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BUILDING MATERIALS AND STRUCTURES

REPORT BMS103

Measurements of Heat Losses From Slab Floors

by

RICHARD S. DILL,
WILLIAM C. ROBINSON *and*
HENRY E. ROBINSON

NATIONAL
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Measurements of Heat Losses From Slab Floors

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RICHARD S. DILL, WILLIAM C. ROBINSON
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ISSUED MARCH 10, 1945

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

Heat losses from slab floors is at all times of interest in connection with low-cost housing, since it is essential that floors be satisfactory as well as inexpensive. In wartime, however, the subject is of more importance than usual on account of the necessity for saving fuel, and because only a minimum of critical materials is procurable for use in floor construction.

This paper presents the results of Bureau tests of eight floors. It gives quantitative information that may be used for estimating heat losses through floors and by means of which typical floors can be compared on the basis of heat-transfer properties.

LYMAN J. BRIGGS, *Director.*

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CONTENTS

ABSTRACT

Four concrete floors laid on the ground and three concrete and one wood floor laid over crawl spaces were tested for heat-transfer properties in a special structure provided for the purpose.

It was found that the heat loss of the floors laid on the ground was decreased by insulating the edges; that the heat loss through the center of such floors is relatively small when the enclosing structure is continuously heated; that the edge loss for a wood floor laid over a crawl space is small; and that the edge loss for an insulated concrete floor laid over a crawl space was considerable.

Observed ground temperatures at various depths, down to 13 ft below the surface, are reported in the paper and some factors are suggested for estimating floor heat losses.

I. INTRODUCTION

Design of low-cost houses involves a compromise between the cost and the performance of building elements. Therefore, information on the heat-transfer properties of floors should be helpful to designers, especially in the low-cost housing field. Insofar as heat transfer is concerned, the desirable characteristics of a floor are (1) low heat loss, considered as an economic factor in heating the house, and (2) warmth or a feeling of warmth to the touch, as it affects comfort.

The two characteristics are related, inasmuch as a floor with a high heat loss is normally expected to be colder on the surface than a floor with a low heat loss. However, comfort does not depend solely upon temperature; with the same surface temperature, materials of high thermal conductivity and of high heat capacity per unit volume feel colder to the touch than others. For example, a concrete floor feels colder to the touch than a wood floor at the same temperature. Insulation in the form of rugs on the floor tends to nullify this difference with floors at the same measured temperature.

Floors can be classified on the basis of arrangement as follows: Those laid over heated basements or over other heated spaces, those laid over unheated spaces, and those laid on the ground.

In most houses having heating devices in the basement, the heat loss through the floor is practically negligible because the basement is warmed by radiation and convection from the heating device and from the pipes and ducts. Very often the same condition is true of floors laid over closed crawl spaces containing heating pipes and ducts. In many cases there is an actual gain of heat in the house from the basement through the floor. This accidental effect probably accounts for the satisfactory performance of some heating systems that would not otherwise provide uniform heat in houses. In view of these facts, further consideration will not be given in this paper to floors laid over heated spaces.

The temperature at a given point or given region of a floor obviously depends upon the rate at which heat is gained or lost at that point or region. If the walls are poorly insulated, the floors will be cold near the exposed walls because a cold draft of air descends along the surface of such walls.

Floors gain and lose heat by radiation, convection, and conduction, and the radiant gain is sometimes important. Floors laid over unheated spaces have been observed to be several degrees warmer than the air directly above or below them. The conclusion is that such floors are warmed by radiation from the ceiling, the walls, and the contents of the room.

From the observations herein described, it will be seen that the heat loss through a floor laid on the ground or laid over a crawl space is likely to be small compared to the total heat loss from the house. For this reason, the temperature of the floor as it affects comfort is, in most cases, as important as the heat loss considered as an economic factor.

For determining the heat loss through several types of floors, the general plan adopted for the floor tests was to provide a heavily insulated structure above a specimen of each kind of floor and to observe the amount of heat, supplied in the form of electric energy, necessary to maintain a temperature of 70° F within the structure during cold weather. Although the walls and ceiling of the structure were heavily insulated, some heat loss through them was inevitable. In order to correct the data for this condition, tests were made during which the floors themselves were so insulated that the heat loss through the structure could be measured.

Objectives of the project were to furnish comparative data on floors of different types, and, as far as practicable, to furnish data whereby the performance of proposed floors could be predicted.

II. TEST EQUIPMENT

For the purpose of obtaining floor test data, the structure shown in figure 1 was erected at the National Bureau of Standards. It provided a number of similar enclosures or compartments in which floors of different types could be simultaneously tested under similar conditions.

The structure was about 58 ft long and 12 ft wide and was divided lengthwise into 10 compartments; the two end compartments, without test floors, were used only as shields for the other compartments in which eight different types of test floors were installed. The structure, located with its long dimension east and west, was built of wood, and its walls and ceiling were insulated with 3⅝ in. of rock wool to minimize heat exchanges everywhere except through the floors under test. There were no windows in the structure and only one door in one of the end compartments. For access to the compartments, manholes about 4 ft square were provided through the walls. The manholes were closed during tests and the closures insulated.

Each test compartment was built to accommodate a floor about 6- by 12-ft, with the 6-ft edges on the exposed sides of the structure. This arrangement provided about the same ratio of exposed edge to floor area as exists in a one-story house 25 ft sq.

As a precaution, an air space was provided between adjacent concrete floors to minimize the exchange of heat between them. This was accomplished by means of the arrangements shown in figure 2. The concrete of two adjacent floors was held apart during construction by a wood dam composed of two walls or faces of 1-in. plank, separated by wood battens. The dam between adjacent slab floors laid on the ground extended down about 2 ft into the ground, as shown in figure 2, *A*. The dam between adjacent slab floors laid over crawl spaces extended to the cap sill, as shown in figure 2, *B*. The dams remained in place during the tests. The arrangement of wood floor 5 is shown in figure 2, *C*.

The temperature difference between floors was slight during tests, and this fact and the above precaution were considered sufficient ground for ignoring heat exchanges between floors.

The compartments were heated electrically, and the amount of energy required to heat each compartment was measured by means of a watthour meter. The heaters consisted of cast-iron radiators with immersion electric resistors of the hairpin type screwed into their bottom connections. The radiators used were of the conventional free-standing, tubular type, consisting of eleven 26-in. 3-tube sections making an over-all length of 29½ in. Each radiator contained sufficient water to cover the heating element. The heaters were controlled automatically by thermostats located in their respective compartments. In each compartment, the thermostat was located in the middle of the east wall, 30 in. above the floor. The thermostats were of the type commonly used for domestic heating devices, with bimetallic sensitive elements and metal contacts. Each thermostat controlled its respective heater through a relay with a mercoid contact. Alternating current of 110 volts was used for both the controlling and the heating circuits.

During some of the tests, the radiators used to heat the compartments were enclosed in plywood jackets, with reflective inside surfaces, so that they functioned substantially as top-outlet convectors. This had no measurable effect on the heat loss from any of the compartments nor on the floor-surface temperatures except near the radiators. The results of the tests with the jackets on the radiators were therefore averaged with the results of the other tests and not treated separately.

A form of the Nicholls heat-flow meter was used for observation of heat losses through the

