U. S. DEPARTMENT OF COMMERCE

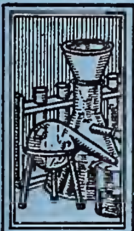
BUILDING MATERIALS AND STRUCTURES

REPORT BMS62

Structural Properties of a Precast Joist Concrete Floor Construction Sponsored by the Portland Cement Association

by

HERBERT L. WHITTEMORE,
AMBROSE H. STANG, *and*
DOUGLAS E. PARSONS



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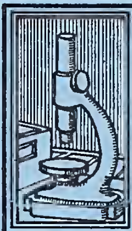

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ISSUED OCTOBER 31, 1940

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

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Foreword

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

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

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

Lyman J. Briggs, *Director.*

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ABSTRACT

For the program on the determination of the structural properties of low-cost house constructions, the Portland Cement Association, Chicago, Ill., submitted six specimens representing a floor construction, which consisted of precast concrete joists and bridging and a reinforced-concrete floor slab.

The specimens were subjected to transverse, impact, and concentrated loads. All loads were applied to the upper 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 each increment of load. The results are presented in graphs and in a table.

I. INTRODUCTION

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

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

The present report describes the structural properties of a floor construction sponsored by an association of cement manufacturers. Transverse, concentrated, and impact loads were applied to the specimens simulating the loads to which the floor of an occupied house would be subjected. Transverse loads are applied by furniture and occupants; impact loads by objects falling on the floor; and concentrated loads by furniture, for example, the legs of a piano.

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

II. SPONSOR AND PRODUCT

The specimens were submitted by the Portland Cement Association, Chicago, Ill., and represented a reinforced-concrete floor construction, fabricated by assembling precast joists and bridging blocks in the building and then casting the floor slab.

III. SPECIMENS AND TESTS

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

TABLE 1.—*Specimen designations, floor CY*

Specimen designation	Load	Load applied
T1, T2, T3	Transverse	Upper face.
I1, I2, I3	Impact [a]	Do.
P1, P2, P3	Concentrated	Do.

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

Except as mentioned below, the specimens were tested in accordance with BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions, which also gives requirements for the specimens and describes the presentations of the results of the tests, particularly load-deformation graphs.

The deflections and sets under the impact loads were measured by means of two deflectometers and two set gages instead of one each as described in BMS2. The deflectometers were placed in contact with the unloaded face of the specimen at midspan, one under each joist, and the set gages rested on the loaded face, one over each joist. The readings, therefore, showed the effect of the impact loads on the joists, not the local effect on the slab.

The indentation under concentrated load as well as the set after the load was removed were measured, instead of the set only, as described in BMS2. The apparatus is shown in figure 1. The load was applied to the thick steel disk, *A*, to which the crossbar, *B*, was rigidly attached. The load was measured by means of the ring dynamometer, *C*. Two stands, *D*, rested on the face of the specimen, each supporting a dial micrometer, *E*, the spindle of which was in contact with the crossbar 8 in. from the center of the disk. The micrometers were graduated to 0.001 in. and readings were recorded to the nearest division. The initial reading (average of the micrometer readings) was observed under the initial load, which included the weight of the disk and the dynamometer. A load was applied to the disk and the average of these micrometer readings minus the initial reading was taken as the depth of the indentation under load. The set after the load was removed was determined in the same manner.

Before applying the transverse loads, the speed of the movable head of the testing machine was adjusted to 0.16 in./minute.

