Strawbale as Prefabricated Building Material in India

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Abstract - For any developing country the key factor and manifold in influencing the quality living is in housing problem. A faster production system of housing is required for maintaining quality of houses and economy is required to overcome the huge shortage the formal housing needs. As per the globe organization expectations by 2050, 64.1% and 85.9% of the developing and developed world is getting to be urban. According to National plans Government's role has been changed from provider to enabler during couple of decades. Including the backlog and additional need for population increase overall 12% household do not have house. National Housing and Habitat Policy (NHHP) focused on prefabrication system of housing and mentioned the necessity of a faster housing supply. In present context to fulfill the housing shortage in India scope for appropriate prefabricated building system must be reassessed. Fabrication could be a promising resolution to housing deficiency due to restricted resources of labor, time and finance, slums around the world. For quick and efficient construction prefabrication can help builders to a great extent and plays a significant role in nearly every project today. Starting with strawbale sustainable material and technique in the market is needed to be introduced gradually. Scope for acceptable ready-made building system to meet the housing shortage in India should be reassessed in present context. This paper presents a comparative statement of straw bale construction with alternative fabrication techniques and additionally identifies the requirement of a quicker system of housing delivery and makes an attempt to see the acceptable kind and method for low- value housing in the Indian context. This paper aims to the various aspects of ready-made building methodologies for low - cost housing by highlighting the straw bale construction and compare it with various fabrication techniques, and so the economical construction is achieved by its adoption. A material is needed to be accepted by the building industry and a part of the industrial way of building whether they need to be better or as good as existing ones. Material like straw is adaptable and more sustainable material to the industrial way of building .It is very necessary to make an effort so that it can become a mainstream construction method. Further research will analyze other prefabrication house building methods to establish the factors that helped them to move from a niche into the mainstream and what could happen for straw bale building. This paper will also focus on quantifying the environmental benefits of one natural building material strawbale, in comparison to more widely accepted conventional residential construction techniques used in India.

Keywords – Strawbale construction, affordable housing, prefabrication

I. INTRODUCTION

India is characterized by vastness and variations of geography, economy and cultural practices of construction of houses and habitats. In spite of a great variety of such construction there are several problems of housing including the shortage of housing in significant amount in urban and rural areas. The shortage is characterized by a larger share by Lower Income Group (LIG) and Economically Weaker Section (EWS) of around 96% of total shortage (MOHUPA). To overcome the housing shortage for low- income families several attempts in reducing the cost of the building has been tried post- independence. However, such low- cost housing materials and techniques could not address the housing shortage on a mass scale. A systemic approach in technology and innovative use of materials has been envisaged in the Pradhan Mantri Awas Yojona (PMAY) and Technology Sub-Mission (TSM). Prefabricated housing delivery has not been received much attention till the contemporary housing policy since the1990s came. Even after that also there were not much systemic interventions in housing delivery through prefabrication. Few private industries have been attempting developer- driven housing delivery through prefabrication. However, the government- sponsored laboratories and housing delivery organizations limited their attempts within low- cost housing research. Such interventions only in the specific cost- oriented approach using so-called low- cost housing materials have been successful only in small- scale project. After the PMAY and TSM, we find an attempt which envisages the integration of market, industry and R & D organization in bringing a tangible outcome in housing delivery using innovative, faster and resilient technology. Therefore this is an opportunity to explore all available building materials and technologies to assess the applicability in Indian context. BMTPC, the nodal organization for implementing TSM has identified technologies to develop further.

With the opportunity in PMAY and TSM, the scope for acceptable ready-made building system to meet the housing shortage in India should be reassessed in a new context. This paper presents a comparative statement of straw bale construction with alternative fabrication techniques and additionally identifies the requirement of a quicker system of housing delivery and makes an attempt to see the acceptable kind and method for low- value housing in the Indian context.

II. EARLIER WORKS IN STRAWBALE CONSTRUCTION

The best thing about Straw bale homes is that they are built around the world and can be applied to any economic income. Straw bale buildings are being built by knowledgeable contractors, designers ,and architects besides a common person. Following are the case studies of national and international straw bale buildings.

