ROOF COOLING COVER WITH THE USE OF POLYESTER FABRIC AND NATURALLY AVAILABLE LOW THERMAL CONDUCTIVITY MATERIAL

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Abstract : In this study a cool roof cover is one that has been designed to reflect more sunlight and absorb less heat than a standard roof. Cool roof cover can be made of a highly reflective type of paint, a sheet covering, or highly reflective tiles or shingles. In our country, India, most of the day we fill summer weather. This weather makes our life most uncomfortable. To get comfort or relief from hot weather we use different electrical devices like fans, air conditioner etc which need electricity. But some time these devices also failed to satisfy human need because due to global warming and pollution the atmospheric temperature rise quite high (sometime 40°**C** to 45°**C**). In our society there are different people in different class with respect to the economical point of view. But every people expect life having peace, happiness and comfort. Lots of money spent to afford an air conditioner.In our project we are making a roof cooling cover. It has high reflectivity against solar radiation energy and it act as better insulation because thermal conductivity of this cover is very low. That is why it can be used to reduce the temperature of roof by which we can control the temperature of room also. Those people who can't afford AC even fan (in rural areas) due to scarcity of electricity can use roof cooling cover for reducing temperature of their room.

***Keywords*:** Roof cooling cover, Straw ,Rural areas, Sun Light

1. INTRODUCTION

From very ancient period the concept of Thatching was used to decrease the temperature of room. Now-a-days also in rural areas thatching is done to make their room cool but they could not able to reuse it. By using this concept in this project we are introducing a modified roof cooling cover with a proper design and different materials. Just as wearing light-colour clothing can help keep you cool on a sunny day, cool roofs material that is designed to reflect more sunlight and absorb less heat than a standard roof. Cool roofs can be made of a highly reflective type of paint, a sheet covering, or highly reflective tiles or shingles. Standard or dark roofs can reach temperatures of 150°F or more in the summer sun. A cool roof under the same conditions could stay more than 50°F cooler and save energy and money by using less air conditioning. The atmosphere heated up due to solar radiation. There is a big impact of thermal radiation on earth surface. The roof cooling cover like thatch resists some radiation and makes a good effect for living means.

The roof and walls in the urban areas contribute to major share in the absorption of solar radiations and also retard the outflow of the absorbed radiation from the building envelope, thereby increasing the global warming by inducing the heat island effect. The impact of using cool roof technologies on the thermal comfort of the office buildings has been estimated. Cool roofs reduce electricity consumption for maintaining the temperature of the air-conditioned buildings in the comfort level and also increase comfort in buildings merely not relying completely on cooling equipment.

A significant portion of the energy is consumed by today's buildings in developed countries. For example, about 39% of the total US primary energy is consumed by buildings today, this fact emphasizes on the imperative need for energy savings in buildings. Both governments and scientific communities across the world have identified the potential and need for energy efficiency in the buildings, and initiated significant efforts in this direction. As of date, the WGBC (world green building council) has involved 82 nations all across the globe in taking up green building initiatives to some degree. LEED (Leadership in Energy and Environmental Design), an internationally recognized green building certification system, also identifies energy efficiency as an important attribute of green buildings. The buildings we find today are expected to achieve both energy efficient and environmental-friendly design. Improvements to heating, ventilation and air conditioning (HVAC) systems, electrical lighting, etc. can be categorized as active strategies, whereas, improvements to building envelope elements can be classified under passive strategies. Recent years have seen a renewed interest in environmental-friendly passive building energy efficiency strategies. Thatching is a rural art. Much of the thatching industry is centred around conservation and bound by the need to meet regulations governing listed buildings. In order to preserve vernacular diversity the thatcher must be master of many ancient techniques. Two natural materials are used, water reed and straw. Henry Best's seventeenth century diary (Rural Economy in Yorkshire in 1641) records wheat and rye straw as the best for thatching although barley straw is good also if it be without weedes .For a new house water reed, which could last around fifty years before needing repair, is often recommended, although conservation officers may disapprove if straw is a more common regional material. Arguments for reed durability are based on research done in the 1950‘s which took no account of regional variations in climate or whether a

