COMPARISON OF UNDER-FLOOR INSULATION SYSTEMS

INTRODUCTION

In recent years, interest has grown in the residential marketplace for building products that contribute to energy conservation. This has resulted in the development of several new basement slab insulation products.

Some builders are installing foil-faced bubble pack under slabs. One insulation supplier is promoting the use of the window cut-out panels from steel-skin doors as under-slab insulation. These 44-mm thick polyurethane panels have the steel door skins on each side. Many builders stick with the traditional 50-mm extruded polystyrene (XPS) panels.

As the number of products available to consumers increases so does the confusion about their performance. While many of these products are very good, not all have had their thermal performance independently verified.

This study measured, in field tests, the performance of three basement slab insulation products. Each product was analysed during the heating season for its thermal performance. A comparison of thermal performance and capital cost provides a relative measure of the value of these products.

METHODOLOGY

This study monitored four new houses in Paris, Ontario, to evaluate the thermal performance of several under-floor insulation products.

In one house, the basement floor was insulated with a double-layer bubble pack with an intermediate foil layer; in the second house it was insulated with steel-skinned 44-mm polyurethane panels; and, in the third, with 50-mm extruded polystyrene. The fourth one was the control house and had no under-slab insulation.

All four basements slabs were instrumented and monitored. Each house was analysed using data gathered every two weeks from February 2004 to June 2004.

Resistance temperature detectors (RTDs) were used to measure temperature. Each house was equipped with two sets of four sensors and an indoor temperature sensor, for a total of nine sensors in each house.

Each set of four sensors was aligned vertically to measure the thermal gradient from the top of the slab through the insulation and into the soil below. One stack of sensors was installed in the centre of the slab, and the second stack of four sensors was installed near the edge of the slab, about one metre from the foundation wall. A single sensor was installed one metre above the floor slab at the centre of the room to read basement air temperature.

Key findings

The RSI values (metric) for all three insulating materials were assumed to be unknown and were calculated from the monitored data. (see Table 1). The values are for *in-situ* performance and therefore include all modes of heat transfer.

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Table 1: RSI of three insulation materials	
Insulation product	**Thermal resistance (RSI)**
44-mm, steel-skinned polyurethane	2.56
50 mm XPS	2.13
Bubble pack	0.40

Figures 1, 2, 3 and 4 on page 3 show the temperature profile through the basement floor slab for the four houses monitored over the test period. The control house produced the results in Figure 1. There was little temperature difference between the inside of the basement and the ground below; the ground temperature varied with indoor temperature, and the ground under the insulation was warmer than expected for undisturbed, deep-ground temperatures.

Bubble-pack insulation showed performance quite similar to an uninsulated floor, as seen by comparing Figure 2 to Figure 1.

The XPS performed as a well-insulated floor slab would be expected to perform (see Figure 4). There was a wide temperature difference between the inside of the basement and the ground below; the ground temperature appeared to be influenced much more by ambient in-ground conditions than by indoor temperature fluctuations; and, the ground temperatures were closer to expected undisturbed ground temperatures as determined using ASHRAE ground temperature data.

The steel-skinned polyurethane panels performed similarly to 50 mm of XPS, as shown by comparing Figure 3 to Figure 4.

As an indicator of the test accuracy, the calculated thermal resistance of the installed XPS is compared to published data. Table 2 provides the results.

Table 2: RSI comparison of XPS	
Insulation product	**Thermal resistance (RSI)**
Calculated *in-situ*	2.13
Canadian Construction Materials Center (NRC)*	1.86
ASHRAE*	1.76

** Note: both of these values are for long-term, aged material. The* in-situ *tested value is for new material.*

ECONOMIC ANALYSIS

A cost-benefit analysis of each insulation is best provided in terms of $/m²RSI—in other words, the cost to obtain a given insulating level per square metre of insulated floor.

Table 3 compares the relative costs and the cost effectiveness of the materials tested. On a pure cost per unit-area basis, 50 mm of XPS is the most expensive. The bubble pack and the steel-skinned polyurethane are about one-third the cost.

