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Possibilities of Using Acoustic Materials in Open Plan Offices in Green Buildings

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Abstract
One of the most important reasons for the increase in climate change in our world is buildings built based on old methods. In order to reduce the damages caused by the buildings to the environment, sustainable energy use, efficient use of resources, effective and long-term use of rainwater and natural light should be targeted. It is important for the materials used in green buildings to be recyclable in terms of reducing waste generation and supporting sustainable living. Technology, population growth, urbanization and the resulting work environments have also changed. The vast majority of work environments are designed as open offices due to the need for more employees and shared work areas other than closed offices. Open offices offer employees a more flexible work environment. Apart from the advantages of open offices, there are also disadvantages. The interventions to be made to solve the most important problem of noise have come to the fore. In open offices where noise is at a high level, it is aimed to reduce noise with decorative sound-absorbing acoustic materials covered on the wall partitions. In order to achieve this; ambient noise is reduced with acoustic materials used on the walls, ceiling and reinforcement elements. As a result, the prominent criteria and acoustic materials in the selection of acoustic partitions, acoustic ceilings and reinforcement elements in a green office were examined.

Keywords
Acoustic Materials. Green Buildings. Partitions. Ceilings. Green Office.

1. Introduction

With all the changing conditions, the workload has been transferred to technology. Developing technology, rapid urbanization, population growth, industrial development, the world changing every day have also caused the working environments to be affected in these cases. New structures have been built to meet the needs with the innovations that have occurred. However, today, some of the working environments are designed as open office designs that will appeal to more employees, unlike closed offices.

Open-plan office types provide employees with a common working area. The purpose of this office type is to offer work areas that are more flexible against institutional changes. While communication and interaction between employees in open offices are tighter, the flow of information and communication between teams is faster and easier.

In addition to the advantages provided by open offices, there are also disadvantages brought by this type of working environment. One of the most important negatives is the formation of noise. The importance of using acoustic material elements to prevent noise emerges at this point. In spaces where noise is intense, the effect of noise is reduced by using dividing acoustic panels instead of walls. In order to achieve this, various factors need to be taken into consideration; sound absorbers in ceilings, walls and furniture, high screens and storage units, distance between workstations, enclosure of workstations and use of artificial masking (Gümüşçü & Demirarslan, 2019:197-209).

Based on literature, in interior spaces where noise is high, ambient noise is reduced with decorative sound absorbing acoustic panels covered on wall partitions. Acoustic panels designed in accordance with the structure of your space are covered with hard surface finish areas that cause high reflection of sounds, and damping is provided.

2. The aim of the study

The purpose of this study is that instead of buildings that harm nature and living beings less due to climate change, green buildings that do not harm nature have begun to be built. It is aimed to move workplaces to these buildings by building green buildings that are sensitive to this system. This study is aimed at examining the effects of acoustic materials used in open offices in green buildings on noise and how the material approach should be. It is aimed to create an efficient source about open office and acoustic materials by evaluating how the material used should be and with these materials.

3. Method

For the study, firstly, the examination of studies conducted on this subject and scanning of written and internet sources is the method chosen for this study. In the second stage of the research, the material usage of the open office selected in the metropolitan city of Istanbul will be examined with visual data, the materials will be evaluated in terms of acoustics and will be illustrated. An evaluation was made with the data obtained as a result of this study. The use of the examined materials in offices and the positive aspects they provide to acoustic comfort were discussed. The use of open offices and the office approach in green buildings were examined and the sustainable materials used were examined. The method to be used in the research will be examined from the internet data of master's and doctoral theses, articles, library resources on the subject and also the materials used on the previously used offices. The acoustic materials used in open offices in green buildings will be supported with visuals and scientific data and the types of noise they prevent will be explained based on the literature.

4. Open Plan Office

Open office types are office types planned on a common work area. There are no walls or other dividing elements between employees, planning is created with reinforcement elements. Employees do not have individual access to windows. The purpose of these office types is to be flexible against institutional changes and to ensure that employees work together more motivated. It can be done by using reinforcement elements, panels and acoustic materials to reduce noise and some privacy. Open-plan offices have different types depending on the number of people sharing the work area.

