UNIT -5

Acoustics

The word acoustics is originally derived from a Greek word meaning to hear. Hence, the acoustics is defined as the science of sound and as such, it discusses the origin, propagation and auditory sensation of sound. A sound is produced when part of the atmosphere is compressed suddenly.

This compression would have remained stationary at that place only in case the air was

not elastic. But due to elasticity of air, the particles originally disturbed in turn disturb

the neighbouring particles. Ultimately the compression is propagated or spread away

from the source. The sound thus travels in the form of waves and when these waves

come near our ear-drums, we feel a sensation of hearing.

Following important facts in connection with the sound are to be noted:

(i) The sounding body which throws the sound waves is in a state of vibration. If vibrations of the sounding body die out, the sound emitted by the sounding body will also die out.

(ii) It is absolutely necessary that for a sound to be heard by our ears, the sound body and ear must be connected by an uninterrupted series of portions of elastic matter. The physical state of the matter, namely, solid, liquid or gaseous, is of no importance.

(iii) The presence of some matter is required for the transmission of sound. The sound cannot travel in vacuum.

(iv) The sound waves are longitudinal waves and hence, each particle of the medium through which sound wave is proceeding, moves backwards and forwards along a line in the direction in which the sound wave is travelling.

The relation of sound with the human being is so common that we rarely appreciate its functions in our daily life. It permits us enjoyable experiences like listening to the musical programme, singing of birds, etc. It also permits the spoken communication with our family members and friends. It also warn us or alerts us

eg: ringing of telephone, knock at door, etc..

Noise And Its Effects

When the sound waves are periodic, regular and of long duration, they produce a pleasing effect and such a sound is known as the musical sound. On the contrary, when the sound waves are non-periodic, irregular and of short duration, they produce a displeasing effect and such a sound is known as the noise. Thus, a noise is an unwanted abrupt sound of complex character with an irregular period and amplitude originating from a source of non-periodic motion.

Following are the important effects of noise:

(i) The noise creates uncomfortable living conditions.

(ii) The prolonged exposure to the noise may result into temporary deafness or nervous breakdowns.

(iii) It is observed that the noise has an influence on blood pressure, on muscular strain and even on sleep.

(iv) The noise leads to the fatigue and consequently, the efficiency of persons exposed to the noise decreases considerably.

(v) It is an established fact that reduction in the noise increases to a great extent the output of labour.

(vi) The presence of noise takes away the essence of music and speech.

Properties of noise

The properties of noise can be described in both physical and subjective terms. Here are some of the key ones:

- **Physical properties:**

1) Frequency

The frequency or pitch is defined as the number of pressure variations which a sounding body makes in each unit of time. The greater the number of variations, the higher will be the pitch. The intensity of sound is defined as the flow of sound energy per unit of time through unit area.

The difference between the of ear of listen quantity which can dealer be noted the **intensity.**

Thus, the frequency the pitch is a measure of the quality of sound while intensity intensity is measure of the quantity of sound energy. The difference between the two terms intensity of sound and loudness should. The intensity of independent of ear of listener. On the other hand, the loudness is the degree of sensation which is not wholly physical, but partly subjective and it does depend upon the ear of listenear.

The frequency is measured in cycles per second or Hertz (Hz) as it is now called by the interna 20000 Hz (ment. The range of human heng (Hay from 20 Hz to 20000 Hz (or 20 kHz). It may be noted thaingrange from the lowe to the highest note of piano is about 27.5 Hz to 4186 Hz.

The lower limit indicates the frequency which is required for an average human ear to perceive the sound. If the frequency of sound is below the lower limit, the effect of sound is lost and distinct pulses are experienced. The upper limit of frequency depends receive the sound. on the age of the person and his physical fitness to

The wavelength of sound i.e. the physical distance in air from one wave top to the next can be found out by knowing its speed and frequency with the help of the following equation:

$$\textbf{Wavelength} = \frac{speed}{frequency}$$

or acoustics and sound measurement purposes, the speed of sound is taken as 340 m/sec. Thus, the wavelerith at 20 Hz will be 17 m while at 20 kHz, it will be only 17 mm.

