

A Review on a Fire Retarding - Thatched Roof for Rural Development

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Abstract: Most of the rural population suffers from poor housing, occupation, and education. Rural development focuses on providing a proper housing to rural people which is a basic need for a human being and also to bring them above their poverty status with the aid of economically and naturally available material for rural housing to make it a sustainable one. The study focuses on the various properties of thatch (i.e. dried coconut leaves) that which can be used as a roofing material for rural housing and also a suitable material is being identified to coat on thatch to make it resistance to fire. Simultaneously necessary techniques are examined out to resist the thatch against wind, rain, and insects by enhancing the construction methods. Thus, this study delivers a suitable fire resistant material to coat on thatch which in turn enhances the rural housing to be economical and sustainable with the locally and naturally available material.

Keywords: thatch, dried coconut leaves, sustainable rural housing, red soil, lime

I. Introduction

• Rural development

The term rural development naturally, indicates "Organizing Things" that which in turn results in changing the existing fettle to make it better. Initially, the term rural development has entirely relied upon the economic change that includes factors for betterment; but now the idea of rural development stretched its arms towards changes in the cultural, social, political, economic, technological and also psychological design of society.

Rural development is concerned with the enhancement of human capacities, to achieve the goals. The term rural development is of Central interest and is broadly heralded in both the developed and the developing countries of the world. Rural development is generally not confined for a particular betterment or enhancement, it is a terminology that can be seen in many ways and can be widely explained in various aspects. But on the whole, it describes the improvement in the quality of life of people living in rural areas.

This involves giving hands to the poor people who seek a livelihood in rural areas not just for developing rural areas but also to put forth the idea of sustainable rural development. And also due to the increased shortage of rural housing which is because of the increased rural population has led to the need for rural development. (Ref. fig 1).

• Sustainable rural development

"We do not inherit the earth from our ancestors, we borrow it from our children", thus it is mandatory to leave something for our future generation.

This is the basic principle of sustainable development. Sustainable rural development is not just aimed at improving the quality of life of rural poor, but also enhances their capacities towards community participation, environmental protection, food, and shelter security and also sustainable economic growth thereby mooting the members of the community to achieve their full benefit.

The principle of sustainable development is a far-reaching challenge to cope up with the change. It is a standard rule which binds social, ecological and economic objectives at various scales across the world. In general, sustainable rural development needs some properly defined aggregates of ecological, social and economic capital to be preserved over time. This mainly relies upon the development of rural areas through environmental or natural resources than improving them with urban economics, by making a semi-natural environment to natural ones which provide amenities and livelihood values to the rural population.

Sustainable rural development aims at improving the art of exploration of resources that are naturally available and use them in our day to day life, thus making the rural living sustainable and economical. One way to make rural areas more sustainable is thatched roofing. In rural areas, the majority of people live in thatched houses even today. Since most of south India is bounded with abundant coconut leaves cultivation and Tamil Nadu is one of the leading producers of coconut, using them for a resolving the rural housing shortage will result in sustainable rural development. (Ref fig 2)

• **Importance of thatch**

The term ‘thatch’ is Anglo-Saxon in origin and is used as roof covering. It can also be described as a vegetable covering. It is one of the traditional and earliest construction techniques by humans. Thus, this style is undoubtedly a true classic ever used. For a traditional and classic appearance for a house, it should include materials like shingles or clay, but it is very expensive. Even though thatch is not widely used and it is not common design today, it seems to be more beautiful and is worth considering for a truly time-honored look. Centuries ago, it was the most popular one because of its abundant availability of the materials such as water reed, long straw, combed wheat reed, heather, etc. It is broadly utilized as popular roofing material because of the ready availability of materials and also has more benefits which in turn contribute to making this kind of roofing. It is not only the oldest but also one of the best types of roofing. Even though thatch is the oldest form of roofing, it is still in existence, is been in use for the last 10,000 years. Nowadays, it is broadly used on houses, cottages and on converted barns to gain a traditional appearance.

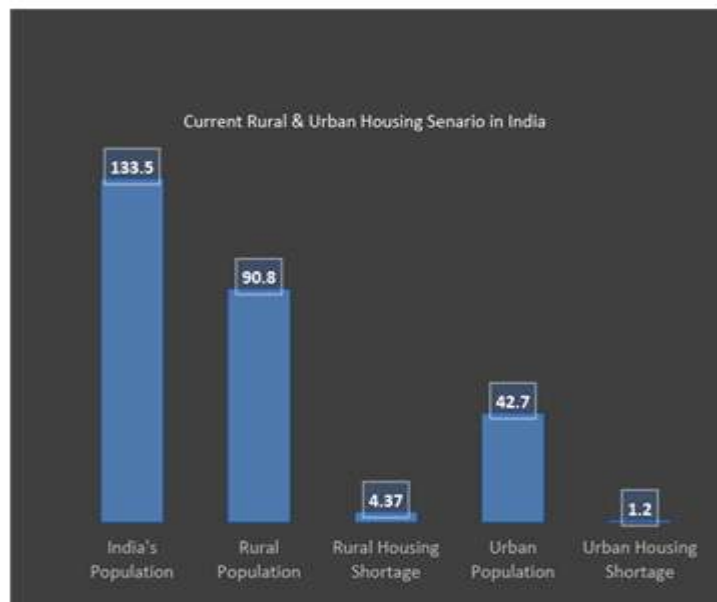


Fig 1. Graph representing the current scenario of shortage in rural and urban housing



Fig 2. Coconut producing states in India

- **Characteristics of thatch**

Thatched roof generally has more benefits compared to other artificial roofing systems. Thatch is an ecologically renewable source which is one of the important aspects of sustainability. It provides a unique and identical look. The main characteristics of thatched roofing are it provides and acts as an excellent insulator in winter and also cool during summer. Thatched roofing is relatively cheap, compared to normal tiled roofing. It also raises the selling price of the house that it seems to be a good investment.

The lifespan of the thatch depends on various factors such as its condition of roof to shed water, that is related to the pitch of the roof and also the climatic or weather conditions of a particular area, wind and high humidity are also other main factors influencing its life span; the lifespan also is greatly affected by the type of thatch used in construction i.e. for a long straw, life span is 15-20 years.

- **Thatch as a roofing material**

Thatch is a natural reed and grass that which is properly cut, dried and installed, accepted as a material for construction. Traditionally, thatcher's use of locally available materials for construction. If in case farmer's main cultivation is growing wheat, then wheat reed or straw is used for thatching. Palm leaves and coconut leaves are also used as a material for thatching and it is the most commonly used material for thatching in rural areas. Rye, barley and oat straw and even heathers are also used as a thatching material.

In case of wet low land, sedge is being used as a traditional thatching material especially for ridging material. The most durable thatching material is water reed which lasts up to 60 years. Since thatching materials are easily and locally available materials on the land, these raw materials don't require quarrying or mining. When compared to cement tiled or slated roof, the thatch is less expensive.

- **Sustainability of thatch as a building material**

In many villages, thatched roofs are still being made, but if they are not supported or encouraged properly, then the future generation may lose people with skills for making thatch roofs and thus we may lose the eco-friendliest roof in the annals of history. Since it is not economical or affordable in case of rural people's occupational status. Concrete manufacturing creates a lot of pollution but the traditional thatch is an eco-friendly material. Where other materials houses fail to provide thermal comfort, thatched roofs are proven to be thermally efficient for decades.

Generally, thatched roofs are made of naturally available materials (i.e.) locally available material. It is easily available and also an economically cheap material for housing. And it is the by-product of the naturally grown plants and vegetation. Thus, it satisfies the recycling aspect of sustainability. A product which originally belongs to the waste category can be transformed as an eco-friendly construction material for roofing.

Thatched roofing is undoubtedly a true classic because it is one of the popular and oldest methods of roofing ever used. Thatched houses generally give an aesthetic look and are healthy housing to survive. Its main attraction is that it is thermally efficient for a living being to survive. A thatched roof will ensure that a building will be cool in summer and warm in winter. It even acts as an excellent insulating material. Thus, local materials for constructions are identified based on this performance to prove co-operative features.

- **Drawbacks of thatched roofing**

Even though thatched roofing seems to be more beneficial in many aspects, especially in the case of thermal efficiency, it has a few disadvantages too:

- Thatch which is derived from naturally available material is prone to fire, wind, rain, and even birds and insects especially weavers.
- As it is the green leaves getting dried catch fire more quickly than other building materials.
- The main disadvantage with thatch roof is the ridge since it is the vulnerable part of a thatch roof that has to be properly governed.
- Only skilled and practiced thatcher can carry out these constructions.

- **Aim**

- To review a fire retarding thatched roof for the rural development.

- **Objective**

- To study the importance and moral values of thatch for sustainable development.
- To identify a suitable fire-resistant material for coating on thatch.
- To study about the various properties of fire retarding material for coating on thatch.

II. Literature review

2.1 Literature Review (National status)

V.K. Mathur et al. (2000), "Skeleton system is an approach for construction of rural buildings in earthquake-prone areas", states the main aim for rural development is the construction of a cost-effective rural housing, that which has flexibility in deciding the building materials and skilled laborer. It explains to us about the effective construction of the skeleton system for a house to withstand the various climatic conditions. It also states that the building materials like glass, reed, wood, bamboo etc. are good earthquake resistant but will suffer due to rapid decay because they are from natural origin. And thatched roof can gain strengths of fire-retardant properties by pressing the panel material in between two split bamboo mats and tied with GI wires. It is said that waterproofing can be done with mud-plastering of which 62.5 Kg of bitumen cut-back is being added with 1 cubic meter of soil-animal dung paste is applied as plaster. It is inferred that if the skeleton of the construction system is properly carried out, then it can withstand any climatic conditions. And we also understand that to make a material waterproofing, mud-plastering: bitumen and soil animal dung is applied as plastering on the thatched roof. Hence, for making a roof fire resistance and also to gain its optimum strength, one has to press the panel material in between two split bamboo mats and tied with GI wires. These techniques give an idea to use an easy, locally and economically available material to be used for plastering in thatched roofs to resist fire.

Chhabhaiya Ronak.P et al. (2016) "Critical Review on Lime Mortar" presented the importance of Lime mortar and how even now it can be used in modern construction.

The paper represents lime as a binding material over cement mortar due to multiple advantages. The study suggests that lime mortar has much lower impacts on the environment than cement mortar. The paper demonstrates the past methods that were carried out on lime mortars. It also shows the influence of materials like Metakaolin, Linseed oil, Herbs, etc. on the lime mortar. It helps to understand why lime mortar is still one of the classic binding material. We also get to know that lime mortar is more eco-friendly than conventional cement mortar. Lime mortar release less heat than cement mortar and it can expand, contract and be flexible with an increase or decrease in temperature. Moreover lime combines well with foreign materials than cement mortar since materials like Metakaolin, Linseed oil, etc. have shown good influence on mixing with lime mortar.

T.Samba Siva Rao et al. (2016) "Experimental investigation on partial replacement of cement with fly ash and quarry dust as a fine aggregate" presented the need for replacing cement with fly ash. Given in this paper the feasibility of fly ash and various mix designs have been showcased using the IS approach. The study explains the environmental constraints and how waste material such as fly ash can be utilized. Test on the basis of physical, mechanical, workability, sieve analysis, water absorption was conducted and the outcomes are compared with the conventional cement concrete. It shows a clear picture of utilizing waste materials like fly ash as a suitable replacement of cement. Fly ash is composed of tiny particles, thus making the concrete dense and reduces the permeability. The reducing in water will eventually lead to high strength. From the outcomes of tests conducted, we can infer that concrete made using fly ash has higher compressive strength than cement concrete for various mix designs. Also, the flexural strength is higher for fly ash than cement. It is also inferred that fly ash acts as a better binding material compared to cement which when mixed with soil yields better results.

Upendra Singh Narwaria et al. (2017) "Amelioration of Thermal stress using Modified Roof in Dairy Animals under Tropics: A Review", presented that roof is an integral part of a good housing system that protects the animals in dairy farms from solar radiation and rainwater. It is said that instead of changing the entire structure of the house, it is worth modifying the roof alone to provide a better sustainable, economic and thermally efficient shed for the animals in the dairy farm, which is done with various roofing materials like thatched roofs, green roofs etc. Thus, it reduces heat stress to a greater extent in the tropical region. It is inferred that modifying the roofing element alone, instead of changing the entire structure produces a good outcome and better results. Adopting a thatched or green roof for roofing results in the least thermal conducting of 0.05 Cal/mh0C compared to the conventional one. And it is also a cheap and easily available material that produces an excellent result against heat stress which reduces thermal discomfort to a greater extent. From this, it is also inferred that thatched roof is the best source of modifying a roofing system of a structure with few modifications for resisting the fire and other external parameters.

2.2 Literature review (International status)

Brendon Taylor et al. (2005) "Comprehensive strength testing of earthen plastering for straw bale wall application" presented about earthen plastering in straw-bale for reducing the embodied energy of the structure and their effectiveness in building construction.

This study explored about the importance of drying time, initial plaster moisture content, clay content and moisture content at the time of testing, where compressive strength tests were conducted on 50mm plaster cubes and 100 mm x 200 mm cylinder.

The results put forth was that as initial moisture content increased, the modulus of elasticity and strength was unaffected for plaster with earthen soil. The drying time has increased between 10 to 18 days, affects the modulus of elasticity proportionally whereas the strength is unaffected. But it is said that during testing of moisture content is increased, then both strength and stiffness are decreased proportionally. In spite of this, the study said that the plastering made out of soil was found to give a good strength than the clay or cement plaster. It is inferred that the use of earthen plaster increased the compressed strength to some extent, but there was a significant increase in elastic modulus with drying. It is also inferred that always the plaster needs to be done during hot climates and not in humid because it increases the moisture content which in turn lowers the strength. As such the earthen plaster in coated as plastering material on straw-bales, it is significant to use a mixture of red soil, lime and fly ash as a plastering material for coating on dry coconut leaves to bring them to its similar properties and values.

Mander et al. (2012) "Development and testing of the prototype straw bale house", presented the research, development, construction, and testing of the straw bale on a prototype house. The use of straw bale helps to identify a new and low cost widely available low-carbon co-product of farming as a construction material, in housing and other application. The various tests were conducted during the research as durability assessment, fire resistance tests, sound transmittance testing, air permeability tests, and thermal surveys. Based on the above test results the acceptance of straw bale as construction materials was put into action. It is clear that there is a possibility of use of straw bale as a good construction material and in order to accept this, the straw bale has to pass on through several tests namely test for air permeability, fire, acoustic durability, and thermal resistance. The results of fire resistance test were found to be satisfactory, that for a 135min test, the straw bale was able to withstand for another 45 minutes even after the lime render failed at the 90th minute at 20 Pa air pressure.

Odinma et al. (2013) "comparative study on the effect of three flame retardant compounds on flame behavior of a roofing thatch", presented the potency of Di-Ammonium Hydrogen Phosphate, Potassium Aluminium Sulphate (Alum) and Ammonium Chloride as flame-retardant. The study was conducted by experimenting with various concentrations of the flame retardant into a Thatch that is commonly used as a roofing material. The outcome of the test shows an increase in ignition time, Percentage add-on and decrease in flame propagation rate, flame duration time and time after-glow. The conclusion was made based on the fact that on heating, the flame retardants gradually develop a substance that rival with the combustion of grass. It is identified that Di-Ammonium Hydrogen Phosphate, Potassium Aluminium Sulphate (Alum) and Ammonium Chloride can be used as a flame-retardant for roofing thatch. From the test results, it understands that these three fire retardants can be lifesaving as it can improve the flammability nature of Thatch.

