

Green Design and the City

Straw Buildings

Project: Flows

Yuming Shen
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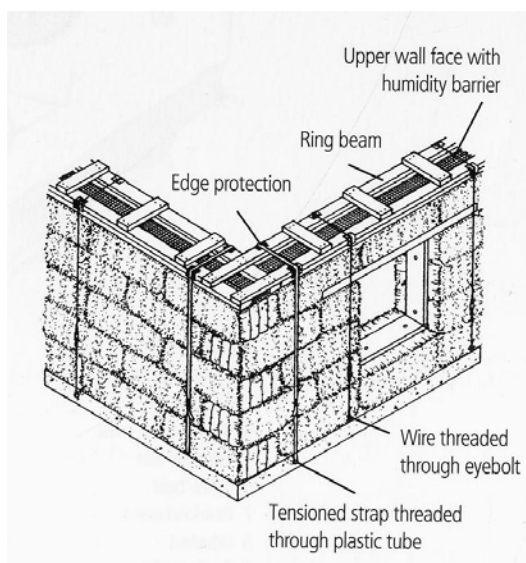
In the world of eco-friendly construction, straw bale builds are experiencing a resurgence of interest due to the sustainability of straw's lifecycle. The United States has a long history of building with straw. Straw bale houses were first built in the Sand Hills of western Nebraska in the 1800s in response to the lack of available wood in the area from which to construct buildings and the sandiness of the soil that prevented sod homes from being built (Chiras 166). In the United States, the oldest straw house is around 100 years old (Minke and Mahlke 11). Straw is a renewable product that can be grown yearly and in a wide variety of climates. The best straw bales to use for constructing buildings are made from wheat, spelt, and rye. Contrary to popular belief, straw also rots very slowly due to its high silica content (Minke and Mahlke 19). The annual production of straw makes it an even better sustainable material than wood, which takes years to grow. The production and transportation of straw also uses a lot less energy than wood harvesting and transportation (Minke and Mahlke 10). This is why straw is said to have low embodied energy, or the energy it takes to produce a material, as it can usually be found locally and harvested easily (Chiras 99). Straw bale buildings can also be free of a lot of chemicals if the straw is grown organically and the plaster used is earth-based or limestone (Magwood, Mack and Ohi 9). Straw bale walls are also great for insulation (Chiras 101). Houses built from straw bale walls can pass passive-house standards, or houses that consume less than 15kWh/m² of annual heating energy. Straw bale walls can be used for all one or two storey buildings (Minke and Mahlke 11). In Germany, there is enough straw production to insulate 350,000 single family homes per year (Minke and Mahlke 11).

How Straw Bales are used

Straw bales come in multiple dimensions. Small straw bales that are 32 to 35 cm X 50 cm X 50 to 120 cm with a higher density, 90 to 120 kg/m³, are usually used in home constructions. The lower density bales, 80 to 90 kg/m³, are unsuitable as they are too unstable and would have to be recompressed to be used for construction (Minke and Mahlke 19-20). Ideally polypropylene straps should be used to tie the bales together as sisal straps offer too much slack and allows the straw to expand (Minke and Mahlke 20).

When stored the bales should be kept as dry as possible and not be allowed to touch moist ground or be exposed to rain as this induces the straw to rot quicker (Minke and Mahlke 20).

Straw bale buildings can be load-bearing or non-load-bearing. Load-bearing walls are made from straw bales stacked in a running bond pattern, which increases the rigidity of the wall. Wall rigidity is further assured by driving pins made of rebar or some natural material, like bamboo, into the bales for internal pinning or attaching them to the outer and inner surface of the bales for external pinning. External pinnings provides better support against wind loads but are difficult to plaster over. Walls that aren't prestressed tend to buckle easily when put under horizontal pressure (Minke and Mahlke 23). Ring beams and tension straps are used to help compress the straw bales and prestress the

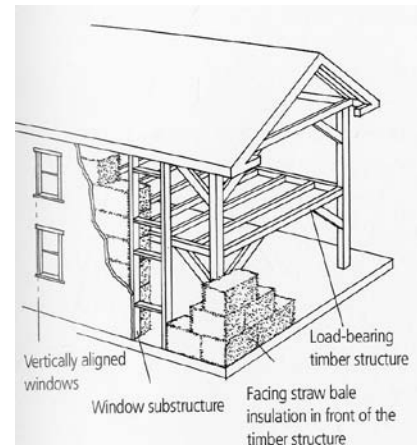


walls, as seen in the figure to the left (Minke and Mahlke 22). The running bond pattern also helps to lock the bales together. The straw bale walls provide insulation and are sturdy enough to hold up the weight of the roof. The bales are stacked on top of a waterproof foundation. An example of an eco-friendly foundation is straw bales placed on top of wooden pallets resting on used car tires, creating ventilation and keeping moisture from collecting underneath the house (Minke and Mahlke 27). For roofing, a wooden top plate is

installed on top of the walls and a roof is then secured on top of that. The top plate secures the roof to the walls, distributing the weight of the roof evenly on all the walls and preventing walls from buckling. In load-bearing walls, the top plate needs to be securely attached to the foundation. Load-bearing straw bale walls are pretty sturdy and are able to support seven times the weight of a 2 X 4 stud bearing wall (Chiras 167). The compression of the straw bales and the prestressed walls are needed to avoid compression when the roof is added to load-bearing walls. The denser the bale the less

it will compress (Minke and Mahlke 22, 24). Straw bale walls can support roof loads that are greater than 1,000 kg/m³ (Minke and Mahlke 23).