The intensity of sound is measured on a logarithmic scale due to a wide range of variation of the intensity of sound. The two sounds of the same character and of intensities I_1 and I_2 (energy units) are said to differ by a bels when $\mathbf{n = \log_{10} \frac{I1}{I2}}$ .The unit of bel is named after Alexander Graham Bell (1847-1922), U.S. inventor of the telephone, born in Scotland.

The unit of bel is comparatively large and hence, in practice, a shorter practical unit of decibel (abbreviated to db) equal to $\frac{1}{10}$ of a bel is used. Thus, the two sounds as mentioned in the previous case are said to differ by m decibels when $\mathbf{m = 10 \log_{10} \frac{I1}{I2}}$ The difference in loudness m of the two sounds is technically known as the intensity level.

If m=1 db.

$1 = 10 \log_{10} \frac{I1}{I2}$

$\log_{10} \frac{I1}{I2} = \frac{1}{10}$

INTENSITY :

The range of audible sound to painful noise varies from 1 to 1013. But this we range is covered on logarithmic scale between 1 to 130 db units. One do unit approximately the smallest change of sound intensity which the human ear is able to appreciate.

It is quite clear that intensity of sound is affected by the frequency of sound and as this scale does not take into account this factor, the more representative of phen is used. The phon indicates the level of sounds of equal loudness at a frequencies. For convenience, the phons and decibels differ so slightly that they may be treated as synonymous.

SOME TYPICAL SOUND LEVELS:

Threshold of audibility - zero

Rustling of leaves due to a gentle wind - 20

Quiet whispering - 30

Conversation at a distance of 1 meter - 40

Quiet speech - 50

Average Office – 55

Small Shop – 60

City traffic in busy street – 70

Printing press – 80

Large factory – 90

Boiler factory – 110

Loud noise accompanying lightning – 120

Aeroplane noise at a distance of 3 meters – 130

ARBITRARILY :

It should be noted that the intensity of sound in do and frequency of sound in cycles per second are physical quantities which are defined arbitrarily. These quantities are measured with the help of mechanical or electrical equipment. There is no compulsion on the ear of the human being to Interpret these physical quantities according to the same rules

The sound pressure corresponding to the threshold of hearing is about 0.03 KN per m and that corresponding to the threshold of painful hearing is about 30000 kN per

TIMBER:

One of the important characteristic of sound is its timbre or quality. The notes given by two musical instruments like planta or quality, The notes of a novenalty, are clearly distinnd come, they may The quality of a musical note is called its timber.

A tone is a sound of distinct pitch that may be put into harmonic relation with other such sounds. In general, the musical notes are compose harmonic recognisation the note being that corresponding to the lowest tone Imposed of tones, the pitch of the frequency n is called the fundamental tone he additional tones of frequency 2π 3π 4π etc. are called the overtones or upper partials of the fundamental The quality or timbre of a note is determined by its complex structure and it depends

The quality or timbre of a note is determined by its complex structure and it depends on the overtones which accompany the fundamental. In general, the noted in which the fundamental is relatively strong and the overtones in grew and feebles are of soft and sweet character. On the other hand, the notes in which the overtones are sumerous and strong, are harsher and have a so-called metallic sound. It is to be noted that the memory of this tonal quality assists us in recognising a large number of different sounds such as cries of animals, voices of friends and relatives, sounds of familiar musical instruments, etc.

MEASUREMENTS OF SOUNDS:

bjects: Following are the objects or purposes of measuring the sound:

(i) It helps in improviding building acoustics and loudspeakers and thus enhances our enjoyment of music, both in the concert hall and home.

(i!) It indicates when a sound may cause hearing damage and thus helps in taking corrective measures to be taken, for avoiding the same.

(iii) It permits evaluation of the hearing sensitivity of an individual.

(iv) It permits precise and scientific analysis of the annoying sounds and as such, gives us an objective means of comparing annoying sounds under different conditions.

(v) It permits the improvement of the quality of our lives.

(vi) It serves as a powerful diagnostic tool in the noise reduction programmes.