However, on a cost-benefit basis the order essentially reverses. The steel-skinned polyurethane panels have the best cost-benefit ratio, at under $2/m²RSI; XPS is in the middle at $6 to $8/m²RSI; and bubble pack has the worst cost-benefit ratio at $12 to $13/m²RSI.

Table 3: Cost effectiveness of three insulation materials			
Insulation product	**Cost per unit area ($/m²)**	**RSI value**	**Cost benefit ($/m²RSI)**
Bubble pack	4.85–5.35	0.40	12.13–13.38
50 mm XPS	12.90–17.22	2.13	6.05–8.08
44 mm steel-skinned polyurethane	4.85	2.56	1.89

Figure 1: Temperature profile for no insulation

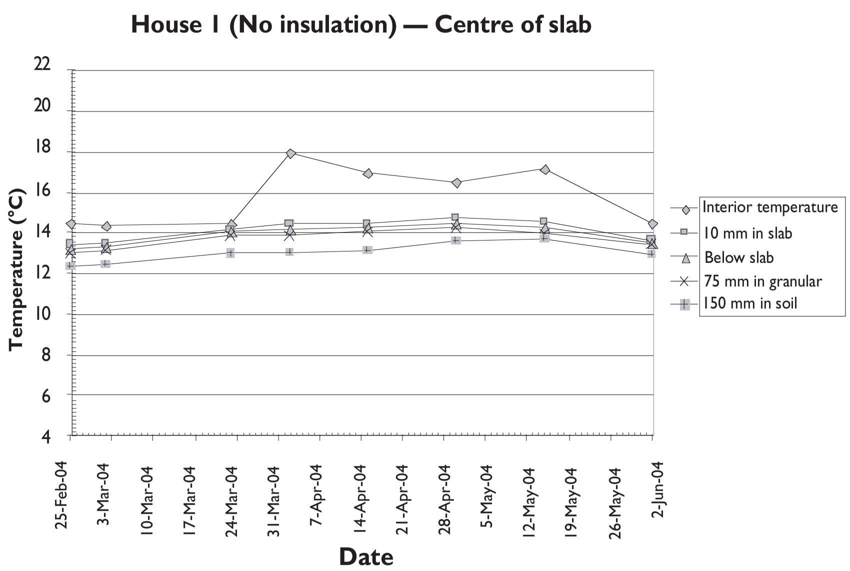


Figure 2: Temperature profile for bubble pack

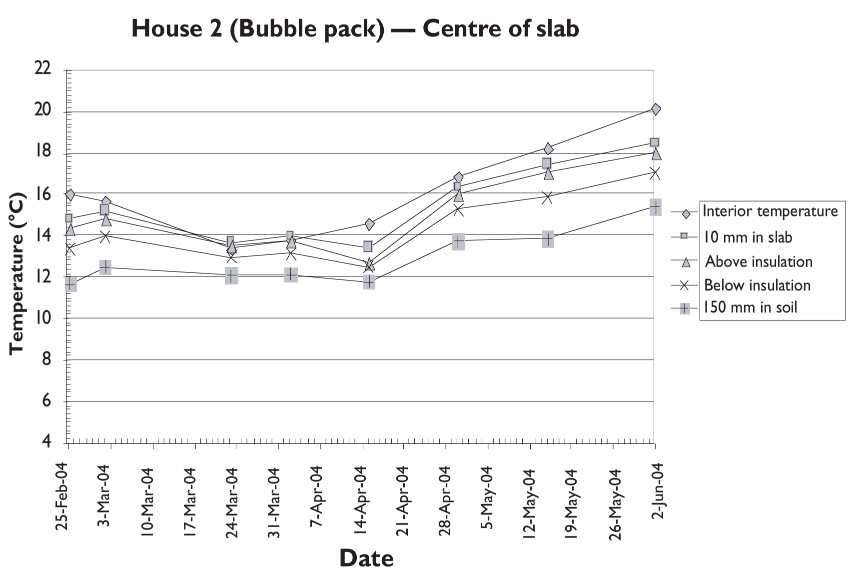


Figure 3: Temperature profile for polyurethane

