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# SLAB-ON-GRADE THERMAL LOSS IN HOT CLIMATES

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## ABSTRACT

*Slab-on-grade floor construction techniques are used extensively in the United States in climates where cooling is a prominent part of the annual conditioning load. This paper reports on an investigation of the effect of insulation on the thermal performance of slab-on-grade residences in climates where both heating and cooling performance must be considered. The study investigated the thermal losses from both uninsulated and insulated slab-on-grade floors for an 1800 ft$^2$ (167.1 m$^2$) residence typical of those being constructed in the region.*

*It was determined that insulation was as important to the cooling performance of the house as it was to the heating performance. It was also determined that care should be exercised in the placement of insulation if one is to gain its full benefit. The slab edge was found to account for a large part of the total perimeter loss and any insulation strategy that failed to interrupt this thermal bridge was ineffective.*

## INTRODUCTION

Building codes in many parts of the United States require some form of slab or perimeter insulation. The requirements and level vary and, in general, decrease as the climate becomes warmer. Unfortunately, builders do not like to insulate building slabs because of the difficulty in placement and in maintaining integrity while construction continues. Considerable disbelief has been expressed in the building community about recommendations of earlier ASHRAE standards relative to slab thermal loss. The work discussed here was undertaken specifically to address the concerns of local builders by dealing with the climatic conditions of the Southeast. The work specifically treated the question of whether insulation is desirable in climates with heating degree-days less than 3000.

Recent work has shown that significant energy savings will result from compliance with the foundation recommendation in ASHRAE Standard 90.2P, "Energy Efficient Design of New, Low-Rise Residential Building" (ASHRAE 1988). The slab insulation requirements of Standard 90.2P, based primarily on work by Shipp (1983), do not require insulation for those slabs constructed in locations with less than 3000 heating degree-days. Qualitative observations of slab-on-grade houses in the southern part of Georgia indicate that slab insulation has a significant effect on the comfort level in locations with heating degree-days as low as 1200. Comfort is a frequent indicator that thermal reasons exist for insulation in cooling-dominated climates.

## APPROACH

### Foundation Description

It was considered extremely important to investigate slabs as they are actually constructed in the region rather than under laboratory conditions. Several studies have investigated slab configurations that either cannot be constructed as evaluated or lead to other problems.

Experience indicates that most residential slab-on-grade construction in this region is monolithic in nature. The assembly varies mostly in the nature of the perimeter condition of grade beam, thickened edge, or traditional short foundation walls over separate footings.

Placement technique varies from a single integral assembly to the more common three-step process involving the sequential construction of an individual footing, foundation wall, and slab. When not integral, the components are typically immediately adjacent and are seldom separated by isolation strips or other material varying in conductivity or density. Occasionally, a small separation is placed between the foundation wall and the slab to accommodate expansion and contraction. This thin control joint offers no significant thermal resistance.

Good construction practice and common sense dictate that the top of any slab be above exterior grade for moisture and insect control. The typical recommendation is a minimum of 8 in. (203.2 mm) above grade with all wood framing and exterior siding terminating at that point. This poses a particular problem in the formation of a thermal bridge of highly conductive concrete to the exterior.

A large percentage of the construction typical of the region consists of hollow concrete masonry units in a short foundation wall. The section is typically composed of a poured concrete footing placed over undisturbed soil with a short foundation wall of courses of 8 in. by 8 in. by 16 in. (203.2 mm by 203.2 mm by 406.4 mm) (height by depth by width) stretcher concrete masonry units capped with an 8 in. by 8 in. by 16 in. (203.2 mm by 203.2 mm by 406.4 mm) header concrete masonry unit. A concrete slab averaging 4 in. (101.6 mm) in thickness is poured on top of the native soil consolidated by compaction. The concrete of the slab completely fills the cores of the

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header concrete masonry unit and partially fills the cores of the stretcher concrete masonry units below.

For this investigation, a basic rectangular plan at a single elevation with four outside corners was assumed. A three-component foundation wall assembly was chosen, as shown in Figure 1, incorporating concrete masonry units to an overall height of three courses totaling 24 in. from the top of the footing to the top of the slab. The entire upper course was assumed to be filled with concrete. No control or thermal separation joint exists between the individual components of the slab assembly.

## Building Model

A 33.4 ft by 53.6 ft (10.2 m by 16.3 m), 1800 $ft^2$ (167.2 $m^2$) residence considered typical of those being constructed in the area today was used for this study. A two-dimensional unit section was taken through the residence. This section extended from the midpoint of the the slab along the narrow width to a position approximately 21 ft opposite the foundation wall. This section extended to a depth of 20 ft.

Assuming a single zone for the model residence and neglecting the effect of orientation, affected primarily by incident solar radiation on the exposed vertical surfaces, the section is representative of all similar sections sufficiently removed from the corners. This study investigated only two-dimensional flow and ignored the effects of the corners. Walton (1987) showed that external corners may increase total energy flow by as much as 30%. An investigation of the three-dimensional flow occurring at corners was beyond the scope of this study.

The investigation was divided into a two-step process. Hourly thermal loads were calculated for the model house for each of the two locations, excluding the floor energy transfer, using hourly TMY weather data. Loads also were calculated for each of the locations using hourly data constructed from monthly average weather data. The hourly simulation results were smoothed and slightly biased toward the average results to eliminate the large abrupt changes in building load resulting from the use of actual weather data. These smoothed loads were used to develop a building hourly gain profile for the finite difference program used to solve the foundation energy flow. Table 1 gives the attributes of the model residence used in this study.

