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HEAT LOSSES TO CRAWL SPACES IN BUILDINGS

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1. INTRODUCTION

In the Netherlands most single family houses have below the ground floor ventilated crawl spaces of about 0.6 to 0.8 m. height. Heat losses through the floor to the crawl space depend on the thermal conditions and the ventilation rate of this space, as well as on floor insulation. In general crawl spaces get only little attention in literature. One just includes it as a small factor in the energy losses. As the temperature in the crawl space is between the outside and room temperature the losses have to be calculated separately. Only in Sweden a large study on crawl spaces has been reported by Elmroth [1].
We have made a set of tests on the thermal and hygric phenomena during a winter season in a typical Dutch house. The effects on thermal and comfort condition in the living used above it have been included in this study.

2. DESRIPTION OF THE HOUSE, CRAWL SPACE AND EXPERIMENTAL SET-UP

A single family house of about 110 m^2 living area (2 stories and an attic) has been taken as the measuring object. It had similar houses on its side. Fig. 1 gives a ground plan. Hot water radiators below the windows give the necessary heating load. A family lived in the house, day temperatures were about 20^o C, night temperatures lower due to a night set-back.
The crawl space is shown in Fig. 2, dimensions are 8.4 x 4.8 x 0.65 m. It has 4 ventilation openings of 2.2 10^3 mm^3, 2 at each side. The ground has a small sand layer on clay. The ground water level is only about 0.1 to 0.2 m below it. The floor between living area and crawl space consists of concrete elements with included air spaces. Its insulation value is 0.28 m^2 K/W. Moreover a floor covering gives a additional thermal resistance of 0.2, so the total value is 0.48 m^2 K/W. Using air side heat loss coefficients of 4 W/m^2K this results in a k-value for this floor of 1.3 W/m^2K.
In the crawl space as well as in the living room above it many temperature measurements have been done during the winter of 1981/82. Also heat fluxes to the crawl space and to the ground have been measured with special installed heat flux meters. Also the ventilation rate and during a short time also the humidity has been measured.

3. RESULTS

3.1 Temperature profiles

Figure 3 gives the measured 24 hrs. average temperature profiles over a vertical line in the mid of the crawl-space for 2 months. It is clear that the crawl space temperature varies little, with-outside temperature, due to the thermal capacitance of the ground. The floor temperature above the covering is low only 15.3° C in January. This is a 24-hrs. average, including the night set-back period (10 hrs.). However from the data we found that during the daily heating period the temperatures were still below 17° C. Cold feet is a regular comfort complaint in these houses. The room temperature at 2.2 m height during the heating period was about 21°C. We found during the time that the radiators were on a vertical temperature gradient of 4° C over 2 m. At night, without heating this reduced to 2° C. Thermal stratification occurs mainly during the heating period.

Also in the crawl space a strong stratification exists. Cold air from the outside flows along the bottom. Convective heat transfer below the floor of the house is low (< 0.5 W/m^2K). The main heat transfer is by radiation from the floor to the bottom(ground). Ventilation rate of the crawl space varied between 0 and 2 h^{-1} depending on wind conditions, the average value being 0.6 h^{-1}.

3.2 Heat fluxes

Figure 4 gives a picture of the monthly averaged heat fluxes as measured in the mid of the crawl space. A heat loss of about 4 W/m^2 through the ground floor occurs during the whole heating period. This is relatively low and gives only a small fraction (< 10%) of the total heat loss of the house. The Figure also shows the convective and radiative transfer at the surfaces. In January the ground still gives a positive flux to the crawl space, only in April the sign reverses. The latent heat effects due to water evaporation could be found from the humidity measurements. These showed that the humidity was always between 90 and 95%. Temperature measurements at the side of the crawl space near the facades showed surface temperatures below the wet bulb temperature. Here condensation of water could be observed. Also in the living room surface temperatures of the floor near the North facade sometimes were below the dew point temperature of the room. This again due to the large thermal stratification and relatively low infiltration allowed in the house. Complaints of mouldy surfaces occured in several cases.

4. DISCUSSION

The study clearly indicated that the relatively limited energy losses through the crawl space nevertheless have a great effect on comfort conditions in the living room above it. Together with hot water radiator heating it gives a large thermal stratification (2° C/m). With a thermostat setting at 20° C it gives floor temperatures below 17° C. This gives cold feet complaints. Also near the facades cold surfaces can give unwanted condensation. To compensate for this negative comfort effects people tend to use a higher thermostat setting, up to 22° C. This removes cold feet and condensation complaints, but introduces additional energy losses of the house, due to the increase of average room temperature of 2° C. A better floor insulation is clearly required, however not for the original incentive, to the crawl space. As the main heat transfer mechanism is radiation, the use of aluminium foils or other radiation reducing means below the floor can already be sufficient in the case studied.