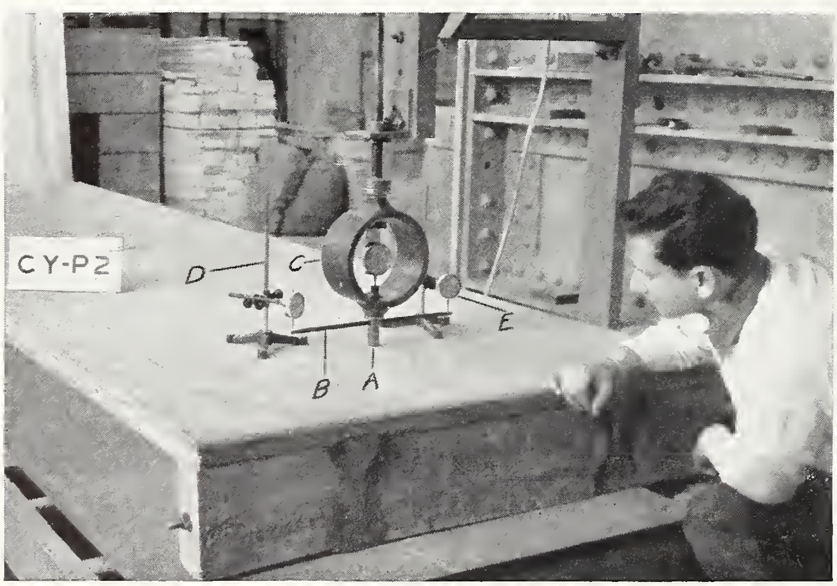
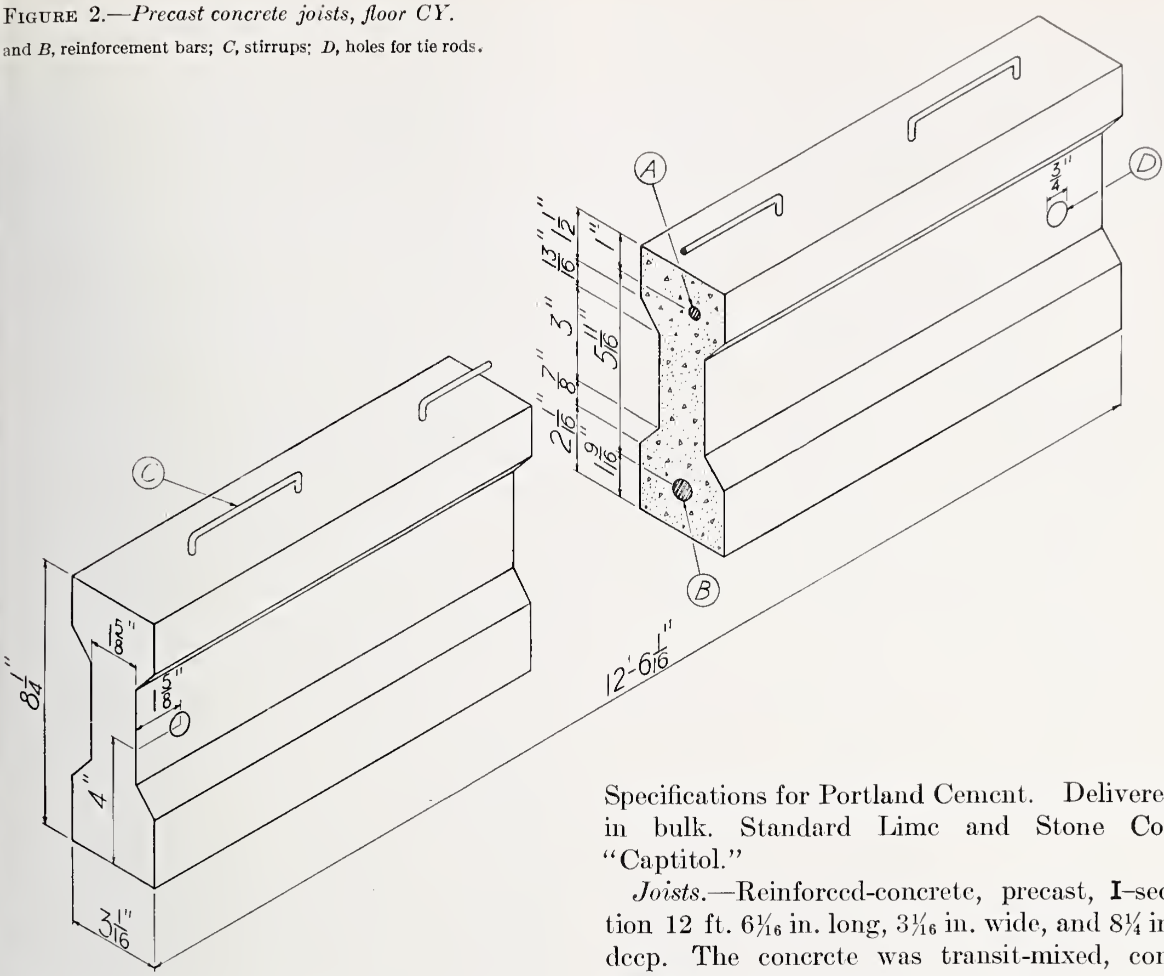


FIGURE 1.—*Apparatus for concentrated-load test.*

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

FIGURE 2.—*Precast concrete joists, floor CY.*

A and *B*, reinforcement bars; *C*, stirrups; *D*, holes for tie rods.



The specimens were tested Dec. 26 and 27, 1939, on the 28th day after the concrete slab was cast and 53 days after the joists were made.

The sponsor was notified when the tests were to be made, but found it impossible to have a representative present.

IV. FLOOR *CY*

1. SPONSOR'S STATEMENT

This information was obtained from the sponsor and from the inspection of the specimens, except that the Masonry Construction Section assisted by determining the physical properties of the concrete in the slab.

(*a*) *Materials*

Cement.—Portland cement, complied with ASTM Serial Designation C 9–30, Standard Specifications for Portland Cement. Delivered in bulk. Standard Lime and Stone Co., "Captitol."

Joists.—Reinforced-concrete, precast, **I**-section 12 ft. 6 1/16 in. long, 3 1/16 in. wide, and 8 1/4 in. deep. The concrete was transit-mixed, containing 1 part of portland cement, 2.23 parts of fine aggregate, 2.29 parts of coarse aggregate by dry weight, with 6 gallons of water per sack of cement (94 lb). The aggregates complied with the specification given in table 2. The volume of fine aggregate removed by sedimentation did not exceed 3 percent.

TABLE 2.—*Specification for aggregates, concrete joists*

U. S. Standard Sieve	Passing, by weight			
	Fine aggregate (sand)		Coarse aggregate (gravel)	
	Minimum	Maximum	Minimum	Maximum
	Percent	*Percent*	*Percent*	*Percent*
3/8 in			95	
No. 4	95			10
No. 50	10	30		
No. 100	3	7		

A joist is shown in figure 2. The reinforcement bar *A*, 3/8-in. diam, and bar *B*, 5/8-in. diam, were billet, open-hearth steel, intermediate grade, deformed, 12 ft 5¼ in. long, and complied with ASTM Serial Designation A 15–33, Standard Specifications for Billet-Steel Concrete Reinforcement Bars. The required mechanical properties were: Tensile strength, minimum

