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VERBAND DER EUROPÄISCHEN PORENBETONINDUSTRIE

Passive houses built with AAC

Rising energy prices, in particular for fossil fuels, and current CO_2 emission reduction commitments are two challenges currently facing the building industry. In order to meet these, alternative, more efficient solutions for the housing sector are required. AAC materials constitute such an alternative developed by the building industry.

1. Definition

A passive house is a building with very low heating/cooling energy demand. The energy required can mainly be covered by so called 'passive' energy sources, such as solar gain, residents and household appliances.

2. Passive House concepts in Europe

The first passive house concept was developed in a German Swedish cooperation which resulted in the construction of the first passive house in 1990 in Darmstadt, Germany. The standard is providing a concept with a calculation tool (PHPP – Passive House Planning Package) with registered and certified building components.

Some European countries adapted the standard to their special requirements (climate, construction methods, regulations, etc.) and issued their own certificate while others are following the original concept and apply for the certificate in Darmstadt or using the calculation tool only.

Germany/Austria: Passivhaus Standard
Switzerland: Minergie
France: Effinergie

3. Requirements

Despite the fact that there exist various types of certificates in Central Europe, they generally have the following requirements in common:

- The building must be designed to have an annual heating demand as calculated with the Passivhaus Planning Package of not more than 15 kWh/m² per year in heating and 15 kWh/m² per year cooling energy OR to be designed with a peak heat load of 10W/m²

- The total amount of primary energy consumption (source energy for electricity etc..): primary energy for heating, hot water as well as electricity used for appliances cannot exceed 120 kWh/m² per year.

- The building cannot leak more air than 0.6 times the house volume per hour ($n_{50} \leq 0.6$ / hour) at 50 Pa (N/m²) as tested by a blower door.

Recommended:

- It is recommended, but not required, that the specific heat load for the heating source at design temperature is less than 10 W/m².

4. Key points to meet the requirements

- **minimised energy losses**
  - the shape of the building should be compact in order to reduce the surface area
  - well insulating building envelope
  - minimised influence of thermal bridges
  - air tightness
  - controlled air ventilation (heat exchanger to recover energy from ventilated air)

- **optimised solar gain**
  - optimised orientation of the building
  - large openings to the South
  - minimised opening to the North
  - shading
  - thermal mass to prevent overheating during summer

- **space heating**[1]
  - heat pump
  - natural gas or oil boiler
  - solar energy

5. Building envelope: Wall structure

Concerning wall material, the guideline is to keep the heat transfer coefficient equal to or below U=0.15 W/m^{2}K. There are three established ways to construct a well insulated passive house walls:

1. Monolithic wall construction
2. Monolithic wall construction combined with insulating material
3. Frame structure with insulation

6. Solutions in AAC

With its sound product characteristics, AAC is an important product for energy efficient construction in Europe. This is demonstrated by an increased AAC market share and boosted sales in the past decades. Monolithic AAC masonry and AAC masonries with marginal additional insulating layers are frequently used as exterior wall solutions in energy efficient constructions.

A single solid leaf of AAC masonry or element can be used to meet all the requirements for the house wall design. This constitutes a cost effective solution and provides a good balance between energy and financial savings. Therefore, the overall structure is robust and durable, based on more than 80 years of experience.

Despite its low heat conductivity, AAC has a relatively high density; its coefficient of thermal conductivity (relation between heat conductivity and heat storage) is considerably lower than normal insulating material. That means that AAC constructions can exhibit an optimal

[1] A conventional central heating system is not necessary but sometimes installed based on client demands.

insulation during both winter and summer. High room temperatures in summer – which can be found in highly insulated Scandinavian houses - can be reduced with AAC constructions, reducing the need for air conditioning and therefore also reducing CO_2 emissions.

AAC - Thermal bridges

AAC is an isotropic building material demonstrating the same characteristics in any spatial direction which ensures that energy losses are low at corners and joints (thermal bridges). Corresponding proofs on many details have been determined.

Photo1: even when using clay brick or other materials, AAC can be used to avoid thermal bridges (source: www.passzivhazepito.hu)

AAC - Air tightness

Air tightness can easily be achieved with AAC - no additional layer is required for air tightness as in light-weight construction.

AAC is airtight; constructions do not need additives such as foils or other artificially produced materials that can be used in order to guarantee air tightness. In addition, the indoor air climate is healthy with no mould growth and with a high quality humidity control.

AAC allows natural air tightness that facilitates the protection of the building against high infiltration losses without using further layers. With AAC wall and roof constructions, low infiltration air exchanges can be reached. Measurements have proven that values of 0,6 h^{-1} and lower can be obtained through the carrying out of an air tightness test of 50 Pa low / overpressure. That is why massive constructions can compare with lightweight frame constructions in all cases. To the contrary: the AAC capacity to keep the moisture out of the room leads to a comfortable ambiance. There will be no shanty climate based on high room moisture and no high surface moisture supporting mould formation.