2.1 China

A strawbale building was started on the northern provinces of China in 1998, affordable housing for the rural and poor affordable housing for the rural poor called the Straw Bale Housing Technology Transfer Project. It provides local training for local community so that they can participate in building 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). [1]

2.2 Pakistan

Pakistan is a major supporter of strawbale at the international level. 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 the earthquake and extreme weather regions in developing countries, such as Pakistan" (PAKSBAB, 2008).PAKSBAB is currently developing systems that incorporate locally resourced materials, unskilled labor 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. [1]

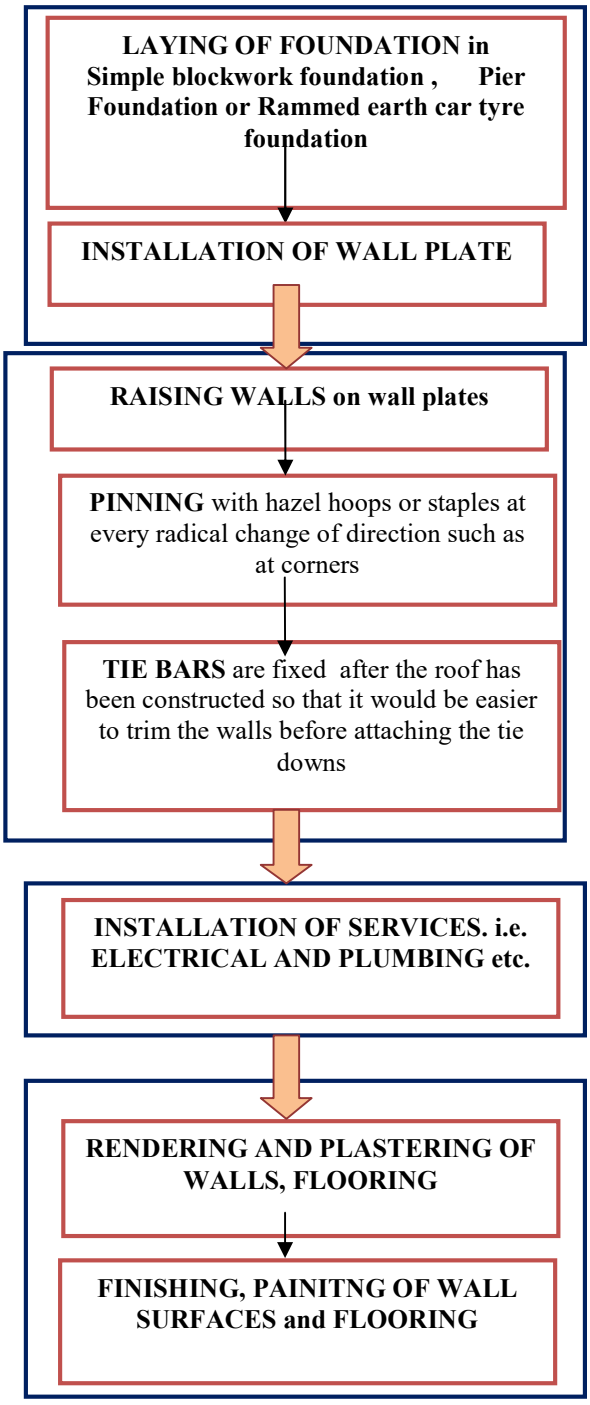
2.3 Ithaca, New York

Straw bale building is also been constructed at the local level near Ithaca, New York. EJ George and Aaron Dennis built an 1100 square feet straw bale house between 2003 to 2005 at 6301 Searsburg Road,Trumansburg, New York. Dennis owns and operates Tugley Wood Timber framing 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, refrigerator, and compact fluorescent lighting. [1]

2.4 San Francisco

Presentation Center Dining Hall, California Presentation Retreat Center is a conference center. Its new Welcoming and Dining Facility is a strawbale building approximately 900 sq. meters in size. The center is in close proximity to the San Andreas Fault, a major fault in the State of California. The project illustrates the suitability of strawbale construction in assembly buildings in highly active seismic areas. In addition to the strawbale walls, the project implemented multiple sustainable features, including a living roof, passive solar, photovoltaic electricity, and solar hot water. Dan Smith of this Proposal team was project architect, and Henri Mannik of our team was a structural engineer for the building. [1]

III. SRAWBALE CONSTRUCTION METHODOLOGY



IV. OVERVIEW OF STRAW BALE AS PREFABRICATING MATERIAL

Straw is a sustainable construction material that is not extracted from the ground like other materials and does not produce any toxins or pollutions during its production. In different parts of the world, the projects with prefabricated straw elements built in field factories are going on.

In order to make the modules less heavy, the straw could be used in combination with other materials is a good idea to save material as well as to lower the price which can be called as "*Sensible Straw*" bale modules.

The "*Sensible Straw*" bale modules are framed with wooden studs, creating a frame. Between internal masonite, I-beams straw bales are stacked in the frame. The standard wall element is just short of 2, 8 meters high (equivalent to 6 bales on edge) and exactly 2,8 meters wide (three bales on edge). By using larger modules would be fewer intersections. In terms of execution and appearance "Sensible Straw" are very flexible since finishing materials are applied on site and they are optional. The cutouts for doors and windows and module sizes must be considered while making the modules though they can be made in any size and shape.