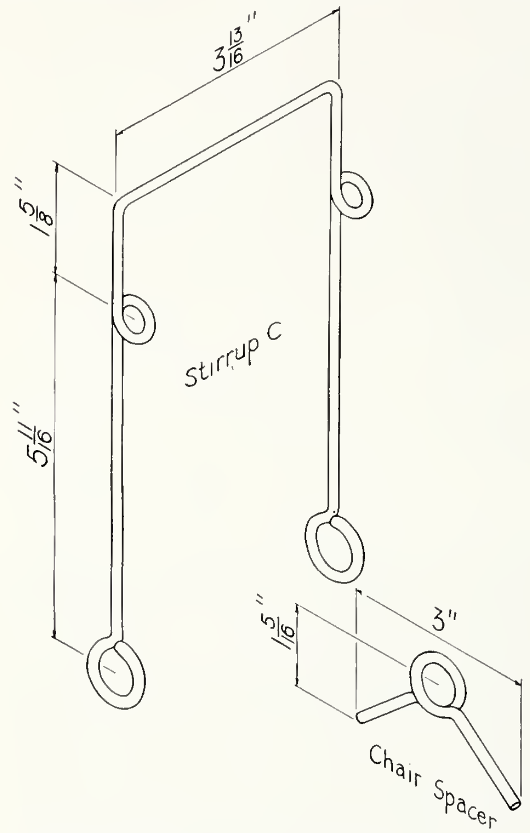


FIGURE 3.—*Stirrup and chair spacer, floor CY.*

70,000 lb/in.², maximum 90,000 lb/in.²; yield point, minimum 40,000 lb/in.²; elongation in 8 in., minimum 14 percent.

The stirrups, *C*, shown in figures 2 and 3, were No. 6 Stl. W. G. (0.192-in. diam) steel wire. Each stirrup was 3¹³⁄₁₆ in. wide and 7⁵⁄₁₆ in. deep and had two eyes in each leg for the reinforcement bars, the upper ½-in. diam, the lower ¾-in. diam. There were 13 stirrups in each joist, one at midlength, and six near each end, spaced 8 in. on centers. The distance from the end of the joists to the center of the adjacent stirrup was 4 in.

The chair spacers, shown in figure 3, were No. 6 Stl. W. G. (0.192-in. diam) steel wire, 3 in. wide and 1⁵⁄₁₆ in. deep. There were three in each joist, one at midlength and one 5 in. from each end. The lower reinforcement bar *B*, passed through the eye in the chair spacers.

The assembled reinforcement was placed in the form, with bar *A* in a horizontal position above bar *B*. Wood plugs were placed at each end to provide holes, *D*, ¾-in. diam, in the completed joist. Twelve forms made from sheet steel, ¹⁄₁₆ in. thick, were mounted on a table which was vibrated while the concrete was placed. The stirrups projected ¼ to ½ in. above the surface of the concrete, which was unfinished to increase the bond with the slab.

The joists were made by the Drew Construction Co., Washington, D. C.

Bridging blocks.—The concrete for the blocks was the same mix as that for the joists. A full-sized block, shown in figure 4, was 1 ft 10 in. long, 8¹⁄₁₆ in. deep, and 3 in. wide and the ends fitted between the flanges of the joists. Longitudinally of each block there was a ¾-in. steel pipe, *A*. The half-sized blocks were the same as the full-sized blocks, cut transversely at midlength. Drew Construction Co., Washington, D. C.

Tie-rods.—Some of the tie rods were mild steel ⁷⁄₁₆-in. diam, 4 ft 4 in. long, having a National Coarse (N. C.) thread 2 in. long on each end. The nuts were mild steel, square, unfinished. The steel washers were of different sizes, some being ½ in., No. 12 U. S. Std. Gage (0.1072 in).

Other tie rods were mild-steel bolts, ⁷⁄₁₆-in. diam, 4 ft 3¾ in. long, having a head on one end, square, unfinished, and a thread on the other end, National Coarse (N. C.) 5 in. long.

Slab reinforcement.—Bars, billet-steel, open-hearth, intermediate grade, round, plain, ¼-in. diam, two lengths, 12 ft 4¼ in. and 3 ft 11⅛ in. The bars complied with ASTM Serial Designation A 15–33, Standard Specifications for Billet-Steel Concrete Reinforcement Bars. The required mechanical properties were: Tensile strength, minimum 70,000 lb/in.², maximum 90,000 lb/in.²; yield point, minimum 40,000 lb/in.²; elongation in 8 in., minimum 16 percent.

Reinforcement ties.—Steel wire, No. 16 Stl. W. G. (0.0625-in. diam).

Concrete.—The concrete for the slab, delivered in two batches, was transit-mixed, and

