Investigations of Mass Flow in the Existing Building Stock

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Summary

Within the framework of investigations regarding "building material usage and the primary energy input for residential buildings constructed at different times", 20 residential buildings of varying ages (typical examples of solid-wall type of construction) were examined with regard to their building material and mass composition. In addition, the primary energy contents of the buildings concretized in the form of building materials - the so-called accumulated energy expended in the production of the building materials (PEI_H) - was also determined. The purpose of the investigation is to obtain information regarding the composition of building materials in residential buildings dependent on their age, and thus gain knowledge for dealing with existing buildings.

1 The Composition of Building Materials of Buildings Constructed at Different Times

A mean value of 0.528 Mg/m³ gross cubic content is obtained for all examined buildings. Single family houses (mean value 0.592 Mg/m³ gross cubic content) tend to be heavier due to their higher proportion of building materials; the used building materials here normally enclose a smaller volume than for residential buildings for several families (with a mean value of 0.479 Mg/m³ gross cubic content). Over 90% of building material masses are mineral. Figure 1 shows the usage of building materials in residential buildings as changing with time as a mass percentage distribution. It can be seen that the composition of the building materials changes from one age group to the next. Whereas the concrete portion has increased since the mid 1920's, the portion of timber as an organic building material has decreased to under 5 %. Although the buildings of the age groups from 1918 to the present day are mainly examples of the solid-wall type of construction, the portion of block and brickwork walling decreases in this presentation. This illustrates the fact that the increased use of concrete is not only at the expense of the building material timber but also block and brickwork walling. In comparison, a continual increase in the use of inorganic materials such as glass and steel as well as insulation materials can be observed.

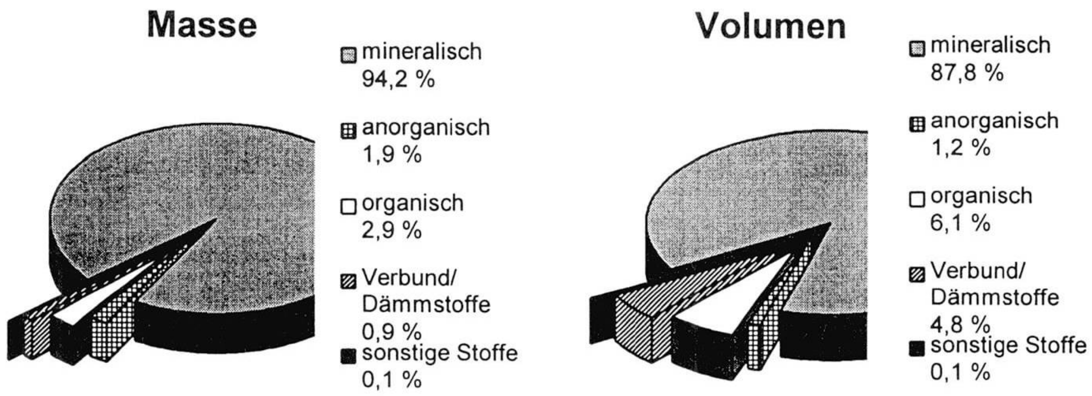

Fig. 1 Usage of Building Materials in Buildings of Various Age Groups as a Mass Percentage Distribution

The investigatin has shown that more than 80 % of the building material masses of the examined residential buildings can be apportioned to the loadbearing structure, and less than 20 % on the finishes. A displacement of the building material masses from the loadbearing construction to finishes is recognisable in the younger building groups. This emphasises the increased use of building materials in the area of finishes due to the increasing requirements made for thermal and sound insulation. The classifikation of the total mass of all examined residential buildings into the individual building element groups according to DIN 276 has shown the dominance of external walls and floor/ceiling construction each with a value of 31 % for multi-family houses, followed by internal walls with 21 %. For single family houses the proportion for external walls with 39 % is much more characteristic, instead the floor/ceiling construction portion is barely 21 % and the internal walls with 14 % are of less influence. Taking the external and internal walls together, it becomes apparent that the proportion of the walls for single and multi-family housing in total are almost identical with just over 50 % of the total mass.

2 Primary energy input of residential premises

The examination of residential buildings with regard to the cumulative production energy input (PEI_H) carried out on 20 buildings has shown that the basic primary energy input values for the building materials are not decisive but rather the building material mass, defined by the specific material density. The investigated buildings vary around the value PEI_H/mass = 2 GJ/Mg. But for example a building in the age group 1945 - 1955 is not only the heaviest but also has the highest PEI_H value; nevertheless however its relationship PEI_H/mass is more favourable than for buildings of the following building age groups. Overall it was ascertained that building elements with a heavy mass give a favourable level of the PEI_H/mass ratio; on the other hand a higher expenditure is required here for demolition and recycling. The elements of the building exterior are lighter, show however a higher building material energy level; on the other hand they contribute to the reduction of heating energy in the use phase.

3 References

Wörner, J.-D., Kloft, H. „Untersuchungen zum Baustoffeinsatz und zu den Primärenergieinhalten von Wohngebäuden verschiedenen Baualters“, Forschungsbericht, 1997
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