The "Sensible Straw" bale modules will achieve a better U-value and more sustainable than many other alternative materials due to quite thick walls for meeting out the passive house requirements. Modules can be made thinner if desired by the client otherwise the thick window sill can act as a bay window for sitting purpose. The 60 mm external wood fiberboard and the internal 40 mm straw board could be replaced with a conventional gypsum board. Both the sides of the modules can be plastered. By making the modules thinner the U-value will reduce resulting in more of heat transfer.

There are certain parameters set by BMPCT for a new material to be assessed for implementation in any project. Analysis of Strawbale construction on the bases of those parameters is as follows:

4.1 Strength and Stability Requirements

Structural load bearing straw bale walls can withstand loads of more than 48,826 kg/m2.

A wall of "conventional field bales" is able to support a roof load of 600 pounds per foot (900 kg/m), the high-density bales can support up to 3,000 to 4,500 pounds per foot (4,500 to 7,000 kg/m). The stiffness (E-modulus) of strawbales found to be between 0.1 and 0.2 MPa (15 to 30 psi), depending on density. The bales did not fail or crush in tests which subjected them to over 25% compression, but the useful level of stress was approximately 0.01 to 0.02 MPa (1.5 to 3 psi). These values are based on tests conducted by TUNS on oat, barley, and wheat bales from various suppliers, with a density of 55 kg/m^3 (3.4 pcf) to 115 kg/m^3 (7 pcf). Higher density bales are stiffer.[2]

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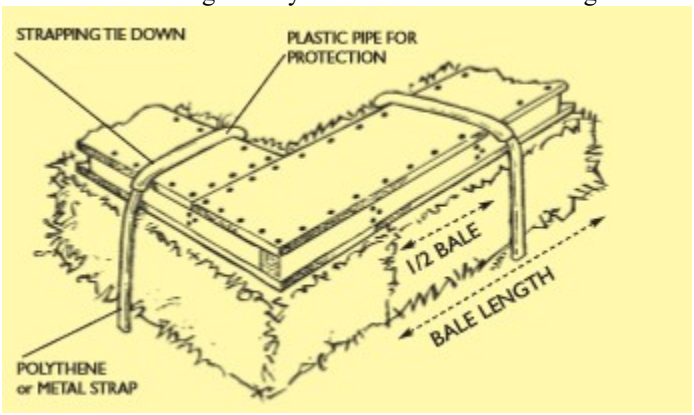
4.2 Performance of Joints (TA) For Loadbearing:

(Internal pinning) At every radical change of direction, such as at corners, the bales need to be pinned together with hazel hoops or staples. These can be made from 900mm (3') lengths of hazel,25-32mm (1-11/4") in diameter. The walls of a single or ground floor are usually either six or seven bales high, depending on the design of the foundations and the type of floor installed. First floors are generally from three to five bales high but can be higher.



Source: Information guide to Strawbale building for self -builders by AMAZON NAILS 2001

For Framed Type: External pinning is done where the pins run from base-plate to wallplate in one continuous piece The pins are placed externally to the straw, again two per bale inside and outside the wall about 50cm apart and opposite each other.

Source: Library.uniteddiversity.coop

4.3 Fire Resistance

Two- hour fire-resistance-rated non-load-bearing cement plastered strawbale walls shall comply with the following:
1. Bales shall be *laid flat* or *on-edge* in a *running bond*;
2. Bales shall maintain a thickness of not less than 14 inches (356 mm);
3. Gaps shall be stuffed with *straw-clay*;
4. 1 1/2 inch (38 mm) by 17 gauge galvanized woven wire mesh shall be attached to wood members with 1 1/2 inch (38 mm) staples at 6 inches (406 mm) on center. 9 gauge U-pins with minimum 8 inch (203 mm) legs shall be installed at 18 inches (457 mm) on center to fasten the mesh to the bales;
5. Cement plaster on each side of the wall shall be not less than 1 inch (25 mm) thick; and
6. Plaster application shall be in accordance with Section AR104.4.8 for the number and thickness of coats. [3]

4.4 Thermal Comfort

The thermal properties of straw bales depend upon the density of the bales. Load-bearing straw bale walls will require the bales to have a higher density, typically more than 110 kg/m3. Non- load-bearing straw bales used for infill can tolerate lower densities, often in the range 80–100 kg/m3. Strawbale can have a wide range of densities. Most strawbale codes in the US have chosen to use a minimum density of 7 pounds per cubic foot, (110 kg/m^3) since it is generally agreed that higher density bales are superior (e.g., bales up to 12 pcf are available). [2]

4.5 Acoustic Performance

Strawbale walls are super insulative acoustically. There are two recording studios in the USA built of straw bales for their soundproofing quality and insulation. Strawbale wall systems have also been used near airport runways and motorways in the USA and Europe as sound barriers.

4.6 Weather-Resistance

If a straw bale is left out in the field during rain it will become very heavy that can't be lifted due to its weight and will be of no use then. Bales must be stacked off the ground by raising them and covering with a roof they will withstand the weather and the outside edges simply get wet and dry out. Straw does not suck water into itself as concrete does. It simply gets wet as far as the force of the wind can drive the rain into it. When the rain stops, the natural movement of air or wind around the bales dries them out. This cycle of wetting and drying does not damage the bale.

4.7 Design Flexibility

Straw is a flexible material and requires us to work with it somewhat differently than if it was rigid. It is very self-supporting , can resist tipping keep out the wind, inhibiting air or moisture infiltration, resist heat transfer (insulation),reduce water intrusion and migration by storing moisture within the wall, keep the assembly from buckling, under a compressive load and from deflecting in a strong wind, keep the plaster from cracking after it is cured of shrinkage and support the plaster skins from buckling ,reduce damage or failure from high winds and earthquakes and stops bullets .

4.8 Restriction on Number of Floors

In the load-bearing straw bale method, walls of up to 3 stories have been constructed, with infill walls, in post and beam type structures; the straw does not take weight anyway.

4.9 Service Life and Durability

The time period is not certain but it can surely last for at least a century, as there are some straw houses that were built more than one hundred years ago and are still in perfect health. A pre-compressed bale assumes the same characteristics of wood and it can look like a normal brick house.

4.10 End-user-friendliness

Organic straw is a healthy alternative to modern materials natural and harmless. Living within straw walls can enhance the quality of the air we breathe because it is a breathable material and does not give off harmful fumes such as formaldehyde, as many modern materials do so it helps to keep the inside air fresh. Another health benefit is that when it is coupled with the use of non-toxic organic finishes such as clay, natural pigments, paints, and with opening windows, it can provide one of the safest and most comfortable atmospheres to live and also the ambiance inside a strawbale house is calm, cozy and peaceful. A beautiful, nurturing and safe environment to inhabit needs a high level of sound insulation, air quality and the organic feel to the house -. Bales are a healthy choice.

4.11 Versatility

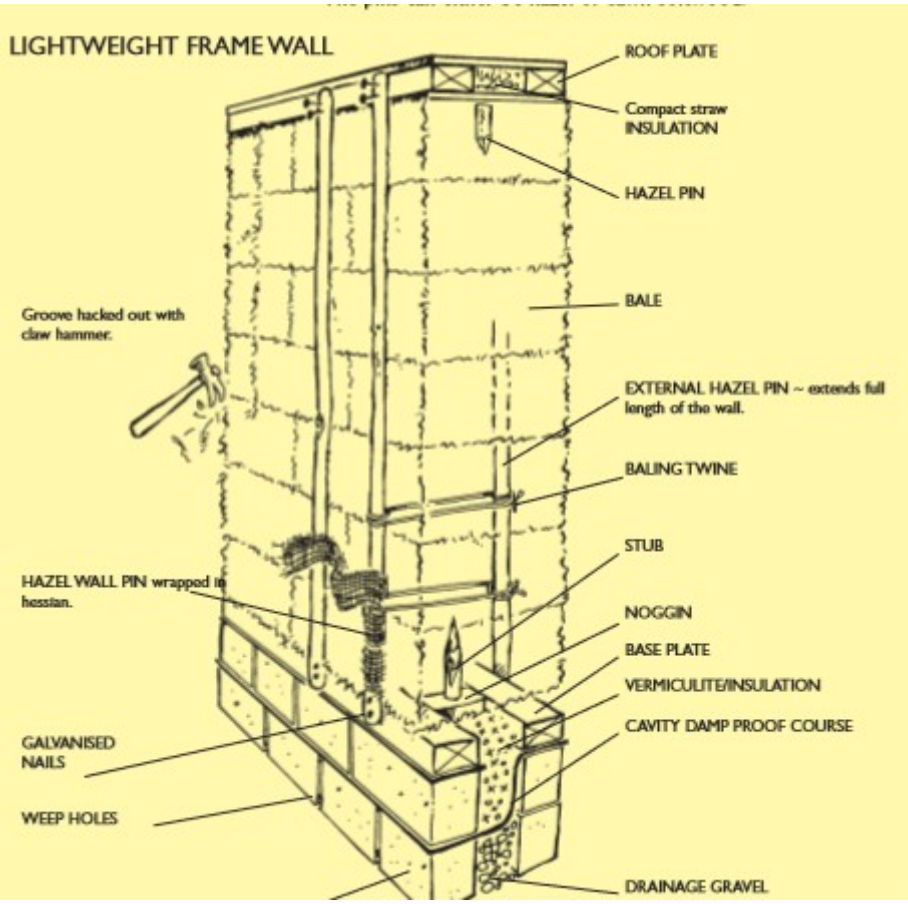
Straw is a versatile material, has good thermal properties, biodegradable, it is a by-product from agricultural practices and low embodied energy compared to other building materials. Straw can be used as building material in the field where it grows, which is unique for any building material and does not emit poisonous fumes in case of fire. Forever rising inflated housing needs this agro-waste material in the current shortage of wood is a good alternative building material.

4.12 Design Compatibility

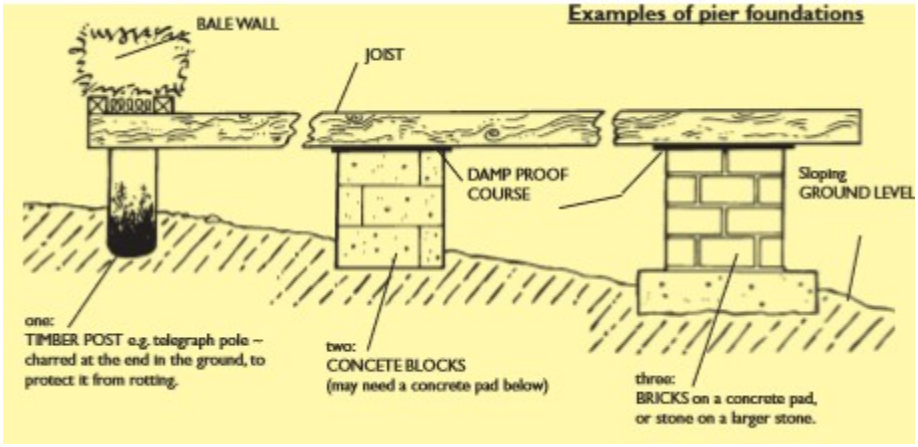
Curved walls can be easily made using strawbale blocks but arches and domes are not possible
The mechanical, electrical and plumbing services can be easily installed.
Big overhangs are needed to be provided for preventing them from the rain.

4.13 Foundation Type

Simple block work foundation This is often a good choice for a cheap and cheerful building

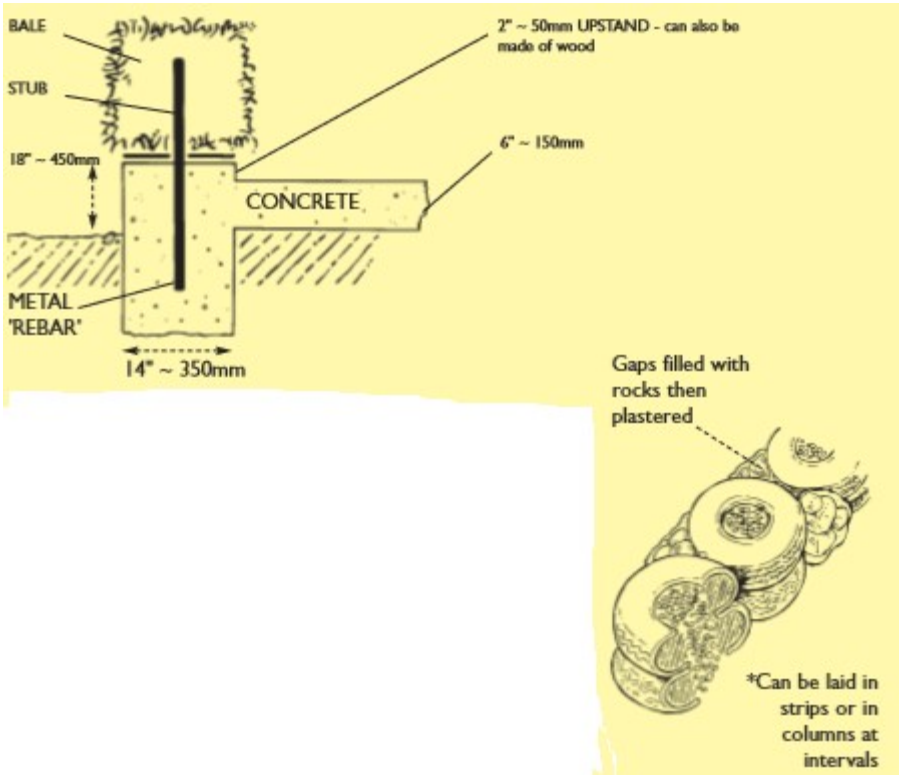


- There is constant potential for damp problems between the concrete block and whatever is above it, as concrete is a 'wet' material and draws moisture into itself.



