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INSULATION THICKNESSES FOR HOUSES

By

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Insulation thicknesses for houses

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Insulation thickness affects construction costs, fuel costs, and sometimes the cost of the heating system. The relationships among these costs are discussed in this note and illustrated with charts in which several typical house constructions and the effects of climate and fuel are considered. With the aid of the charts home buyers and house builders can readily appreciate the significance of these costs and can choose insulation thicknesses that will result in minimum or near-minimum over-all expenditures. The large savings possible through the use of more insulation than the usual minimum are also shown.

This Note is concerned only with heat losses through the insulated portion of a house. Additional heat losses through windows and from air leakage are not considered, since these have no effect on the economic thickness of insulation.

How much insulation should houses have?

The amount of thermal insulation that should be installed in Canadian houses depends on a proper balance between yearly cost of fuel and cost of insulation. The optimum condition occurs when the total cost per year for fuel and insulation is at a minimum. Insulation, unlike fuel, must be paid for only once, but when its cost becomes part of the mortgage the increase in the yearly mortgage payments can be compared directly with yearly payments for fuel.

Figure 1 shows how annual heating and insulation costs vary with insulation thickness. It also gives a Total Cost Curve (fuel plus insulation which illustrates how the total costs per year dip to a minimum for the optimum amount of insulation and increase for greater or lesser thicknesses of insulation. The typical Total Cost Curve is relatively flat near the optimum point, so that there is a range of insulation thicknesses for which total costs are very nearly minimum.

Costs of insulation

The cost of installing insulation in wood frame and masonry walls and in ceilings is considered here. The insulating material in each case is mineral wool, either rock wool or glass fibre. Unit cost estimates are based on averages of information obtained from all parts of Canada. It is recognized that actual costs will vary with local practice and the skill and ingenuity of the builder, but small variations between actual and estimated insulation costs will have a correspondingly small effect upon the economic thickness of insulation.

Wood frame walls

Up to 3 5/8 in. of insulation can be installed very easily in standard stud walls, but greater thicknesses require the use of either 6-in. or 8-in studs, with consequent extra expense for material, installation, and loss of floor space. The estimated material and installation cost per square foot of wall for mineral wool batts is 4 cents plus 2 cents per inch of thickness. A 2-in. increase in stud thickness is assumed to cost 5 cents per square foot of wall; and the value of the lost floor space resulting from the use of studs thicker than 4 in. is assumed to be $4 per square foot.

Masonry walls

Masonry walls are commonly used in the Toronto area, with the interior finish applied over furring strips ¾ in. thick. Insulation more than ¾ in. thick will require thicker furring strips or framing, with associated extra costs for material, installation and lost space. Estimated costs per square foot of wall area are: 6 cents for 1-in. furring; 9 cents for 2-in. furring; 11½ cents for 3-in. framing; and 2½ cents extra for each additional inch