It also shows that the Roof consists of multiple layers of thatch and these fire retardants are placed on the top layer, however, 80% of the fire catches from inside and thus the aim remains unfulfilled. Therefore, we can learn that fire retardant as to be applied on both upper and lower portions of the roofing thatch.

Nirmal Kumar (2014) "Technological Solution for Sustainable Rural Housing by 2022", presented the problems associated with Rural Housings in India and in what ways it can be sorted by the year 2022. The study says houses in rural areas are self-built using locally available materials and self-managed by unskilled labors which is why the strength and durability in buildings are not so high. The papers show where rural housing lags behind and what all the possible solutions to develop rural housing are. It helps to understand the gap between urban housing and rural housing and the urgency to close this gap requires a lot of research and development. One way we can help develop rural housing is by using naturally available materials like thatch for roofing as it is an eco-friendly material and is easily available in rural areas.

Arman Hashemi, et al. (2015) "Improving Thermal Comfort in low-income Tropical housing: The case of Uganda", estimated that there will be a rise in average temperature of about 3-40 C in next 70 years in east African countries due to global warming. The poor living condition of people in eastern African countries like Uganda will be worst affected because of these climatic changes. One of the main reasons behind, the rise in average temperature is due to the use of harmful construction materials like concrete and iron sheet roofs which are, in turn, causes the thermal discomfort and also affects the health and well-being of the low-income people. Whereas traditional materials such as thatched roof are 15 times better thermally efficient compared to the iron sheet roof. It is inferred that after various evaluations, the average internal temperature that a human could be at their thermal comfort is 260 C. The most important factor to be considered for thermal comfort is low-rise buildings is the roofing method/materials. The type of roofing plays a vital role in maintaining the internal temperature of the building and we can also understand that the risk of overheating was reduced up to 15% while using thatched roof instead of Iron sheet roof.

J Prakash Arul Jose et al. (2018) “Grancrete-An Innovative Building Construction Material” presented the need for the new invention of material in the construction industry has made way to a modern hybrid called "Grancrete". The paper shows the advantages and dominance of Grancrete in terms of strength over conventional concrete. It paves way for buildings that can have a longer and healthier lifespan. Grancrete is a mixture of sand (50%), ash (25%) and binding material like magnesium oxide and potassium phosphate (25%). Another main feature about Grancrete is that it keeps building warm at cold regions and cool at arid regions thus proves to be a thermally efficient combination for construction. It is inferred that Grancrete is a new invention and has a lot of advantages. Grancrete being a mixture of sand, ash and binding material can be taken into account for the study. Grancrete was found to be an excellent fire retardant which is also important for this study. Other properties that can be taken is that it does not require reinforcement and making it one of the low-cost material available in the construction market. The outcome from this literature is that replacing sand with red soil, fly ash and using lime as a binding material can yield a similar kind of material but with most of the same property.

2.3 Inferences

The research gap is that nowadays people concentrate more on developing urban areas than the rural. That is why some countries are still at the developing stage. One has to concentrate more on developing and enhancing the rural areas to raise the rural people's economic status and to reduce poverty.

For this, it is necessary to provide economical and sustainable housing with proper planning. From the above works of literature, it is inferred that in rural areas there is a need for low cost and thermally efficient housing which is achieved by building houses with naturally available materials. It is clear that in a house generally, heat enters through walls and roofs and thus by making a better roofing system will enhance their thermal properties.

The easily and readily available materials like thatch (dry coconut leaves) reduce the overall cost by 20 to 30 % when compared to other roofing materials and overheating is also reduced by 15%, because their thermal conductivity is 0.05 W/MK that meet these above requirements. Although it has several disadvantages like it's prone to fire, wind, and insects it can be easily overcome by reviewing the various properties of thatch and identifying a suitable material to coat on thatch. It is inferred that not only by identifying and applying fire resistant materials gives a better roofing system, the skeleton system for roofing also plays a vital role. The reviews from the various pieces of literature and studies says that, the fire resistance material has to be coated both in inner and outer surfaces, since 80% of fire catches on the inner surface and coating has to be necessarily carried out only during hot climates to enhance its properties and to make it best suitable and sustainable one for rural housing.

- **Techniques to overcome the issues with thatched roofing system**

One can also overcome all these negative issues against a thatched roof by the following methods:

- In order to resist the fire in the thatched roof, proper fire retarding materials are to be coated on thatch as a protective coating.
- Wind is being resisted by providing necessary wind clips.
- Waterproofing components like paints help to resist water penetration into the house.
- In case of failure of a ridge, then it can be overcome by covering with a fiberglass hood or old method of mortar and its apex should be maintained at the proper condition to reduce failures and to provide a watertight structure.

The study mainly focuses on providing a fire retarding material for coating on thatch and the fire-resisting materials are as follows:

- Magma TAS fire stops sprays - Although Magma TAS fire stops sprays, Flame safe is fire resisting materials that can be coated on thatch since they are made up of chemical components they can't be an eco-friendly material and their availability is also less in rural areas compared to urban areas.
- Stucco (cement based plaster) - Stucco is a material made out of cement, again here coating stucco as a fire resisting material will cause pollution to the environment and exhibits heat because it is cement content.
- Ceramicrete (a mixture of magnesium oxide, phosphate, and water) - Again ceramicrete is a combination of chemical components which on its applications as a fire resisting material can't be considered as an eco-friendly material.
- A combination of red soil, lime and fly ash - Finally a mixture of red soil, lime and fly ash is being a naturally available material and individually each component is environment-friendly and doesn't need much strain to collect these materials because they are local and easily available materials. Red soil is better than sand since it is halfway between sand and clay.

This soil typically has a mix of organic material, sand and clay and it's also noted that clay has better fire resistance properties. Lime is a good binding material instead of cement. It produces low heat and also flexible with temperature. It is also thermally efficient. Fly ash is also a very good binding material instead of cement. It composed of tiny particles which bind well with other materials. It also reduces the usage of water which leads to high strength. Thus, this combination, on the whole, proves to be a good fire resisting material that can be coated on the dried coconut leaves. Also to make this thatch a waterproof roof guard can be used to resist the water permeability into the thatch and also avoids peeling of the coating mixture from the dried coconut leaves.

Thatch is not only beautiful but also a practical and economically beneficial if properly utilized and maintained. It is the most durable and attractive material off the market.

Thus, the review focus on the development of the traditional rural living by providing a suitable fire retarding material to be coated on a thatched roof. This study mainly focuses on the traditional rural roofing system – thatched roof and to find ways to make it more beneficial for the rural people.

- **Future implementations / applications**

Immense efforts are being made in order to produce sustainable housing to the rural poor. Thus, these identified combinations of materials can be further coated on any naturally available material for roofing to make it an economical and environmentally friendly alternative for rural housing. Since, in some areas other than India where there is no abundant availability of dried coconut leaves, other roofing materials can be used in the same way to satisfy the purpose and needs of rural housing.

III. Conclusion

The study clearly explains about the importance and characteristics of thatch as a roofing material. It explains even about the drawbacks and necessary measures or techniques that can be adopted to resolve the issues with thatch. The main disadvantage of thatch is, it's not resistant to fire and which is then been resolved by examining various materials to be coated on thatch and finally a naturally and easily available materials that is red soil, lime and fly ash as a combination is being identified from various studies which on other way proved to be a good fire resisting material and it is also eco-friendly material which can be easily coated on thatch with simple techniques.

Also, waterproofing of thatch (i.e. dried coconut leaves) can be done using a waterproofing agent namely roof guard which gives good results both for resisting water penetration into the thatch and also avoids the peeling of the coated mixture from thatch. On the other hand, the wind is being resisted by necessary wind clips. Thus, with all these techniques it will be sufficient to provide a sustainable rural housing especially for the rural poor to bring them above the poverty status with the use of natural, locally and economically available material.

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