] 10.0	

[a] Test discontinued. Specimen did not fail.
[b] Face did not fail.

On specimens *T1*, *T2*, and *T3* the plaster cracked transversely at most of the lath joints. The first cracks occurred at loads of 35, 50, and 50 lb/ft² and deflections of 0.07, 0.14, and 0.17 in. in specimens *T1*, *T2*, and *T3*, respectively. At a load of 575 lb/ft² one outer joist of specimen *T1* cracked between loading rollers, and at the maximum load the specimen failed by rupture of all the joists between the loading rollers. In specimen *T2* at a load of 350 lb/ft² one outer joist cracked between loading rollers and at the maximum load the specimen failed by rupturing of the other outer joist and crushing at the top of the center joist under a loading roller. At the maximum load specimen *T3* failed by rupture of an outer joist and the center joist between loading rollers. Neither the lath nor the flooring separated appreciably from the joists and no large pieces of plaster fell from the lath.

3. Concentrated Load

The results for floor specimens *BS–P1*, *P2*, and *P3* are shown in table 10 and in figure 23.

The concentrated loads were applied to the upper face midway between joists over an end-matched joint in the finish flooring from 2 to 3 ft from one end. The indentations after a load of 1,000 lb had been applied were 0.008, 0.011, and 0.013 in., for specimens *P1*, *P2*, and *P3*, respectively, and no other effects were observed.

4. Impact Load

Floor specimen *BS–I1* during the impact test is shown in figure 24. The results for floor specimens *BS–I1*, *I2*, and *I3* are shown in table 10 and in figure 25.

The impact loads were applied to the center of the upper face on the flooring over the center joist. In specimens *I1*, *I2*, and *I3* the plaster on the lower face cracked transversely at lath joints at one or two places. The first crack occurred near midspan at drops of 3.5, 3, and 1.5 ft and deflections of 0.39, 0.33, and 0.28 in. for specimens *I1*, *I2*, and *I3*, respectively. At drops of 10, 6, and 8.5 ft, respectively, the faces not struck failed by opening of the plaster cracks. After the 10-ft drop the sets were 0.047, 0.046, and 0.050 in., respectively, and no other effects were observed.

VIII. ROOF *BT*

1. Description, Sponsor's Statement

Roof *BT* was a conventional wood frame with wood sheathing and asphalt roofing as the upper face, and with lath and plaster as the lower face. The frame was like that of floor *BS*, with the exception that it was 2 ft longer; and the lower face was similar to that of floor *BS*.

The price of this construction in Washington, D. C., as of July 1937, was $0.38/ft².

The roof specimens were 14 ft 6 in. long, 4 ft 0 in. wide, and 9⅝ in. thick. Each specimen consisted of a wood frame to which the faces were fastened. The frame consisted of three rafters, *A*, shown in figure 26, fastened to end members, *B*, at each end by nails and braced at midlength by bridging, *C*. The upper face consisted of wood sheathing, *D*, and built-up