The minimum net size of the work area is at least 2.8m², 3.5m² for general units and 6.5m² for senior personnel. For a work area with suitable circulation, an area varying between 6m² and 9m² should be allocated to a staff member. While there is 12m² of area per staff member in traditional plan type offices, this ratio is halved in open plan type offices. The work areas that need to be allocated for group areas vary depending on the number of people working in this space, the subjects they will work on and their grouping. The most important positive aspect of open offices is the modular partitions. The modular units that form the forms and character of the plan are separated by designing standardized panels or panels with a height of 140cm to 200cm from each other. However, these panels are designed not only as dividing elements in some office buildings but also to meet the storage needs, thus providing ease of use and increasing space saving (Erol & Çakır Kıasıf, 2021:324).

Acoustic Material

Noise control is an important problem that has emerged as a result of technological developments. Petroleum-based materials are widely used to solve this problem. However, it has become clear that the material obtained should not harm human life and that new materials should be found and developed. At this point, natural fibers offer many advantages when evaluated in terms of sound insulation. Natural fibers stand out with their renewable, cheap, local, abundant and environmentally friendly features. As a material, the properties of main materials rich in fibers such as pumpkin, tea leaf, sheep

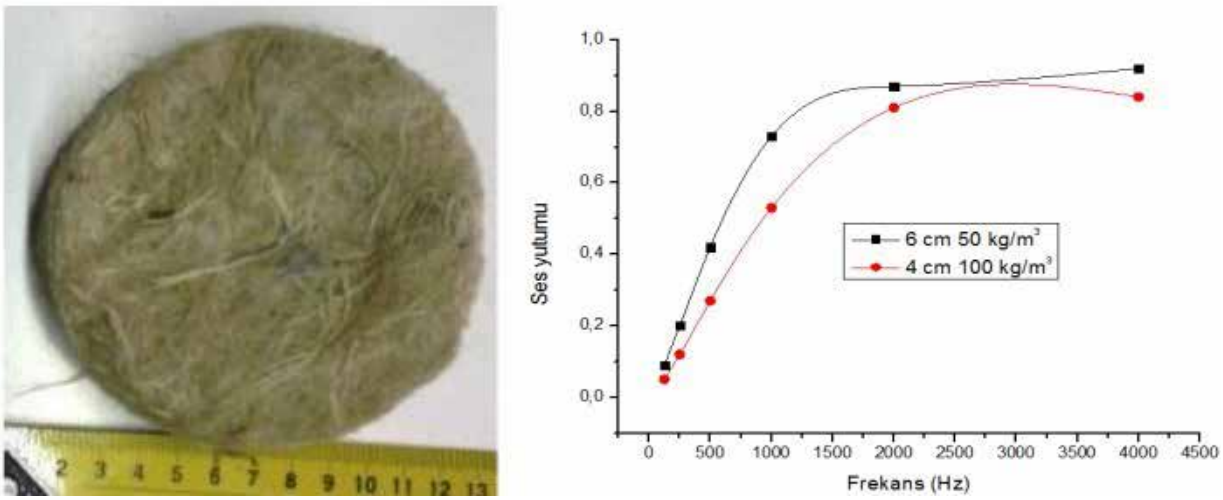

Figure 1. Sound absorption value of kenaf fiber (Berardi & Lannace, 2015; Kaya & Dalgar, 2017:32)

wool, kenaf, palm tree, hemp have been mentioned. In addition, the focus has been on acoustic resistance at frequencies from 125 Hz to 4000 Hz. The results obtained have shown that natural fibers are within acceptable limits in the specified frequency ranges and that their acoustic properties increase to a certain extent as the physical properties of the fibers increase. Noise control and sound insulation issues play an important role in areas such as landscaping, structural design, architecture and acoustic engineering. Therefore, researching and evaluating the acoustic properties of natural fibers offers great potential for adopting an environmentally friendly and sustainable approach.

