Sustainable Echo Absorption Material with Recycled Plastic

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Abstract

The echo absorption system is the reduction of echo and noise reverberation within a room and in doing so helps to reduce the volume of noise, whilst increasing the clarity. Firstly, sound absorption material is particularly important for large enclosed spaces such as classrooms, cinemas, and exhibition halls. These huge and spacious rooms are subjected to echo sounds, even a drop of a pen can make a huge sound in these rooms; so, an acoustic material is introduced to reduce such echo. Secondly, sea life is affected by plastic on a huge scale. Billions of tons of plastic have been used on earth which is affecting everything on earth like: humans, plants, trees, animals, sea life. To overcome such issues, we as human beings must do some efforts to reduce the waste of plastic. Every item comes in plastic bags e.g., disposal cups, grocery polyethylene's, plastic bottles, etc. In this century every engineer would like to introduce sustainable material to clients/investors to make a safe and healthy living environment. Using plastic as a construction material is relatively new. The main objective of the paper is to take the first step and reduce the plastic from the earth by recycling & reusing plastic to reduce pollution. By using this acoustic material, we can reach to ideal sound absorption level. This paper describes a sustainable material that has acoustic properties. This material is made of perforated wood panels, fabric, and recycled plastic. An airborne test is conducted to find the noise reduction coefficient (NRC). The target is to have absorption CLASS A standard, the very highest rating in sound absorption. The acoustic testing data are presented for different thicknesses of these layers which will be fixed above block walls.

Keywords

Sustainable material, Recycle Plastic waste, and Noise Reduction Coefficient.

1. Introduction

Engineering is a tag that comes with many responsibilities not only aesthetic, design, and function both must be also considered. In this century every engineer would like to introduce sustainable material to clients/investors to make the environment safe & healthy greenhouse. So, in this project, waste plastic & old clothes are used as both can be easily found in homes, markets, restaurants, malls, etc. Using plastic as a construction material is relatively new. The aim of this paper is to make echo absorption classrooms in Universities by using perforated wooden panels, fabric panels which will be fixed on the block walls. University is a place which should be silent/peaceful to study well, focused and concentrated, especially in library halls. The main objective of the paper is to take the first step and reduce the plastic from the earth by recycling & reusing plastic to reduce pollution. Due to the increase in population, the government or private sector are making bigger scale colleges, the more the campus, the classroom sizes will also be bigger to fit more students. Bigger classrooms are subject to Echo sounds, even a drop of a pen can make a huge sound in classrooms. So, an echo absorption material is introduced in this paper. This material is aesthetically pleasing with technically proven, this is what in demand nowadays. This sustainable material will have a significant contribution to Civil Engineering.

1.1 Objectives
The main objectives of this paper are
1. To make echo absorption classrooms using a sustainable material
2. To reduce the plastic from the earth by recycling & reusing plastic to reduce pollution.

2. Literature Review
Figure 1 explains the sound behaviors that should be taken into account when undertaking the acoustic conditioning of a space. Different researchers have worked on echo absorption materials like rubber [1,2] and natural fiber [8,11]. The sound absorption coefficient [3-7,12,13] is studied and the application of sound level meter [14,15] is evaluated. Billions of tons of plastic have been used on earth which is affecting everything on earth like: humans, plants, trees, animals, sea life. To overcome such issues, we as human beings must do some efforts to reduce the waste of plastic. Every item comes in plastic bags e.g., disposal cups, grocery polyethylene's, plastic bottles, etc. In this century every engineer would like to introduce sustainable material to clients/investors to make a safe and healthy living environment. In this paper, the echo absorption material introduced is made of recycled plastic which makes it sustainable.