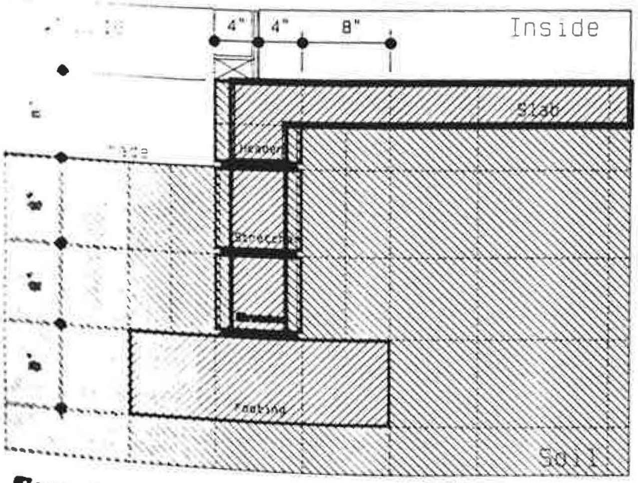

**Figure 1** *Typical three-component foundation wall*

The heating thermostat was set at 68°F (20°C) and the cooling thermostat was set at 78°F (25.6°C). Infiltration was established at a base condition of 0.4 air changes per hour (ach) plus 0.015 per degree temperature difference. For Atlanta, GA, the 97.5% design conditions established by ASHRAE are 22°F (-5.6°C) for winter and 92°F (33.3°C) for summer. Using the winter and summer inside thermostat setting of 68°F (20°C) and 78°F (25.6°C), the infiltration rate reached 1.09 ach and .061 ach for winter and summer, respectively.

The residence was assumed to be unshaded. Surrounding surfaces were assumed to be horizontal and to have a surface reflectivity of 0.20. Interior shading in the form of draperies with a transmissivity of 60% was used. The draperies were assumed to cover 60% of the window area in the winter and 70% in the summer.

## Finite Element Model

A finite difference model consisting of 84 nodes was used to calculate the energy flow in this study. Each node was assigned a mass and a conductance to all adjacent nodes. Table 2 gives the soil properties used for these models. Figure 2 shows a cross section of the house and soil showing the position of each of the nodes relative to the floor and foundation wall. Values used are considered representative for the two locations. Thermostats were established on nodes 1, 53, 56, and 61 controlled by a 24-hour temperature schedule for each month. The temperatures of these four nodes were reset at the end of each hourly time step. Auxiliary energy needed to reset these temperatures was calculated and reported.

**TABLE 1**
**Residence Description**

| | |
|---|---|
| Conditioned floor area | 1800.0 $ft^2$ |
| Conditioned volume | 14,499.0 $ft^3$ |
| Perimeter (33.4 by 53.9 ft) | 174.6 ft |
| Gross exterior wall area | 1396.8 $ft^2$ |
| Glazed area | 240.0 $ft^2$ |
| % of floor area | 13.3% |
| Door area | 34.0 $ft^2$ |
| Roof area | 1800.0 $ft^2$ |
| Facades | |
| Northern and southern facades: | |
| Net exterior wall area | 344.2 $ft^2$ ea |
| Net glazed area | 70.0 $ft^2$ ea |
| Net door area | 17.0 $ft^2$ ea |
| Eastern and western facades: | |
| Net exterior wall area | 217.2 $ft^2$ ea |
| Net glazed area | 50.0 $ft^2$ ea |
| Thermal Description | |
| Wall | |
| U-value | 0.083 Btu/h · $ft^2$ · °F |
| Roof | |
| U-value | 0.05 Btu/h · $ft^2$ · °F |
| Glazing | |
| U-value | .56 Btu/h · $ft^2$ °F |
| Shading coefficient | .88 |

### TABLE 2
### Soil Properties

| | Atlanta | Albany |
|---|---|---|
| Type | Clay Silt | Sandy Loam |
| Moisture content | 10.0% | 10.0% |
| Specific heat | 0.23 Btu/lb · °F | 0.23 Btu/lb · °F |
| Density | 110.0 lb/ft$^3$ | 110.0 lb/ft$^3$ |
| Conductivity | 0.750 Btu/h · ft · °F | .833 Btu/h · ft · °F |
| Diffusivity | 0.71 ft$^2$/day | 0.79 ft$^2$/day |
| Average mean temp. | 60.5°F | 68.0°F |
| Average amplitude | 21.0°F | 14.0°F |
| Phase constant | 35 days | 27 days |

Node 1, representing the inside air mass of the residence, was regulated by two thermostats, the same as those used to determine the above-slab thermal loads. The inside temperature of the air node was permitted to swing between the thermostat setpoints for the entire season. Energy required to keep the air node below 78°F (25.6°C) and above 68°F (20°C) was calculated and reported.

Node 53, the deepest vertical node in the soil field, received a schedule of temperatures representing the undisturbed ground temperature at the node depth. This node functions as a sink, representing the larger mass of the soil beneath the defined model. Similarly, nodes 56 and 61 were given a temperature schedule representing the temperature of the undisturbed soil at the sides of the model.