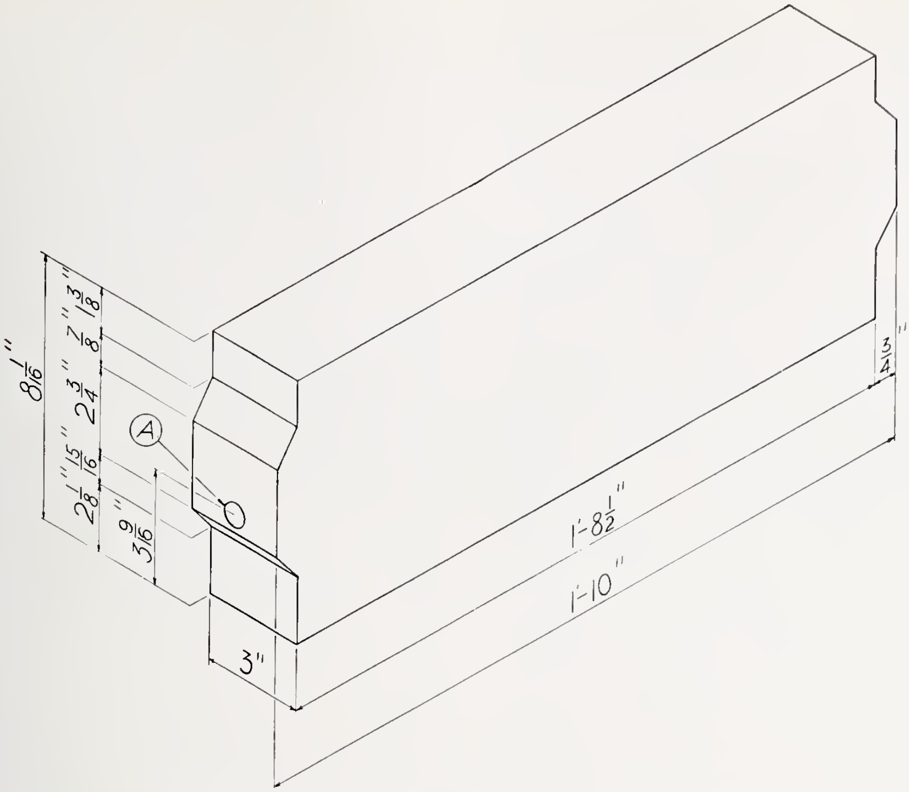


FIGURE 4.—*Full-sized precast bridging block, floor CY.*

A, pipe insert.

contained 1 part of portland cement, 1.91 parts of sand, and 3.32 parts of coarse aggregate, by dry weight. The sieve analysis of the aggregates, furnished by the Smoot Sand and Gravel Co., Washington, D. C., is given in table 3.

TABLE 3.—*Sieve analysis of aggregates, concrete for the slab*

U. S. Standard Sieve	Passing, by weight	
	Fine aggregate (sand)	Coarse aggregate (gravel)
	Percent	*Percent*
¾ in.		95
⅜ in.		43
No. 4	98	7
No. 16	70	
No. 50	17	
No. 100	4	

For each floor specimen the slump was determined in accordance with ASTM Tentative Standard D138–32 T, Method of Test for Consistency of Portland-Cement Concrete. Two 6- by 12-in. cylinders were made from the concrete for each specimen; one cylinder was stored in air near the floor specimen and the other was stored at 70° F and a relative humidity of 95 to 100 percent. The compressive strength of each cylinder was determined on the day the corresponding floor specimen was tested, age 28 days. The physical properties of the concrete are given in table 4.

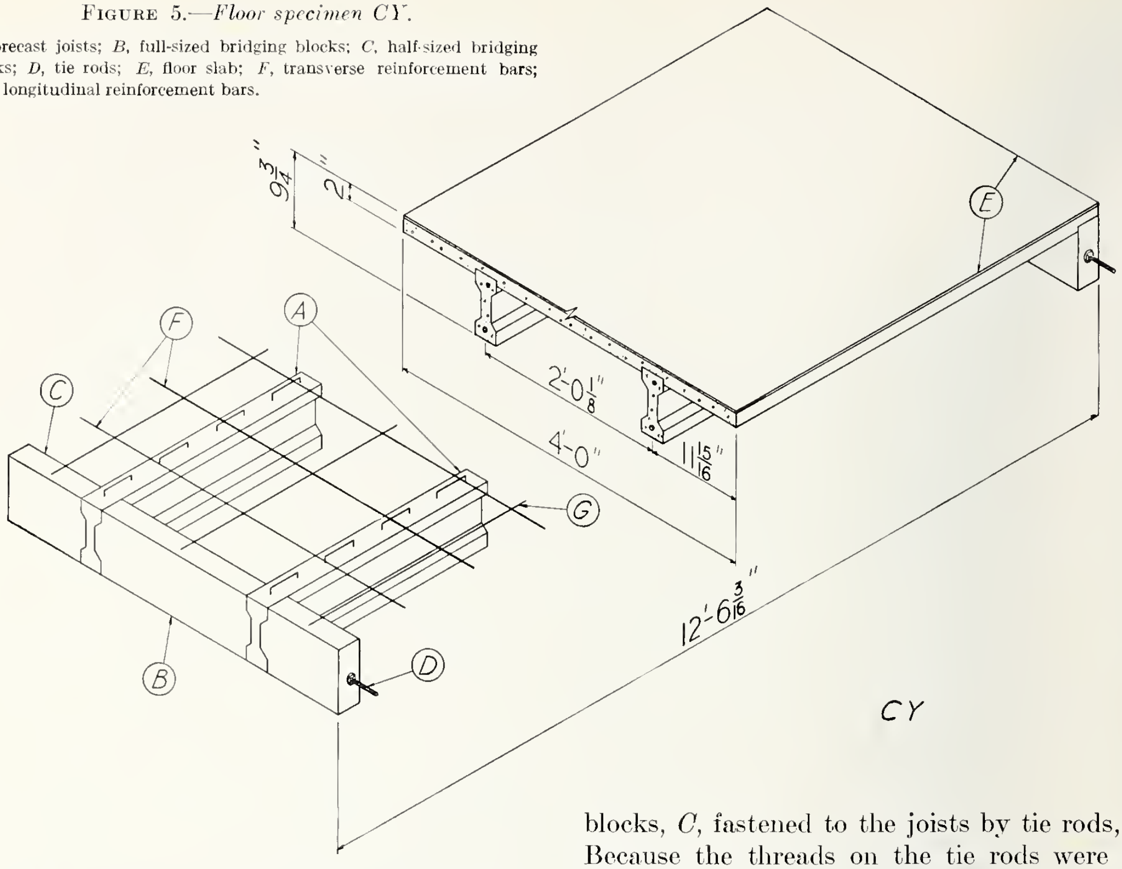
TABLE 4.—*Physical properties of the concrete in the slab, floor CY*