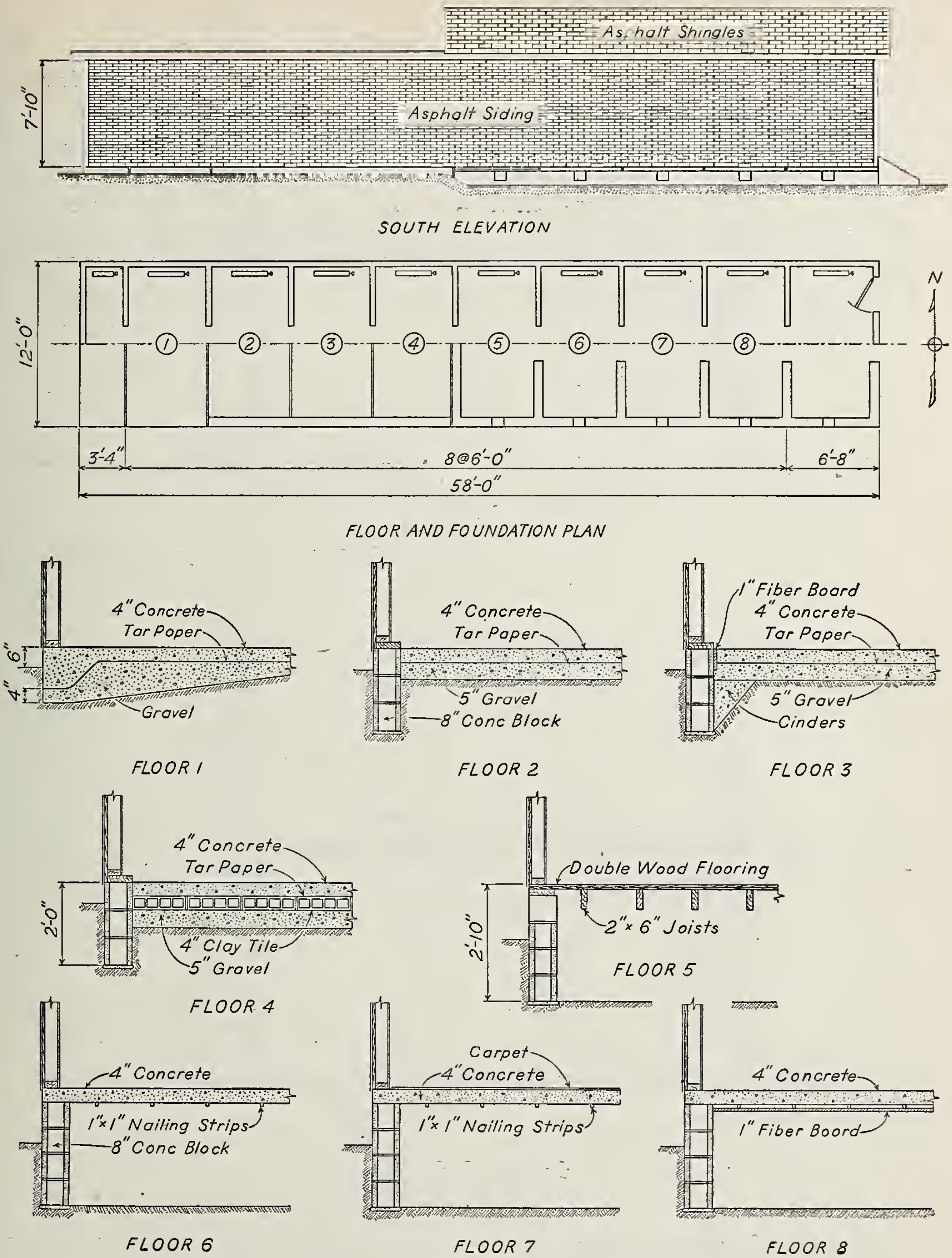

Asphalt Shingles
Asphalt Siding
7'-10"
SOUTH ELEVATION
N
12'-0"
1
2
3
4
5
6
7
8
3'-4"
8@6'-0"
6'-8"
58'-0"
FLOOR AND FOUNDATION PLAN
4" Concrete
Tar Paper
6"
4"
Gravel
FLOOR 1
4" Concrete
Tar Paper
5" Gravel
8" Conc Block
FLOOR 2
1" Fiber Board
4" Concrete
Tar Paper
5" Gravel
Cinders
FLOOR 3
4" Concrete
Tar Paper
2'-0"
4" Clay Tile
5" Gravel
FLOOR 4
Double Wood Flooring
2"× 6" Joists
2'-10"
FLOOR 5
4" Concrete
1"×1" Nailing Strips
8" Conc Block
FLOOR 6
Carpet
4" Concrete
1"× 1" Nailing Strips
FLOOR 7
4" Concrete
1" Fiber Board
FLOOR 8

FIGURE 1

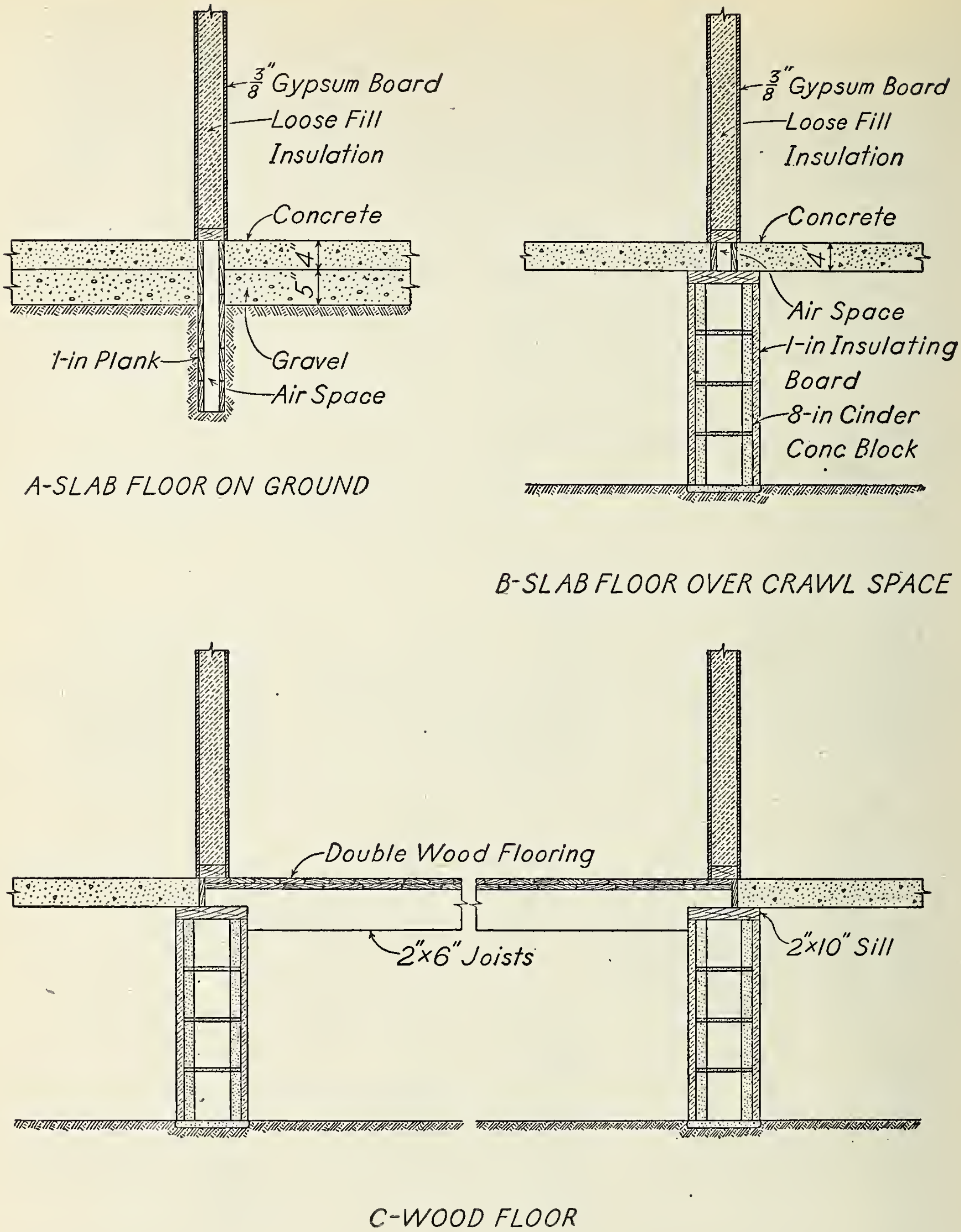


FIGURE 2

structure above the test floors. This heat-flow meter consisted of a panel of 1-in. insulating board, approximately 6 by 8 ft, with thermocouples on both surfaces. The surfaces of the panel were divided into areas approximately 2 ft sq, and a thermocouple was located at the center of each square. The thermocouples were so connected that the electromotive force between those on the two sides indicated the temperature difference between the two sides and hence the heat flow through the panel. One of these heat-flow panels was installed on furring

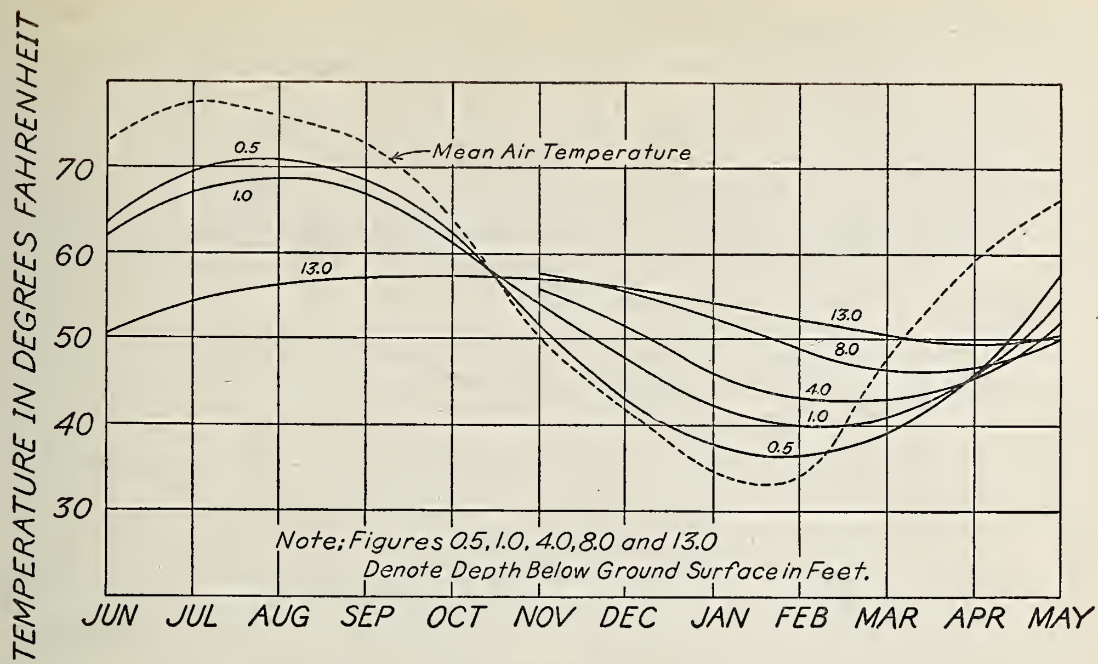


Figure 3

strips on each of the two exposed sides of the eight inside compartments in the structure. The method of using the panels is described in section III.