The homogenous structure of AAC, contrary to hollow building materials or frame constructions, assures air tightness to be kept even if the surface of the wall is modified (when applying electric cables or hanging loads on the wall).

AAC - Thermal mass

Constructions made with AAC result in reduced overheating through its thermal mass and ability to retain heat during the hot periods and release heat during the cooling period (cf. Fig. 1). In order to achieve insulation levels of a Low-Energy-House, a physical connection is required between low thermal conductivity on the one hand and a sound heat storage capacity on the other hand. Good storage properties therefore lead to a balanced room climate and offer an essential precondition for the comfort of residents. (Only the reduction of U-values can cause an over damping of buildings and can result in too high indoor temperatures in summer.) AAC has both got low thermal conductivity and sound heat storage capacity. In summer, the room temperature in AAC buildings is on average 3-5°C lower than in lightweight frame constructions. The cooling load in AAC buildings basically to be covered by electricity is solely reduced caused by the good combination between low thermal conductivity and high storage capacity by 10-15 %.

The frequency of overheating in an AAC massive constructed house is considerably lower than in a lightweight framed house. The annual mean is approximately 3.4 % with a maximum value of 28.9° C whereas the lightweight framed house's value is approximately 13.1% with a maximum temperature of 32.8° C. The daily fluctuation degree of room temperature is considerably lower in the massive house than in the lightweight framed house. In AAC massive constructed houses, overheating mainly occurs in July or August whereas overheating in lightweight framed houses the whole period from April until October is extremely severe. Fig. 1 shows the influence of thermal inertia on the cooling load of the building which also affects the yearly amount of CO_2 emissions – especially in regions where cooling is urgently needed.

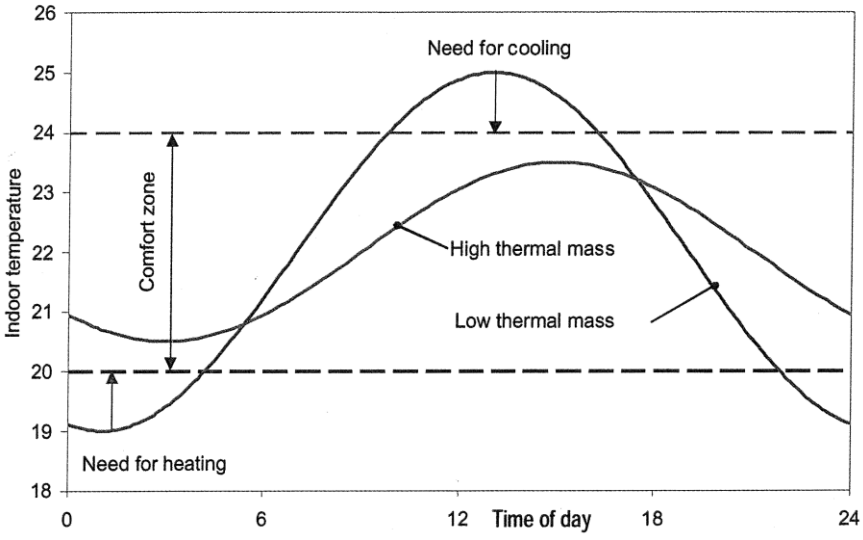


Fig. 1: Differences in cooling load requirements of buildings with light or massive constructions

In addition, AAC disposes the capacity to considerably defer heat from penetrating the material. This means that even during the heat-up phase, comfortable surface temperatures can be reached in unheated rooms. The windchill factor in winter is 2°C higher than the effective room temperature. For that reason, additional energy can be saved.

AAC - Thermal insulation

Building components made of AAC provide low energy losses over the building envelope thanks to low heat conductivity.

Practical examples answering passive house requirements:

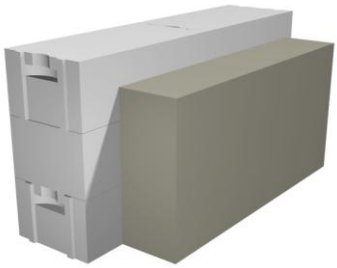
AAC + insulation

Sustainable and environmentally friendly solution made by a combination of AAC products with different densities.

AAC + AAC based insulation
(with Nature Plus certificate)

AAC masonry with additional non AAC insulation.

AAC + EPS/mineral wool



AAC – monolithic

Monolithic AAC wall without additional insulation.

Example:
40-50cm AAC monolithic AAC masonry

7. Conclusion

We can easily build airtight constructions with AAC masonry, with the help of system compounds (lintels, panels, etc.) the effect of heatbridges are already minimised below the external insulation layer. Furthermore, the linkbetween heat conductivity and heat storage of AAC leads to comfortable room conditions during winter and summer by minimized use of energy.
The big number of certified AAC passive houses proove that not only the wall material but the whole building can match the requirements.