Non-load-bearing straw bale walls include a support structure, usually a post-and-beam frame, which can hold the weight of the roof. The support structure can be made from posts, logs, or concrete blocks. Walls made this way are said to be made by the in-fill method since the straw bales are fitted into the support frame in a running bond pattern to provide insulation, as seen in the figure to the right (Chiras 167) (Minke and Mahlke 23). An advantage to non-load-bearing walls is that should the straw bales start to decay the decaying sections can be taken out without affecting the structure of the house (Palmer 11/10/09). Straw bales can also be used to insulate roofs if incorporated into the plans at an early stage. If the height of and distance between the



rafters equal the dimensions of a straw bale then it's a pretty simple process to install straw bales. The straw bales used to insulate roofs do need to be secured against wind uplifts and from sliding if the roof is pitched (Minke and Mahlke 25). Straw bales can also be used to insulate the floors. In both roof and floor straw bale installation, there needs to be particular attention to be paid against allowing moisture to accumulate in the straw bales (Minke and Mahlke 26).

Advantages to Straw Bale Buildings

Straw bale homes have great insulation due to the thickness of the walls. Thick walls and the fairly low conductivity of straw greatly prevents heat loss to the outside (Magwood, Mack and Ohi 6). The effectiveness of straw bales as insulation can be seen in the R-values, which expresses the ability of a material to resist the flow of heat, of R-35 to R-50 for straw bale walls compared to traditional residential walls that range from R-12 to R-20. Straw bale walls also offer an unbroken surface while a frame wall uses studs that are R-1 per inch (Magwood, Mack and Ohi 6). Compared to mineral building materials, like brick, the thermal conductivity of straw bales is affected a lot less by

humidity (Minke and Mahlke 29). However, a home built with walls of equal thickness out of other materials will offer the similar amounts of insulation, just at greater costs (Magwood, Mack and Ohi 9). Additionally, straw bale walls reduce the amount of wood used in building homes if the walls are load-bearing.

Through the process of photosynthesis, the crops used to create straw bales act as carbon sinks and are able to use more carbon dioxide than what is created during the creation and transportation of straw bales (Minke and Mahlke 10). Straw bales are created as a by-product of harvesting for grains so the energy output to harvest straw is already being used to harvest the grain, giving farmers two products for the price of one (Magwood, Mack and Ohi 8). Straw is also often burned on farms to get rid of the straw and to provide nutrients for the soil and is often viewed as a waste by-product of grain production. Straw from farms is usually more locally available and thus reduces the energy used in transporting the material. In demolition, straw bales can easily be separated and used as mulch in gardens or on farms (Minke and Mahlke 10). The technique for building straw bale homes is also relatively simple compared to other building methods, which promotes home-owner projects. Straw bale homes can also be cheaper to build than a conventional home but that depends largely on several factors including whether you are hiring contractors or doing-it-yourself and if you are building load-bearing or non-load-bearing walls (Chiras 169). Normally, the cost of a bale wall is around one-fourth the cost of a comparable wall made from conventional materials (Magwood, Mack and Ohi 34).

After being coated with plaster, straw bale walls become extremely fire resistant, with a F90 rating or fire resistant for 90 minutes, but fire is a very real hazard during the construction process due to the loose straw surrounding the construction site (Minke and Mahlke 12). Apart from the fire resistant aspects of the plaster used on the walls, straw bales themselves are naturally fire resistant since the compression process to make bales forces the air out of the bales (Magwood, Mack and Ohi 19). The plaster also makes the walls resistant to mold. One fear that people have of building with straw bales is that vermin or insects will get into the walls and nest. This is unfounded as mice

don't feed on straw and, built correctly, mice should not be able to penetrate the walls to reach the straw bales to nest. Termites also do not prefer straw and it was found in old straw homes that while termites had infested the wood sections, they left the straw alone (Minke and Mahlke 12).

