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Field Data on Settling in Loose-Fill Thermal Insulation

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ABSTRACT: Blown loose-fill thermal insulation was introduced to Sweden in the late 1970s and has become more common since then. Today loose-fill insulation is used especially for attics, both as insulation in new building production and as additional insulation in older buildings. Loose-fill insulation is mainly manufactured from mineral wool and cellulosic materials.

As users of loose-fill thermal insulation know, this insulation type can settle, which means that it will compress. It is of great importance to know the long-term behavior of the insulation thickness, so as to be able to estimate the insulation capacity during the lifetime of the structure.

This paper reviews a field study of settling in loose-fill thermal insulation performed by the National Swedish Institute for Building Research. The study is confined to the use of loose-fill insulation for horizontal structures and formed part of a wider project in which a laboratory study also was performed.

In the field study both mineral wool and cellulosic loose-fill materials were investigated. The loose-fill materials were blown on several test attics, and settling was measured during one year within the project. The paper presents results of settling after three years in practice.

KEY WORDS: loose-fill insulation, settling, attics

Loose-fill thermal insulation materials like slag and different kinds of shavings have been used in Sweden for several years. Wall and floor structures of older buildings were insulated by hand-filling their cavities.

Since the late 1970s, blown loose-fill thermal insulation has been available on the Swedish market. Today a considerable part of the thermal insulation manufactured in Sweden is loose-fill material. The main types of loose-fill insulation are mineral wool and cellulosic materials. The blown loose-fill materials are especially used for attics, both as additional insulation in older buildings and as insulation in new building production.

As users of loose-fill thermal insulation know, this type of insulation can settle, which means that the insulation layer will compress. It is of great importance to know the long-term behavior of the insulation thickness, so as to be able to estimate its insulation capacity (thermal resistance) during the lifetime of the structure.

In 1984 a project for the purpose of studying settling of loose-fill thermal insulation was started at the National Swedish Institute for Building Research. The survey was initiated by the Swedish thermal insulation manufacturing industry and was partly financed by that industry. The investigation was confined to the use of loose-fill insulation for horizontal structures, primarily attics, and was divided into a field study and a laboratory study. The settling project was completed at the beginning of 1986.

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Purpose of the Field Study

The purpose of the field study was to investigate the long-term settling development of loose-fill materials under practical conditions.

Loose-Fill Materials Investigated

Table 1 shows standard values of thermal conductivity, moisture ratio, and density for the four different types of loose-fill materials that were investigated. The data in Table 1 are taken from the Swedish standard approval certificate for each material.

The λ_{10}-value is the thermal conductivity test value measured in the laboratory with a mean temperature of 10°C. The λ_n-value is the thermal conductivity value, which is used for calculations. The nominal density value is the value at which the Swedish contractors have to blow their loose-fill material. Below the minimum density the contractors should not blow any material.

Both cellulosic and mineral wool loose-fill materials were studied in the field investigation. The cellulosic materials consisted of cut newspaper and were treated with different kinds of chemicals in order to prevent fire, moisture, and fungus attack. Cellulosic 1 was treated with boron compounds; Cellulosic 2 was treated with aluminum compounds. In general the newspapers were cut into smaller fibers for Cellulosic 1 than for Cellulosic 2. The mineral wool material consisted of one rockwool material and one glass fiber material.

Performance

In the field study four test buildings were chosen: two stone houses and two wooden houses. Each test building was more than 30 years old.

The attic floor structure of the stone houses was made of concrete; on top there was a 10 to 15 cm thick slag insulation layer. The wooden houses had roof structures of wood trusses. Between the roof trusses there was a 15 to 20 cm thick insulation layer of cutter shavings.

The attic areas of the test buildings were divided into four areas, one for each loose-fill material tested. Each test area was 100 m^2 in the stone houses and 50 m^2 in the wood houses.

Each test area was prepared with a number of measuring sticks (Fig. 1). The greater test areas were allotted five sticks, the smaller areas three sticks. The zero level of each measuring stick was calibrated to the upper level of the old insulation. The height scale of the measuring stick was graduated in millimetres.

The loose-fill materials were installed in each attic area as additional thermal insulation. In the stone houses the installed thickness varied between 23.5 and 44.5 cm. In the wood houses the additional insulation thickness varied between 16.0 and 36.0 cm.

During the test period, which originally was limited to one year but was extended to three years, the thickness of the insulation layer was read manually. The reading time intervals were

TABLE 1—*Standard values of different properties for the loose-fill materials investigated.*[a]

Loose-Fill Materials	Thermal Conductivity (W/m K)		Density (kg/m³)		Moisture Ratio (wt. %)
	λ_{10}	λ_n	Nom.	Min.	
Cellulosic 1	0.037	0.045	35	31	10
Cellulosic 2	0.038	0.045	35	32	10
Glass fiber	0.040	0.051	17	14	0
Rock wool	0.039	0.051	29	26	0

[a] λ_{10} = thermal conductivity, tested at 10°C mean temperature (W/m K).
[b] λ_n = calculating thermal conductivity (W/m K).

