Wall Systems made of Renewable Resources

Robert Wimmer Dipl. Ing., Luise Janisch Dipl. Ing., Hannes Hohensinner Dipl. Ing., Manfred Drack Mag.[1]

[1] GrAT – Center for Appropriate Technology at the Vienna University of Technology. Wiedner Hauptstrasse 8-10. A-1040 Vienna. Phone: ++43 1 58801 49523. Fax: ++43 1 58801 49533. E-mail: contact@grat.tuwien.ac.at

INTRODUCTION

Beside a good marketing concept, the successful introduction of new products into the building product market is dependent on technical certification. The aim of this project is to guide the innovative straw bale building method from the experimental stage to the professional stage, and to support its market introduction by providing the necessary product certificates, tools for efficient and effective quality management and optimized constructions suitable for passive houses. To achieve this, research and development work has to be done on three different levels:

- Developing technical tests to provide fire resistance and heat insulation certificates to meet the criteria set down in the Austrian and European Building Codes
- Optimising straw bale wall systems and connections of building components
- Developing a mobile straw bale testing lab to provide a tool to ensure efficient and effective quality management from the field to the straw bale house

THERMAL INSULATION TESTS

The post and beam straw bale construction used in the project was tested at the research institute of the MA 39 in Vienna and led to some exceptionally good results concerning heat insulation and fire resistance.

Thermal insulation of straw bales had already been tested in the USA. From these results a specific heat conductance of about ([lambda]; SI-unit: W/mK) 0,05 W/mK was expected. This would allow for a [lambda] of 0,06 W/mK taking into account the 20% humidity supplement for organic materials provided in Austria. The actual test results showed an even lower specific heat conductance of [lambda] = 0,0337 W/mK and 0, 0380 W/mK. With the 20% humidity supplement, straw bales have a [lambda]value of 0,0404 W/mK and 0, 0456 W/mK
The first value was measured according to ISO 8301:1991 (Thermal insulation - Determination of steady state thermal resistance and relate d properties - Heat flow meter apparatus), the second one according to ÖNORM B 6015 Teil 1 (Determination of thermal conductivity by the guarded hot plate apparatus).
These test results confirm the high performance of straw bales in terms of heat insulation.

FIRE RESISTANCE TESTS

The fire resistance of the building material (straw bales) and the building component (the straw bale wall system), was tested. Building materials are classified into four different groups:

A not inflammable, B1 hardly inflammable, B2 normally inflammable, B3 easily inflammable

To be able to use building materials without legal restrictions, a B2 certificate is needed.
Building components are classified into F30, F60 and F90, which implies how many minutes the building component resists fire. Tests already carried out in the USA led to the conclusion that the lack of oxygen in the compressed straw bales is responsible for a high fire resistance. This conclusion was confirmed by the tests carried out within the scope of the project. The straw bale and the straw bale wall system were tested according to ÖNORM B3800.
The straw bale was classified as B2 and the tested straw bale wall system was classified as F90.
These excellent test results show that highly fire resistant constructions can be realised without chemical treatment of the straw bales.

BUILDING PHYSICAL CALCULATIONS AND OPTIMISATION OF STRAW BALE CONSTRUCTIONS FOR PASSIVE SOLAR HOUSES

The avoidance of sources of error and the optimisation of building junction elements is essential to guarantee the high functionality of the products used and to ensure passive house standards in the long term. To this end 8 different wall systems based o n the post and beam straw bale wall (wooden framework construction with straw bale in-fill) were developed further and optimised.

Construction 1: Straw bale wall, outside ventilated at rear, interior gypsum plaster board
Construction 2: Straw bale wall ventilated at rear, interior clay plaster
Construction 3: Straw bale wall ventilated at rear, interior Hourdis brick
Construction 4: Straw bale wall ventilated at rear, interior clay board
Construction 5: Straw bale wall plastered, interior gypsum plaster board
Construction 6: Straw bale wall plastered, interior clay plaster
Construction 7: Straw bale wall plastered, interior Hourdis brick
Construction 8: Straw bale wall plastered, interior clay board