5. CONCLUSIONS

Ventilated crawl spaces in a typical Dutch single family house, with average floor insulation show about 4 W/m^2K energy loss in the heating season. However it still introduces low floor temperatures, leading to cold feet and condensation complaints. A radiation shield right below the floor can for the case studied prevent the complaints.

REFERENCES:

1. Elmroth, A., Crawl Space Basements, Moisture Balance, Desiccation, Ventilation, Temperature, Building Design, Nat. Swedish Building Res., Report and Summaries, R12, 1975.

ACKNOWLEDGEMENT

This study has been sponsored by the Stichting Bouwresearch. A full report of this work can be obtained from them. Title: Een kruipruimte thermisch doorgemeten, 72 pages, 1985. In Dutch with an English Summary and Text of Figures in English. Stichting Bouwresearch, Postbox 20740, 3001 JA Rotterdam, The Netherlands.

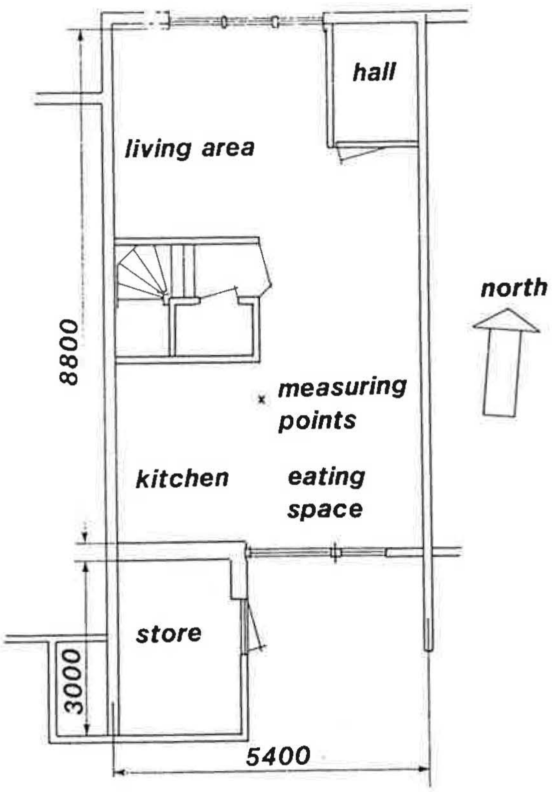

Figure 1. Ground floor plan of the dwelling studied.

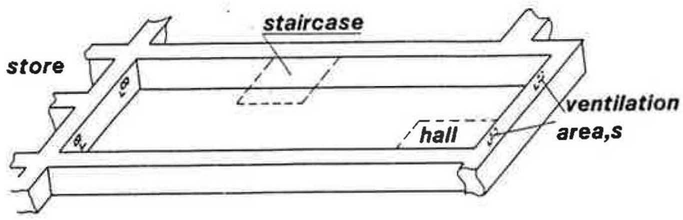

Figure 2. The crawl space: 8.4 x 4.8 x 0.65 m.

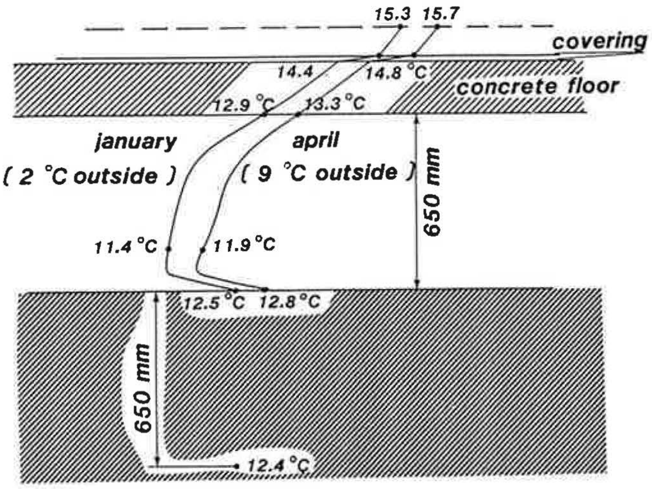

Figure 3. Verticale temperature distribution in and around crawl space. Monthly averages for January and April.

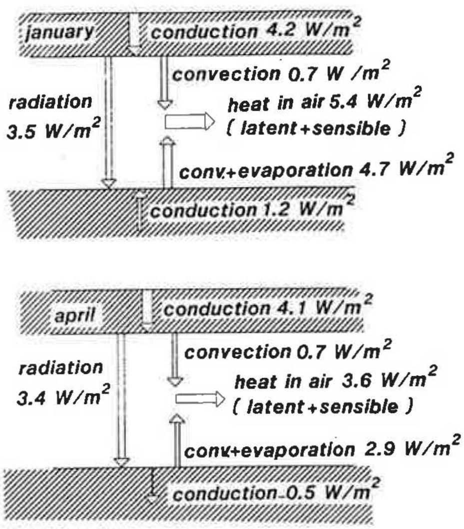

Figure 4. Montly average heat fluxes in January and April for the crawl space (central part).