Straw Bale Construction

Introduction:

Demand for well insulated, comfortable affordable housing is worldwide for any class of people, old or young, wealthy or poor. All of humanity wants to be happy in their home, to be safe, warm and comfortable. Straw bale housing offers that solution and can be applied to almost any climate on earth.

In this report, we will examine straw bale building construction from the inside out by providing a brief history of straw bale building, a look at the two major construction techniques for straw bale structures and then discussing the pros and cons of straw bale building.

Taking a macro approach to the outside in aspect of straw bale housing entails comparing some current policies and initiatives on straw bale building at national and international levels and examining some case studies of straw bale housing at the international, state and local levels. The conclusion covers projecting the effect of straw bale building in cities.

Inside Out:

This section will examine straw bale housing from the inside out, stating a brief history of straw bale building, investigating what entails constructing a wall of straw bale using two different building techniques and then discussing the pros and cons of straw bale construction.

Brief History

Straw bale construction was first used during the early 1900’s in Nebraska since wood was scarce and straw was plentiful. Straw bales from the farm were used for constructing load bearing walls. The roof was then built directly on top of the straw bale walls. Houses in this time frame were small and rectangular shaped, adding to the ease of constructing a house from straw bales.

A lime and/or clay plaster covered the straw bale walls on the interior and exterior keeping out moisture, insects and rodents. Chicken wire was attached to the straw bales so the plaster would adhere. Some houses used other materials to cover the straw bale walls such as Masonite, paneling or plywood.
Construction Techniques of Straw Bale

Traditionally, straw bales are stacked in horizontal bands, like bricks, to make walls. The first straw bale houses were built load-bearing, often referred to as the “Nebraska method” (Lacinski & Bergeron, 2000).

Load bearing and non-load bearing construction of straw bales are the two main construction techniques for building straw bale walls. Other hybrids do exist, but only these two techniques will be covered in this report.

Load bearing construction of straw bale walls was traditionally used in the first residences built in Nebraska, and is still being used in some housing applications now. In load bearing construction, the roof is placed directly on top of the straw bales. A roof bearing assembly resembling a ladder structure sits on top of the straw bale wall and distributes the roof load. See the illustration of load and non-load bearing walls shown below. The straw bale walls are compressed into place using cables, creating a more level surface for the roof placement. Sometimes, uneven distribution of loads can occur, causing the roof to settle irregularly. Using the straw bales as a load bearing identity eliminates the use of wood or steel as structural load bearing elements, saving construction material costs.

Today, non-load bearing walls are usually used in straw bale construction due to local building code laws. Non-load bearing walls consist of either wood or steel framed buildings with straw bales filling in between the columns or posts. The straw bales can be inside, outside or in between the columns and posts since the frame distributes the building loads and holds up the building. Another name for this non-load bearing procedure is called the post and beam method of construction.

Sturtz Ranch, Stapleton, Nebraska built in 1905. The bale walls were covered with paneling in the interior. The home consists of living room/kitchen, dining, bath, and two bedrooms.

Source:
http://www.strawhomes.com/sban/tour/tour.html
Many wood and/or steel studs are eliminated by using the post and beam method of construction for straw bale. Judicious design, using only structural beams or columns where necessary eliminates the need for studded walls every 16 inches on center, saving money and materials for each straw bale house constructed.

Typical straw bale walls are 16 to 18 inches thick while standard construction walls are between 4 to 6 inches thick depending upon the stud size. Below is a simple schematic comparison of straw bale wall design and the typical wall construction using 2 x 4 or 2 x 6 studs.

Most noticeable is the width of the walls and the associated R value. R value is a contrived number used by the insulation industry to measure thermal resistance. The higher the R value, the better the product is at resisting heat loss in the winter and some types of heat gain in the summer (Lacinski & Bergeron, 2000, 35). Straw bale walls are exceptional at preventing heat loss in the winter and heat gain in the summer. The size of each straw bale depends on what tension is used to compact the bale and what kind of baler is used to size the bales.
Straw bale walls do not need a vapor barrier like the traditionally constructed wall system. Using plaster containing clay, lime, water and small straw fragments allows the walls to breathe and does not trap the moisture inside the straw bale wall.