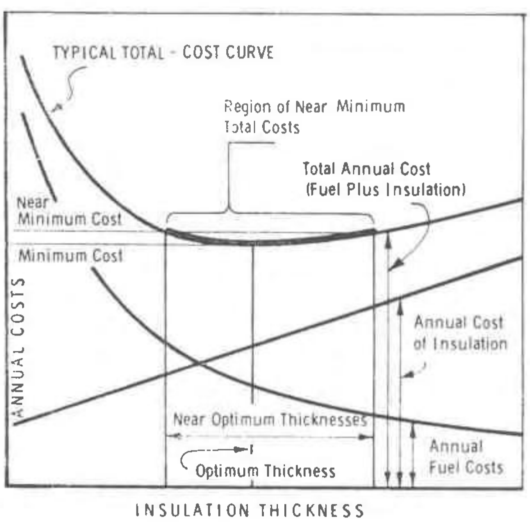

FIGURE 1 TYPICAL COST THICKNESS CURVES FOR HOUSE INSULATION

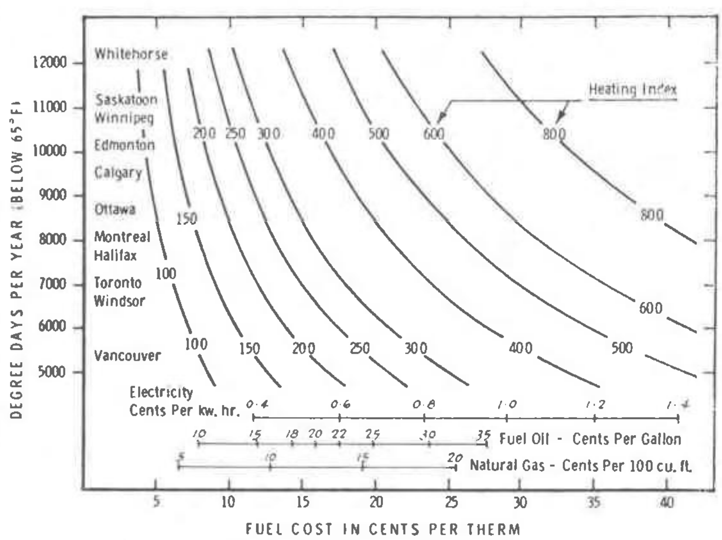

FIGURE 2 HEATING INDICES

ECONOMIC MINERAL WOOL INSULATION THICKNESSES

CITY	FUEL	OPTIMUM THICKNESS		NEAR-OPTIMUM* THICKNESS	
		Frame Walls in.	Ceiling in.	Frame Walls in.	Ceiling in.
Calgary	Gas	3	5	2	3
Edmonton	Gas	3	5	2	3
Vancouver	Oil	3	6	3	4
Regina	Gas	3	6	3	4
Saskatoon	Gas	3	6	3	4
Windsor	Oil	3	6	3	4
Toronto	Oil	3**	6	3**	4
Halifax	Oil	3	6	3	4
Winnipeg	Gas	4	7	3	5
Ottawa	Oil	4	7	3	5
Montreal	Oil	4	7	3	5
Quebec	Oil	4	7	3	5
Any area with electric heating*** and with following conditions:		6**	11	4**	8

(a) average Canadian climate (approximately 9000 degree-days) and electricity costing approximately 1 cent per kw hr, or

(b) mild Canadian climate (approximately 6500 degree-days) and electricity costing approximately 1.4 cents per kw hr

* Insulation thicknesses which give total costs within $5 of optimum per year per house.

** Values are the same for masonry walls with mineral wool insulation between suitable framing or furring members.

*** The insulation thicknesses noted here for use with electric heating take into account the savings in electric heating plant cost due to generous insulation.

of framing thickness. Lost floor space is estimated at $4 per square foot of floor area.

Ceilings with attic space

Insulation in batt or loose fill form is assumed to cost 4 cents plus 2 cents per inch of thickness per square foot of ceiling.

(Basements are usually left uninsulated, although calculations indicate that they are a source of considerable heat loss. Insulating procedures are not so well established as those for walls above grade, however, and this aspect, as well as the economic thickness to be used, merits special attention. It will be the subject of a future Note.)

Use of the charts

Total Cost Curves have been calculated precisely and are illustrated with charts. To use the charts refer first to Figure 2, from which the Heating Index for the house concerned may readily be determined. The Heating Index is used here to take into account climate conditions and the type, combustion efficiency, and cost of fuel. To use Figure 2, it is only necessary to know the degree-days (a measure of the severity of climate) and the cost of fuel. The degree-days for a few typical cities are marked on the chart. Degree-days may also be found from the nearest weather office or from Supplement