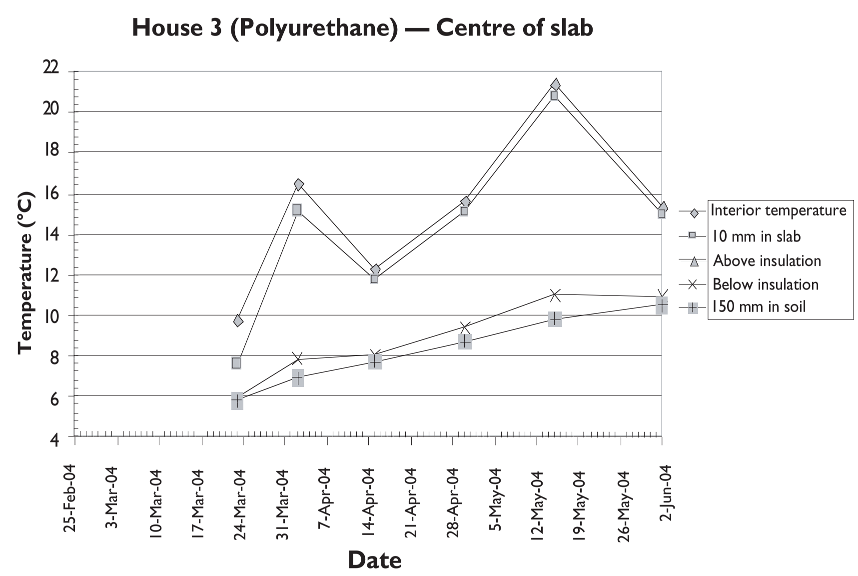
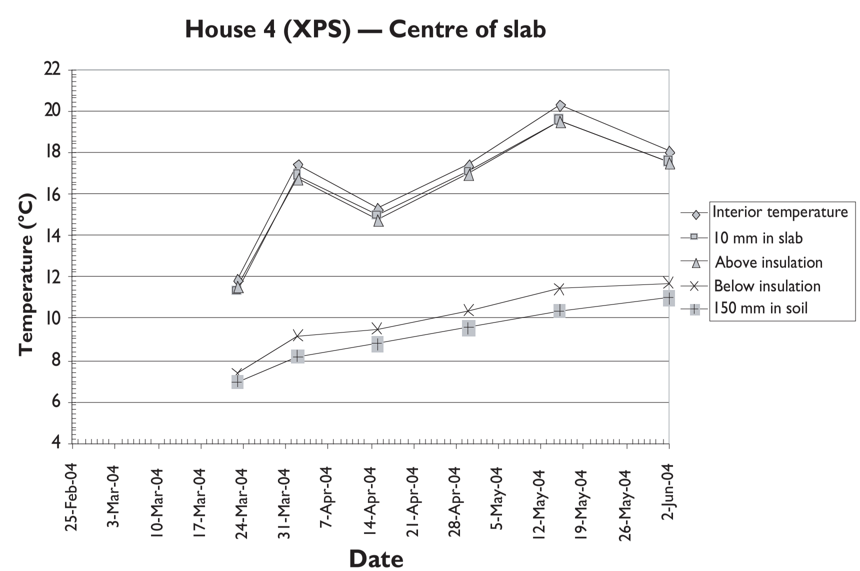


Figure 4: Temperature profile for polyurethane



CONCLUSION

The bubble-pack insulation had a low insulating value compared to the polyurethane panels and the XPS board. It's cost benefit was the poorest of all insulating materials tested.

The more common 50 mm of extruded polystyrene insulation had an RSI value similar to published data for the material. A cost-benefit analysis suggests it is a better option than the bubble-pack insulation in terms of $\$/m^2RSI$.

The steel-skinned polyurethane had an RSI value slightly better than the XPS and a much lower material cost. It was found to have the best cost-benefit value of the materials tested.

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