The effect of solar radiation was calculated for all exterior nodes in the soil field and exposed foundation. The surface nodes of the soil field were assumed to be horizontal and to absorb 30% of the incident radiation. The two nodes describing the outer edge of the exposed upper 8 in. (203.2 mm) of the foundation wall were assumed to be vertical with an absorptivity of .75 when exposed and .15 when covered with exterior insulation. The vertical surfaces were assumed to face north to minimize the effect of orientation yet include some effect of solar radiation. Radiation at night was assumed to be zero.

Convective coefficients with radiation components were used to describe the transfer of energy from ambient conditions to the soil field and from the inside air mass to the surface of the slab. In both cases, the lesser of the values recommended in the ASHRAE *Cooling and Heating Load Calculation Manual* (ASHRAE 1978) were used. A heat transfer coefficient of 4.0 Btu/h · ft$^2$ · °F (22.72 W/m$^2$ · °C) was used for exterior conditions with a coefficient of 1.08 Btu/h · ft$^2$ · °F (6.13 W/m$^2$ · °C) being used for interior conditions.

An interior load profile representing the thermal load of the above-slab house was added to node 1. This permitted the model to calculate the dynamic loads on the house due to all factors. The thermal model thus defined was solved using a microcomputer program called TNODE (Benton 1983). TNODE uses a forward differencing technique to determine the simultaneous solution of energy transfer in the field using a Cholskey matrix manipulation.

## RESULTS

### Base Case

A base case consisting of the above-grade model plus a slab with no insulation was used for comparison purposes. Table 3 gives a comparison of the base case and the house with no floor loads calculated earlier for both Atlanta and Albany, GA. The addition of an uninsulated slab-on-grade floor increased the annual loads by approximately 12% for both locations. The seasonal loads, however, show a much more drastic shift, with the

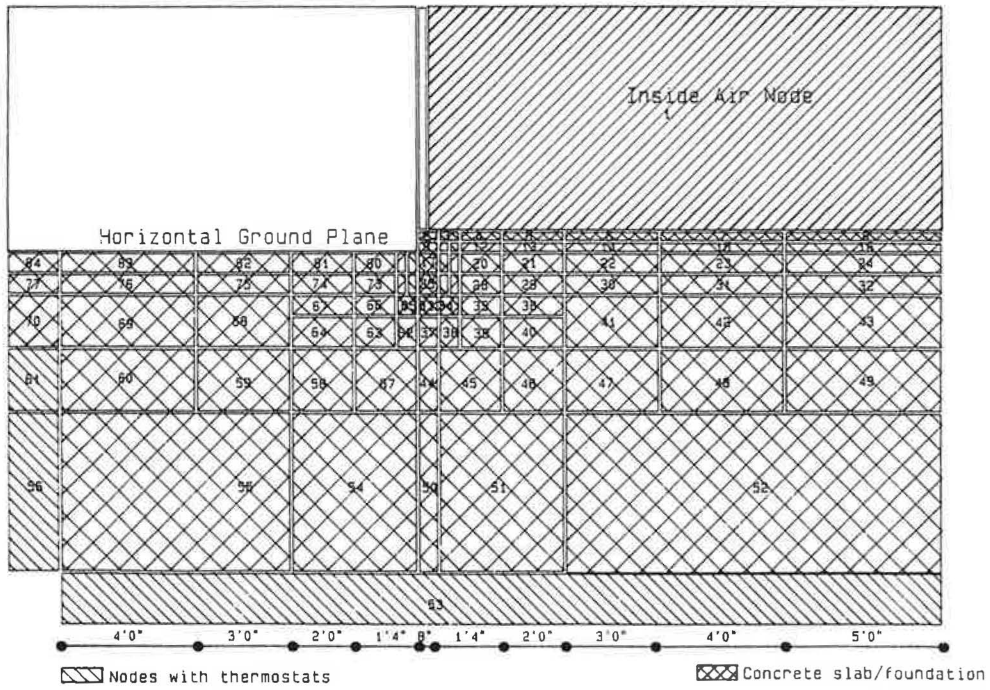

*Figure 2 Finite difference model*

### TABLE 3
### Annual Building Loads
### (kBtu)

| | Season | Including Floor Slab | Excluding Floor Slab | Percent Change |
|---|---|---|---|---|
| Atlanta | Heating | 39,526 | 24,836 | +59.1 |
| | Cooling | 12,246 | 21,103 | -42.0 |
| | Total | 51,774 | 45,939 | +12.7 |
| Albany | Heating | 23,491 | 12,697 | +85.0 |
| | Cooling | 24,688 | 30,331 | -18.6 |
| | Total | 48,179 | 43,028 | +12.0 |

thus substantially increasing the heating and decreasing the cooling loads. The Atlanta heating loads increased 59.1%, while the cooling loads decreased 42%. The Albany heating load increased 85%, while the cooling loads decreased 18.6%.

Figure 3 shows how the monthly loads varied in both Atlanta and Albany for the residence without a floor. As expected, Atlanta, with 3021 base 65 heating degree-days, has a significantly higher heating load than does Albany, with only 2062 base 65 heating degree-days. Albany, with 739 base 75 cooling degree-days, has a much higher cooling load than Atlanta, with 415 base 75 cooling degree-days. It should be remembered that these loads are without floor loss or gain.

Figure 4 shows the monthly loads for Atlanta with an uninsulated slab floor and with no floor. Notice that all of the months that had a cooling load with no floor, with the exception of November, showed a substantial increase in load. November showed a slight decrease in heating load. April shifted from a slight cooling load to a slight heating load. The remainder of the cooling months showed some decrease in loads, with the cooling loads in May and October being completely eliminated.

