**Frequently Asked Questions about**

# Straw Bale Building

*A brief overview of the main principles of straw bale building applicable for Georgia*

## Principles of straw bale building

Straw bale building typically consists of stacking rows of bales (often in running-bond) on a raised footing or foundation, with a moisture barrier or capillary break between the bales and their supporting platform. Bale walls can be tied together with pins of bamboo, rebar, or wood (internal to the bales or on their faces), or with surface wire meshes, and then stuccoed or plastered. The bales may actually provide the structural support for the building ("load-bearing" or "Nebraska-style" technique), as was the case in the original examples from the late 19th century.

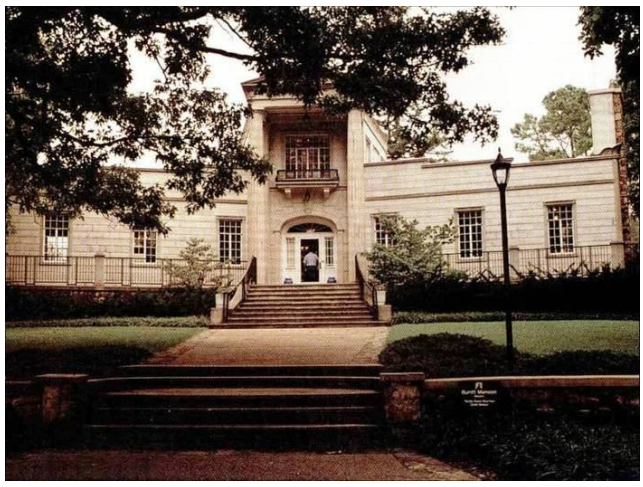
*Picture 1 Straw bales are filled into a wooden frame*

Alternatively, bale buildings can have a structural frame of other materials, usually lumber or timber-frame, with bales simply serving as insulation and plaster substrate, ("infill" or "non-loadbearing" technique), which is most often required in northern regions and/or in wet climates. In northern regions, the potential snow-loading can exceed the strength of the bale walls. In wet climates, the imperative for applying a vapor-permeable finish precludes the use of cement-based stucco commonly used on load-bearing bale walls. Additionally, the inclusion of a skeletal framework of wood or metal allows the erection of a roof prior to raising the bales, which can protect the bale wall during construction, when it is the most vulnerable to water damage in all but the most dependably arid climates. A combination of framing and load-bearing techniques may also be employed, referred to as "hybrid" straw bale construction. (source: Wikipedia)

## History of Straw bale building

The oldest houses can be found in the United States, Nebraska dated from the beginning of the 20th century. Due to the invention of the combine it was possible to use straw blocks to build houses on. Out of poverty and lack of other building materials people began to experiment with straw building. The bales composed a strong wall that supported the weight of the roof. A loam plaster for the inside and a cement plaster for the outside were used.

In the 90ies straw bale building became again popular in Western Europe and the United States due to environmental reasons, the comfortable houses it provides and its accessibility as do – it – yourself technology.



*Picture 2 Straw bale station in Nebraska from 1930*

## How strong and durable is a straw bale house?

The oldest straw houses are about 100 years old. If well constructed, a straw bale house is as durable as a conventional house.

Walls can be load bearing and carry the load of the roof. Straw and clay are extremely flexible

materials, about 10 – 15 more flexible than an iron construction, and can resist a pressure of 20/90 kN/m. The strengths of the walls is due to the plastering, that has to be supported by the basement. In wind tests straw bale walls scored well.

**Humidity and straw building:**
The clay plaster is letting through moister and air, it is a 'breathing' material. If the indoor air is humid, the clay absorbs the humidity, and will release it when the air is dryer, regulating humidity and ensuring a stable and pleasant indoor air quality.

What to do so that humidity doesn't harm a straw building:

1. The foundation should reach at least 20 - 100 cm above the ground in order to protect the straw and clay walls from splashing rainwater
2. A moisture barrier between the foundation and the straw bales
3. Roof: The roof should have a long 'overhang' to prevent rain falling directly on the walls, at least 50 cm.
4. Plastering: The outside plastering can contain lime or cement to increase the water resistance of the plastering, where hydraulic lime has preference.
5. Protection layer: The side from which the rain usually comes can be protected by wooden slats instead of plastering or on top of the plastering.

