Performance of Insulated Shallow Footings Under an Elevated Cottage

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TECHNICAL NOTE

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PREPARED FOR Inquiry and Record Purposes

SUBJECT PERFORMANCE OF INSULATED SHALLOW FOOTINGS UNDER AN ELEVATED COTTAGE

Based on experience gained with insulation installed under streets and roadways to prevent or reduce frost penetration, it should be possible to protect shallow footings from frost heaving. The opportunity to carry out some preliminary studies became available when the owners of Pickerel Bay Lodge, White Lake, Ontario, inquired about remedial methods to reduce frost heaving of footings supporting elevated cottages already in use.

HISTORY

The wood frame structure investigated is 686 sq ft in floor area and was originally founded on a series of 4- x 6- x 18-in. posts resting on concrete pads 18- x 18- x 7-in. deep. The top surface of the concrete pads was placed approximately level with the ground surface. The soil on the building site is a silty till. Because the site is only slightly above the high water level of the lake the area is highly frost susceptible.

An earlier attempt by the owners to reduce the heaving of the structure was only partially successful. They replaced the shallow footings around the perimeter with tiers of concrete blocks resting on pads about 5 ft below the ground level. The seven footings in the centre were not replaced and during the following winter the inner footings heaved more than the outer, causing considerable

differential movement. The owners believed the new perimeter footings behaved satisfactorily but, as will be shown later in the results, the new footings did not offer sufficient resistance to overcome the heaving forces generated during ice lens growth.

Because of the difficulty in constructing new footings in the stony till under the structure it was decided to try to protect these footings from freezing by placing insulation on the surface of the ground with only a thin protecting layer over it.

MATERIAL AND METHOD

Figure 1 shows the footing detail and the placement of the insulation. In some cases, as indicated, the wood posts were insulated from the surface of the concrete pad to the floor beams.

Figure 2 shows a plan of the footing locations and the insulated area. The seven centre footings (A to G) were constructed as shown in Figure 1. Experience has shown that 4 ft of lateral cover is sufficient to prevent freezing from the edges; the extent of the insulation beyond the footings is based on this.

The insulation used consisted of 2- by 4-ft sheets of an expanded polystyrene, extruded in 2-in. thickness which gave it impervious skin on both sides of the sheets. After the insulation was placed it was covered with about 2 in. of fill. Thermocouples were placed in the insulated zone under footing C which had insulation around the wood posts from the concrete pad to the floor beam of the structure. Footing B had no insulation on the posts. A thermocouple was placed directly under the insulation at the centre of footings F, E, C and B. Between footings E and B thermocouples were placed above, directly under, and 6, 12 and 18 in. below the insulation. The thermocouples were 20-gauge copper-constantan pairs with nylon insulation. EMF readings were taken weekly with a manually-operated potentiometer with reference to an ice-water bath.

Before the start of the freezing period elevations were established on all the perimeter footings with an engineers level. Levels of inside footings were established with a water-levelling device. The second survey was carried out when heave was

considered to be at its maximum based on weekly surveys of frost heave on roads in the Ottawa area.

RESULTS

Table I gives the total heave of each footing as well as the average heave for the insulated centre footings and the uninsulated perimeter footings. The perimeter footings heaved as much as 2.75 in. with an over-all average of 1.62 in.; average heave for the centre footings was 0.28 in.

Air and ground temperatures are plotted in Figure 3 (a, b, and c). The air temperatures shown in Figure 3(a) are for the Ottawa area some 60 miles from Pickerel Bay Lodge. It is interesting to compare the trends of the these air temperatures with the temperatures above and below the insulation at the site.

Figure 3(b) gives the temperature measurements for various depths under the structure as a function of time. Above the insulation, (under 2-in. fill) the thermal pattern corresponds directly with the air temperatures. The temperature immediately under the insulation was below freezing during February and March but only once, during the latter part of March did below freezing temperatures penetrate deeper than 6 in. Figure 3(c) shows temperatures beneath footings with and without insulation on the wood posts between concrete pad and floor beam in the insulated area. It is clear that only slight added protection is obtained from this additional insulation. Under the concrete pads where the posts were insulated the temperatures stayed above zero all winter; the temperatures under the pads of the uninsulated posts dropped slightly below zero just once during the winter.

DISCUSSION

Two-in.-thick insulation was not sufficient to prevent frost penetration completely during this winter that was characterized by 1780 degree days of frost so a small amount of heaving resulted; it is believed that this amount of heaving can be tolerated. The sixty-five-year average freezing index for the Ottawa area is 1900. It is thought, therefore, that 2 in. of this type of insulation will, on the average, give sufficient protection.