Temperatures in the compartments, on the floors, and under the floors, were measured with a copper-constantan thermocouple system and a suitable potentiometer.

The temperatures underground at various levels beneath the surface, down to 13 ft, were also measured by means of a thermocouple system. For this purpose, a hole of the desired depth was made in the ground about 50 ft from the test structure by means of a mechanical post-hole digger. The thermocouples and their wires, enclosed in a rubber tube, were lowered into the hole and the earth was replaced around them. Thermojunctions were thus provided at about 1-ft intervals down to 13 ft below the surface as noted on the figures. The tube fitted the wires snugly, protecting the wires and the thermocouples from dampness. Because the tube wall was thin, and the temperature changes slow, it was considered unlikely that the rubber would cause significant error in the temperature measurements. The results of the observations made on earth temperatures are shown in figures 3 and 4.

Four of the floors tested were constructed of concrete, slab type, laid on the ground, arranged and insulated in various ways.

The other four floors were laid over crawl spaces—of these, one was wood, conventional in construction; the rest were concrete. The details of construction for these floors are shown in figure 1. Nailing strips were provided on the under side of the concrete laid over crawl spaces, for floors 6, 7, and 8, as shown on the drawing. The strips, placed on the forms before pouring the concrete, were attached by nails that had been previously driven through them and bent, and which remained in the concrete. Only the strips under floor 8 were put to use. They supported the insulating material.

The floor-test structure had a pitched roof over one part, as shown in figure 1, and a flat roof over the other. It was thus designed to determine the heat loss through ventilated pitched and flat roofs. However, inasmuch as the subject of heat loss through roofs is not a part of this report, and as the roofs and ceilings were not changed during the floor tests, it is presumed that the tare observations will compensate for any difference between roofs and ceilings as well as for any other differences in construction of the compartments.

The ceilings of the test structure consisted of gypsum board supported by 2- by 6-in. joists running crosswise of the building. The ceilings, like the side walls, were insulated with 3⅝ sn. of rock wool.

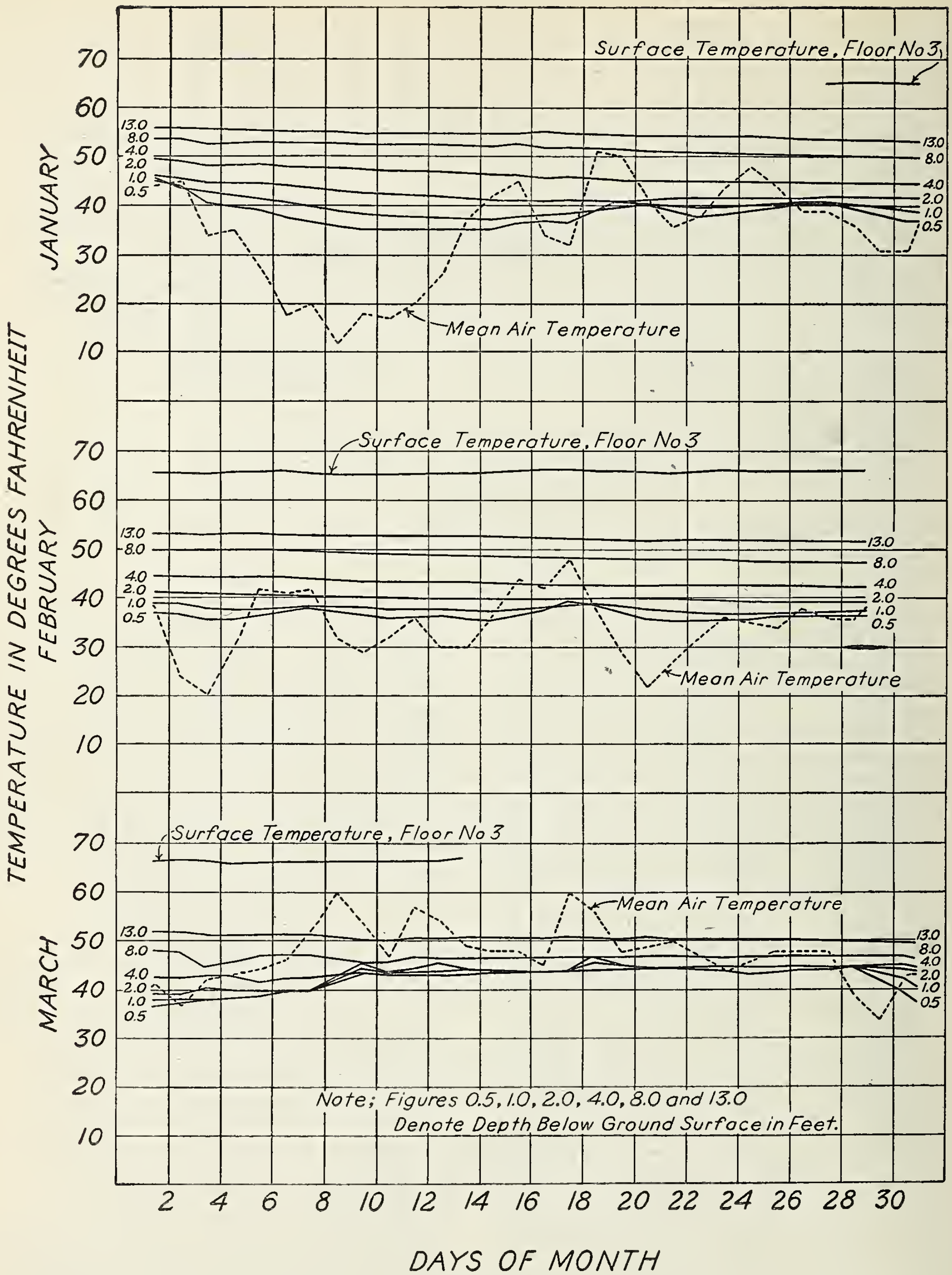

TEMPERATURE IN DEGREES FAHRENHEIT
JANUARY
FEBRUARY
MARCH
70
60
50
40
30
20
10
13.0
8.0
4.0
2.0
1.0
0.5
Surface Temperature, Floor No 3
Mean Air Temperature
Note; Figures 0.5, 1.0, 2.0, 4.0, 8.0 and 13.0
Denote Depth Below Ground Surface in Feet.
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
DAYS OF MONTH

FIGURE 4

III. PROCEDURE AND OBSERVATIONS

For any compartment at a steady state of operation the total heat supplied escaped in two ways, partly through the floor and partly through the walls and roof of the structure. Therefore the structure heat loss plus the floor heat loss equaled the heat supplied, or, what is more convenient for present purposes since it was desired to determine floor heat loss, the floor heat loss equaled the heat supplied minus the structure heat loss.

The amount of heat supplied was determined from the watthour-meter readings, and special tests were conducted to determine the structure heat loss.

The structure heat loss was termed the *tare*; to determine the tare, the floor in each compartment was covered with 8 in. of sawdust insulation and the compartment maintained at approximately 70° F during 3 days. The power input, observed by means of watthour meters, was equal to the total heat loss. Some heat escaped through the floor despite the insulation on it, and, to correct for this, the heat loss through the sawdust was estimated by means of the measured temperature difference through it from air above the sawdust to the floor surface below the sawdust in conjunction with conductivity and conductance factors from the ASHVE "Guide." The observed tare then equaled heat input minus the computed heat loss through the floor insulation. The observed tare was then corrected for the effect of that portion of the side walls covered with sawdust during the tare determinations, but which was not covered during the floor tests.

These operations yielded two factors of importance in connection with each compartment: One was the tare, or structure heat loss, for a specific indoor temperature and a specific outdoor weather condition; the other was the electromotive force (emf) developed by the thermocouples on the heat-flow panels for the existing heat loss. The problem then was to compute the tare, corresponding to another weather condition, from available data. For this purpose, it was assumed that the tare was proportional to the temperature difference through the heat-flow panels, and that this temperature difference was proportional to the emf developed between the thermocouples on the two sides of a panel.

From this,

$$\frac{T_a}{T_0}=\frac{E_a}{E_0}$$

or

$$T_a=E_a\frac{T_0}{E_0}$$

when

T_a=tare existing during floor test, watts,
T_0=tare observed during preliminary test, increased by 4 percent to correct for the effect of sawdust insulation against a portion of the side walls during the tare determinations, watts,
E_a=emf developed by heat-flow panel, thermocouples, during floor test, microvolts,
E_0=emf observed during tare determinations, microvolts.

