Modular Acoustic Treatment System for workspaces.

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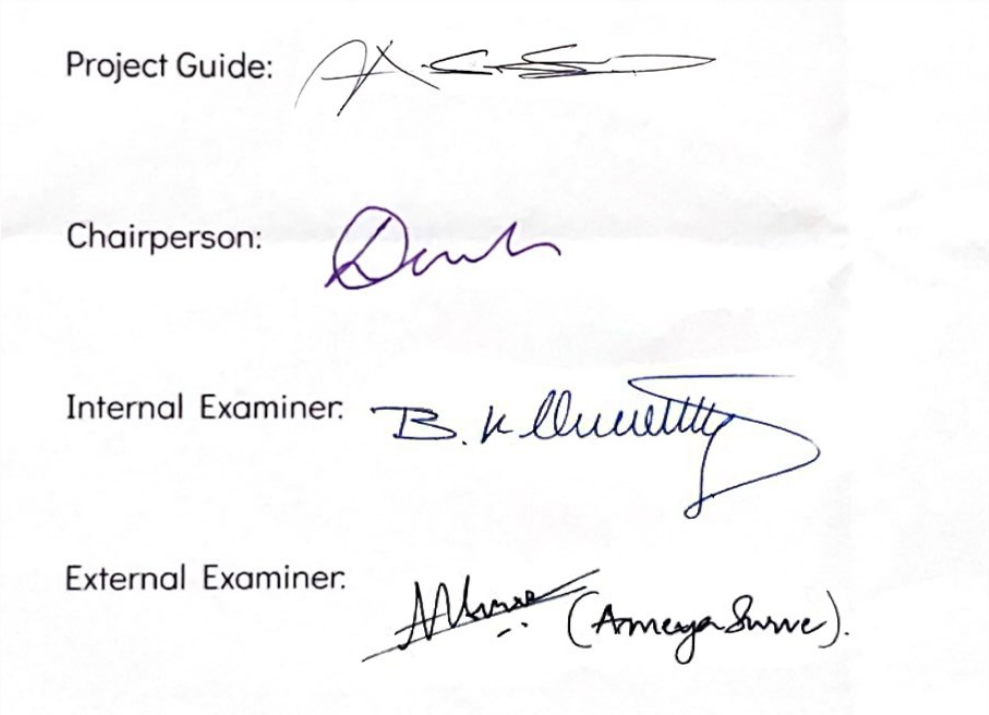
Approval

This is to certify that Industrial Design Project - III (P3) entitled **"Modular Acoustic Treatment System for workspaces."** by **Malhar Vinay Pilvalkar** is approved in partial fulfillment of the Master's Degree of Industrial Design at IDC, Indian Institute of Technology, Bombay.



Date: 27 June2023

Declaration

I declare that this written report represents my ideas in my own words. Where others' ideas or phrases have been included, I have adequately cited and referenced the sources.

I also declare that I have adhered to all academic honesty and integrity principles and have not falsified, misinterpreted, or fabricated any idea, data, facts, or source in my submission.

I understand that any violation of the above will be caused disciplinary action by the Institute and can also evoke penal action from the source, from which proper permission has not been taken or improperly cited.

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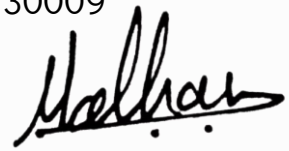

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Acknowledgement

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Lastly and most importantly I thank and dedicate this project to my parents and friends without whom I might not be here at this stage of life.

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Introduction

In the modern era of open-plan office layouts and collaborative work environments, and noisier cities ;the challenge of managing acoustic disturbances has become increasingly critical. The comfort, efficiency, and general satisfaction of an office's inhabitants are directly impacted by the acoustic quality of the space. Organisations are now investing in cutting-edge technology to create a conducive auditory environment that encourages focus, privacy, and efficient communication as a result of realising the importance of acoustic comfort.

Every modern society uses its buildings continuously and intensively, placing everyone in them for most of their daily activities. That makes it important to design healthy modern workspaces considering all the factors like Privacy, collaboration, lighting, ventilation, ergonomic workstations, and cleanliness etc.

This project tries to understand how noise pollution affects attention spans, stress levels, and general job satisfaction. Being aware of the negative impacts of excessive noise will help to design better soundscapes.

Along with acoustical properties the design also focuses on interactions of a user with his surrounding physical space. The design tries to break the rigidity of conventional partition cubicle. And add more value to the product in terms of usability and experience

The design also employs principle of modularity to explore more.interactive design. Concepts like fabric manipulation, paper engineering are explored to achieve surface development and modularity.

Understanding Sound

What is Noise ?

Sound is a **form of energy**. It refers to the vibration of air molecules that travel through the air or other medium and can be perceived by our ears. Sound allows us to **communicate** with the world around us. We use sound to convey our thoughts and feelings through speech, music, and other forms of expression. Sound provides us with important information about our environment, such as warning signals, the location of objects, and the presence of danger. Additionally, sound can have a significant impact on our mood and emotions. These are the reasons which make designing sound is important.

Depending on a number of factors, including its frequency, intensity, and personal preferences, sound can be either pleasant or unpleasant. For instance, most people find the sound of music or nature to be relaxing. Contrarily, the characteristics of noise are often its unwantedness, lack of harmony, or excessive intensity. Traffic noise, construction noise, or a high-pitched shrieking sound are a few examples of noise.

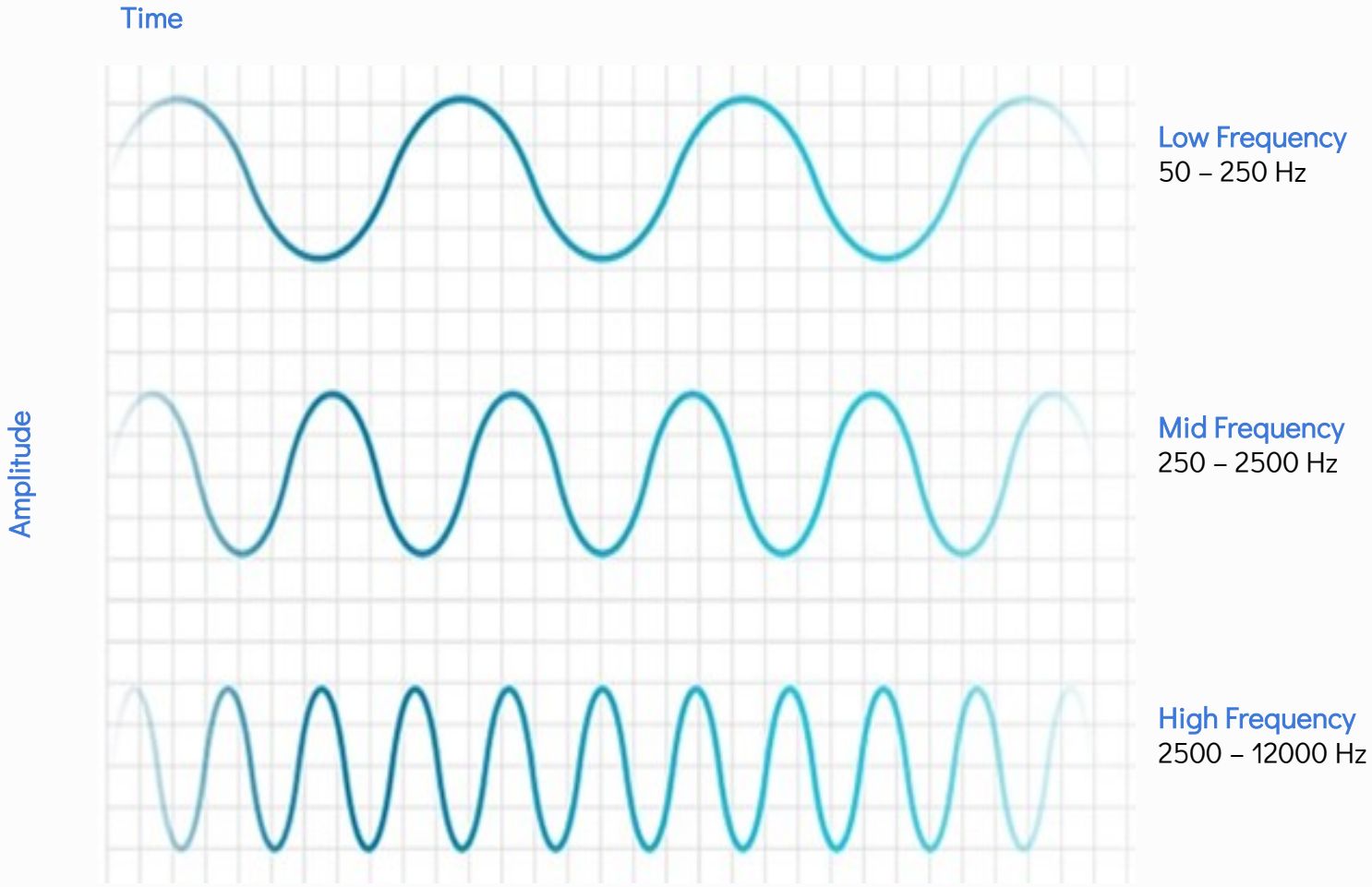
While sound generally refers to any auditory sensation, noise can be considered as an unwanted or unpleasant sound. **Noise** is often described as a random, chaotic, or irregular sound that interferes with desired sounds or disrupts a particular environment. The main difference between sound and noise lies in their subjective perception and the context in which they occur.

It's crucial to remember that what constitutes sound or noise can differ from person to person and from context to context. For instance, one person might find enjoyment at a loud concert while another finds it annoying.

In conclusion, noise refers to undesirable or unpleasant sounds, whereas sound refers to any auditory impression brought on by vibrations. Our lives are greatly impacted by sound, which makes communication easier and enhances our experiences while noise obstructs or interferes with desired sounds or situations.

Understanding Sound

The sounds have different characteristics because of differences in wavelength. They are defined as either short, middle, or long. The frequency of the wavelength is measured in Hertz (Hz).



Understanding Sound

1. Pitch:
The highness or lowness of a sound.
For example, a high-pitched sound would be like a bird chirping, while a low-pitched sound would be like a bass guitar.

2. Volume:
The loudness or softness of a sound.
For example, a loud volume would be like a rock concert, while a soft volume would be like a whisper.

3. Frequency:
The number of waves that pass by a certain point in a given amount of time.
This is related to pitch, as higher frequencies produce higher pitches.

4. Amplitude:
The height of a sound wave, which determines the volume of the sound.

5. Echo:
A reflection of sound waves off a surface, which can create a repeating or reverberating effect.

6. Frequency Range:
The range of frequencies that a particular sound system or instrument can produce, usually measured in hertz (Hz).

7. Timbre
The quality or character of a sound that distinguishes it from other sounds of the same pitch and volume.
For example, a trumpet has a different timbre than a violin.

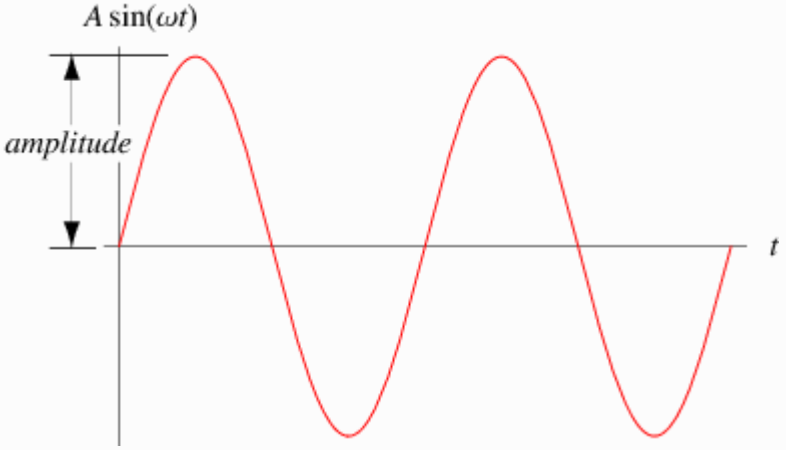
8. Resonance:
The natural frequency at which an object vibrates, which can amplify or enhance certain sounds.

9. Noise:
Any unwanted sound that interferes with hearing or communication.

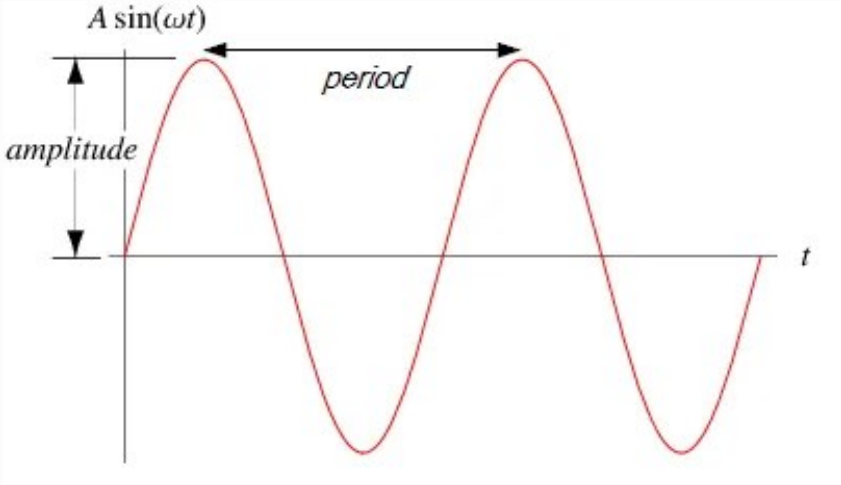
10. Sound wave:
A pattern of vibrations that moves through a medium, such as air or water, and produces sound.

11. Direct Sound
Direct sound issues from the source itself.
such as those frequencies coming from an actors mouth.

12. Indirect Sound
The same sound reaching the listener after it reflects from various surfaces is indirect sound.



Amplitude:
The height of a sound wave, which determines the volume of the sound



Frequency:
The number of waves that pass by a certain point in a given amount of time.

Behavior of Sound

Reflection:
When sound waves hit a hard surface, like a wall or floor, they bounce back instead of passing through. This is called reflection. Depending on the shape and size of the room, the reflections can be very strong and create echoes.

Absorption:
When sound waves hit a soft surface, like curtains or carpets, they are absorbed and don't bounce back as much. This is called absorption. The more absorption there is in a room, the less echo and reverb there will be.

Refraction:
When sound waves pass through a material with different densities, like air and water, they bend or change direction. This is called refraction. This is why sound travels differently in different mediums, like how it's harder to hear underwater than on land.

Diffusion:
When sound waves bounce off of irregular surfaces, like a bookshelf or acoustic panel, they scatter in many directions instead of reflecting back in one direction. This is called diffusion. Diffusion can help to even out the sound in a room and make it more pleasant to listen to.

Diffraction:
When sound waves encounter a barrier or opening that is smaller than their wavelength, they can bend and spread out around it. This is called diffraction. Diffraction can be helpful for getting sound to travel around corners or into other rooms.

Transmission:
When sound waves pass through a material, like a wall or ceiling, they are transmitted. The amount of transmission depends on the material and the thickness of the wall or ceiling. Materials like glass or thin walls allow sound to pass through more easily than thicker, denser materials like concrete.

Measuring Sound

Sound is measured in terms of units to quantify its intensity, frequency, and other relevant characteristics. The primary units used to measure sound are decibels (dB) for intensity or level, hertz (Hz) for frequency, and sometimes seconds (s) for duration. Let's explore each unit in more detail:

1. Decibels (dB): Decibels are used to measure the intensity or level of sound. Sound level is a logarithmic measurement that compares the pressure of a sound wave to a reference level. The reference level for sound is usually the threshold of human hearing, which is approximately 0.00002 Pascals. The decibel scale allows us to represent a wide range of sound intensities, from the quietest sounds to the loudest. In general, a higher dB value indicates a louder sound.

2. **Hertz (Hz):** Hertz is used to measure the frequency of sound waves. Frequency refers to the number of cycles or vibrations per second that a sound wave completes. Humans can typically hear sounds in the frequency range of 20 Hz to 20,000 Hz. Low-frequency sounds have a lower pitch, while high-frequency sounds have a higher pitch.

3. Seconds (s): The unit of seconds is used to measure the duration or time-related aspects of sound, such as the length of a sound event or the time between two sounds.

Loudness of Sound

Sound loudness is measured in decibels (dB), and it is a logarithmic scale where a 10 dB increase represents a tenfold increase in sound intensity.

- A quiet library typically has a sound level of around 30 dB, comparable to a whisper or a ticking watch.
- Normal conversation occurs at approximately 60 dB, similar to the sound of an air conditioning unit or background music.
- A busy street can have a sound level of 70-80 dB, similar to the noise produced by a vacuum cleaner or a blender.
- Concerts or nightclubs often reach sound levels of 100 dB, similar to a motorcycle engine or a chainsaw.
- A jet taking off or a rock concert can exceed 120 dB, approaching the threshold of pain and risking potential hearing damage.
- The loudest sounds recorded, such as rocket launches, can exceed 180 dB, far surpassing the limits of human hearing.

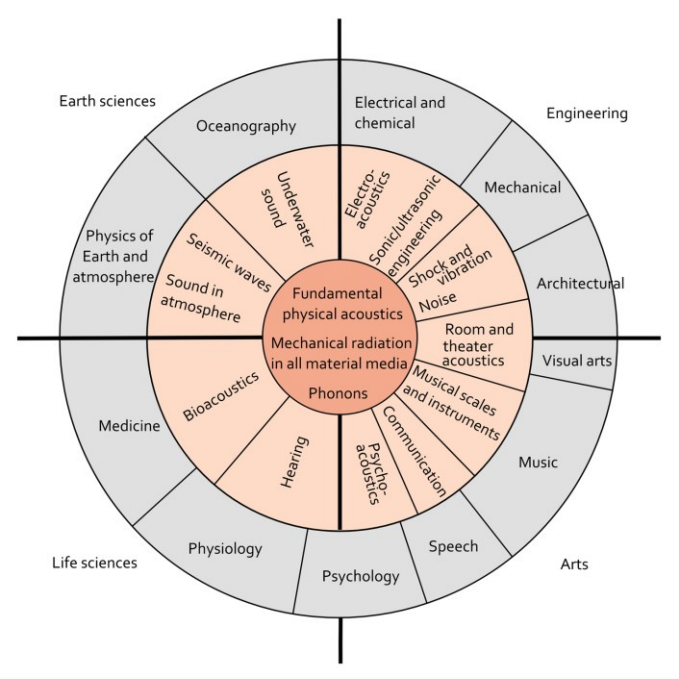
These comparisons demonstrate the range of sound loudness levels, with each increase of 10 dB representing a significant increase in sound intensity. It is important to note that prolonged exposure to sounds above 85 dB can lead to hearing loss, emphasizing the need for appropriate sound management and protection in various environments.

Understanding Acoustics

What is Acoustics

Acoustics; the science concerned with the following aspect of sound,It encompasses the behavior of sound waves in various mediums and the interaction between sound and the surrounding environment.

- Production
- Transmission
- Effects
- Reception
- Control



By 1947, acoustical engineering expertise developed from submarine warfare was being implemented to help make homes and businesses more quiet.

What is Acoustics ?

Beginning with its origins in the study of mechanical vibrations and the radiation of these vibrations through mechanical waves, acoustics has had important applications in almost every area of life. It has been fundamental to many developments in the arts—some of which, especially in the area of musical scales and instruments, took place after long experimentation by artists and were only much later explained as theory by scientists. For example, much of what is now known about architectural acoustics was actually learned by trial and error over centuries of experience and was only recently formalized into a science.

Other applications of acoustic technology are in the study of geologic, atmospheric, and underwater phenomena. Psychoacoustics, the study of the physical effects of sound on biological systems, has been of interest since Pythagoras first heard the sounds of vibrating strings and of hammers hitting anvils in the 6th century BC, but the application of modern ultrasonic technology has only recently provided some of the most exciting developments in medicine. Even today, research continues into many aspects of the fundamental physical processes involved in waves and sound and into possible applications of these processes in modern life.

Source

Spatial Acoustics ?

Spatial acoustics refers to the study and manipulation of sound waves in physical spaces. It examines how sound behaves in different environments, such as rooms, concert halls or outdoor spaces. Room acoustics studies factors such as sound propagation, reflection, diffraction, absorption and resonance that affect the perception and quality of sound in a given space.
The goal of room acoustics is to understand and optimize the acoustic characteristics of a room to improve sound quality, minimize unwanted echo or noise, and create an immersive listening experience. It finds applications in architectural design, sound engineering, concert hall acoustics, virtual reality and much more.

Sound Proofing VS Sound Absorption

Before exploring soundproofing materials, it is advised to firstly understand the key differences between sound absorption and soundproofing.

It's a common misconception to think that sound absorption is the same as soundproofing.

In reality they are not one and the same.

Sound absorption is in actual fact one element of sound proofing and is used in two ways:

Firstly, as part of a soundproofing system, as a material which is invariably added within a structure such as between the voids created in a stud wall, which can reverberate sound, adding sound absorption can prevent this.

Secondly, when sound absorbing materials are added to the surface of a wall or ceiling, it absorbs sound waves and reduces resonance and regeneration of the sound back into the room.

In doing so, improves the acoustics of a room which is called acoustic calibration.

For example, a noisy restaurant with hard surfaces typical of industrial influenced design of today's trendy eateries, can result in a cacophony of sound from clattering cutlery and chattering diners.

This noise can be softened with panels of sound absorbing materials which equalize and balance the internal acoustics of a room which is acoustic calibration.

Hopefully this explanation is reasonably clear, but in a nutshell, sound 'absorbing' materials reduce the resonance and reverberation of sound waves within a space or room.

Sound 'proofing' materials prevent sound waves from passing in or out of the room.

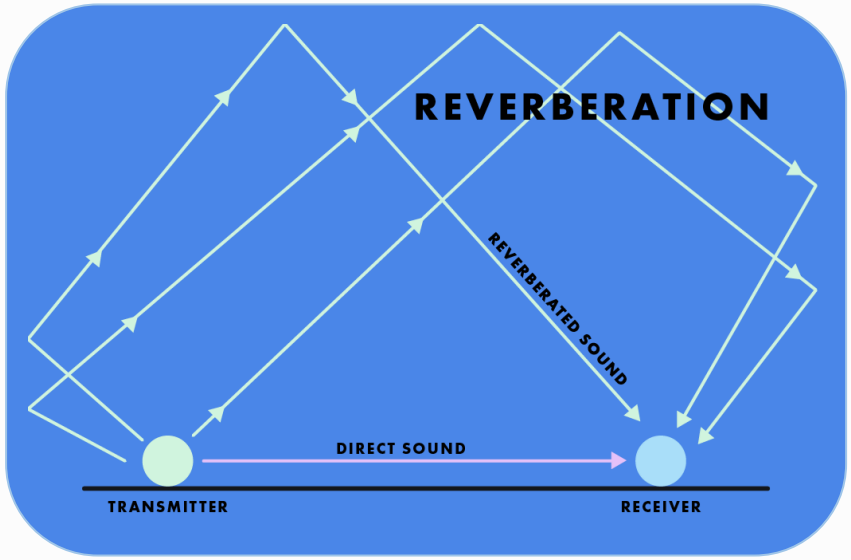
Source

What is Reverberation Time?

The amount of reverberation in a room is measured by the reverberation time. The time it takes for a sound pressure level to drop by 60 decibels after the sound source in a room has been turned off is what we mean by the phrase "sound deadening time" more precisely. However, because different materials, including stone, wood, carpet, and textiles, absorb sound to different degrees, the reverberation time is frequency-dependent. As a result, the cubature of a building as well as all absorption surfaces affect the length of the reverberation time.