Figure 5 shows the monthly loads for Albany with an uninsulated slab floor and with no floor. Albany data show a trend similar to that of Atlanta. All heating months, except November, showed an increase. April also shifted from a slight cooling load to a slight heating load. Three cooling months showed a slight decrease and three showed a slight increase.

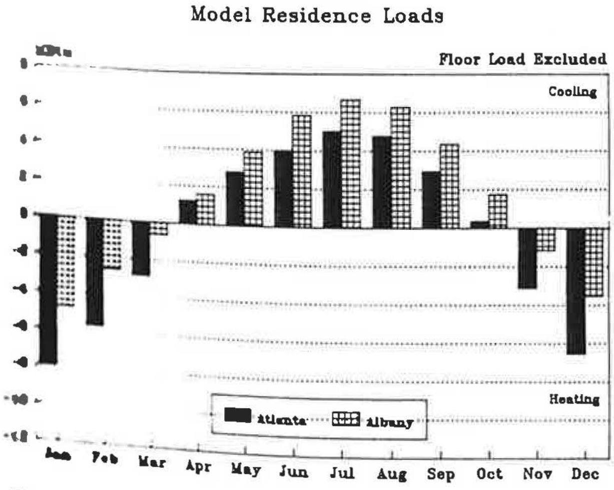

**Figure 3** *Loads with floor excluded*

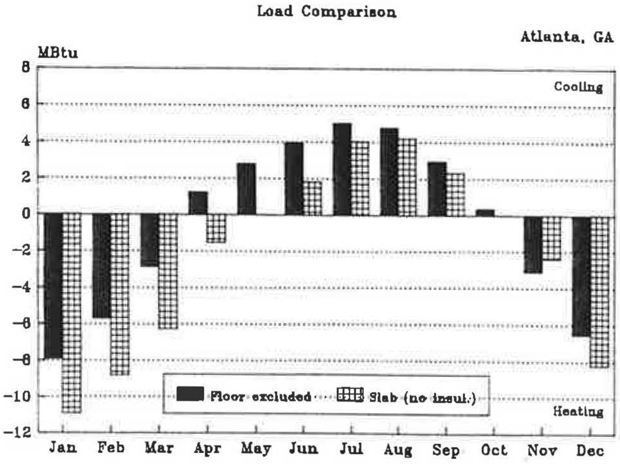

***Figure 4*** *Atlanta loads with and without floor*

Figures 4 and 5 show that while slab-on-grade floors cause a significant increase in the heating load, they are beneficial to the cooling loads for houses in these climates. The earth beneath the floor is at a lower temperature than the house above the floor and thus acts as a cooling source during most months. This indicates that slab-on-grade floors may be desirable for these climates if some means can be found to control the energy losses during the heating months. This research has been directed at the determination of proper insulation levels and placement for controlling energy losses during the heating season and energy gains during the cooling season. It also is important to observe that the slab has a similar impact on the building loads in Albany, with 2062 heating degree-days, as for Atlanta, with 3021 heating degree-days.

## Insulated Slabs

Seventeen different insulated cases were modeled and compared to the uninsulated base case. The effect of insulation was modeled for four different insulation

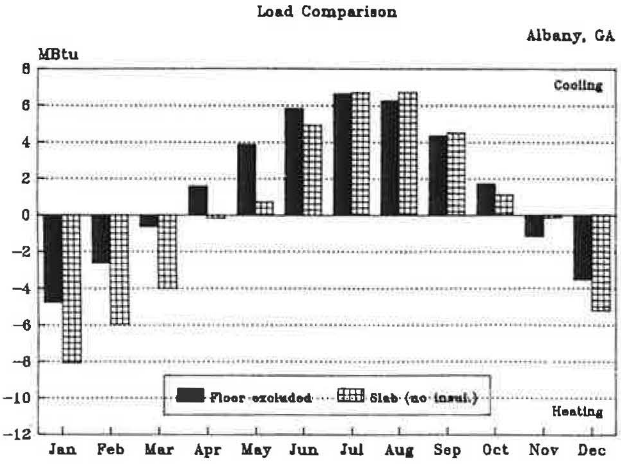

***Figure 5*** *Albany loads with and without floor*

placements. Vertical insulation covering only the exposed slab edge and vertical insulation at the exterior foundation wall from the top of the slab to the top of the footing were two of the cases modeled. Vertical insulation at the interior foundation wall stretching from the bottom of the slab to the top of the footing and horizontal insulation beneath the slab from the footing inward for a distance of 2 or 4 ft (.61 or 1.22 m) were the other two placements modeled. Each of the insulation placements was modeled for three levels of insulation, R 2.5, R 5.0, and R 10 ft$^2$ · h · °F/Btu (.44, .88, and 1.76 m$^2$ · °C/W).

Two simulations were conducted for each geographic location based on the present State of Georgia recommendation of interior horizontal insulation for 2 ft (.61 m) or interior vertical insulation for 2 ft (.61 m), both at R 2.5 ft$^2$ · h · °F/Btu (.44 m$^2$ · °C/W) and without treatment of the slab exposed edge. These simulations showed negligible reductions in heating loads, with the edge loss overwhelming the reduction in loss through the slab vertically or through the foundation wall horizontally.