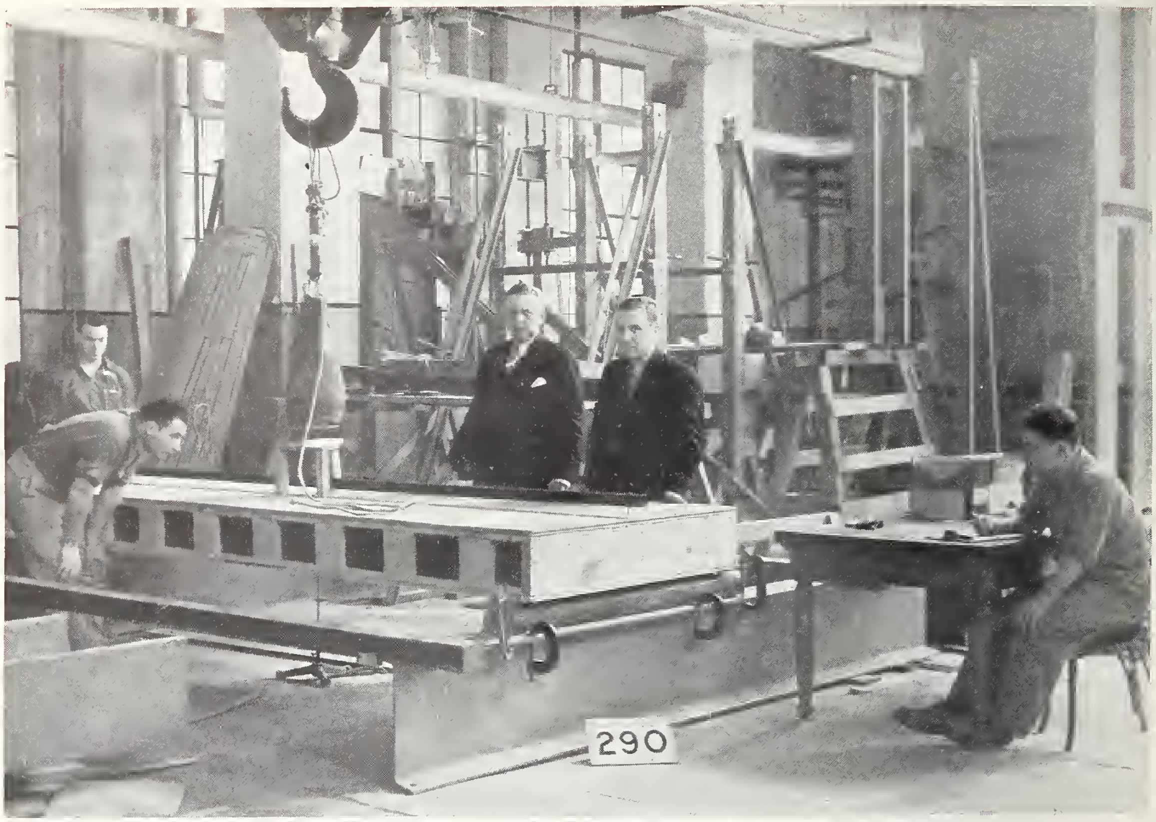

FIGURE 24.—*Floor specimen BS-I1 during the impact test.*

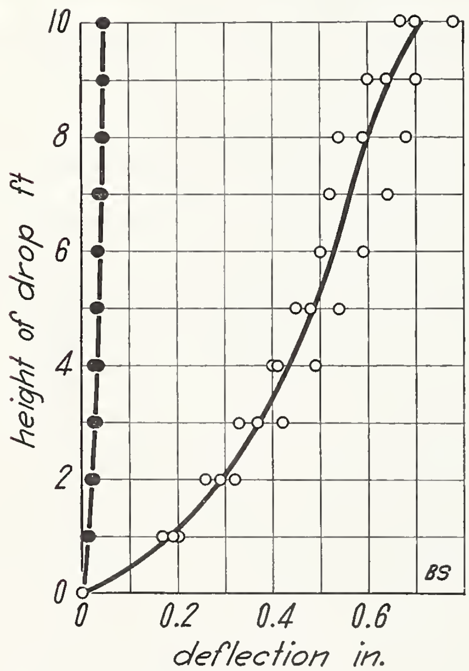

FIGURE 25.—*Impact load on floor BS.*

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

asphalt roofing, *E*. The lower face consisted of lath, *F*, and plaster, *G*. The overhanging edges of the lath were supported by spacer blocks, *H*, and ground strips, *I*. The lower face was covered with paint.

Rafters.—The rafters, *A*, were longleaf southern pine, 1⅝ by 7½ in. (nominal 2 by 8 in.), 14 ft 2¾ in. long, spaced 1 ft 4 in. on centers. The ends of each rafter were fastened to the end members, *B*, by four 16d common nails driven through the end member into the rafter.

End members.—The end members, *B*, were longleaf southern pine, 1⅝ by 7½ in. (nominal 2 by 8 in.), 4 ft 0 in. long.

Bridging.—The bridging, *C*, was shortleaf southern pine, 1 by 3 in., 1 ft 5¼ in. long. The bridging pieces were placed diagonally between top and bottom of adjacent rafters and fastened to each by three 8d box nails toenailed through the end of the bridging into the rafters.

Sheathing.—The sheathing, *D*, was shortleaf southern pine, $^{25}/_{32}$ in. thick by 5¼ in. face width (nominal 1 by 6 in.), tongued-and-grooved on sides and fastened transversely across the rafters by 8d box nails; two nails were driven through each piece into each rafter and into the end members, for those pieces which were in contact with them.

Asphalt roofing.—The roofing, *E*, was three-ply built-up roofing. The first ply was 30-lb asphalt-saturated felt in strips 36 in. wide, laid over the sheathing across the rafters with a 2-in. overlap, and fastened to the sheathing by 1-in. roofing nails, with roofing caps under the heads, spaced 7 in. along the laps and 12 in. along the longitudinal edges of the specimen. After mopping down with 30 lb of asphalt per 100 ft², 15-lb felt strips, 36 in. wide, were laid over this ply, with a 19-in. transverse overlap, thus forming two additional plies. Each 15-lb strip was mopped down with 30 lb of asphalt per 100 ft² before placing the next strip. The finished roofing thus consisted of three thicknesses of asphalt-saturated felt, each covered with an asphalt coating.