[The compressive strength of the cylinders was determined on the day the corresponding floor specimens were tested, age 28 days]

Specimen	Water, per sack of cement	Slump	Compressive strength	
			Cylinders cured with floor specimens	Cylinders cured at 70° F and 95 to 100% relative humidity
	gal	*in.*	*lb/in.²*	*lb/in.²*
T1	6.35	5¼	3,680	4,070
T2	6.05	3½	4,250	4,040
T3	6.05	4	4,550	3,720
I1	6.35	5¼	3,670	4,060
I2	6.35	4¼	3,910	4,340
I3	6.05	3½	4,790	3,790
Average	6.20	4¼	4,140	4,000

FIGURE 5.—*Floor specimen CY.*

A, precast joists; *B*, full-sized bridging blocks; *C*, half-sized bridging blocks; *D*, tie rods; *E*, floor slab; *F*, transverse reinforcement bars; *G* longitudinal reinforcement bars.



Cement mortar.—The cement mortar contained 1 part of portland cement, 2 parts of damp sand, by weight, and was mixed manually. The amount of water was adjusted to the satisfaction of the mason.

(*b*) *Description of Specimens*

The floor specimens *CY*, shown in figure 5, were 12 ft 6$\frac{3}{16}$ in. long, 4 ft 0 in. wide, and 9¾ in. thick at the joists. Each specimen consisted of two precast concrete joists, *A;* bridging blocks, *B* and *C*, secured by the tie rod, *D;* and a concrete slab, *E*, reinforced by transverse bars, *F*, and longitudinal bars, *G*.

The price of this construction in Washington, D. C., as of July 1937, was $0.35/ft.[2]

Joists.—The I-section precast concrete joists, *A*, were 12 ft 6$\frac{1}{16}$ in. long, 3$\frac{1}{16}$ in. wide, and 8¼ in. deep; spaced 2 ft 0⅛ in. on centers. The joists were supported only at the ends while assembling the specimens and casting the floor slab.

Bridging blocks.—In each specimen there were 2 full-sized blocks, *B*, and 4 half-sized blocks, *C*, fastened to the joists by tie rods, *D*. Because the threads on the tie rods were too short, soft wood blocks were placed under the washer and nut. After the specimens were assembled, the outside joints between the joists and the bridging blocks were pointed with cement mortar to improve the appearance. In a house there are no tie rods in the floor.

Floor slab.—The form for the floor slab was wood. Four crosspieces were held in contact with the bottom of each joist by U-bolts ($\frac{3}{16}$-in. diam steel rod) placed over the joist and through the crosspieces. The crosspieces were 2 ft 6 in. from the ends of the specimen and spaced 2 ft 6 in.

The bottom of the form was plywood, five-ply, $\frac{5}{16}$ in. thick, supported from ¼ to ½ in. below the top of the joists by wood blocks resting on the crosspieces and at the ends of the specimen on the supports for the joists. The sides of the form, 1¾ by 2 in., 12 ft 6 in. long, rested on the plywood and were fastened by nails and by three transverse steel tie rods, $\frac{3}{16}$-in. diam, through the sides, 1 in. above the plywood bottom. The ends of the form were 1¾ by 9½ in. by 4 ft 3 ½ in. long. Each end rested on the supports for the joists and was fastened by two steel tie rods, 3/16-in. diam, through the stirrups nearest the end of the joists.

The U-bolts for the crosspieces and the ties for the sides and ends remained in the slab after the form was removed. In a house tie rods are not usually necessary to brace the sides and ends of the form.

In the slab, there were 14 transverse reinforcement bars, each 1/4-in. diam, 3 ft 11 1/8 in. long, and spaced 10 in. The distance from the ends of the specimens to the adjacent transverse bar was 10 in. Bars at the stirrups were placed under the stirrups. There were three longitudinal reinforcement bars, 1/4-in. diam, 12 ft 4 1/4 in. long, placed on the transverse bars, one at midwidth of the specimen and one at a distance of 1 ft 6 1/2 in. on each side of it. Each longitudinal bar was tied to each transverse bar with steel wire, No. 16 Stl. W. G. (0.0625-in. diam).

The concrete was carefully placed in the forms and leveled 1/8 to 1/4 in. below the upper surface of the slab. The top of the slab was finished by immediately applying 1/8 to 1/4 in. of cement mortar to the concrete and working to a smooth surface with a steel trowel.

(c) *Comments*

It is estimated that since 1930 five million linear feet of precast concrete joists have been used in about 5,000 housing units in this country, most of them in the East and Middle West. These floors are fire-resistant and their use expedites erection of the building.