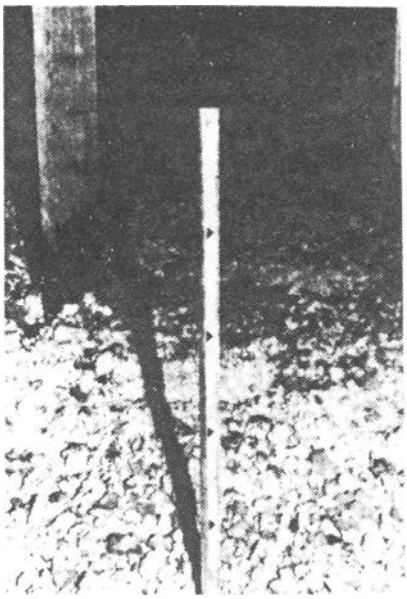

FIG. 1—*Measuring stick used for settling measurements of loose-fill materials.*

rather short during the first year of the test period (after one day, one week, one month, three months, six months, nine months, and twelve months). During the rest of the test period the readings were performed every six months. The accuracy of the readings was ±5 mm.

Results

Settling

The field study has shown that there is a great difference in settling between cellulosic and mineral wool materials. Figures 2 and 3 show the settling for each material group. The results are expressed in percentages of the end-height of the insulation layer after a test period of three years. In the figures the settling is shown as an average settling value. The average values for each material group are calculated from 16 measuring points.

Figure 2 shows the settling of cellulosic loose-fill materials. After one year the average value for cellulosic materials is about 15%. The variation between the two tested cellulosic material types is about 5%. The settling after three years shows an average value of 19%, still with a variation of 5% between the two cellulosic materials. After three years the average settling of cellulosic materials expressed in absolute values is about 4.6 cm.

The settling of the mineral wool materials occupies a lower average level compared with the cellulosic materials. After one year the average value for mineral wool materials is about 5%. The variation between glass fiber and rock wool materials is negligible. The glass fiber material showed a generally somewhat higher value than the rock wool material, but the difference was less than 2% (Fig. 3). After the three-year test period the settling had only marginally changed compared with the one-year value and was still on a 5% level. In absolute values the average settling is about 1.3 cm.

The large difference in settling between the two material groups is due to several factors. One concerns the insulation materials and their way of forming an insulation layer. The cellulosic loose-fill materials consist of small material fibers that are laid loosely on each other without any