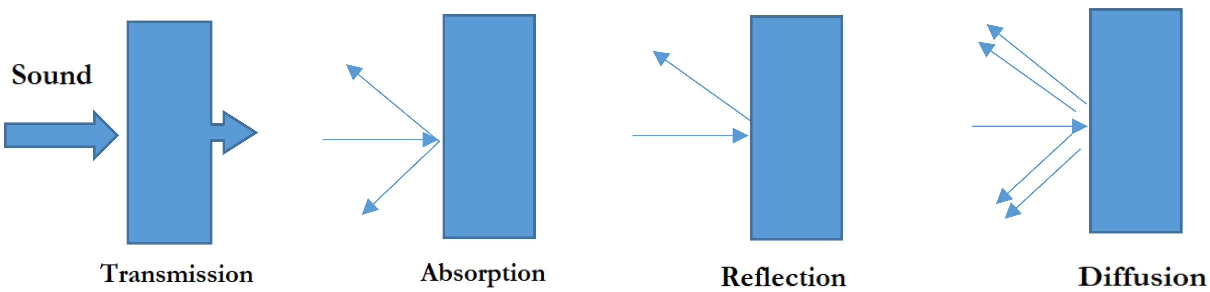
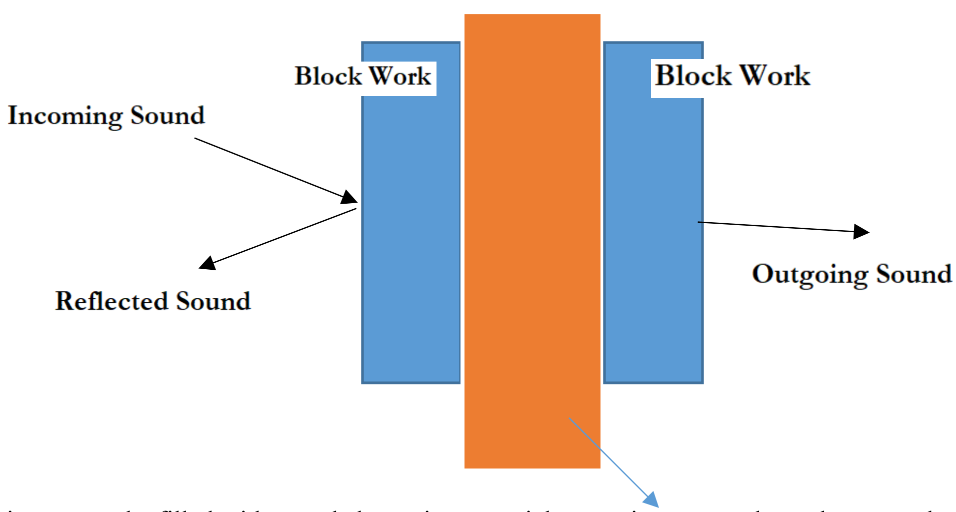


Figure 1: Sound behaviors



This area can be filled with sound absorption material or an air gap can also reduce sound entry to a room but inside the room, there will no absorption only outside sound will be less inside [5-15].

Figure 2: Soundproof system

3. Methods
Table 1 shows the acoustic testing data with noise reduction coefficient (NRC) for different thicknesses. Our target is to achieve a 50mm thick system which will have absorption CLASS A (Standard), the very highest rating in sound

absorption. Figure 3 shows the sample used for the experimental study and its section details can be found in Figure 4.

Table 1. Performance/Sound Absorption											
Frequency Hz	63	125	250	500	1000	2000	4000	8000	NRC	Alpha w	Class
25mm Thickness	0.15	0.23	0.63	0.93	0.90	0.98	1.04	1.13	0.85	0.90	A
50mm Thickness	0.28	0.39	1.04	1.09	1.09	1.13	1.16	1.17	1.10	1.00	A

The test is conducted to check the echo absorption for three different thicknesses. The following material/tools are used to perform the test:

1. Loud Speaker's quantities of the speaker depending on room size.
2. Sound level meter
3. Mike
4. Headset (Defender)
5. Sound Level meter

Figure 3: A sample of echo absorption material made for the experimental study

The test is conducted in 2 rooms Source Room and Receiving Room. The Airborne Test Procedure is as follows:

1. Turn on the speaker in the source room to make a lot of noise.
2. Then start taking measurements of sound by the sound level meter in different areas in the same room.
3. Turn on the speaker and with the help of mike, the measurements are taken while moving in the room. This method of taking measurements is called as Continuous sweep method.
4. Receiving room is right next to the source room, then take the same measurements in the receiving room.
5. The next step is to move the loudspeaker to different locations, repeat the above steps to take a different measurement.
6. To measure reverberation, the loudspeaker is shifted into the receiving room.
7. The next step is to fire a short burst of pink noise through the loudspeaker then the graph will occur which will show how much time it makes the sound die away.