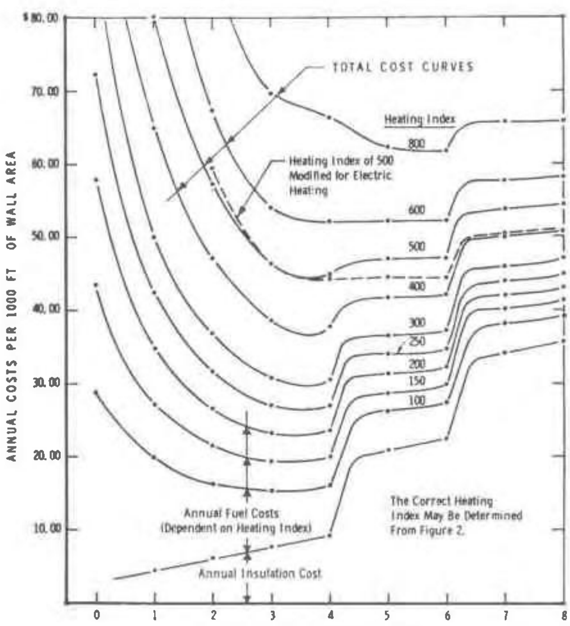

FIGURE 3A INSULATION THICKNESS VS. COST FOR FRAME WALLS

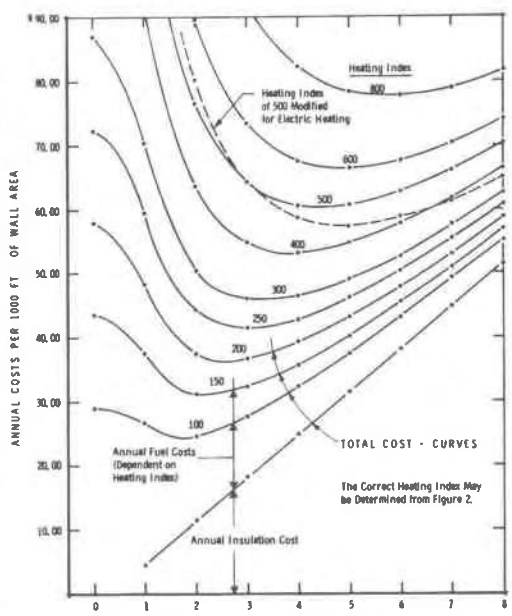

FIGURE 3B INSULATION THICKNESS VS. COST FOR MASONRY WALLS

No. 1 of the National Building Code of Canada. Unit costs for common fuels are shown on special scales at the bottom of Figure 2. In deriving these figures the heating plant efficiency was assumed to be 75% for oil and gas and 100% for electricity. Equivalent fuel costs, expressed in cents per therm, are also shown directly on the chart for use when desired.

The second step is to choose the appropriate chart (from Figures 3A to 3C) and to select the Total Cost Curve that corresponds to the Heating Index. In using the chart the curve nearest the actual Heating Index can be chosen, or the values between any two curves can be estimated. The cost variations with thickness can then readily be seen.

Abrupt increases in the Total Cost Curves for frame walls (Figure 3A) represent the cost of providing 6-in. or 8-in. framing members in place of the normal 4-in. ones. The Total Cost Curves for ceilings (Figure 3C) are valid only for roofs with attic space in which the insulation thicknesses shown on the chart can be installed without increased framing.

The optimum economic thickness of insulation corresponds to the lowest point on the Total Cost Curve. The extra annual costs of choosing insulation thicknesses other than optimum are also shown by the Total Cost Curve. The vertical scale gives the cost per year of insulating and heating 1000 sq ft of surface, the approximate area of the walls or ceiling of an average bungalow. Thus a difference of $2 on this scale represents an actual difference of about $2 in annual cost to an average homeowner.

Table I has been prepared from these charts to show optimum insulation thicknesses as well as lesser thicknesses (which give total cost per house within $5 per year of optimum) for houses in several Canadian cities. It illustrates that fuel cost has more effect than climate on economic insulation thicknesses. This Table is only a brief summary of the information available on the charts, based on approximate local fuel costs, and should be supplemented by reference to the charts.