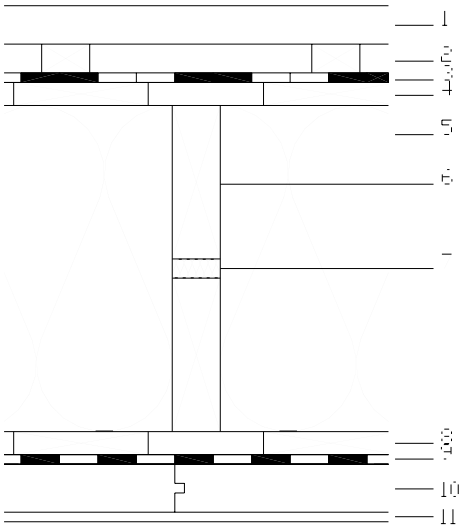

Figure 1 Construction 4 – Straw bale wall ventilated, clay panels on the inside

Table 1 Structure of construction 4

1	Shuttering	2 cm
2	Wooden bracing 4/4	3 cm
3	Wind barrier	0,02 cm
4	Wooden bracing diagonal	2,4 cm
5-7	Straw bale layer / wooden frame	34 cm
8	Wooden bracing diagonal	2,4 cm
9	Vapour barrier	0,02 cm
10	Clay panels	5 cm
11	Clay plaster two layers, reinforced	1.5 cm

Table 2 Building physical indicators of construction 4

Bauphysics - construction	Unit	
Thermal transmittance U-Value	W/m²K	0.13
Condensation/dry out potential	kg/m²a	
Straw bale insulation layer		0/0
Wooden frame		0/0
Heat storage capacity interior	kg/m²	66.8

All constructions fulfil passive house standards. Available calculations of thermal storage capacity to avoid overheating show low to middle values. The diffusion-open constructions avoid humidity problems within the wall and even enable fast drying after unexpected water damage. Sound insulation can be sufficiently achieved using double shell construction. Single shell constructions still have to be optimised. All the constructions exemplified can be made airtight without problem. Fire resistance is F90 without further adaptation. The connection of the straw bale wall to the other building components can be realised without creating thermal bridges. Installation of water and electricity causes no damage to the airtight layer. Joints of the straw bale to windows, ceiling and cellar can fulfil passive house standards.

QUALITY MANAGEMENT AND DEVELOPMENT OF A MOBILE TESTING LAB

To ensure the top quality of the building straw an efficient and effective quality management process has to be built up. To this end the development of a mobile testing lab for straw bales is the first major step. The testing equipment is responsible for the analysis and assessment of the quality of the straw bales. It also allows for the measurement of all relevant parameters of the bales. Dimensions, weight, temperature and humidity are measured. Furthermore, colour, shape, homogeneity, purity of the bale and appearance of mould are analysed and assessed by the testing person. The measuring equipment fits into a specially developed suitcase. A lab test series led to the adaptation and optimisation of the measuring equipment and allowed its functionality to be checked. The lab provides a reliable and easily applicable testing tool for the whole process, from the field to the straw bale house.

An important point of quality management is the avoidance of pest infestations during the storage of the bales and the building's construction. Literature points out that mice and insects are not a problem if straw bale constructions are properly made. It is also stated that clean straw has a low allergic potential.

It is important to use high quality bales and proper constructions also because badly

constructed buildings and the use of humid straw bales, or permanent penetration of water into the wall can cause mould growth and reduce duration of use and occupant comfort considerably.

CONCLUSION

The results of the study lead to the conclusion that straw bale building has a very high development potential, something which had already been indicated in studies carried out in the USA.

The fundamental technical basis and the necessary building certificates provided by this project prepare and facilitate the market introduction of this organic building material. In other words, an innovative building material is made available to the passive house sector. The study "Supporting and hindering factors for renewable resources in the building sector" (Wimmer, et al., 2001) points out that straw bale building can be used in many more fields than single family houses. This conclusion leads to further R&D questions which need to be worked on if the economic potential of straw bale building is to be fulfilled. R&D work to be done includes the following points:

- Improving the dissemination of straw bale building
- Expanding the variety of straw bale constructions regarding technique and design
- Improving the availability of straw bales in the desired quality and quantity
- Enabling the full regional potential of straw bale building to be fulfilled
- Maximising regional added value for local entrepreneurs and farmers
- Efficient co-operation structures for straw bale building
- Long term tests

The currently ongoing project "S-House" (www.s-house.at) a EU LIFE-Environment Project, will put into practice a straw bale demonstration project based on the results of this project. The "S-House" will help to disseminate all relevant information about ecologically sound constructions and building products made out of renewable raw materials.

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