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RESEARCH ARTICLE

THE RELEVANCE OF ACOUSTIC MATERIALS IN TERMS OF SUSTAINABILITY

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ABSTRACT

As the field of sustainable design grows and matures, the relevance of acoustics in architecture is paramount, generally subjected to attributes of human comfort and sustainability. With the general faith being instated into the saying, "Quality is more important than Quantity of any built space", noise abatement is the major issues of sustainable design of built environment focussing the same; because one of the criteria for establishment of indoor and outdoor spaces of good quality is the abatement of noise pollution. Due to bad planning and fastest growth of the city, noise exposure is also rising in the developing countries. But still, acoustics are an aspect of design that has been scarcely ever discussed when the design works well, but they can be a major source of annoyance or worse when there are problems. Since, acoustic comfort is paramount in all kind of environment we live, in that, the major concerns remain to be the low cost and sustainable acoustic design which is influenced by its materials. Poor acoustical conditions can cause unhealthy environment while good acoustics increase the overall comfort level of a space. The aim of this research paper is to present the various essential aspects & attributes of sustainable materials which can be used in the acoustical treatment, with the brief description of the types of materials which absorb and reflect sound, low carbon and natural materials for acoustic treatment with varieties of low-cost materials and also methods to compare the amount of sound insulation from different materials.

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INTRODUCTION

Sustainable materials can play a significant role since less energy is generally required for their manufacture than the one needed for conventional materials. Hence, the selection of sustainable materials for noise control is important for built environment, Although research and development studies are restorative on new materials as an alternative to the traditional ones (glass, rock or wood wool) which are largely used in building acoustics. These materials are divided into two main categories i.e. natural materials (cotton, cellulose, flax, hemp, sheep wool, clay, etc.) and recycled material (rubber, plastic, carpet, cork, etc.) which also includes mixed and composite materials. A sustainable product is largely made from natural or recycled materials and its production involve a small quantity of energy, made a restricted use of non-renewable resources and has a low environmental influence. As per requirement, the type of materials is also described such as materials which absorb and reflect sound, low carbon and natural materials for acoustic treatment. Nowadays, the use of such kind of materials is wider day by day to maintain the ecological, biodegradable and renewable terms.

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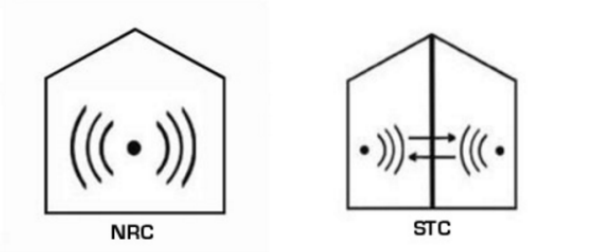
"Sustainable development meets the need of the present, without compromising the ability of future generations to meet their own needs."

The solutions to acoustical issues fall into three categories: absorption, blocking and covering. There are various types of materials to be maintained accordingly such as sound absorbers, diffusers, noise barriers and reflectors and also there are various methods to compare the amount of sound insulation from different materials are to be discussed in this paper with the numerous ideas of low-cost acoustical materials.

Measuring sound insulation

To compare the amount of sound insulation which is to be delivered from different materials, the study of measuring sound insulation is important. There are various ratings which are used to measure the sound insulation such as Noise Reduction Coefficient (NRC) and Sound Transmission Class (STC). While one measures the build-up of noise within a space, the other measures the sound transmission between spaces. It is important to understand the difference between these two ratings.



The Noise Reduction Coefficient (NRC) measures the build-up of noise within a space. For a material, single number index rating is used to measure the sound absorption of a material. Insulation products have an NRC rating from .75 to .82 depending on wall design, materials and applied density of the product. Insulation products will absorb 75% to 82% of the sound that it comes in contact with and will reflect 18% to 25% of the sound back into space. However, NRC does not address a material's barrier effect and it does not give information as to how absorptive a material is in the low and high frequencies. NRC is only the average of the mid-frequency sound absorption coefficients (250, 500, 1000 and 2,000 hertz) and rounded to the nearest 5%.

The Sound Transmission Class (STC) measures the sound transmission between spaces. It is single number rating which is used to measure the assembly's barrier effect. A higher STC rating blocks more noise from transmitting through a partition. Loud speech can be understood through an STC 30 wall but should not be audible through an STC 60 wall. Insulation products have an STC rating of 44 to 68 depending on the wall construction. STC ratings do not measure the low-frequency sound transfer. It depends on the performance with frequencies from 125 to 4,000 hertz (speech frequencies). The STC rating is a lab test that does not take into consideration weak points, perceptions, or flanking paths. NRC and STC are completely mutually exclusive. A material with a high NRC will help to absorb sound, stopping it from reflecting back into the room. The same material having a low STC will allow a large amount of sound to pass through it and into an adjacent room. Acoustic wall treatment with a high NRC can stop sound from reflecting back into space, possibly lowering the noise level within a space, while in STC it will not stop sound from passing through and into an adjacent space, therefore they do not improve STC.