Two simulations were conducted for each geographic location with R 2.5 and R 5.0 ft$^2$ · h · °F/Btu (R .44 and R .88 m$^2$ · °C/W) insulation covering only the 8 in. (203 mm) exposed edge of the slab to investigate the nature of the thermal bridge from the slab to the foundation wall. The results showed that insulation of the exposed above-grade edge is more effective than 2 ft (.61 m) of R 2.5 ft$^2$ · h · °F/Btu (R .44 and R .88 m$^2$ · °C/W) insulation beneath the slab or inside the foundation wall. No further simulations were conducted without a minimum of R 2.5 ft$^2$ · h · °F/Btu (R .44 and R .88 m$^2$ · °C/W) edge insulation.

Six simulations were conducted for each geographic location modeling three levels of horizontal insulation below the slab extending from the foundation wall for a distance of 2 and 4 ft (.61 and 1.22 m). Each case used a minimum of R 2.5 ft$^2$ · h · °F/Btu (R .44 and R .88 m$^2$ · °C/W) insulation over the exposed edge of the slab. In all cases the Atlanta annual heating load was decreased and the annual cooling load was increased slightly. The annual heating load in Albany was decreased in all cases; however, unlike Atlanta, the annual cooling load was also reduced in all cases. The simulations showed that only small improvements resulted from extending the insulation from 2 to 4 ft (.61 and 1.22 m).

Three simulations were conducted for each geographic location modeling three levels of insulation placed vertically at the interior of the foundation wall from the bottom of the slab to the top of the footing. Each case had a minimum of R 2.5 ft$^2$ · h · °F/Btu (R .44 and R .88 m$^2$ · C/W) over the exposed edge of the slab. All three cases showed load reductions comparable to the horizontal insulation.

Expansion of the exterior exposed edge insulation to extend from the top of the slab to the top of the footing proved to be the most effective insulation strategy. Figures 6 and 7 show that heating loads were reduced by more than 1 MBtu (1 Gj) per month for six months in Atlanta and four months in Albany, even at the lowest insulation value modeled. Atlanta had only one month with a load increase, while Albany experienced two months of load increase, which is negated by larger monthly savings during other months.

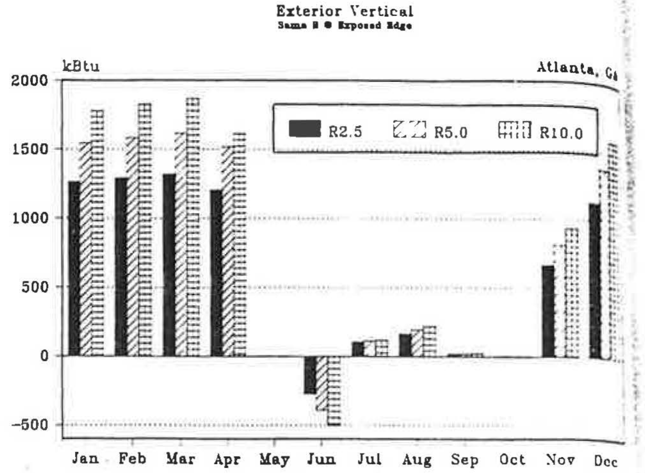

*Figure 6 Exterior—Atlanta savings relative to no insulation*

Table 4 lists all of the configurations investigated and provides a key to the numbers listed in the following tables and figures. Table 5 and Figure 8 summarize the results from all of the simulations for Albany conducted in this study. Table 6 and Figure 9 summarize all of the simulations for Atlanta conducted in this study. It is important to note that insulation is just as effective in reducing the thermal loads due to slab-on-grade floors in Albany as in Atlanta. Disregarding the two cases with no exposed edge insulation, annual heating savings ranged from 4.7 to 9.6 MBtu (4.96 to 10.13 Gj) in Atlanta and from 4.1 to 8.2 MBtu (4.32 to 8.65 Gj) in Albany.

It was observed in these simulations that load reductions were not linear with insulation thickness, i.e., increasing the insulation from R 2.5 to R 5.0 ft$^2$ · h · °F/Btu (R .44 and R .88 m$^2$ · °C/W) did not double the load reduction experienced when going from uninsulated to R 2.5 ft$^2$ · h · °F/Btu (R .44 m$^2$ · °C/W). Analysis of the energy flow paths showed that adding insulation in one place caused the energy flow in other places to increase, i.e., the energy took the path of least resistance.

