Title of the paper: - A review of traditional insulating materials with the combination of contemporary material for roof design in Hot and dry climatic region in India

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Abstract:

The Energy Consumption in building in increasing very fast requiring no further evidence required to prove that the climate change is happening ad real, primarily due to due to human activity. The old settlement pattern and developmentsare not harmful as the construction material were climate friendly and also locally available. The material used for construction was protecting inside environment from outside climatic condition. In the hot and dry climate, the buildings receive solar radiations throughout the year and to achieve thermal comfort one needs to cut down the heat gain through surface of the building. Roof is the part of building which is in maximum contact with sun, thusaffecting the ambient temperature to a large amount. There are different materials used in construction of roof which helps to reduce cooling demand as the material itself haslowconductivity.But some materials have drawbacks and result in failure and often not suitable for high-rise construction. The paper reviews the traditional materials and techniques and the combination traditional and contemporary material for roofingwhich would reduce the energy demand in Hot and dry climate in India.

Keywords: traditional material, contemporary material, thermal comfort, roof, Hot and dry.

Introduction:

India can broadly be categorized into five regions with distinct climates. The climates are normally designated as hot and dry, warm and humid, composite, temperate and cold. Each climatic zone has different characteristics as difference in Temperature, Humidity, Cloud cover, Precipitation etc. and different building materials more suitable according to different climate regions.

Traditional architecture in hot and dry climate hasmany
aspects which contributes to thermal comfort in dwellings, i.e., compact settlement pattern leading to better shading of external surfaces, heavy building structure for less heat transmission , white painted external surfaces to reflect solar radiation, blind facades, open courtyards, etc. Thermal microclimate around the building can be modified by plantation of trees, presence of vegetation and water (if sufficient water available in that area) in the surroundings of building. With the advent of energy crisis there has
been a renewed interest in those aspects of arc
hitecture which contributed to thermal comfort in a building with minimum energy consumption. In rural areas, the building is most exposed to external environment through its facades and roof, whereas in urban area the most exposed part to radiation and winds of the building is the roof. According to several study and investigation showed that the 50 % of total heat gain in the building is through roof, so there are different solutions to reduce the excessive heat problem through roof. The use of low emissivity material in the attic of a building reduced the temperature inside the ceiling, which ultimately reduced the room air temperature.

The practice of constructing of building by local people has become the primary and most significant mode of production of housing in India. Most of the construction undertaken by the communities is based on traditional materials and local skills. These local skills should consider with the consideration of Geo-ecological and Socio-economic Consideration of Social,economic, ecological context of their habitation, traditional wisdom has gradually changed over time of housing typologies that are the most appropriate and sustainable and suitable climatically in the surrounding area. In last few years there are more changes in choice of construction methods, materials and technological skills than the general quality of architecture and urban space despite.

About Hot and Dry Climate:

The hot and dry zone lies in the western and central part of India i.e. Rajasthan, Parts of Gujarat, Parts of Maharashtra. [1] Solapur,

Bijapur are some of the districts in Maharashtra and Karnataka, as are Kutch-Bhuj, Ahmedabad from Gujarat which experience hot and dry climate.

A hot and dry climate is characterized by a mean monthly maximum temperature above 30 ºC.The main characteristic of the climate is it has Very high day-time temperatures; very less precipitation and a short and mild winter season .This type of region contains usually flat with sandy or rocky ground conditions. [2]

The western arid zone of India maximum temperature reaches around 45º C and minimum temperature is around 40ºC in Summer and in winter the range is around 5º C to 10º C . Rainfalls is very less , it ranges around 300-400 mm.

In regions with Hot and arid climates excessive heat is the major problem that causes human thermal discomfort. Basic requirement of building occupants is cooling. In modern buildings, cooling is achieved by mechanical and electrical appliances.

Existing condition of Western Zone of India

Traditionally mud rolls, Straw clay panel, Rice husk, wood panels was used for construction but that time the development was totally low rise. New developments in the western region of India are not climate responsive. High quality construction was achieved with seismic safety with use of locally available materials and the techniques ensuring earthquake resistance.

Source: (Housing Practices in Gujarat, 2004)

The rural region of western part in India where the low rise settlement exist, the traditional material like mud rolls, Straw clay panel, Rice husk, wood panels are still suitable but in urban areas these materials are not suitable for mid-rise and high rise buildings. The roof should design with the combination of traditional and contemporary material.

In Urban area of western part in India, particularly medium and building high-risestructures, the development is happening with the use of contemporary materials. The structure is rarely made up of locally available

material even the technology base is not even remotely similar to the traditional techniques.

Source: Rajasthan: Plan to map existing land use in Urban areas.