It was noted that the uninsulated perimeter footings heaved enough to cause jamming of the outside door. This was thought to be mainly due to the large differential heave between footings Nos. 1 and 2.

RECOMMENDATIONS

It is recommended that the perimeter footings be insulated for the 1967-68 winter season using the same technique as that used for the centre footings. This should reduce the heaving to levels not damaging to the structure. The insulation around the perimeter of the building should be covered with 3 or 4 in. of fill to protect it from damage under the walkways.

ACKNOWLEDGEMENTS

The author expresses his appreciation to Messrs. Bob Pierce and Joe Martin for taking the weekly soil temperature readings and for allowing the Division to carry out these experiments on their property.

TABLE 1

TOTAL CHANGE IN ELEVATION OF FOOTINGS DUE TO FROST HEAVING BETWEEN 5 OCTOBER 1966 AND 4 APRIL 1967

Perimeter Footings

Footing No.	Change, ft
1	0.018
2	0.163
3	0.205
4	0.213
5	0.190
6	0.151
7	0.103
8	0.088
9	0.087
10	0.212
11	0.233
12	0.115
13	0.205
14	0.102
15	0.048
16	0.027
	2.160
Average	0.135 ft or 1.62 in.

Centre Footings in Insulated Area

Footing	Change, ft
A	0.010
B	0.010
C	0.040
D	0.010
E	0.001
F	0.020
G	0.070
	0.161
Average	0.023 ft or 0.28 in.