Acoustic fabrics obtained from natural resources are materials that cause excessive noise in closed environments, conference halls, hospitals, sports areas and entertainment areas due to their resistance to impacts. They are also used in cars, passenger compartments and to minimize the noise generated by the engine noise in vehicles. For this reason, in order to reduce the sources of sound, door materials, floor coverings, partition panels and acoustic material application of these panels and ceiling application should be made. It is seen that materials such as sponge fabric are also produced for sound absorption purposes.

Kenaf

Kenaf fiber is a plant that grows in hot climates and is especially common in South Africa, Asia and India (Kaya & Dalgar, 2017:32). It is used in various areas due to its fibrous structure, it is used both in pure form and in composite materials.

Kenaf fiber has a large market share, especially in areas such as paper production, construction materials and animal feed. The sound absorption feature of kenaf fiber was examined in a study (Berardi & Lannace, 2015; Kaya & Dalgar, 2017:32). With the data obtained, it was observed that the sound was absorbed at a frequency of 1600 Hz-3600 Hz, which is the approximate value of 6 cm wide and 50 kg/m^3 density, 4 cm wide and 100 kg/m^3 density, and 0.91% percent. These results show that kenaf fiber is quite successful in terms of sound absorption.

Wood Fiber

31% of the world is covered with forests. The value of wood is due to its ability to meet various needs. (Kaya & Dalgar,2017:32). It is known that wood is used in acoustics due to its porous structure. The sound absorption value of wood fiber is given in Figure 58. According to the acoustic properties of wood fiber, the sound absorption value increases linearly up to a frequency of 1500 Hz and reaches a value of 0.81. Then,

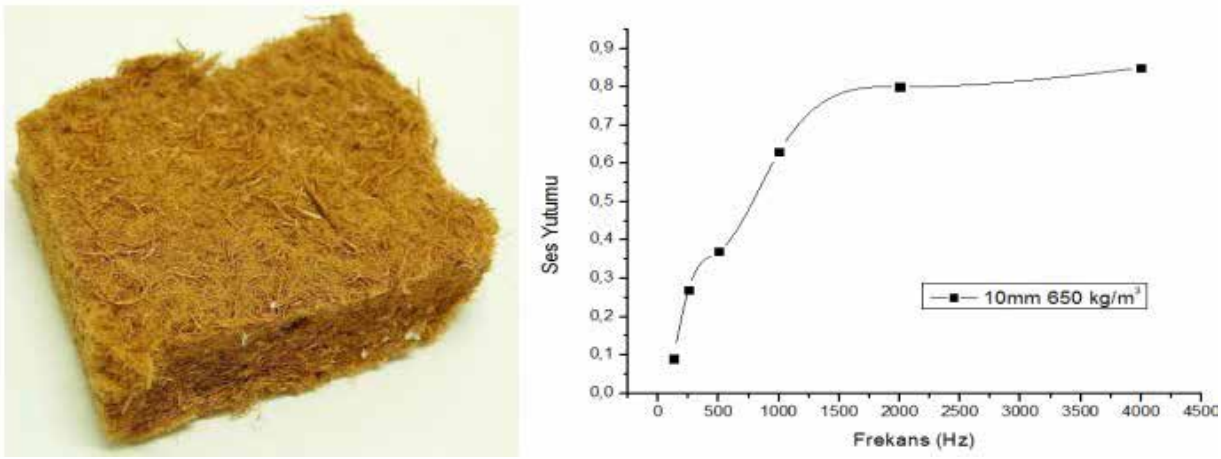

Figure 2. Sound absorption value of wood fiber (Kaya & Dalgar,2017:32)

the value continues approximately in the direction of 0.82 in the frequency range of 2000 to 3800 Hz and reaches 0.84 at 4000 Hz. For this reason, it is seen that wood fiber is used in noise and noise prevention (Kaya & Dalgar, 2017: 32).

