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HEAT TRANSFER MEASUREMENTS IN CONNECTION WITH THERMAL INSULATION OF LOW-COST HOUSING

The objectives, procedure, and scope of the Bureau research program on building materials with respect to their use in low-cost housing, are outlined in Letter Circular 502. Each separate project is described in detail in an additional letter circular such as this. While the research as a whole deals mainly with studies of structural elements, it includes consideration of special problems such as durability, thermal insulation, ventilation, and standardization.

The program on thermal insulation in connection with the low-cost housing program includes a number of separate projects. The general purpose of the work is to provide data on the insulating value of materials and constructions where such data are now lacking or conflicting, and to investigate the effect of moisture on the insulating qualities of materials. The economy of using the several materials can then be determined.

1. Heat Transfer through Insulating Materials in Thicknesses up to Four Inches

For some years the opinion has been held in various quarters that the thermal conductance of fill insulating materials in so-called "full wall thickness" (about 3 1/2 to 4 inches) is considerably less than would be calculated from tests on a one-inch thickness. A recent paper on this subject contains data to support this view. In addition, the conductance was found to vary with the temperature difference across the sample during test. There is no apparent reason for these anomalous results, and if true they are of considerable importance in determining the relative economy of insulating layers of different thickness. To determine the facts, it is planned to make measurements on fill and other insulations in thicknesses up to four inches. For this purpose a three foot square "hot plate" conductivity apparatus will be built with a new type of sheet metal guard ring. The principle of this guard ring is to maintain, by electric heating, a substantially constant temperature gradient along a sheet metal strip extending from the hot to the cold plate all around the edges. The strip is thermally insulated from the edge of the hot plate, and the portion of the strip adjacent to the edge of the hot plate maintained at the same temperature as the latter by means of a separate heater.

If the results obtained on a few light fill types of insulation are in agreement with results already obtained in small scale tests, relatively few measurements on a large scale will need to be made on insulating materials, since tests on a small scale are much more convenient and rapid. If, on the other hand, the anomalous effects noted above are substantiated in whole or in part, a much longer program will be required, the extent of which will depend largely on the preliminary results obtained.

2. Heat Transfer through Wall Sections

Data are already available on the insulating properties of many wall types which are of interest in low-cost housing. Some of these data are published in N.R.S. Research Paper R.P. 291. On certain types of walls which have not been investigated such as those containing steel studs measurements will be made on typical sections, which seem to be promising from other standpoints.

In making these tests, the apparatus briefly described in the previous section, with some modifications, will be utilized. Two similar hot plates will be used, if necessary, so that tests can be made on 3 by 6 feet panels. No cold plates will be required, the apparatus being housed in a constant temperature room.

In this method of test, the outside surface of the wall is exposed to the air while the inside surface is either in contact with the hot plate or separated from the latter with a thin flexible insulating layer. In either case, the inside surface coefficient (surface to air) of the wall is not obtained, but adequate data on this factor in heat transfer through walls are already available. The object of the thin insulating layer between wall surface and hot plate is to interpose a thermal resistance equivalent to that between the inside air and the wall surface under actual conditions. In this way very nearly the same temperature distribution over the surface of the wall is obtained in the test as would occur in service condition. This is of importance only in the case of walls having steel studs which cause the inside surface temperature along the line of the stud to be somewhat colder than the adjacent portions of the wall. Walls in which this effect is marked will become a nuisance on account of the rapid deposition of dust on the wall along the line of the stud, an accentuation of the so-called lath mark phenomenon.

3. Heat Transfer through Reflective Insulation

Considerable data on reflective types of insulation are already available, and these will be reviewed and put into more usable form. This type of insulation may find considerable application in low-cost houses. If it develops that more data are necessary, measurements will be made in the large conductivity apparatus already mentioned.

4. Effect of Moisture on the Thermal Conductivity of Insulating Materials

All materials consisting primarily of vegetable or animal matter are more or less hygroscopic. When in equilibrium with air at a definite temperature and relative humidity, these materials contain definite percentages of water. So long as the relative humidity remains constant, the effect of moderate changes in temperature on the amount of water present is relatively small. The data available on the effect of hygroscopic water on the conductivity of insulating materials are very few and conflicting.

There is a generally prevalent idea that the conductivities of hygroscopic materials normally containing a small percentage of water are much higher than those of the same materials in a bone dry condition. A few tests made here indicate that this is not the case, but in order to settle the question a more systematic investigation is required. Apparatus is being built to measure the conductivity of insulating materials under definite and controllable relative humidity conditions. Our present small conductivity apparatus will be inclosed in an air tight box, in which the relative humidity can be controlled by exposing saturated solutions of various metallic salts. If the effect of moisture content is not very large, the number of materials which may be used for thermal insulation is greatly increased.

This program will also include routine measurements on such new thermal insulating materials as may appear on the market from time to time.

5. Heat Losses Through Doors and Windows

Recent general use of effective insulation of walls and ceilings in dwellings, which is a necessity if adequate air conditioning is to be realized, has proceeded without much attention to the windows and doors. In modern insulated buildings the heat losses through the ordinary windows and doors both by air leakage and by conduction through glass are all out of proportion to losses through walls and ceilings.

It is proposed to make a thorough study of the heat losses in cold weather and the entrance of heat in hot weather through doors and windows and window openings, including air leakage and heat transfer by conduction and radiation through the glass. This will include not only various kinds of doors, but also single windows, with and without effective weatherstripping, with and without storm windows, as well as new developments in the way of double glazed or other windows. It will include also metal windows since the heat transfer through the metal itself often becomes important. Metal windows with both single and double glazing will be studied with attention to differences which may arise from different distances apart of the two glazings.