Reverberation time (RT) is defined as the time it takes for the sound pressure level to decrease by 60 decibels (dB) after the sound source has stopped emitting sound. It characterizes the persistence of sound in a room and is commonly expressed in seconds (s).

The measurement of reverberation time can be performed using different methods, including the impulse response technique, the interrupted noise method, and the steady-state method. These techniques involve generating a test signal and measuring the decay of sound over time using specialized equipment such as microphones and sound level meters.



Source

Factors affecting Reverberation Time

Room Volume: Larger rooms tend to have longer reverberation times due to the increased amount of air and surfaces for sound waves to bounce off of.

Room Geometry: The shape and dimensi
ons of a room can affect the distribution of sound reflections and impact the reverberation time. Irregular shapes and angles can create complex reflections, while symmetrical shapes can lead to more uniform sound distribution.

Surface Materials: The choice of materials used for the walls, floor, and ceiling can significantly affect reverberation time. Hard and reflective surfaces like concrete or tile can increase reverberation, while softer materials like carpeting or acoustic panels can absorb sound and reduce reverberation.

Surface Area and Texture: The total surface area of a room and the texture of the surfaces can influence reverberation. Rougher or textured surfaces tend to scatter sound and reduce reflections, leading to shorter reverberation times.

Absorption: The presence of sound-absorbing materials in the room, such as acoustic panels, curtains, or furniture, can help reduce the amount of sound energy bouncing off the surfaces and decrease reverberation time.

Room Occupancy: The number of people present in a room can affect reverberation by adding absorption and altering the sound field. A crowded room absorbs more sound, resulting in shorter reverberation times compared to an empty room.

HVAC Systems: The design and placement of heating, ventilation, and air conditioning systems can impact the airflow and distribution of sound in a room, potentially influencing the reverberation time.

Room Usage: The intended purpose of a room can determine the desired reverberation characteristics. For example, concert halls typically require longer reverberation times to enhance the sound of live music, while recording studios may require shorter reverberation times to minimize unwanted reflections.

Sound Isolation: The level of sound isolation between the room and its surroundings can affect reverberation. If sound can easily escape or enter the room, it can affect the perceived reverberation time.

Room Furnishings: The presence of furniture, curtains, and other objects can influence reverberation by absorbing or scattering sound waves, thereby affecting the overall reverberation time in a space.

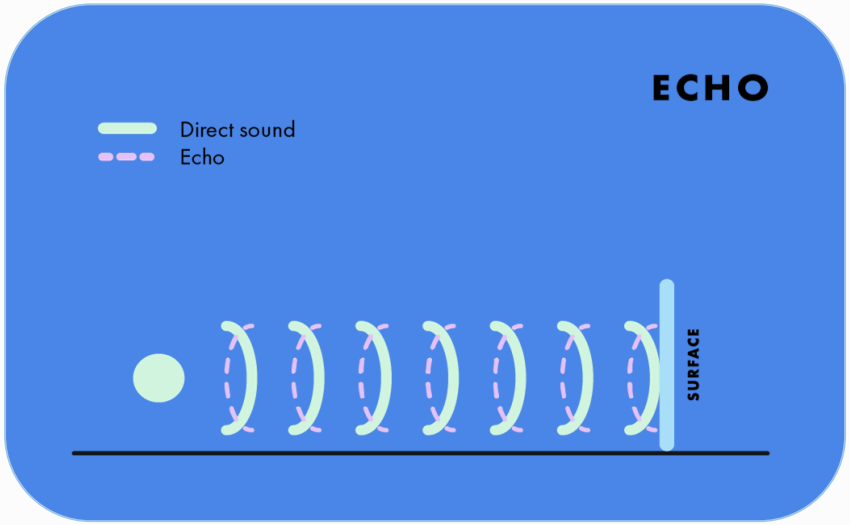
What is Echo ?

Sound echo occurs when a sound wave reflects off a surface and returns to the listener with a delay. It is a phenomenon that arises from the principles of acoustics, specifically the behavior of sound waves and the interactions they have with the surrounding environment.

The human ear perceives an echo as a distinct repetition of the original sound. If the time delay between the original sound and the echo is short (typically less than 50 milliseconds), the echo may merge with the original sound, creating a sense of reverberation or spaciousness. However, if the delay exceeds a certain threshold (around 50 milliseconds), the echo becomes perceptually distinct from the original sound.

In enclosed spaces, such as rooms or halls, sound echoes can be more pronounced due to multiple reflections off the surrounding surfaces. These reflections combine with the direct sound to create complex patterns of echoes and reverberations, influencing the overall acoustic characteristics of the space.

Understanding and controlling sound echoes are crucial in various fields, including architecture, concert hall design, audio engineering, and communication systems. Techniques such as sound absorption materials, diffusers, and acoustic treatment can be employed to minimize unwanted echoes and optimize sound quality in different environments.



What is Echo ?

Several factors can affect the occurrence and characteristics of sound echo:

Surface Reflectivity: The reflective properties of the surfaces in the acoustic space significantly influence the echo. Hard, smooth, and flat surfaces such as glass, concrete, or marble tend to reflect sound waves more efficiently, leading to stronger and longer-lasting echoes. On the other hand, soft, porous, and irregular surfaces like carpets, curtains, or textured panels tend to absorb or scatter sound waves, reducing the intensity and duration of echoes.

Room Size and Shape: The size and shape of the room impact the formation of echoes. In large rooms with high ceilings, sound waves have more space to travel and reflect, increasing the likelihood of noticeable echoes. Similarly, rooms with irregular shapes, multiple surfaces, or parallel walls can create complex echo patterns due to multiple reflections and interference.

Distance to Reflective Surfaces: The distance between the sound source, listener, and reflective surfaces affects the perception of echo. When the listener is close to reflective surfaces, such as standing near a wall, the time delay between the original sound and the reflected sound is shorter, resulting in a more distinct echo. As the listener moves further away from the reflective surfaces, the echo becomes less noticeable.

Sound Absorption: The presence of sound-absorbing materials in the acoustic space helps to minimize echo. Materials such as acoustic panels, drapes, carpets, and foam can absorb sound waves, reducing their reflection and preventing excessive echo. The strategic placement of these materials in areas where echoes are likely to occur can effectively control and dampen their effects.

Room Furnishings and Occupancy: The presence of furniture, people, and other objects in the room can influence the formation of echoes. Furnishings and occupants can absorb or scatter sound waves, altering the acoustic properties of the space and mitigating the occurrence of echo.

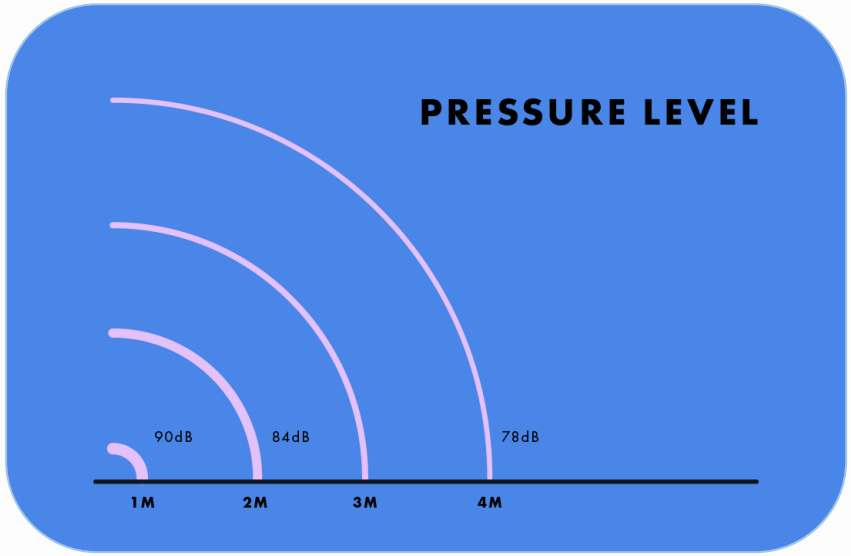
Understanding these factors and employing appropriate acoustic design techniques, such as the use of sound-absorbing materials, diffusers, or adjusting room dimensions, can help minimize and control sound echoes, creating a more desirable acoustic environment.

Pressure levels of sound propagation

Sound waves propagate in the air by disturbing the ambient pressure. The human ear can detect this disturbance, despite the fact that it is typically very slight. The threshold of hearing is the lowest sound that a human can hear, which is nine orders of magnitude smaller than the surrounding pressure. The sound pressure level (SPL), which is expressed on a logarithmic scale in decibels (dB), correlates with how loud this disturbance is.

The amplitude or intensity of sound waves, which control how loud or powerful a sound is, is referred to as pressure levels in the study of sound propagation. Decibels (dB) are commonly used to measure these volumes. In many disciplines, including acoustics, engineering, and environmental studies, it is essential to comprehend pressure levels. The pressure levels at which sound propagates are influenced by a number of factors, including:

When assessing or minimising the effects of sound propagation on the environment or human perception, it is important to take these factors into account. Designing efficient noise control strategies and improving the acoustic performance of systems and spaces both benefit from an understanding of pressure levels and the factors that influence them.



Principles of Acoustic Treatment

Attenuation

This method, also known as dampening, is the reduction in the intensity of sound waves as they travel through a medium, such as air, water, or a solid material.
When sound waves encounter a barrier, such as a wall or a door, some of the energy in the waves is absorbed by the barrier, and some is reflected or transmitted through it.
high-frequency sounds tend to be more easily absorbed by barriers than low-frequency sounds, and dense materials like concrete are better at blocking sound than lighter materials like wood.

Absorption

In this case sound waves are absorbed by the surface, rather than bouncing off it, and are converted into heat energy.
Porous or soft surface materials such as textiles contribute to sound absorption. Hard surfaces like glass or concrete reflect sound and thus create echoes. By using absorption solutions, such as cloth-upholstered screens or wall panels that feature a sound-absorbent core, it is easy to balance the presence of hard materials, shorten reverberation times, and thereby create a more harmonious soundscape.

Diffusion

It is the process of scattering sound waves in different directions, instead of having them travel in a straight line. When sound is diffused, it fills a space more evenly, creating a more natural and pleasing acoustic environment.
Diffusion helps to break up those sound waves and redirect them in different directions, which creates a more even distribution of sound throughout the room.

Key acoustical Terms

Noise Reduction Coefficient (NRC):
"The average of sound absorption coefficients as tested at 250, 500, 1000 and 2000 cycles per second (Propst, 58)."

Sound Absorption Coefficient (SAC):
"The performance of sound-absorbing materials, ranging from 0-1, where zero equals no sound and one equals complete sound absorption (Lechner, 180)."

Ceiling Attenuation Class (CAC)
A laboratory rating of the ability of a suspended ceiling to block sound transmission between adjacent rooms through a shared plenum. Approximately equivalent to STC for
ceilings. A higher number reflects less transmission.

Confidential Privacy
A condition where overheard speech is not intelligible, even though it may be audible. Corresponds to privacy index (PI) of 95 or greater.

Flanking Transmission: "Transmission paths which transmit acoustic energy around a sound barrier (Yerges, 189)." "Leakage of sound through its transmission path ("Acoustics in Buildings")."

Flutter: "A rapid reflection or echo pattern between parallel walls, with sufficient time between each reflection to cause a listener to be aware of separate, discrete sounds (Yerges, 189)."

Hertz (Hz): Measurement of the pitch or frequency, of a sound ("Building Acoustics").
Masking: When background noises are used to drown out sounds that are not being absorbed (Doelle, 19).

Need of Acoustics

Why Acoustics? Need and background

Until a few years ago, noise was rarely a concern in society, or at least it was not considered a serious nuisance, so it was not considered a health problem either. Today, the picture is very different, The world has become noisier. There are currently 7.7 billion people in the world. More than 50% of the population lives in cities; densely in apartments and apartment buildings. Every modern society uses its buildings continuously and intensively, placing everyone in them for most of their daily activities. Noise is a constant problem in our daily life.

The noise problem is compounded by ongoing construction work, increasing vehicle traffic, etc. Carved into our walls, ceilings, rooms and interiors - when spending time indoors, echoes and reverberations are often indoor noise crimes.

Noise pollution is a public health issue that "interferes with normal activities such as sleeping, conversation, or disrupts or diminishes one's quality of life", according to the United States Environmental Protection Agency (EPA). "The fact that you can't see, taste or smell it may help explain why it has not received as much attention as other types of pollution, such as air pollution, or water pollution."

Source

While noise sensitivity varies, its effects on our minds and bodies are real. "The air around us is constantly filled with sounds, yet most of us would probably not say we are surrounded by noise," according to the EPA. "Though for some, the persistent and escalating sources of sound can often be considered an annoyance. This 'annoyance' can have major consequences, primarily to one's overall health."

As this Hogarth etching from 1741 shows, noisy surroundings have long been a problem, especially for people living in cities.

India and Noise Pollution

Honking the biggest noise worry in city

Cops Seek More Power For Stricter Crackdown

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@timesgroup.com

Kolkata: Honking, according to experts, is the single biggest contributor to noise pollution in Kolkata. The city, along with Asansol, now stands sixth — and second in India after Moradabad — among the noisiest south Asian cities, says the United Nations Environmental Programme (UNEP)'s report 'Frontiers 2022: Noise, Blazes and Mismatches'.

According to the report, Kolkata's average is 65-89 decibel, way above the maximum threshold of 75 decibels in the day (for commercial areas) and 40 decibels at night (residential areas).

Times View

This needs our immediate attention. Unwanted and unnecessary noise, besides being a major irritant, has mental and physical health repercussions. We should update policies, if needed, and implement the existing rules much more forcefully.

"All forms of musical horns, TT horns and airhorns are banned. Yet, several motorists continue using them. Similarly, there are mandates under the law that silent generator sets are to be used. But for all this, mass awareness is the need of the hour," said a senior scientist working for a Bengal government body. The scientist added: "It is important that taking action — say against airhorns — should not lie with transport inspectors alone." Environmentalists also blame the inaction by authorities to repeated complaints of noise pollution.

Green crusader Subhas Datta said: "Kolkata is the noisiest city of India. I personally measured noise level in hospitals way back in the 80s and found gross violations. The same tradition is continuing. Noise is a silent killer as it affects the nervous system. It must be stopped and strict monitoring of ambient noise level must be enforced."

Kolkata Police officers said they will seek more powers under Section 15 of the Environment Protection Act to prosecute people for noise pollution. This penal measures allow for fines up to Rs 1 lakh. As per statutes, only the Pollution Control Board can prosecute under this section. At present, police act under the Motor Vehicles Act that allows them to slap penalties of Rs 500-Rs 1000.

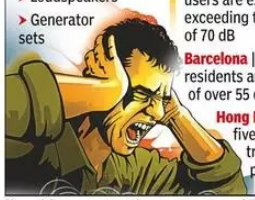
Kolkata Traffic Police, which launched anti-honking drives last year, has challaned 1,264 motorists in the last 12 days, an average of 222 each day. The Sealdah traffic guard, which covers hospitals like NRS and the BR Singh Hospital, a portion of Medical College and the R Ahmed Dental College, has reported the highest number of violations.

"Scientific and proper diversion of traffic should be implemented to control noise pollution. Involvement of NGOs could help us reduce noise pollution," said expert Indrajit Roy Chowdhury in one of his research articles.

SILENT KILLER

Where Kolkata stands | Kolkatans are exposed to noise levels ranging between 65 decibels and 89 decibels

Three major contributors
- Honking
- Loudspeakers
- Generator sets



Moradabad 2nd in world in noise pollution: UN report

Moradabad: UP's Moradabad is the second-most noise polluted city globally, according to the recent 'Annual Frontier Report, 2022' published by the United Nations Environment Programme (UNEP). The area recorded noise pollution of an earsplitting 114 decibels at its highest (dB) in 2021, the report said, re[illegible] The [illegible] around

NOISIEST CITIES
Dhaka (Bangladesh) 119 dB
Moradabad (UP, India) 114 dB
Islamabad (Pakistan) 109 dB
Rajshahi (Bangladesh) 103 dB

TOI | MAR 27, 2022

What about other big cities

New York | Nine of 10 mass transit users are exposed to noise levels exceeding the recommended limit of 70 dB

Barcelona | Over 72% of the city's residents are exposed to noise levels of over 55 dB

Hong Kong | Two among five are exposed to road traffic noise above the permissible limit

Source: UNEP report

IN NOISY INDIA, EVEN RULES ARE UNSOUND

As the season of firecrackers and loudspeakers rolls in, here is fresh evidence from WHO about the harmful effects of noise pollution. In a survey it released recently, WHO identified 5 broad sources of noise pollution. India introduced its Noise Pollution Rules in 2000, but the WHO guidelines are based on newer research. A comparison shows India's permissible thresholds are much higher

HOW NOISE POLLUTION IS CLASSIFIED

WHO identifies five sources: ROAD TRAFFIC, RAILWAYS, AIRCRAFT, WIND TURBINES, LEISURE

India frames noise pollution rules for zones: INDUSTRIAL, COMMERCIAL, RESIDENTIAL, SILENT

ROAD TRAFFIC (Values in decibels)

WHO guidelines: Daytime limit 53; Night-time limit 45*
*Noise higher than this level affects sleep

India has a higher threshold: Motorbikes, scooters & 3-wheelers 80; Passenger cars & commercial vehicles 82-85; Larger vehicles 89-91

RAILWAY

WHO guidelines: Daytime limit 54; Night-time limit 44

India says people, especially in areas that have railway tracks, need protection from rail noise but there are no specifics

AIRCRAFT

WHO guidelines: Daytime limit 45; Night-time limit 40

India lays down safeguards, but does not cap safe decibel levels

India can make rapid progress in cutting noise pollution if we start with our roads. TOI has been raising awareness on this through a No-Honking campaign. Here are a few snapshots of our reports

NO HONKING DRIVE
THE TIMES OF INDIA

WIND TURBINE — India's ceiling for industrial or commercial areas is higher than WHO guidelines

WHO guidelines: Below 45 dB (no recommendation for night noise exposure)

Industrial area		Commercial area		Residential area		Silence zone	
75	70	65	55	55	45	50	40

LEISURE

WHO says yearly average of all leisure noise sources should be 70 dB

Indian rules say loudspeakers cannot be used between 10 pm and 6 am, noise level should not exceed the standard for the zone by more than 11 dB

Firecrackers with noise of more than 90 dB at 5m distance from the site of bursting are banned

EFFECTS ON HEALTH

WHO says noise pollution causes sleep disturbance, hearing problems, heart disease and leads to poorer work performance

Less than 30 dB noise in bedrooms at night for good quality sleep and less than 35 dB in classrooms

Source: WHO, Government of India; Text: Kenneth Mohanty; Graphic: Karthic R Iyer

Impact of Noise Pollution

Hearing Problems

- Any undesirable sound that the ears are not designed to filter can cause health issues.
- Our ears can only absorb a certain amount of sound before it becomes damaged.
- Noises created by humans, such as jackhammers, horns, machines, airplanes, and even automobiles, can be too loud for us to hear.
- Constant exposure to loud noise can easily damage our eardrums and cause hearing loss, resulting in tinnitus or deafness.
- It also lowers our sensitivity to sounds that our ears pick up unintentionally in order to keep our bodies in sync.

Psychological Issues

- Excessive noise pollution in places like businesses, construction sites, pubs, and even our homes can have a negative impact on our mental health.
- Studies show that excessive noise levels have been associated with aggressive behavior, sleep disturbances, persistent stress, weariness, sadness, anxiety, hysteria, and hypertension in people and animals.
- The amount of irritation rises as the volume of noise rises, and people become less and less patient.
- These, in turn, can lead to more serious and long-term health problems later in life.

Source

Physical Problems

- Noise pollution its physical health impacts might occur as a direct or indirect outcome of noise exposure.
- Loud noises can directly cause hearing loss in severe circumstances.
- Tinnitus (a chronic high-pitched ringing in the ears) and paracusis (distorted hearing) are examples of aberrant loudness perception.
- According to certain studies, noise pollution may also have a role in the development of other health problems.
- According to research conducted in the year 2018, there is evidence that short-term exposure to noise pollution can briefly raise blood pressure and increase blood viscosity.

Cognitive Issues & Behavioral Changes

- Noise has an effect on people's neural response and capacity to focus, which can lead to poor performance over time.
- When too much noise reaches the brain, it causes reduced response rates and dulls the mind, just as it does with other sound waves.
- It also affects memory, making studying difficult.
- According to surveys, schoolchildren who live near train stations or airports have difficulty learning.

Acoustics in Work Spaces

Acoustics in Work Spaces

We live in a world that stimulates our senses in a variety of ways. Our senses take in 11 million bits of information every second from the environment around us. Our ears alone take in 100,000 bits of information per second. With so much noise present in our daily lives, it's important to understand why the acoustics of a workspace influence our ability to process these sounds.

Depending on the activity you're engaging in, and how you apply your focus, the amount of information transmitted to our senses is processed in varying degrees. While some people are visual or kinesthetic learners, others rely on auditory cues to retain information. Any employees that rely on auditory cues will rely on available acoustics.

The acoustics of a workplace are important because they can hinder or help us process sensory information. A workspace that's too quiet can be as distracting as a workplace that's too loud. Sound influences our productivity and wellness. The structures and furnishings within an office can be modified to help your employees concentrate or diffuse noise to maximize performance. Without taking the time to outfit your offices and workspaces with the right acoustics, you can almost hear productivity being silenced.

Source

There are many factors which affect the productivity in an organization, including unwanted and distracting noise. So, when you consider that employees' salaries and benefits can make up to 52% of an organization's operating budget, anything that boosts productivity will have positive financial impacts on an organization (C. Deeb). Furthermore, distracting noises do not only affect productivity, but can also increase stress levels and affect job satisfaction. Therefore, providing acoustic solutions in an office environment should be a strong consideration when an organization wants to improve productivity and output from their employees.

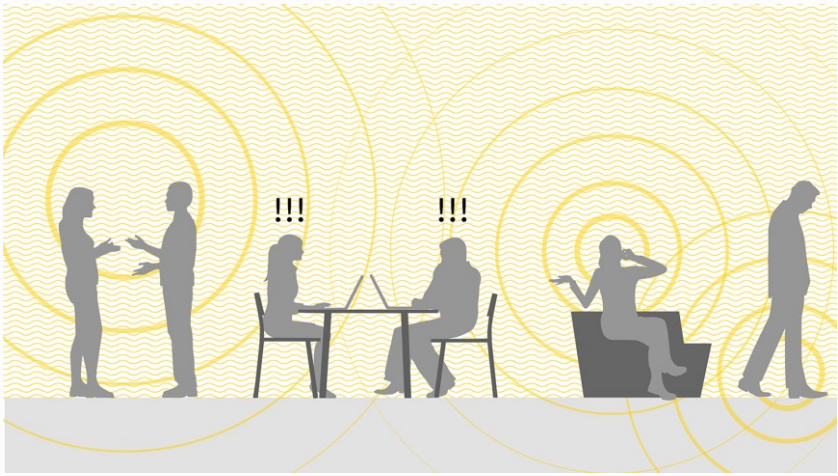
The increase in open work spaces, which are designed to encourage collaboration, communication and interaction, also impacts the office's sound environment. In addition, the common use of hard surfaces in an office, such as wooden floors, glass walls and concrete areas, enables sound waves to bounce easily, creating noisy and echoey spaces. These two factors lead to an increase in the amount of distracting noises in an office, which are transmitted from internal or external sources of noise, including conversations from colleagues or noises from devices. That said, it takes 20 minutes for an employee to regain focus after a minor sound distracts them (University of California). These distracting noises are one of the main reasons for ongoing productivity losses and declining job satisfaction in office environments.

