**Environmental Engineering**

**Lec.1 Noise Pollution 4th year**

 **1.1 Noise**

 Noise can be defined as unwanted sound or sound in the wrong place at the wrong time. Noise is undesirable because it interferes with speech and hearing, is intense enough to damage hearing or is otherwise annoying.

 The definition of noise as unwanted sound implies that it has an adverse effect on human beings and their environment, including land structures and domestic animals. it is also disturbs natural wildlife and ecological systems.

**1.2 Sound Wave**

 Sound is a mechanical energy from a vibrating surface which spreads as spherical or plane wave forms and is transmitted by a cyclic series of compressions are rarefactions of the sound transmitting media. The sound results in a sound pressure longitudinal wave that alternatively rises to a maximum level.

 Waves may be of two sorts, transverse and longitudinal. While solids will transmit both kinds, liquids and gases will transmit only longitudinal waves. Sound waves



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are usually shown as if they were for instance on an oscilloscope (transverse compression) and drops to a minimum level (rarefaction). On striking the ear, it may be heard as sound waves.

Sound pressure variation of a sine wave showing the phase relationship between pressure and particle displacement.

Amplitude (A) : the maximum or minimum pressure.

Wavelength (λ) : the distance between successive troughs or crests.

Period (T) : the time lapse between successive peaks.

Frequency (f) : the number of complete pressure variations or cycles/second.

***Relationship:***

 Based on energy transmittance characteristics they are categorized as electromagnetic and mechanical waves. An electromagnetic wave is a wave, which is capable of transmitting its energy through a vacuum whereas a mechanical wave is not capable of transmitting its energy through a vacuum.

The speed of propagation (c) of sound in air is 340 m/s, at 20oC and 1 atmosphere pressure. At other temperatures, it may be calculated by using the formula:

Sound / noise results from periodic disturbances of the air at room temperature are propagated in air at a speed of approximately 340m/s. In water (1500m/s) and steel (5000m/s), the speed is much greater.

**1.3 Categories of Waves**

 On the basis of the direction of the movement of the individual particles of the medium relative to the direction, waves are categorized as transverse waves, longitudinal waves, and surface waves. A transverse wave is a wave in which particles of the medium move in a direction perpendicular to the direction, which the wave moves, i. e. they are characterized by particle motion being perpendicular to wave motion. A longitudinal wave is a wave in which particles of the medium move in a direction parallel to the direction, which the wave moves, i.e. they are always characterized by particle motion being parallel to wave motion. A surface wave is a wave in which particles of the medium undergo a circular motion. They are neither transverse nor longitudinal waves.



 Longitudinal wave

 Source moves Coils move

 Left and right left and right

 Transverse wave

 Source moves Coils move

 up and down up and down



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Energy Transport

Energy Transport

Surface wave

**1.4 Octave Bands**

 Most sound sources contain energy over a wide range of frequencies. For measurements, analysis and specification of sound, the frequency range is divided into sections called the frequency bands. One command standard division into 10 octave bands identified by their center frequencies:

 31.5, 63 , 125 , 250 , 500 , 1000 , 2000 , 4000 , 8000 and 16000 Hz.

 The frequency of these 10 octave bands is 22.4 – 22400 Hz. Furthermore, there are 4 other octave bands covering the infrasonic range of frequency with centre frequencies of 2 , 4, 8 and 16Hz, the frequency range of these 4 octave bands is 1.41 – 22.4 Hz.

 In each octave band, the upper limiting frequency fU is exactly twice the lower limiting frequency fL. The centre frequency fC of each octave band defined as:

𝑓C=

|  |  |
| --- | --- |
| Octave bands Hz | Octave centers 𝑓C Hz |
| fL | fU |
| 1.41 | 2.82 | 2 |
| 2.82 | 5.62 | 4 |
| 5.62 | 11.2 | 8 |
| 11.2 | 22,4 | 16 |
| 22,4 | 44.7 | 31.5 |
| 44.7 | 89.1 | 63 |
| 89.1 | 178 | 125 |
| 178 | 355 | 250 |
| 355 | 708 | 500 |
| 708 | 1410 | 1000 |
| 1410 | 2820 | 2000 |
| 2820 | 5620 | 4000 |
| 5620 | 11200 | 8000 |
| 11200 | 22400 | 16000 |

**1.5 Sound Pressure**

 The sound is caused by rapid fluctuations in air pressure; a sound wave consists of pressures above and below the normal pressure in the air. The smallest sound pressure that an average young adult can detect corresponds to a sound pressure of 20 µpa at a frequency 1000Hz. This value of sound pressure is internationally accepted as the threshold of hearing.

**1.6 Sound Intensity and Sound Power**

The sound power flowing per unit area, in a given direction, measured over an area perpendicular to the direction of flow, its units are W/m2, Symbolically, the sound intensity is then

Where I= sound intensity (W/m2)

 W= acoustical sound power of the source (W)

 A= surface area (m2), for a point source, the areas over which sound

 power distributes are concentric spheres with an increasing

 radius and therefore an increasing area of

also, it can used the equation below to calculate Sound Intensity:

Where P= mean square sound pressure (Pa2)

 ρ= density of medium (kg/m3)

 c= speed of sound (m/sec)

the term (ρc) is known as the acoustic impedance ( is a basically a measure of the resistance a fluid or material medium gives to the propagating of sound waves, it is the product of the speed of sound in the medium and its density), in the air =429 rayls (rayl =kg/m2.sec).

|  |  |  |  |
| --- | --- | --- | --- |
| Material | Density (kgm-3) | Speed of sound (ms-1) | Acoustic impedance(kgm-2s-1x106) |
| Air | 1.3 | 330 | 0.000429 |
| Water | 1000 | 1450 | 1.50 |
| Bone (average) | 1500 | 4000 | 6.00 |

**1.7 What is a decibel?**

The decibel (dB) is used to measure **sound level**, but it is also widely used in electronics, signals and communication. The dB is a logarithmic way of describing a ratio. The ratio may be power, sound pressure, voltage or intensity or several other things.



The reference value in sound levels corresponds to minimum audible sound to the average human ear at 1000Hz.

**1.8 Sound Pressure Level, Sound Intensity Level, Sound Power Level**

Sound Pressure level measured on a dB scale:

Where SPL= Sound Pressure Level (dB)

 Prms= Root mean square sound pressure (Pa)

 Po= Reference value (20×10-6 Pa)

Where SIL= Sound Intensity Level (dB)

 I = Sound intensity (W/m2)

 Io= Reference value (10-12 W/m2)

Where SWL=Sound Power Level (dB)

 W= Sound power (W)

 Wo= Reference value (‎10-12 W)

**1.9 Some Common Sounds**

Table below illustrate sound pressure and sound pressure level for some common sound .



Notes:

A change in level of <1 dB is not predictable

A change in level of 3 dB is just predictable

A change in level of 5 dB is clearly predictable

A change in level of 10 dB is twice as load

Zero dB level does not mean an absence of sound , it merely implies that the level is equal to the reference value.

**1.10 Addition of Sound Pressure Level and Sound Power Level**

In most industrial environments, sound is emitted from than one source or at different frequencies, so, the cumulative or overall or total SPL can be calculated from this equation:

When many sources have the same SPL, this equation can be used:

Increase in dB level =10 log (N)

 Where N=Number of sources

and total SWL can be calculated by: