

STRAW AND EARTH

-The Sustainable Materials of the Past and the Future



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Summary

The modern concept of sustainability often seems determined to reinvent the wheel.

By drawing on historically well-proven materials combined with modern research in health, embodied energy, structural integrity, low-energy design etc., we outline how such fundamentally basic ingredients as straw and earth can be a significant solution to the task of providing modern sustainable buildings for the future. *...in effect improving the wheel...*

Keywords: Straw, earth, low embodied energy, passive energy, breathable membrane, earthen plaster, Kyoto protocol, local resource, non-allergic, cost effective, low environmental impact.

1 Strawbale building of the past

It was only a matter of a couple of years from the invention of the first straw bale pressing machine to be introduced to the prairies of Nebraska, before the first house were build out of straw bales in the second half of 19t century. What else do you do when you have no timber or bricks available, only a load of over-sized Lego bricks? Fact is that some of the houses build back then still exists, as do a few which were build in Europe around 80 years ago.



<Nebraska 1900

France 1921>



Straw bale building has been gaining a fast revival since the mid-80'ies when it was re-discovered in USA and since spread to all other continents. Several countries in Europe has adopted specifications for straw bale building in their national building codes, and it is estimated that min. 2000 'authentic' straw bale buildings has been build in Europe during the past 10 years, covering everything from cabins, homes, schools to school gymnasium/hall. Several more types of structures exists where straw serves only as an insulation between 2 other walls, however keeping within the topic of sustainability, this paper will highlight the original approach where the bale wall is the actual wall, with rendering [plaster] applied direct to the straw. -We believe that applying other wall elements is an unnecessary waste of resources and energy.

The story of the 3 little pigs and the wolf has frequent been proven wrong, as a good earthen plaster enhances the structural solidity of the building while making it not only resistant to fire, but also classified as fire preventing: The official German fire test in 2003 proved that an earth rendered straw bale wall resisted ignition for 90 minutes in a 1000-degree burn chamber (MPA-iBMB). Naturally designs exist to reduce earthquake and hurricane risk; the main Achilles' heal for these structures are construction in areas prone to flooding and even this is somewhat possible to design around.

It is clear that a majority of the modern straw bale buildings are custom build and often in a rather time consuming process as (in Europe) there exists only a few building companies specialized in building with straw bales. The aim of this paper is to demonstrate how straw bale building can be the solution for a sustainable building process of the future.

2 The basics of straw bale building

A straw bale building is traditionally either designed as a loadbearing or non-load bearing structure: Fact is that well pressed bales are perfectly capable at carrying a roof or additional storeys (up to 3) if properly designed. Strawbales come in many dimensions, and several of the smaller ones can be slightly bend, which means that a variety of shapes has been obtained; circular, round, arched, spiral, and naturally a majority of variations of the common rectangular house shape. With insulation values around app. 0,05-0,06 W/m²K, sound insulation value: $R_w = 53/54$ dB and vapour diffusion resistance = 0,3-0,5, there's enough solid evidence to take this material serious when planning a low energy building project. (Keller, 2002)

History has taught us that the use of an impermeable membrane on natural building materials is prone to failure. This is most often witnessed with cement-based plasters on unbaked brick walls. The same factor is central in straw bale construction, which highlights the values of earthen plaster, as it protects and strengthens the bale walls, while remaining able to absorb and disperse moisture from within the bales. Once the earth plaster is capped with another time-proven element; lime wash, the coating will be complete and weatherproof as long as protection from direct rain and flooding has been incorporated into the design: Give a natural house tall boots and a wide-brimmed hat.

3 Straw bale building for the future.

Buildings account today for about 40% of the final energy consumption of the EU, with a

large energy saving potential of 22% in the short term (up to 2010) (Eicker, 2002). Under the Kyoto protocol, EU has committed itself to reducing the emission of greenhouse gases by 8% in 2012 compared to the level in 1990. Buildings have a major role to play in achieving this goal. We believe that both academia and industry need to be able to present real sustainable solutions, despite the overwhelming heavy industry lobbying for over-processed materials.

3.1 Effectivity combined with ecology in passive house construction:

One such approach to modern, commercially applicable straw bale building has been developed by Arch Werner Schmidt from Switzerland, in his design for private passive energy homes made by ‚Jumbo bales‘. The approach is unique in the ease of assembly, impressive strength and insulation due to the thickness of the walls and the fact that the house can be 80% made by products grown locally and often considered a waste product. Add to this modern spray plastering equipment, pre-fab low energy window section, pre-fabricated roof trusses of FSC certified lumber. The bales has to settle/compress for 1 month, which means it seems quite possible that such a house can be build during a 2 month period. Naturally it would be preferably to have a series of these houses being build at one time, capitalizing on the use of the heavy machinery and teamwork. The ecological footprint of such construction will rapidly be reclaimed due to the low impact living situation created.



