ECO-MATERIALS (RECYCLED, MATERIALS FROM WASTE, BIO BASED MATERIALS ETC.)

Abstract

India is a very populous nation that is also heavily agricultural, producing a lot of agricultural waste, including straw from crops like rice, wheat, and sugarcane. Straw bales may be used in construction to cut waste and make good use of this plentiful resource. Because of a rise in pollutants, an expanding population is contributing to environmental damage. It struggles with a variety of climatic issues, such as excessive heat in several areas. Excellent insulation offered by straw-bale constructions may keep indoor areas cool throughout the sweltering summer months and lessen the need for expensive cooling equipment. There are environmental issues in this nation, such as air pollution and deforestation. Utilizing straw bales lessens the need for more energy-intensive, environmentally destructive construction materials like bricks and concrete. Overall, this chapter will cover the advantages of using straw bales in structures in India as well as the characteristics of straw walls and the acceptable climatic conditions needed for their construction.

Keywords: Eco-Materials, Recycled
Bio Based Materials

Author

Megha Singh
meghaansal99@gmail.com

I. INTRODUCTION

Many responsible clients prefer to construct in an ecologically sustainable way, utilizing locally sourced materials, and using insulation to reach the passive building standard. They now have a more appealing option, the straw bale house, thanks to recent developments. Old natural materials are being rediscovered by architects as the eco-home trend gains traction. A straw-bale home is cost-effective, good for the environment, has a comfortable indoor climate, and is a pleasure to live in. Everything relating to the antique building material resurgence. Living in a straw-bale house may seem counter-intuitive, yet it offers several benefits over conventional building techniques. Not the least of which is the eco-friendly construction and living of straw bale homes.

Straw and grasses have been used to construct safe, durable, and comfortable homes in a wide range of climates and conditions for as long as people have been making shelter.

In Asia and Europe, huge lengths of straw have been wrapped into bundles and layered in mud mortar for ages to build walls. Another traditional technique, used in both Asia and Europe, included compacting loose straw and covering the walls with a clay slip.

These techniques and materials are still in use today, with modern building techniques, materials, and codes being more commonplace in certain areas. With the invention of stationary horse- and steam-powered balers, which allowed hay and straw to be compressed into rectangular units known as bales, a new age of construction with straw and grasses began in the United States in the late 1800s. Early homesteaders in the Great Plains of North America's timber-scarce environment were able to imagine utilizing bales as large bricks with no difficulty. The earliest bale houses were made in the sandhills of Nebraska, a region known for its excellent meadow hay stands.

Many pioneers preferred to use bales of straw or hay to construct their homes for a variety of reasons. Others said it was simpler to build with bales than with sod, while some people just seemed interested in the technique. Some families made the choice to switch from their little sod homes to bigger bale homes. It was also found that utilizing meadow grasses that had been baled appeared to be far more effective than removing a sizable portion of rich meadow land to make way for sod.

Bales were sometimes seen as the easiest option to get a roof over the heads of those that needed accommodation right now. Many of those buildings were first thought of as temporary, but as it was learned that they could withstand the harsh Nebraska winters and summers while still being comfortable, they were quickly plastered and used as permanent homes.

The easy availability of common building materials as transportation networks developed made strawbale construction unpopular, but in the last 10 years as people have grown more ecologically conscious, it has had a major resurgence. In Australia, strawbale building techniques have been developed during the past five years that are affordable, effective, and simple for individuals without trade skills to use. In order to maintain the required consistent temperature throughout our testing of the wall modules' insulation performance, we actually employed a commercially available strawbale cold room.

1. Procedure:

- First, harvest waste stalks from wheat, rye, and other crops are gathered together and made into bales of straw.
- The bales are linked with three threads using polypropylene wire twine or baling wire to create a load-bearing wall.
- The initial layer is constructed using 12mm threaded rods, and the subsequent layer is placed on top.
- With each further layer, more rods are inserted.
- The bales have windows and door openings carved into them.
- The midpoint of each bale in the subsequent higher layer is located above the beam between two bales on the lower layer due to the staggered placement of the second layer or course of bales over the first. The term "running bond" refers to this configuration of bales.
- The wall is stronger and more secure as a result of this (stacking) when a running bond is used.
- The top plate supporting the roof is made of a wooden box beam.
- The entire wall is fastened together by the threaded rod that extends through the box beam.
- In the grooves between the bales, plumbing, wiring, and conduit are installed.
- After executing work and laying the straw bale to beam level are finished, plastering using cement plaster in a ratio of 1:6 or 1:8 starts.

