

### FURRING FOR ARCHITECTURAL CONCRETE WALLS— THERMAL INSULATION

**T**HE PURPOSE of furring or otherwise insulating the walls of buildings to increase thermal resistance is twofold: first, to minimize heat loss; and, second, to prevent condensation of air-borne moisture on the inside surface of exterior walls. Sometimes buildings are insulated to maintain more comfortable temperatures or to maintain especially low temperatures, as in cold storage buildings, by preventing the transmission of heat from the outside to the inside. The problem involved is essentially the same as reducing heat loss and will not be considered independently.

#### HEAT LOSS

Not all heat loss occurs by transmission through the walls and roof of a building; in fact by far the greatest loss may be through the glass of windows and by infiltration of air around doors and windows and through open joints in the construction. In a complete study of heat losses, due consideration must be given to all these causes of loss. However, the discussion here will be confined to the heat transmission through building walls of architectural concrete and the necessity for furring under certain conditions.

Heat transmission and the necessity for furring depend upon a number of factors. Those of principal importance are:

1. The inside and outside temperatures or, more specifically, the difference in temperature of the two sides of the wall;
2. The materials of which the wall is constructed;
3. The thickness of each part;
4. Air spaces between component parts;
5. The rate of movement of air over the surfaces;
6. The time interval.

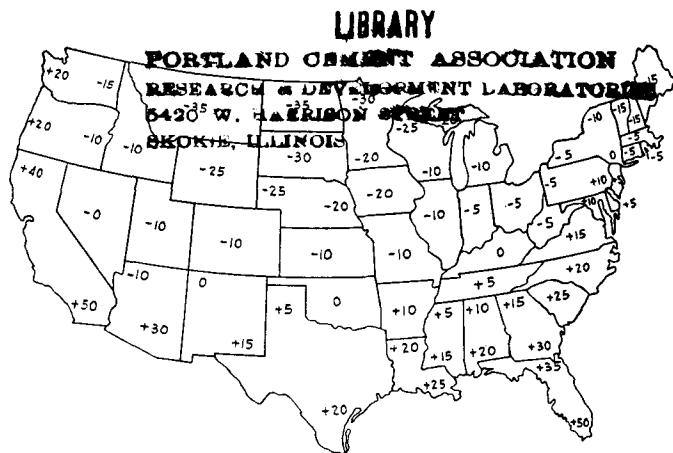


FIG. 1. AVERAGE OUTSIDE MINIMUM TEMPERATURES FOR HEAT LOSS CALCULATION.

#### INSIDE TEMPERATURE

The inside air temperature which must be maintained depends upon the occupancy of the building or that part of the building under consideration. The temperature at the "breathing line" is the one generally used in heat loss computations unless the ceiling is more than 15 ft. high.

Commonly maintained inside temperatures are given in Table I\*.

TABLE I

Type of Building (Occupancy)	Temperature Deg. F.
Warm air baths . . . . .	120
Steam baths . . . . .	110
Hospital operating rooms . . . . .	85
Bath rooms . . . . .	85
Paint shops . . . . .	80
Hospitals . . . . .	62-75
Public buildings . . . . .	68-72
Residences . . . . .	70
Schools . . . . .	70
Factories . . . . .	65
Stores . . . . .	65
Gymnasiums . . . . .	55-60
Machine shops . . . . .	50-65
Foundries, boiler shops, etc. . . . .	50-60

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#### OUTSIDE TEMPERATURE

The outside temperature assumed for heat loss computations is somewhat a matter of judgment. In southern cities where the lowest recorded temperatures are maintained for only a few hours or a day, it is satisfactory to assume an outside temperature of 15 to 20 deg. higher than the minimum. Where the lowest temperatures may be maintained for several days, it is inadvisable to assume a temperature more than 10 to 15 deg. above the lowest recorded. There is a considerable variation in minimum temperatures in different parts of states, so local weather reports should be consulted if available. Average outside minimum temperatures for the different states and parts of states, corrected to take into account duration of the lowest recorded temperatures for use in heat loss calculations, are shown in Fig. 1.

#### THERMAL RESISTANCE

All materials possess some thermal resistance. Structural materials having high strength generally have less heat resistance than non-structural materials commonly used for insulation. The thermal resistance of a material is expressed as a coefficient in terms of b.t.u. transmitted per hour per square foot of surface per inch of thickness for a difference in temperature of 1 deg. F. between the inside and outside. Table II shows usual values for various materials.