Source

Acoustics in Work Spaces

Moreover, the COVID-19 pandemic has had a massive impact on how employees carry out their daily and organizational tasks within an organization. Since the majority of organizations had to put their employees in home office, and now have normalized the use of the hybrid working model, a completely different working environment and behaviour in offices has emerged. This hybrid model allows employees to work a couple of days at home, working independently on tasks that require a high level of concentration, and work the other days in the office, collaborating and communicating intensely with fellow employees on team projects. Many organizations believe this is the future of working as everything begins to normalize again after the pandemic (McKinsey & Company). However, as people have become accustomed to working in a home office with noise due to children, partners or other distractions, the demand for highly productive office environments has increased, especially in terms of regulating noise. Therefore, this will lead to further investments in acoustic solutions in order for organizations to provide an environment conducive to this.

Nevertheless, there are many ways to combat unwanted noise in offices. Analyzing the acoustics and utilizing various acoustic materials and furnishings throughout an office can create an environment that promotes productivity and well being for employees. With less noise distractions in an office, a study has shown that up to 75% of employees will be more productive, and also more focused and efficient (W, Thibodeaux). In addition to that, good room acoustics can help decrease sick days and improve employee morale. With many sound absorbing and acoustic solutions available, each room can be optimized in order to solve the acoustic challenges each office space is facing. Therefore, whether an organization is utilizing acoustic panels, room dividers, or acoustic lighting, there is a suitable solution for all office spaces to increase the productivity and well being of their employees, and overall impact on the organization.



Better Acoustics in Work Spaces can,

Lower work errors by

10%

48%

Reduce employee stress by

27%

Reduce conversational distractions by

51%

Acoustics in Work Spaces

Types of Noises in workplaces

There are four different types of sounds we have to control — continuous, intermittent, impulsive and low-frequency noise. Different tools are used to measure each noise and will help determine which method of sound control you can use to lessen these potentially disruptive sources. All four types of noises could come from internal and external sources.

Internal

Internal office noise is quite unpredictable. Verbal communication is only a small contributor to the sounds that regularly fill a workspace. Especially in offices that feature open spaces, the daily sounds of typing, printing and walking can become quite distracting to employees. Of the many internal sounds around the workplace, they may also include:

- Continuous internal noises, which can include beeping of machinery like printers or sounds made by ventilation equipment.
- Intermittent internal noises, which may include sounds that rise and fall quickly, like the cycling of machinery.
- Impulsive internal noises, which could be attributed to bursts of laughter, clapping or groups of employees suddenly speaking loudly.
- Low-frequency internal noises, which include the low rumbles and hums of refrigerators or appliances.

External

External noises can be unpredictable and disruptive, and they're often much more difficult to control than internal noises. For instance, old machinery that naturally operates at a loud volume could be replaced. Employees could also be encouraged to keep their volume lower when congregating in certain areas. However, you cannot control how many cars drive by your workplace or how loud people speak on the floors above or below yours. External noises emanating from outside may include:

- Continuous external noises, which include the noises of traffic outside the workplace.
- Intermittent external noises, which are common, often stemming from planes or trains passing or equipment operating in surrounding businesses.
- Impulsive external noises, which may be attributed to construction impacts or explosions.
- Low-frequency external noises, which could be the humming of an outdoor generator or appliance.

It's also important to consider internal and external noise in the way they affect individual personalities and mental struggles. For example, someone suffering from health issues like headaches may be more affected by loud noises like nearby construction work. Another instance could be when an individual is cognitively distracted by personal issues — their focus may be hindered even more by the presence of internal office noises like rattling ventilation, beeping machines or the sounds of their coworkers.

Privacy in Work Spaces

Types of privacy

People instinctively assess four segments which are usually overlap and determine if a space can provide the type of privacy experience they desire.

Acoustical Privacy

Undisturbed by noise and/or able to create noise of your own without disturbing others.

Territorial Privacy

Claiming a space and controlling it as your own (olfactory privacy is a subset).

Visual Privacy

Not being seen by others and/or freeing yourself from sight-induced distractions.

Informational Privacy

Keeping content (analog and/or digital) and/or a conversation confidential.

Privacy in Work Spaces

Privacy refers to an individual or group's ability to conceal information or aspects of their lives. This includes personal data, behavior, and online activities.

It's considered a fundamental human right, protected by laws and conventions. It's crucial for autonomy, freedom of expression, and protection against discrimination and abuse.Everyone's life is impacted greatly by their level of privacy. It is the equivalent of water in a desert to mothers of young children. It helps writers concentrate their thoughts. It is sought after by lovers who want to share its blissful seclusion. Everyone needs their own space just as much as they need to interact with others in public.

No matter their identity, all people require some level of privacy in order to live healthy lives. Lack of personal privacy impedes growth and self-expression and can cause disruptions in one's thought processes.

Need of Privacy in Work Spaces

1. Workplace Information Protections

Businesses small and large have to deal with the workplace security of the information they are working on, or holding. Whether it is a retail outlet with customer credit card or personal information, or a major corporation dealing with sensitive business information or government contract secrets – They all need a safe, secure, and private area in which to handle that information.

With identity theft becoming such an issue these days, employees that are put in charge of handling sensitive information need to have secure and private areas in which to do their jobs, regardless if it is a client's social security number, or the company's new plans for the next multi-million dollar widget to hit the market.

Open office areas do not provide these kinds of protections for sensitive business information. Just like you would not use a computer in this day and age without virus protection, employees with access to any type of sensitive information need privacy and security to do their jobs properly.

2. Concentration

Constant interruptions, distractions, and background noise can severely hinder an employee's ability to work. Without privacy and clear train of thought, concentration wanders to everything else except what an employee is supposed to be working on.

According to Teresa Lesiuk, assistant professor at the University of Miami, music can break a worker out of a narrow train of thought, and open their minds to more than just one certain way of thinking.

When an employee is surrounded by cubicles full of fellow employees yammering on phones or to other coworkers, quiet music has been found to be able to give the office worker a sense of personal privacy in their office and enhance concentration in a noisy environment.

No matter what tricks an employee uses in order to drown out the clatter of a busy office, it is a widely accepted fact that privacy is the number one means of ensuring proper concentration on the task at hand in an office setting.

Source

Need of Privacy in Work Spaces

3. Personal Space

Definition of Personal Space: The physical space immediately surrounding someone, into which any encroachment feels threatening to or uncomfortable for them.

Everyone has heard of the unseen 4 feet of personal space that people need when interacting with the rest of society. In an office building full of busy coworkers this rule of human nature prevails as well.

Workers in the office or out of it need their own personal space around them in order to feel comfortable. If an employee does not feel comfortable, then they will not be in the proper mindset to work.

This is why privacy is so vital to provide employees with if one wants happy, efficient employees who get the job done on time and get along with their fellow coworkers.
Offices with open spaces need to provide quiet zones and some form of privacy for their employees.

Cubicle workers need enough separated space between other workers cubicles as well in order to also feel that they have some designated personal area in-between them, in order to feel that they have an adequate amount of privacy to do their work in.

4. Productivity

Privacy for some workers is detrimental to their productivity. These are the workers who absolutely abhor open space office environments. They collaborate when they need to with fellow coworkers and then go back to the sanctity of their cubicle or office in order to finish their work unhindered by needless interruptions.

Increased productivity with an appropriate amount of given effort on the employee's part, is of course the goal of all businesses worldwide. Regardless of whether the working environment is open spaced or cubicles employees will still need a certain amount of privacy in order to accomplish their working goals also.

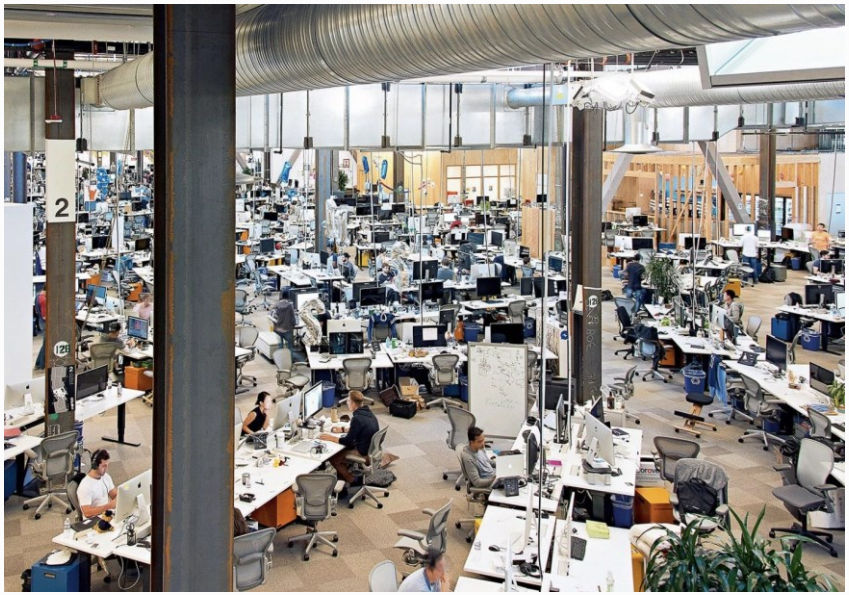
The IOSR Journal of Business and Management stated that visibility, accessibility, and informal interaction are all keys to workplace productivity. But without the privacy to sit down alone unhindered, those three important factors to better employee's productivity are rendered impotent.

Source

Problems Faced in Open Plan Offices

While open-plan offices save corporations a lot of money, they wreak havoc on your ability to focus. They can even impact your health. First, a look at how open-plan offices harm your productivity and communication.

What was once hailed as a step towards better communication (and lower costs) has turned into a failure in many companies. A 2018 Harvard Business School study found that open-plan offices (office space without walls and doors) actually lead to a 70% decrease in face-to-face communication (Bernstein & Turban, 2018). Also, constant noise can make you tired and feel a sense of sensory overload, making you less productive. Many people find that quiet or absolute silence is essential to their productivity. People who work in an open-plan office had a deterioration in their perceived health and performance, and more absences due to illness (Richardson, et al., 2017).



Also, people eventually get tired of being around other people. Everyone has their individual level of "people exposure" - how long you can be around people before you need time alone. An open-plan office leads to more potential to mess with your belongings and your work. While one can argue that less sabotage can occur because a coworker is in view of everyone else, keep in mind that the more visual stimuli we have, the less we truly observe. This is the idea of committing a crime "in plain sight."

Spatial Design of Work Spaces

Office Layouts

When it comes to the fast-paced environment of a workroom, the office layout has never been more important.

Whether it is a large, open-planned office with communal meeting spaces, or a smaller home office suited to just a few key employees, the design and functionality of the work area is critical to the overall productivity levels and direct output of the team.

In fact, research has shown that an office design layout does directly impact its workers' focus and attention to detail. A recent study highlighted by the ASE (American Society of Employers) found that up to 28% of staff spend their working day dealing with "unnecessary interruptions."

From noise disturbances, inefficient management of employee desk allocations, meeting areas in close proximity to work stations and open-plan lunch rooms, these poorly designed and unconsidered office layout ideas ultimately affect the overall productivity of the workplace.

However, it does not stop there. The study from the ASE also found that poor office layout can directly affect team collaboration. The statistics revealed that 97% of both workers and staff executives believe that a lack of team collaboration can "negatively impact the outcome of a project."

To put it simply, the success, creativity and overall productivity of your employees is directly affected by the layout and design of your office space.

So what can we do to stimulate the creative senses of the common workspace? From creating modern offices to designing work environments that flow according to the needs of your employees, simple changes to the layout can often make all the difference.

The effectiveness and suitability of each layout can vary depending on the organization's specific needs, industry, and culture. It's important to consider these factors when selecting an office layout.

Source

Principles of Office Layout

Inter-departmental relationships:
the degree of relationship of one department to another is a crucial factor to consider.
For example, the areas designated for production, purchase, and sale departments should be near one another since they're closely related.

The flow of work:
the office layout should ensure a regular flow of work.

Space requirements for workers and equipment:
the office layout should provide adequate space for free movement of staff and storage of equipment.

Efficient utilization of floor space:
space can be very costly in the city, so efficient use of the available space is a must.

Effective supervision:
the supervisor's office or seat should be near the working group.

Uniform Appearance and flexibility of office:
the furniture and equipment used should be of a uniform type to ensure flexibility and aesthetically pleasing appearance.

Lighting and ventilation:
proper lighting and fresh air are necessary for efficient work performance. No employee should face an objectionable light source and air conditioning should be prioritized.

Expansion:
the office layout should allow for future expansion within departments.

Service facilities:
these include drinking water, restrooms, fax, computer, internet, and canteen. The office layout should provide such facilities.

Safety:
the office layout should provide a sufficient number of exits in case of emergency.

Source

Open Plan Layout:

In an open plan layout, the office space is primarily open without walls or partitions. It promotes a collaborative and interactive work environment.
Features large, shared workspaces with desks arranged in a grid-like pattern.
It encourages communication and easy interaction among employees, fostering teamwork and idea sharing.
Suitable for creative industries, startups, and organizations that prioritize collaboration.

Pros:

- Promotes collaboration and communication among employees.
- Increases flexibility and allows for easy reconfiguration of workspace.
- Facilitates a sense of equality and transparency within the organization.

Cons:

- Noise and distractions can hinder concentration and productivity.
- Lack of privacy and personal space may lead to decreased employee satisfaction.
- Potential for spreading illnesses and infections due to close proximity.

Cubicle Layout:

Cubicle layout divides the office space into individual workstations using cubicle partitions.
Each employee has their own enclosed workspace with partial visual and sound privacy.
It strikes a balance between open plan and private office layouts, providing personal space and reducing distractions.
Commonly found in corporate environments where employees require focused work or limited interaction.

Pros:

- Provides employees with a degree of privacy and reduced distractions.
- Offers personal space for individual work and focus.
- Can be more cost-effective compared to private offices.

Cons:

- Limited collaboration and communication opportunities.
- May create a sense of isolation and hinder teamwork.
- Cubicles can still generate noise, reducing overall productivity.

Private Office Layout:

Private office layout assigns separate enclosed offices to individual employees or teams.
Each office provides complete privacy, allowing employees to work independently and hold confidential meetings.
Commonly used by executives, managers, and employees who require concentration, confidentiality, or authority.
Suitable for professions such as law, finance, or roles that involve sensitive information.

Pros:

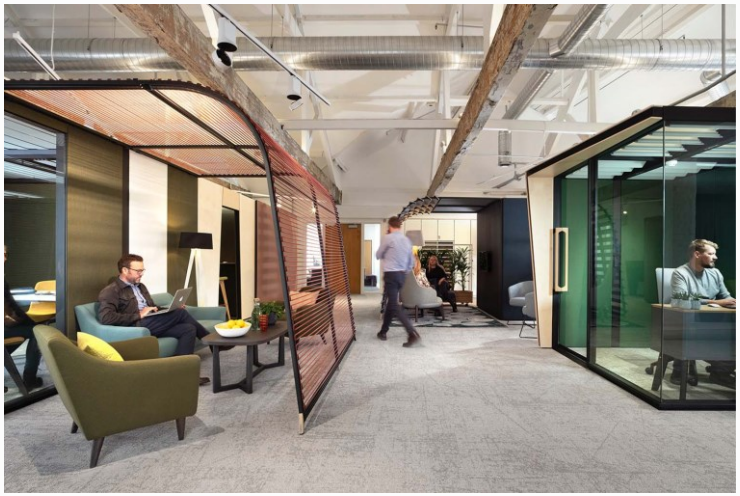
- Offers maximum privacy and concentration for individual work.
- Provides a space for confidential discussions and meetings.
- Creates a sense of hierarchy and importance for occupants.

Cons:

- Limits collaboration and spontaneous interactions among employees.
- Can lead to a hierarchical and less inclusive work environment.
- Requires more space and resources, increasing costs.

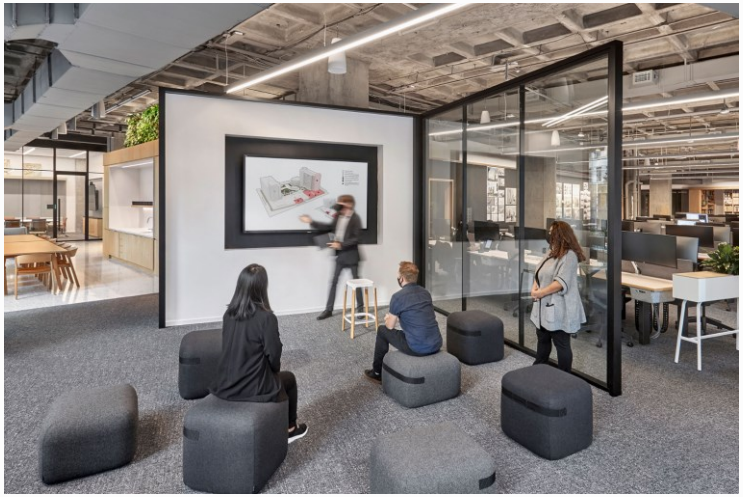
Hybrid Layout:

Hybrid layout combines different elements from various office layouts to cater to different work styles and tasks. It may include a mix of open areas, private offices, collaboration zones, and dedicated meeting spaces. Offers flexibility and adaptability, allowing employees to choose the most suitable environment for their work. Suitable for organizations that value both collaboration and focused work.



Pros:

- Combines elements of different layouts to cater to various work styles.
- Allows for flexibility and adaptability to different tasks.
- Provides a balance between privacy and collaboration.

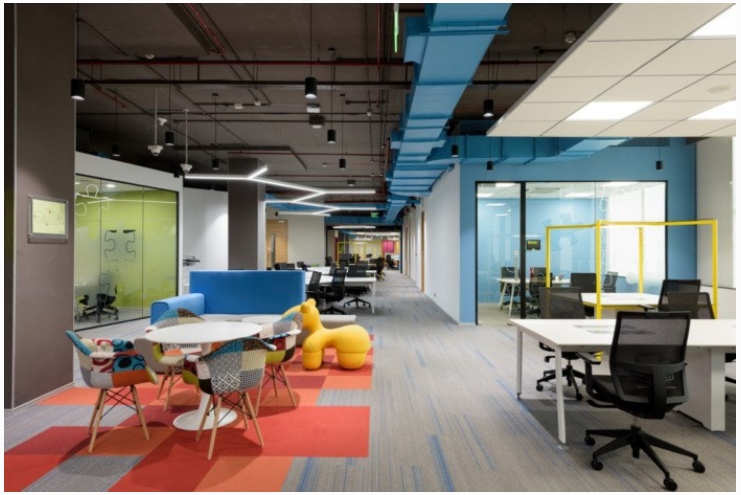


Cons:

- Requires careful planning and design to ensure an effective blend.
- Communication and coordination between teams can be challenging.
- It may be more expensive to implement due to the need for customization.

Activity-based Layout:

Activity-based layout designates specific areas for different types of work activities, such as individual work, collaboration, or relaxation.
It includes spaces like quiet zones, meeting rooms, brainstorming areas, and breakout spaces.
Enables employees to choose an environment that matches their specific task or work mode, increasing productivity and satisfaction.
Ideal for organizations with diverse work requirements and employee preferences.



Pros:

- Tailors different work areas for specific activities or tasks.
- Supports different work modes, such as individual focus or team collaboration.
- Enhances employee engagement and satisfaction by providing suitable environments.

Cons:

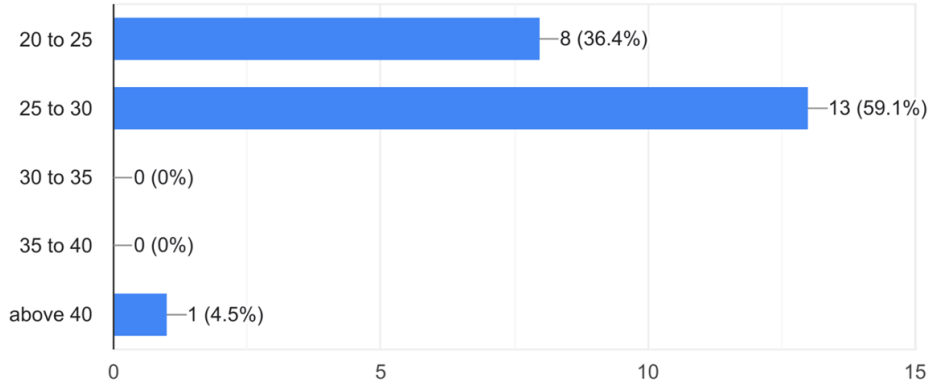
- Requires a thorough understanding of employee needs and activities.
- May lead to confusion or difficulty in locating appropriate spaces.
- Requires effective management to ensure spaces are used optimally.

User Study
Privacy in workplaces

An online survey was conducted amongst working individuals. The following are the outcomes of the study.

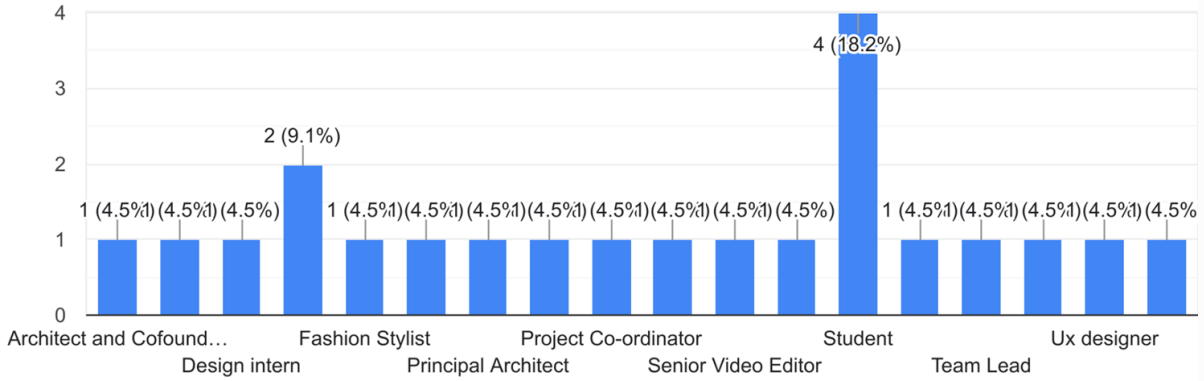
What is your current age?

22 responses



What is your current job title/designation?

22 responses



What is nature of your job ?!

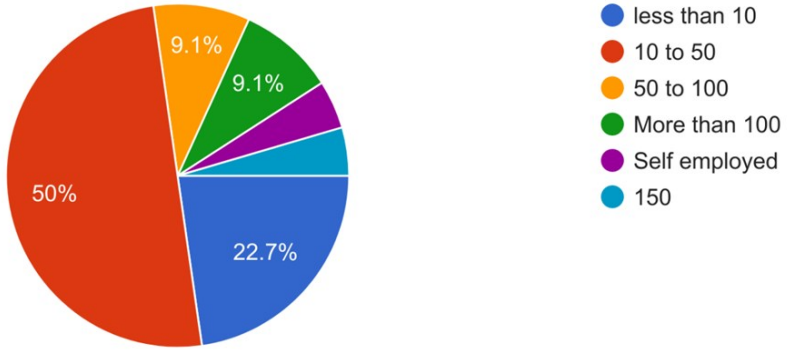
22 responses

How long you have been working for this role ?!