2. Advantages

- Straw is a commonly available renewable resource, straw bale construction is a sustainable method of building.
- With R-values between 40 and 60 when constructed properly, straw bales offer high insulation qualities and keep the structure cool in the summer and warm in the winter.
- It is readily available from agricultural by-products and is reasonably priced.
- The advantage of straw bale building is that it is a very simple technique for novice builders, allowing owner-builders or volunteer crews to use it. Additionally, this lowers construction labor expenses, which may be high in many wealthy countries.
- Building using straw bales has attractive visual features, such as sturdy walls that can support shelves and window seats and are adaptable to many different architectural styles.
- Straw bales are biodegradable.
- More fire resistant compared to conventional timber-frame houses.

3. Disadvantages

- If straw bales are not kept dry, they can rot and grow mold.
- Since straw bales are not a typical building material and are not covered by all municipal building rules, constructing using straw bales can also be difficult in terms

of getting building licenses or insurance coverage.

- During construction, care must be taken to prevent rats and other small animals from entering straw bales.
- The building's overall floor space is less usable due to the thickness of the walls.

II. CLIMATE THAT IS SUITABLE FOR STRAW BALE CONSTRUCTION

The 10% to 15% moisture content in the air is resisted by straw bales. Dry climates are therefore ideal for the creation of straw bales. These areas are those where the rate of water evaporation exceeds the rate of moisture obtained through precipitation. In such an environment, the amount of moisture is relatively low.

1. Tropical Semi-Arid Climate:

- Receive minimal annual rainfall 40-75cm.
- Winter month is December (20 to 24 degree Celsius).
- Hot and dry (upto 32 degree Celsius)- March.
- Marathwada, Central Maharashtra.
- Subtropical Arid (Desert) Climate:
- Receive scanty of rainfall annual (less than 30 cm).
- Summer temperature upto 35 to 50 degrees.
- Thar Desert, Rajasthan (exclusively Eastern and southern fringes)
- North Gujarat, Kutch Region.

2. Sub-Tropical Semi-Arid (Desert)Climate:

- Annual rainfall 30 to 65 cm.
- Summer temperature upto 45 degree Celsius.
- Experience humidity during monsoon only.
- Malwa region Madhya Pradesh, east Rajasthan etc.

III. CASE STUDIES

1 Office Building- Hrubý Sur, Slovakia:

Design: Gernot Minke
Detail design: Bjørn Kierulf, Createrra
Workshop management: Gernot Minke with Pierre Bortnowski, Samuel Gros, Olaf Eggers, Dittmar Hecken, Stefan Ohnesorg, Pavel Pakuza
Earth plaster: Piet Karlstedt
Wall system: Load Bearing straw bale vaults and dome Completion: 2011
Floor area: 62 m²

The first straw bale load-bearing dome in history was constructed in Hrub Sr, a tiny town close to Bratislava. It is made up of eight load-bearing straw bale vaults that are topped with a green roof. Eight vaults, each with a 4m2 niche for office workstations and a tea kitchen, surround the building's core octagonal area for seminars and exhibits.

The building houses the architectural office of Slovakia's top Passivhaus expert, Createrra, which is located there.

A dome with a clear diameter of 6.20 meters covers the central region and is supported by an octagonal ring beam. Eight circular posts made of wood that are 30 cm thick support this ring beam. The straw bales were sliced conically on both sides using a saw created by the Research Laboratory for Experimental Building (FEB) at the University of Kassel. The straw bales have a cross section of 36 x 48 cm.

The tool includes two saw blades with an accuracy of 0.5 degrees that may be changed. In order to prevent open joints, straw bales can be stacked directly on top of one another without the use of cement, resulting in flat bale surfaces. The bales had to be twisted to create an arch in order to construct the dome. The eight vaults' bales were built on top of formwork. However, the dome was constructed without the use of forms thanks to a rotating guide created by FEB that kept the bale in place until it was secured with wooden pins.

Earth plaster, put in three layers on either side, was 5 cm thick and covered the inside and outside of vaults and domes. Straw bales and bags filled with foam glass gravel were placed in the "valleys" between the external vaults.

Using an EPDM roof membrane, the roof was covered. It was sealed in plastic bags to stop the substrate from slipping. Then, the seeds for wild grass were put on top of these bags.

Insulation for the façade and the rammed earth floor was 30 cm of cellulose flakes and 50 cm of expanded glass gravel. The vault cross section has a U-value of 0.134 W/m2 K), whereas a U-value of about 0.08 W/(m2 K) is attained close to the filled "valleys" with 36 cm upright straw bales, 2 x 5 cm clay plaster, 12 cm substrate, and plant layer. The acrylic glass skylight dome has a four-layer glazing, while the windows have a three-layer glazing. Despite the -11°C outdoor cold, just 1600W of heating electricity is required.