**Pros and Cons**

There are a number of benefits of using straw bale in building. One of the most important benefits of using straw bale is that it is cheaper. Using straw bale instead of conventional wood-frame construction could reduce the cost per square foot in building from $75 to $30 (Ecoville ArchiTechs, 2009). It should be noted reduction in costs has a lot to do with house owners doing their own work instead of hiring outside help. Moreover, the actual cost of the straw bales differs depending on the time of year they are harvested as well as how they will be transported. If straw bales are purchased at the time of harvest they are much cheaper. Higher prices of bales result from the costs associated with the storage of them from the previous season. In addition to purchasing at the right time of the year to ensure low prices, one must also make sure they protect the bales from getting wet.

Another benefit of using straw bale is the actual nature of it in itself. Straw bale is non-toxic, almost completely fire resistant and strong. Straw bale smolders and burns slowly which reduces the risk to life. However, it is difficult to extinguish straw bale as the embers tunnel through the bales. In regards to the strength of straw bale, straw is known to yield high results in
both strength and thermal performance. For example, when bales are plastered they combine high thermal insulation with thermal mass, resulting in exceptional performance. During the summers it will be cool, and during the winters it will be warm. It should also be noted that when using straw bale there is little energy used as opposed to conventional wood-frame construction. Furthermore using straw bale provides a use for agricultural waste. Most straw in the United States is burned, resulting in a high particulate pollutant. Each year in the United States, enough straw is burned to build between two and three million homes (Ecoville ArchiTechs, 2009). One last upside of straw bale is that compared to wood, termites like straw less.

Outside In:

Construction of new homes has declined over the past few years in the United States. The NAHB, National Association of Home Builders, reported that as of November 2008, a seasonally adjusted annual rate of 625,000 units was tracked, being the slowest pace for new housing starts recorded by the federal government since 1959 (NAHB, 2008, 9). In time though, new housing starts will increase. The NAHB predicts the trend for 1.9 to 2.0 million housing units per year in the United States alone within the next few years (NAHB, 2008). The NAHB forecasts that these housing units will be composed of 1.5 million single family units, between 350 and 400 thousand multifamily units, and between 100 and 150 thousand manufactured homes.

Using straw bale construction for a percentage of this projected trend will reduce carbon dioxide emissions, reduce construction costs and is able to create more affordable housing with less waste. Following is a look at some policies and initiatives concerning straw bale building.

Policies/Initiatives on Straw Bale: National and International Levels:

United States

On June 20, 2008, the EIIS, the Environmental and Energy Study Institute, hosted a briefing about straw bale construction and how it can address some of our most serious national policy challenges.

Presenters included: Laura Bartels, President of GreenWeavers, Inc., Builders without Borders Building Team; Bob Gough, Secretary of Intertribal Council On Utility Policy; Sandy Wiggins, LEED AP, Principal, Consilience LLC and Immediate Past Chair, U.S. Green Building Council (USGBC); and David Eisenberg, Director, Development Center for Appropriate Technology. Mr. Eisenberg is the chair of the U.S. Green Building Council’s Codes Committee.

This briefing was provided to members of Congress. The presenters are experts in their various fields and pointed out that current challenges include record energy prices and unemployment, inadequate supply of affordable housing, the threat of climate change, and pressing needs in transportation and infrastructure funding. They stated that the modern building industry uses 40 to 50% of energy, placing heavy demands on the energy and transportation sectors. Straw is a locally-sourced, widely available, and is a renewable resource that builders,
architects, engineers, and home owners are turning in to affordable, safe, durable, and energy-efficient buildings in many climates. The presenters discussed the benefits of using straw bale construction, the regulatory barriers and institutional biases against straw-bale construction, and the role of the federal government in resolving these issues.

The EIIS is a non-profit organization established in 1984 to provide timely information and develop innovative policy solutions for a cleaner, more sustainable energy path. The EIIS provides briefings to members of Congress, distilling information so that critical data is used in decision making policies (Environmental and Energy Study Institute, 2008). With a briefing dedicated solely to straw bale building, members of Congress are exposed to the energy savings approach to this construction technique, and hopefully will be able to make better decisions when faced with federally related housing policies.

California

A leader in the straw bale building initiative is the state of California. In 1996 the California Straw Building Association (CASBA) was formed. The association goes by the mission to “further the practice of straw building by exchanging current information and practical experience, promoting and conducting research and testing, and making that body of knowledge available to working professionals and the public at large” (CASBA, 2009). By following this mission CASBA hopes to continue the growth of the number of straw bale buildings in California as well as in other states. California has been the sight of exceptional change towards straw bale building, including legislation.