Hemp Fiber

Hemp fiber is a type of fiber mostly used in the textile sector. Its combustion resistance is at a low level, which is the general feature of natural fibers, but its combustion insulation feature can be increased by using substances such as boron. It has been determined that panels made of hemp fibers do not contain harmful factors to human health. Hemp fiber has intense sound-absorbing (acoustic) properties and is also a suitable material for heat control in the construction sector (Kaya & Dalgar, 2017:32).

Hemp fiber has a sound absorption feature that increases linearly within the 500 Hz frequency range at a density of 164 kg/m^3. Then, it decreases to 0.62% between 600 Hz and 1000 Hz, as a result of which the most intense sound absorption value of the 2000 Hz frequency is approximately 0.82%. The maximum sound absorption value of this material is approximately 2000 Hz at a density of 126 kg/m^3.

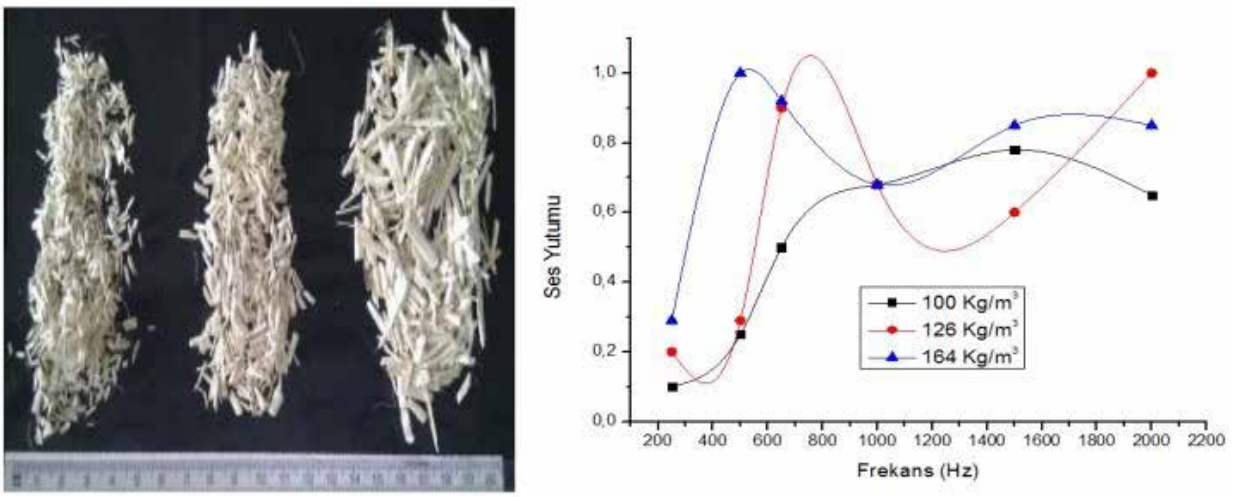

Figure 3. Sound absorption value in hemp fiber (Kinnane, 2016; Kaya & Dalgar,2017:33)