For conventional types of concrete floors it is necessary to shore the concrete forms from the floor below. If the span does not exceed 12 ft the forms for the precast joist floor slabs are suspended from the joists and no shores are necessary. For longer spans the shoring consists only of one row in the center of the span. Therefore, construction work on the floor below may proceed with less interference than where closely spaced shores are required.

Precast concrete joists are made in depths of 8, 10, and 12 in. The 8-in. joists are suitable for spans up to 16 ft, 10-in. joists up to 20 ft, and 12-in. joists up to 24 ft. The joists are spaced 24 to 33 in., depending upon the span and the load.

In a building, the ends of the joists are supported on masonry walls or steel beams. To provide lateral support, the spaces between the ends of the joists are filled with bridging blocks or other masonry units laid in mortar. For spans of 20 ft or more, bridging blocks are also placed at midspan.

When framing around openings such as stair wells, the headers and the joists around the opening are doubled. The ends of the joists intersecting the headers are supported by steel hangers. If a nonload-bearing partition is parallel to the joists, the joists below the partition are doubled. If the partition is at right angles to the joists, the floor is designed for an additional load of 20 lb/ft^2.

The form for the floor slab may be made of sheet metal, 5/8-in. plywood, or 1-in. sheathing overlaid with building paper. These forms insure a smooth surface on the underside of the slab (ceiling of the room below). The form may be supported from the joists, as described in this report, by wood spreaders which fit between the joists or by crosspieces suspended from wire hangers hooked over the joists.

The upper surface of the floor may be finished in many ways, depending upon the requirements and upon individual tastes. The troweled concrete surface is the least expensive. This floor may be laid off in squares and colored by painting or by adding pigments to the cement mortar. Coverings such as rubber, cork, or asphalt tile and linoleum are often cemented to concrete floors.

Wood-parquetry floors may be laid in bituminous mastic. Conventional wood floors may be laid on wood sleepers placed across the joists, tied to the stirrups, and embedded in the concrete floor slab. The sleepers also may be fastened to metal or wire clips embedded in the floor slab. The sleepers should be 2 by 2 in. or 2 by 3 in. and spaced not more than 12 in.

For many buildings, the lower surface of the floor (ceiling of the room below) may be satisfactorily and inexpensively finished with casein or cement paint applied directly to the concrete. There is little necessity for hiding the joist and slab by a flat ceiling because they are true to shape and size and the surfaces are smooth.

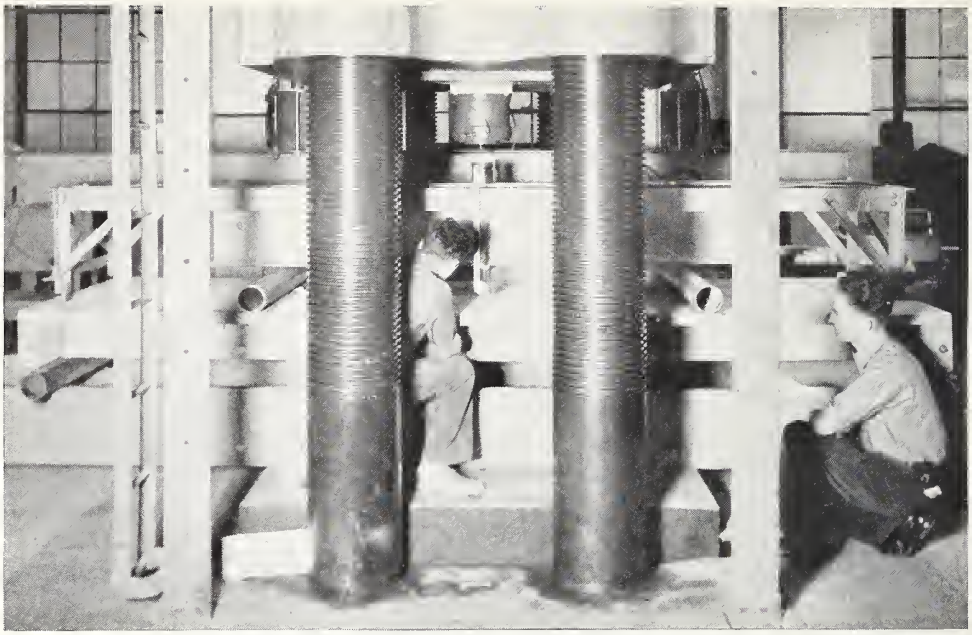


FIGURE 6.—*Floor specimen CY–T1 under transverse load.*

If, for appearance, a greater spacing of the joists is desired, they may be doubled and the spacing increased provided the thickness of the slab is also increased. The two joists may be in contact or spaced about 1 inch, the space being filled with concrete when the slab is cast. If the spacing of the doubled joists is 48 in., the slab is 2½ in. thick; if more than 48 in., the slab is 3 in. thick.

If a flat ceiling is desired, wood nailing strips are wired to the joists. Wallboard or plywood may be fastened to the nailing strips, or lath and plaster may be applied. Metal lath may be attached to metal rods suspended from wires embedded in the slab.

2. TRANSVERSE LOAD

Floor specimen *CY–T1* under transverse load is shown in figure 6. The results of the transverse load on specimens *CY–T1*, *T2*, and *T3* are given in tables 5 and in figure 7.