Of these factors, T_0 and E_0 were known for each compartment by means of the preliminary tests described above. The value of E_0 for any compartment was close to the average for all the compartments, so the average E_0 was used in computing a factor, K, as follows:

$$K=\frac{T_0}{E_0}.$$

Since the average emf developed by the heat-flow panels was 1,598 microvolts during the tare-determination tests, the value of K for each compartment was computed by the formula

$$K=\frac{T_0}{1598}.$$

The tare for each compartment was computed during the floor tests by the formula

$$T_a=KE_a.$$

The data and derived tare factors for each compartment are given in table 1.

TABLE 1.—*Tare*[1] *determinations*

Floor number	Energy input during 108 hr	Average power input	Loss through floor insulation and partitions	Observed tare[2]	Factor K[3 4]
	whr	*w*	*w*	*w*	*w/μv*
1	15,088	139.7	14.9	124.8	0.0811
2	16,826	155.8	14.7	141.1	.0917
3	14,051	130.1	9.5	120.6	.0784
4	20,239	187.4	23.4	164.0	.1066
5	16,805	155.6	23.3	132.3	.0860
6	16,362	151.5	25.1	126.4	.0822
7	15,757	145.9	26.2	119.7	.0778
8	11,524	106.7	13.9	92.8	.0603

[1] *Tare* is defined as the heat loss from a compartment except that through the floor. It was determined for each compartment by insulating the floor with 8 in. of sawdust.
[2] *Observed tare* is power input minus calculated heat loss through the insulated floor and partitions between compartments.
[3] K is tare in watts per microvolt of over-all average emf between thermocouples on the two sides of the heat-flow panels. K is corrected for that portion of the walls covered by sawdust during the tare observations but not covered during the floor tests.
[4] Over-all average of panel emf during tare observations was 1,598 μv.

After completion of the observations of tare, the sawdust was removed and the tests of the floors commenced. The compartments were maintained at approximately 70° F at the thermostat location continuously from November 1 to May 23. Observations of several days' duration were made a number of times. Inclusion in this report of results obtained during all the observation periods was considered unnecessary, but those obtained during the first observation period are shown in table 2 to illustrate the type of data gathered.

Table 2.—*Floor heat loss*

[Observation period No. 1, from 8:00 a. m. January 27 to 8:00 a. m. January 31]

Floor number	Energy input	Average power input	Factor K (from table 1)	Tare[1]	Floor heat loss: Net	Floor heat loss: Net	Floor heat loss: Per foot of exposed edge
	whr	*w*	*w/μv*	*w*	*w*	*Btu/hr*	*Btu/hr*
1	25, 190	262. 4	0. 0811	142. 5	119. 9	409	34. 08
2	25, 344	264. 0	. 0917	161. 2	102. 8	351.	29. 25
3	20, 966	218. 4	. 0784	137. 8	80. 6	275	22. 92
4	28, 944	301. 5	. 1066	187. 4	114. 1	389	32. 42
5	27, 466	286. 1	. 0860	151. 2	134. 9	460	--------
6	36, 144	376. 5	. 0822	144. 5	232. 0	792	--------
7	33, 187	345. 7	. 0778	136. 8	208. 9	713	--------
8	26, 986	281. 1	. 0603	106. 0	175. 1	598	--------

[1] *Tare* is defined as the heat loss from a compartment except that through the floor. It was determined for each compartment by insulating the floor with 8 in. of sawdust.

1. Slab Floors Laid on the Ground

Results of the tests indicated that heat loss through a slab floor laid on the ground, when the floor and the ground outside the house are at substantially the same elevation, is more nearly proportional to the length of the "exposed edge" of the floor than to the area of the floor. "Exposed edge" here means an edge of the floor next to an exposed wall of the house, an edge imbedded in such a wall, or an edge on the outside of such a wall in contact with the ground, as in the case of a wall resting on the floor near the edge.

The heat loss of a floor laid on the ground is not proportional to the temperature difference between the air inside and the air outside of the house at any given instant. The floor heat loss appears to be dependent upon the temperature of the ground at some region beneath the surface, and this, in turn, depends upon the average temperature of the air above the ground and the amount of heat received by the ground from the sun and the amount of heat lost from it by radiation or otherwise during some period prior to the observation.

For each of the floors, 1, 2, 3, and 4, the observed heat loss was divided by the length of the exposed edge, as defined above, and the result entered in the tables as "heat loss per foot of exposed edge." From this, the following three heat-loss factors were derived:

1. The heat loss in Btu per hour per linear foot of exposed edge was divided by the number of degree-days estimated to have occurred during the month preceding the observation, to yield factor F_1.
2. The heat loss in Btu per hour per linear foot of exposed edge was divided by the average temperature difference observed during each observation period between the air inside the structure and the air outside, to yield factor F_2.
3. The heat loss in Btu per hour per linear foot of exposed edge was divided by the average difference observed during each observation period between the temperature of the air inside the structure and the temperature of the ground 1 ft below the surface, at a distance of 35 ft from the structure, to yield factor F_3.

Derivation of these factors is shown in tables 3, 4, and 5.

Table 3.—*Determination of the factor F_1*

[F_1=Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree-day occurring during month preceding observation]

Slab floors laid on the ground	Observation period 1	2	3	4	5	Mean F_1	Maximum deviation
							Percent
Degree-days during month before test ... *Number*	980	947	917	906	882	--------	--------
No. 1:							
Hourly heat loss ... *Btu per ft of exposed edge*	34. 0	32. 9	34. 5	30. 3	31. 2	--------	--------
F_1=heat loss ... *Btu per hr, per ft, and per degree-day*	0. 035	0. 035	0. 038	0. 033	0. 035	0. 035	8. 5
No. 2:							
Hourly heat loss ... *Btu per ft of exposed edge*	29. 3	28. 2	30. 1	26. 3	25. 3	--------	--------
F_1=heat loss ... *Btu per hr, per ft, and per degree-day*	0. 030	0. 030	0. 033	0. 029	0. 029	. 030	10. 0
No. 3:							
Hourly heat loss ... *Btu per ft of exposed edge*	22. 9	21. 7	21. 8	21. 0	19. 8	--------	--------
F_1=heat loss ... *Btu per hr, per ft, and per degree-day*	0. 023	0. 023	0. 024	0. 023	0. 022	. 023	8. 6
No. 4:							
Hourly heat loss ... *Btu per ft of exposed edge*	32. 4	31. 3	30. 3	26. 7	29. 8	--------	--------
F_1=heat loss ... *Btu per hr, per ft, and per degree-day*	0. 033	0. 033	0. 033	0. 029	0. 034	. 032	9. 3

TABLE 4.—*Determination of the factor F_2*

[F_2=Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree Fahrenheit difference in average air temperature between the inside and outside of structure occurring during observation period]

Slab floors laid on the ground	Observation period 1	2	3	4	5	Mean F_2	Maximum deviation
No. 1:							Percent
Hourly heat loss — *Btu per ft of exposed edge*	34.0	32.9	34.5	30.3	31.2		
Temperature difference, inside to outside — *avg deg F*	39.1	40.9	42.7	39.2	38.9		
F_2=heat loss — *Btu per hr, per ft, and per deg F*	0.87	0.80	0.81	0.77	0.80	0.81	7.4
No. 2:							
Hourly heat loss — *Btu per ft of exposed edge*	29.3	28.2	30.1	26.3	25.3		
Temperature difference, inside to outside — *avg deg F*	38.9	41.0	43.0	39.1	39.0		
F_2=heat loss — *Btu per hr, per ft, and per deg F*	0.75	0.69	0.70	0.67	0.65	.69	8.6
No. 3:							
Hourly heat loss — *Btu per ft of exposed edge*	22.9	21.7	21.8	21.0	19.8		
Temperature difference, inside to outside — *avg deg F*	38.3	39.5	42.1	38.6	38.1		
F_2=heat loss — *Btu per hr, per ft, and per deg F*	0.60	0.55	0.52	0.54	0.52	.55	9.0
No. 4:							
Hourly heat loss — *Btu per ft of exposed edge*	32.4	31.3	30.3	26.7	29.8		
Temperature difference, inside to outside — *avg deg F*	39.4	41.4	43.2	38.2	39.5		
F_2=heat loss — *Btu per hr, per ft, and per deg F*	0.82	0.76	0.70	0.70	0.75	.75	9.3

TABLE 5.—*Determination of the factor F_3*

[F_3=Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree Fahrenheit difference in temperature between the air above the floor and the ground 1 ft below the surface and 35 ft from the structure]

Slab floors laid on the ground	Observation period 1	2	3	4	5	Mean F_3	Maximum deviation
No. 1:							Percent
Hourly heat loss — *Btu per ft of exposed edge*	34.0	32.9	34.5	30.3	31.2		
Temperature difference, inside to ground — *deg F*	30.6	32.6	32.8	31.9	33.2		
F_3=heat loss — *Btu per hr, per ft, and per deg F*	1.11	1.01	1.05	0.95	0.94	1.01	9.9
No. 2:							
Hourly heat loss — *Btu per ft of exposed edge*	29.3	28.2	30.1	26.3	25.3		
Temperature difference, inside to ground — *deg F*	30.5	32.7	33.0	31.9	33.3		
F_3=heat loss — *Btu per hr, per ft, and per deg F*	0.96	0.86	0.91	0.82	0.76	0.86	11.6
No. 3:							
Hourly heat loss — *Btu per ft of exposed edge*	22.9	21.7	21.8	21.0	19.8		
Temperature difference, inside to ground — *deg F*	29.9	31.3	32.5	31.6	32.4		
F_3=heat loss — *Btu per hr, per ft, and per deg F*	0.77	0.69	0.67	0.66	0.61	.68	13.2
No. 4:							
Hourly heat loss — *Btu per ft of exposed edge*	32.4	31.3	30.3	26.7	29.8		
Temperature difference, inside to ground — *deg F*	31.1	33.3	33.8	32.5	33.9		
F_3=heat loss — *Btu per hr, per ft, and per deg F*	1.04	0.94	0.90	0.82	0.88	.92	13.0

Heat losses estimated by means of F_1 may differ from those estimated by means of F_2 for two reasons: First, that the number of degree-days occurring during the month preceding each observation period was estimated from data in the ASHVE "Guide" by weighting the degree-days given for Washington, D. C., with respect to the time of the month when each observation period occurred. The degree-day data on which F_1 are based do not coincide, therefore, with what would be obtained if the temperature data obtained at the site were used in determining the degree-days. Second, that the commonly accepted degree-day system is based on an outside temperature of 65° F, whereas F_2 is based on an inside temperature of 70° F for the structure.

2. Floors Laid Over Crawl Spaces

The results of the test of the floors laid over crawl spaces are given in table 6.

TABLE 6.—*Determination of the factor U for floors laid over crawl spaces*

[U=Heat loss in Btu per hour for each square foot and for 1 degree Fahrenheit difference in temperature between the air 30 in. above the floor and the air in the crawl space 15 in. below the floor]

Floors laid over crawl spaces	Observation period 1	2	3	4	5	Mean U	Maximum deviation
							Percent
Crawl space ventilated	Yes	No	No	No	Yes		
No. 5:							
Hourly heat loss ... *Btu per sq ft*	7.46	4.95	5.02	4.65	7.61		
Temperature difference, inside air to crawl space ... *deg F*	30.4	21.4	20.2	19.1	32.6		
U=heat loss ... *Btu per hr, per sq ft, and per deg F*	.25	.23	.25	.24	.23	0.24	4.1
No. 6:							
Hourly heat loss ... *Btu per sq ft*	12.84	8.04	8.00	7.06	13.07		
Temperature difference, inside air to crawl space ... *deg F*	29.8	17.6	16.3	15.9	30.0		
U=heat loss ... *Btu per hr, per sq ft, and per deg F*	.44	0.47	.49	.44	.44	.46	6.5
No. 7:							
Hourly heat loss ... *Btu per sq ft*	[a] 11.56	[a] 7.54	[a] 7.12	[b] 6.06	[b] 10.26		
Temperature difference, inside air to crawl space ... *deg F*	[a] 29.0	[a] 17.5	[a] 17.1	[b] 17.0	[b] 32.0	[a] .42	[a] 4.7
U=heat loss ... *Btu per hr, per sq ft, and per deg F*	[a] .40	[a] .43	[a] .42	[b] .36	.32	[b] .34	[b] 5.8
No. 8:							
Hourly heat loss ... *Btu per sq ft*	9.69	7.19	6.69	6.35	8.99		
Temperature difference, inside air to crawl space ... *deg F*	32.5	23.2	21.6	20.3	33.7		
U=heat loss ... *Btu per hr, per sq ft, and per deg F*	.30	.31	.31	.31	.27	.30	10.0

[a] Bare floor.
[b] Carpeted floor.

Each of the crawl spaces was provided with ports for ventilation with areas of 1 sq ft for each 15 lin ft of wall in accordance with Federal Housing Administration recommendations.[1] As indicated in table 6, some tests were made with the ports open, others with the ports closed, to show the effect of ventilation.

When the ports are open and there is wind, it is a safe presumption that the air in the crawl space approaches the outdoor air in temperature. For estimating heat losses through floors laid over ventilated crawl spaces, it is therefore recommended that the same temperature be assumed for the crawl space as for the outside.

With no ventilation, the crawl-space temperature will be somewhere between the inside and the outside temperature and will be lower for an insulated floor and for a greater ratio of exposed foundation wall to floor.

The U factor for the floors laid over the crawl spaces was computed from data contained in the "Guide," and the computed and observed values are given in table 7 for comparison.

The computed U values are based on the difference in temperature of the air near the upper and lower surfaces of the floors, whereas the observed U values are based on the temperature difference of the air 30 in. above the floors and 15 in. below. Since the air temperature differences are larger in the first case, the agreement between observed and computed U values is better than that indicated in table 7, at least for floors 5, 6, and 7. The considerable excess of the observed over the computed value of U for floor 8 is probably due to edge loss, since this floor was insulated underneath, which should result in a large ratio of edge loss to total loss.

TABLE 7.—*Comparison of observed and computed values of U for floors laid over crawl spaces*

[U=Btu per hour for each square foot and for 1 degree Fahrenheit difference in temperature between air over the floor and air in the crawl spaces]

Floor number	U value: Observed [a]	Computed [b]	Difference: Numerical	Percentage
5	0.24	0.27	−0.03	−13
6	.46	.50	−.04	−9
7	.34	.38	−.04	−12
8	.30	.17	+.13	+43

[a] Observed conductance indicated by results of tests.
[b] Conductance indicated by computations based on handbook data.

A mathematical expression for the heat loss from concrete floors laid over crawl spaces should, if precision is necessary, take into account both the loss to the crawl space and the loss through the edge. The crawl-space temperature depends upon the outdoor and indoor temperature, upon the ratio of side-wall areas to floor areas and upon the conductances of the side walls. The loss through the edge depends upon a number of factors also. The complexity of computing precise estimates of heat losses through floors laid over crawl spaces makes it doubtful that builders will consider attempts to make them worthwhile.

[1] FHA Minimum Requirements for Rental Housing Projects, submitted under title VI, section 608, National Housing Act, May 26, 1942, and FHA Minimum Requirements for New Dwellings (issued separately for each State).

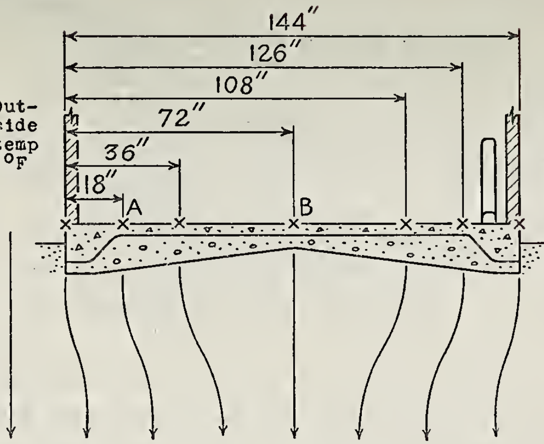
Floor No. 1

Cross section showing observed heat losses and temperature distributions.

X indicates thermocouple location on floor surface.

Floor surface thermocouples were on line across middle of floor.

Room air thermocouple was 30 in. above floor.



Period No.	Test Condition	Observation Period	Average heat loss Btu/hr per sq ft	Outside temp °F	AVERAGE TEMPERATURE DEGREES F							Bogey temp °F	Room temp °F
1.	Enclosed radiator	Jan. 27 to Jan. 31	6.63	31.5	43.7	60.0	62.8	64.5	64.2	65.4	48.5	38.6	70.6
2.	Enclosed radiator	Feb. 2 to Feb. 7	6.41	29.7	42.4	59.7	63.2	65.2	64.9	65.8	48.0	31.9	70.6
3.	Enclosed radiator	Feb. 9 to Feb. 13	6.72	27.5	41.9	59.4	62.6	64.8	64.4	65.3	47.0	34.6	70.2
4.	Unenclosed radiator	Feb. 16 to Feb. 21	5.89	31.0	44.7	60.4	63.5	65.6	66.5	66.7	49.9	37.9	70.2
5.	Unenclosed radiator	Feb. 23 to Feb. 27	6.06	31.4	44.9	60.8	63.6	65.8	66.6	66.5	48.9	34.4	70.3

Average gradient from point A to point B:

G = 0.0388 deg. F per foot for each degree F difference between point B and Bogey temperature.

To compute heat loss by Edge method:

Use $F_1 = 0.035$ or $F_2 = 0.810$ or $F_3 = 1.01$

F_1 = Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree-day occurring during month preceding observation.

F_2 = Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree F difference in average air temperature between the inside and outside of structure occurring during observation period.

F_3 = Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree F difference in temperature between the air above the floor and the ground 1 foot below the surface and 35 ft from the structure.