Such coefficients are determined experimentally or by computation. Knowing the thermal properties of the component parts of the wall, the rate of heat loss through a wall or the transmission coefficient can be determined, depending upon the materials of which the wall is constructed, the thickness of the various materials, the number of reflecting surfaces (two, in case of solid walls), and the velocity with which the air on the inside and outside is moving. It is generally assumed that the outside wind velocity is 15 m.p.h. and the inside air is still. The transmission coefficient for a solid wall is expressed as:

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o} + \frac{x}{k}} \quad (1)$$

in which

$f_i$  = the inside surface coefficient, average value for still air is 1.65;

$f_o$  = the outside surface coefficient, average value for wind of 15 m.p.h. is 6.00;

$x$  = thickness of wall in inches;

$k$  = conductivity of material expressed in b.t.u. per hr. per sq. ft. per 1 deg. F. per 1 in. of thickness.

If the wall involves more than one material, the thickness of each and its conductivity must appear in the formula for the over-all coefficient of transmission, therefore:

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o} + \frac{x_1}{k_1} + \frac{x_2}{k_2} + \text{etc.}} \quad (2)$$

in which

$x_1$  and  $x_2$  = thicknesses of various materials;

$k_1$  and  $k_2$  = conductivities of various materials.

If there are air spaces between the component parts of the wall, coefficients for them must be inserted in the expression for  $U$ . In the case of a single air space as between a reinforced concrete wall and masonry furring or rigid insulation, Equation 2 becomes:

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o} + \frac{x_1}{k_1} + \frac{1}{a} + \frac{x_2}{k_2}} \quad (3)$$

in which

$a$  = conductivity of the air space which is dependent upon the width of the space, the mean temperature and the enclosing material. For average conditions a value of 1.10 is generally used.

#### Illustrative Problem No. 1

Determine the over-all heat transmission coefficient for an 8-in. solid gravel concrete wall with still air on the inside and a 15 m.p.h. wind on the outside.

$$U = \frac{1}{\frac{1}{f_i} + \frac{1}{f_o} + \frac{x}{k}} = \frac{1}{\frac{1}{1.65} + \frac{1}{6.00} + \frac{8}{12}} = 0.70$$

#### Illustrative Problem No. 2

Determine the over-all heat transmission coefficient for an 8-in. solid concrete wall with 4-in. 3-core cinder concrete masonry furring laid in contact with the concrete.

$$U = \frac{1}{\frac{1}{1.65} + \frac{1}{6.00} + \frac{8}{12} + \frac{1}{1}} = 0.41$$

It will be seen that the effect of the furring is to reduce the transmission coefficient and, consequently, the heat loss through the wall by about 41 per cent.

#### Illustrative Problem No. 3

Determine the value of  $U$  for the wall in Problem No. 2, if the furring is separated from the reinforced concrete wall by a 1-in. air space.

$$U = \frac{1}{\frac{1}{1.65} + \frac{1}{6.00} + \frac{8}{12} + \frac{1}{1.10} + \frac{1}{1}} = 0.30$$

The effectiveness of the air space is apparent by comparison of the  $U$  values in Problems 2 and 3.

TABLE II  
CONDUCTIVITIES ( $k$ ) OF VARIOUS KINDS OF  
CONCRETE, CONCRETE MASONRY AND  
INSULATING MATERIALS

Material	Conductivity ( $k$ )
<b>CONCRETE AND CONCRETE MASONRY</b>	
Concrete—Cinder.....	4.90
Concrete—Haydite.....	3.73*
Concrete—Limestone or Gravel.....	12.00
Concrete Block—Cinder	
4 x 8 x 16-in.—3-Core Partition Tile.....	1.00*†
8 x 8 x 16-in.—3-Core Block.....	0.58*†
Concrete Block—Haydite	
8 x 8 x 16-in.—3-Core Block.....	0.50*†
Concrete Block—Gravel	
8 x 8 x 16-in.—3-Core Block.....	0.90*†
<b>PLASTER</b>	
Plaster, Portland Cement.....	8.00
Plaster, Gypsum.....	3.30
Metal Lath and Gypsum Plaster, $\frac{3}{4}$ in. thick.....	4.40†
Metal Lath and Cement Plaster, $\frac{3}{4}$ in. thick.....	11.80†①
<b>INSULATING MATERIALS AND BUILDING BOARDS</b>	
Compressed Cement and Asbestos.....	2.70
Corkboard.....	0.30
Fiberboard.....	0.33
Plaster Board, $\frac{3}{8}$ in. thick.....	3.73†
Plaster Board, $\frac{1}{2}$ in. thick.....	2.82†

\*Average of values obtained in tests conducted in Engineering Experiment Station, University of Minnesota, 1935, sponsored by the American Society of Heating and Ventilating Engineers in cooperation with the Portland Cement Association. All other values in this table were taken from A. S. H. & V. E. Guide, 1949 except ① taken from 1931 Guide.