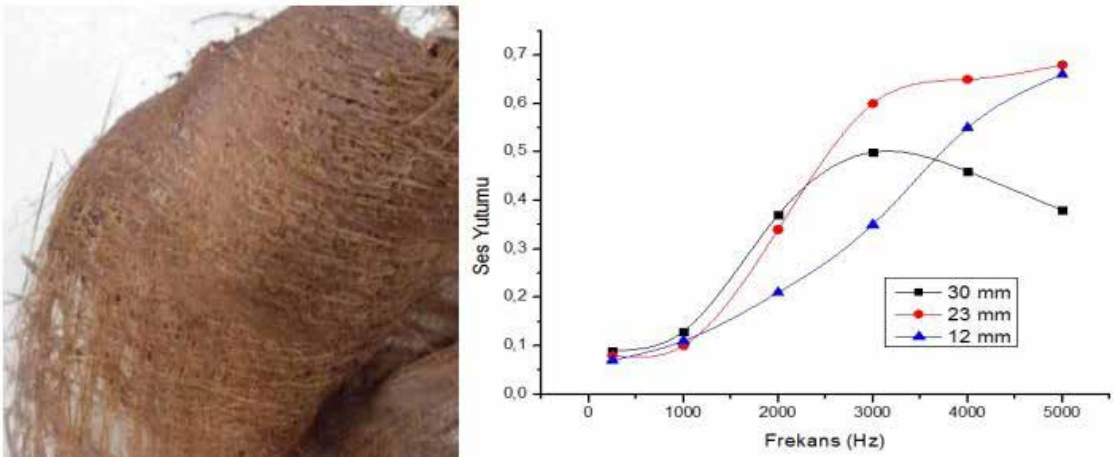

Figure 4. Sound absorption value of palm tree fiber (Elwaleed, 2014; Kaya & Dalgar,2017: 34).

Palm Tree

Date palm (Phoenix dactylifera) is produced and exported worldwide in countries such as Iran, Egypt, Arabia, Iraq, Pakistan and Sudan (Khristova, 2005; Kaya & Dalgar, 2017:34). This fiber has a light texture. Due to its high humidity, it is dehumidified after collection and the fiber has an approximate value of 0.408 mm and a weight of 919 kg/m^3 (Elwaleed, 2014; Kaya & Dalgar,2017:34).

In Figure 4, it is seen that the maximum sound absorption rate drops to 0.50 when the compression value of the fiber between the samples is 30 mm. However, in the 23 mm thick sample, it reaches a sound absorption rate of 0.68% at its highest value at 2800 Hz.

Coconut Fiber

Coconut is a palm fruit that grows in hot climates. The fiber obtained from this nut enables agricultural waste to be used in many areas due to the hard substance found in the outer shell of the fruit. It is taken from the mature coconut fruit and dried. Then, the form obtained by compressing the fibers is used (Berardi & Lannace, 2015; Kaya & Dalgar,2017: 33). The tests conducted show that this fiber has an acoustic feature and that it is a valuable material to use due to the importance of sustainable material in our developing world. This material, which meets new world standards, is more cost-effective, less weight-sensitive and sustainable in nature compared to innovative sound absorption, mineral and fiber materials (Rozli & Zulkarnain, 2010; Kaya and Dalgar,2017:33). While coconut fiber shows insufficient sound absorption properties at 10 mm thickness, it is a successful material, especially at 20 mm thickness, where sound absorption absorption reaches 0.98% after 2500 Hz.

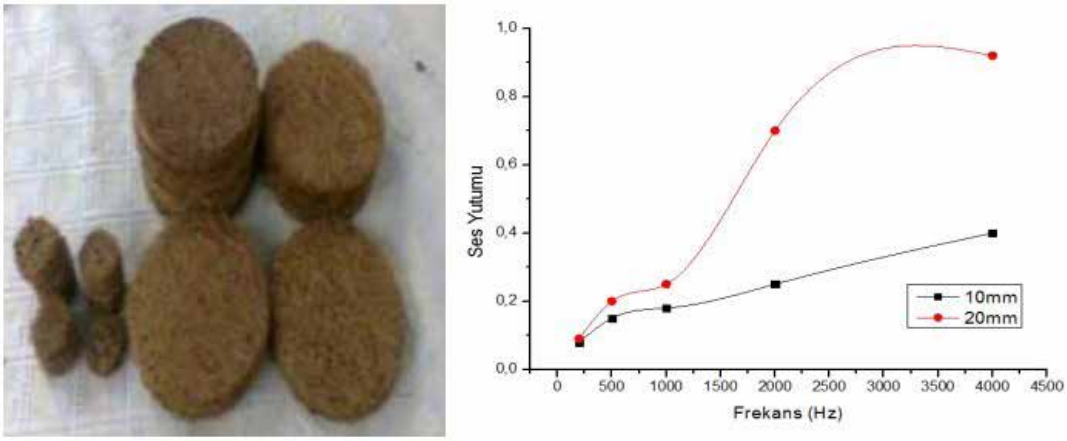

Figure 5. Sound absorption value of coconut fiber (Rozli & Zulkarnain, 2010; Kaya & Dalgar,2017)

