EXPLORATION OF THE FEASIBILITY OF HUMAN HAIR AS INSULATION IN CONSTRUCTION

Jessica Whelan

INTRODUCTION

Looking at the possibility of recycled human hair waste as an insulation material in construction using hotbox testing to find the thermal conductivity and compare against existing materials and regulations

AIM

To investigate the thermal properties of recycled human hair fibers

Natural

Renewable

Sustainable

Accessible

OBJECTIVES

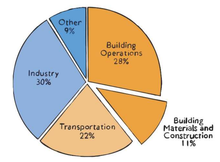
Identify the main properties and characteristics of human hair fibres.
- Identify the previous uses of human hair.
- Research other natural fibre insulations.
- Conduct hotbox testing.
- Carry out an analysis of the results found from testing.

METHODOLOGY

RESEARCH → TESTING → CALCULATIONS → ANALYSIS

MOTIVATION

The growing demand to find Eco-friendly alternatives to synthetic materials to help reduce the building sectors carbon emissions.



6.5 Million kilograms of human hair waste is produced annually in the UK alone most of which ends up in landfills

72 Million kilograms of human hair waste annually ends up in landfills across Europe, this is the same weight as

7 Eiffel towers.

HUMAN HAIR FIBRES

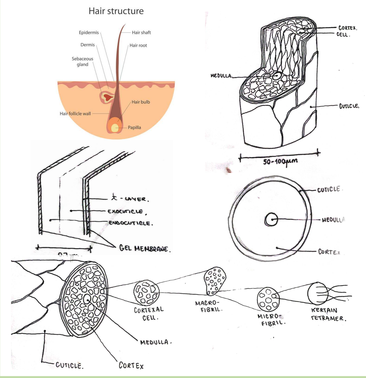
Hair is a protein filament that is grown from organs found in the skin called follicles. Hair fiber are composed by three main structures: cuticle, cortex and medulla.

The cuticle covers the hair thread from the scalp to the end with overlapping sheets

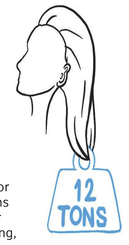
The cortex occupies most of the hair area and is filled with cells. Each cell surface is rough, irregular, and tie crossly to each other.

The medulla is a thin cylindrical layer in the center of the hair thread. Its function is not yet completely known, although its cells may become dehydrated and its spaces may be filled with air, which affects both color and shine in white brown and blond hair.

Hair Fibres are hygroscopic, they have the ability to absorb an release moisture as humidity rises and falls, although the fibre is hygroscopic the surface of the fibre is hydrophobic towards liquid water, repels water.



In general, the weight needed to produce a natural hair thread tear is 50-100 g. An average head has about 120,000 threads of hair and would support about 12 tons.



The cortex keratin is responsible for the strength of hair , its long chains are compressed to form a regular structure which, besides being strong, is very flexible.

When dry, the hair thread may stretch 20-30% of its length and when in contact with water, this may reach up to 50%.

Due to the rate that human hair fibres break down, it can large spaces in dumps for a long time and over time cause nitrogen leaching.

The process of burning hair releases foul odors and toxic gases' such as ammonia, carbon sulphides, hydrogen .

PREVIOUS USES OF HUMAN HAIR

Agriculture

Medicine

Textile

Construction

Due to its high tensile strength and friction coefficient human hair has been used for reinforcing clay-based construction. Studies show that the addition of human hair fibres to clay bricks enhances both the structural strength and the thermal insulating capacities .

NATURAL FIBRES INSULATIONS

Natural fibres are fibers that are produced by geological processes, or from the bodies of plants or animals.

They can be used as a component of composite materials, where the orientation of fibers impacts the properties, they can also be matted into sheets to make paper or felt.

The earliest evidence of humans using fibers is the discovery of wool and dyed flax fibers found in a prehistoric cave in the Republic of Georgia that date back to 36,000 BP.

Each type of natural insulation has its own set of key characteristics that makes them suited to different applications.

Hemp Fibre

Sheep's Wool Fibre

Wood Fibre

Coconut Fibre

Sustainability

Their sustainability and minimal impact on the environment are two of the greatest advantages of natural insulation.

Health

As they contain no harsh chemicals or irritating fibres, natural insulation materials are not generally harmful to health.

Clean Air

Using natural insulation in your home isn't just helping the earth, it's cleaning the air inside your property too. Natural insulation materials such as sheep's wool emit zero toxins throughout their long lifespan

SHEEP'S WOOL

Similar to human hair fibers, sheep's wool fibres are also protein fibres.

They are completely covered by a cuticle that anchors it to the sheep's skin.

Most of the area is also occupied by the cortex with a similar cell build up to human hair fibres

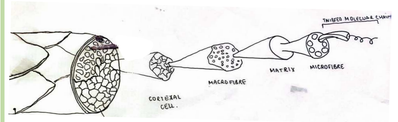
Sheep's wool fibres are also hygroscopic with a hydrophobic surface.

therma fleece COSYWOOL

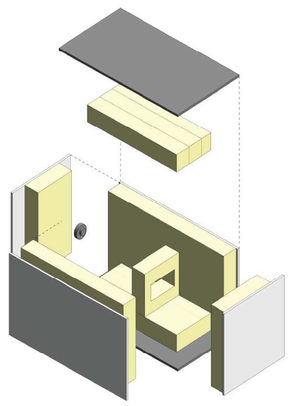
Thermal Conductivity: 0.039 Wm-1K

Substance	% Content
Wool	70% - 80%
Recycled Polyester	10% - 15%
Polyester Binder	5% - 10%
Sodium Borate	<4%

Standards and Certifications
Manufactured in accordance with ISO 9001 & 14001



PROTOTYPE



Revit model hotbox

PREPARATION

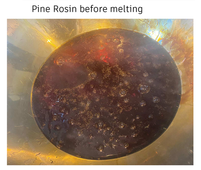
Collected hair

Physical Prototype

Pine Rosin before melting

Hair Being Washed

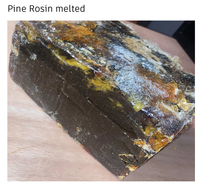
During Hotbox Construction



Pine Rosin melted

Hair Being Muddled

Calibrating Dimmer



Hair mixed rosin

TESTING

The box is split into two chambers a cold side and a hot side that was fitted with a 10W Halogen bulb.

Samples are inserted in the wall separating the two chambers.
The sample size is 100x210x100cm

Three Elitech data loggers with probes record the temperature on either side of the box and outside the box every 20 minutes.

The heat source is tuned on and the box is sealed

The test run for avg. 15 hours.

Each sample is to be tested several times to minimize error

BRITISH STANDARD — BS EN ISO 8990:1996

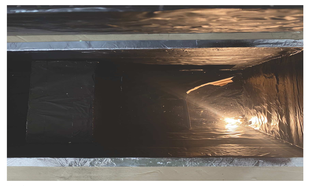
Thermal insulation — Determination of steady-state thermal transmission properties — Calibrated and guarded hot box

1. Sheep's wool
Therma Fleece Cosywool
Weight 56g

2. Loosely packed hair
Recycled hair
Density 1.625 kg/m^3

3. High density hair
Recycled hair
Density 3.125 kg/m^3

4.Ridged Recycled hair mixed
With pine resin
Density 12.083 kg/m^3



Hotbox

Hotbox

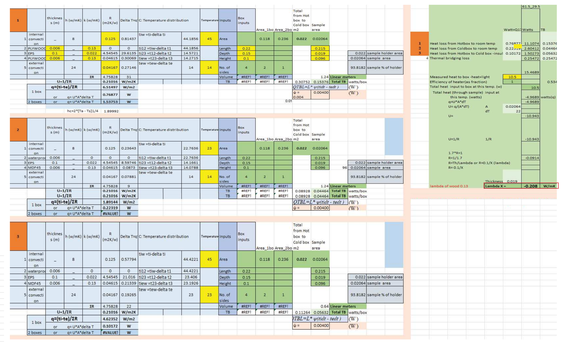
Sheep's Wool Being Tested

Hair Being Tested

Hair with Resin Being Tested

Sheets produced by Elitech

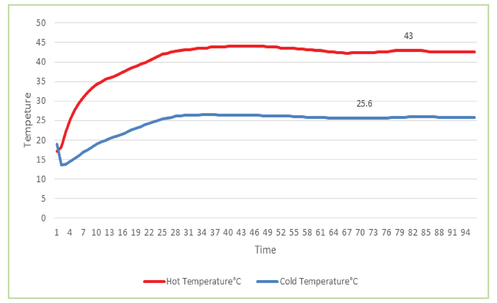
Information transferred to Microsoft Excel



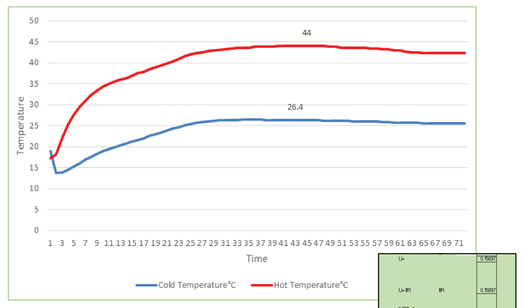
Information put into calculator on Excel