**What about fire resistance?**
Straw houses score fairly good in fire tests. The straw is compact and has not enough air inside to burn. It is as trying to burn a closed telephone book. A straw and clay wall resists one hour during fire tests with 1000 C. In the EU there are usually no problems to obtain the building permission and fire insurance for a straw house.

**Can pests harm straw bale walls?**
Straw bales are thick and dense enough to keep out of pests. As well, the layer of plaster makes them unattractive or impenetrable to animals and insects. The lower 30 cm of the wall can be covered with a fine mesh inside the plaster to keep out rodents. Finally, because straw contains little nutrient value to most animals and insects, it does not attract pests. The denseness makes it unsuitable for rodents to nest.

**Are there any limitations in size for straw buildings?**
Continued load bearing straw bale walls have been constructed up to 23 meter length and 3.35 height. If the wall is too high, the plastering can not bear its own load and the wall cracks or the plastering comes down in its whole. It is possible to construct buildings with several floors. Between the floors the plastering should be supported by a wooden base or any other interruption.

**How to make the framework?**
The framework should be firmly connected to the foundation. The load should be carried by strong bars. Frames for windows and doors should be integrated in the framework. The distance between the bars within the wall should depend on the lengths of the straw bales to avoid cutting of bales.
The placement and nature of the bars and slat can be designed in many different ways. An experienced carpenter will be able to construct a proper wooden frame for a straw house.

*Picture 3: an example of a wooden framework to be filled with straw*

**Is an iron frame possible?**
An iron frame is possible, but wood is to be preferred for three reasons:

1. Wood, straw and clay are natural materials with a certain flexibility, and therefore fit together well. Iron is not so flexible, and the combination may cause cracks if the wall is moving a little bit.
2. Iron is a very good heat conductor, and may cause 'cold bridges' in the wall if it has contact to the outside of the building and the wall, conducting the cold from outside to inside. This is decreasing the insulation effect of the wall. Furthermore, the cold parts cause condensation inside the wall, where water can gather wetting the straw. Wet straw will start molding.
3. Iron production is highly energy demanding, while wood is a renewable natural material using sun energy to grow.

**How to build the foundation?**
The foundation should be wide enough to support the plaster layers on both sides of the bale. There should be a moisture barrier between the foundation and the straw bales. It should be 20 – 100 cm high. The foundation can be build like in any other house from concrete. In humid areas it is recommended to apply the traditional pillars below the house.

**How to make and apply the plaster?**
The straw wall needs to be plastered on the inside and the outside. A plaster contains clay, sand, chopped straw and water in different proportions, and in some cases for the outside walls hydraulic lime or cement. To get a smooth wall, different layers of plaster with different properties are needed.
The very first mixture is quite sandy and contains 10 cm pieces of straw.Its function is to close the 'gaps' in the wall that occur at junctions with the wooden frame..

1. The first layer of plastering has a similar composition, only the straw pieces are smaller now. It is applied by hand or by compressor (needs to be more liquid) and its function is to even out the relief of the wall.

The second layer contains a bit more clay and is applied by plastering tools. The wall is straightened out with the help of long slats. After the second layer the wall should be really straight. A glass fiber mesh or jute mesh should be plastered into the second layer to increase stability of the plastering and avoid cracks.
The third and last layer is the thinnest layer and contains even more clay. Its function is to finish off and smooth the wall. In some cases for the outside wall lime or cement (not recommended) can be added to the last layer of the outside walls. It can also contain a natural color to improve appearance.
In total the plaster should be about 5 cm thick.

*Pictures 4-8 show the different layers of plastering, filling the gaps and the first and second layers*

In the Netherlands, the plaster is delivered ready made to the building site. In Georgia the right mixes have to be identified. This can be done by making different mixtures with small cups to test their quality by applying them on small pieces of wall.
As a rule the inner layers are more sandier than the outer layer. The more clay, the thinner the layer has to be because clay tends to crack. The thicker the layer, the higher the chance for cracks. As a rule of thump, no more than 5 cm at a time should be applied.

*Picture 9 the right plaster mixture was identified by experimenting*

*Picture 10 the final layer of plastering gives a beautiful look*

**Is it needed to strengthen the plaster with armature?**
It is possible but not needed to use armature in the plaster. The experts recommend to use glass fiber mesh or jute for strengthening the second layer. Chicken wire is also possible, but costly and might cause cracks on the places where the iron runs. Iron is extending and decreasing under influence of temperature, causing cracks in the plaster.