Lath.—The lath, *F*, consisted of "Red Stripe" lath, ten full courses and one course cut to 1 ft 2 in. The lath was applied with no clearance between courses and with a longitudinal joint in most courses, centered on a rafter, with no clearance between lath boards at the joint. The lath was fastened to the rafters by 1¼-in. plasterboard nails, five nails to each course at each rafter; and to each end member by five nails, one nail at each rafter and at each end of the member.

Spacer blocks.—The spacer blocks, *H*, were shortleaf southern pine, 25/32 by 6 23/32 in., 6 in. long, and supported the overhanging edges of the lath. The blocks were centered at the joints between lath courses, and rested on ground strips. The blocks were fastened to the ground strips and the sheathing by 8d box nails, two nails through the ground strips or sheathing into each block.

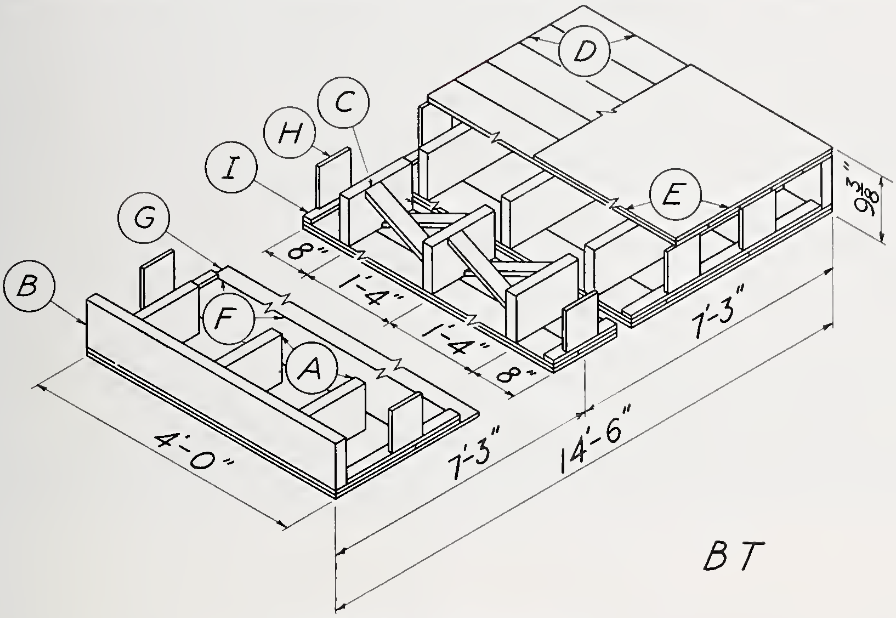

FIGURE 26.—*Roof specimen BT.*

A, rafter; *B*, end member; *C*, bridging; *D*, sheathing; *E*, asphalt roofing; *F*, lath; *G*, plaster; *H*, spacer block; *I*, ground strip.

Ground strips.—The ground strips, *I*, were shortleaf southern pine, 25/32 by 1⅝ in., 14 ft 2¾ in. long. The lath was fastened to the ground strips by 1¼-in. plasterboard nails, five nails for each course driven through the lath into the ground strip. The ground strips were cut at every lath course just before the specimen was tested so that they did not affect the strength of the specimen. These ground strips and spacer blocks are not used in a house.

Plaster.—The plaster, *G*, was ⅜ in. thick and consisted of a base coat and a finish coat. The lath was dry when the plaster was applied.

Paint.—The lower face was prepared for painting by the application of one coat of size,