21 responses

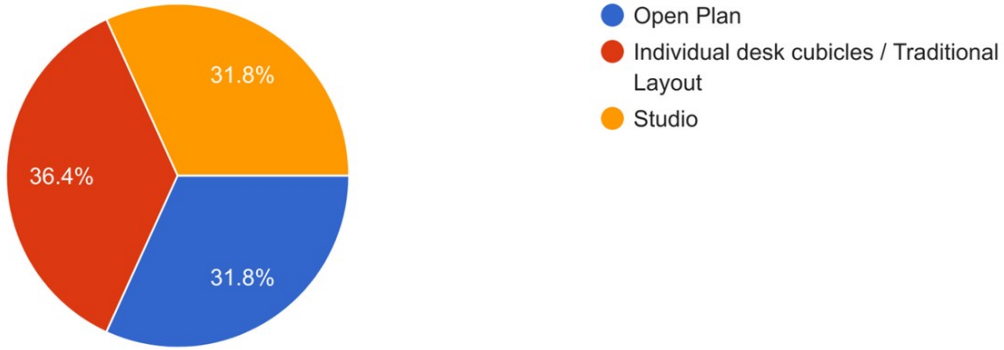
How many employees work along with you at your workplace

22 responses



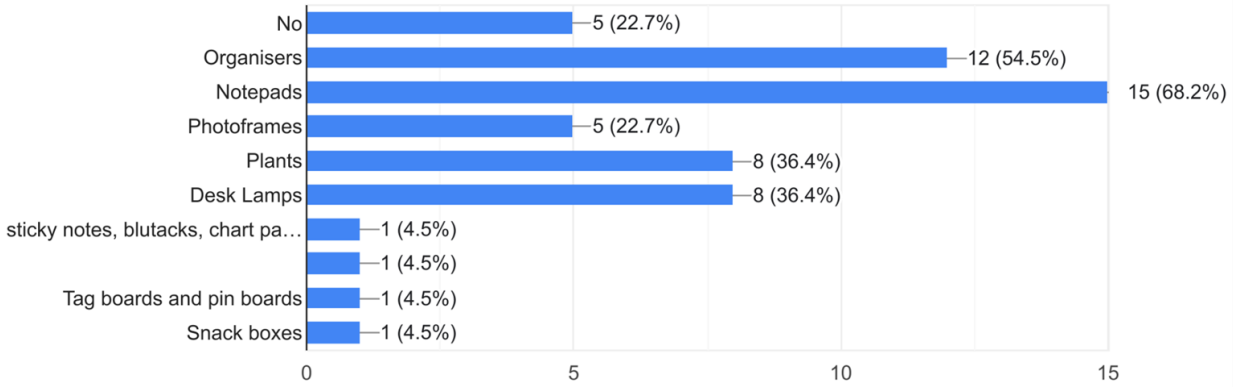
What kind of office space do you work in !?

22 responses



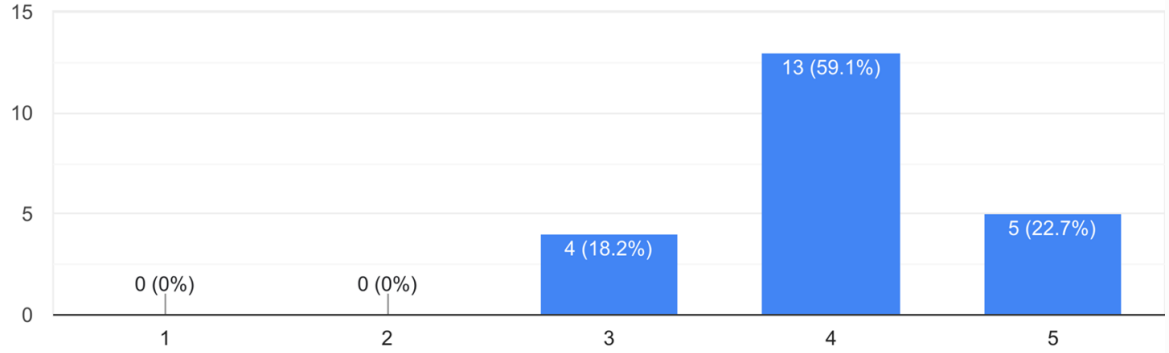
Do you use any desk accessories ?!

22 responses



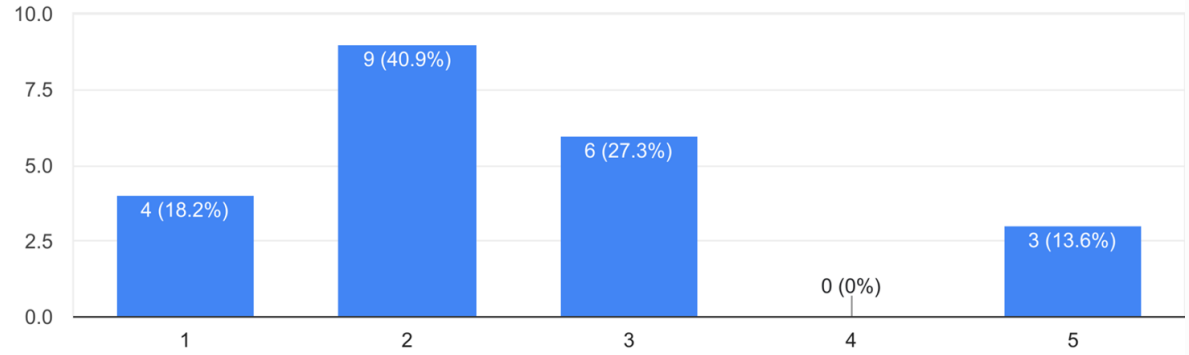
How important is acoustic and visual privacy to you in the workplace?

22 responses



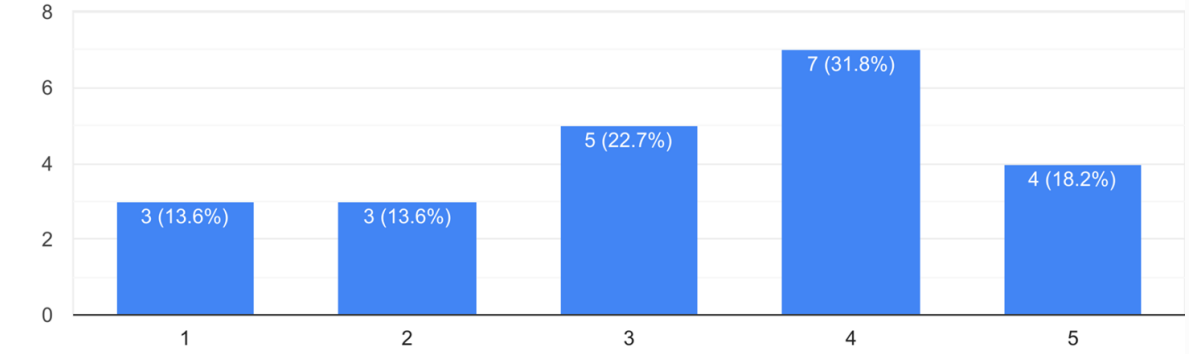
How satisfied you are with level of visual and auditory (sound) privacy in your workplace ?!

22 responses



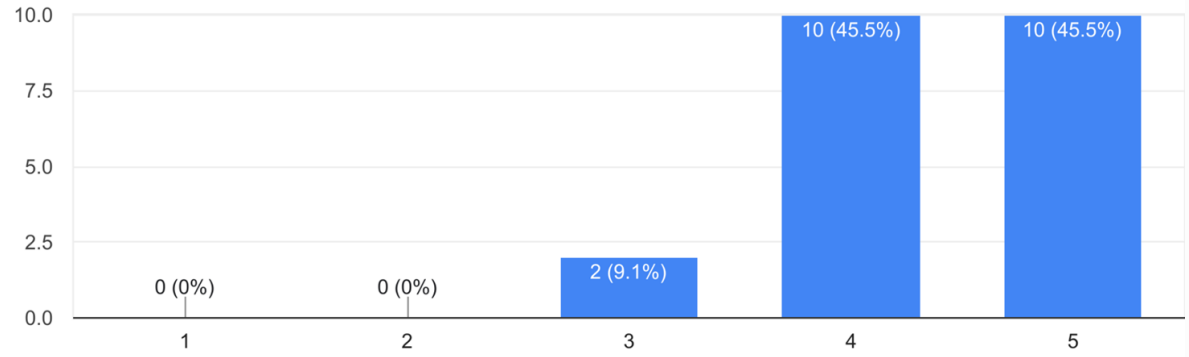
How useful you think the partition system are to maintain the privacy ?!

22 responses



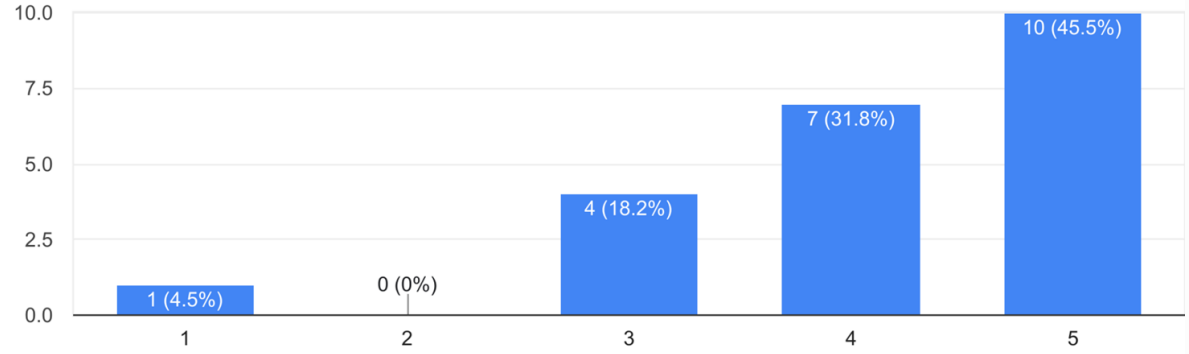
Do you think partitions can be more than just space dividers ?!

22 responses



Will you prefer customizing your own partition for your individual workplace.

22 responses



Have you faced any challenges related to noise disturbance or lack of privacy in your current workspace?

1. If someone is in a meeting and speaking loudly at the same time you are trying to think or read something can create a disturbance.
1. If I want to present in a meeting or working on something then it's not possible in an open workspace(bay area) plus everyone can hear what you are talking or speaking with someone.
1. Yes, since it's a studio set up and it's almost always busy with people coming in and out and performing different tasks, it has been tough sometimes to find privacy. Also we have some 3d printers around which make constant noise that sometimes I don't appreciate .
1. No
1. Yes
1. No. Nothing as such
1. More than space dividers it should be hassle free to use and shouldn't feel complicated to use.
1. I do face. Coz people behave like weird most of the time, they forgets that they are in office and not in home or garden.
1. When back to back meetings, and I'm loud, I worry if people will get disturbed
1. Not much...
1. Due to open space i need to go out to look for a meeting room or empty space
1. Yes while presenting to the client or even on team calls its very disturbing and sometimes ppl dont even use headphones so its more annoying
1. no, I like working in noisy environments
1. Architecture is a highly collaborative practise. There are constant discussions and exchange of ideas. So I don't think the usual corporate privacy is needed. Rather more collaborative spaces and open plans would work better with an option of turning them into individual spaces.
1. It's hard to focus on work in nuisance, also as a designer I feel that privacy is must while working as it affects my work when someone is looking at me while working
1. Our office has small rooms for individual meetings. However it's not enough and due to people being remote there are meetings for everyone the entire day. people usually move around to another place during meetings.
1. Most definitely. We work on sets

What suggestions will you share regarding space design in order to improve privacy in office spaces ?!

1. *Spaces which are collaborative but can be turned into individual spaces when required would be very useful.* If there are options of seating spaces and areas where different kinds of work (collaborative, individual etc) can take place it will be very valuable.

1. *While privacy is important during meetings, it's important to not box people in!* A lot of office work is about collaboration and simple learning from white noise. So along with privacy would appreciate something that allows communication.

1. I think office spaces require more than one kind of space. *Open plan or studio layouts are conducive to collaboration but occasional privacy is important.* So probably a separate cabin space/meeting space would be great!

1. As a designer I feel open spaces are good to collaborate and to work, but in case of privacy there needs to be some space or area where one can take their meetings/calls without getting disturbed.

1. May be partition plants + shelves(kinda semi open thing), or just plants ,partly frosted glass, acoustic furniture or moveable panels .

2. Fresh air, lovable fragrance, mild music, sufficient light arrangement and most imp education to people how to maintain others privacy.

1. *Some way to easily create a private space amidst the chaos* but also something that can be removed when not needed.

1. Cubicles or cabins maybe! Or if it's a open space then keep more than enough space between all workstations.

1. If the partitions are going to be in the office spaces, it *can be used as Brainstorming board also.*

1. more public spaces, where people can put their stuff. they become conversation starters

1. Transformative and customisable workspaces according to needs of the user.

1. Bigger space for individual if possible or ample meeting rooms.

1. Separate call rooms for taking phone calls.

1. Private spaces for meetings and calls.

1. Design something sexy.

Insights from the user study

- Around **30 %** of users work in open plan offices while other **30%** work in traditional office layouts.
- Around **80%** of users use some or the other kind of desk accessories while working. Most commonly used are notepads, Organisers, plants and desk lamps.
- Around **60%** people find visual and aural privacy crucial at workplaces. While **less than 15%** are satisfied with current scenario of privacy in their workplaces.
- Great majority of users that is **90%** ; think that partitions can be more than space dividers. Also majority no of users will prefer customising their own partition and microspaces.
- Users need their spaces to be adaptive as per type of work, like collaborations or individual works.

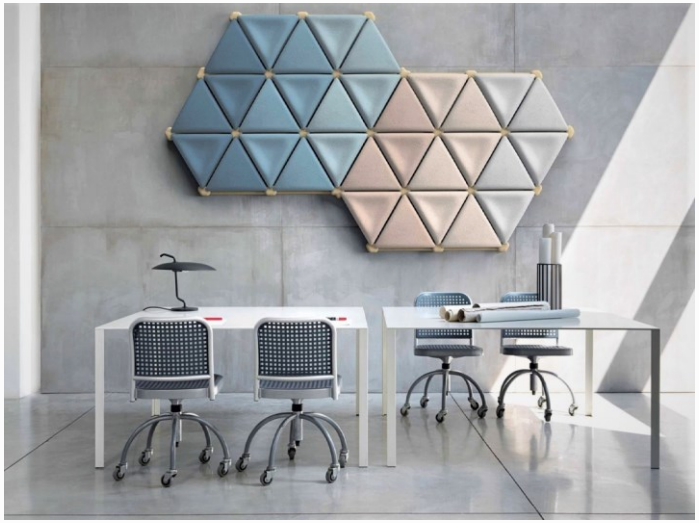
Different Types of Acoustic Treatments

Different Types of Acoustic Treatments

Wall-Mounted Panels

Wall-Mounted Acoustic Panels offer a great variety in design, they can lay flat parallel to a wall or perpendicular to it, improving the acoustic performance of the room with their absorption and reflection features.

Moreover, they give the opportunity to the designer to experiment with art in more than one way. The varying installing methods allow for different materials to be used, as well.



Acoustic Screens

In spaces that are already designed and constructed or where walls or ceilings can not take acoustic panels due to design or functional reasons, free-standing acoustic panels can do the job effectively. Moreover, free-standing panels can double act as acoustic treatments and as room dividers, which makes them perfect for spaces like open-plan offices and classrooms.

Different Types of Acoustic Treatments

Suspended acoustic Baffles

In these circumstances, suspended panels, also known as acoustic clouds, can be useful. They provide the necessary noise absorption and echo reduction while having a contemporary, industrial appearance.

As opposed to wall-mounted panels, suspended acoustic ceiling panels are used in larger rooms where sound waves will travel further and bounce off the ceiling.

Acoustic Desk Partitions

Designed for spatial privacy and safe social distancing within open-plan and shared spaces, Desk Modules also reduce ambient noise and visual distractions whilst accommodating collaboration and human connectivity. They create physical barriers between workstations, preventing direct line-of-sight and reducing visual distractions.
Some partitions are freestanding and can be easily moved and repositioned, while others attach directly to the desk or are suspended from the ceiling. Additionally, these partitions may offer additional features like built-in storage, cable management, and even integrated lighting.

Different Types of Acoustic Treatments

Acoustic Art Panels

Printed acoustic panels or alternatively called acoustic art panels comprise printed images that are wrapped around a panel made of an acoustic absorptive material like fabric or fiberglass. One of the great advantages of these panels is that they are highly customized.

Acoustic lighting

Acoustic lighting is an innovative lighting solution capable of significantly reducing ambient noise in open-plan commercial interiors. They combine form and function to enhance workspaces visually and acoustically, creating distraction-free, productive and comfortable environments.

Different Types of Acoustic Treatments

Acoustic Furniture

Small groups and individuals can benefit from a quiet workspace that is transformed by acoustic office furniture while being close to the main workspace. The product's positioning, size, and location all affect how private it is. Office dens, booths, and sitting pods provide the most seclusion, followed by acoustic office pods and phone booths.

Market Study of Acoustic Treatments

Fika By Magical Mushroom

Named **Fika,** the wall tiles are made from UK-grown mycelium that is manufactured by Magical Mushroom Company. The tiles also contain industrial hemp.

The tiles are available in a range of colour schemes and have a geometric design, including angular and curved designs. This allows for the tiles to be rotated on-site to create different patterns and designs when combined.

Fost Lamps By De Vorm

De Vorm created the lamp with a large, oversized shape to make a visual statement in offices, public spaces and conference rooms.

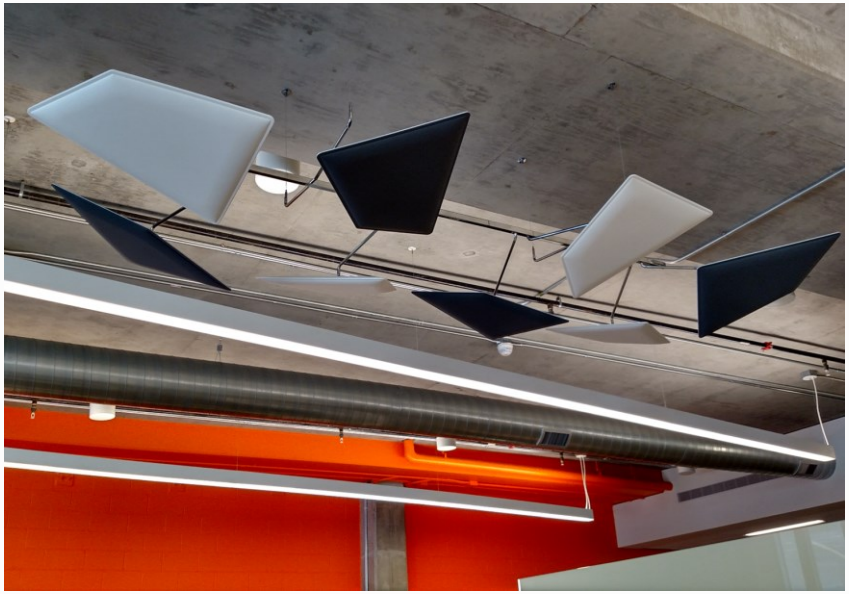
Fost Large provides its settings with sound-absorbing qualities due to its felt construction, an additional benefit for any spaces that may typically be loud.

Fuji By Woven Image

The Fuji collection responds to the growing trend for commercial offices with industrial material surfaces and exposed ceilings.

With their concave three-dimensional shapes, the tiles offer higher acoustic performance than typical flat panels, tiles or baffle systems.

Flap By Caimi Brevetti Spa



Flap panels feature a rear chrome-plated steel plate connected by an articulated spherical hinge to a chrome-plated steel arm that can be mounted directly to ceiling-mounted frames.

The ceiling-mounted frames are in chrome-plated steel, fitted with mobile arms, to which Flap panels are anchored with articulated hinges. The frames are modular and can be connected together in a parallel line. The panels can be rotated and inclined to make planar, concave or convex configurations, depending on aesthetic and acoustic needs. The configurations can be easily adjusted at any time.

Flexfelt System By Baux

The Stockholm based design studio Form Us With Love (FUWL) have recently collaborated with entrepreneurs Johan Ronnestam and Fredrik Franzon to create acoustic panels made out of textile waste.
The studio has always ventured into exploring and establishing new sustainable ways by taking conventional architectural products and making them more visually appealing. One instance is where the FUWL team used thermal acoustic insulation properties of a Swedish-made building material Traulit, which was first invented in 1940,and reinvented its aesthetics. However, the team recently introduced the BAUX Acoustic Flexfelt System which is fully compostable at the end of its life.

Hemp Husk Panels by aotta

Aotta's hemp husk panels are a natural porous membrane that absorbs sound reflections, regulates the humidity and temperature in the interiors, creating a comfortable and healthy space. the designers preserve the shape of the original natural raw material, creating a unique surface pattern with an unusual visual and tactile effect. the composition of the binder provides 100% biodegradability of panels, but it is sufficiently stable for long-term use inside the interiors. the panels are non-flammable and have antifungal properties.

Materials used in Acoustic Treatments

Properties required for an acoustic material

Sound absorption:
An effective acoustic material must be able to absorb sound waves to prevent them from bouncing back and creating echoes or reverberation.

Density:
A material with a higher density typically has better sound absorption properties.

Porosity:
An acoustic material with an open, porous structure is better at absorbing sound waves than a dense material.

Thickness:
Thicker materials generally provide better sound absorption than thinner ones.

Durability:
Acoustic materials need to be durable and able to withstand wear and tear over time.

Fire resistance:
Depending on the application, an acoustic material may need to be fire-resistant to meet safety requirements.

Chemical resistance:
Depending on the environment where the acoustic material will be used, it may need to be resistant to chemicals or other corrosive substances.

Environmental impact:
In some cases, environmental considerations may be important, and the material should be sustainable and eco-friendly.

Disadvantages of synthetic acoustic materials.

Health Risks:
When disturbed or damaged, fibreglass, which is frequently used in acoustic panels, can release minute particles or fibres into the air. Skin irritation, respiratory issues, and other health problems can result from inhaling or coming into contact with these particles. Working with fibreglass requires careful handling and safety measures.

Damage Proneness:
As compared to natural alternatives like wood or stone, synthetic materials like foam and felt are typically more prone to damage. Over time, they may rip, deform, or otherwise deteriorate, jeopardising their overall performance and acoustic qualities.

Non-Biodegradable:
Fibreglass and some varieties of foam are two synthetic acoustic materials that are non-biodegradable. They don't decompose naturally over time, which contributes to waste accumulation and long-term environmental pollution.

Production that uses a lot of energy:
Synthetic acoustic material production frequently involves energy-intensive manufacturing processes. Environmental issues are made worse by this energy use, which increases greenhouse gas emissions

Chemicals and volatile organic compounds (VOCs):
Some synthetic materials used in acoustic products contain chemicals or VOCs that can be harmful to the environment. These substances may be released throughout the process of making the material, installing it, or even while it is still in use, which could endanger people's health and cause air pollution.

Limited Recyclability:
It can be difficult to recycle synthetic acoustic materials, especially those with complex compositions or layered structures. The separation and recycling process may be hampered by the presence of various materials or adhesives, making it less technically or economically feasible.

Landfill Waste:
Synthetic materials frequently end up in landfills when they have reached the end of their useful lives or are irreparably damaged. The buildup of non-biodegradable acoustic materials in landfills increases waste production and has an adverse effect on the environment.

Commonly practiced acoustic Materials

- Polymer felt
- Acoustic foam
- Fiberglass
- Perforated plywood.
- Straw board / Chip boards.
- compressed fibre board.
- Asbestos cement boards.
- Thermocol.
- Foam plastic.
- cork sheet.

Research on sustainable acoustic materials

sustainability

MDPI

Editorial

Sustainable Acoustic Materials

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Abstract: Technological advances in materials science, manufacturing processes, chemistry and nanoscience have led to enormous developments in innovatively engineered materials over recent decades. Among them, sustainable acoustic materials have helped to improve acoustical comfort in built environments, and their use is rapidly growing in the architecture, automotive, aerospace and construction industries. These materials are manufactured through a responsible interaction with the environment in order to avoid a depletion or degradation of the natural resources, and to allow for long-term environmental quality. This Special Issue reports on some research studies on membrane absorbers and fibrous materials of natural origin that can be sustainable alternatives to traditional acoustic materials.

Keywords: sustainable materials; sound-absorption; natural fibers; acoustic materials; recycled and recyclable materials; membrane absorbers; nanofibers

1. Introduction

Although the term is complex, and several definitions of 'sustainability' can be found in the literature, the report presented by the World Commission on Environment and Development to the United Nations General Assembly in 1987 stated that the use of resources and the development of technologies should "meet the needs of the present without compromising the ability of future generations to meet their own needs" [1]. Therefore, every manufactured material for use in the built environment should fulfill this definition.

Public awareness and concern about environmental issues has led to the development of several initiatives, such as the concept of green building materials being used in practice in several countries. This has also been considered for local construction recommendations and building regulations, favoring the use of environmentally-friendly materials, less contaminating processes and recycled products.

The purpose of this Special Issue is to report on recent research and development findings in the field of sustainable acoustic materials, also called eco-materials. Acoustic materials come in a variety of forms to provide sound-absorption, insulation and vibration damping. These environmentally-friendly materials are manufactured through a responsible interaction with the environment, to avoid the depletion or degradation of natural resources and to allow for long-term environmental quality.

2. Sustainable Materials

Sustainable materials is a broad topic, and the answer to the question of what sustainable materials are is not simple. However, it is reasonable to consider several intrinsic characteristics in order to assess how sustainable a particular material is. These characteristics include the material's function during its whole life-cycle, its performance, availability and regeneration time, the environmental impacts of its manufacturing process, the net water and energy consumed during its production, the generated waste

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SUSTAINABILITY OF ACOUSTIC MATERIALS AND ACOUSTIC CHARACTERIZATION OF SUSTAINABLE MATERIALS

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Abstract

In the current western society, sustainable development becomes an increasingly significant goal in the evaluation and promotion of constructions. This paper briefly recalls the main methods for construction sustainability evaluation and the environmental impacts associated with various types of building techniques. It presents an evaluation of the sustainability of certain traditional insulating materials (glass, rock or wood wool), which are largely used in building acoustics, and presents the acoustic performances (airborne/impact sound insulation and sound absorption) of alternative materials recommended for their "sustainable" properties. These materials are either natural (cotton, cellulose, hemp, wool, etc.) or recycled (rubber, carpet, cork, etc.). A global comparison of the various characteristics is carried out for traditional and alternative materials.

INTRODUCTION

Sustainable construction can be defined as the creation and responsible management of a healthy built environment based on resource efficient and ecological principles. It is the way construction sector contributes to sustainable development, trying to match its three components: environment, economy, and society. In the last ten years, necessity to measure such issues has led to research on sustainability performance indicators, assessment methods and tools.

At the scale of materials and building, noise pollution is taken into account besides a number of sustainability aspects. Designing and improving acoustic environment, on the other hand, is linked to a choice of particular building techniques

Research on sustainable acoustic materials

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Sustainable panels with recycled materials for building applications: environmental and acoustic characterization

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Abstract

Sound absorption materials structure is generally based on porous synthetic media (rock wool, glass wool, polyurethane, polyester, ect.): they have expensive production processes, important energy consumptions, and high environmental impact. Recycled materials are becoming an interesting alternative, due to their good acoustic behavior, similar to traditional porous materials; they also allow low impact production costs, thanks to the use of wastes derived from other production cycles.

This work focuses on the evaluation of the acoustic absorption properties of new panels made of recycled paper and other scrap materials, as wool and nonwoven polyester fabric: different samples were produced and tested by means of impedance tube, according to ISO 10534-2. In order to present the environmental benefits, Life Cycle Assessment was carried out in terms of primary embodied energy and greenhouse gas emissions, considering a "cradle-to-gate" approach.

Furthermore, the behavior of innovative absorption materials was investigated in order to improve the acoustic performance of a lecture room, by means of an acoustic simulation software. A comparison with traditional materials was also carried out for both acoustic and environmental aspects. In the simulation model, calibrated by an in-situ experimental campaign of the main acoustic quality indexes (Reverberation Time, Clarity and Definition Indexes, Speech Transmission Index), different acoustic correction solutions were implemented: both the new recycled and traditional panels were applied as wall and ceiling absorbers.

The analysis of the acoustic absorption trends, in 100 - 5000 Hz frequencies range, shows that the new materials are suitable as acoustic correction systems, especially the panel composed by waste paper and wool fibers. The LCA analysis results show that, considering the same acoustic performance, the recycled panels allow to reduce the environmental effects and the global production costs.

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Research Article

Biomass from Paddy Waste Fibers as Sustainable Acoustic Material

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Utilization of biomass for green products is still progressing in the effort to provide alternative clean technology. This paper presents the utilization of natural waste fibers from paddy as acoustic material. Samples of sound absorbing material from paddy waste fibers were fabricated. The effect of the fiber density, that is, the fiber weight and the sample thickness, and also the air gap on the sound absorption coefficient is investigated through experiment. The paddy fibers are found to have good acoustic performance with normal incidence absorption coefficient greater than 0.5 from 1 kHz and can reach the average value of 0.8 above 2.5 kHz. This result is comparable against that of the commercial synthetic glass wool. Attachment of a single layer of polyester fabric is shown to further increase the absorption coefficient.

1. Introduction

Use of synthetic porous and fibrous acoustic materials is still frequently found especially in building acoustics as well as in noise control applications. The products such as foam, rock wool, and glass wool made from minerals are known for their toxicity and polluting effects which are harmful to human health as well as to the environment. It has been presented that their production can release more carbon dioxide into the atmosphere compared to those made from natural materials [1]. In order to support "green" environment campaign, acoustic absorbers from natural materials are therefore of interest due to their biodegradability and sustainability.

Several works have been published which studied the potential of natural materials to be employed as sound absorbing materials. The bamboo fibers are found to have absorption coefficient similar to that of the commercial glass fiber. The fibers were also used to develop a fiber board of a resonant-type absorber and are found to have better acoustic performance compared to plywood [2].

The sound absorption of kenaf fibers was investigated by D'Alessandro and Pispola [3] through a reverberant room test showing absorption coefficient of 0.85 above 1 kHz. Ersoy and Küçük [4] studied the potential of waste industrial tea leaf and found that the absorption coefficient of the waste fibers increases significantly when backed with a single woven cotton cloth. For 10 mm thickness, the acoustic performance of the tea leaf fiber at high frequency is superior to that of polyester and polypropylene.

Waste ramie fibers treated and nontreated with alkalization can also produce promising results with an average absorption coefficient of 0.6 at frequency range of 500 Hz–3.2 kHz [5]. Comprehensive studies on panels made from coir fibers have been conducted to investigate the effect of perforated facing, multiple-layer arrangement, and the panel compression on the acoustic performance [6–8]. Overall, coir fiber is a naturally good sound absorber at medium to high frequency at 1.5–5 kHz.

Investigation on the acoustic properties of *Arenga pinnata* fibers which can be found from a palm sugar tree has been reported [9]. These are the type of hard fibers which are similar to the coir fibers. Usually this type of fiber starts to perform at frequency range higher than that of the soft fibers. The normal incidence absorption coefficient can reach 0.75–0.85 at frequency between 2 and 5 kHz with sample thickness of 40 mm. Jute fibers have also been tested to have potential acoustic absorptivity [10]. The flammability properties are also found to be better than a commercial sound absorber.

Example sustainable acoustic materials

Cork: Cork is a versatile and sustainable material that has excellent acoustic properties. It is commonly used for soundproofing walls, floors, and ceilings.

Wool: Wool is a natural and renewable material that is often used as an acoustic material. It has good sound absorption properties and can be used in the form of panels or insulation.

Recycled Cotton: Recycled cotton is made from post-industrial or post-consumer cotton waste. It can be used as a sound-absorbing material in the form of panels or insulation.

Hempcrete: Hempcrete is a bio-composite material made from the inner core of the hemp plant mixed with lime and water. It has good acoustic insulation properties and is commonly used in construction.

Recycled Polyester: Recycled polyester, also known as PET felt, is made from recycled plastic bottles. It is often used as a sound-absorbing material in the form of panels or tiles.

Bamboo: Bamboo is a fast-growing and renewable material that has good sound absorption properties. It can be used in the form of panels or woven mats for acoustic applications.

Strawboard: Strawboard is made from compressed straw fibers and is a sustainable alternative to traditional particleboard. It has moderate sound absorption properties and can be used for acoustic panels.

Mycelium: Mycelium is the root structure of mushrooms and can be grown into various shapes and forms. It has been used to create sound-absorbing materials that are biodegradable and sustainable.

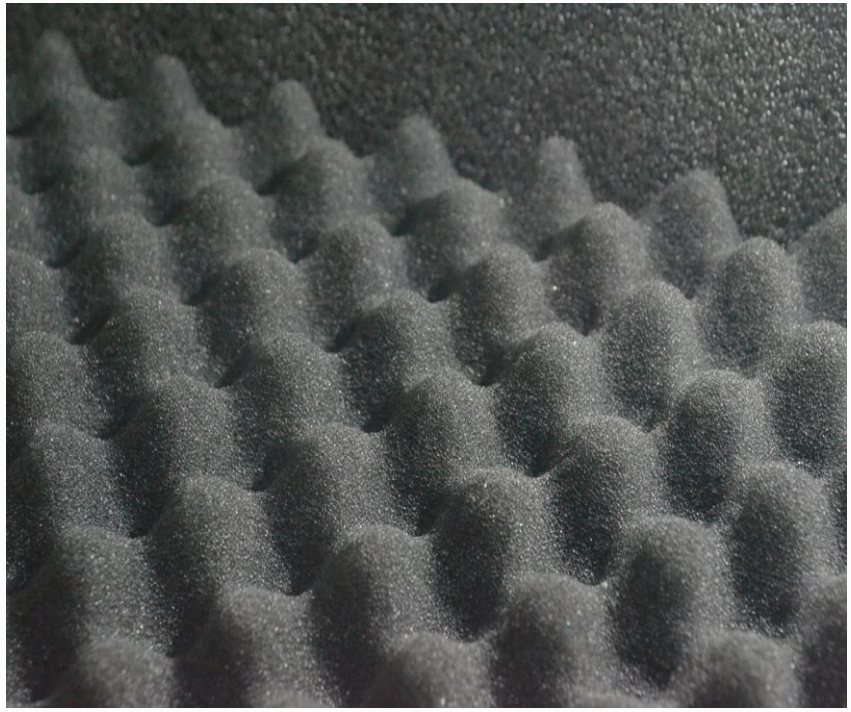
Flax Fiber: Flax fiber, also known as linen, is a natural and renewable material that has good sound absorption properties. It can be used in the form of panels or fabric for acoustic applications.

Acoustic foam

Acoustic foam is ideal for sound absorption and is offered in a variety of thicknesses, sizes, and colours.

Some even sell this material in appealing colours because some clients purchase products for their visual appeal as much as their use.

Acoustic foam is typically made from open-cell polyurethane foam or melamine foam. The foam is designed with a specific cellular structure that helps absorb sound waves. The foam is usually lightweight, flexible, and easy to install



Fiberglass

Soundproof fibreglass comes in boards / slabs rather than rolls and can be used in various places and applications including to make acoustic panels in home studios, theatres and commercial buildings.

This soundproofing material is very effective in diminishing noise that enters or leaves a room, and also improves internal acoustics.

There are different types which you can choose from with differing thicknesses, densities and strengths.

For example 703 boards are best for reducing high frequency noises whilst 705 boards are more suited to low frequency bass noises. Its suitable for various frequency ranges, come in different thicknesses, and also easy to cut. One of the known to be an irritant so protective gear must be worn when handling.

Mineral Wool

Mineral, rock, or stone wool insulation, effectively absorbs both acoustic and thermal energies. It is commonly used in cavities like stud walls and is available in different thicknesses and densities..

It has several advantages, including affordability, being a natural material, and being resistant to fire and moisture. However, it requires a significant depth to be effective on its own. It is important to wear protective breathing gear while cutting it to avoid slivers that can get lodged in the skin or irritate the lungs.

It is a very flexible material that can be formed into a variety of shapes, faced with a variety of sheet materials, and manufactured to many different densities to give varying properties. The product line includes ceiling tiles, acoustic panels, pre-formed and faced pipe sections, rolls of loft insulation, slabs for walls and loose granular material used for blown insulation of cavity walls.

Wood Wool

Acoustic Wood Wool is an environment-friendly, recyclable material made from wood wool, cement and water.

The natural components together provide many functional characteristics. The moisture-resistant material evens out air humidity by absorbing moisture from or emitting moisture to the ambient air.

Context and Scenarios for Design Intervention

Context and Scenarios for Design Intervention

With modern offices and working methodologies it's important to maintain privacy and wellbeing of people. In office layouts like open plan and hybrid layouts its difficult to maintain privacy for employees. Also especially in country like india where real estate and spatial design are very diverse, micromanagement of spaces and privacy becomes crucial.

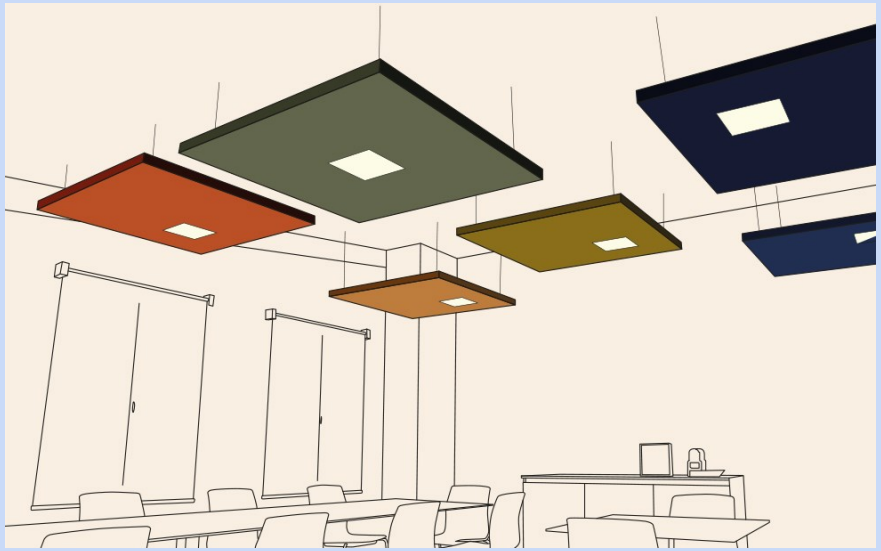
Current acoustic partition systems come in defined types of arrangements and have no customisation option. Majorly serving larger areas acoustic systems can be more micro level and more adaptive.

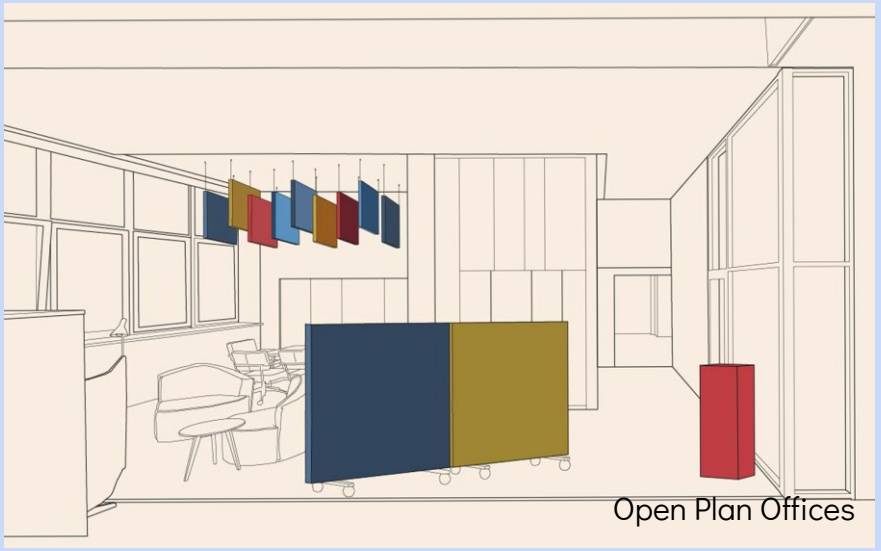
The idea is to provide people to create their own spaces according to their functionality and privacy needs and also to initiate better collaborations and personal wellbeing and workplaces.

Context and Scenarios for Design Intervention

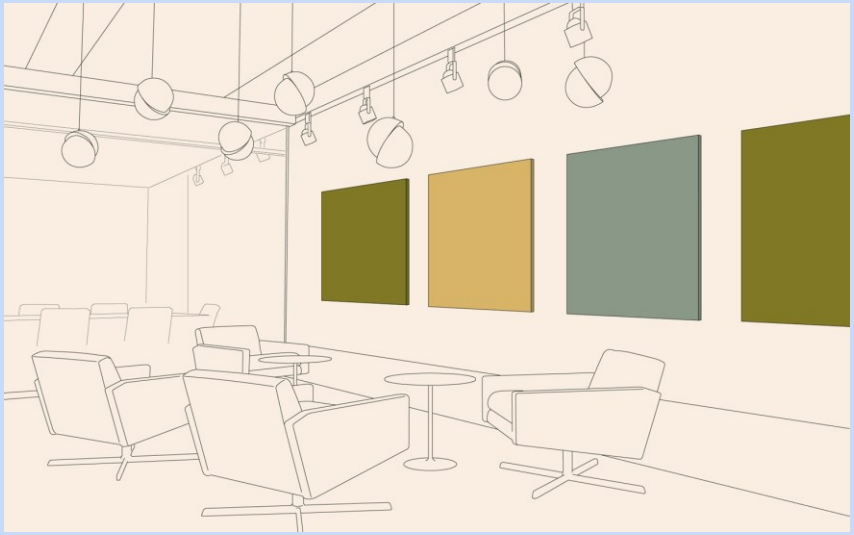

Study Rooms

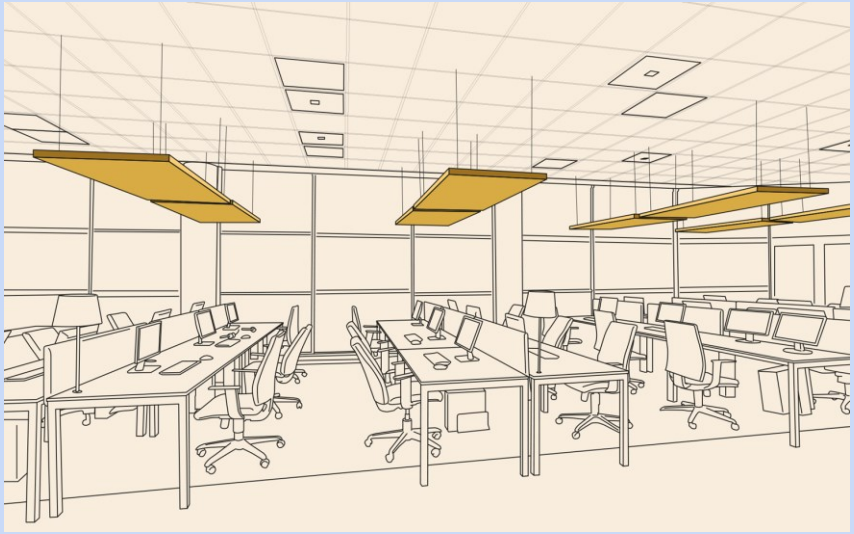

Multipurpose Halls

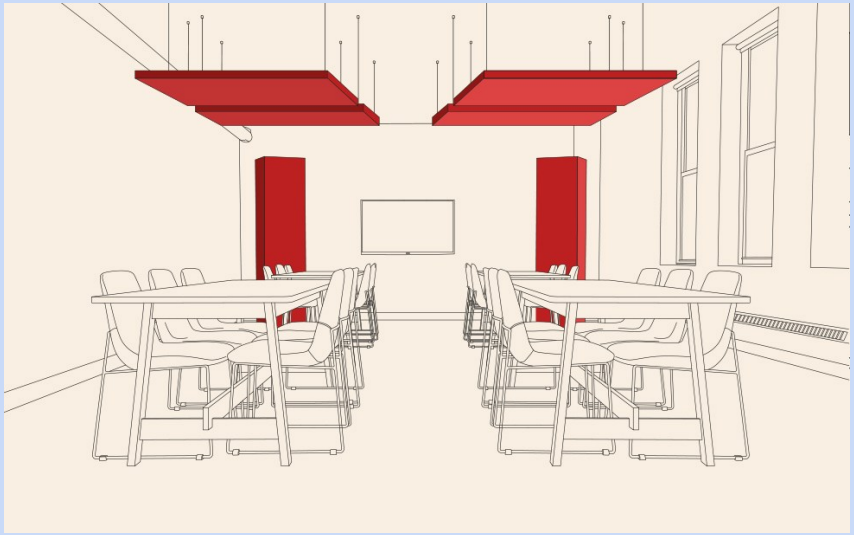



Open Plan Offices

Context and Scenarios for Design Intervention







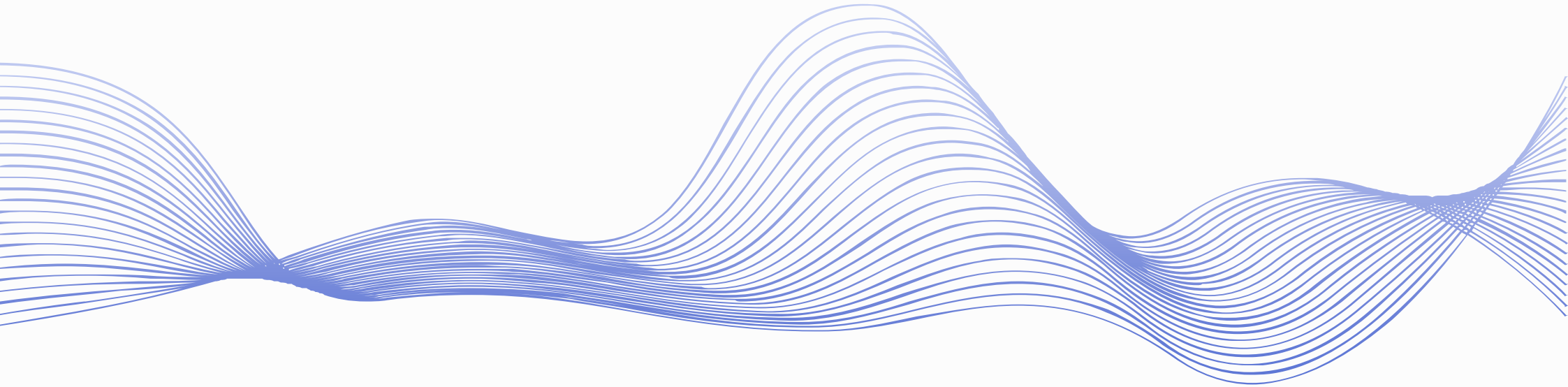
Design Brief

Privacy is prominent concern in modern workplaces. Especially in hybrid and open layout offices. One way to deal with this is to give people ability to design their own spaces according their privacy and functional needs.

The derived direction is to design a customisable modular acoustic treatment system for office or institutional spaces.

Factors to be considered:

- Adaptable to variety of spaces of target category.
- Easy to assemble, flat pack.
- Adding value more than just partition system.Should have multiple accessories to aid utility at workplace.
- Matching to standard acoustic properties.
- Product with the sustainable life cycle.
- Most commonly used acoustic materials like fiberglass and PU foam are non biodegradable and take a heavy toll on environment after use. This invites scope of incorporating sustainable materials. Here hemp fibre based non woven sheets are proposed as the alternative.



Ideations and Directions

Initial Brainstorming

Material Exploration - **Felt**

Felt, which is among the oldest textiles known to mankind, possesses numerous beneficial characteristics owing to its distinctive structure that enables it to ensnare gaseous, liquid, and solid substances, soak up heat and sound, and mold into various forms.