FIGURE 5

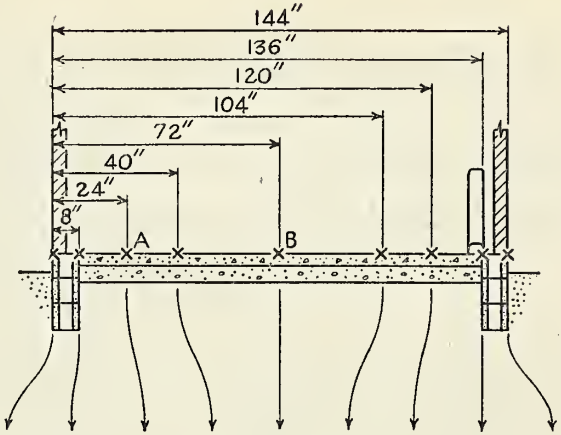
Floor No. 2

Cross section showing observed heat losses and temperature distributions.

X indicates thermocouple location on floor surface.

Floor surface thermocouples were on line across middle of floor.

Room air thermocouple was 30 in. above floor.



Period No.	Test Condition	Observation Period	Average heat loss Btu/hr per sq ft	Outside temp °F	AVERAGE TEMPERATURE DEGREES F									Bogey temp °F	Room temp °F
1.	Enclosed radiator	Jan. 27 to Jan. 31	5.69	31.6	40.7	55.0	61.8	----	65.2	65.0	66.1	58.7	37.3	38.6	70.5
2.	Enclosed radiator	Feb. 2 to Feb. 7	5.48	29.7	39.8	54.1	61.4	63.8	65.6	65.4	66.3	58.2	35.1	31.9	70.7
3.	Unenclosed radiator	Feb. 9 to Feb. 13	5.85	27.4	38.3	54.4	61.5	63.8	65.4	65.0	65.8	57.7	33.9	34.6	70.4
4.	Unenclosed radiator	Feb. 16 to Feb. 21	5.10	31.1	40.2	55.7	62.2	64.1	66.0	66.7	67.4	60.4	37.7	37.9	70.2
5.	Unenclosed radiator	Feb. 23 to Feb. 27	5.92	31.4	41.3	56.5	62.4	64.4	66.1	66.6	67.7	59.7	36.1	34.4	70.4

Average gradient from point A to point B:

G = 0.0315 deg. F per foot for each degree F difference between point B and Bogey temperature.

To compute heat loss by Edge method:

Use F_1 = 0.030 or F_2 = 0.69 or F_3 = 0.86

F_1 = Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree-day occurring during month preceding observation.

F_2 = Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree F difference in average air temperature between the inside and outside of structure occurring during observation period.

F_3 = Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree F difference in temperature between the air above the floor and the ground 1 foot below the surface and 35 ft from the structure.

FIGURE 6

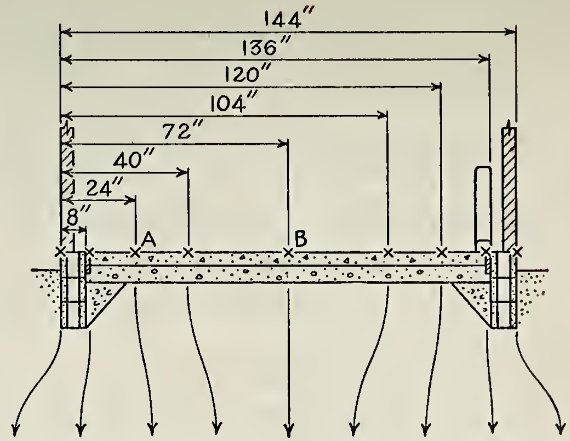
Floor No. 3

Cross section showing observed heat losses and temperature distributions.

X indioates thermocouple location on floor surfaoe.

Floor surface thermocouples were on line across middle of floor.

Room air thermocouple was 30 in. above floor.



Period No.	Test Condition	Observation Period	Average heat loss Btu/hr per sq ft	Out-side temp °F	AVERAGE TEMPERATURE DEGREES F									Bogey temp °F	Room temp °F
1.	Enclosed radiator	Jan. 27 to Jan. 31	4.46	31.6	35.8	59.9	62.6	64.1	65.3	65.4	66.5	64.5	39.3	38.6	69.9
2.	Enolosed radiator	Feb. 2 to Feb. 7	4.21	29.8	34.9	58.4	62.0	63.9	65.8	65.7	66.5	63.9	37.3	31.9	69.3
3.	Enclosed radiator	Feb. 9 to Feb. 13	4.25	27.8	33.2	59.2	62.2	64.0	65.5	65.7	66.7	64.1	36.8	34.6	69.9
4.	Unenclosed radiator	Feb. 16 to Feb. 21	4.09	31.3	35.9	59.8	62.9	64.5	66.0	67.1	68.5	66.4	40.0	37.9	69.9
5.	Unenclosed radiator	Feb. 23 to Feb. 27	3.85	31.4	37.1	60.4	63.1	64.6	66.1	66.9	68.0	65.8	38.2	34.4	69.5

Average gradient from point A to point B:

G = 0.0262 deg. F per foot for each degree F differenoe between point B and Bogey temperature.

To compute heat loss by Edge method:

Use $F_1 = 0.023$ or $F_2 = 0.55$ or $F_3 = 0.68$

F_1 = Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree-day occurring during month preceding observation.

F_2 = Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree F difference in average air temperature between the inside and outside of structure occurring during observation period.

F_3 = Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree F difference in temperature between the air above the floor and the ground 1 foot below the surface and 35 ft from the structure.

FIGURE 7

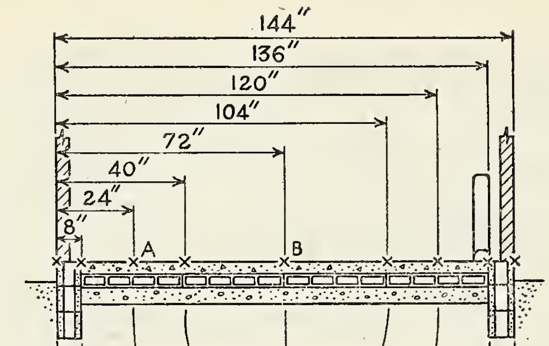
Floor No. 4

Cross section showing observed heat losses and temperate distributions.

X indicates thermocouple location on floor surface.

Floor surface thermocouples were on line across middle of floor.

Room air thermocouple was 30 in. above floor.



Period No.	Test Condition	Observation Period	Average heat loss Btu/hr per sq ft	Out-side temp °F	AVERAGE TEMPERATURE DEGREES F									Bogey temp. °F	Room temp °F
1.	Enclosed radiator	Jan. 27 to Jan. 31	6.31	31.7	39.2	54.0	62.4	64.2	65.7	65.4	66.3	60.6	38.3	38.6	71.1
2.	Enclosed radiator	Feb. 2 to Feb. 7	6.09	29.9	38.4	52.2	61.4	63.7	65.6	65.4	66.2	58.7	36.3	31.9	71.3
3.	Enclosed radiator	Feb. 9 to Feb. 13	5.88	23.0	36.9	52.6	61.7	63.9	65.5	65.6	66.4	59.5	35.8	34.6	71.2
4.	Unenclosed radiator	Feb. 16 to Feb. 21	5.19	32.6	38.4	53.9	62.3	64.2	66.3	67.2	69.3	62.4	39.2	37.9	70.8
5.	Unenclosed radiator	Feb. 23 to Feb. 27	5.78	31.5	40.3	55.4	62.6	64.4	66.1	66.5	68.4	61.9	37.8	34.4	71.0

Average gradient from point A to point B:

G = 0.0309 deg. F per foot for each degree F difference between point B and Bogey temperature.

To compute heat loss by Edge method:

Use $F_1 = 0.032$ or $F_2 = 0.75$ or $F_3 = 0.92$

F_1 = Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree-day occurring during month preceding observation.

F_2 = Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree F difference in average air temperature between the inside and outside of structure occurring during observation period.

F_3 = Floor heat loss in Btu per hour per linear foot of exposed edge and for 1 degree F difference in temperature between the air above the floor and the ground 1 foot below the surface and 35 ft from the structure.

FIGURE 8

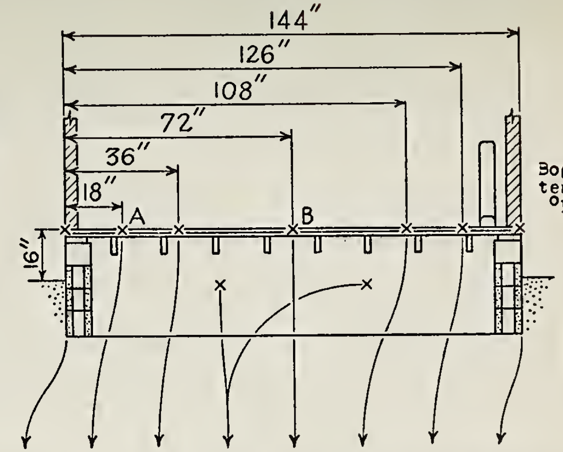
Floor No. 5

Cross section showing observed heat losses and temperature distributions.