Sustainable materials for noise control

Materials obtained from synthetic fibers, such as mineral wool, are commonly used for thermal and sound insulation, because of their good performances and low cost. Moreover, they can pulverize and are not resistant to water, oil and chemical agents and this can make their application not suitable for absorbing noise barriers. Mainly sound absorbing materials made up of recycled raw materials and of natural fibers such as plant fiber or wool, can be used to construct sustainable sound absorbers which create good sound according to the reverberation properties of the room. The primary method of controlling reverberation times is through the introduction of absorptive and reflective surfaces and materials into space.
In recent years, an increasing attention has been turned to natural fibers as alternatives to synthetic ones, in order to combine high acoustic and thermal performances with a low impact on the environment and human health. Natural fibers have very low toxicity and their production processes can contribute to protecting the environment. Recycled materials, can even be regarded as a sustainable alternative, as they contribute to lower the waste production and use of raw materials. However, it is very important to assess the 'sustainability' of a natural or recycled material and to verify the total energy use in its production process.

As previously said, many new materials for noise control as alternatives to the traditional ones have been proposed in recent years. These materials can be divided into three main categories:

- Natural materials.
- Recycled materials.
- Mixed and composited materials.

Natural materials

They aremore natural and less treated, the higher they perform in energy saving; native materials have to be preferred to reduce transport energy. The use of natural materials contributes to achieving a bigger sustainability of buildings.
It is well known that natural fibers have anegative impact as far as climate change due to CO2 absorption during the growth of the plant. Production requires very little energy and is not polluting. Dust of paper fibers has no indoor polluting known risk; no measurable migration of dust into living accommodation should ensue with proper use, hence no radiation emission is released. It is recyclable and owing to its durability and no maintenance is required if properly installed.
The disadvantages of natural materials are parasites with the resistance and limited fire resistance in comparison with some traditional, man-made materials. For this reasons in some cases, natural materials require a chemical treatment that reduces their sustainability rating.

Sound absorption

Natural fibers are generally good absorbers. The extremely wide variety of natural fibers allows finding anappropriate material for almost every absorbing need. Many natural materials such as kenaf, flax, sisal, hemp, cork, sheep wool, bamboo or coconut fibers show good absorbing performance and can, therefore, be used as sound absorbers in room acoustics and noise barriers. Absorption is used to address the intelligibility and understanding of sounds that occur within a room by controlling the reverberation of time and echo. Reverberation time is the period of time which takes for a sound event to become no longer audible. The NRC rating is an average of an absorptive material at four frequencies (250, 500, 1000 and 2000 Hz) and is here used for a comparison of the various materials.

Recycled materials

Recycled materials can be observed as an alternative to natural materials, as they contribute to lower waste production and also reduced the use of raw materials. There are many examples of which are materials falling into this category. These include recycled rubber, plastics, textile fibers and solid wastes. The efficiency of the rubber crumb as material for acoustically absorbing panels has been also confirmed with the study by the University of Valencia, where sample with the sound absorption coefficient is above 50% at frequencies of

1000 Hz and has been detected. Recycled material can be used for the acoustic lining of noise barriers. The sound insulation and absorption of two different types of anoise barrier is one with recycled foam and other with recycled plastic.

Mixed and composites materials

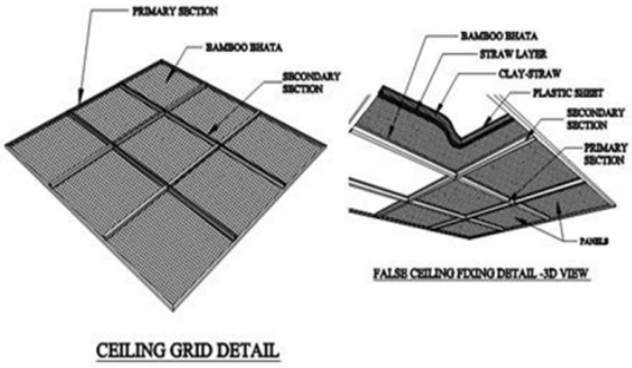
These materials are made up of both natural and plastic or conventional materials. In mixed materials, the sustainable and the conventional materials are simply mixed to create a new material. On the contrary, in composite materials, a natural fiber is for example which is chemically linked to a coupling agent to a polymer, to create a composite. The percentage of natural fibers in mixed and composite materials is basically high and for this motive, they can be considered a sustainable solution. For example, The term Wood-Plastic Composite (WPC) is referred to any material which is made mixing with plantfiber (cotton, jute, kenaf, etc.) and thermosets or thermoplastics. Thermosets are plastic that once cured cannot be melted by reheating while Thermoplastics are plastics that can be repeatedly melted.

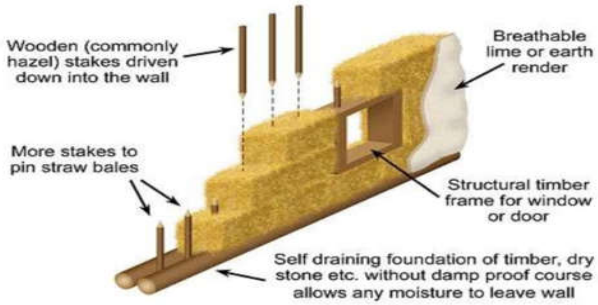
Low-cost acoustic materials

Low-cost materials can be employed for acoustical treatment which can be cheap & easy to handle. Such materials should be used on a greater scale so as to overcome money factor. These should come in common use on alarger scale.

•**STRAW:-**Straw is the inedible chaff, or stalks, of grain grasses such as wheat, barley, rice and rye, and has been used by farmers for generations as animal bedding and also for visual and sound barriers for their homes and fields.

- Straw can be used in the form of panels or bales and it is also used as construction material.
- Straw also can be stitched into a frame to make panels and available in various sizes.
- The fragile but flexible material is easy to work with because it is a natural material.
- Full sound absorption, attenuation, and sound transmission are seen.



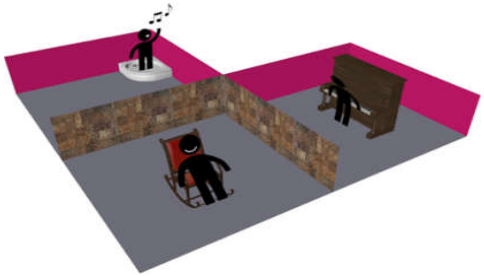


This material provides noise reduction through sound absorption, thermal insulation, reduces ceiling maintenance and it is lightweight with alow of acost, it is easily available, also natural and eco-friendly but not a conventional material.

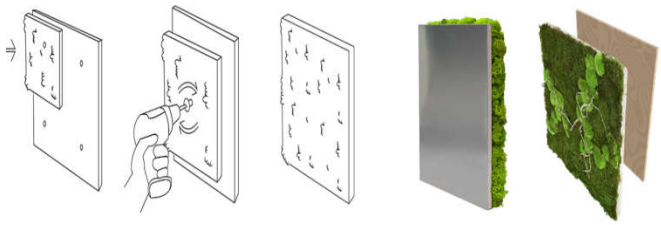
•**Coir Fibre: -**Coir Fibre is obtained from the husk of the coconut. It is suitable as a substitute for synthetic fibers and wood-based materials for acoustic absorption purposes. These fibers have many advantages because they are cheaper, renewable, and non-abrasive and do not give rise to health and safety issues during processing and handling. It is being used in tropical areas like Kerala for some time.

- Cork is very easy to install.
- It is used in buildings where it is necessary to reduce noise transmission from entire floor to floor or from anentireroom to room.
- Acoustic cork reduces the impact noise, which is made by high heel shoes on hardwood floors, marble, ceramic, or stone flooring.
- Cork wall panels and cork ceiling tiles are also used for acoustical treatment.

- It can help absorb and dissipate sounds to reduce disturbances and improve the acoustics in a room.
- It is very light-weight, it is durable and long-lasting
- It is renewable and resistant to dust and toxin absorption.
- It is inexpensive, without proper protection, it can stain.
- it is not water-proof.



•**Moss :-** Moss is a natural lichen which can use indoors as well as in shaded outdoor areas. It needs a min. relative humidity of 40%, and does not require any maintenance, light or water. It blends with other acoustic materials like wood, ceramic, PVC, EPS etc. which has an absorption value of around 1.0.



Method of installation

Moss panels are attached to a base (eg-MDF, aluminum) with an acoustic layer of natural fibers. It is available in various sizes like 30cmx30cm, 80cmx80cm, and can be attached with or without seams. It could enhance the 'Green' proportion of buildings.Itis a lichen and hence it has a grass-like appearance. It is available in various colors.

- easy installation and requires no maintenance
- high performance acoustic insulator
- bio-degradable, non-toxic, available in colours
- compliments other materials
- Dust repellent/ does not attract fungal attacks
- Delays the spread of fire
- Cons
- High initial cost
- Technology mostly in development stage
- Environmental factors needs to be taken care of.

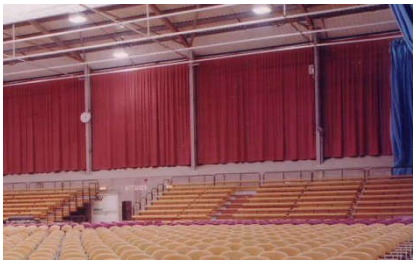
•**Hempcrete**:- Hempcrete is a bio-composite material, hence it is made of the inner woody core of the hemp plant mixed with a lime-based binder. The hemp core has a high silica content which allows it to bind well with lime. It is not used as a structural element, it is only used as an insulating infill between the frame members though it does tend to reduce racking and All loads are carried by internal framing. Wood stud framing is most the common method, making it suitable for low-rise construction. And also Hempcrete buildings ten stories high have been built in Europe.

At the stage of construction, The material is mixed in mortar mixers for 1-2 minutes and stuffed by hand into the wall cavities. The wall is slip-formed with temporary plastic or wooden “shuttering” forming the inner/outer surface forms. Construction costs may be reduced by Shallower foundations30-40% less lumber, labor in framing Lower transport costs of materials to site Reduced mechanical (HVAC) requirements.

- Hempcrete breathes well, and care must be taken to maintain it.
- In this material, only lime-based paints can be used, hence they are more expensive and more difficult than the modern latex acrylic paints.
- In this, Thermal Mass Insulation also Durable and Recyclable.
- Negative Carbon and High Thermal Resistance
- Design Flexibility (adjustable thickness) and Fire and Pest Resistant (NO Termites)
- Significantly Reduce Co2 Emissions also Inherently Airtight
- No Waste (re-build or fertilize) and zero landfills.

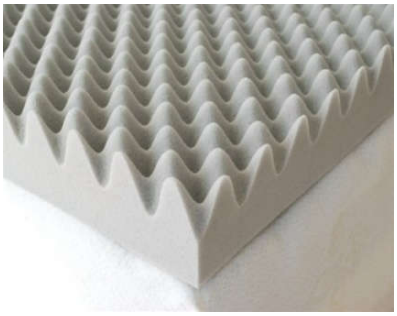
•**Carpeting :-**Carpeting is popular for soundproofing. It is available in different colors and it is cheap. Usually the rougher the surface the more sound waves it will absorb. Carpet is heavy so 24" squares are applied instead of a very heavy piece of carpet. complimenting colors are attach to the wall with tiny nails or large pins Applying carpet with glue will be expensive to repair.

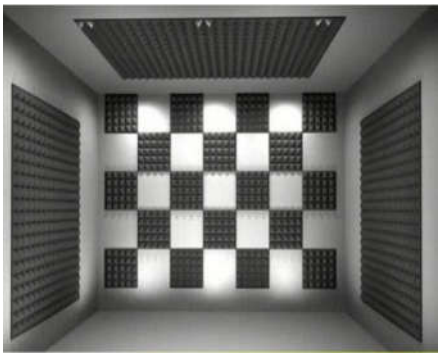
•**Heavy fabric, Drapes, and Blanket:-**Heavy drapes can also be added to windows to minimize noise going out and coming it. Considering adding a drape on a curtain rod over doors to add additional soundproofing to doors and closet area. blanket can also be used but will provide theas much lesser amount of sound dampening. Use of washer is necessary at the nail heads to prevent the material from tearing over the nailand Applyduct tape to the back of the material to reinforce it.



•**Boards with mineral wool backing layer :-** Walls can also be lined with boards which employ a beaten or compressed mineral wool backing layer. These are best used within 8mm render or parge coat when combined with a blockwork wall and vary in thickness (usually between 32-50mm). This type of treatment performs well when installed on the residential side of a separating wall to a common area (stairwell, hallway, corridor).

•**Egg crate pads**:- They offer a wavy sine wave looking surface. Egg crate mattress pads are available at any discount store or store that sells bedding. Like carpet, it can be heavy and difficult to keep from falling down. It may be best to cut it into manageable pieces before you apply in sections to the wall.





Conclusion

Noise control is the most important issue of sustainable building design since it effects the human well- being direct. On the other hand controlling the noise level within the acceptable limits is one of the major criteria for a sustainable environment. For this reason, the importance of acoustic comfort in terms of sustainability must in emphasized and Acoustical sustainable materials, show good sound absorbing performances; cork or recycled rubber layers can be very operative for impact sound insulation. These materials also demonstrate good thermal insulation properties, are often light-weight and also they are not harmful to human health. Many of these materials are currently accessible in the market at absolutely competitive prices. There is, however, a need to complete their characterization, a theoretical point of view. For impact sound insulation, sustainable materials are correctly designed and used are generally as good as other traditional products. These "sustainable" materials can also be used in room acoustics, even if their absorption coefficient is generally lower than mineral wool. Slow cost acoustical materials can be cheap and easy to maintain, such materials should be used in greater scale as to overcome money factor. These should come in come use in large scale.

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