Felt, being composed of numerous vibrating fibers that dampen sound waves passing through it, is an efficient sound absorber.

There are two main methods to produce felt. The first is called wet felting, and its core is the same as centuries ago: influenced by steam, hot water, and pressure, wool fibers change their shapes, intertwine, and flatten, forming a single piece of fabric.
The second way is needle felting. In this process, water is not used, and wool is compressed by needles piercing it. The two methods are different in terms of their result: felt produced with needles better retains its shape. However, needle felting consumes less energy and can be used to make felt from synthetic or plant-based fibers that do not react to water and pressure the same way wool does.
Often, felt is produced using several types of fibers: in this case, the matter needs to undergo a preparatory mixing phase.
In special carding machines, fibers are tangled together to form nets that are later transformed into felt by either one of two methods.

Source

Initial Brainstorming

Material Exploration - **Felt**

Dense and entangled, felt is useful when something needs to be absorbed.

The material is widely used in manufacturing as a filter for solid, liquid, and gaseous substances: it can trap both small and light particles, like dust or flour, and heavy matter, like oil.

The textile is also effective in sound absorption. When sound waves pass through felt, they lose their energy, as the material consists of manifold individual fibers vibrating under the influence of sound.

Due to the complicated inner structure, acoustic panels made of felt can be quite thin—less than a centimeter. That means that lightweight felt tiles can also be formed or layered to have more control over acoustics, or simply for the purpose of decoration.

Felt barely conducts not only sound but also heat. Containing lots of air cavities inside, it serves as an insulating material, both in manufacturing and construction.

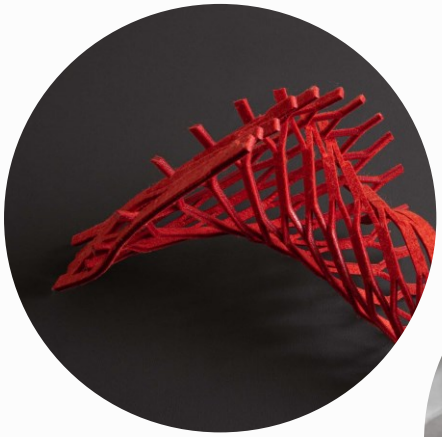
This flexibility of material can be used in the final product as well: for instance, felt can form a folded configurable chair that will adjust to the body of the person sitting in it.

Source

Idea Board based on existing explorations with felt.

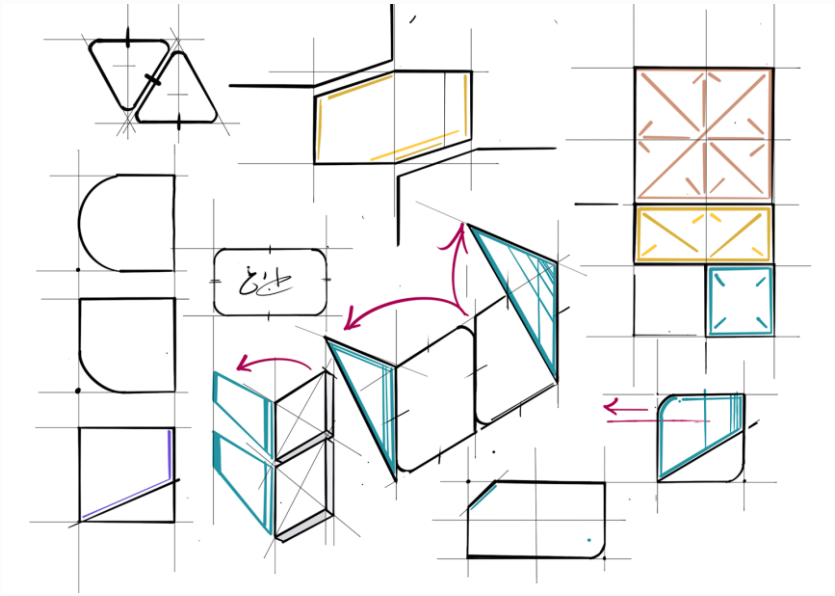


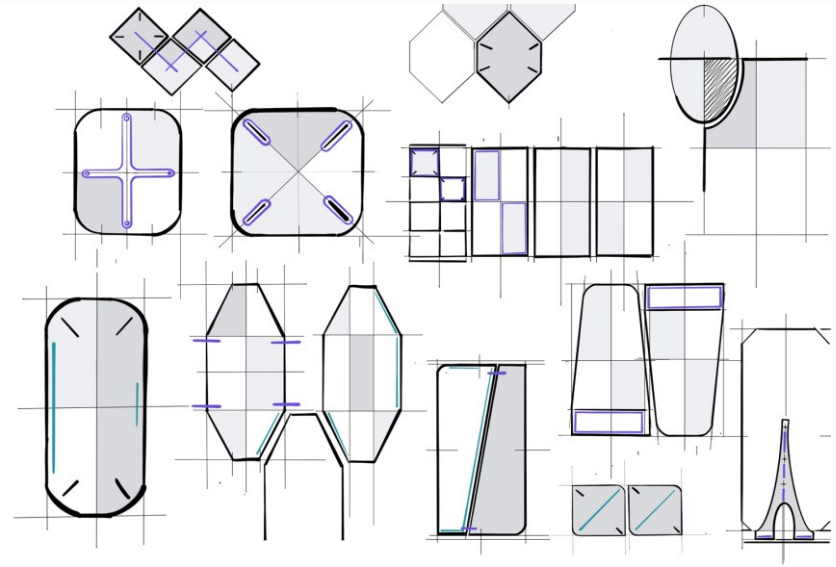


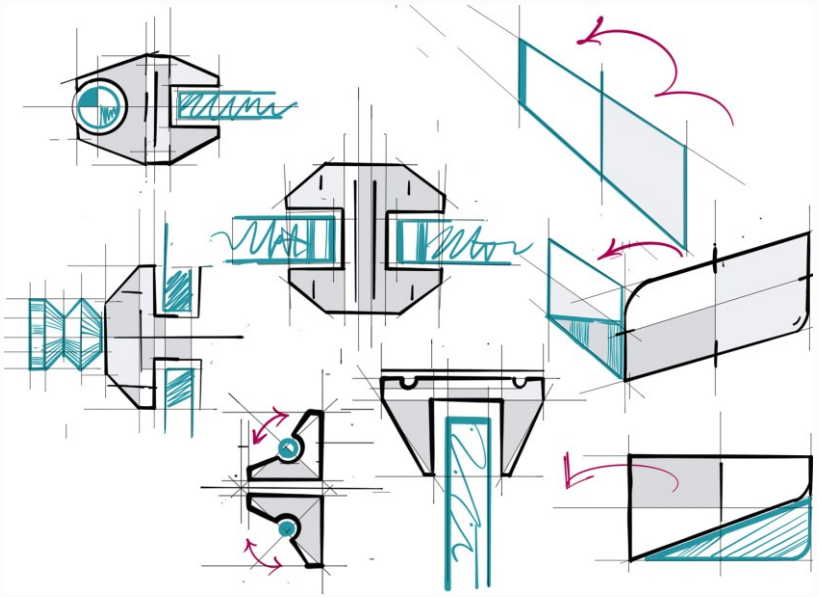



Initial Brainstorming

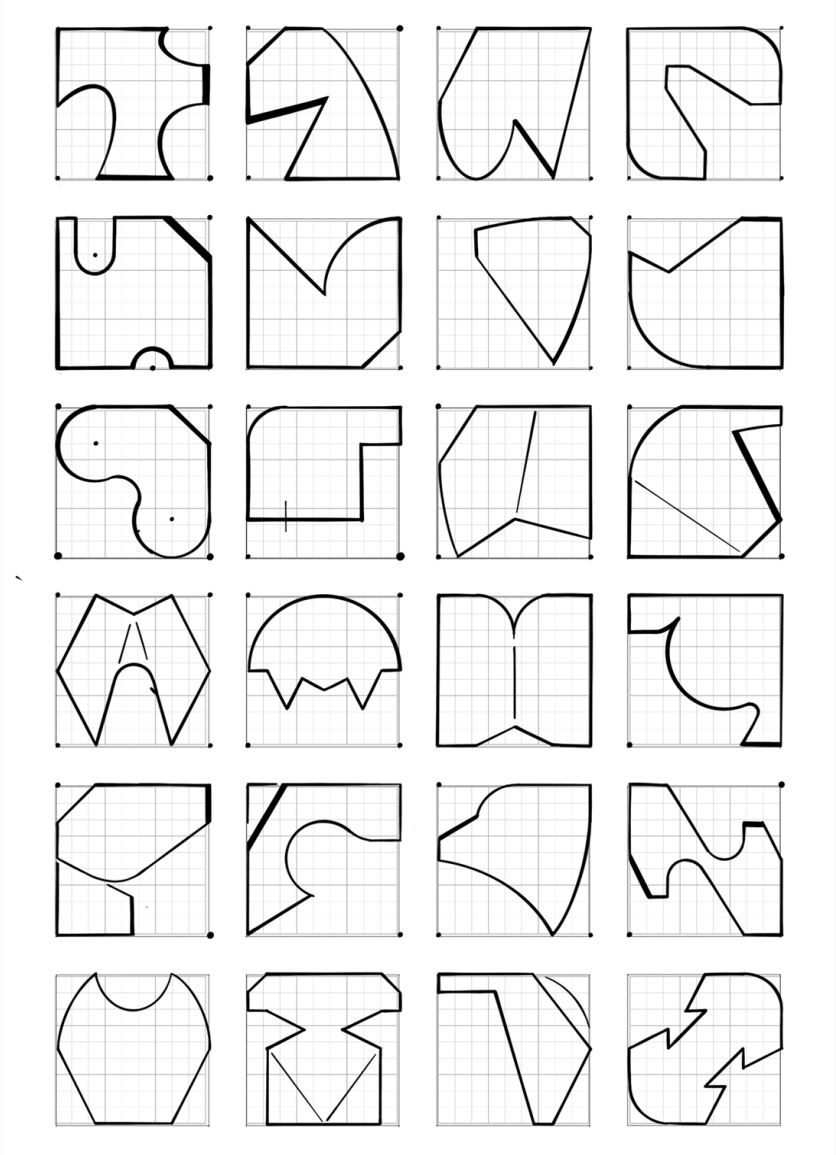
- Exploration for modular units , which can be multiplied into systems .
- Exploration for Connectors. For various setup options like connecting two panels, rotation axis, wall mounting etc.

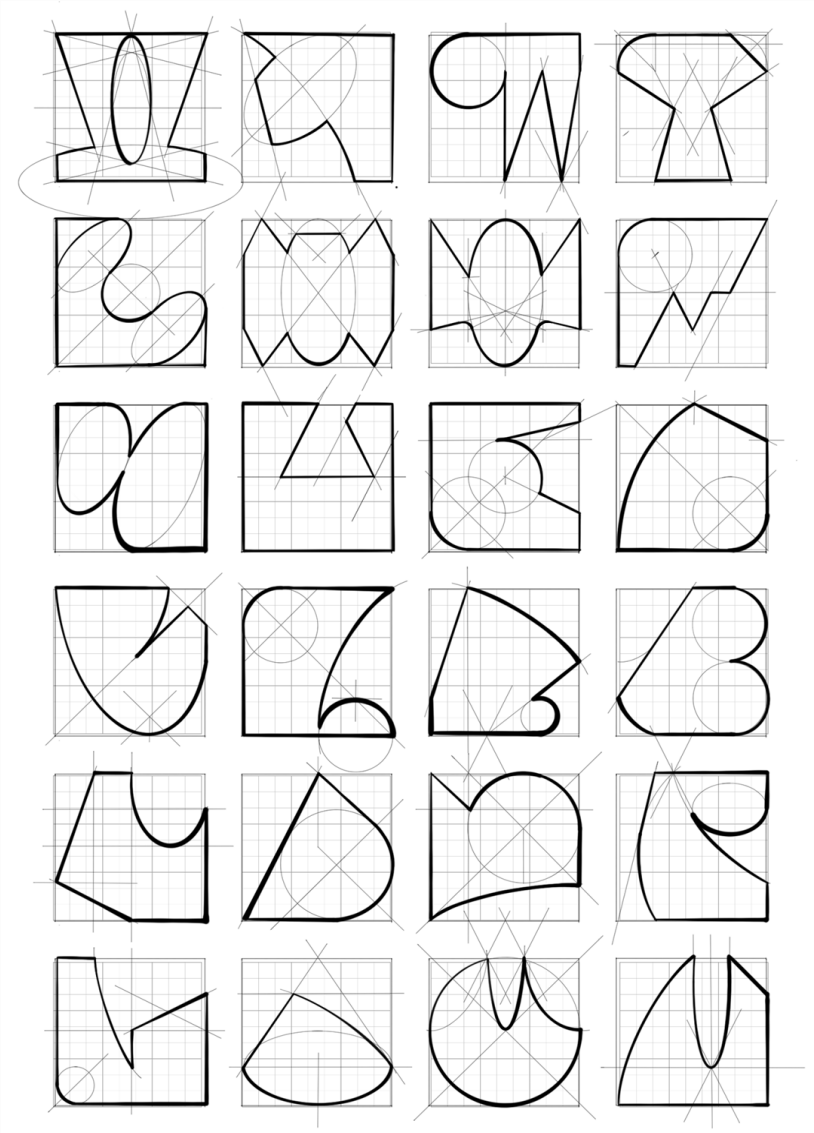






- Exploration for 2d shapes for individual modules.





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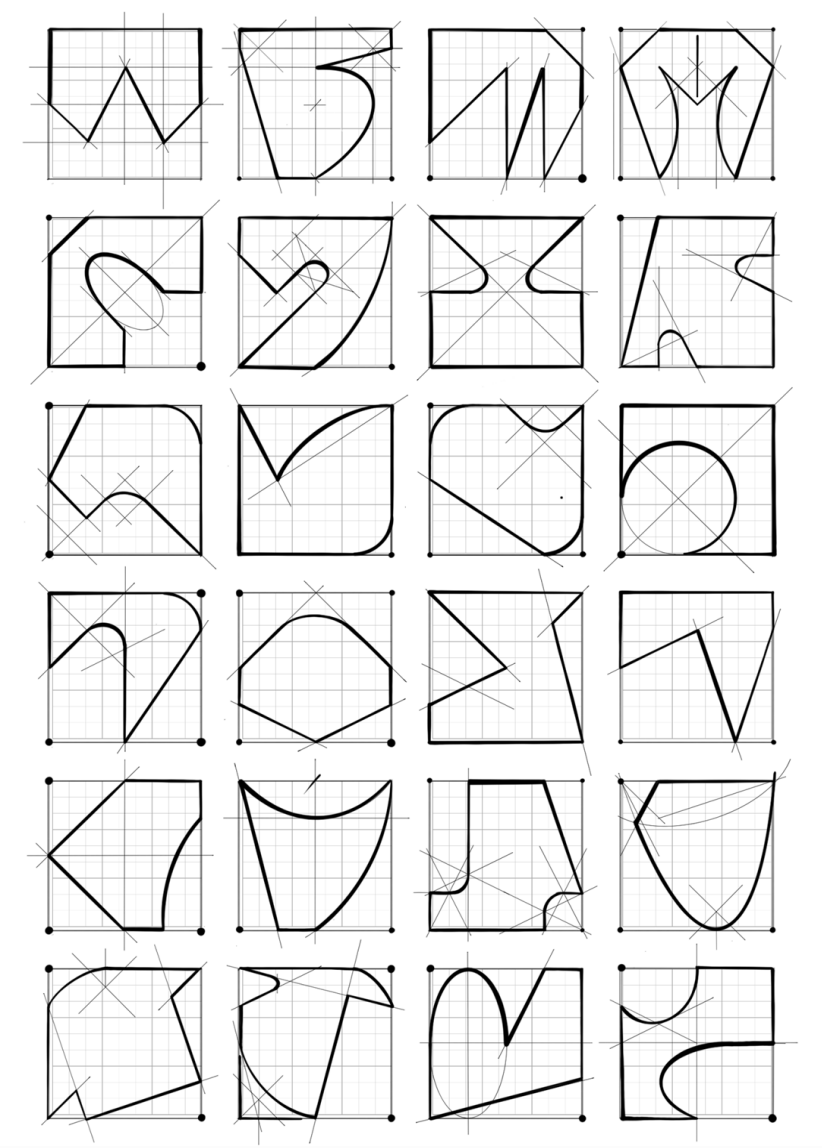
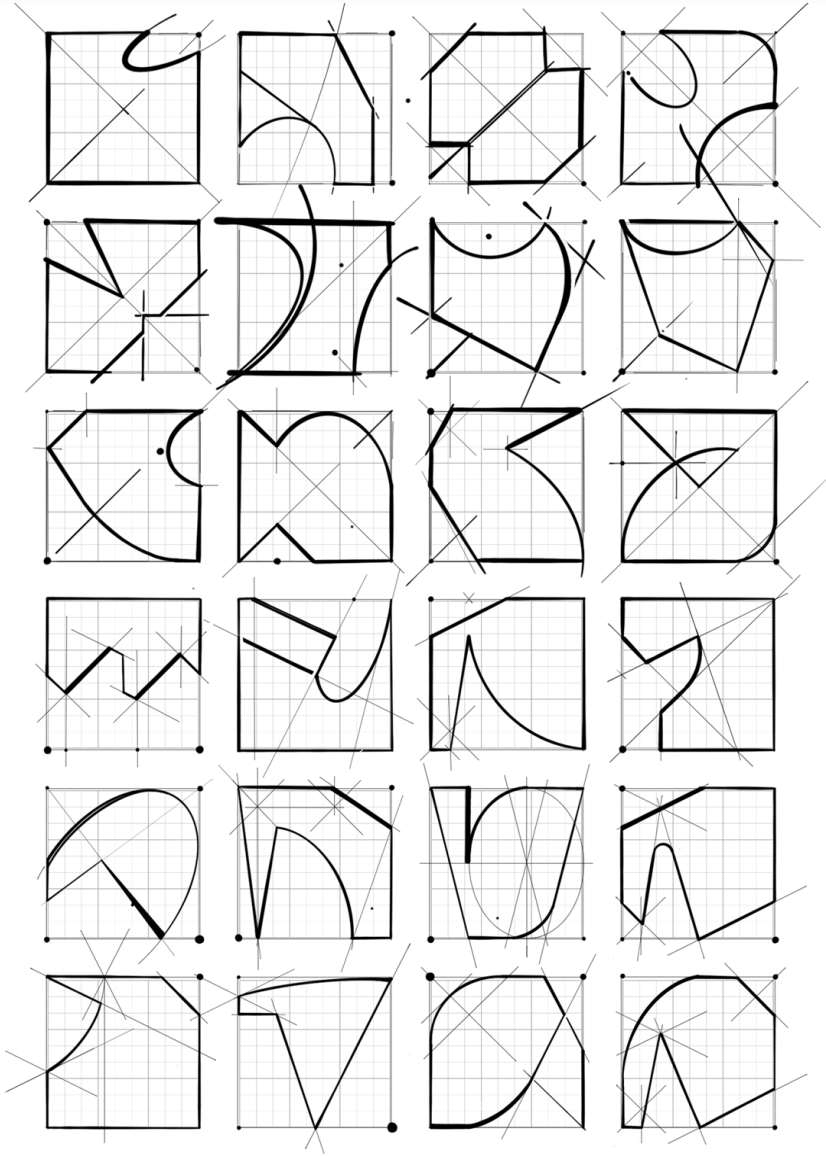
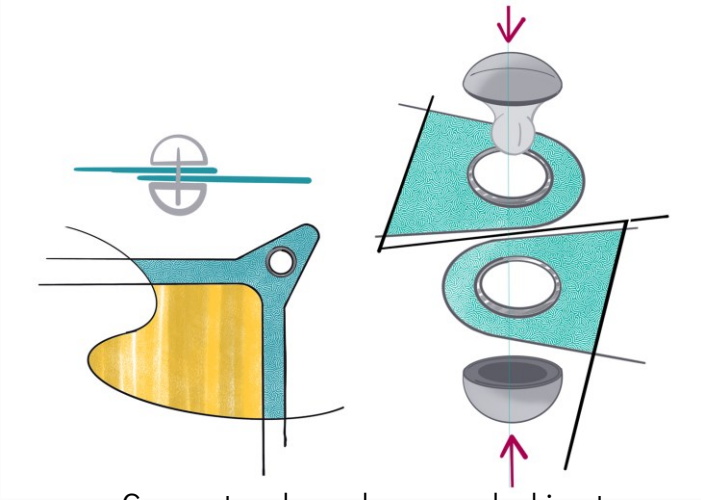
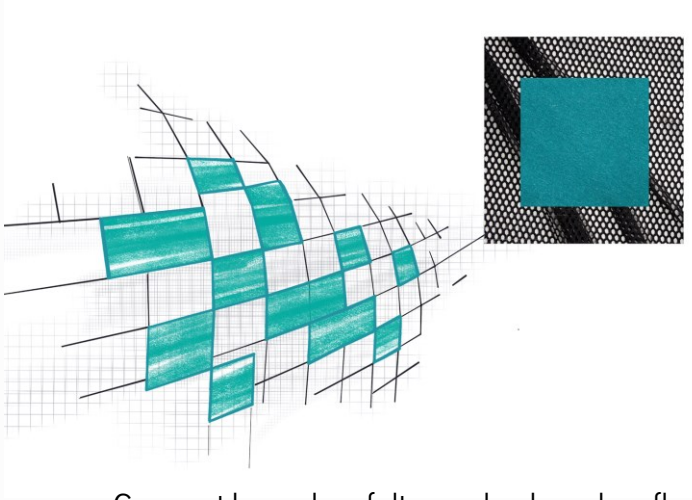




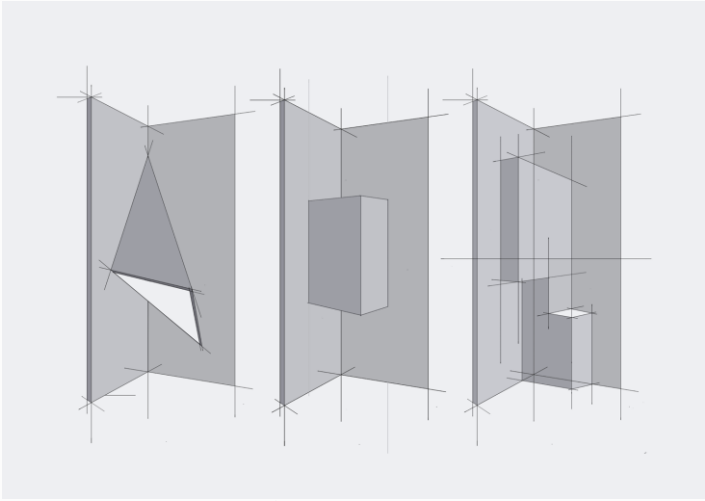
Initial Brainstorming



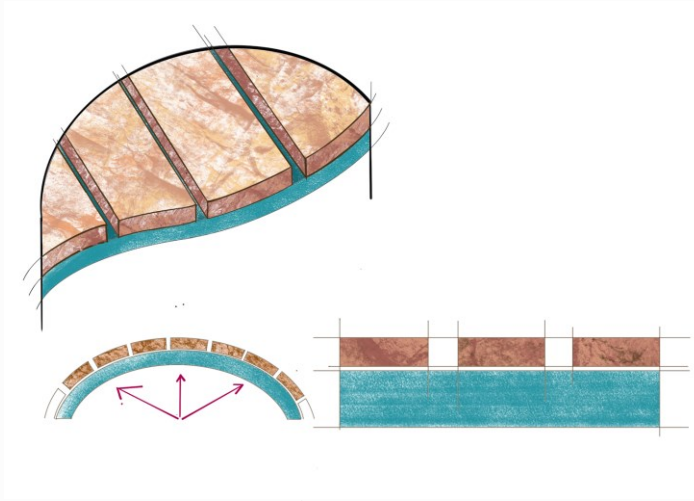
- Connectors based on snap locking to connect to panels or units from the corners.