Sound level meter: A sound level meter is an instrument which responds to the sound in approximately the same way as the human ear and which gives objective reproduceable measurements of the sound level.

The sound level is converted to an identical electrical signal by a high quality microphone and since the signal is quite small, it must be amplified before it can be read on a meter.

It must have uniform frequency response le. It must be equally sensitive at all The quality of the measuring microphone must meet many high standards frequencies. The microphone should be equally sensitive to the sounds coming from All angles or the other opbeds, it must possess an omnidirectional characteristic.

The sound level meter is a precise Instrument and hence provision ihe principles of acoustics in buildings involve the study of sound transmission, absorption, reflection, and reverberation within a built environment. Effective acoustic design aims to create spaces that enhance communication, comfort, and overall well-being. Here are some key principles of acoustics in buildings:s made calibrate it for accurate results. It is best done by placing a portable acoustic calibrate directly over the microphone. This calibrator is basically a miniature loudspeaker giving a precisely defined sound pressure level to which the sound level meter can be adjusted.

PRINCIPLES OF ACOUSTIC OF BUILDINGS:

The principles of acoustics in buildings involve the study of sound transmission, absorption, reflection, and reverberation within a built environment. Effective acoustic design aims to create spaces that enhance communication, comfort, and overall well-being. Here are some key principles of acoustics in building.

Sound Absorption:

Materials: Use sound-absorbing materials such as acoustic panels, baffles, and ceiling tiles to reduce the reflection of sound waves.

Placement: Strategically place absorptive materials in areas where sound reflections are likely to occur, such as in large open spaces or rooms with hard surfaces.

Sound Reflection:

Surfaces: Design surfaces that reflect sound appropriately. In some cases, controlled reflection can be desirable to enhance the quality of music or speech.

Angles: Use angled surfaces to direct sound in specific directions, avoiding excessive reflections that can lead to reverberation issues.

Sound Transmission:

Isolation: Implement measures to isolate sound between different spaces. This is crucial in preventing unwanted noise transfer between rooms or between indoor and outdoor environments.

Sealing: Ensure that doors, windows, and other openings are properly sealed to minimize the transmission of airborne and impact sounds.

Reverberation Control:

Time: Manage the reverberation time, which is the time it takes for sound to decay by 60 decibels after the source has stopped. This is important for controlling the clarity of speech and preventing excessive noise buildup.

Materials: Choose materials with appropriate acoustic properties to control reverberation. Soft materials tend to absorb sound and reduce reverberation.

Room Shape and Design:

Geometry: The shape of a room can influence the way sound behaves. Irregular shapes and the presence of diffusers can help distribute sound more evenly.

Ceiling Height: Higher ceilings generally lead to longer reverberation times, so they may need additional acoustic treatment.

Background Noise:

HVAC Systems: Consider the noise generated by heating, ventilation, and air conditioning (HVAC) systems. Proper design and placement can minimize their impact on the overall acoustic environment.

Equipment: Select quiet equipment and appliances to avoid adding unnecessary background noise.

Occupant Comfort:

Speech Intelligibility: Strive for good speech intelligibility by controlling background noise, reverberation, and reflections.

Comfortable Sound Levels: Aim for comfortable sound levels in different areas of a building, taking into account the function of each space.

Regulations and Standards:

Compliance: Be aware of local building codes, regulations, and industry standards related to acoustics. Compliance with these standards is often necessary for both residential and commercial buildings.

By incorporating these principles, architects and acoustic consultants can create buildings that provide optimal acoustic conditions for their intended purposes, whether it be a concert hall, office space, classroom, or residential area.

SOUND INSULATION:

Sound insulation, also known as soundproofing or acoustical insulation, is the process of minimizing the transmission of sound between different spaces. This is important for maintaining privacy, reducing disturbances, and creating a comfortable and quiet environment within a building. Here are key principles and methods related to sound insulation:

Mass and Density:

Heavier Materials: Sound transmission can be reduced by using heavy and dense materials. Thicker walls and floors with higher mass are more effective in blocking sound.