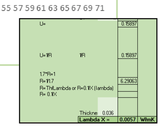
RESULTS

Sheep's Wool at 10W

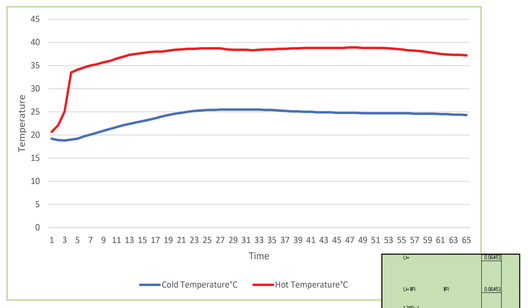


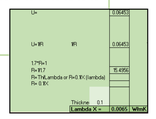
156G of Hair at 10W



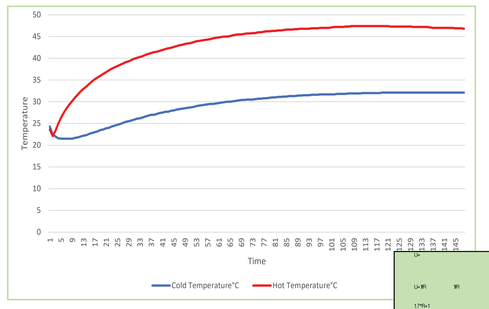


156G of Hair at 6.5W

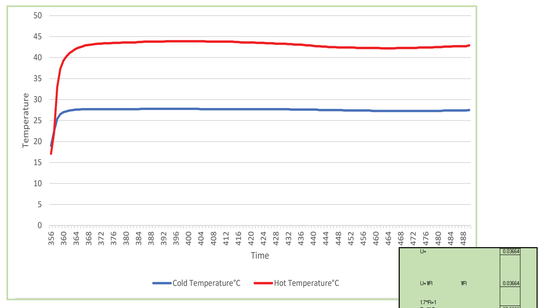


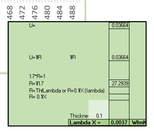


300G of Hair at 10W

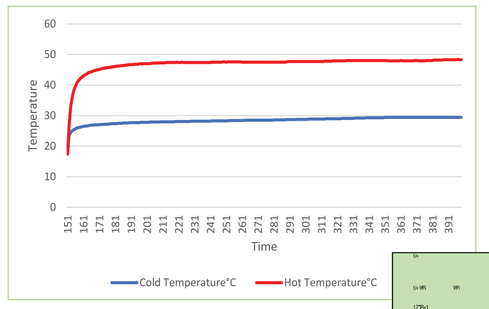


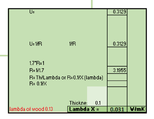
300G of Hair at 6.5W



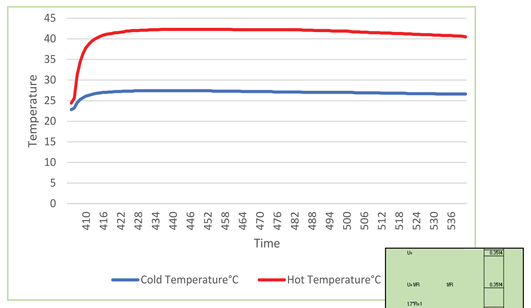


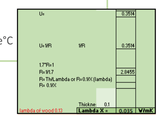
Hair with Resin Hair at 10W





Hair with Resin Hair at 6.5W

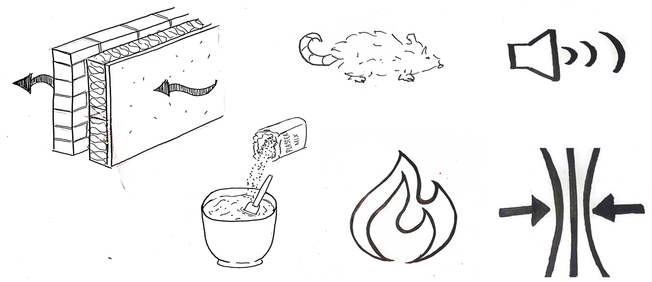
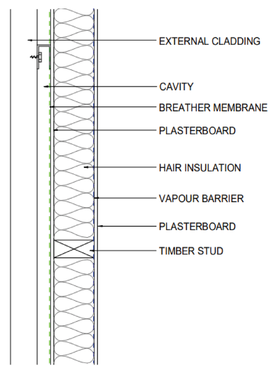
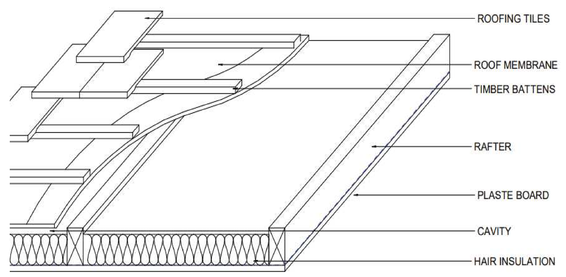




Conclusion

- Natural
- Renewable
- Sustainable
- Accessible
- Low lambda value

Further Testing



Possible Applications