house faced North, South, East or West. Both weather and location can affect the longevity of thatch, so long straw is ok on Suffolk but not suitable in Devon. Some would say that it is better to have a whole roof in one material, others argue that it is important to maintain local diversity. Mike Smith, Principal Planning Officer Rutland County Council, considers it important to ask why there were two materials used in the first place and says that they always work closely with the Conservation Officer, Elizabeth Bryan, who is the authority on the subject. Elizabeth says, while it is important to have diversity across the UK we must try to keep regional character. After the First World War patterned ridges became more common as thatchers came in from other regions. Long straw is more comfortable for people to look at, softer on the eye , and it has better insulation properties reed needs loft insulation. Oakham based thatcher, Paul Dear, says although he offers clients advice on what is the best economic and aesthetic choice he usually has to leave the decision to the Conservation Officer when a building is Listed John Barber reports his 2001 crop as, only 40% of average and of shorter length than I would like. On twenty-one acres, he mostly grows Wigeon, a wheat variety produced in 1968 which is widely used all over the UK. Trials with the wheat/rye hybrid Triticale were unsatisfactory as it produced, straw five feet high which was so heavy when cut green it caused hernias and shrank on drying meaning we had to re-tie stooks. Poor harvests make it difficult to get farmers to consider growing what is a high-risk, but high-return, crop.

In the 1970's 1980's the Rural Development Commission (formerly COSIRA) realised there was almost no machinery left to process thatching materials. They got access to the best three Murch combers made in Umberleigh, Devon and drew up a set of plans which were made available to farmers. John spent around eighteen months of farmers spare time building his comber and supplies much of the thatching material used in Rutland.

The concept of this roof cooling cover comes from the use of thatching used in rural areas. Thatching is the craft of building a roof with dry vegetation such as straw, water reed, sedge, rushes, or heather, layering the vegetation so as to shed water away from the inner roof. Figure 1 shows a typical thatching roof construction. It is a very old roofing method and has been used in both tropical and temperate climates. Thatch is still employed by builders in developing countries, usually with low-cost, local vegetation. By contrast in some developed countries it is now the choice of some affluent people who desire a rustic look for their home, would like a more ecologically friendly roof, or who have purchased an originally thatched abode.
Here in this work we are modifying old thatching technique with adding polyester fabric for increasing life of thatching in different climate and season.

Fig-1: Thatching roof construction

2.THEORY

The atmosphere heated up due to solar radiation. The visible portion of the electromagnetic spectrum lying between 0.4µm and 0.76µm is what we call light, which triggers the sensation of vision in the human eye. A body that emits some radiation in the visible range is called a light source. The sun is our primary light source. The electromagnetic radiation emitted by the sun is called the solar radiation which falls in the wavelength band 0.1-3µm. About half of the solar radiation is light (visible range), while the rest is ultraviolet and infrared.
Matter can emit ,absorbs, reflect and transmit radiant energy. If Q is the total radiant energy incident upon the surface of a body. Some part of it (Q_A) will be absorbed, some part (Q_R) reflected, some part (Q_T) Transmitted through the body.
By energy balance,

$$Q_A + Q_R + Q_T = Q$$
$$\frac{Q_A}{Q} + \frac{Q_R}{Q} + \frac{Q_T}{Q} = 1$$
$$\alpha + \rho + \tau = 1$$

Where α is the fraction of incident radiation which is absorbed, called absorptivity, ρ is the fraction which is reflected called reflectivity and τ is the fraction which is transmitted through the body ,called transmissivity or transmittance.
A body is said to be opaque if $\tau = 0$ and $\alpha + \rho = 1$, most solids do not transmit any radiation and are opaque. If ρ is increased, α decreases. The reflectivity depends on character of the surface. Roughening a solid surface enhance its absorptivity and smoothening a solid surface enhance reflectivity of incident radiation.

3. MATERIAL USE FOR ROOF COOLING COVER

According to the value of thermal conductivity we choose the useful material for making this cover. These are-

- Rice straw
- Saw Dust
- Silver coated polyester fabric
- Paper

Table.1 shows the thermal conductivity of different material

Table-1: List of Thermal Conductivity of Different materials

Material	Thermal Conductivity(W/m K)
Straw	0.09
Asbestos	0.08
Chalk	0.09
Saw Dust	0.08
Charcoal	0.084
Calcium silicate	0.05
Fibre glass	0.04
Glass wool	0.04
Polyester	0.06
Paper	0.05

3.1 STRAW

Straw is an agricultural by product, the dry stalks of cereal plants, after the grain and chaff have been removed. Straw makes up about half of the yield of cereal crops such as barley, oats, rice, rye and wheat. It has many uses, including fuel, livestock bedding and fodder, thatching and basket making. It is usually gathered and stored in a straw bale, which is a bundle of straw tightly bound with twine or wire. Bales may be square, rectangular, or round, depending on the type of baler used. Figure 2 shows Straw bale and straw bundle.

USES:

- Biogas: Straw, processed first as briquettes, has been fed into a biogas plant in Aarhus University, Denmark, in a test to see if higher gas yield could be attained.
- In many parts of the world, straw is used to bind clay and concrete. A mixture of clay and straw.