The eight vaults are served by supply air that is warmed by exhaust air in a heat exchanger and sent through the ring beam, which also functions as an air duct. Because it was believed that the exterior layer of earth plaster would adequately collect condensation humidity in the winter and then release it again in the summer, the roof structure does not have an interior vapour barrier. Twelve sensors were set up to keep track of the moisture content of the straw. After three years, measurements revealed that the humidity inside the bales didn't go beyond 14%. The building was made available for two sessions that lasted two weeks each.


1


2


3

4

5

6

7

- Conically cut bales on formwork.
- Shrinkage cracks are being refilled .
- Plastering of the interior surfaces of the vaults .
- Interior view .
- The dome under construction is covered with earth-filled bags.
- The building with vegetation in summer after one year.
- The building in winter.

2 Residential and Office Building London, United Kingdom:

Design and site supervision: Sarah Wigglesworth
Straw bale works: Scott Clark Wall system: Partly load bearing, partly primary timber frame with straw infill panels
Completion: 2001 Living area: 264 m² Office area: 210m²

The residential and office complex is tucked away between railroad lines and tiny Victorian railroad cottages at the end of a street in a former industrial district of London. The office is located in one leg of the L-shaped structure, while the residential wing is located in the other. The two wings are connected by a space that may serve as both a dining room and a conference space. The five-story tower makes the structure a

recognizable feature. The building isn't strictly speaking a straw-bale structure since a variety of construction techniques and materials were employed instead of using straw bales consistently throughout the whole structure.However, each technique made sure that the materials were minimal in energy and came from sustainable sources. Therefore, recycled concrete was utilized in place of sandbags that were filled with cement, lime, and sand. As the organic textile fibers disintegrate, the mixture will expose a coarse concrete texture.

Straw bales sandwiched between latticed wooden poles served as insulation for the sleeping space. They can be seen between the vented polycarbonate shell, which prevents dampness from harming the bales. The straw bales might be exposed and protected at the same time thanks to this constructional solution. The straw bales are lime-rendered on the inside. Because of the type of insulation utilized, these areas only need to be heated for a few weeks during the winter.

1

2

3

1

5

1,2,3. Views of meeting /dining rooms.
4 On the exterior , the straw bales are visible behind the polycarbonate cladding.
5 The exterior with a 5 storey tower at dusk.

3 **The University of Ladakh:** The University of Ladakh's campus was built utilizing straw bale technology in India, a country where conventional building materials are frequently expensive and hard to come by. The project's goal was to show that environmentally friendly building techniques are feasible and may be used in distant areas with little resources.

4 **The Straw Bale Village in Tanzania :** It serves as an example of how straw bale building may be utilized to build cost-effective homes in poor nations. Locals constructed the straw bale homes in the village as a more eco-friendly and affordable substitute for traditional construction supplies.

5 **The Roberts Residence:** The Roberts Residence is a stunning example of a straw bale house, and it is situated in California, USA. This project, which was finished in 2004, demonstrates the adaptability and effectiveness of straw bale building. This project employed locally obtained bales, which was both economical and environmentally beneficial. The home is extremely energy-efficient because of the great insulation provided by the thick straw walls.

IV. CONCLUSION

These case studies show how straw bale architecture may be modified to fit different climatic conditions, types of structures, and architectural styles. It is an energy- and environmentally-friendly construction method that is gaining appeal among builders and homeowners throughout the world.

Most importantly, why is it essential to promote the construction of straw bale houses or buildings in India?

The goal of straw bale construction is to encourage the building of straw bale homes in nations like India, where agriculture still serves as the primary source of revenue and where a vast amount of straw is produced.

- To lower the cost of building and the annual straw waste that occurs.
- To construct modern, environmentally suitable homes for the populace.
- To bring people closer to nature.
- To eliminate burning straw in fields since it severely increases the risk of chronic chest ailments, releases gaseous pollutants into the air, and decreases soil fertility.

REFERENCES

[1] https://www.ijresm.com/Vol.2_2019/Vol2_Iss10_October19/IJRESM_V2_I10_
[2] pdf
[3] https://www.researchgate.net/publication/232723440_Straw_Bale_in_construct
[4] ion_of_building_and_its_future_in_India
[5] https://houseofstraw.com/introduction-to-straw-bale-houses/
[6] https://www.huduser.gov/publications/pdf/southwesthousing/sw_housing_traditions.pdf