†For thicknesses stated and not per 1 in. of thickness.

## PREVENTION OF CONDENSATION

Air-borne moisture within buildings condenses on exterior walls when the wall surfaces reach a certain temperature, which varies with the inside air temperature and the relative humidity of the air. The temperature at which moisture condenses is known as the dew point. In order to avoid condensation it is necessary to prevent the inside wall surface temperature from reaching the dew point temperature, to reduce the humidity in the air, or to increase the velocity of air passing over the surface. It is generally undesirable to reduce the humidity; to increase the velocity of the air circulation usually requires forced ventilation, which may not be feasible. Prevention of condensation is then resolved into minimizing the heat loss through the walls so as to keep the inside surface temperature above the dew point. The necessity for furring can be determined

by ascertaining for a given set of conditions the over-all heat transmission coefficient at or above which condensation will take place and comparing that value with the  $U$  value of the unfurred wall.

The minimum heat transmission coefficient to prevent condensation may be determined from the formula:

$$U = f_i \left( \frac{t - t_1}{t - t_0} \right) \quad (4)$$

in which

- $f_i$  = the inside surface coefficient (1.65);
- $t$  = the inside air temperature;
- $t_0$  = the outside air temperature;
- $t_1$  = the wall surface temperature (dew point).

Dew point temperatures to the nearest degree F. for various relative humidities and temperatures are shown in Table III. Normal room humidity during the heating season should be maintained at between 30 and 40 per cent.

TABLE III

DEW POINT TEMPERATURES—DEGREES F.

Dry Bulb or Room Temperature	Relative Humidity—Per Cent									
	10	20	30	40	50	60	70	80	90	100
40	-9	5	13	19	24	28	31	34	37	40
45	-5	9	17	23	28	32	36	39	42	45
50	-1	13	21	27	32	37	41	44	47	50
55	3	17	25	31	37	41	45	49	52	55
60	6	20	29	36	41	46	50	54	57	60
65	10	24	33	40	46	51	55	58	62	65
70	13	28	37	45	51	56	60	63	67	70
75	17	31	42	49	55	60	65	68	72	75
80	20	36	46	54	60	65	69	73	77	80
85	23	40	50	58	65	70	74	78	82	85
90	27	44	55	62	69	74	79	82	86	90

Illustrative Problem No. 4

Determine the minimum value of  $U$ , above which condensation will form if the room temperature ( $t$ ) is 70 deg. F., the outside temperature ( $t_0$ ) is -10 deg. F., and the relative humidity is 40 per cent.

From Table III, the dew point ( $t_1$ ) = 45 deg. F.; then

$$U = \frac{1.65 (70 - 45)}{70 - (-10)} = 0.52$$

The 8-in. solid concrete wall in Problem No. 1 would require furring, or the thickness might be increased to reduce the  $U$  value. The furred walls in Problems No. 2 and 3 are satisfactory because the  $U$  values are considerably less than 0.52.

By means of Fig. 2, the maximum allowable over-all coefficient of heat transmission ( $U$ ) can be obtained for any inside, outside, and dew point temperatures. Simply obtain from Table III the dew point temperature corresponding to the inside temperature and the relative humidity maintained. Enter Fig. 2 at the left with the difference between

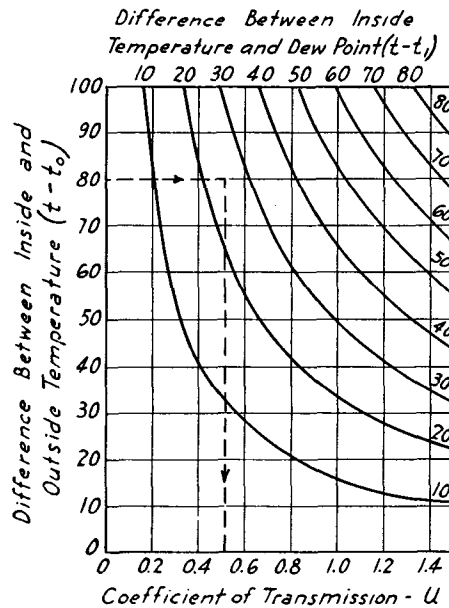


FIG. 2. MAXIMUM ALLOWABLE HEAT TRANSMISSION COEFFICIENTS TO PREVENT CONDENSATION.

