THERMALLY CONDITIONED CERAMIC FLOORING: ENERGY SAVING WITH CERAMIC TILING

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1. INTRODUCTION

In the last few years, several European countries have approved Ordinances aimed to reduce energy consumption in buildings and to lower CO_2 emissions. Germany, for example, through initiatives like the EnEV (Energy Saving Ordinance), is trying to lower CO_2 emissions until the year 2012 to the levels established by the Kyoto protocol.

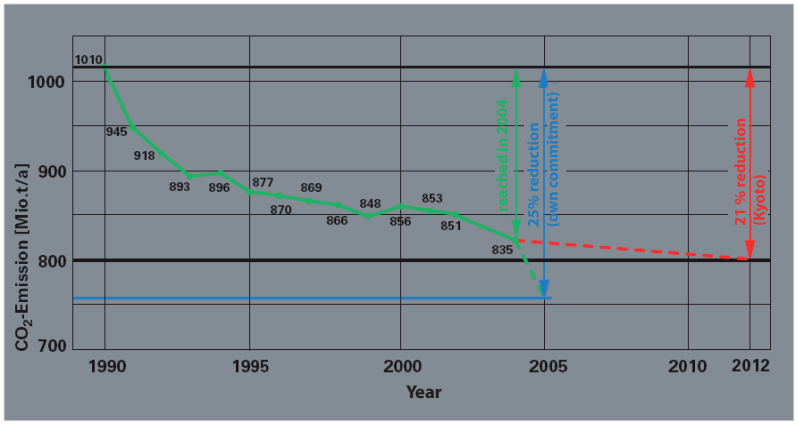

Figure 1. Evolution of CO_2 emissions in Germany (Source: DIW).

As a result, in the last few years, Germany has reduced CO_2 emissions by 29.5% in the industrial sector, 18% in thermal plants, and 2% in private homes, while car and airplane emissions, etc. increased by 11%.

To carry out this task successfully, work needs to be done in the following areas:

1. Optimization of energy sources.
2. Optimization of thermal insulations.
3. Optimization of energy transmission systems.

In private homes, the installation of heating systems that meet these requirements is being especially promoted. Final energy consumption in heating accounts for almost 80% of total energy consumption, whereas the other 20% is split among sanitary water, electrical appliances, cooking, and lighting. Therefore, there should be a particular interest in reducing energy consumption in home heating systems.

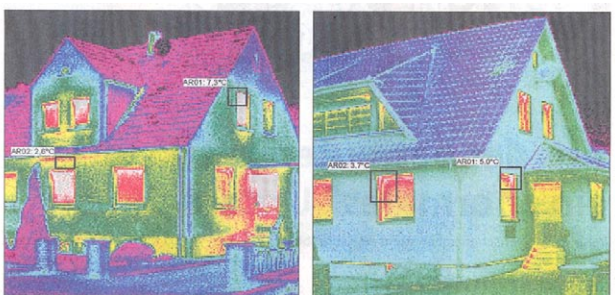

Figure 2. Thermographic images of a house before and after reform.

2. ENERGY EMISSION SYSTEMS

In private homes, it is common to find the traditional system of radiators and a radiant underfloor heating system. Several health studies assign radiant floor heating systems a greater feeling of comfort. Two thirds of heat transmission through radiant flooring is produced through conduction, and one third through convection, ensuring uniform temperature at one's feet, as well as at one's head.

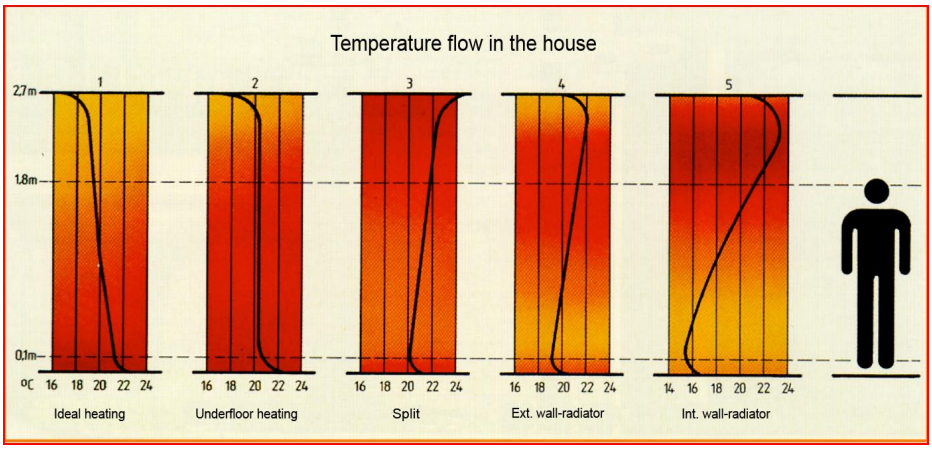

Figure 3.