X indicates thermocouple location on floor surface.

Floor surface thermocouples were on line across middle of floor.

Room air thermocouple was 30 in. above floor.



Period No.	Test Condition	Observation Period	Average heat loss Btu/hr per sq ft	Outside temp °F	AVERAGE TEMPERATURE DEGREES F								Bogey temp °F	Room temp °F
1.	Enclosed radiator, crawl space ventilated	Jan. 27 to Jan. 31	7.46	32.0	36.4	60.9	61.0	39.3	62.3	62.1	70.3	33.6	38.6	69.7
2.	Enclosed radiator, crawl space closed	Feb. 2 to Feb. 7	4.95	30.1	36.8	62.3	62.5	48.7	64.1	64.1	72.4	32.1	31.9	70.1
3.	Enclosed radiator, crawl space closed	Feb. 9 to Feb. 13	5.02	28.4	36.1	62.5	62.8	49.6	64.4	64.3	70.4	32.4	34.6	69.8
4.	Unenclosed radiator, crawl space closed	Feb. 16 to Feb. 21	4.65	31.5	38.8	63.1	63.4	51.4	65.1	66.6	72.0	34.9	37.9	70.5
5.	Unenclosed radiator, crawl space ventilated	Feb. 23 to Feb. 27	7.61	31.6	36.6	60.8	61.0	38.3	62.5	64.4	71.2	32.0	34.4	70.9

If G is defined as the average gradient from point A to point B in degrees F per foot for each degree F difference between point B and Bogey temperature, then

G = 0.0133 with crawl space ventilated
G = 0.0141 with crawl space closed

Observed value of U = 0.24

U = Heat loss, Btu per hour for each square foot and for each degree F difference in temperature between air 30 in. above and air 12 in. below floor.

FIGURE 9

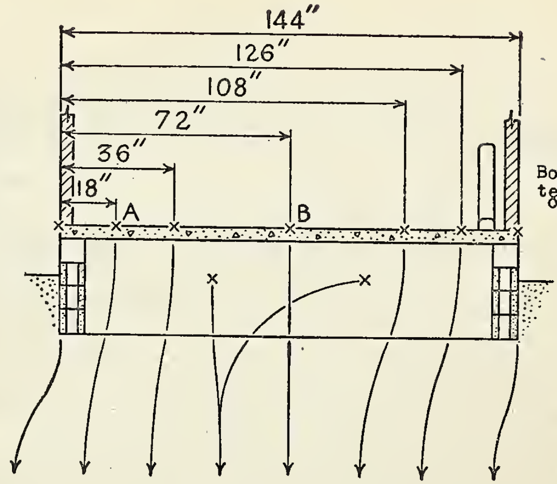
Floor No. 6

Cross section showing observed heat losses and temperature distributions.

X indicates thermocouple location on floor surface.

Floor surface thermocouples were on line across middle of floor.

Room air thermocouple was 30 in. above floor.



Period No.	Test Condition	Observation Period	Average heat loss Btu/hr per sq ft	Out-side temp °F	AVERAGE TEMPERATURE DEGREES F								Bogey temp °F	Room temp. °F
1.	Enclosed radiator, crawl space ventilated	Jan. 27 to Jan. 31	12.84	32.0	43.7	54.7	56.7	40.7	57.3	57.4	61.9	43.4	38.6	70.5
2.	Enclosed radiator, crawl space closed	Feb. 2 to Feb. 7	8.07	30.2	50.0	59.4	61.0	52.9	61.9	62.2	65.9	48.5	31.9	70.5
3.	Enclosed radiator, crawl space closed	Feb. 9 to Feb. 13	8.00	28.7	50.2	60.2	61.8	53.9	62.4	62.8	66.6	48.6	34.6	70.2
4.	Unenclosed radiator, crawl space closed	Feb. 16 to Feb. 21	7.06	31.7	51.7	60.8	62.3	54.4	62.9	64.7	67.6	50.8	37.9	70.3
5.	Unenclosed radiator, crawl space ventilated	Feb. 23 to Feb. 27	13.07	31.8	45.4	55.2	56.9	40.1	57.4	59.0	62.1	42.9	34.4	70.1

If G is defined as the average gradient from point A to point B in degrees F per foot for each degree F difference between point B and Bogey temperature, then

G = 0.0261 with crawl space ventilated
G = 0.0182 with crawl space closed

Observed value of U = 0.46

U = Heat loss, Btu per hour for each square foot and for each degree F difference in temperature between air 30 in. above and air 12 in. below floor.

FIGURE 10

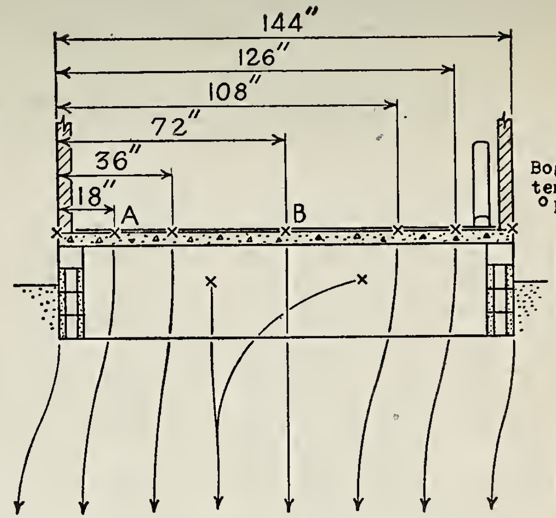
Floor No. 7

Cross section showing observed heat losses and temperature distributions.

X indicates thermocouple location on floor surface.

Floor surface thermocouples were on line across middle of floor.

Room air thermocouple was 30 in. above floor.



Period No.	Test Condition	Observation Period	Average heat loss Btu/hr per sq ft	Out-side temp °F	AVERAGE TEMPERATURE DEGREES F									Bogey temp °F	Room temp °F
1.	Enclosed radiator, crawl space ventilated	Jan. 27 to Jan. 31	11.56	32.1	44.6	54.9	56.9	41.5	57.5	57.5	62.3	43.6		38.6	70.5
2.	Enclosed radiator, crawl space closed	Feb. 2 to Feb. 7	7.54	30.5	51.1	59.3	61.0	52.7	61.8	62.2	66.8	48.6		31.9	70.2
3.	Enclosed radiator, crawl space closed	Feb. 9 to Feb. 13	7.12	28.8	51.3	59.9	61.5	53.1	62.2	62.5	67.1	48.6		34.6	70.2
4.	Unenclosed radiator, crawl space closed, floor carpeted	Feb. 16 to Feb. 21	6.06	31.7	52.0	58.8	59.6	53.3	60.6	61.4	64.6	50.4		37.9	70.3
5.	Unenclosed radiator, crawl space ventilated, floor carpeted	Feb. 23 to Feb. 27	10.26	31.9	45.8	52.7	53.2	38.4	53.2	54.0	58.0	42.9		34.4	70.4

If G is defined as the average gradient from point A to point B in degrees F per foot for each degree F difference between point B and Bogey temperature, then

G = 0.0305 with crawl space ventilated
G = 0.0182 with crawl space closed

Observed value of U = 0.42 for bare floor
U = 0.34 for floor covered with carpet

U = Heat loss, Btu per hour for each square foot and for each degree F difference in temperature between air 30 in. above and air 12 in. below floor.

FIGURE 11

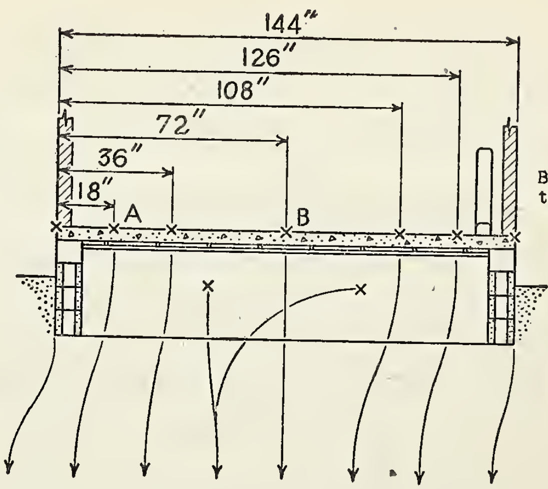
Floor No. 8

Cross section showing observed heat losses and temperature distributions.

X indicates thermocouple location on floor surface.

Floor surface thermocouples were on line across middle of floor.

Room air thermocouple was 30 in. above floor.