the inside and outside temperatures, then trace horizontally to the curve representing the difference between the inside temperature and the dew point. From the intersection follow down to the bottom of the figure and read the value of  $U$ . This value may then be compared with the  $U$  value for any wall under consideration computed by Equations 1, 2 or 3 or taken from Table IV. If the  $U$  of the wall is greater than that necessary to prevent condensation, some change in the thickness or construction of the wall must be made to reduce the  $U$  value below the allowable maximum, if condensation is to be prevented.

FURRING

It has been shown that, under certain conditions, furring of architectural concrete walls is necessary to prevent condensation. The selection of the type of furring depends primarily upon:

1. Extent to which the conductivity of the concrete wall must be reduced;
2. Character of the interior surface desired;
3. Cost.

Other considerations are resistance to fire, moisture and vermin.

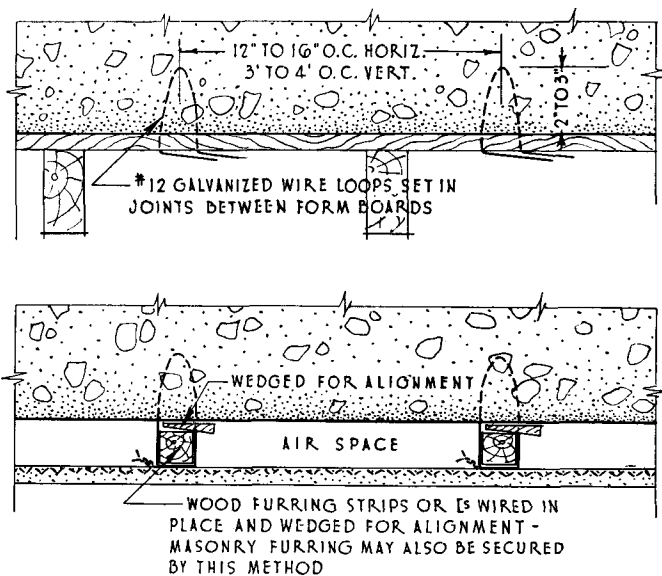
In Table IV the effectiveness of a variety of methods of furring is shown by the respective values of the heat transmission coefficients. Having determined the required thermal resistance by Equation 4, a wall thickness and type of furring presenting the desired interior finish and having the required thermal resistance,  $U$ , can be selected from the table. The cost of furring selected will depend upon local labor and material prices and the ease of installation. No cost figures have been included in Table IV because of the numerous variables which must be taken into account.

Furring must be securely anchored to the reinforced concrete wall, whether the furring consists of hollow masonry, lath and plaster, or some type of rigid insulation. There are numerous patented anchors on the market which are quite satisfactory for this purpose. Wire is also used, particularly

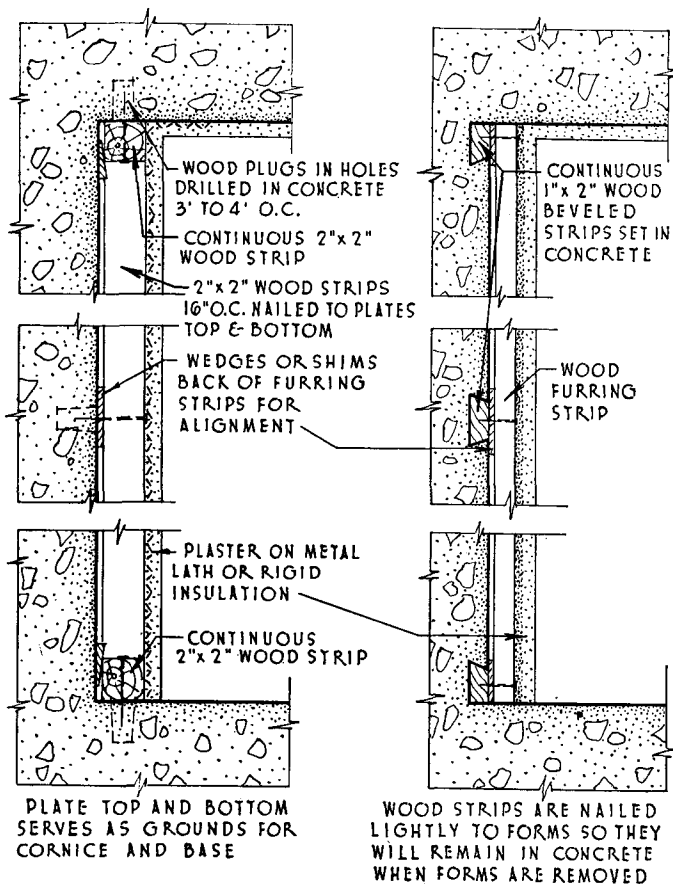
**TABLE IV**  
**HEAT TRANSMISSION COEFFICIENTS (U) FOR**  
**ARCHITECTURAL CONCRETE WALLS**