- Concept based on felt panels placed on flexible membrane to achieve free flowing surfaces.



- Explorations for individual panel designs based on paper engineering techniques .



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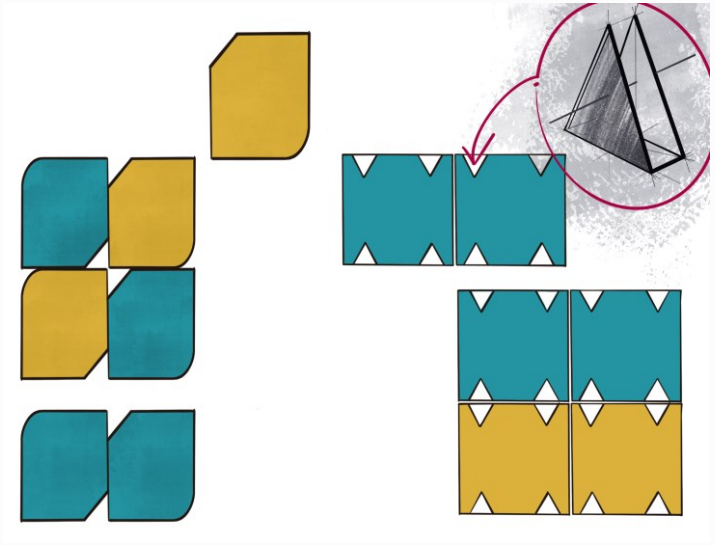
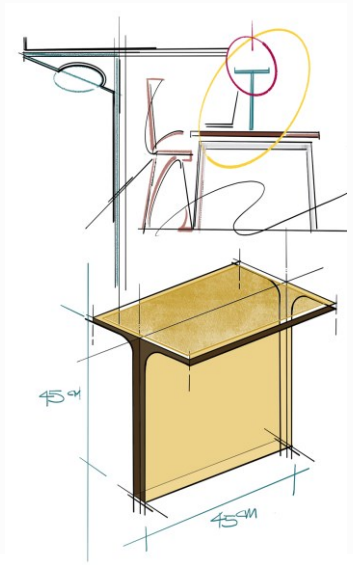
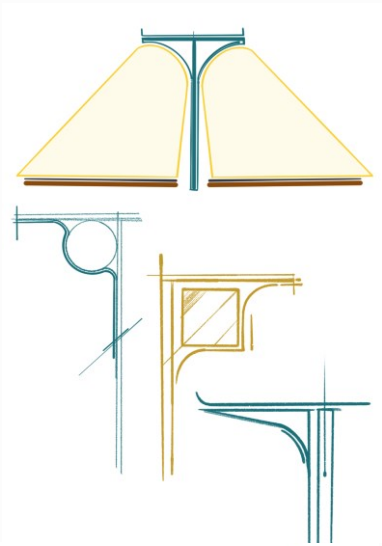
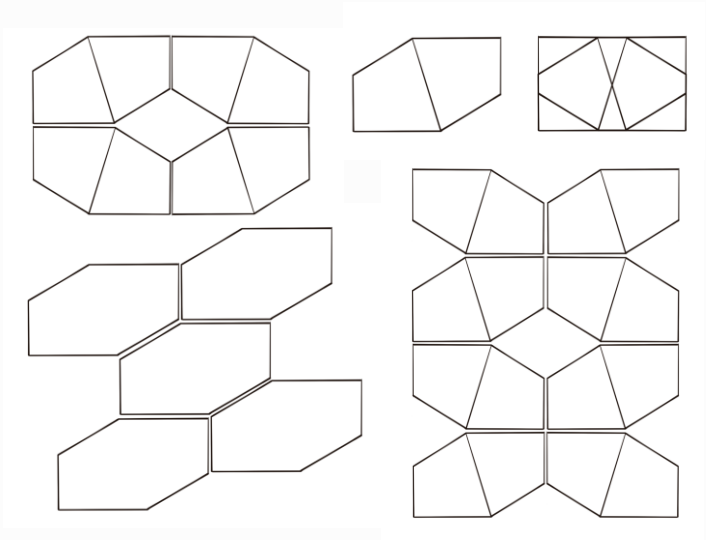
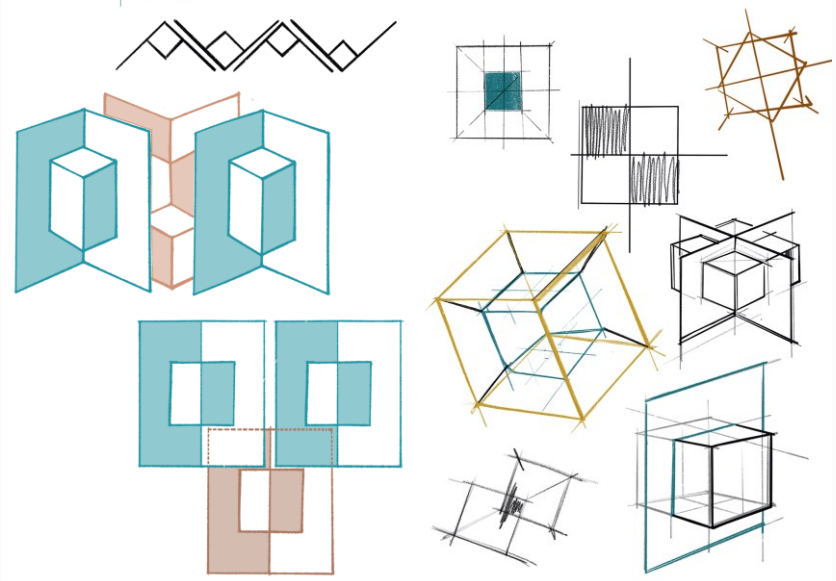