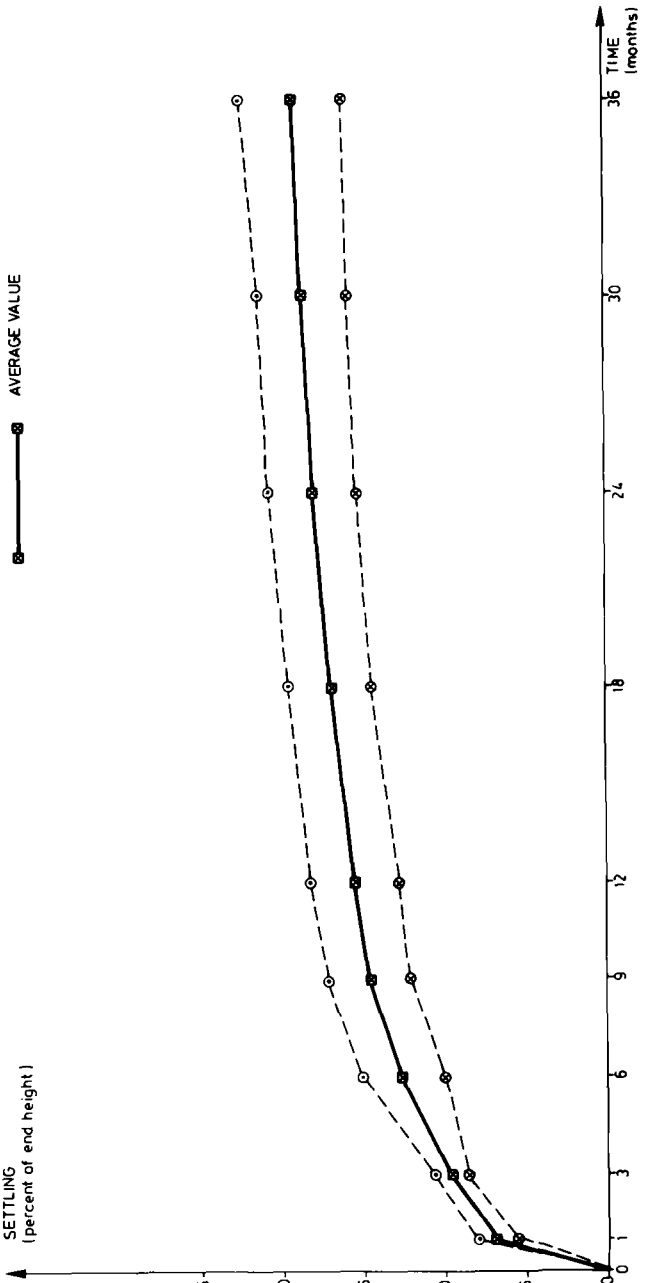

FIG. 2—*Settling versus time for cellulosic materials (field objects).*

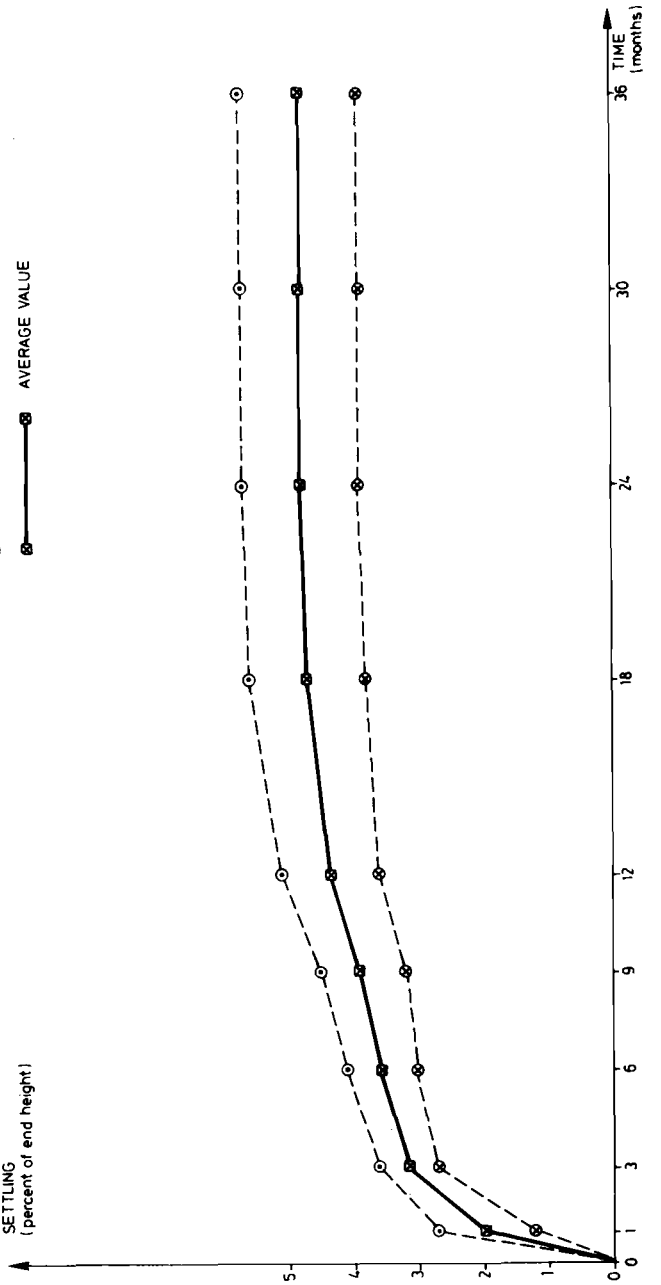

FIG. 3—*Settling versus time for mineral wool materials (field objects).*

anchorage between them. The mineral wool materials consist of long, thin fibers which are connected to each other. Thus the mineral wool materials are less affected by external factors than the cellulosic materials.

Densities

For Cellulosic 1 the densities installed varied between 46 and 30 kg/m^3; for Cellulosic 2 the densities varied between 43 and 34 kg/m^3. The densities of the rock wool material installed were between 30 and 26 kg/m^3; for glass fiber the densities installed were between 21 and 16 kg/m^3.

Conclusions

In order to calculate the thermal insulation resistance of loose-fill materials it is important to know the long-term behavior of the insulation thickness. Thickness changes concurrently with the settling of the loose-fill materials.

The settling of loose-fill insulation materials has been investigated in a Swedish study performed by the National Swedish Institute for Building Research. Cellulosic and mineral-wool materials for horizontal application were studied in the field and laboratory.

An important finding of the field study is that there is a large difference between cellulosic and mineral-wool materials. After a three-year test period the cellulosic loose-fill materials show an average settling value of 19%. The settling of mineral wool materials occupies a much lower average level compared with the cellulosic materials. After the same test period the settling of mineral wool materials is about 5%. Settling is expressed in percentages of the end-height of the insulation layer after the test period.

References

[*1*] Svennerstedt, B., "Settling of Loose-Fill Thermal Insulation," Bulletin M85:31, National Swedish Institute for Building Research, Gävle, Sweden, 1986.