*Picture 11 Glass fiber mesh*

**Is it possible to use cement in the plastering?**
The oldest straw houses in Nebraska have a cement plastering for the last layer. However in modern times cement is not much used anymore in straw building for three reasons:

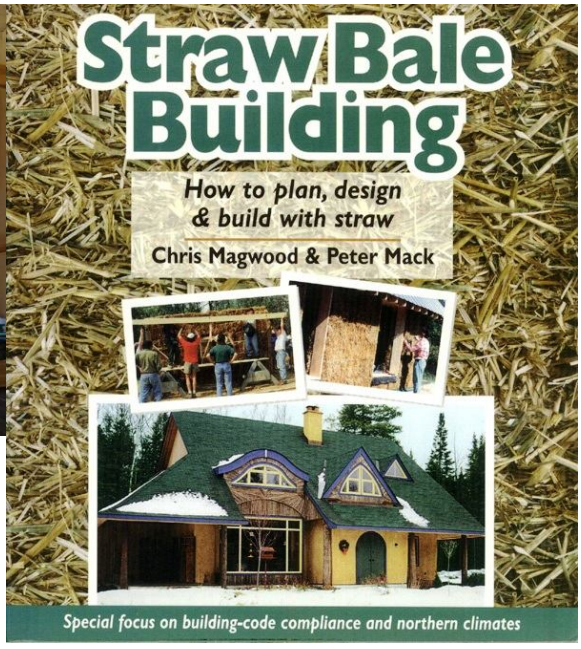
1. Cement is not moisture permeable, thus the risk for condensation or high humidity inside the wall with cement plastering is higher than with clay plastering.
2. Straw and clay are materials with a high flexibility, while cement is rather inflexible. Possible small movements in the straw and clay wall may cause the cement to crack.
3. Cement production is very energy intensive, thus responsible for high CO2 emissions.

**How well is straw insulating?**
With straw the best energy efficiency can be achieved for an affordable price, and even zero energy houses can be built with straw and clay. Straw has a heat conductivity capacity (Lambda) of 0.08 W/m°C, which means that it is a fairly good insulator. However a straw wall with 42 cm straw and 2.5 cm plastering on both side has an Heat Resistance R value of 6.689 m²°C/W, which is extremely high in comparison with almost all other insulation possibilities. A not insulated brick wall has a R value of 0.93 m²°C/W, and a brick wall with 12 cm polystyrene insulation a R value of 3.953 m²°C/W.

**How much will it cost?**
Straw is much cheaper than any other building or insulation material. A straw bale house will be the costs of a brick /wooden house minus the costs of the walls. Although construction is more labor intensive, the material costs will be 40 - 50% less than that of a brick house, though depending on many factors.
During exploitation a lot of costs for heating are saved if well build; one simple wood stove will be able to heat the whole house.

**Advantages of straw bale building for Georgia**

1. Cost effective building
2. Relatively easy to build also for do-it-yourself-ers
3. Very good insulation – significantly less costs for heating needed and increased comfort
4. Healthy and pleasant indoor air climate due to natural materials
5. Environmentally friendly materials and production
6. Straw bale walls do not let through sound well
7. Fire and earthquake resistance
8. Durable materials – if well build houses stand for a long time.




*Picture 12- 13 Straw bale houses can be very comfortable and beautiful*

**Challenges to overcome:**

**Technical:**
No plastering ready mixes are available in Georgia, and the mixtures have to be made experimentally by adding sand and clay from the surroundings.

There is no standardized straw bale production in Georgia suitable for straw bale buildings. The straw bales should be tested on humidity (not more than 15%), they should be firmly pressed and contain a minimum of weeds.

**Regulations:**
Straw bale is not officially recognized as a building technique, and it might be difficult to get a construction permission for a straw bale house. However Straw bale is sufficiently tested in other countries, building standards are developed and gets building permissions even in Germany.

**Knowledge:**
There is only very limited experience and knowledge available and no architects yet in Georgia that are experienced with straw bale buildings. It is crucial to involve experts from Europe, who already indicated their will for supporting the development in Georgia.

**Useful links in Russian:**
http://www.strawhouse.ru/
http://www.ecodom.ru/
http://neoklassika.ru
http://biodoma.ru/
List of films (**tip**!): http://neoklassika.ru/?id=43
film: http://ecodom.ru/Services/Cinema/our-video/our-video_28.html
film: http://skillopedia.ru/material.php?id=1662

German:
http://www.baubiologie.at/index.html