Source: Information guide to Strawbale building for self -builders by AMAZON NAILS 2001

Pier Foundations



Rammed earth car tire foundation

Source : Information guide to Strawbale building for self- builders by AMAZON NAILS 2001

4.14 Skilled Labor

Skilled labor is required and they could be assigned to tasks appropriate to their skills. Labor needed to be trained to work on strawbale as the process will be different from the conventional process.

4.16 Equipment

The baling machine is the most important and foremost equipment that is required before starting the construction.

4.17 Construction Safety

The degree of risk is less than the conventional method as it is not a high rise construction and strawbale can be handled easily.

4.18 Temporary Services Requirement

Electric supply is required initially for running baling machine. Water will only be required at the time of foundation casting.

4.19 Economic Viability

A saving of approximately 10 % in the direct cost of the walls is achieved when building with straw bales due to the elimination of formwork the quantity of materials needed is reduced. Due to precasted construction lesser waste is generated because of utilization of cheap sources far from the construction site and the shuttering is eliminated with a saving. Similar components when produced repetitively results in faster execution, plenty of productivity and economy. This direct saving in prices is else to the environmental profit of reducing the energy consumption as compared to cement and reinforcing production.

4.20 Speed of Construction

The construction time is shortened due to the construction of the prefabricated parts since structural work is confined to constructing the foundations. The building dries out quicker than a building of conventional construction due to low wetness content in the precasted modules and is sooner prepared for service. In ready-made housing system, time is saved by the employment of precasted elements that are casted off-site as the finishes and services could also be done below the block directly tends to save of money. The construction with prefabricated components takes less time resulting in less expenditure on labor. Up to one- third cost can be saved as compared to a conventionally built home of the same size through prefabrication.

4.21 Efficiency of Design

Strawbale building can actually cause a net decrease in greenhouse gas emissions because over 50% of all greenhouse gases are produced by the construction industry and the transportation associated with it. Coupled with vastly reduced heating requirements, thereby further reducing carbon dioxide emission (greenhouse gas) from the

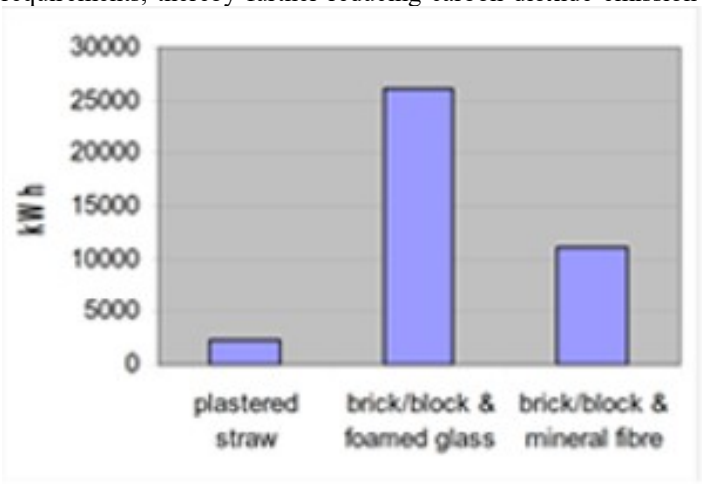


Fig 3.energy consumed by plastered straw

burning of fossil fuels,.

Source: www.amazonails.org.uk

4.22 Supply Chain Reliability

Straw is an annually renewable agricultural residue that is being turn out in ample quantity in India having dry steams of cereal grains left when the seed heads are removed. We will get this from wheat, rice, oats, hops, barley. Among this rice straw is that the toughest one due to its high oxide content. If this waste material will not be recycled and burnt for disposing of it which will cause black cloud results in serious chronic chest diseases and carbon evolved on the surroundings directly or indirectly. Hence straw is easily available material in the very initial stage and can be produced locally in India using local resources.

4.24 Sustainability

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4.25 Eco-friendly Construction

Carbon is stored in all plant-based material during plant growth and continues to be stored through its use as a building material. The embodied carbon of straw bale products is very low relative to many other construction materials. As. Combined with a well-designed passive solar system straw bale houses require very little energy to keep warm in winter and cool in summer. It has a natural "trombe" effect, in other words, it soaks up the coolness or the heat of the inside and stores it/releases it like a giant heater or an efficient refrigerator. This is due to the exceptional insulating properties of the bales. Combined with a well-designed passive solar system straw bale houses require very little energy to keep warm in winter and cool in summer.