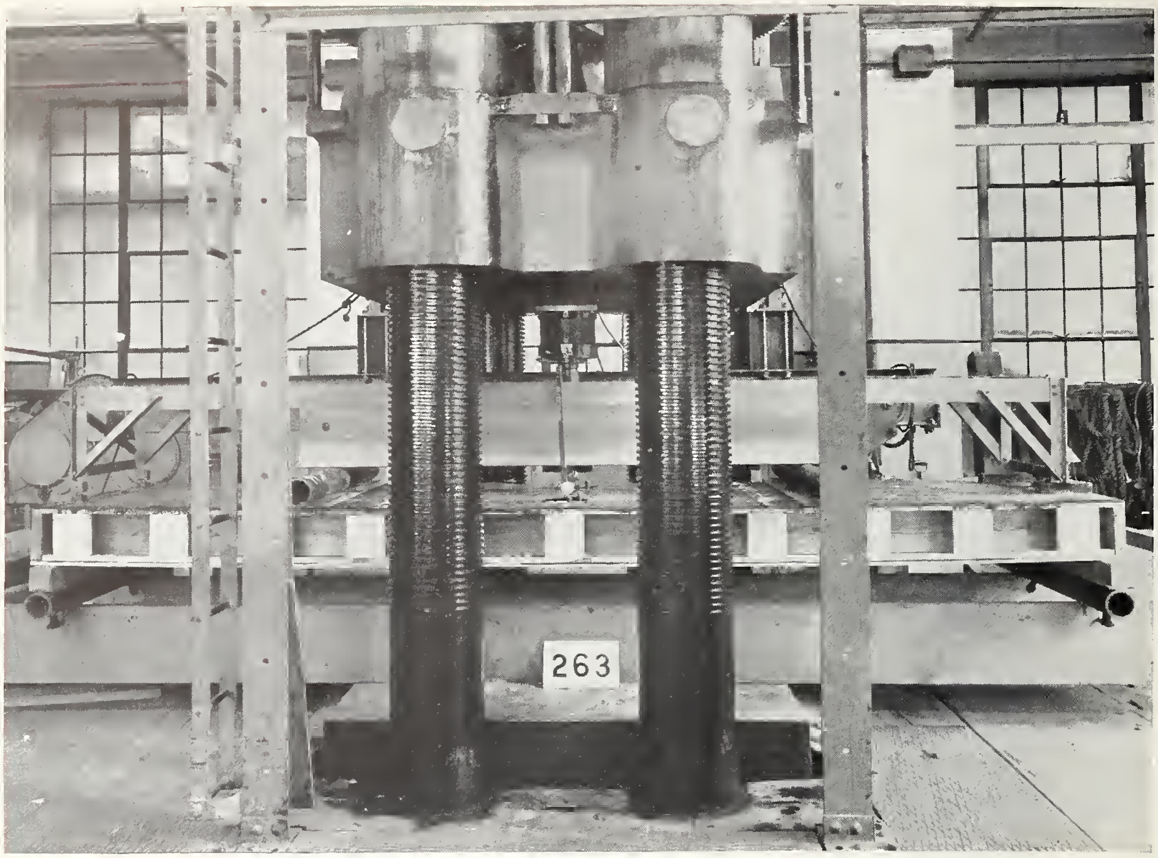

FIGURE 27.—*Roof specimen BT–T2 under transverse load.*

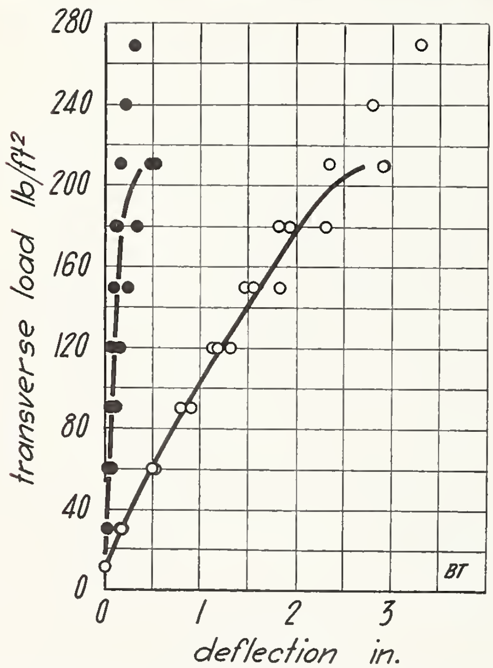

FIGURE 28.—*Transverse load on roof BT.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *BT–T1*, *T2*, and *T3* on the span 14 ft 0 in.

and finished with one coat of inside paint. Both paint and size were applied with a brush.

2. Transverse Load

Roof specimen *BT–T2* under transverse load is shown in figure 27. The results for roof specimens *BT–T1*, *T2*, and *T3* are shown in table 11 and in figure 28.

TABLE 11.—*Structural properties of roof BT*

[Weight, 11.5 lb/ft²]

Load	Load applied	Specimen designation	Maximum load
			lb/ft²
Transverse	Upper face; span, 14 ft 0 in.	*T1*	282
		T2	218
		T3	223
	Average		241
			lb
Concentrated	Upper face	*P1*	[a] 1,000
		P2	[a] 1,000
		P3	[a] 1,000
	Average		[a] 1,000

[a] Test discontinued. Specimen did not fail.