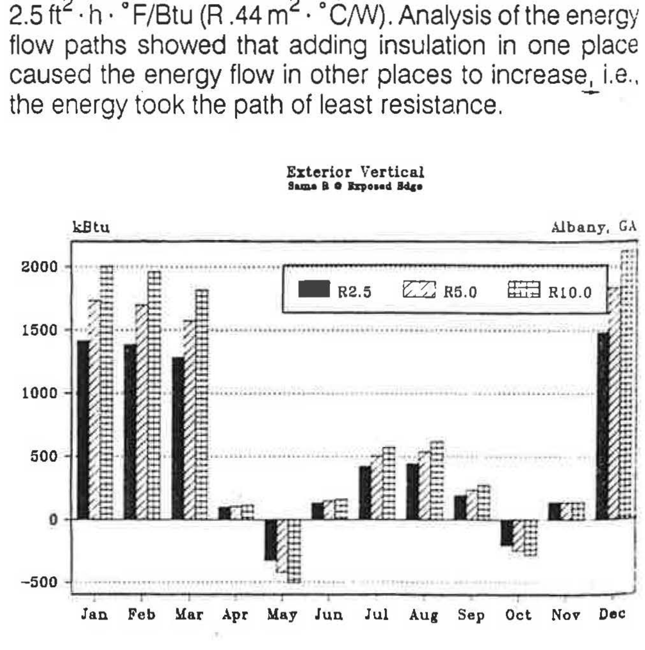

*Figure 7 Exterior—Albany savings relative to no insulation*

## TABLE 4
## Index to Insulation Placement Strategies

| Case Number | Description | |
|---|---|---|
| 1 | Interior Horizontal R 2.5 × 2 | (None @ Edge) |
| 2 | Interior Vertical R 2.5 × 2 | (None @ Edge) |
| 3 | R 2.5 @ Exposed Edge | |
| 4 | R 5.0 @ Exposed Edge | |
| 5 | Interior Horizontal R 2.5 × 2 | (R2.5 @ Edge) |
| 6 | Interior Horizontal R 2.5 × 4 | (R2.5 @ Edge) |
| 7 | Interior Horizontal R 5.0 × 2 | (R2.5 @ Edge) |
| 8 | Interior Horizontal R 5.0 × 4 | (R2.5 @ Edge) |
| 9 | Interior Horizontal R10.0 × 2 | (R2.5 @ Edge) |
| 10 | Interior Horizontal R10.0 × 4 | (R2.5 @ Edge) |
| 11 | Interior Vertical R 2.5 | (R2.5 @ Edge) |
| 12 | Interior Vertical R 5.0 | (R2.5 @ Edge) |
| 13 | Interior Vertical R10.0 | (R2.5 @ Edge) |
| 14 | Exterior Vertical R 2.5 | Full height |
| 15 | Exterior Vertical R 5.0 | Full height |
| 16 | Exterior Vertical R10.0 | Full height |

### Design Conditions

Ambient peak design conditions occurred on day 27, January 27, in Albany, and day 35, February 4, in Atlanta. A special simulation was performed for each of the insulation strategies to determine peak design heat loss per lineal foot of perimeter. Table 7 gives the results for Atlanta. It should be noted that these differ substantially from the 50, 40, and 30 Btu/h · ft (48.1, 38.5, 28.8 W/m) for uninsulated, R 2.5, and R 5.0 $ft^2 \cdot h \cdot °F/Btu$ (R .44 and R .88 $m^2 \cdot °C/W$) insulation given in ASHRAE (1985). Table 8 gives the design losses for Albany, GA.

### As a Conservation Measure

It is informative to compare the losses resulting from slab-on-grade floors to other residential losses. Figure 10 compares uninsulated slab losses with roof, wall, glass, and infiltration losses in Atlanta. Table 1 gives the thermal properties of the residence used in this comparison. Notice that annual slab losses exceed wall, roof, and glass losses and are only exceeded by sensible infiltration. This shows how important insulating slab-on-grade floors can be relative to other conservation strategies.

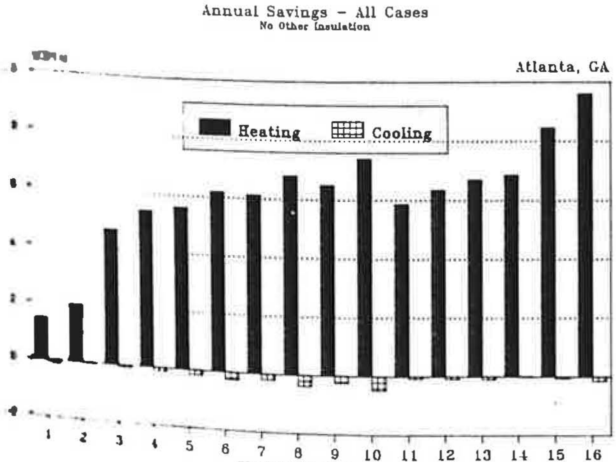

*Figure 8 Atlanta savings relative to no insulation—all*

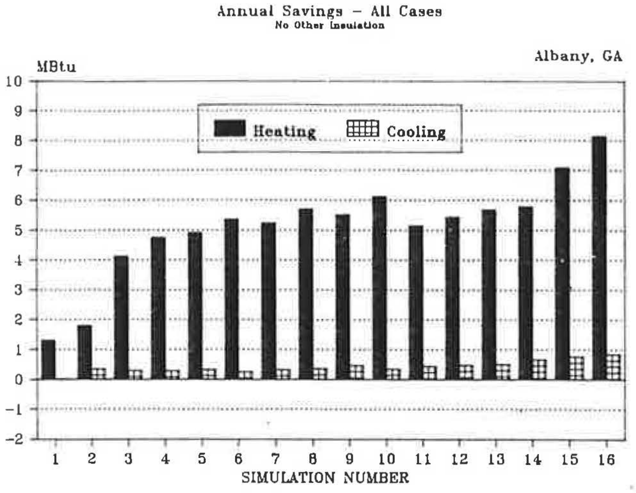

*Figure 9 Albany savings relative to no insulation—all*

## CONCLUSIONS

The following conclusions may be drawn from this study:

1. The use of an uninsulated monolithic slab-on-grade floor assembly substantially increases the heating load of a residence in both locations.
2. The slab-on-grade floor reduces the cooling load of a residence in both locations.
3. The exposed edge of the slab-on-grade acts as a thermal bridge and, if left uninsulated, serves to make ineffective perimeter insulation.
4. Increasing the R-value of interior insulation has a nonlinear effect on the slab loss.
5. Appropriate use of insulation with a monolithic slab-on-grade floor can produce substantial energy savings that on an annual basis are equal to or greater than most above-grade conservation measures.
6. The need for slab-on-grade insulation is not climate-dependent and is only slightly less effective at locations with less than 3000 heating degree-days than it