4.26 Embodied Energy

The embodied energy of strawbale wall section is six times less than that of most common conventional style. The plaster mix containing an increased amount of cementitious materials(equal parts of cement and lime)has smaller embodied energy value. This construction method has minimal impact on the environment as the production and transport to the building site of straw bales consumes very little energy.

4.27 Exterior and Interior Finish Quality

Lime plasters in three coats appear to be ideal. They adhere well to straw and do not seem to require reinforcing mesh although hair or its modern equivalent of polypropylene fiber helps. Lime plasters are durable, are not too brittle, do not crack readily, are self-healing from small cracks, breathe well, and look good! Any surface decorative coating must be free breathing Earth plaster on the inside and earth or lime plaster on the outside is preferable.

The California straw code (2001) has it that minimum bale thickness shall be 13inches. Also, plaster can be lime-gypsum, lime – cement plaster. Plaster is used generically to include traditional earthen plasters, lime and gypsum plasters and cement stucco.

4.28 Drawbacks

The size, weight, and shape is a drawback which can perhaps be a disadvantage on the construction site with using straw as a building material as nowadays thin walls are preferable as compared to thick walls due to lack of land available. Secondly, it is an agricultural rather than a manufactured product which makes it difficult to ensure that bales have high enough quality. Additionally, straw needs to be protected from moisture as it deteriorates in presence of moisture, especially for organic ones.

If a new material is introduced in the market it needs to meet local laws and regulations to bring it in compliance with the laws, the building industry is like as many other industries.

V. NEED OF A NEW MATERIAL AS COMPARED TO OTHER PREFABRICATION MATERIALS

For new possibilities of construction in the last decades, there is an enormous advancement in construction technologies, from traditional site-based methods to a more dynamic combination of methods have been developed. Over the world a large number of innovative buildings and cost effective construction technologies have been developed as a result of intensive research and development efforts that have been done for low cost construction. This task requires a multi-prolonged approach including the introduction of fast track, innovative, cost- effective, environment- friendly, building materials and technologies.

There is a need to study these innovative techniques and materials specifying there functional requirements as well as specification as compared to conventional materials and techniques for taking a decision on their deployment in their work area. It is, however, required to study the technologies in detail with respect to their functional performance in Indian conditions, their structural behavior and also their suitability for the specific region.

The technology that is being identified must satisfy requirements of weather resistance, structural safety, durability, fire safety, thermal behavior, water tightness and acoustic, mandatorily to allow its use.
Building Materials & Technology Promotion Council (BMTPC) has been identifying and evaluating new materials and construction technologies. These mandatory and desirable criteria should be studied and adapted by implementing agencies to suit their needs.
A number of rapid construction techniques developed both within the country and abroad have been found to be suitable for mass housing projects in the country. Some states have taken initiative to introduce technologies in their projects. BMPCT has also identified, evaluated and recommended technologies:1) Monolithic Concrete Construction System Using Plastic - Aluminium Formwork,2) Expanded Polystyrene Core Panel System ,3) Glass Fiber Reinforced Gypsum (GFRG) Panel Building System, 4) Factory Made Fast Track Modular Building System. The reason behind selecting these four prefabrication technologies is that these are technologies which are mostly implemented in housing projects in the India. They are the technologies that are implemented for constructing prefabricated walls and Strawbale construction is also implemented in constructing walls. Above all the parameters like Time Efficiency, Cost Efficiency, Versatility, Structure Behavior and Thermal Behavior on bases of which strawbale construction can be analyzed are common in these materials also.

COMPARATIVE ANALYSIS OF PREFABRICATED MATERIALS THAT ARE AVAILABLE IN THE MARKET

1	**STRAW BALE CONSTRUCTION**	**MONOLITHIC CONCRETE CONSTRUCTION SYSTEM USING PLASTIC - ALUMINIUM FORMWORK**	**EXPANDED POLYSTYRENE CORE PANEL SYSTEM**	**GLASS FIBRE REINFORCED GYPSUM (GFRG) PANEL BUILDING SYSTEM**	**FACTORY MADE FAST TRACK MODULAR BUILDING SYSTEM**
Time Efficiency	1/3rd time of conventional construction	1/6th of the X time	One building of two storied (total 1981 sqft) was constructed in IIT Madras in one month. **Source : www.bmtpc.org**	40%	15 to 20%
Cost Efficiency	10 % direct cost saving in walls	15% Cost saving	40 % Cost saving	20–30%	30% cost saving
Versatility	By-product from agricultural practices, biodegradable, good thermal properties and low embodied energy	Designed for any condition/component of building such as bay windows, stairs, balconies, and special architectural features. **Source:aluminiumformwoktechnology.blogspot.in**	Panels can be easily anchored to other construction elements, such as steel, wood, and pre-stressed concrete. **Source:naredco.in**	Panels can be used not only as walls but also as floors, roofs and staircase. **Source:naredco.in**	Structure can be transported and erected fast due to its lightweight.
Structure Behavior	Straw bale walls can withstand loads of more than 48,826 kg/m2	Resistant to earthquakes than the traditional RCC column and beam designs **Source:aluminiumformwoktechnology.blogspot.in**	Withstand a maximum load of up to 1530 KN/m ≈ 153 ton/m, have a low seismic mass **Source:naredco.in**	Filled with reinforced concrete, possess the substantial strength to act not only as load-bearing elements, but also as the shear wall. **Source :**	Less earthquake force generation is due to light weight. Highly ductile and load carrying nature of closely spaced studs/joists. Very light