Use of mud, adobe, straw are not possible in high rise buildings because according to study of Jonathan Besozza, this roofs are creates problem of leakage and inadequate compaction. So these types of roofs are not suitable. In urban areas the population density is more and even the land cover is shared by number of occupants so the periodic maintenance that is required in traditional roofing system is difficult to accomplish.

Study of different material used for construction (Existing condition)

Mud rolls:

Thermal performance of building plays an important role in determining the overall comfort level inside it. Mud is used as a construction material from Neolithic times, particularly in hot and dry climate where mud is available in abundance and the precipitation is less.

According to Laurie Baker "The thing that hit me in the eye, right from the beginning, was that an enormous amount of use was made of mud! Mud is the material which we can use differently for different purposes, there are different techniques and to use it with different combinations for different uses" [3]

Source: [4]

Mud required for building can be taken from the plot itself. The soil below the depth of 60cm is collected, as the top layer is full of organic matter, it is not suitable hence not used. Hard rock is not used to make soil.

Table 1 : Advantages and Disadvantages of Mud rolls

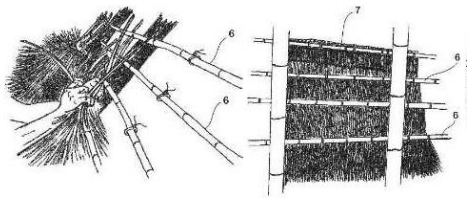
Advantages of mud	Disadvantages of Mud
In hot dry climates; adobe constructed	Mud walls can absorb water so

buildings have ability to keep cools air throughout day time also keep warm at night.	these wall should be protected from water and dampness
Mud is a reasonable as no expensive equipment or tools are required for construction	Strength largely depend in the stabilization process and degree of stabilization.
Availability of mud is easy and it can be consume without reducing the resource base.	
These mud bricks can be recycled without harming the environment.	
Mud construction gives good result if it finished properly and expertly	

About Straw

Straw has been used for thatch roofing centuries ago. The term 'thatch' is Anglo-Saxon in origin and is used as roof covering. Straws are derived from vegetable covering, grasses and are renewable part of material. It is one of the traditional, earliest and widely used construction techniques by humans. Thus, this style is undoubtedly a true classic ever used. For traditional appearance of the building materials like shingles or clay area also used .it gives classic and finished look to the building . but it costs little more.

"Thatch is abundantly available materials and we get it from 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 of 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." [5]



Theconstruction technique oftraditionally constructed thatch roofs using pressed palm leaves.[5]

Table 2 : Advantages and Disadvantages of Thatch

Advantages of Thatch	Disadvantages of Thatch
Thatch is an ecologically renewable source which is one of the important aspects of sustainability.	Thatch catches fire more quickly.
It provides a unique and identical look	Thatch roof is the ridge since it is the vulnerable part of a thatch roof that has to be properly governed.
Thatch is an excellent insulator in winter and keeps cool during summer.	Skill labors are required for construction
Thatched roofing is quite cheap, if we compared it to the normal tiled roofing	

Source: [6]

The life span of thatch roof is vary with pitch of the roof, the climatic condition of the constructed area, wind speed, wind direction, humidity etc. these factors also influences the life of the roof.

Straw-Clay panel:

Each year farmers producing grain battle with the remains of their harvest i.e. Straw. “Straw is waste material and it can’t be used to feed animals so it is collected and burned at the end of year which causes lot of air pollution. Straw does not decompose very rapidly and becomes a burden for the farmers.”[7]

Straw-clay mixtures are composed of unprocessed earth mixed with water and straw. Straw clay panels has low environmental footprint on environment. Straw-clay mixtures are composed of unprocessed earth mixed with water and straw. It has a very low embodied energy. Straw is also a renewable raw material (by-product of agricultural activities) that contributes to carbon storage. [8]

A composite of rice straw particles bounded by a polymer to produce roof insulations. Satisfying results were achieved to nominate the 80% polyurethane foam and 20% rice straw composite gives good result. [9]

Source: [4] [8]

The material was obtained by filling a mold with a wet straw-clay mixture, and then packed by hand. Even if this production method is very convenient, the samples revealed apparent heterogeneities[8]

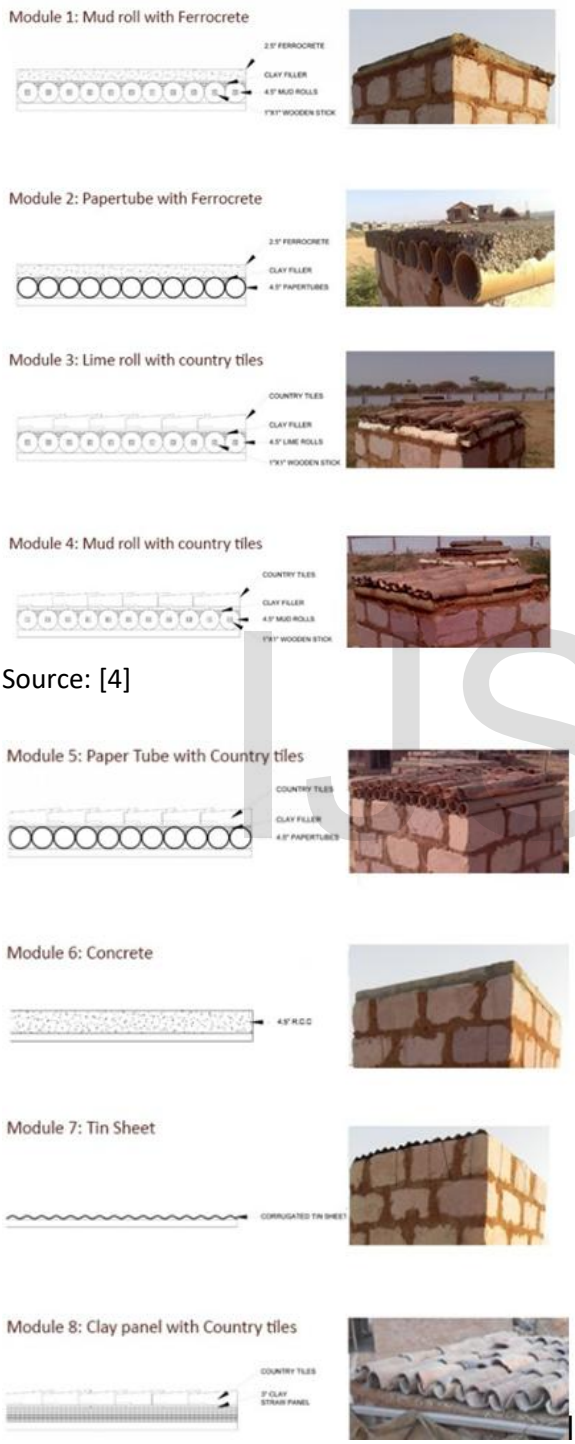
Table 3 : Advantages and Disadvantages of Straw clay panels

Advantages of Straw clay panels	Disadvantages of Straw clay panels
Straw clay panels made from a waste product.	The technique is not difficult but still the contractor will need to learn new construction techniques.
The farmer makes some money by selling the bales and the user gains an excellent insulation and building material.	If this material is not the part of local codes, it may be a bit more work to get your plans approved.
Straw clay panel acts as a good insulating material R value ranges from R-30 to R-35 or more. The thicker the bale, the better the R-value.	Straw bale walls need to be kept dry as moisture is tending to cause harm,not only straw, but to other building material also
The concept of straw bale construction is easily understood by even novice builders.	If straw bales are not available locally, the transportation cost and pollution is also taken into account.
Straw bale acts as good insulating material.	Due to the large thickness of the walls, more space get occupied reduces the usable area.
Straw bales are 100% biodegradable	Rainy Areas and moisture containing areas may not be suitable for straw bale construction.
It has a low-embodied energy.	

Source: [10]

Combination of both Traditional and Contemporary material for roof design:

The different contemporary combinations for roof design in the region of Kutch and Bhuj is like Mud roll with ferrocene , Lime roll with country tile , Paper tube with country tile , tin sheet , clay panels with country tile has been analyze by the research team in CEPT and concluded with this chart .



Source: [4]

Source: [4]

As per study Clay panels containing fly ash with lime did not respond positively in terms of strength because of the insufficient binding. All the other materials tested responded positively.

But there is a less consideration of existing traditional material used in Bhuj like thatch, Straw clay panel, Rice husk, wood panels. [4]

The modules paper tube, ferrocrete with the combination of traditional material like clay can also be the good roofing material. These different type of compositions gives good strength to the roof and get benefits of traditional as well as contemporary materials

Conclusion:

The traditional roofing material for the construction is good insulator as restricting or reducing the load on Mechanical cooling is required in Hot and Dry climate. In urban areas the population density is more and even the land cover is shared by number of occupants so the periodic maintenance is required to traditional roofing system. But now the development is happened in the western region in India as the population is increasing but the development is not climate responsive.

Use of mud, adobe, straw are not possible in high rise buildings because according to study

of Jonathan Besozza this roofs are creates problem of leakage and inadequate compaction. So these types of roofs are not suitable for high rise and medium rise buildings. There is need of combining both the material considering there advantages.Innovative roof design by combining the advantages of the traditional insulating materials and contemporary techniques and materials of high thermal capacity with the help of new composition of Sandwich roof for any height of Building in Hot and Dry Climate in India with the help of ecofriendly sustainable materials.

Some positive results of composition of traditional and modern roof shows there scope for further research of different material composition for roof of high-rise building in Hot and Dry.

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