Under a load of 120 lb/ft^2 on specimens *CY–T1* and *T2*, vertical cracks appeared in the lower flanges of both joists at midspan. A crack also appeared in one joist of specimen *CY–T3* at 40 lb/ft^2 and in the other joist at 80 lb/ft^2. As the loads increased, more cracks appeared between the loading rollers and all the cracks extended upward toward the floor slab. Diagonal cracks also appeared in the joists under each loading roller. The lower surface of the floor slab cracked near midspan at loads of 354, 337, and 312 lb/ft^2 on specimens *CY–T1*, *T2*, and *T3*, respectively. Under the maximum load the deflection of each specimen was about 10 in.

TABLE 5.—*Structural properties, floor CY*

[Weight, based on face area: 36.6 lb/ft^2]

Transverse load, span 12 ft 0 in.		Impact load, span 12 ft 0 in.		Concentrated load	
Specimen	Maximum load	Specimen	Maximum height of drop	Specimen	Maximum load
	lb/ft²		*ft*		*lb*
T1	427	*I1*	[a]10.0	*P1*	[a]1,000
T2	348	*I2*	[a]10.0	*P2*	[a]1,000
T3	385	*I3*	[a]10.0	*P3*	[a]1,000
Average	387	Average	[a]10.0	Average	[a]1,000

[a] Test discontinued. Specimen did not fail.

3. IMPACT LOAD

Floor specimen *CY–I3* during the impact test is shown in figure 8. The results of the impact load on specimens *CY–I1*, *I2*, and *I3* are given in table 5 and figure 9.

The impact load was applied to the center of the upper face of the floor specimens, the sandbag striking the floor slab midway between the

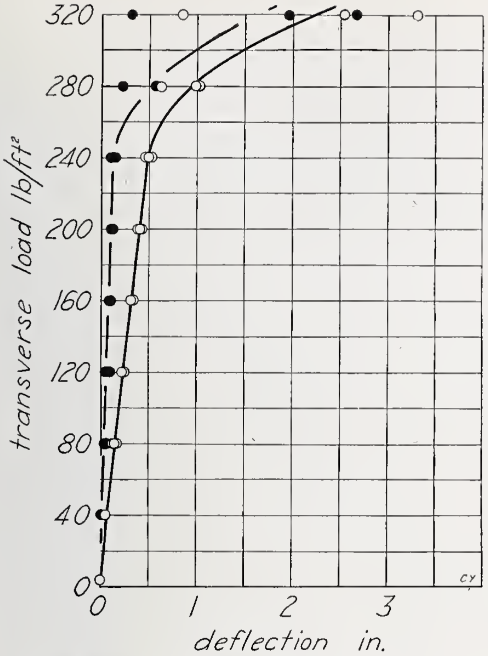


FIGURE 7.—*Transverse load on floor CY.*

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

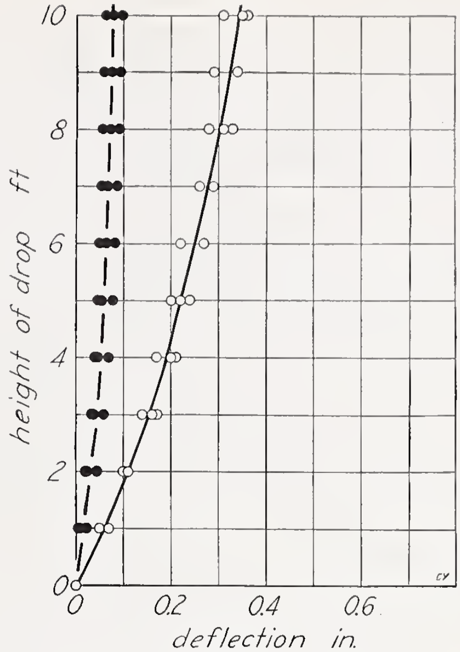


FIGURE 9.—*Impact load on floor CY.*

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

FIGURE 8.—*Floor specimen CY-I3 during the impact test.*

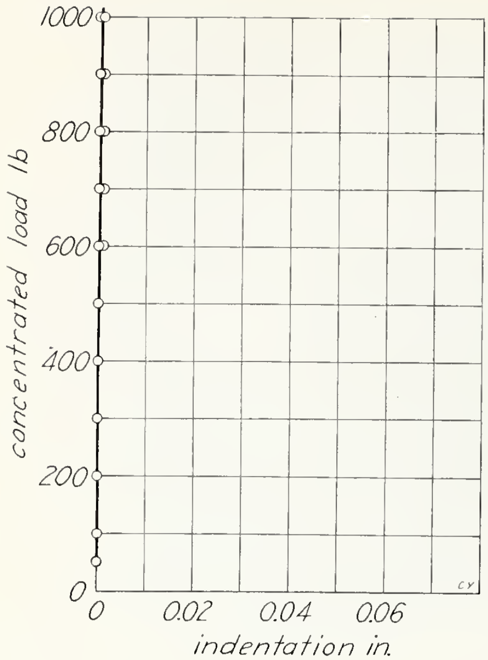


Figure 10.—*Concentrated load on floor CY.*

Load-indentation (open circles) results for specimens *CY-P1*, *P2*, and *P3*. The load-set results were nearly the same as the load indentation results, and therefore are not shown.