No initial cracks were observed in the plaster surface of specimen *T1*, but on the surface of specimen *T2* there were two cracks at lath joints 2½ and 4 ft from an end of the specimen. In specimen *T3* there was an initial crack at a lath joint under a loading roller.

In each of the specimens under load the plaster cracked transversely at most of the lath joints. The first cracks occurred at loads of 30, 45, and 23 lb/ft^2 and deflections of 0.17, 0.36, and 0.11 in. in specimens *T1*, *T2*, and *T3*, respectively. In specimens *T1* and *T2* at the maximum loads the specimens failed by rupture of an outer rafter and the center rafter at or between the loading rollers. In specimen *T3* at a load of 210 lb/ft^2 an outer rafter ruptured and at the maximum load the specimen failed by rupture of the two remaining rafters, all rafters breaking between the loading rollers. The lath sections were separated under the broken rafters of all specimens, but no lath or large pieces of plaster fell from the specimens.

3. Concentrated Load

The results for roof specimens *BT–P1*, *P2* and *P3* are shown in table 11 and in figure 29.

The concentrated loads were applied to the asphalt of the upper face midway between rafters, over a joint in the sheathing boards from 2 to 3 ft from one end. The indentations after a load of 1,000 lb had been applied were 0.277, 0.389, and 0.446 in., for specimens *P1*, *P2*, and *P3*, respectively, and no other effect was observed.

IX. COMMENTS BY SPONSOR

There are advantages in decreasing the transmission of heat and moisture through the walls of a house. This is particularly true if the house is air-conditioned. Therefore, there has been an increasing demand from the building industry for a low-cost lath which provides heat insulation and moisture resistance and is suitable for plastered walls, partitions, and ceilings.

Using the experience of 45 years in the manufacture of chipboard, strawboard, and jute liner board, "Red Stripe" lath for gypsum plaster was developed to meeet this demand. The two corrugated sheets in the lath provide strength and stiffness and the many enclosed air spaces decrease the heat transmission. Resistance to the transmission of moisture (vapor seal) is provided by the continuous asphalt coating in each corrugated sheet and by the bituminous coating on the edges of the lath.

The lath can be fastened to any wood frame either by lath nails or by "clip strips." It is recommended that the lath be fastened to comply with American Standards Association A42.1–1938, Standard Specifications for Gypsum Plastering.

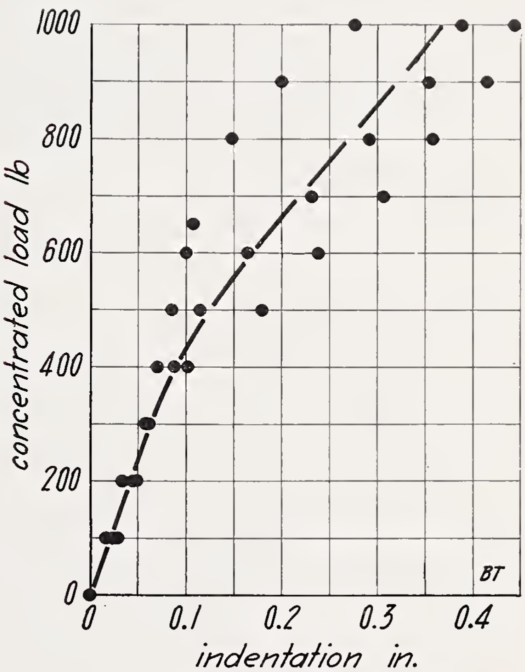

Figure 29.—*Concentrated load on roof BT.*

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

Lath having holes uniformly spaced over the surface is available. The holes provide a mechanical key for the plaster and are designed to increase the fire resistance of the wall.

It is estimated that this lath has been used on about 60 houses built during the past 3 years in the region between the Great Lakes and the Mason and Dixon line, where it has been subjected to wide variations in temperature and humidity.

The physical properties of the plaster were determined by the Lime and Gypsum Section of the Bureau, under the supervision of L. S. Wells, with the assistance of W. F. Clark. The thermal conductivity of the lath was determined by H. W. Woolley, of the Heat Transfer Section of the Bureau. The physical properties of the lath were determined by the Paper Section of the Bureau under the supervision of B. W. Scribner, with the assistance of S. G. Weissberg.

The descriptions and drawings of the specimens were prepared by E. J. Schell, G. W. Shaw, and T. J. Hanley, of the Building Practice and Specifications Section, under the supervision of V. B. Phelan, from this information and from the specimens themselves. That Section also cooperated in the preparation of the report.

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, August 18, 1939.

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