The high ductility property of the straw bales makes the material suitable for earthquake prone areas since it is able to absorb the kinetic energy released from earthquakes. After compression, straw bales tend to return to their former shape if the pressure is released (Minke and Mahlke 24). Straw bale homes are being introduced by the Adventist Development and Relief Agency as a housing solution for people affected by the earthquake in the Sichuan Province of China due in part to its earthquake resistant capabilities (McGill 11/09/09). Straw bales also insulate against air-borne sound better than other building materials, as seen in the

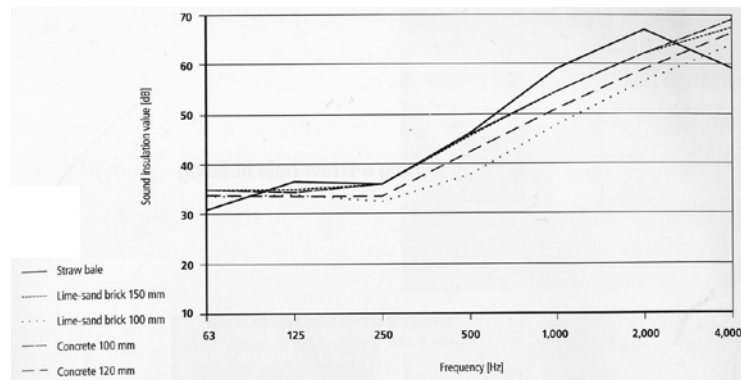


figure to the right (Minke and Mahlke 35). Mortgages and insurance plans are available for straw houses in the United States and the resale market is respectable (Chiras 169).

Disadvantages to Straw Bale Building

Unfortunately, straw from farms have usually been sprayed extensively with pesticides during the growing process since they are the shaft section of cereal crops. The use of straw for building also means that it can't be plowed under and provide nutrients to the soil on farms (Chiras 169). Additionally, the smaller straw bales are harder to come by since most producers of bale presses have stopped making the smaller versions (Minke and Mahlke 19). Straw bales also differ in size. The faster the pace of the harvest processes the more the shape and density of the straw bales starts to differ. Straw harvested in the mornings also has a higher moisture content and needs to be left to dry out (Minke and Mahlke 20). Weeds in the field also pose a problem as they decay at a

faster rate than straw, compromising the integrity of the walls built from the bales (Minke and Mahlke 20).

Straw bale homes are not suited for humid climates. If not constructed correctly, water can get into the walls of straw bale buildings and the bales could mold and deteriorate. Mold can grow in the bales if the moisture level is high; dry straw bales have a moisture content below 15%. To prevent moisture from accumulating a vapor barrier needs to be installed on the inside of the wall, which is not easy to do, to prevent moisture from getting into the bales or the exterior walls needs to be vapor permeable enough for condensation to diffuse out. During the plastering process the plaster has to dry quickly and allow for diffusion so that the straw, which through plastering became moist, can also dry. Organic additives in plaster can slow the drying process, which is why the outer most layer of plaster should contain no or very low organic additives (Minke and Mahlke 12). Dust allergies can also be an issue during the construction process but actual tenants of the building shouldn't have issues with dust as the walls are finished with plaster (Minke and Mahlke 12). Straw bales also have poor heat storage capacities due to its low thermal mass so the plaster used is very important in regulating indoor climate (Minke and Mahlke 28).

The cost of a straw home also depends on everything else that goes into the home and can sometimes be quite expensive (Chiras 169). For example, in non-load-bearing straw bale homes the foundation needs to be wider, the embrasures deeper, and the roof overhang greater to accommodate the load-bearing frames and the straw bale insulation (Minke and Mahlke 24). The rendering process of coating the walls in plaster, filling the gaps, and smoothing the bale surfaces, takes a lot of time and creates much higher costs than that of a masonry wall (Minke and Mahlke 71). While the cost of the bales are lower than traditional insulating materials, straw bales only make up a small portion of the overall cost of constructing a building (Minke and Mahlke 71). There is also a lack of planning permission in some countries to build straw bale homes even though it has been a tried and tested method of construction for years in the United States (Minke and Mahlke 24). While fire damage isn't an issue, water damage from a

busted pipe or from flooding is a problem as it is expensive and very labor intensive to dry straw bales and could add an additional cost to any insurance plan (Minke and Mahlke 72). Straw bales are still not a popular enough of a building choice for some people to risk investing in it financially when taking into account insurance, mortgages, and the ability to resell straw bale homes.

In the end, a successful straw bale house needs to be constructed carefully to avoid the disaster that could occur when building with decaying or moist straw bales. In Minneapolis there was a highly published story of a straw bale house that had to be condemned and then destroyed several years after it was built due to the walls decaying (Palmer 11/10/09). However, if done well a straw bale home will provide great insulation and help save home owners money from their energy bill. Straw bales are also very sustainable. Straw is grown and harvested annually and has low embodied energy. If a home was to be demolished, straw bales are recyclable. They can be used as mulch in gardens or on farms, decreasing the amount of construction and demolition waste that ends up in landfills. Straw bales, however, do only replace the insulation used in buildings if the walls are non-load-bearing and thus can only do so much to increase the eco-friendliness of the construction process.

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