Decoupling:

Isolation: Decoupling involves separating building elements to minimize the direct transmission of vibrations and sound waves. This can be achieved by using resilient mounts, isolating walls, and floating floors.

Airborne vs. Impact Sound:

Airborne Sound: This is sound that travels through the air, such as speech or music. Insulation against airborne sound involves using materials that absorb or block sound waves.

Impact Sound: This is sound that is transmitted through direct contact with a surface, such as footsteps or machinery vibrations. Insulation against impact sound often requires isolating structural elements.

Sealing and Gaps:

Weather Stripping: Ensure that doors and windows are properly sealed with weather stripping to prevent the passage of sound.

Gaps: Seal any gaps or openings in walls, floors, and ceilings. Even small gaps can significantly compromise sound insulation.

Double Walls and Ceilings: Double Stud Walls: Building double stud walls with a gap in between can help reduce sound transmission.

Double Drywall: Adding a second layer of drywall with damping adhesive can enhance sound insulation.

Resilient Channels:

Installation: Resilient channels are metal or wooden strips that are attached to the framing, providing a break in the direct connection between the drywall and the structure. This helps to reduce sound transmission.

Use of Insulating Materials:

Insulation Materials: Install sound-absorbing or insulating materials within walls and ceilings. Common materials include fiberglass, mineral wool, and foam panels.

Ceiling Clouds and Baffles:

Hangings: Suspended baffles and clouds can be used to absorb and block sound reflections in open spaces, such as auditoriums or gymnasiums.

IMPORTANCE OF SOUND INSULATION:

Privacy: Sound insulation is crucial for maintaining privacy within different spaces. It prevents the transmission of conversations, music, or other noises from one room to another, ensuring that confidential discussions remain confidential.

Productivity: In office environments, sound insulation helps create a quieter atmosphere, reducing distractions and enhancing concentration and productivity. This is particularly important in open office layouts where employees work in close proximity.

Comfort in Residences: Sound insulation contributes to a peaceful and comfortable living environment in residential spaces. It helps prevent noise disturbances from neighboring units, busy streets, or other external sources, allowing residents to enjoy a restful and undisturbed living space.

Health and Well-being: Exposure to constant or excessive noise can have negative effects on physical and mental health. Sound insulation measures contribute to creating a healthier indoor environment by reducing stress and promoting relaxation.

Compliance with Building Codes: Many building codes and regulations include requirements for sound insulation, especially in multi-unit residential buildings, hotels, and commercial spaces. Compliance ensures that buildings meet minimum standards for occupant comfort.

Meeting Specific Needs: Certain spaces have specific requirements for sound insulation. For example, recording studios, home theaters, and medical facilities demand high levels of soundproofing to achieve optimal acoustic conditions.

Measures for Sound Insulation:

Wall Construction: e double-stud walls with an air gap to reduce sound transmission.

Incorporate heavy and dense materials in wall construction to increase mass and block sound.

Floor and Ceiling Construction:

Use floating floors or suspended ceilings to minimize direct contact between surfaces.

Install resilient channels or joist isolators to break the transmission path for impact sound.

Sealing and Weather Stripping:

Seal gaps and openings around windows, doors, and other openings using weather stripping and caulking.

Insulating Materials:

Use sound-absorbing insulation materials within walls, ceilings, and floors. Common materials include fiberglass, mineral wool, and foam.

Double Glazing:

Install double or triple-pane windows to reduce the transmission of sound from outside.

Resilient Mounts:

Use resilient mounts for mechanical equipment and appliances to isolate vibrations and prevent them from transmitting through the building structure.

Doors:

Install solid-core doors with weather stripping to minimize sound transmission.

Acoustic Panels:

Use acoustic panels on walls and ceilings to absorb sound and reduce reflections within a space.

Consult with Acoustic Professionals:

Use acoustic panels on walls and ceilings to absorb sound and reduce reflections within a space.

Consult with Acoustic Professionals:

Seek guidance from acoustic consultants or professionals who can assess specific needs and recommend tailored solutions.

By implementing these measures, builders and designers can create spaces that provide effective sound insulation, contributing to a comfortable and functional environment for occupants.