Fig-2: Straw bale and straw bundle

known as cob, can be used as a building material. There are many recipes for making cob.

- Composite lumber Wheat straw can be used as polymer filler combined with polymers to produce composite lumber.
- Enviroboard can be made from straw.
- Thatching uses straw, reed or similar materials to make a waterproof, lightweight roof with good insulation properties. Straw for this purpose (often wheat straw) is grown specially and harvested using a reaper-binder.

3.2 **Saw dust**

Sawdust or wood dust is a by-product of cutting, grinding, drilling, sanding, or otherwise pulverizing wood or any other material with a saw or other tool; it is composed of fine particles of wood. It is also the by product of certain animals, birds and insects which live in wood, such as the woodpecker and carpenter ant. It can present a hazard in manufacturing industries, especially in terms of its flammability. Sawdust is the main component of particleboard.

Uses

A major use of sawdust (Fig.3) is for particleboard; coarse sawdust may be used for wood pulp. Sawdust has a variety of other practical uses, including serving as a mulch, as an alternative to clay cat litter, or as a fuel. Until the advent of refrigeration, it was often used in icehouses to keep ice frozen during the summer. It has been used in artistic

Fig-3: Saw Dust

displays, and as scatter in miniature railroad and other models. It is also sometimes used to soak up liquid spills, allowing the spill to be easily collected or swept aside. As such, it was formerly common on barroom floors. It is used to make Cutler's resin. Mixed with water and frozen, it forms pykrete, a slow-melting, much stronger form of ice. Sawdust is used in the manufacture of charcoal briquettes. The claim for invention of the first commercial charcoal briquettes goes to Henry Ford who created them from the wood scraps and sawdust produced by his automobile factory.

3.3 Polyester fabric

Polyester is a term often defined as ―long-chain polymers chemically composed of at least 85% by weight of an ester and a dihydric alcohol and a terephthalic acid. In other words, it means the linking of several esters within the fibres. Reaction of alcohol with carboxylic acid results in the formation of esters. Polyester also refers to the various polymers in which the backbones are formed by the esterification condensation of poly functional alcohols and acids. Polyester can also be classified as saturated and unsaturated polyesters. Saturated polyesters refer to that family of polyesters in which the polyester backbones are saturated. They are thus not as reactive as unsaturated polyesters. They consist of low molecular weight liquids used as plasticizers and as reactants in forming urethane polymers, and linear, high molecular weight thermoplastics such as polyethylene terephthalate (Dacron and Mylar). Usual reactants for the saturated polyesters are a glycol and an acid or anhydride.

Polyester fabrics and fibres are extremely strong. It is very durable: resistant to most chemicals, stretching and shrinking, wrinkle resistant, mildew and abrasion resistant. Polyester is hydrophobic in nature and quick drying. It can be used for insulation by manufacturing hollow fibres. Polyester retains its shape and hence is good for making outdoor clothing for harsh climates

Uses

The most popular and one of the earliest uses of polyester was to make polyester suits – all the rage in the 70s. Polyester clothes were very popular. Due to its strength and tenacity polyester was also used to make ropes in industries. PET bottles are today one of the most popular uses of polyester.
The moisture regain of polyester is 0.2 to 0.8 and specific gravity is 1.38 or 1.22 depending on the type of polyester fibres is moderate. The melting point of polyester is 250-300°C. A wide of polyester fibres properties is possible depending on the method of manufacture.

Thermal insulating value (TIV):

TIV represents the efficiency of the textile fabric as an insulator. It is defined as the percentage reduction in heat loss from a hot surface maintained at a given temperature. The TIV increases to 100% when a perfect‘ insulator is obtained. The TIV of textile fabric depends upon the thermal conductivity of the fabric, the thickness of the assembly and the thermal emission characteristics of the surface fabric. It is expressed as a percentage which represents the reduction in the rate of heat loss due to the insulation, relative to the heat loss from the surface.

Thus, the following relation represents this value [5]:

$$(TIV)\% = 100 [1 - (K_t / \varepsilon_0) / (L + (K_t / \varepsilon_1)]$$

where ε_0 and ε_1 are the emissivity of one and the other surface of the insulator (textile fabric) respectively.
A typical value of emissivity of textile fabric is 2.06 cal. / m^2 s^{o}C. The conversion of TIV to the tog unit can be written as follows:

$$(TIV)\% = 100 [1- (I_0 / I_1)]$$

where I_0 and I_1 are the tog values of unclothed and clothed bodies respectively, where 1 tog=0.418 $m^2 s^oC$ / cal.
Table. 2 gives the calculated values of the TIV in percent for the samples of the selected fabrics.

