experimental measurements conducted at the *National Bureau of Standards.*[9] Although the conductances of air spaces vary to some extent with thickness in the range over ¾ in., average values are tabulated for the range from ¾ in. to 4 in., for all except horizontal spaces with heat flow downward. The error involved by averaging is less than 10 percent in the extreme case and less than 5 percent in most. For more exact values Reference 9 may be consulted.

For narrow air spaces, which may be defined as those for which the product of the cube of the thickness of the space in inches times the temperature difference (Fahrenheit degrees) across the space is less than 3 for heat flow horizontally or downward, or less than 1 for heat flow upward, the conductance is the sum of the radiative heat transfer coefficient and that for conduction alone through air, since convection is practically suppressed. The radiation component can be computed by means of Equation 4 and Table 4 of Chapter 5; the conduction component can be computed using the conductivity of air at the appropriate mean temperature (see Table 1, Chapter 5).

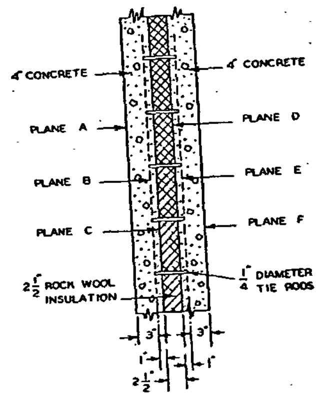

FIG. 5. SECTION OF CONCRETE WALL HAVING STEEL TIE RODS AND INSULATION

The effects of different mean temperatures, temperature differences, and effective emissivities are indicated in Table 3 of this chapter, Section B. As indicated, use may be made of interpolation and moderate extrapolation of conductance values in the table to obtain conductances for conditions moderately different from those given. Interpolation of resistance values is not recommended, especially in relation to emissivity values.

Table 3, Section C gives values for the surface reflectivities and emissivities of materials used as boundaries of air spaces in building construction, for total radiation at ordinary building temperatures. Effective emissivities for various combinations of these materials, for use in conjunction with Section B of Table 3, are given in the last two columns of Section C.

When considering heat transfer across air spaces in building construction, the emissivities of the boundary surfaces must be known. The possibility of change in emissivity of highly reflective surfaces due to exposure to conditions promoting chemical action, deposition of dust, soiling of the surface, or the application of coatings, even though transparent to the eye, must be

considered in selecting a material for use.[10] Surface emissivity values should be obtained by tests.

PRACTICAL COEFFICIENTS AND THEIR USE

For practical purposes it is necessary to compute average coefficients that may be applied to various materials and types of construction. Table 4, gives representative values for dry materials at 75 F mean temperature, as selected by the ASHAE Technical Advisory Committee on Insulation. Since there may be some variation in the materials and in test conditions, these selected values may not be in exact agreement with published data of all manufacturers. The exact value for the conductivity or conductance of a certain manufacturer's material can only be secured from unbiased tests or guaranteed by the manufacturer.

Caution

The conductivity or conductance values given in Tables 3 and 4 are taken from values obtained in most cases by the guarded hot plate method *ASTM* Standard C-177-45 which states,

"Because of the requirements prescribed in this method as to conditions under which conductivity tests shall be made, it should be recognized that the conductivity coefficients obtained will not necessarily be the values pertaining under all service conditions. As an example, the method provides that the conductivity coefficient shall be obtained by test on dry specimens, while in service such a condition will seldom be realized."

The user should realize that the average conductivity and conductance values given in Table 4 do not necessarily apply to all products of the same general description. In using these values, judgment should be exercised with regard to the extent to which the product (either as received or as applied) will comply with the tabulated values. Exact conductivities or conductances for specific materials should be obtained from the manufacturer.

Because U values for heat flow upward, such as for ceilings in winter, may differ greatly from U values for heat flow downward, such as for ceilings in summer, a serious error may be made in calculating heat losses or gains if the appropriate U value is not used. (See Chapter 13 for recommended temperature gradients for cooling loads.)

Due to the inconsistency of actual building construction, because of the human element, many designers do not use overall coefficients of transmission lower than 0.10 for walls and particularly roofs, except where the construction is installed under continuous supervision. It should also be noted that these coefficients do not include any factor of safety and that when no supervision is used, some designers incorporate a 10 percent factor of safety.

Computed Heat Transmission Coefficients

In the analysis of any wall construction for the purpose of calculating the overall coefficient of heat transmission U, it is first necessary to determine the paths of heat flow, that is, whether they are parallel or series, or a combination of both. This is in accordance with the basic laws of heat transfer which state that *in parallel flow the conductances are additive*, while *in series flow the resistances are additive.* Likewise, in order to determine the total resistance for the wall, the conductance must be known.

The importance of this analysis cannot be over-emphasized. This is