Special cases

As a general rule, where insulation costs are significantly less than those estimated here, more than the optimum indicated by the graphs is justified, and vice versa. The estimates for annual insulation costs are based on mortgage terms of 25 years at 6¼ per cent. Changes in available mortgage terms will have the same effect as changes in insulation cost. The optimum thickness can be calculated for any special case by a method described in a paper that will be published shortly by the Division (NRC8151).

In some cases, extra insulation will reduce heat losses sufficiently to permit a reduction in the size and cost of the heating plant. These savings can help to offset the cost of the extra insulation, thereby slightly affecting the shape of the Total Cost Curves and slightly increasing the optimum insulation thickness. With electric heating this is quite important. The effect is illustrated by the Modified Total Cost Curves calculated for typical electric heating installations and drawn as dotted lines on Figures 3A and 3C. These curves show that the optimum thickness is increased by about 1 in. With typical gas or oil furnaces or boiler installations, however, there is less opportunity for this type of cost savings.

Summary

Insulation thickness directly affects the cost of insulation and the yearly cost of fuel for houses, both of which can be minimized by the use of the proper thickness indicated by the accompanying charts. Variations in costs for different thicknesses are clearly shown, and the home builder or buyer can easily choose the thickness that will give minimum, or near-minimum, costs.

(This paper is a contribution from the Division of Building Research, National Research Council and is published with the approval of the Director of the Division.)

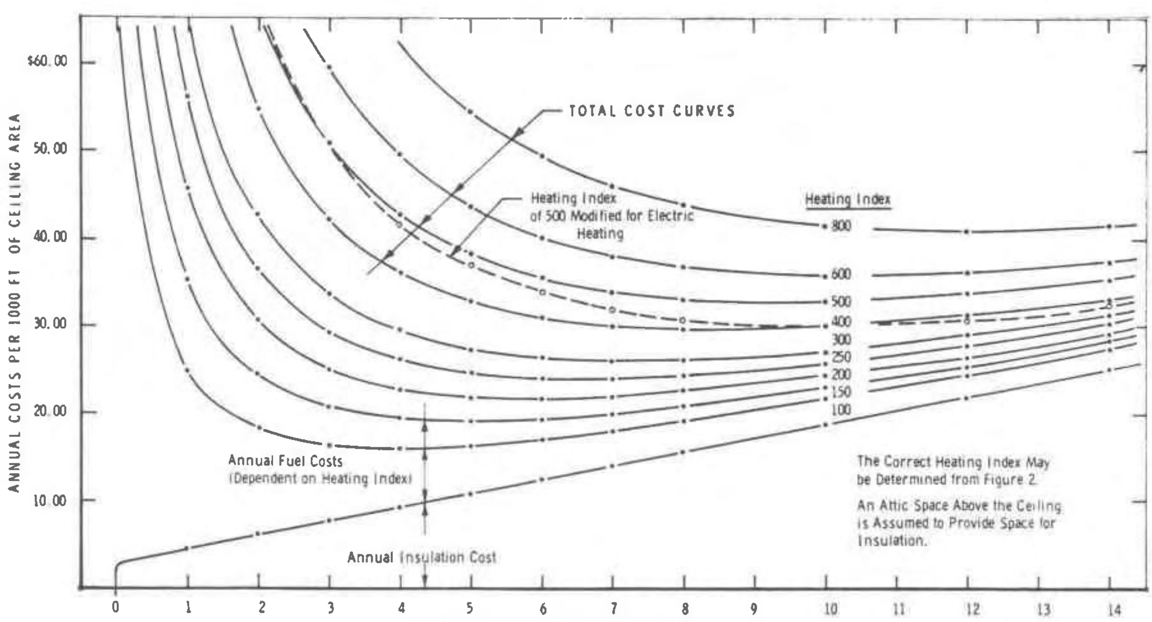

FIGURE 3C INSULATION THICKNESS VS COST FOR CEILINGS WITH ATTIC SPACE