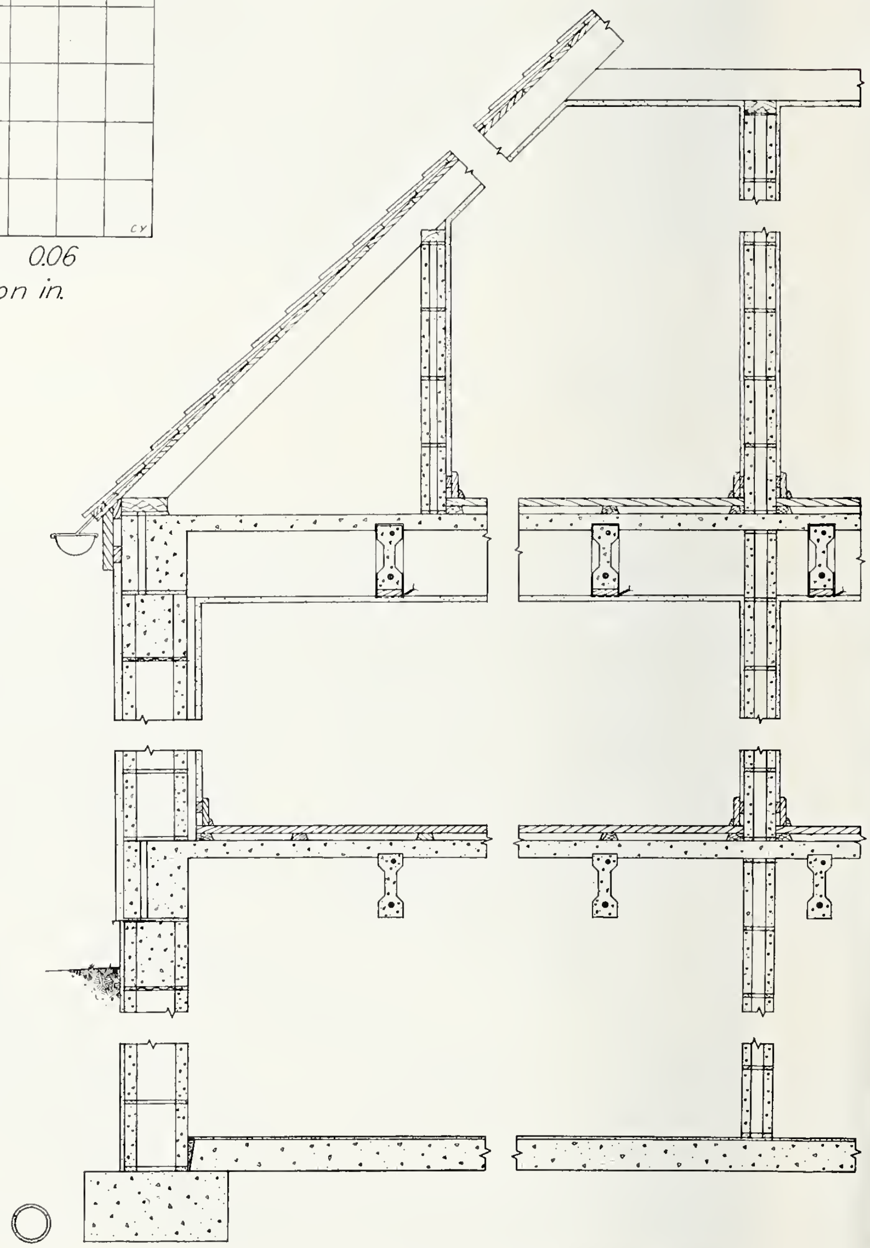


Figure 11.—*Details of typical concrete-masonry house.*

joists. Cracks were observed in the lower flanges of both joists at midspan, after a drop of 5 ft on specimen *CY–I1* and 1 ft on specimen *I2*. Cracks were observed at midspan in one joist of specimen *I3* after a drop of 1 ft and in the other joist after a drop of 3 ft.

4. Concentrated Load

Floor specimen *CY–P2* under concentrated load is shown in figure 1. The results of the concentrated load on specimens *CY–P1*, *P2*, and *P3* are given in table 5 and in figure 10.

The concentrated load was applied to the specimens on the upper face midway between the joists and 1 ft 5 in. from one end. After a load of 1,000 lb had been applied, there was no measurable set and no other effects were observed.

V. ADDITIONAL COMMENTS BY SPONSOR

The details of a masonry house having precast joist concrete floors are shown in figure 11.

The foundation wall below grade is parged on the outside with portland-cement mortar. The outside of the walls above grade may be covered with cement paint or portland-cement stucco.

If the roof is sloping the structural members and sheathing are wood overlaid with building paper and cement-asbestos shingles or concrete tile.

If the roof is flat the walls extend several courses above the roof and are capped by a cast-stone coping. The roof, like the floor, is a precast joist concrete deck overlaid with insulation, a waterproof membrane, and roofing, which may be of the built-up type.

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

The structural properties were determined by the Engineering Mechanics Section, under the supervision of H. L. Whittemore and A. H. Stang, and the physical properties of the concrete in the slab by the Masonry Construction Section, under the supervision of D. E. Parsons. The following members of the professional staff assisted: E. S. Cohen, A. H. Easton, C. C. Fishburn, A. Heiter, W. G. Hoback, A. B. Lanham, D. C. List, P. H. Petersen, L. R. Sweetman, and H. L. Weiss.

VI. SELECTED REFERENCES

R. E. Copeland and P. M. Woodworth, *Some tests of load capacity of floors made with precast concrete joists*, Proc. Am. Concrete Inst. **30**, 311 (1934).

How to design and build precast joist concrete floors, Portland Cement Assn. 19 p. (1938).

F. N. Menefee, *Precast joist concrete floor systems*, Proc. Am. Concrete Inst. **36**, 297 (1940).

Washington, May 3, 1940.

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