Things to be considered while performing the test:

1. The test room should be empty/unfurnished.
2. Doors & windows should be fixed properly.

3. Tiles/carpets whatever is the flooring type should be fixed on the floor.
4. The ceiling should be taken into its place.
5. The full system can be run only if the workmanship is done properly.

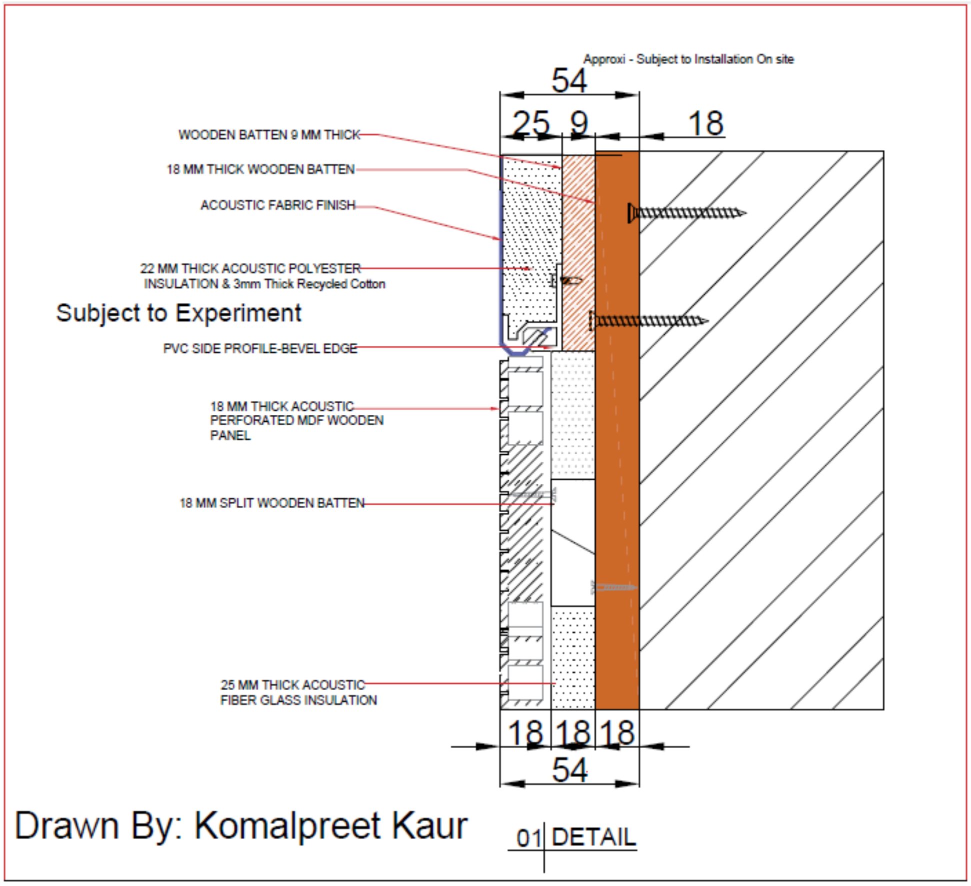


Figure 4: Section drawing of echo absorption material made for the experimental study

4. Results and Discussion:

4.1. Experiment-01

The first test shown in Table 2 was conducted in a room where sound frequency starts coming down from 0.6Hz & reaches to 0.00Hz. In this test, we have used 22mm thick Rockwool & 3mm recycled cotton & plastic layer so the total thickness for sound absorption material will be 54mm as per the following breakdown:

a. Below the Fabric Panel: 52 – 53mm

- 18mm thick wooden batten – to get a smooth finish to proceed with other works.
- 9mm thick wooden batten – to tuck in the Rockwool.
- 22mm thick acoustic polyester insulation (Rockwool).
- 3mm recycled cotton & plastic layer.

b. Below the Wooden Panel: Overall level for the wall will be 52 – 54mm

- 18mm thick wooden batten – to get a smooth finish to proceed with other works.
- 18mm thick wooden batten only on sides – to tuck in the Rockwool.
- 22mm thick acoustic polyester insulation (Rockwool) to be filled inside the battens.
- 3mm recycled cotton & plastic layer.

Table 2: Experimental 01 Results with 22mm thick Rockwool

S.No	Absorption	Frequency
1	85	0.6
2	81	0.59
3	75	0.56
4	78	0.53
5	78.5	0.5
6	79.5	0.49
7	78	0.48
8	78.3	0.47
9	77.9	0.45
10	75	0.456
11	74	0.3
12	83	0.25
13	80	0.2
14	75	0.18
15	70	0.15
16	60	0.12
17	50	0.1
18	40	0.08
19	20	0

Table 3: Experimental 02 Results with 19mm thick Rockwool

S.No	Absorption	Frequency
1	82	0.4
2	77	0.56
3	72	0.22
4	73	0.23
5	75.5	0.41
6	75.6	0.42
7	74	0.18
8	74.8	0.42
9	72.9	0.4
10	75	0.386
11	69.5	0.25
12	77.5	0.23
13	76	0.19
14	75	0.13
15	66	0.13
16	56.8	0.09
17	47.2	0.098
18	35.9	0.06
19	14.4	0

4.1.Experiment-02

Once a test shown in Table 3 was conducted in a room sound frequency starts coming down from 0.8Hz & reaches to 0.00Hz. In this test, we have used 19mm thick Rockwool & 3mm recycled cotton & plastic layer so the total thickness for sound absorption material will be 52mm as per the following breakdown:

a. Below the Wooden Panel: Overall level for the wall will 50 – 52mm
- 18mm thick wooden batten – to get a smooth finish to proceed with other works.
- 9mm thick wooden batten only on sides – to tuck in the Rockwool.
- 19mm thick acoustic polyester insulation (Rockwool) to be filled inside the battens.
- 3mm recycled cotton & plastic layer.

b. Below the Fabric Panel: 49 – 52mm
- 18mm thick wooden batten – to get a smooth finish to proceed with other works.
- 9mm thick wooden batten – to tuck in the Rockwool.
- 19mm thick acoustic polyester insulation (Rockwool).
- 3mm recycled cotton & plastic layer.

Table 4: Experimental 03 Results with 16mm thick Rockwool

S.No	Absorption	Frequency
1	78.5	0.83
2	73	0.65
3	68.5	0.93
4	69.5	0.86
5	72	0.62
6	72.1	0.59
7	70.5	0.81
8	71.3	0.55
9	69.4	0.53
10	69.5	0.556
11	66.5	0.38
12	68.5	0.3
13	68	0.24
14	67	0.26
15	61	0.2
16	56.8	0.18
17	50	0.132
18	40.9	0.13
19	25	0.12

4.2. **Experiment-03**
In this test shown in Table 4, we have used 16mm thick Rockwool & 3mm recycled cotton & plastic layer so the total thickness for sound absorption material will be 54mm as per the following breakdown:

a. Below the Fabric Panel: 48 – 50mm
- 18mm thick wooden batten – to get a smooth finish to proceed with other works.
- 9mm thick wooden batten – to tuck in the Rockwool.
- 16mm thick acoustic polyester insulation (Rockwool).
- 3mm recycled cotton & plastic layer.

b. Below the Wooden Panel: Overall level for the wall will 49 – 51mm
- 18mm thick wooden batten – to get a smooth finish to proceed with other works.
- 18mm thick wooden batten only on sides – to tuck in the Rockwool.
- 16mm thick acoustic polyester insulation (Rockwool) to be filled inside the battens.
- 3mm recycled cotton & plastic layer.

Final Thickness subject to site execution above mentioned are Approximate.

4.3. Discussion

Table 5 describes different types of layers present in the sample shown in Figure 3. The above experiments are conducted for three different thicknesses of 19mm, 22mm, and 25mm of Rook wool and Recycled plastic & cotton. The graph in Figure 4 shows three of the tests conducted with different thicknesses for the material. Test was conducted for 15-20 mins until the sound level reach 0.00Hz. The more thickness of material can absorb more sound comparing to less thickness of acoustic & waste material. In first and second experiment with 22mm and 25 mm have reached frequency zero while the 19mm thick shows 0.12Hz; this shows the sound was not completely absorbed in the third experiment.

Table 5: Different Layers in the sample used for experimental study

Type	Perforated wooden Acoustic panels + Fabric Panels
Structure	Base Materials/Finishing/Back Acoustic Fleece
Base	Standard no added formaldehyde Eco-Friendly
Finishes	Melamine/Laminate/Veneer/Paint
Thickness	25mm/22mm/19mm

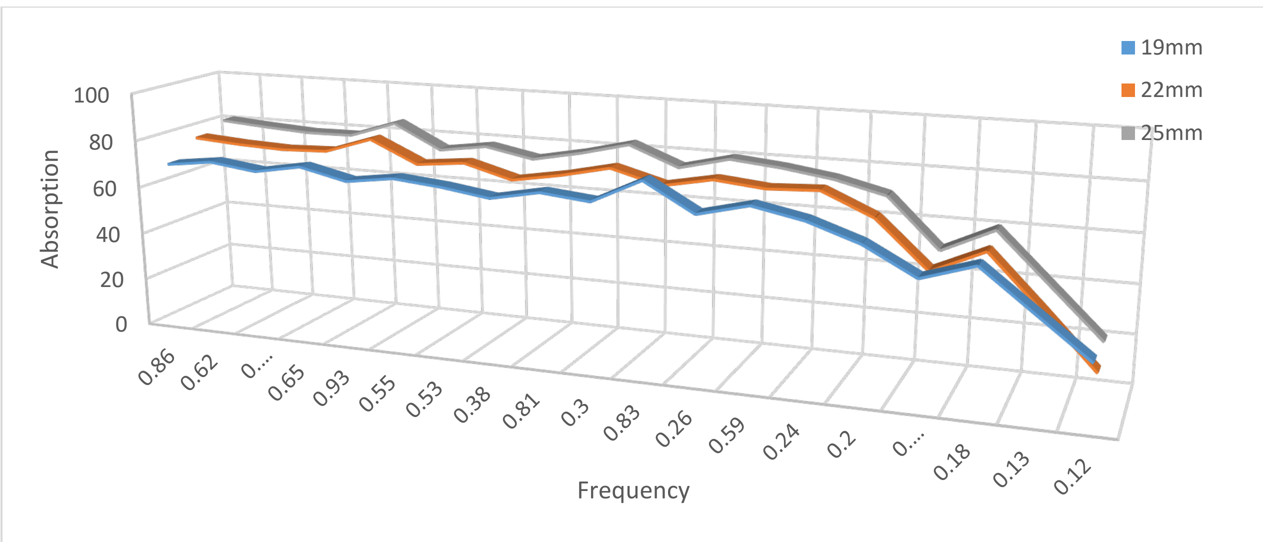


Figure 4: Comparison of sound absorption for different thicknesses of echo absorption material

To improve the absorption in less time more thickness can be added but adding thickness means the wall thickness will be more than 55mm. It is recommended to use 22mm thick panels with 19mm thick Rockwool & 3mm recycled cotton & plastic because the cost will be less as compared to 25mm thick but results will remain the same only time what makes difference as the sound we play in the room is more than regular voice so in future sound frequency will be low in less time.

5. Conclusion

When designing a classroom, special attention is given to architectural acoustics to control noise and create a calmer, more peaceful environment for the students. Understanding sound isolation, mechanical noise and vibration control, and room acoustics is an essential component of designing any student housing facility. The above characteristics can be achieved with waste plastic & old clothes which helps to reduce the plastic waste from the earth. So, we have two benefits. Firstly, Echo Absorption system will be done and secondly, plastic can be reduced from earth & help to reduce global warming. This material can be used in many places like hotels, meeting rooms, hospitals, sports halls, music halls, museums, etc. The experiments are conducted for three different thicknesses of 19mm, 25mm, and 22mm of Rook wool & recycled Plastic & cotton. It is recommended to use 22mm thick panels with 19mm thick Rockwool & 3mm recycled cotton & plastic considering the cost and sound absorption.

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Biographies:

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