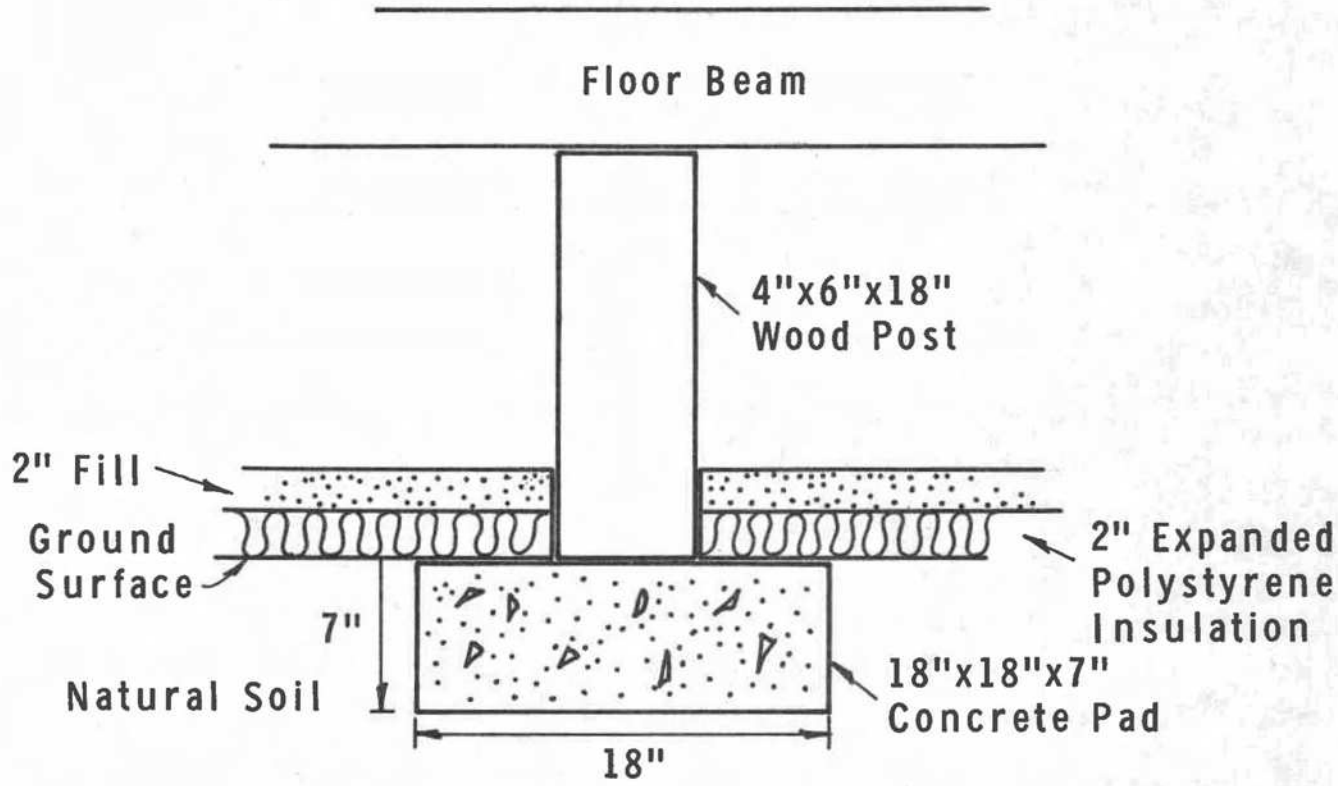

FIGURE 1

FOOTING AND INSULATION DETAIL OF CENTRE FOOTINGS

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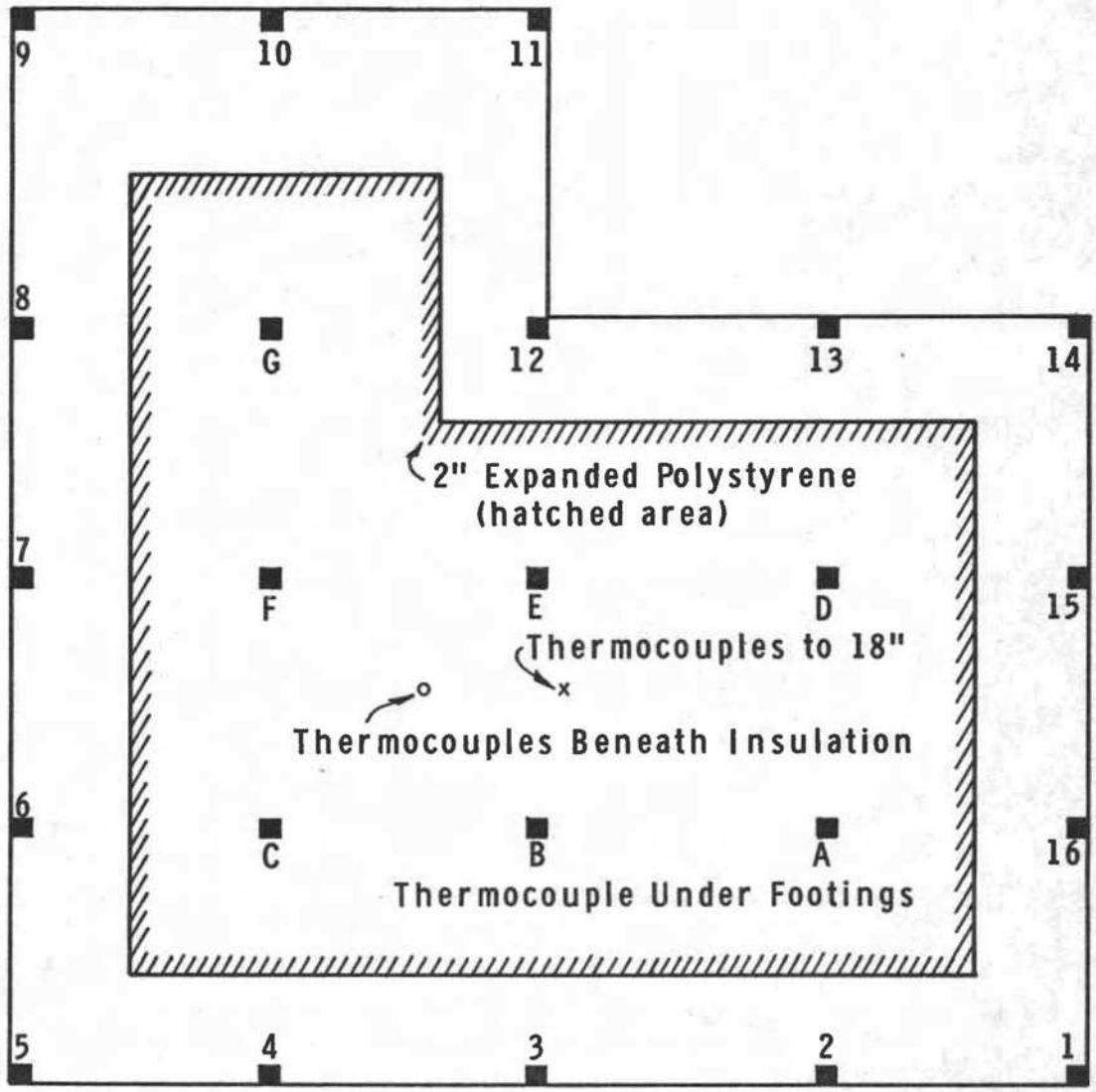

Note:

1. All Perimeter Footings - Concrete Block from Ground Surface to Approximately 5' Deep 4"x6" Wood Posts, Approximately 18" Long Between Beam and Foundations
2. Inside Footings - 4"x6"x18" Timbers on Concrete Pads 7" Thick and 18" Square
3. (a) No Insulation on Outside of Posts at A, B & F
   (b) Two Inch Thick Insulation on Post up to the Beam
   (c) Two Inch Thick Insulation on Post, from Ground Level to 6" at D, E & G

FIGURE 2

PLAN VIEW OF COTTAGE SHOWING FOOTING LOCATIONS AND INSULATED AREA

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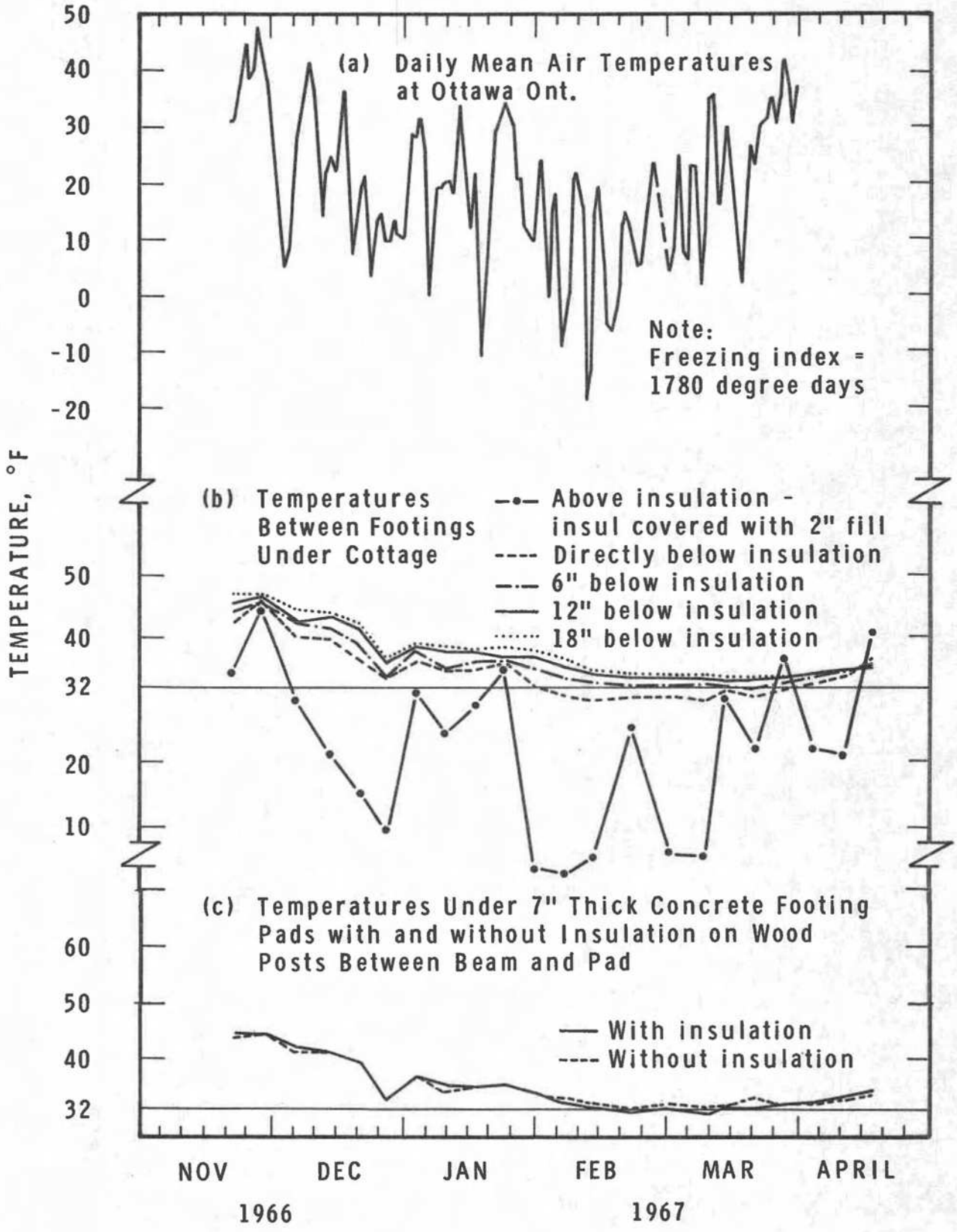

FIGURE 3

AIR AND GROUND TEMPERATURES 1966-67

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