Besides, a conventional radiant heating system works with an output water temperature of about 40°C, compared with the 70°C normally required by radiator-based heating systems. There are also radiant heated floors with a low height available in the market, which can even lower the output temperature to 28-32°C, which means quite reduced energy consumption.

Radiant floor heating is the most appropriate heating system for energy saving and, in combination with ceramic tilings, this feature stands out even more, owing to the outstanding ceramic thermal transmission characteristics. Other types of coverings, such as parquet, wood, carpeting, or linoleum are also suitable for installation on top of radiant flooring, though they are not recommendable due to their insulating characteristics.

3. PHYSICAL PROBLEMS IN THE CONSTRUCTION OF FLOATING FLOORS

The fixing of ceramic tiles on thermal and/or acoustic insulating panels, radiant floor slabs, or other systems non-adhered to the base substrate, is known as fixing on "floating screeds". This floating construction system of radiant floors causes pathologies in most ceramic floor tiling.

3.1. Movements due to shrinkage.

It is not possible to install ceramic tiles on thermal insulating panels, owing to the high compressibility of the latter, which makes it necessary to apply a cement

mortar load distribution layer. The mortar loses all the unnecessary water in the first weeks after its application in order to harden correctly, leading to mortar volume loss and shrinkage-related movements, producing cracks in the mortar and perimeter detachments. These cracks are transmitted directly to the ceramic tiling and to the floor and wall junctures.

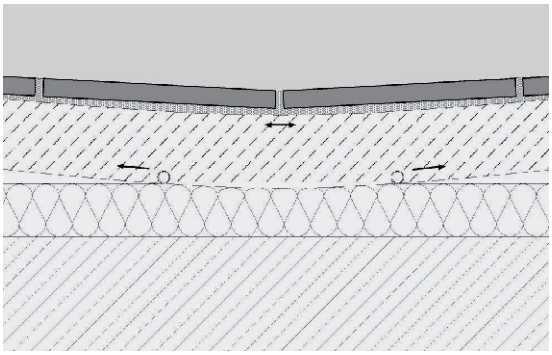

Figure 4. Movements in floating screeds due to the shrinkage produced in screed hardening.

3.2. Movements due to thermal expansion.

Moreover, in conventional radiant floors, the problem occurs that the water at about 40-45°C in the circuits heats up the mortar screed. The thermal expansion coefficient of cementitious screeds is about 0.012, which leads to movement due to mortar thermal expansion of 2.7 mm in 5 m. The tiling surface usually reaches a temperature of 25°C, so that, along with the low ceramic thermal expansion coefficient of 0.007, the tiling only moves 0.875 mm in 5 m, i.e. almost 2 mm less than the mortar screed. In the case of marble or natural stone coverings, this problem becomes even more serious since their thermal expansion coefficient is even lower (0.004). These different movements between both layers lead to cracks and lifting in the floor tiling with radiant heated floors.

4. PROBLEMS OF CONVENTIONAL CORRECTIVE MEASURES

To solve these issues, until recently it was generally recommended to install a load distribution layer with a minimum thickness of 45 mm, as well as enough movement joints to absorb the movements caused by shrinkage and thermal expansion. However, the thicker the load distribution layer, the greater the energy losses between the pipes in the screed water circuit and the tiling. In the construction of conventional radiant heated floors, this loss is about 20°C.

On the other hand, the movement joints prevent an individual design of the ceramic tile coverings, since it is recommended to install these about every 3x3 m with radiant heated floors.

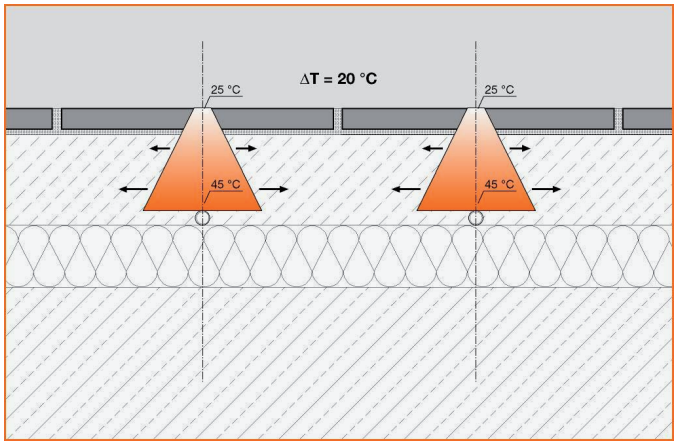

Figure 5. Energy loss between pipes and tiling.

Figure 6. Natural relaxation in a dry river bed.

This situation raises the following concern: Are radiant heated floors, as an ideal heating system, really incompatible with ceramics as optimum heat exchangers?

5. NEW SYSTEMS FOR THE CONSTRUCTION OF FLOATING FLOORS

The fixing of ceramic tiles on floating floors does not only occur in combination with radiant heated floors, but they are also generally installed on top of additional layers such as thermal insulating layers, acoustic insulation, waterproofing, etc. According to the new Spanish Technical Building Code (CTE), the installation of these additional layers in building construction is mandatory, which could lead to new pathologies in ceramic tile installations, since until now the coverings formed a monolithic union with the screeds and substrates.