California’s shift towards straw bale building began with the California Rice Straw Burning Reduction Act of 1991. This act forced farmers to find alternative methods for the disposal of their straw waste. A few years later in 1995, the California State Guidelines for Straw Bale Structures was passed. These guidelines are voluntary and have to be adopted at the local level before being enforced. In 1999, Ken Haggard, an architect and straw bale aficionado led the effort to form the CASBA’s Straw Bale Construction Sourcebook, which describes straw bale and its construction methods. In 2002, the California Senate Bill 332 was signed by then governor Gray Davis. The Bill was the revision of the previous California Guidelines. Eventually CASBA hopes to add “Appendix L” which would officially incorporate straw bale building into the California Building Code. CASBA continues to work with both county and city building departments across the state to help straw bale become a widely accepted form of construction. It should be noted that in California alone, burning rice straw creates more pollution in the state in a year than all of the pollutants by public utilities over the same period.

Colorado

A grassroots effort is in place in Colorado spearheading straw bale building called the Colorado Straw Bale Association (COSBA). As a non-profit organization it sponsors straw bale building workshops, is committed to expanding and sharing knowledge, experience and techniques for sustainable and straw bale building (Colorado Straw Bale Association, 2009).
This year COSBA sponsored the straw bale construction of a small storage building in Siberia, Russia, shown at left. A workshop was held demonstrating the advantages of straw bale construction to the local residents. Photograph source from http://www.coloradostrawbale.org/siberia.php.

COSBA encourages all straw bale residential owners to register their house on the International Straw Bale Registry located at http://sbregistry.greenbuilder.com/. According to this website, 651 straw bale houses are registered in the United States as on November 29, 2009. China has 597 straw bale houses listed. The author estimates that as many as ten times that amount of straw bale houses actually exist, but are not registered on the international site.

### STRAW BALE LISTINGS IN THE UNITED STATES BY STATE

![Graph showing straw bale listings by state](graph.png)

California tops the chart with 120 straw bale houses listed, with Colorado coming in second at 73 listings. The ‘others’ column includes all states with less than ten straw bale listings per state.

No known straw bale building policy exists for the state of Colorado at this time.

**China**

Initiatives in different provinces in China have been started for building straw bale housing, but we could not determine if the Chinese government has an overall policy on straw
bale construction. Some provinces are supplying subsidies for straw bale residential housing in poor rural areas. But, we are not sure if these subsidies are coming just from the individual provinces or from the Chinese government itself. Insufficient evidence has not allowed us to make a viable determination. Also, we don’t read Chinese; otherwise we may be able to uncover government policy involving straw bale housing.

**Case studies of straw bale:**

Straw bale homes are literally being built around the world and can be applied to any economic income. Carolyn, a middle aged single mother of two, built her own straw bale house for about $50,000 in the year 2000 (Carolyn’s story, 2009). It took her a year and a half just to obtain the occupancy permit. She worked full-time while constructing her home and hired out the part she felt she could not do. In total, she estimated it required 250 – 8 hour days or about 2,000 labor hours to build her house.

Besides the common person, straw bale buildings are being built by knowledgeable contractors, designers and architects. Following is just a snippet of case studies nationally and internationally of straw bale buildings.

**Colorado**

Owner John ReHorn and Catherine Andersen built this 2300 square foot house in Durango, Colorado for $90 a square foot. It took 3 and a half years to complete. They used a post and beam/load-bearing hybrid system utilizing recycled natural gas well sucker rods in the walls. The exterior plaster is of lime and earth with aliz paint while the interior plaster is casein based natural clay paint. For more details on the house visit [http://www.coloradostrawbale.org/jrehornkandersenhouse/jrehornkandersenhouse.php](http://www.coloradostrawbale.org/jrehornkandersenhouse/jrehornkandersenhouse.php). The photograph is also from this website.

**China**

A straw bale building initiative was started in the northern provinces of China in 1998 to build warm, affordable housing for the rural poor (Appropriate technology, 2005). Called the Strawberry Bale Housing Technology Transfer Project, it provides local training and expects local community participation to build affordable rural housing using straw bale construction. Between 1998 and 2004, 600 homes and three schools were built by this program in 59 communities (Zhu, 2005).