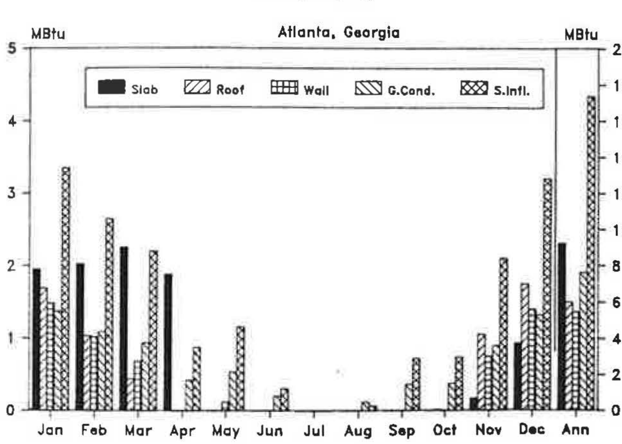

*Figure 10 Heat loss by building component*

### TABLE 5
### Insulation Placement Strategies—Albany, GA

| Case | Heating Load | Heating Savings | Cooling Load | Cooling Savings | Slab Total Heat Loss | | Slab Edge Heat Loss | | Slab C Contri |
|---|---|---|---|---|---|---|---|---|---|
| No. | (kBtu) | (kBtu) | (kBtu) | (kBtu) | (kBtu) | (%Tot) | (kBtu) | (%Tot) | (kBtu) |
| Base | 23,491 | 0 | 24,688 | 0 | 12,525 | 53.3 | 6,737 | 53.8 | 3,150 |
| 1 | 22,181 | 1,310 | 24,678 | 10 | 11,177 | 50.4 | 4,946 | 44.2 | 2,807 |
| 2 | 21,699 | 1,792 | 24,345 | 343 | 10,749 | 49.5 | 4,311 | 40.1 | 2,509 |
| 3 | 19,375 | 4,116 | 24,401 | 287 | 8,483 | 43.8 | 4,458 | 52.6 | 1,971 |
| 4 | 18,740 | 4,752 | 24,412 | 276 | 7,878 | 42.0 | 3,888 | 49.4 | 1,846 |
| 5 | 18,582 | 4,909 | 24,364 | 324 | 7,695 | 41.4 | 3,366 | 43.7 | 1,692 |
| 6 | 18,133 | 5,358 | 24,441 | 247 | 7,247 | 40.0 | 2,867 | 39.6 | 1,609 |
| 7 | 18,260 | 5,231 | 24,368 | 320 | 7,380 | 40.4 | 2,894 | 39.2 | 1,609 |
| 8 | 17,785 | 5,707 | 24,327 | 361 | 6,904 | 38.8 | 2,359 | 34.2 | 1,425 |
| 9 | 17,971 | 5,520 | 24,226 | 462 | 7,110 | 39.6 | 2,525 | 35.5 | 1,469 |
| 10 | 17,370 | 6,121 | 24,345 | 343 | 6,490 | 37.4 | 1,808 | 27.9 | 1,321 |
| 11 | 18,339 | 5,152 | 24,252 | 436 | 7,510 | 40.9 | 2,751 | 36.6 | 1,665 |
| 12 | 18,049 | 5,443 | 24,215 | 473 | 7,239 | 40.1 | 2,271 | 31.4 | 1,580 |
| 13 | 17,818 | 5,673 | 24,187 | 501 | 7,024 | 39.4 | 1,889 | 26.9 | 1,517 |
| 14 | 17,702 | 5,789 | 24,027 | 661 | 6,912 | 39.0 | 4,315 | 62.4 | 1,327 |
| 15 | 16,412 | 7,079 | 23,930 | 758 | 5,710 | 34.8 | 3,613 | 63.3 | 987 |
| 16 | 15,345 | 8,146 | 23,849 | 839 | 4,726 | 30.8 | 3,021 | 63.9 | 720 |

is at locations with more than 3000 heating degree-days.

7. Slab-on-grade insulation increases the slab surface temperatures and reduces occupant radiant losses.

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### TABLE 6
### Insulation Placement Strategies—Atlanta, GA