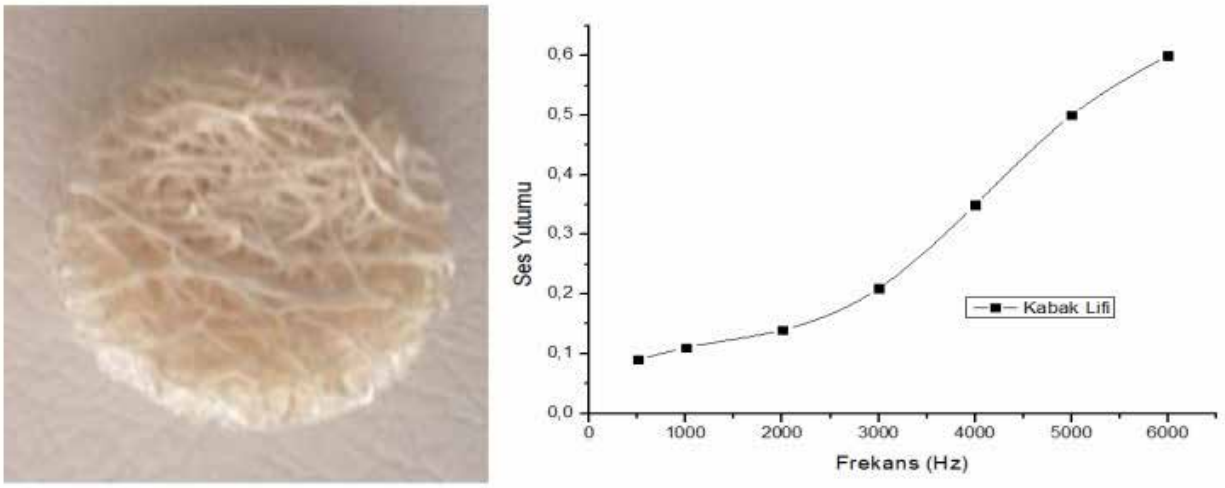

Figure 6. Sound absorption value of pumpkin fiber (Koruk & Genç, 2015; Kaya & Dalgar,2017:35).

Loofah

The fibers obtained from squash grown in different regions of the world consist of sustainable materials and are important materials in terms of acoustics. Studies have shown that squash fibers, when used alone or in combination with different materials, give good results in terms of acoustics (Koruk & Genç, 2015; Kaya & Dalgar,2017:35). As shown in Figure 6, it is important that the squash fiber is sound absorbing and acoustic, where the sound absorption rates follow a linear path between 500 Hz and 6000 Hz.

The fabrics in the fabric structure are examined in two different groups; those used as felt fabrics and the fabric material applied to the surfaces of the suspended ceiling. This fabric applied to these suspended ceiling surfaces is more resistant to fading, burning and abrasion. Figure 7 shows how the fabric applied to suspended ceilings is applied.