No.	Description of Furring	Thickness of Concrete			
		6 in.	8 in.	10 in.	12 in.
1	Plain wall—no furring . . . . .	.78	.70	.62	.56
2	Reinforced concrete wall with 4-in. 3-core cinder block furring laid in contact with concrete wall . . . . .	.44	.41	.38	.36
3	Reinforced concrete wall with 4-in. 3-core cinder block furring laid with 1 in. air space between furring and concrete wall . . . . .	.31	.30	.28	.27
4	Same as No. 2 except ½ in. portland cement plaster on furring . . . . .	.43	.40	.37	.35
5	Same as No. 2 except ½ in. gypsum plaster on furring . . . . .	.41	.39	.36	.34
6	Same as No. 3 except ½ in. portland cement plaster on furring . . . . .	.30	.29	.27	.26
7	Reinforced concrete wall with ¾ in. portland cement plaster on metal lath furred 1 in. or more . . . . .	.44	.41	.38	.36
8	Reinforced concrete wall with ¾ in. gypsum plaster on metal lath furred 1 in. or more . . . . .	.41	.39	.36	.34
9	Reinforced concrete wall with ½ in. portland cement plaster on 1 in. corkboard set in mastic . . . . .	.19	.18	.18	.17
10	Reinforced concrete wall with ½ in. gypsum plaster on ½ in. plaster board furred 1 in. or more . . . . .	.37	.35	.33	.31

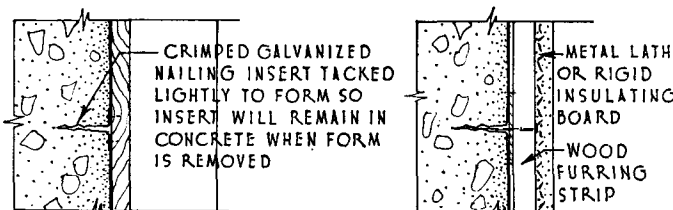
for attaching furring strips and channels to the concrete wall. Whether a patented device or common wire is used, only galvanized or non-corrosive metal should be used. Figs. 3 to 6 illustrate various methods of securing the different types of furring listed in Table IV.



**FIG. 3. WIRE LOOPS.**

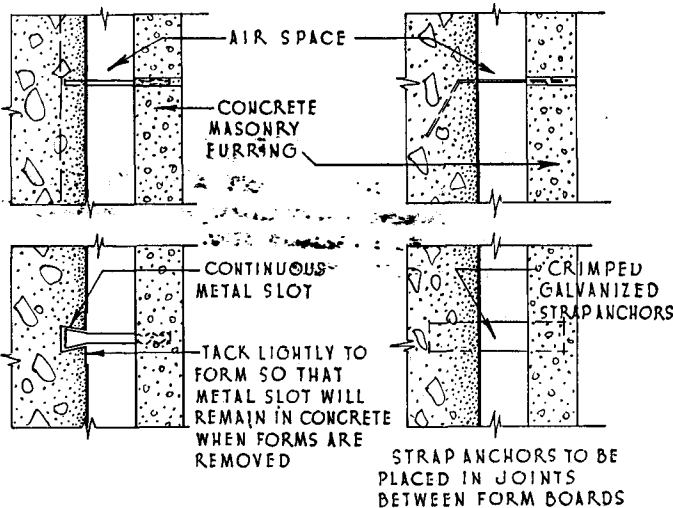


**FIG. 4. WOOD PLUGS OR STRIPS.**



STRAPS OF CRIMPED GALVANIZED IRON MAY BE DOUBLED AND SET IN JOINTS BETWEEN FORM BOARDS

**FIG. 5. CRIMPED NAILING INSERTS.**



THESE TYPES OF FURRING ANCHORS MAY BE USED FOR ALL MASONRY FURRING

**FIG. 6. CONTINUOUS SLOT AND STRAP ANCHORS.**