Table-2: TIV in percent for the samples of the selected fabrics

Fabrics	Sample	Thickness, (m)	(TIV),%
Polyester	Sample 1	3.54×10^{-3}	41.21
	Sample 2	4.32×10^{-3}	49.3
	Sample 3	4.88×10^{-3}	50.5
	Sample 4	5.62×10^{-3}	51.3
	Sample 5	7.97×10^{-3}	52.15

3.4. Apparatus

The following Apparatus are used for the experiment.

- Temperature hygrometer
- Sewing machine
- Straw cutter machine

Temperature hygrometer: A hygrometer is an instrument used for measuring the moisture content in the atmosphere. Humidity measurement instruments usually rely on measurements of some other quantity such as temperature, pressure, mass or a mechanical or electrical change in a substance as moisture is absorbed. Figure 4 shows the hygrometre.

Fig-4: Temperature hygrometer

Specifications of Temperature Hygrometer:
Temperature measurement range: -10ºC ~ +50ºC
Temperature measurement accuracy: ±1ºC(1.8ºF)
Temperature resolution: ±0.1ºC(0.2ºF)
Humidity measuring range: 10% ~ 99% RH
Humidity measuring accuracy: ±5% RH
Humidity resolution: 1%
Battery: AAA 1.5V

Sewing machine: A sewing machine is a machine used to stitch fabric and other materials together with thread. Sewing machines were invented during the first billet Industrial Revolution to decrease the amount of manual sewing work performed in clothing companies. We use it for sewing purpose to make our cooling cover.
Specifications:-
Application: Stitching fabric
Body Shape: Round
Drive/Motion: Gear drive
Hook Mechanism: Rotary
Machine Colour: Black
Max Stitch Length: 4.2 mm
Maximum Number of stitches per minute: 1500 SPM

Straw cutter machine: These paddy Straw Cutter Machine(Fig.5) are used to cut paddy straw for cooling cover. It is powered by 1HP single phase motor, mounted on a heavy steel stand there is no need for foundation for the machine. These products are available in market at economical rates.

Fig-5: Straw cutter machine

4. PROCEDURE:

First with the help of sewing machine ,making pockets of polyester fabric cover. Then after cutting straw by using straw cutting machine, fill up the pocket with cutting straw. After proper distribution of straw sewing the open part of the pocket. After one material

we change the filler material and filled the pockets of cover. We have selected two room with equal dimension wich have a common wall in middle as a partition wall. The reading for room temperature difference between two room with different material has been noted. In a first room always using conventional straw and in the second room using the cover. Figure 6 shows that roof cooling cover with dimension. Figure 7 and Fig.8 shows work place sceneries.
Table.3 shows results with the use of straw dust and Table. 4 shows results with the use of cutting paper. Table.5 shows the results for saw dust and Table.6 shows results with straw only.