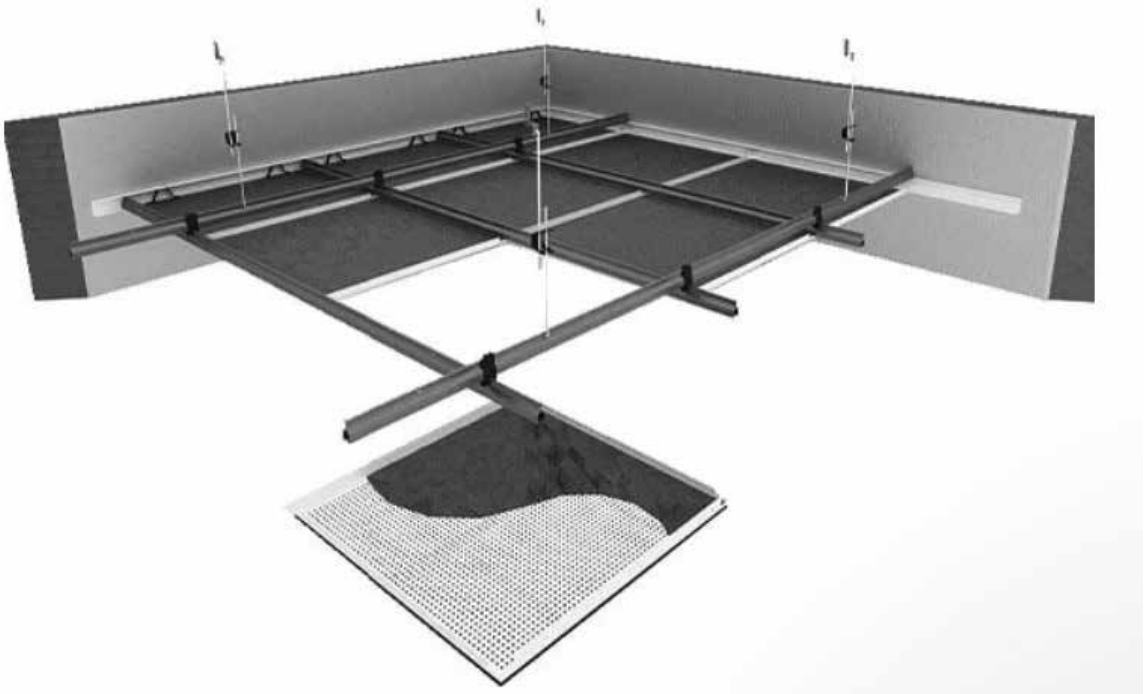

Figure 7. Fabric applied to the back of the panel

Sponge

Sponge materials applied for acoustics are important because they provide good sound absorption. For this reason, there are many different types of sponges, they can be produced in various shapes such as labyrinth, barrier, egg, flat, special bondex and pyramid foam. In addition, the sponge produced by applying different types is resistant to burning. These sponges, which have pores, are used because of their acoustic and insulation properties. When applied with rubber, the sound absorption feature increases (Öz & Köse, 2020:6).

Flat acoustic sponge is a material that reduces intense sounds by approximately 80% and has a complete absorption state of less incoming sounds (Öz & Köse, 2020:7). An example of a flat sponge is given in Figure 8.

Figure 8. Flat Acoustic Sponge

Pyramid sponges are produced in thicknesses of 40, 50 and 70 mm and dimensions of 100 cm x 100 cm. These sponges have the ability to show resistance between -5 ° C and +100 ° C, and their sound absorption capacity varies between 0.30 and 1.12 (Öz & Köse, 2020:7). Pyramid-shaped sponges are designed as shown in Figure 9.

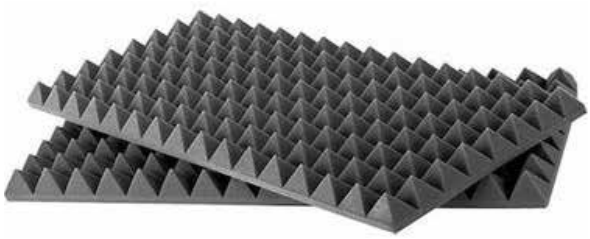

Figure 9. Piramidal Acoustic Sponge

Acoustic sponges produced in the shape of an egg are known to be effective in terms of sound absorption and can be produced by adding fireproofing. These sponges are produced using polyurethane material. They are available in sizes of 100 cm x 100 cm and thicknesses ranging from 30 mm to 50 mm. These sponges are resistant to temperatures between -5 ° C and +100 ° C and their sound absorption coefficients can vary between 0.30 and 1.12 (Öz & Köse, 2020:7). Egg-shaped sponges are shown in Figure 10.

Figure 10. Egg Shaped Acoustic Sponge

“Rebonded Bondex Sponge” is a sponge produced on a sustainable basis. These sponges serve to reduce vibration as well as absorbing sound. One of the acoustic materials used in the absorption of noise is “Echobone Bondex”. It can provide acoustic properties between 60% and 90% according to the standards determined by EN ISO. An example of these sponges is given in Figure 11.

Figure 11. Echobone Bondex Sponge

Firexpan sponge is made of foam material obtained from rubber and is used to reduce the effect of sound formed on glass, ceramic, metal and wood surfaces.