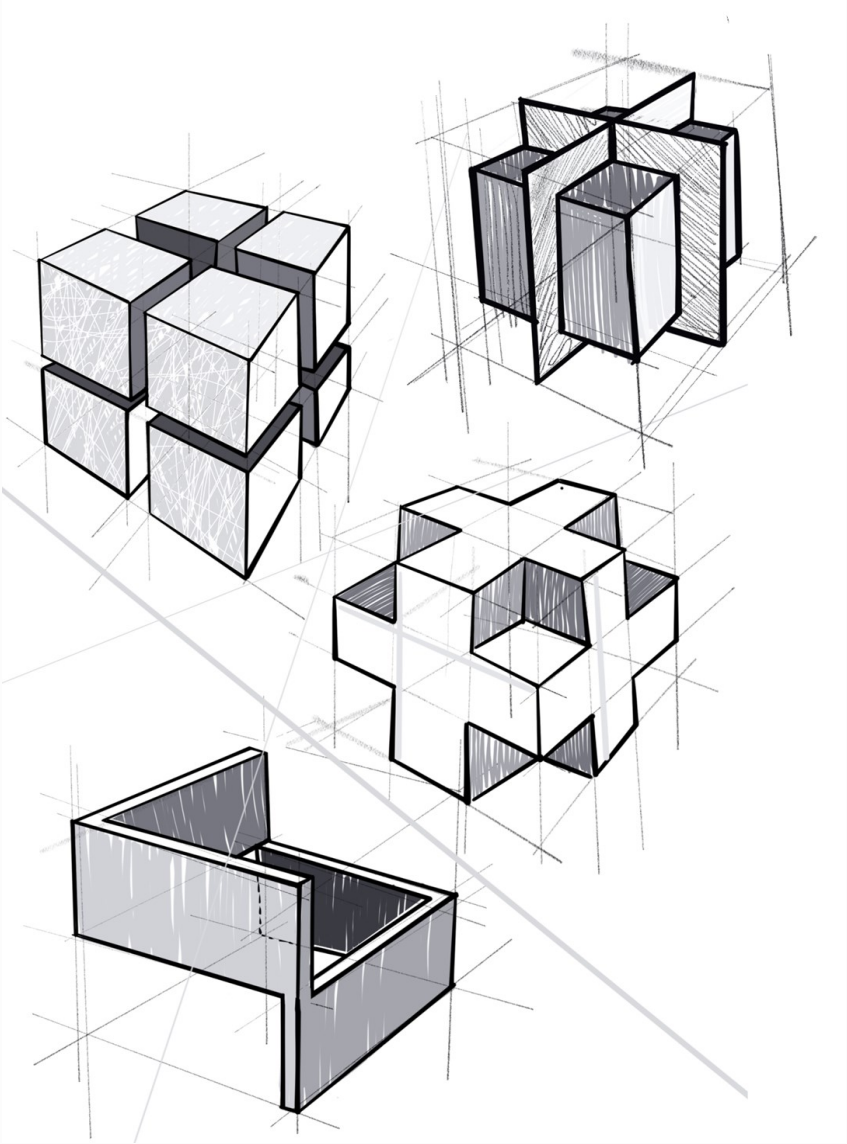


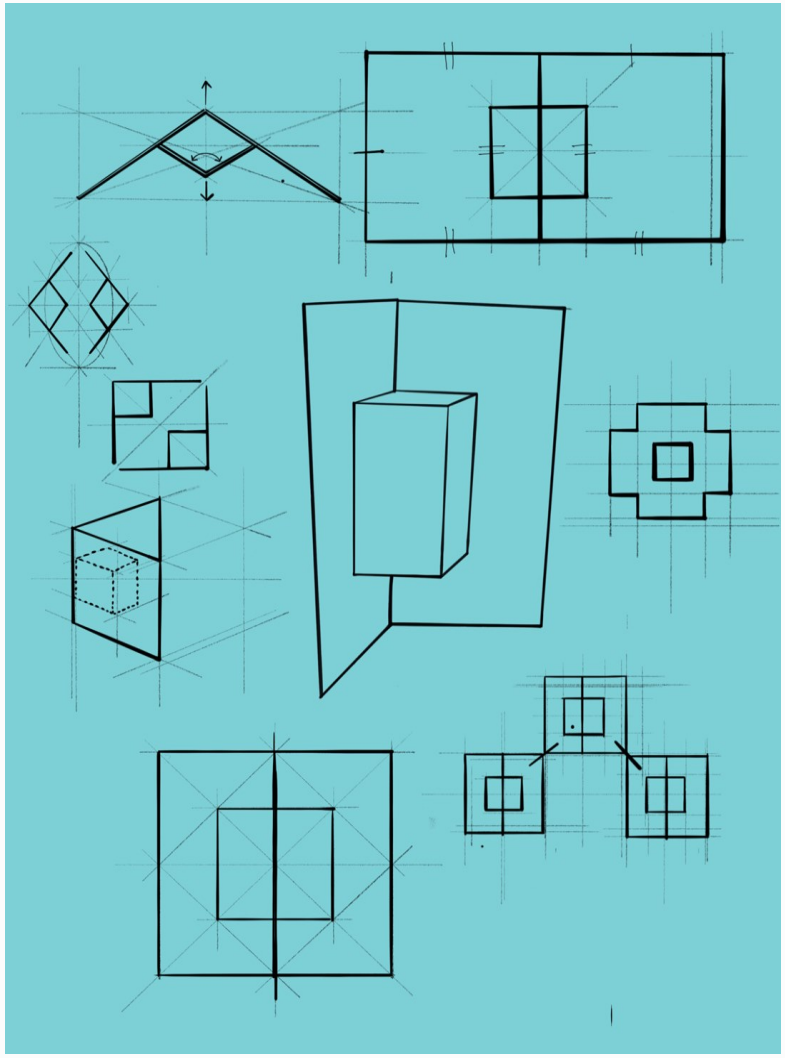


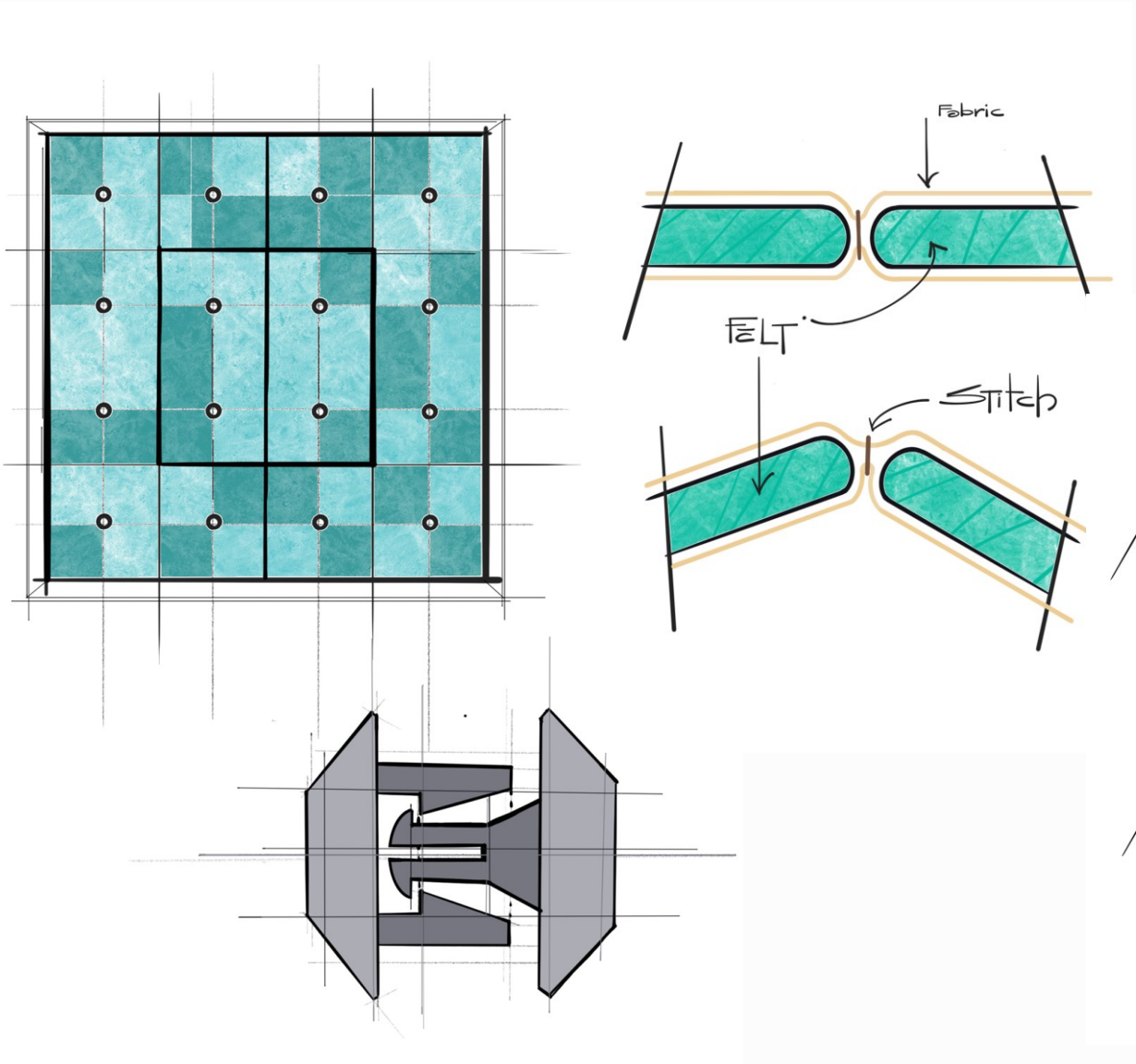




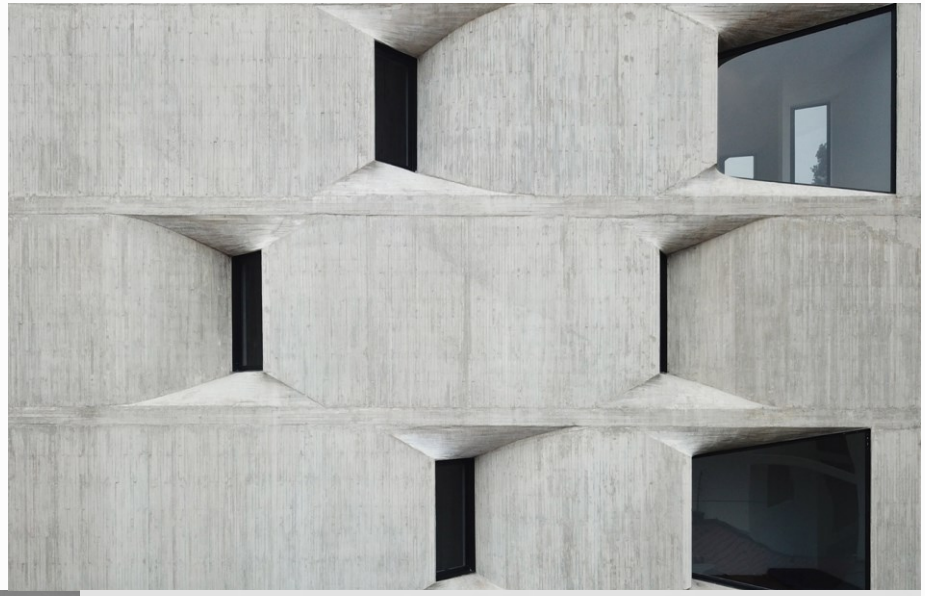
Final Concept

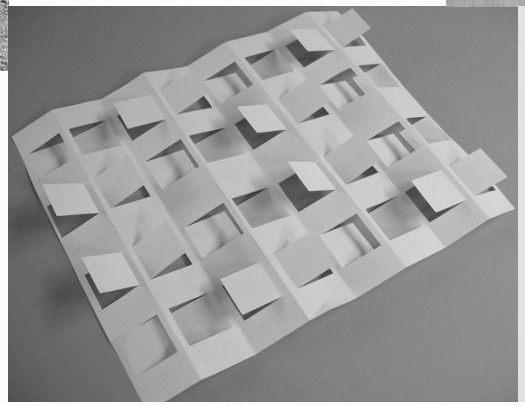


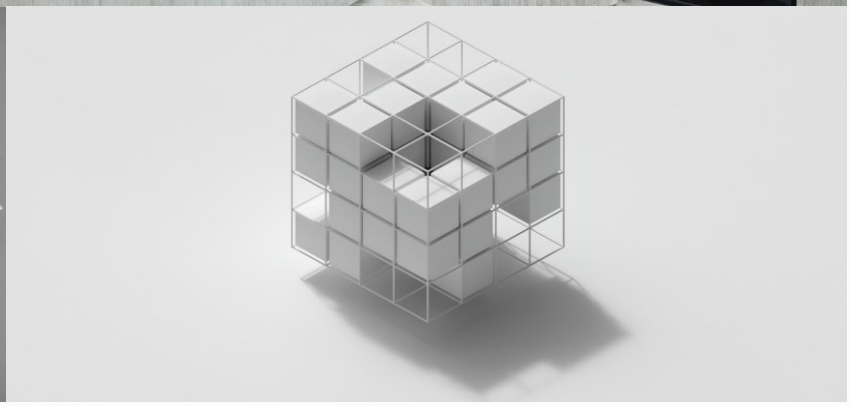



Fabric
FELT
Stitch
Fabric
FELT

MoodBoard

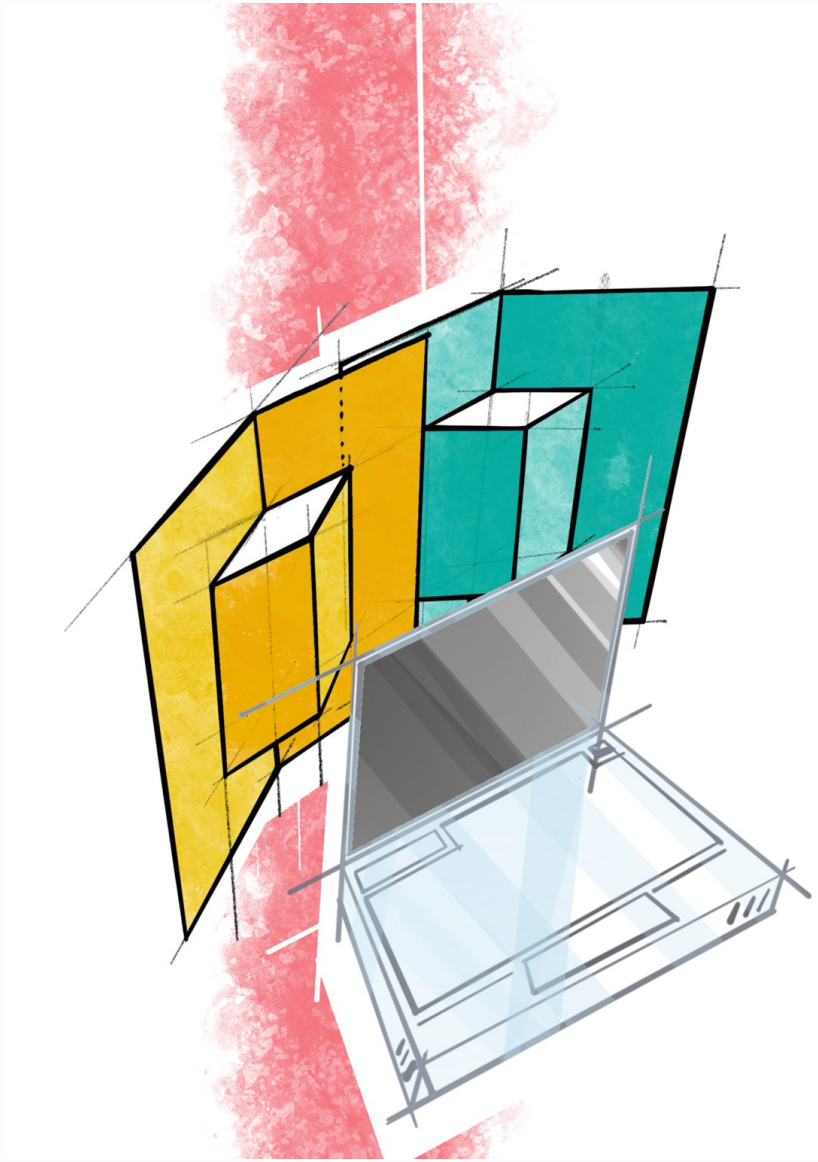






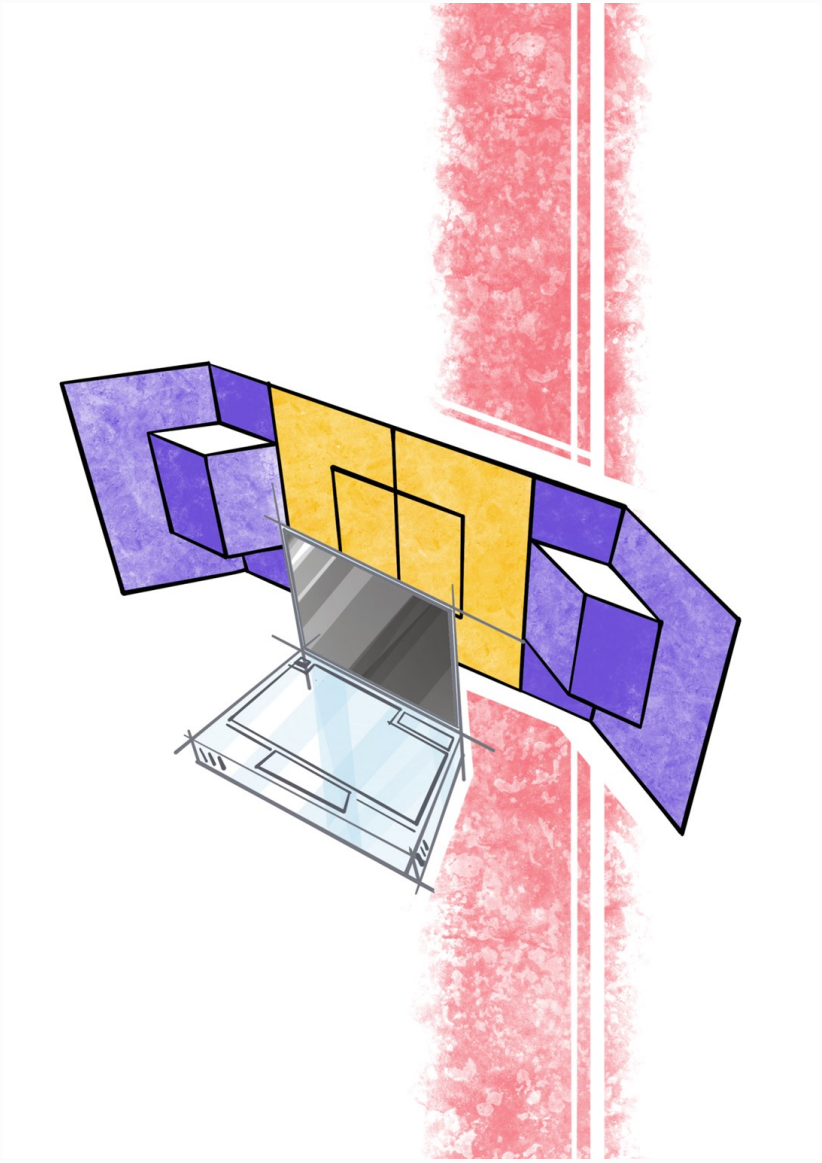
Final Concept

Desk Partition 01



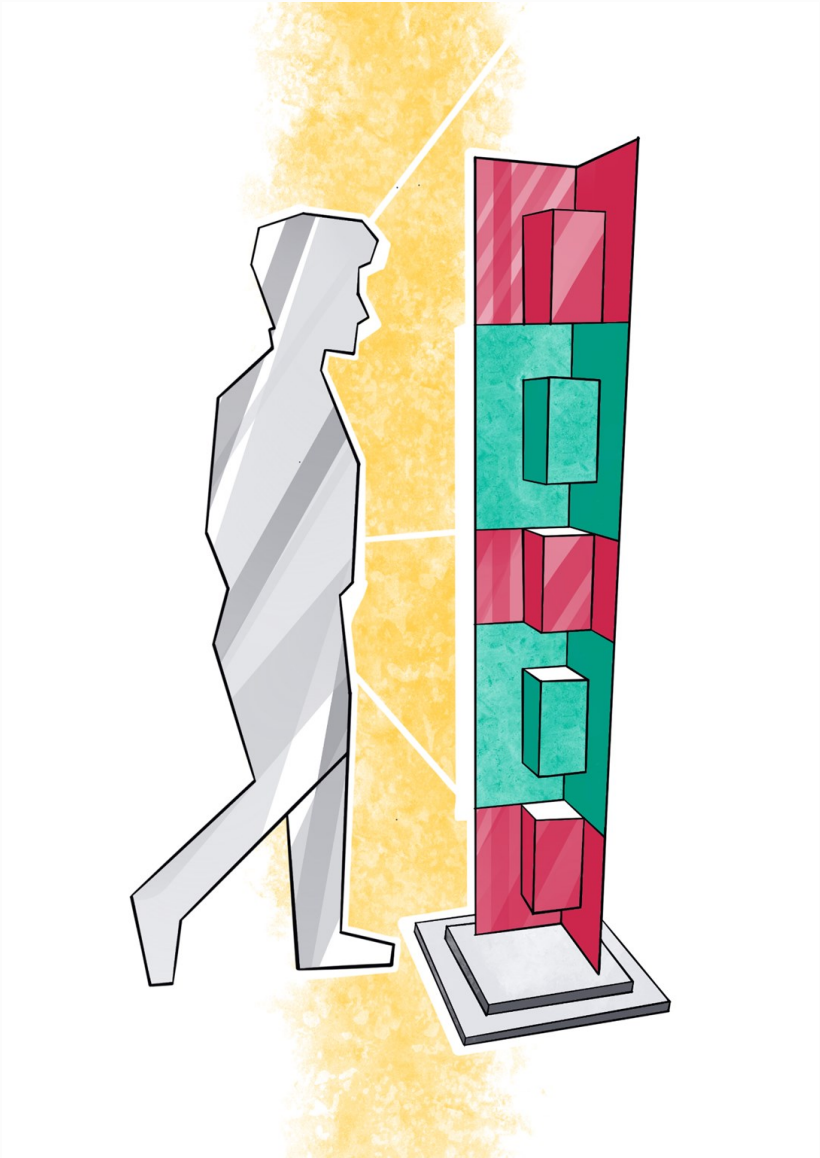
Final Concept

Desk Partition 02



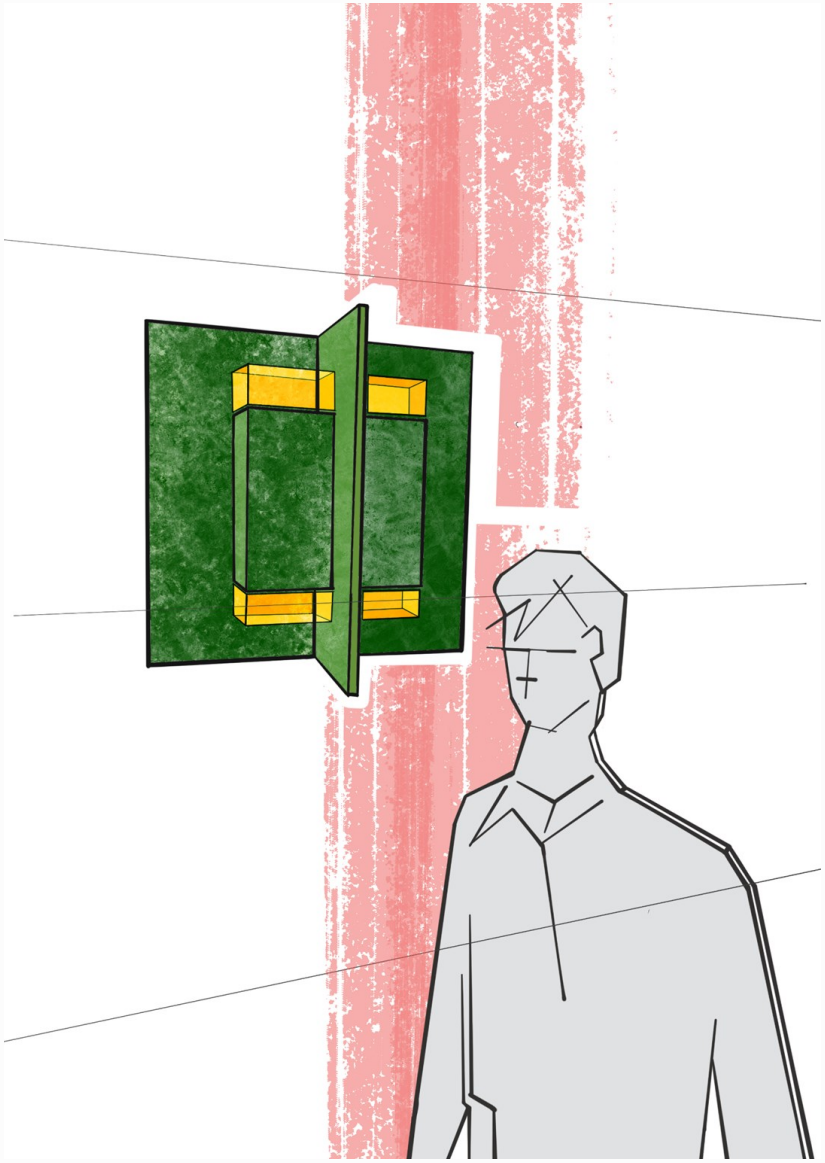
Final Concept

Free standing Screen



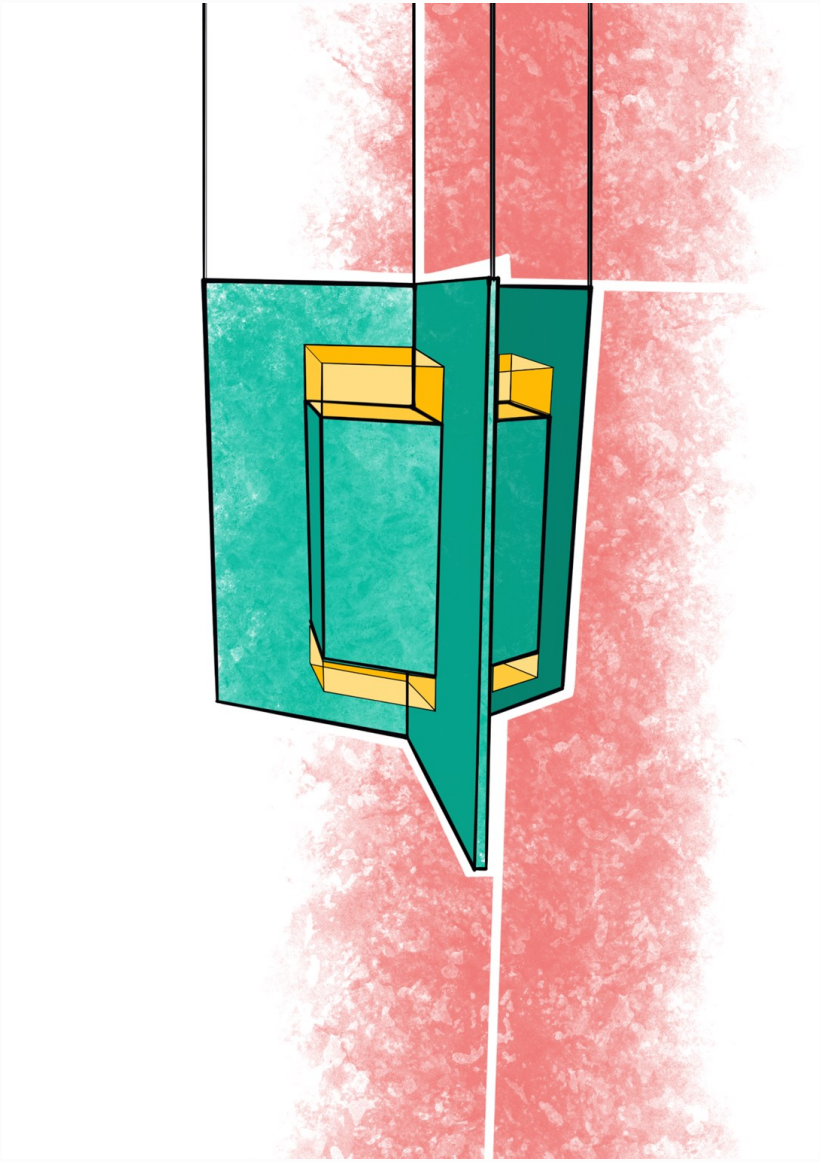
Final Concept

Wall Mounted Panels



Final Concept

Ceiling Hanging Lighting / Acoustic Treatment



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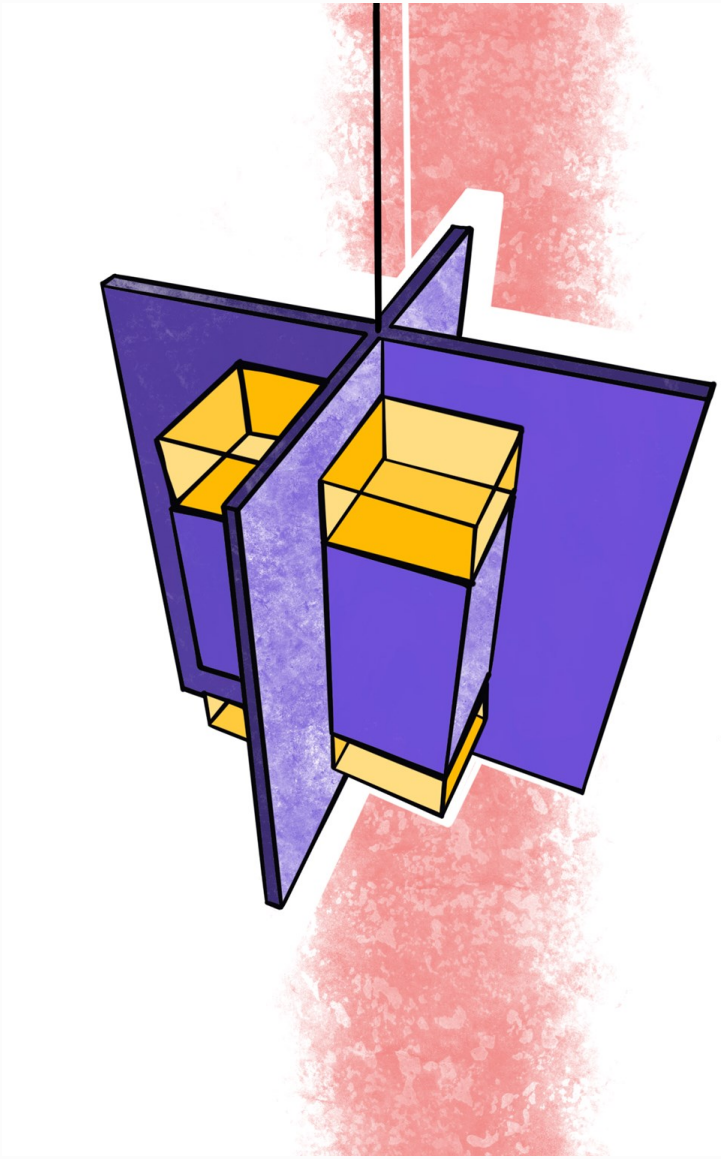

Final Concept

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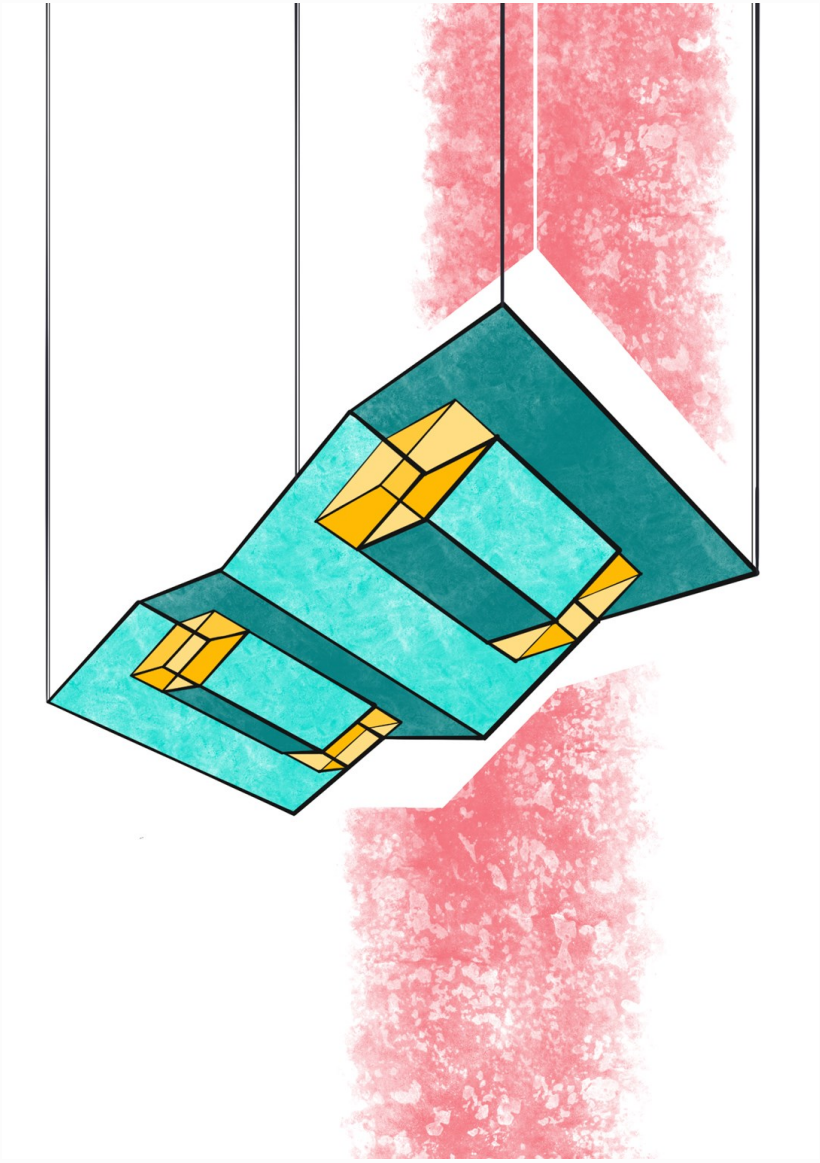
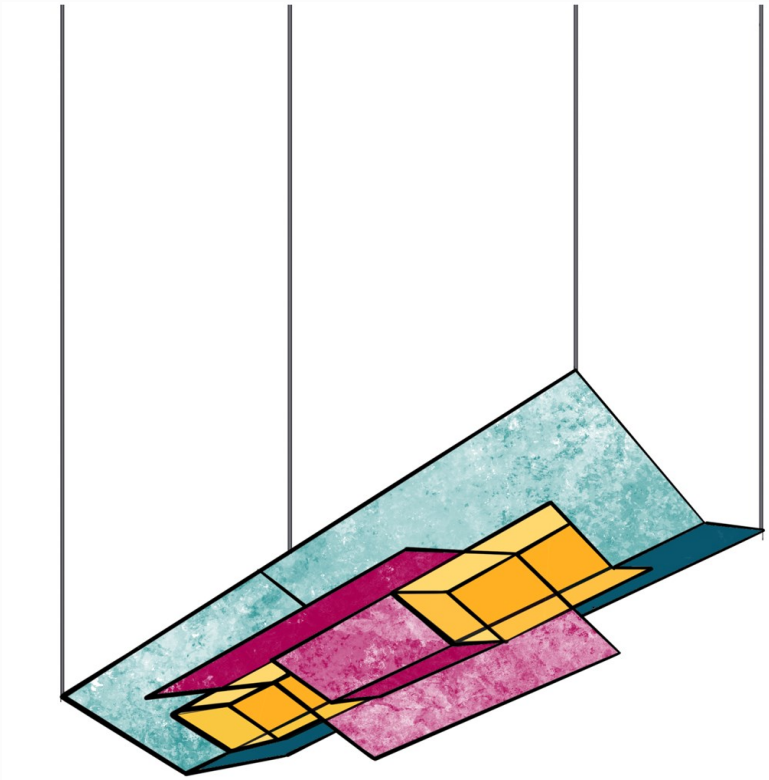


Final Concept

Ceiling Hanging Lighting / Acoustic Treatment

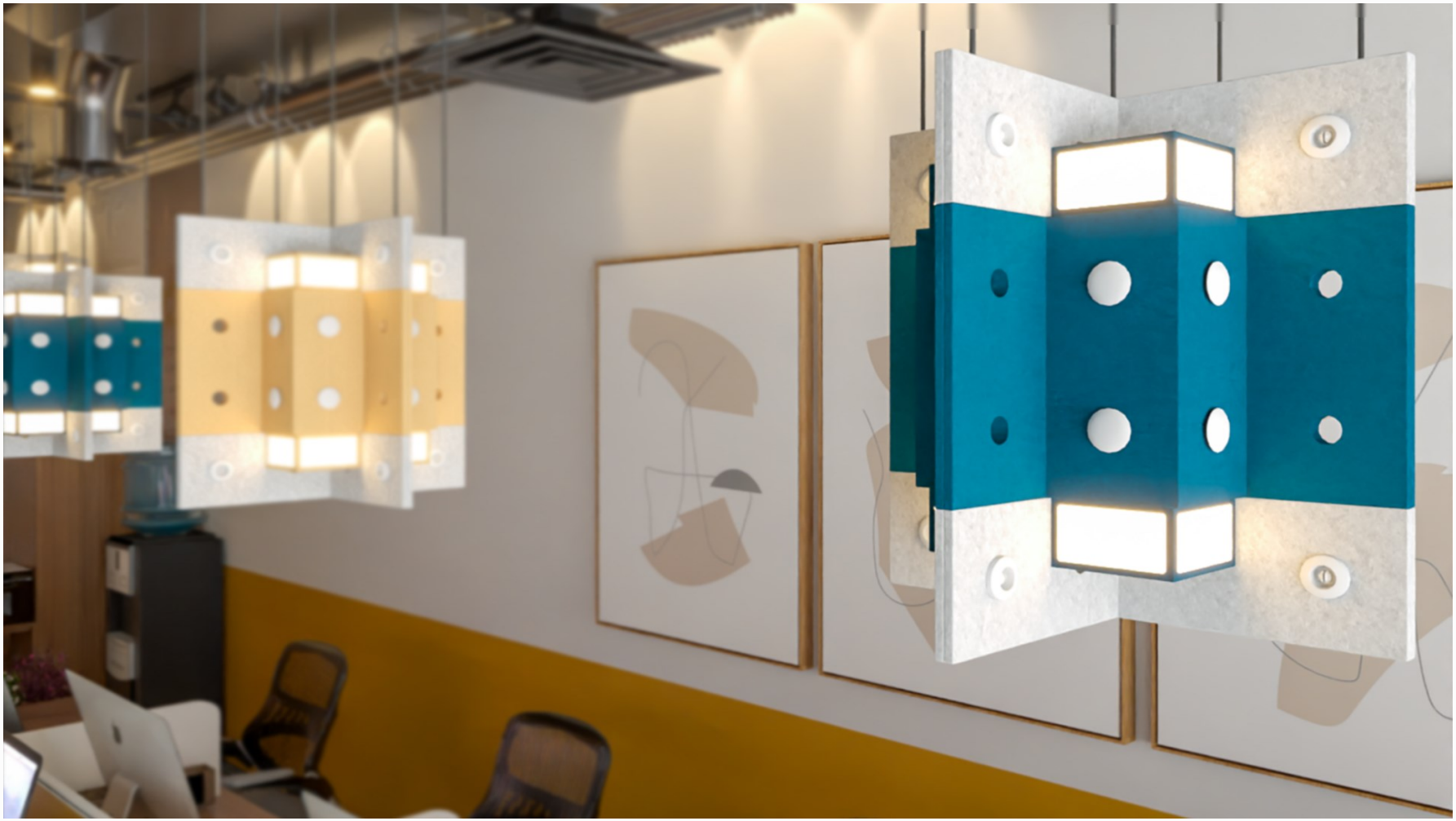


Final Concept

Final Concept


KẾT QUẢ
GIẢI PHÁP
VẠN DẶM
1 BƯỚC CHÂN
Hãy làm
Hoặc
ĐỪNG LÀM GÌ
ĐỪNG
SỢ HÃI
Không có gì
LÀ KHÔNG TH
LUÔN BIẾ


THU THÁCH
LÀM VIỆC
"EM TƯỜNG"
LƯƠNG TÂM
TRÁCH NHIỆM
QUÝ NHẤT
MIỄN PHÍ




VẠN DẶM
BƯỚC CHÂN

Challenges

The challenge in this project was material exploration. Though felt is a very age old and humble materia; it was challenging to work out the details and understand the behaviour of the material in various contexts.

Also as the the project works on multiple scenarios, it was interesting to ind adaptive modular solution for all these scenarios.

Also initially modularity seemed a very modest system to work within. But it was quite demanding while working out with details.

Insights

Leant that simple geometry can also work well with creating adaptive and elegant design.

Modularity can be helpful in achieving efficient and interactive systems.

Learnt how details play crucial role especially in modular systems.

References

Non Woven Fabric Needle Punching Machine for Shoulder Pads Making, Fabric Felt Making machine Manufacturer in India

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