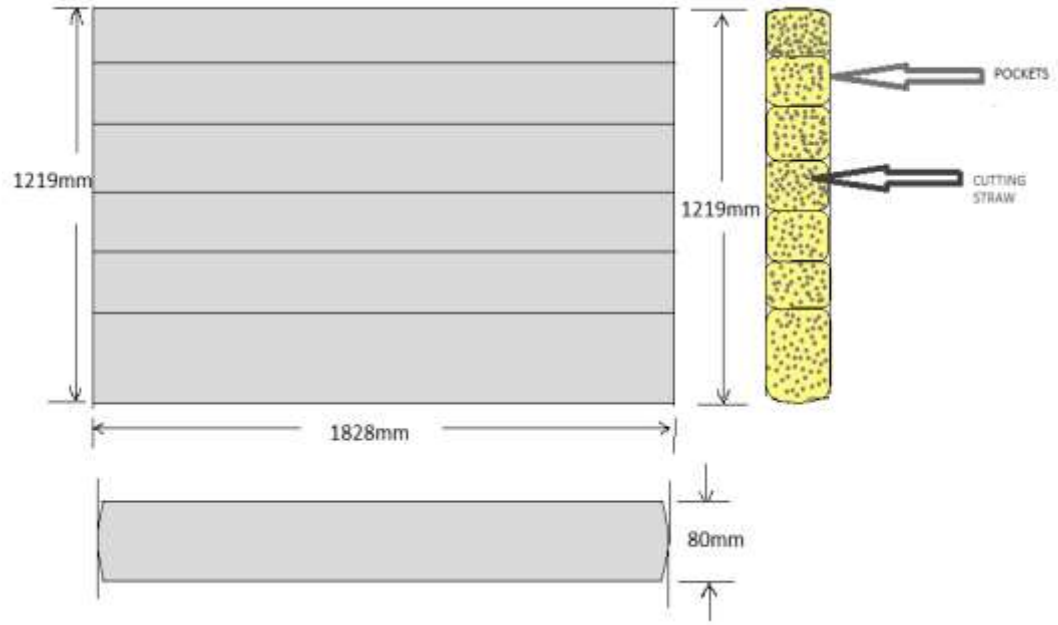

Fig- 6: Roof cooling cover with dimension

Table-3: Observation using straw dust on 30/03/2017

Place	Temperature	Humidity
Room 1(with using roof cooling cover)	32 °C	41%
Room 2(without using roof cooling cover)	36.5 °C	62%
Air	41 °C	32%

Table-3: Observation using Cutting Paper on 25/03/2017

Place	Temperature	Humidity
Room 1(with using roof cooling cover)	32 °C	40%
Room 2(without using roof cooling cover)	35.2 °C	61%
Air	37.7°C	37%

Table-5: Observation using Saw Dust on 28/04/2017

Place	Temperature	Humidity
Room 1(with using roof cooling cover)	30.5 °C	45%
Room 2(without using roof cooling cover)	37 °C	68%
Air	41°C	33%

Table-6: Observation using Straw Only on 17/03/2017

Place	Temperature	Humidity
Room 1(with using roof cooling cover)	30.8 °C	46%
Room 2(without using roof cooling cover)	32 °C	61%
Air	35 °C	39%

Fig-7:- work place sceneries 1

Fig-8:- work place sceneries 2

5. COST ESTIMATION AND MATERIAL'S COMPARISION (For a Standard Roof of Size 12ft *12ft): According to our observation Table.7 shows the cost for different materials use as a filler with the cover and reduction of temperature and Table.8 shows cost effective comparison for different material. According to our experiment result we can reduce our room temperature near about 2° with the conventional process by using only straw. By using polyster fabric cover and cutting straw (in small pieces) as a one unit, the temperature difference of rooms is 4.5°. After replacing straw dust with saw dust we seen that temperature difference is higher between two room is near about 6.5°. Again we replace filler material of cover with cutting news paper and the temperature difference between two room is 3.2°. After experiment we seen that we getting good result with this cover for decreasing our room temperature than simple straw. Result obtain with saw dust is outstanding. The cost of cover is not high and we can fold the cover in rainy season for next summer. For conventional process with simple straw labour cost of Thatching is near about equal to our cover cost and every year we need to expend that amount and it also include labour cost in rainy season for cleaning of roof.

Table-7: Cost Estimation

Roof cover type	Temperature difference	Total Cost (with installation cost)
Polyester fabric cover with cutting straw	4.5ºC	Rs.1350/-
Polyester Fabric cover with saw dust	6.5ºC	Rs.1800/-
Polyester fabric cover with cutting paper	3.2ºC	Rs.1750/-
Only straw layer	2.2ºC	Rs.1500/-

Table-8: Material's Comparison

Materials	Temp Difference	Heat (W/m^2)	Total Cost (RS)	Cooling Effect	Rating
Polyester fabric cover with cutting straw	4.5°C	18.8	1350	Excellent	*****
Polyester fabric cover with saw dust	6.5ºC	19.92	1800	Outstanding	****
Polyester fabric cover with cutting paper	3.2ºC	7.08	1750	Average	***
Only straw layer	2.2ºC	8.879	1500	poor	**

6. CONCLUSION

It can reduce the temperature of room up to 7°C. Comparing with the thatching process, it can prevent the wasting or damaging possibility of straw or inner materials .It is long-lasting so that it can be fold out at the time of rain. It is very economical product. Investment cost is very low to make this product. No Electric energy is required. The cover making process is very simple, Thus skilled worker is not necessary. It is portable and due to light weight easily handled. Due to silver coated polyester fabric cover it is water proof and UV protected. Thus damaging possibility is less. The primary material (straw) is highly available with minimum price. This cover has high reflectivity against solar radiation energy and it act as better insulation because thermal conductivity of this cover is very low. That is why it can be used to reduce the temperature of room by which we can control the temperature of room also. Those people who can't afford AC even fan (in rural areas) due to scarcity of electricity can use roof cooling cover on the roof of their house. This model has proved to be beneficial to us, sincerely this our first real exposure to practical modelling. This model is made to us fulfil all the requirements easily to reduce the temperature of a room which is essential for our daily life. All we are looking forward to the success of this work.

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