(Photos courtesy of Arch Werner Schmidt, www.atelierwernerschmidt.ch)

3.2 Dispelling the myth of the impermeable wall in passive house construction

It is a common conception that to reach any kind of passive house standard, a building requires a completely sealed envelope and heat-exchange devises. Jakub Wihan's computer simulations in 2005 was aimed at disproving this conception. The working question was:

„Is it possible to achieve the passive-energy building standard by design while using natural, ordinary and inexpensive materials without heat recovery and without particular care about air tightness?“ (Wihan, 2005)

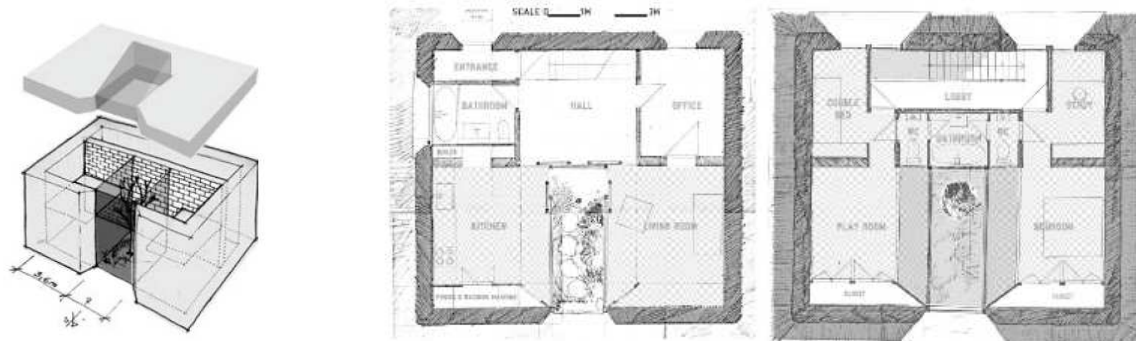
Yes. It is possible indeed; only the importance of air tightness shouldn't be underestimated. The infiltration of 0.5 air changes per hour means that the house was built with concern for air tightness. The increase of infiltration from 0.5 to 1 ac/h (still a low level of infiltration) almost doubles the overall annual heating demand. Increasing air tightness can result in moisture problems and consequent health effects. (Tsongas, 2004). Therefore the interior

earth plaster, acting as a humidity buffer, in combination with kitchen and bathroom ventilation, is essential for keeping the indoor environment healthy.

The research also demonstrated that heat distribution in a house can be effectively achieved solely by natural ventilation; simply by opening the windows.

It does need properly disciplined inhabitants, who would open the windows when they feel too hot, and wouldn't mind the temperature falling to 16 degrees Celsius during winter nights in sparsely occupied rooms. Otherwise 19 degrees is maintained through the whole winter in the most convenient hours every day in the living room, kitchen, upper bathroom and upper studies.

One very significant factor in thermal performance is insulation. Without a 450mm thick super insulating straw bale wall, it wouldn't be possible to achieve the passive building standard. Earth plastered straw bale not only creates a warm environment, it also improves humidity levels within the whole structure. Clayish earth is a great humidity buffer (Minke, 2005). The embodied energy of those two materials can be absolutely minimal. Ideally, earth would be from the building site and straw from a neighboring farmer.



3.2.1. Technical elements of the simulation.

The window orientation plays a crucial role in the thermal behavior in such lightweight, superinsulated house. All the additional windows, except the one in the bathroom downstairs, were oriented to north. Any other orientation would add significantly to overheating. Properties of all additional windows were low-e double glazing with $U = 1.95 \text{ W/m}^2\text{K}$. In the simulation all windows were given cracks along their perimeter with a crack flow coefficient $0.15 \text{ l/(s*m*Pa}^{0.6})$. To complete the picture, casual gains and infiltration were added to the model. Some sources say that for the ideal environment, infiltration of 1 ac/h is necessary in a residential space. According to Show (1987) 0.5 ac/h represents an average level of infiltration in double story, low energy houses. It insures a healthy environment, especially as the interior plastered with earth, functions as an excellent humidity buffer (Padfield 1998).

4 Conclusions

Straw bale building with earthen rendering has proven itself as a viable building material for more than one hundred years. Even with a modern industrial big-bale approach we are able to achieve very comfortable designs, which are close to co2 neutral in the materials, and rapidly will repay the embodied energy of the construction through the impressive insulation and energy savings. Computer simulation has proven that the permeability of the

straw bales does not negatively influence the passive house standards, in fact other research credit this factor as providing a superior healthy indoor climate. The main drawback of the design may be the amount of space occupied for the walls, however with the average family having become half the size of individuals during the past 50 years, along with the average home having double in square meters, perhaps it's not the issue of the space taken by the walls which has to be focused on?

This presentation represents a concept currently being developed for commercial implementation by the authors. We welcome further cooperation by interested researchers and companies who can agree to our aim of creating the best quality design and effective execution at reasonable costs, while ensuring reduced energy consumption in the home and a constant target of reduce fossil fuel use to zero.

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