The China office of the International Adventist and Development Relief Agency and One World Design Architecture (OWD) has partnered with the Straw Bale Housing Technology...
Transfer Project participants in training local residents to build straw bale houses in China (ADRA, 2008). They are using a hybrid approach: brick piers for the load bearing part of the structure with straw bale as infill in the walls as can be seen in the photograph on the left below. This approach was chosen since the rural residents equated a brick house with a higher economic status than building with just straw and mud. In China, a house of brick is a symbol of wealth and success (Zhu, 2005). Photographs are from http://www.adrachina.org/files/story/26/StrawBalesBuilding).

A straw bale building requires 50-68% less fuel to heat during the winter in China and remains comfortable during the summer. The fuel savings, reduced pollution and CO2 release are the basis of the straw bale building’s economic and environmental sustainability. Social sustainability comes from ADRA’s efforts in training architects, project managers, and construction workers using the technique. Since the program began in 1998, over 460 workers have been trained. Because of the light weight nature of straw bales compared to bricks, straw bale construction is safer in earthquake prone areas, including China.

A post occupancy survey of 159 families living in straw bale constructed housing by the ADRA shows a 90% satisfaction rate. The homeowners reported that 40 to 50% less coal is used to heat the home, there is stable, more even heating in their homes and that respiratory ailments have declined (Appropriate Technology, 2005).

Funding for each house comes from ADRA in subsidies, local government help in either cash or labor costs plus homeowner contributions. At first, subsidies were higher to encourage participation from province residents, but now subsidies are lower because the popularity of straw bale homes is increasing. This program was initially designed to benefit the poor, but then middle class families were included to avoid labeling the straw bale construction process as only for the poor (Zhu, 2005).

Pakistan

On the international level, Pakistan has been a major supporter of straw bale. In 2006 the Pakistan Straw Bale and Appropriate Building (PAKSBAB) organization was formed. The mission of the international group was to use straw bale methods to help “the needs of the rural poor living in earthquake and extreme weather regions in developing countries, such as Pakistan” (PAKSBAB, 2008). PAKSBAB is currently developing systems that incorporate unskilled labor, locally resourced materials, and alter traditional building techniques. PAKBAB’s earthquake-safe buildings are actually 80% more energy efficient than conventional buildings.
Additionally their earthquake-safe buildings cost 50% less. Since straw bale and other necessary building materials are indigenous to the region, local industries are then created by the actual building. In 2008, PAKBAB initiated the Community Participation Program which helps build straw bales houses for poor homeless families, using them to assist with the labor. Currently PAKBAB has completed three CPP residences, one in the village of Battal and two in Qalandarabad.

**Ithaca, New York**

Straw bale building is also happening at the local level near Ithaca, New York. EJ George and Aaron Dennis built a 1100 square feet straw bale house between 2003 to 2005 at 6301 Searsburg Road, Trumansburg, New York. Dennis owns and operates Tugley Wood Timberframing so the house features timber framed construction with straw bale infill. Sustainable features include on demand hot water, extensive day-lighting usage, Energy Star appliances, passive solar design, lime stabilizing clay plasters on the straw bale walls, earthen floors, non-toxic materials and finishes, Vestfrost (Conserve) refrigerator, and compact fluorescent lighting.

In an interview, Mr. Dennis stated he uses about two and a half cords of wood per year to heat his home. He said the home was very comfortable and they did not have any cold or hot spots in the house. Below are some photographs of the house.
Photographs: Evelyn Varney.
Conclusion

Having examined straw bale housing from the outside in and inside out, the benefits are clear. If the growth of straw bale construction continues, the amount of money and energy that can be saved could reach millions, even billions. If cities began using straw bale as affordable housing, their energy consumption could be reduced by 60-70%. Moreover, if straw bale construction is used, costs of building could be greatly reduced. Money saved by using straw bale construction could be applied towards other initiatives in cities. We saw in the Pakistan example how straw bale has been used to provide housing for the homeless while at the same time stimulating local economies. We could easily implement similar policies in U.S cities to aid those in need. For example, straw bale could be used for low-income housing. Beyond monetary benefits, the environmental advantages are evident. The use of straw bale rids an agricultural waste that ultimately results in major pollutants. The possibilities of straw bale construction are endless.
Works Cited:


