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To Investigate Which Is The Best Recyclable Material To Insulate Noise

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Abstract

Our experiment is to investigate which recyclable material is able to block out sound waves the most efficiently to help create the best conducive environment for students to learn in. We decided to use different recyclable materials as our sound absorbing materials. We played a sample listening comprehension passage and recorded down how much sound was absorbed using a sound level meter. We found out that plywood is the most effective material in absorbing sound as it gave the greatest difference in sound level compared to the control set-up.

Introduction

The sounds emitted by other classrooms, the school canteen or by students along the corridors can be disruptive to students' learning and concentration during class. This can hinder students' ability to understand what the teacher is teaching which can affect their academic results. For example, as classes have different tests on different days, while one class is sitting for a test, the class beside them might unintentionally distract them from their paper by playing a video or when a teacher is using a microphone to teach the class, which results in excess loud noise. Another situation is whereby during listening comprehension examinations, both classes may not play the recording at the same time. Thus, the students in these classes might find it difficult to concentrate on their own test paper. When they get distracted, they would end up confusing the two recordings and miss out on important information. Another problem is the Listening Comprehension examination during GCE O-Levels. During the examination, a radio is used to amplify the reading of the text in the GCE O-Levels Listening Comprehension examination. However, sometimes the noise outside of the hall might be very distracting, causing the students taking the examination to be distracted. In order to block out the sound from the outside, usually sound insulators such as acoustic tiles and mass loaded vinyls are used. Hence, we chose to find out which affordable recyclable material is able to block out noise effectively. We predict that the material styrofoam would be able to absorb sound the most. Although styrofoam was not one of the heaviest material out of all six of the materials tested, we would like to assume that styrofoam possesses a fair amount of density required to absorb sound. We observed that the small balls of polystyrene in styrofoam packed tightly together would ensure the increased rate of sound absorption. Thus, due to styrofoam physical structure and appearance, we would like to assume that styrofoam is the best recyclable material to insulate noise.

Theoretical Background

Sound is produced by vibrating sources. Sound absorption is sound energy that is absorbed by 'acoustically soft' materials that sound waves encounter, as opposed to being reflected by 'acoustically hard' materials. (Acoustic value refers to the rating of how well a material is able to absorb sound). Sound is bounced (reflected) off a surface and it usually occurs on flat, rigid surfaces with a lot of mass like concrete or brick walls. Thus, we are trying to investigate which kind of material absorbs sound the best because this way, the student would not get affected by the noise outside and would not hear echoes resonating back into their ears and thus distracting them from their paper. This is because if we use materials that reflect sound, it will result in an echo. Echoes may distract the students even further, hence it would be better if we choose a material that is able to absorb sound rather than reflect it. Secondly, sound waves can also be diffused. For example, when a sound wave hits an irregular surface like foam or carpet, the vibration breaks up and travels along many much smaller paths. This divides the energy of the wave, sending it in many different directions which depletes its energy faster. Lastly, sound waves can also be absorbed by the material. When a sound wave hits a particular surface, the sound energy would be diverted into smaller amounts, which lose its energy faster. Airflow, cell size and density, are the three main factors influencing the effectiveness of sound absorption in acoustic foams. An increase in the number of cells of the foam improves the sound absorption at all frequencies. This kind of insulation is normally provided by materials like foam and rubber. However, how well a material absorbs sound waves is due to its density and the mass it possesses. The denser and heavier the material is, the better it is at sound absorbing.

There are three main categories of sound absorbers: Porous absorbents, Resonance absorbents and Single absorbers. The brief explanations for the three categories are as follows. When sound wave penetrates a material, through friction, the sound energy is converted into thermal energy in porous absorbents. Resonance absorbers consist of a mechanical or acoustical oscillation system. One case of this is membrane absorbers. At the resonance frequency, absorption reaches its maximum. The sound absorption over the frequency range is broadened if the cavity is filled with a porous material. Single absorbers are objects like chairs, tables and even people.

Apparatus needed

1. Sound level meter
2. Styrofoam box
3. Clear acrylic slab (a transparent cover to make recording on meter visible)
4. Materials to test (newspaper, cardboard, egg carton, bubble wrap, plywood and styrofoam)

Procedure

1. Place the sound level meter on one side of the styrofoam box.
2. Place the egg carton 12 cm away from the tip of the sound level meter.
3. Place the speaker on the other side of the egg carton lying horizontally, whereby the speaker faces the material.
4. Cover the styrofoam box with a clear piece of acrylic slab, which is of the same dimensions as the styrofoam box.
5. Play the video, "ESL Listening Comprehension" on YouTube. When the word "read" is read aloud by the narrator, record down the reading of the sound level meter.
6. Halt the recording and repeat step 5 two more times.
7. Repeat steps 1-6 with the other materials of the same thickness: bubble wrap, cardboard, plywood, newspaper and styrofoam.
8. After completing all the steps, take the average of all the readings for each material and input them into the table.
9. Calculate percentage difference between control result and end results of each material for easier comparison.

Materials Used

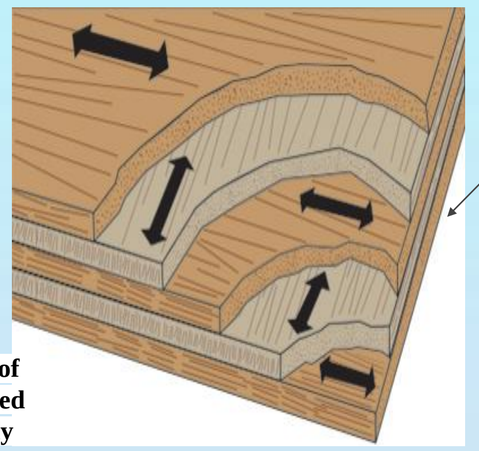
Results and Discussion

	Average reading on Sound Level Meter when recording is played (dB) (without recyclable material)	Average reading on Sound Level Meter when recording is played (dB) (with recyclable material)	Percentage difference (%)
Control	84.0	84.0	NA
Plywood	84.0	71.4	-15.0
Cardboard	84.0	73.1	-13.0
Styrofoam	84.0	73.3	-12.7
Bubble Wrap	84.0	74.1	-11.8
Newspaper	84.0	75.5	-10.1
Egg Carton	84.0	75.8	-9.76

Reason for results (PLYWOOD)

Wood is a natural insulator due to air pockets within its cellular structure. Plywood provides a fair amount of mass as well, thus contributing to its good sound absorbing performance. Wood is suitable for absorbing medium frequency sounds and is commonly used in auditoriums and opera halls so there are no reverberations. Since medium frequency sounds are used in the GCE O-Level Listening Comprehension Examinations, wood would be one of the best materials to insulate noise. The alternate stacking of the layers of wood is effective in preventing the sound waves from passing through.

Structure of plywood



Two different types of layers of wood stacked together alternatively

Reason for results (CARDBOARD)

Cardboard is made of multiple corrugated and flat layers. There is air trapped between the layers and since air is a poor conductor of sound, the amount of sound that passes through cardboard is very little. However, a criteria for a good sound insulator is that a material must possess a fair amount of mass to be able to soundproof effectively, and cardboard has a relatively small mass. Thus, cardboard did not turn out to be the best material to insulate noise.

Reason for results (STYROFOAM)

Styrofoam is made up of closed-cell extruded polystyrene. It is a commonly mistaken belief that polystyrene is good soundproofing material. Instead, polystyrene has very little or no acoustic value (Acoustic value refers to the rating of how well a material is able to absorb sound) due to the little amount of mass it possesses, and the absorbing properties of sound includes the material's density and mass.

Reason for results (BUBBLE WRAP)

The structure of the bubble wrap is such that it is entwined and thus has little pockets of air in between. Air, in a confined space, is a good insulator of sound. However, bubble wrap lacks the required amount of mass and density for it to be considered one of the better insulators of sound. Bubble wrap is also made of plastic which is very lightweight. Hence, bubble wrap is concluded as a poor insulator of sound.

Reasons for results (NEWSPAPER)

Newspaper is made from paper, which is a fairly good conductor of sound. However, newspaper itself lacks mass, which is one of the main factors of sound absorption. The heavier the mass, the better the rate of sound absorption. Thus, from our results, newspaper was not one of the best results from our experiment.

Reasons for results (EGG CARTON)

The low rate of sound absorption by the egg carton was because egg cartons are usually manufactured from recycled paper, like old newspapers, old books and additives such as pigments and glue, which are not suitable materials for absorbing sound. Egg crates, whether they are foam or cardboard, are made of an incredibly porous material and should be good at absorbing sound. However, this porous material might not be an effective absorber for the range of frequencies of the sound produced. Thus, egg carton proved to have the lowest percentage difference out of all materials.

Conclusion

From the results of our experiment, plywood has proved to have the highest percentage difference of -15% of sound absorbed. This is due to plywood possessing the most mass out of all tested materials. Thus, from this experiment we learnt that the material's density and its mass determines the effectiveness of absorbing sound, and that plywood has the best qualities of all recyclable materials in our experiment.

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