				www.bmtpc.org	structure does not require the heavy foundation.
Thermal Behavior	R-value between 40 and 60 A good thermal performance than the other walling materials	100 mm RCC Walls and Roof has thermal transmittance value as 3.59 W/m2k) (as per IS 3792:1978)	80 mm core and finished thickness of about 15cm provides the same thermal insulation as an insulated solid masonry wall of about 40cm.**Source : www.bmtpc.org**	Compared the traditional system with GFRG system, the thermal comfort performance was almost the same	

After comparing strawbale prefabrication housing from other prefabrication techniques 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 the building could be greatly reduced. Money saved by using straw bale construction could be applied towards other initiatives in cities.
.We could easily implement straw bale prefabricated housing for low-income housing. Beyond
monetary benefits, its time efficiency, its Versatility 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.

VI. CONCLUSIONS

Straw bale prefabricated modules are needed to be carefully designed so that they will be accepted as any other conventional alternatives that exist on the construction market today before introducing them to the construction market emphasizing on that they will perform as they are supposed to. The new material must be easier to manufacture, transport and assemble as existing systems and methods and also needs to be economical as compared to the existing materials.
A developer must feel comfortable in switching from their existing modules to the “Sensible Straw” bale these modules are needed to be introduced in steps to make it more likely to get the building sector comfortable and familiar with using straw modules.

Keeping in view the present Indian context regarding the other prefabricated materials discussed above it is proposed to have strawbale construction housing consisting framed structures and made of prefabricated components to achieve a cost- effective and socially acceptable housing supply for Economically Weaker Sections and Lower Income Group who mainly forms slums or unauthorized construction in urban areas.
Straw is an answer to solve the housing demand for the growing population in India.
Enough to build millions of homes as it is available abundantly due to its production every year with the production of cereals all over the country so incorporating straw in home construction.
The strawbale can accommodate the future need of constructions if it will enter the industrial construction market and it is capable of reducing emissions, storing carbon, reducing waste and saving both energy and non-renewable resources.
Straw bale construction is capable of ticking all of those boxes if approached properly. Straw edges from intrinsic ‘green’ values, inaccessibility while not the requirement for specialist skills and a robust support network. It is proved that straw bale building has a good thermal performance than the other walling materials in tropical climatic conditions. It was found that the straw bale construction is a good alternative for common walling materials and also this will be a cost- effective construction method.
Strawbale is ideally suited to dry hot climates, cold climates and temperate climates with hot/cold seasonal swings and not recommended for tropical climates. People have built strawbale buildings in Florida and other hot/humid climates, but I think the benefits will be somewhat less. Wide wrap-around porches, trees for shade, capturing breezes, natural ventilation, good design to guard against roof leaks, and other factors are important considerations. Be sure to use straw made from the stems of cereal grains. Straw-bale construction is an excellent choice for cold climates. Its ability to provide affordable super insulation is unsurpassed. Strawbale houses have been built in

Oregon,
Washington, British Columbia, Nova Scotia, and other rainy climates, and if properly detailed, will last for many years without moisture problems.

REFERENCES

[1] Page No. 8,Ti Kay Pay, A Straw Bale Rebuilding Solution for Haiti
[2] Proposal for the Government of Haiti's ,Building Back Better Communities
[3] RB473 – 13 Appendix R (New)
[4] Proponent: Martin Hammer, representing: California Straw Building Association, Colorado Straw Bale Association, Straw Bale Construction Association – New Mexico, Ontario Straw Bale Building Coalition,Development Center for Appropriate Technology, and Ecological Building Network
[5] Earth and Straw Bale:
[6] An investigation of their performance and potential as building materials in New Zealand
[7] A thesis submitted
[8] Min Hall 2012
[9] www.ijramr.com
[10] www.buildingscience.com
[11] www.bmtpc.org