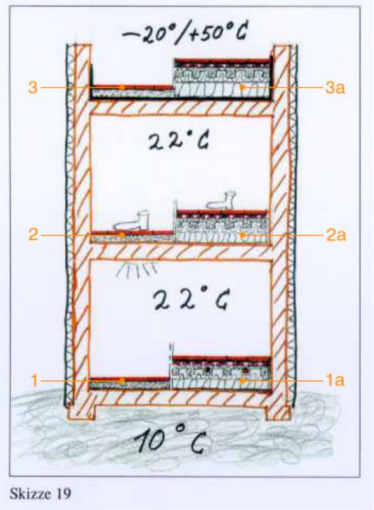

Figure 7. Examples of floating floor applications in building construction.

6. IDEAS FOR INNOVATIVE BUILDING

Future construction techniques should keep in mind the following aspects. It is sought:

- To build a pathology–free system.
- To build a heating system with the lowest possible output temperature.
- To build a system with optimum energy use and distribution.
- The construction of pathology-free ceramic flooring.

6.1. The construction of pathology-free ceramic flooring.

Special studded panels in a dovetail configuration with ridges between the studs split the screeds into micro-zones. These ridges provide screed relaxation and shrinkage control. The panels allow the application of mortar thicknesses of 8 mm and efficiently control load distribution layer shrinkage movements. In addition, the installation of a decoupling sheet on this reduced screed prevents the different movements due to thermal expansion from being transmitted to the ceramic tiling.

6.2. Heating systems with low output temperatures.

The possibility of constructing floating screeds only 8 mm thick enables reduction of the heating system output temperature. To reach a temperature of about 25°C at the tiling surface, one only needs a water temperature of about 30°C in the water circuit pipes. This not only assures radiant floor heating with pathology–free ceramic tiling, without the need for joints, but it also makes the entire heating system more efficient and provides greater energy saving. A 1°C decrease in the output temperature means 2–3% energy saving. A decrease of 15°C x 2% in the output temperature provides energy savings of up to 30%.

Figure 8. Radiant heated floor system with special studded panels and decoupling sheet.

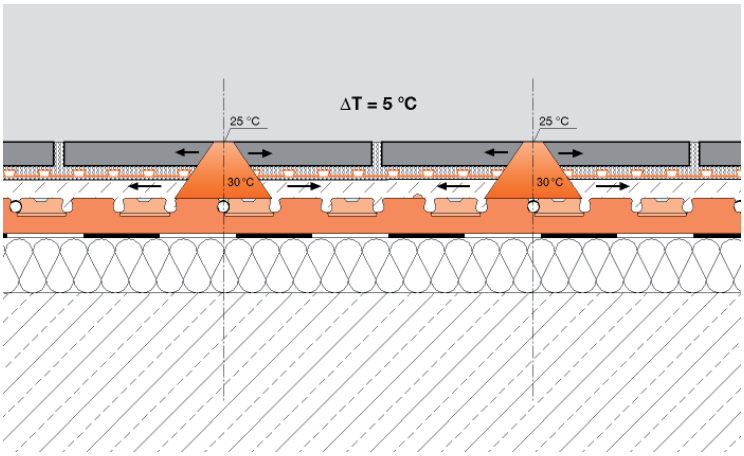

Figure 9. Energy saving with ceramics.

6.3. Energy usage and distribution systems.

Thanks to the low output temperatures, thermally conditioned ceramic floor systems are suitable for use with any source of regenerative power. The new heating pump technology allows solar energy, geothermal energy, and wind power to be used for heating water in radiant heated floors. The suitable characteristics of ceramics make them key elements in this chain:

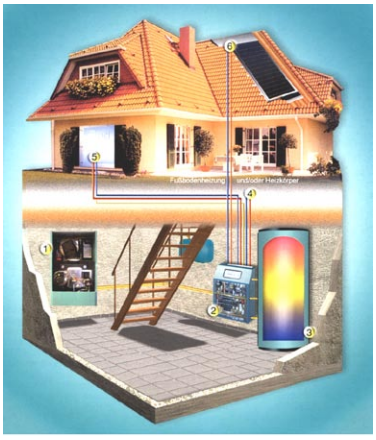

Figure 10. 1) Heating pump, 2) Heat distribution system, 3) Energy accumulator, 4) Thermally Conditioned Ceramic Floor, 5) Sanitary water, 6) Solar energy.

7. CONCLUSIONS

Energy can be saved with ceramics in housing. Their excellent thermal conductivity makes ceramics the most suitable building elements in combination with radiant heated floors. Especially in comparison with other types of insulating coverings (such as wood, parquet, carpeting, and linoleum), ceramics allow more efficient radiant heated floor systems to be built, due also to the availability of innovative systems for the construction of pathology–free floating screeds.