This sponge is a heat-resistant material, This fireproof rubber foam sponge has 4 times the insulation effect against different sponges. It is produced in a way that prevents noise and reduces the effect of sound formed on surfaces. Its weight is 160-220 kg/m3, its heat transfer coefficient is 0.0431 W/mK, and its operating temperature varies between -40 ° C and +110 ° C. It can be produced in 1000 mm x 2000 mm dimensions and 20 mm-50 mm thicknesses (Öz & Köse, 2020: 8). An example of Firexpan sponge is given in Figure 12.

Figure 12. Firexpan Foam Sponge

5. Results and Recommendations:

After industrialization, mechanization has also increased environmental pollution as a result. With the development of industry and technology, it has caused an increase in water, environment and air pollution. Ongoing activities on the world damage the environment and living things are affected as a result of this damage. Construction activities also damage the world, although any kind of initiative on nature is harmful, the goal should always be to cause less damage. Green buildings have emerged in line with this goal and aim to build structures that cause less damage to the environment, starting from the design of the buildings. Green building certification systems have emerged to systematically organize the constructed structures. These systems have led to the emergence of certain principles and criteria for building design. The main ones of these criteria are; integrated process management, site selection and transportation, sustainable land, water efficiency, energy and atmosphere, materials and resources, interior and environmental quality, design and innovation and regional priority titles are at the top of the criteria required for the concept of green building. Integrated process management aims to determine strategic steps, project needs, energy consumption planning and problems and produce solutions for the constructed structure to be sustainable. In site selection and transportation, distance to constructions, land status, resources and infrastructure and opportunities are examined for building construction. In sustainable land criteria; protection of green areas, construction of settlements and factors that will harm agricultural areas and natural balance should be taken into consideration. Water efficiency aims to find solutions for the negative developments faced by water resources and this problem. Climate change and the negative effects brought by climate change are water use, water efficiency and meeting the demands. There are many problems that occur for the determination of material resources and their extraction from the source. It is important to investigate the economic and social effects of building and material resources. In order to evaluate the environmental quality of interior spaces, attention has been paid to the provision of green building conditions for the criteria of “daylight” and “view”. Green building design, operation and maintenance; to reduce negative consequences on water resources and ecosystem. In regional priority criteria, it determines local priorities for the sections, councils and affiliates of USGC that affect the rules of environmental, social equity and public health.

With the 21st century, there have been changes in working environments, especially the spatial design of offices has changed and changes have occurred outside the usual order. There have been some changes in the

emergence of open offices, where it is believed that employees can work harmoniously and efficiently, and instead of the usual order in the office design concept, it has included requirements that target the motivation and harmonious work of employees. Open offices, which bring together many office systems, are an example in this sense. The increase in population, production, consumption, development of trade, and business areas have affected changing needs. More flexible and changing systems that allow employees to work in the area they want and spaces that can be easily adapted with the needs have become. With these developments, productive spaces have been created by creating social areas outside of work in free spaces. In order not to limit the work areas, open offices being more flexible, social and modular areas increases both motivation and work efficiency.

Today, the need for green office designs is increasing. Green offices based on the principle of sustainability have increased the need for green building and green office definitions of offices with the climate crisis and the carbon emissions experienced. It is necessary to design work areas where employees can benefit from daylight when they need it, outside of closed areas and work areas that do not see daylight or have little daylight.

Green offices, together with the rules in the necessary certification system, are an approach adopted to reduce carbon footprints for people and natural resources, based on improvement and savings. It is aimed for office employees to be conscious for the effective and appropriate use of energy savings, carbon emissions, natural resources and sustainable resources. Reducing the negative effects on nature in the work areas where we spend most of our time allows us to work in areas that are economical and sustainable.

In line with the results obtained in this study, the acoustic materials used to reduce the noise problem resulting from the increase in open offices were examined. The types of acoustic materials, their sources, the types of acoustic materials used, and the areas where acoustic materials are mostly applied were examined.

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