Period No.	Test Condition	Observation Period	Average heat loss Btu/hr per sq ft	Outside temp °F	AVERAGE TEMPERATURE DEGREES F								Bogey temp °F	Room temp °F
1.	Enclosed radiator, crawl space ventilated	Jan. 27 to Jan. 31	9.69	32.2	41.6	59.3	63.4	38.4	64.0	64.9	65.9	41.8	38.6	70.9
2.	Enclosed radiator, crawl space closed	Feb. 2 to Feb. 7	7.19	30.9	48.1	61.4	64.8	48.0	65.6	66.4	68.0	48.6	31.9	71.2
3.	Enclosed radiator, crawl space closed	Feb. 9 to Feb. 13	6.69	29.2	48.5	62.1	65.4	49.4	65.9	66.8	68.0	48.7	34.6	71.0
4.	Unenclosed radiator, crawl space closed.	Feb. 16 to Feb. 21	6.35	32.3	50.1	62.8	65.8	51.0	66.7	68.7	69.1	51.3	37.9	71.3
5.	Unenclosed radiator, crawl space ventilated	Feb. 23 to Feb. 27	8.99	32.2	42.9	60.1	63.5	37.6	64.3	66.7	66.0	41.6	34.4	71.3

If G is defined as the average gradient from point A to point B in degrees F per foot for each degree F difference between point B and Bogey temperature, then

G = 0.0361 with crawl space ventilated
G = 0.0283 with crawl space closed

Observed value of U = 0.30

U = Heat loss, Btu per hour for each square foot and for each degree F difference in temperature between air 30 in. above and air 12 in. below floor.

FIGURE 12

It is believed that the observed factors shown in table 6 will be found suitable for estimating heat losses in small houses through floors of the types tested because the test structure was purposely designed to have about the same ratio of exposed wall area to floor area as would exist in a one-story house 25 ft sq.

3. Temperature Distribution

The average temperature distribution observed on the surfaces of the floors are shown in figures 5 to 12, inclusive. The average for all observations and the average differences in temperature between the floors at the center of the room and the air 30 in. above the center are given in table 8.

Table 8.—*Temperature distribution on floors*

[Test conditions: Air temperature at center of room 30 in. above the floor 70° F; ground temperature at 1-ft level 38.2° F]

Floors	Observations				
	Floor surface, distance from wall—			Difference in temperature between—	
	12 in.	30 in.	66 in.	Air and floor surface	Floor surface at 66 in. and at 12 in. from side wall
SLAB FLOORS LAID ON THE GROUND					
	°F	°F	°F	°F	°F
No. 1	60.1	63.1	65.2	4.8	5.1
No. 2	60.4	63.5	65.7	4.3	5.3
No. 3	62.0	63.9	65.7	4.3	3.7
No. 4	60.0	64.0	65.8	4.2	5.8
FLOORS LAID OVER CRAWL SPACES					
No. 5					
Open	60.9	61.0	62.4	7.6	1.5
Closed	62.6	62.9	64.5	5.5	1.9
No. 6:					
Open	55.0	56.8	57.4	12.6	2.4
Closed	60.1	61.7	62.4	7.6	2.3
No. 7:					
Open, bare	59.3	61.0	61.8	8.2	2.5
Open, carpeted	52.7	53.2	53.2	16.8	0.5
Closed, bare	59.6	61.3	62.0	8.0	2.4
Closed, carpeted	58.8	59.6	60.6	9.4	1.8
No. 8:					
Open	59.7	63.5	64.2	5.8	4.5
Closed	62.1	65.3	66.1	3.9	4.0

The data show that the temperature gradients across the floors were smaller and, therefore, in general, conditions were better in this respect for floors laid over crawl spaces than for those laid on the ground. On the other hand, the difference in temperature between the floor and the air above it was less and, therefore, in general, conditions were better in this respect for the floors laid on the ground than for those laid over crawl spaces.

Of the bare floors, wood floor 5 had the least lateral temperature gradient. Of the floors laid over crawl spaces, insulated concrete floor 8 and wood floor 5 had temperatures closer to that of the air above them than the other floors.

The thermocouples on floor 7 were under the rug, so that the readings made with the rug in place are useful in indicating the horizontal temperature gradient, but the difference shown between floor-surface temperature and air temperature 30 in. above the floor is not comparable with the others recorded because in all other cases the floors were bare.

4. Condensation on the Test Floors

It is known that condensation on concrete floors or on surfaces adjacent to them can be a source of difficulty, especially in summer. In order to determine to what extent condensation would occur on the concrete floors, the test structure was gently ventilated with outside air under summer conditions. For one part of the test period all floors were left bare; during another part, some were covered with rugs. Although no condensation was visible, the rugs gained in weight. This fact may indicate that slightly worse atmospheric conditions would have resulted in visible condensation and eventually would have caused the rugs to deteriorate.

Sufficient data to generalize are not available, but it may be necessary to remove rugs or other insulating bodies from concrete floors during the summer in climates with a relative humidity similar to that of Washington, D. C.

The amount of condensation will, of course, be increased by cooking or washing operations, which liberate water vapor within a house.

IV. SUMMARY AND CONCLUSIONS

Information gathered during these tests indicates that, as far as warmth or heat loss is concerned, a concrete floor may as well be placed on the ground as to be laid over an unheated crawl space. This conclusion does not apply to a floor laid over a closed crawl space containing heating pipes or ducts. Such a floor would undoubtedly be warmer in winter and therefore more comfortable than a concrete floor laid on the ground or a concrete floor laid over an unheated space.

Insulation at the edge was found to lower the heat loss from a floor. An arrangement such as that shown for floor 3, or one similar in principal, for insulating slab floors laid on the ground is probably practicable in many cases. Installation of an insulating barrier at the edge of a floor laid above a crawl space complicates the support problem, and the expense may make its use inadvisable. A wood floor requires no special insulating treatment at the edge.

The data indicate that insulation at the edge of the floor is much more important for floors laid on the ground, so far as warmth in winter is concerned, than insulation under the center of the floor. Water may be prevented from entering the floor structure from underneath by using crushed stone, cinders, or gravel, in a depth of a few inches, and a layer of tar paper or other material impervious to water. Such a layer of insulating material between the floor and the mass of earth beneath may also permit the floor temperature to follow the changes in temperature of the air above it more closely. This would lessen the probability of condensation on the floor surface in summer, since, if the floor can be sufficiently warmed by the air at the beginning of a period of warm weather, condensation on the floor will not occur because the temperature will be above the dew point at all times.

The tests described in this report were made with special reference to small houses, but there appears to be no reason why the conclusions are not applicable to large structures as well.

For estimating design heat losses from slab floors on the ground, factors are suggested for use in three formulas, as follows:

$$Q=LF_1DD$$
$$Q=LF_2(T_{is}-T_{os})$$
$$Q=LF_3(T_{is}-T_g),$$

in which

Q=heat loss from floor, Btu per hour;
L=length of edge of floor adjacent to exposed wall of building, feet;
DD=number of degree-days occurring in month preceding instant for which estimate is made;
T_{is}=temperature maintained within building, degrees Fahrenheit;
T_{os}=average outside temperature during a week preceding instant for which estimate is made;
F_1=heat loss factor, Btu per hour for each foot of exposed edge and for each degree-day occurring during the month preceding the instant for which the estimate is made;
F_2=heat loss factor, Btu per hour for each foot of exposed edge and for each degree Fahrenheit average difference in air temperature inside and outside the building during a week preceding the instant for which the estimate is made;
F_3=heat loss factor, Btu per hour for each foot of exposed edge and for each degree Fahrenheit difference in temperature between the air above the floor and the ground 1 ft below the surface, at a distance of 35 ft from the structure, at the instant for which the estimate is made.

Of the three factors, F_1, F_2, and F_3, it is believed that F_3 would yield the best estimate of floor heat loss. However, since ground-temperature data for many localities are not available, the use of F_3 may, in some instances, be impracticable.

For general purposes, factor F_2 is probably the most adaptable because of the possibility of estimating with reasonable accuracy the average temperature during the coldest week occurring in a locality. This factor will probably yield more accurate results than F_1 because so many houses are maintained at other temperatures than 65° F, on which F_1 is based.

Factors for the slab floors tested are given in tables 3, 4, and 5. The data are probably sufficiently accurate basis for many estimating purposes because the floor heat loss is likely to be small compared to other losses. However, the data are incomplete in that they do not cover the cases of frozen ground and of snow-blanketed ground. To supply data, it would be necessary to repeat the tests in a colder climate.

No reason is apparent why the data are not applicable for regions where the average outdoor temperature does not remain continuously below freezing for more than a day or so, except that snow, which is an insulator, may decrease the floor heat loss.

The data indicate that insulating the floor at the edge is beneficial both in saving heat and in reducing lateral temperature gradients across the floor.

The data on floors laid over crawl spaces indicate that the factors contained in handbooks are suitable for estimating heat losses through such floors, except in the case of a floor which is heavily insulated on the underside. In this case, the edge loss increases largely in comparison to the total loss through the floor, and this may result in an underestimate unless it is taken into consideration. The number of factors involved indicate that heat losses through floors laid over crawl spaces should be computed on the basis of an estimated crawl-space temperature. For a continuously ventilated crawl space, the temperature should be assumed to be the same as the outdoor temperature.

The drawings and graphs for this report were prepared by E. J. Schell.

WASHINGTON, November 9, 1944.

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