| Case | Heating Load | Heating Savings | Cooling Load | Cooling Savings | Slab Total Heat Loss | | Slab Edge Heat Loss | | Slab Co Contrib |
|---|---|---|---|---|---|---|---|---|---|
| No. | (kBtu) | (kBtu) | (kBtu) | (kBtu) | (kBtu) | (%Tot) | (kBtu) | (%Tot) | (kBtu) |
| Base | 39,526 | 0 | 12,248 | 0 | 16,049 | 40.6 | 9,222 | 57.5 | 486 |
| 1 | 38,067 | 1,459 | 12,377 | (129) | 14,606 | 38.4 | 7,206 | 49.3 | 473 |
| 2 | 37,545 | 1,980 | 12,278 | (30) | 14,151 | 37.7 | 6,523 | 46.1 | 417 |
| 3 | 34,827 | 4,698 | 12,326 | (77) | 11,543 | 33.1 | 6,592 | 57.1 | 165 |
| 4 | 34,092 | 5,434 | 12,375 | (127) | 10,840 | 31.8 | 5,923 | 54.6 | 146 |
| 5 | 33,928 | 5,598 | 12,412 | (164) | 10,645 | 31.4 | 5,284 | 49.6 | 152 |
| 6 | 33,327 | 6,199 | 12,515 | (266) | 9,610 | 28.8 | 4,454 | 46.3 | 144 |
| 7 | 33,403 | 6,122 | 12,452 | (203) | 9,795 | 29.3 | 4,459 | 45.5 | 151 |
| 8 | 32,722 | 6,804 | 12,622 | (374) | 8,701 | 26.6 | 3,530 | 40.6 | 142 |
| 9 | 33,028 | 6,497 | 12,487 | (239) | 9,217 | 27.9 | 3,860 | 41.9 | 156 |
| 10 | 32,124 | 7,402 | 12,721 | (473) | 7,858 | 24.3 | 2,680 | 34.1 | 143 |
| 11 | 33,657 | 5,869 | 12,326 | (77) | 10,257 | 30.5 | 4,567 | 44.5 | 142 |
| 12 | 33,171 | 6,355 | 12,333 | (85) | 9,498 | 28.6 | 3,766 | 39.6 | 141 |
| 13 | 32,826 | 6,700 | 12,347 | (98) | 9,002 | 27.4 | 3,194 | 35.5 | 141 |
| 14 | 32,661 | 6,864 | 12,238 | 10 | 8,840 | 27.1 | 5,781 | 65.4 | 64 |
| 15 | 31,073 | 8,453 | 12,316 | (68) | 6,925 | 22.3 | 4,571 | 66.0 | 26 |
| 16 | 24,919 | 9,607 | 12,393 | (145) | 5,720 | 23.6 | 3,844 | 67.2 | 7 |

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## DISCUSSION

**J. Huang, Staff Scientist, Lawrence Berkeley Laboratory, Berkeley, CA:** Did you compare your results with those from the *Foundation Design Handbook*?

**J.M. Akridge:** The heating loads agree quite well with the *Foundation Design Handbook*. We show more need for insulation in the cooling mode.

**R. Mohler, Energy Engineer, Market Research, Public Service Co. of Oklahoma, Tulsa:** Have heated-slab thermal losses been evaluated?

**Akridge:** We have not looked at heated-slab thermal losses.

**TABLE 7**
**Atlanta Slab Design Heat Loss**
**(22°F Outside Design Temperature, 68°F Thermostat)**

| Case | Comments | Loss (Btu/hr · ft |
|---|---|---|
| No insulation | | 33 |
| Interior Horizontal R 2.5 × 2 | (none @ edge) | 29 |
| Interior Vertical R 2.5 × 2 | (none @ edge) | 28 |
| R 2.5 @ Exposed Edge | | 23 |
| R 5.0 @ Exposed Edge | | 21 |
| Interior Horizontal R 2.5 × 2 | (R 2.5 @ edge) | 21 |
| Interior Horizontal R 2.5 × 4 | (R 2.5 @ edge) | 20 |
| Interior Horizontal R 5.0 × 2 | (R 2.5 @ edge) | 21 |
| Interior Horizontal R 5.0 × 4 | (R 2.5 @ edge) | 19 |
| Interior Horizontal R 10.0 × 2 | (R 2.5 @ edge) | 20 |
| Interior Horizontal R 10.0 × 4 | (R 2.5 @ edge) | 17 |
| Interior Vertical R 2.5 | (R 2.5 @ edge) | 21 |
| Interior Vertical R 5.0 | (R 2.5 @ edge) | 20 |
| Interior Vertical R 10.0 | (R 2.5 @ edge) | 20 |
| Exterior Vertical R 2.5 | Full height | 20 |
| Exterior Vertical R 5.0 | Full height | 18 |
| Exterior Vertical R 10.0 | Full height | 15 |

**TABLE 8**
**Albany Slab Design Heat Loss**
**(29°F Outside Design Temperature, 68°F Thermostat)**

| Case | Comments | Loss (Btu/hr · ft) |
|---|---|---|
| No insulation | | 29 |
| Interior Horizontal R 2.5 × 2 | (none @ edge) | 26 |
| Interior Vertical R 2.5 × 2 | (none @ edge) | 26 |
| R 2.5 @ Exposed Edge | | 20 |
| R 5.0 @ Exposed Edge | | 18 |
| Interior Horizontal R 2.5 × 2 | (R 2.5 @ edge) | 19 |
| Interior Horizontal R 2.5 × 4 | (R 2.5 @ edge) | 17 |
| Interior Horizontal R 5.0 × 2 | (R 2.5 @ edge) | 17 |
| Interior Horizontal R 5.0 × 4 | (R 2.5 @ edge) | 16 |
| Interior Horizontal R 10.0 × 2 | (R 2.5 @ edge) | 17 |
| Interior Horizontal R 10.0 × 4 | (R 2.5 @ edge) | 15 |
| Interior Vertical R 2.5 | (R 2.5 @ edge) | 19 |
| Interior Vertical R 5.0 | (R 2.5 @ edge) | 18 |
| Interior Vertical R 10.0 | (R 2.5 @ edge) | 17 |
| Exterior Vertical R 2.5 | Full height | 18 |
| Exterior Vertical R 5.0 | Full height | 14 |
| Exterior Vertical R 10.0 | Full height | 12 |