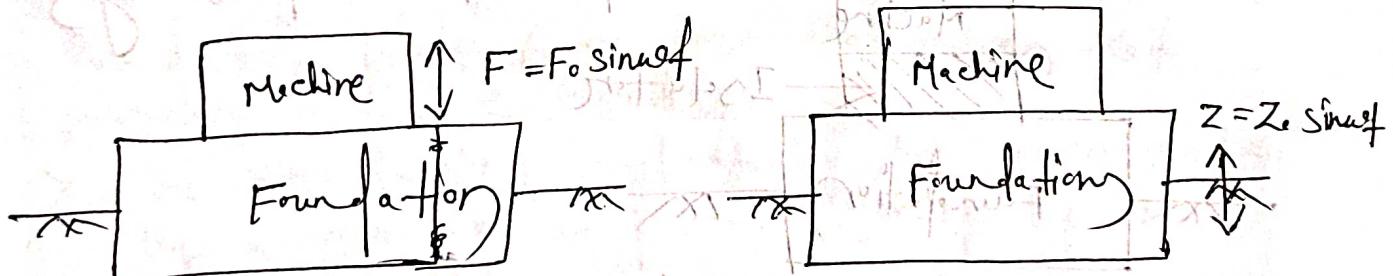


Module - IV

- vibration isolation
- vibration isolation technique
- Mechanical isolation
- Foundation isolation
- Isolation by location
- Isolation by barriers
- Active & passive isolation test
- ⇒ vibration isolation & technique:-

→ In machine foundations, following two types of problems may arise.

- (i) Machine directly mounted on foundation block may cause objectionable vibrations
- (ii) Machine foundation suffering excessive amplitudes due to vibration transmitted from the neighbouring machine.

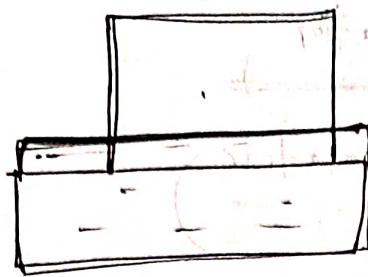


(Excessive vibration
due to machine
itself.)

(Excessive amplitude
caused due to
vibration transmitted
from adjacent
source)

Mod-IV

vibration isolation

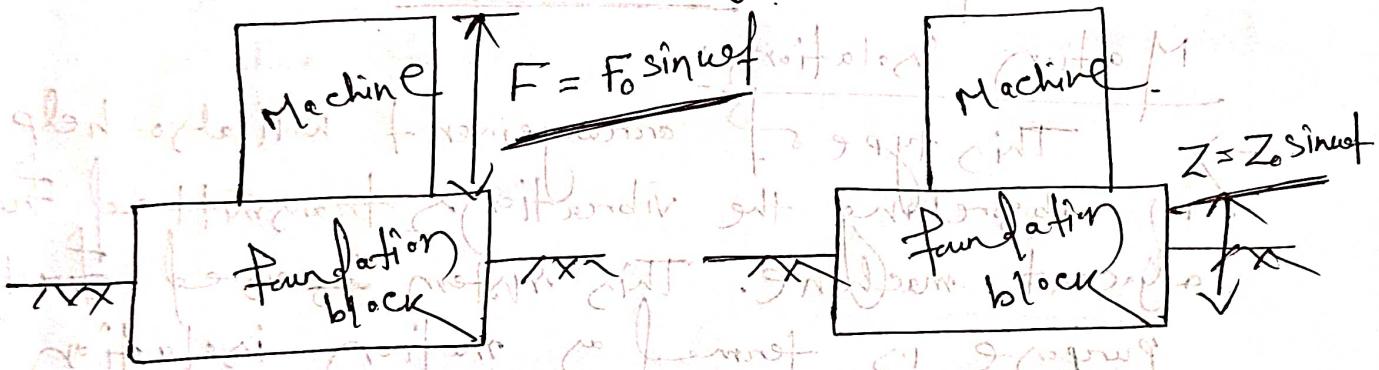


Reduced vibration/oscillation.

Reasons

(i) Machines directly mounted on foundation-block may cause objectionable vibration.

(ii) Machine foundations suffering excessive amplitude due to the vibration transmitted from the neighbouring machine.



Excuse me
due to vibration transmitted from adjacent source

Machine directly mounted on foundation

excuse me
due to vibration transmitted from adjacent source

→ By isolating the machine from foundation through a suitable mounting system such that the transmitted force is reduced which in turn will reduce the

amplitude.

Types of Isolation

1) Force isolation

2) Motion isolation

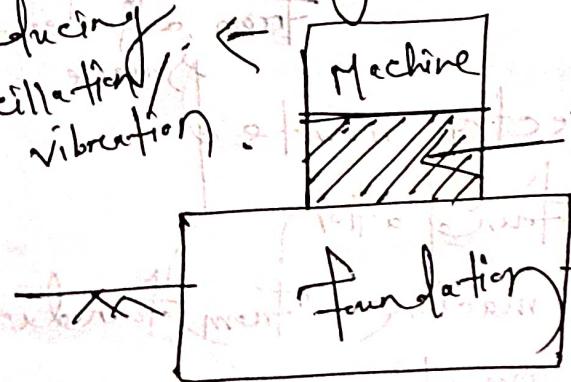
Force isolation :-

→ by isolating the machine from the foundation through a suitably designed mounting system spring mass system such that transmitted force is reduced which in turn will reduce the amplitude. This type of isolation is termed as force isolation.

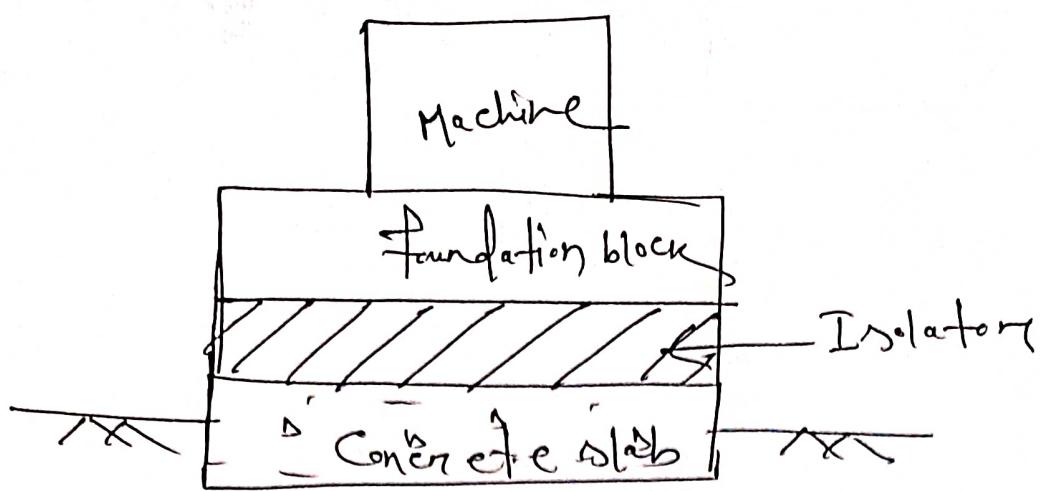
Motion isolation :-

→ This type of arrangement will also help in absorbing the vibrations transmitted from adjacent machine. This system ~~is used~~ for the purpose is termed as motion isolation.

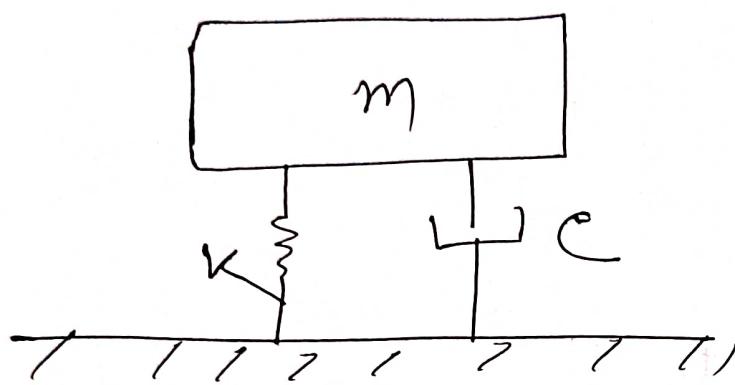
→ The mounting system is an elastic layer which may in the form of → rubber pad
Reducing oscillation/vibration → Timber pad
Isolators → Cork pad
→ Metal springs.



(An isolator placed between machine and foundation)



(An isolator placed between foundation block and concrete slab)



(Mathematical model)

→ The first problem may be tackled by isolating the machine from the foundation through a suitably designed mounting system, such that the transmitted force is reduced to which in turn will reduce the amplitude.

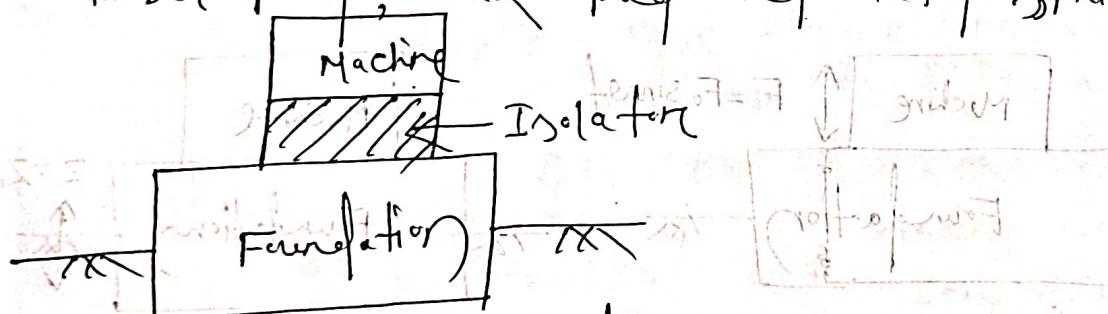
This type of isolation is termed as force isolation.

→ This type of arrangement will also help in absorbing the vibrations transmitted from adjacent machines. The system used for this purpose is termed as motion isolation.

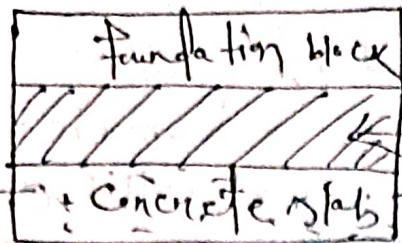
→ For heavier machines, the isolating system may be placed between the foundation block and concrete slab.

→ The machines are rigidly bolted to the foundation block which is isolated from the concrete slab through the mounting system.

→ The mounting system is an elastic layer which may be in the form of rubber pad, timber pad, cork pad and metal springs.



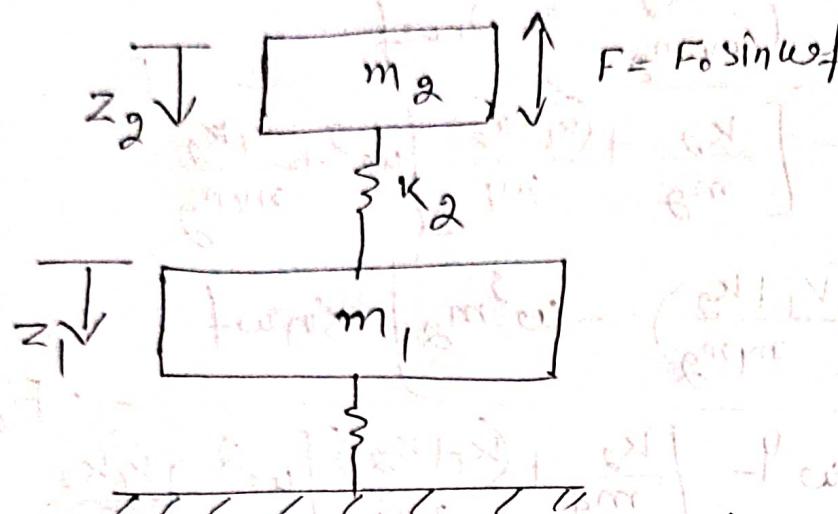
An isolator placed between machine and foundation.



Isolation
between foundation block and base slab

An isolator piece of m_2 mass is placed between foundation block and concrete slab.

\Rightarrow Foundation isolation (force isolation) :-



(Two degrees of freedom model)

- \rightarrow The underlying soil or rock supporting the foundation block (one base slab) does not possess infinite rigidity.
- \rightarrow The foundation soil should be represented by a spring and not solely by a rigid support.

where, m_1 = mass of foundation block or mass of base slab.

m_2 = Mass of machine if isolator is introduced betw' machine and foundation block.

mass of machine plus mass of foundation block if isolator is placed between foundation block and base slab.

K_1 = stiffness of the spring
 K_2 = stiffness of the isolator.

→ If the machine is subjected to a harmonic force ($F_0 \sin \omega t$) the equation of motion will be,

$$m_1 \ddot{z}_1 + K_1 z_1 - K_2 (z_2 - z_1) = 0 \quad (1)$$

$$m_2 \ddot{z}_2 + K_2 (z_2 - z_1) = F_0 \sin \omega t \quad (2)$$

The solution of equations (1) + (2) we get,

$$z_1 = \frac{\left(\frac{K_2}{m_1 m_2} \right) \sin \omega t}{\omega^2 - \left[\frac{K_2}{m_2} + \frac{(K_1 + K_2)}{m_1} \right] \omega^2 + \frac{K_1 K_2}{m_1 m_2}} \cdot F_0 \quad (3)$$

$$z_2 = \frac{\left[\frac{K_1 + K_2}{m_1 m_2} - \frac{\omega^2 m_2}{m_1} \right] \sin \omega t}{\omega^4 - \left[\frac{K_2}{m_2} + \frac{(K_1 + K_2)}{m_1} \right] \omega^2 + \frac{K_1 K_2}{m_1 m_2}} \cdot F_0 \quad (4)$$

→ The principal natural frequencies of the system can be obtained by solving the following frequency equation.

$$\omega_n^4 - \left[\frac{K_2}{m_2} + \frac{(K_1 + K_2)}{m_1} \right] \omega_n^2 + \frac{K_1 K_2}{m_1 m_2} = 0 \quad (5)$$

→ Force transferred to the foundation block or base slab

$$F_t = k_2 z_2$$

$$= \frac{\left(\frac{K_1 K_2}{m_1 m_2} \right) \sin \omega t}{\Delta \omega^2} F_0$$

$$\Delta \omega^2$$

The transmissibility of the system will be

$$T_F = \frac{F_f}{F_0 \sin \omega t}$$

$$T_F = \frac{k_1 \cdot k_2}{m_1 m_2} \frac{1}{\Delta(\omega^2)}$$

$$\frac{k_1}{m_1} = \frac{k_2}{m_2} = p^2$$

$$\frac{m_2}{m_1} = \text{mass ratio} = l/m_1$$

Maximum amplitude of machine foundation is given by $A_Z = \frac{F_0}{(m_1 + m_2)(\omega_{n2}^2 - \omega^2)}$

ω_{n2} represents the natural frequency of mass m_2 resting on isolating spring.

$$\omega_{n2} = \sqrt{\frac{k_2}{m_2}}$$

\Rightarrow Mechanical isolation :- (Motion isolation)

\rightarrow Let us consider a case where a sensitive equipment of mass m_1 is placed on a foundation block of mass m_2 . The spring k_1 represents the foundation soil and spring k_2 is an isolating spring which is placed between the masses m_1 and m_2 .

\rightarrow In order to minimise the transmission of vibration from the ground to the equipment, if the ground is subjected to a periodic displacement given by $Z_0 \sin \omega t$.

The equation of motion will be

$$m_1 \ddot{z}_1 + k_1 z_1 - k_2 (z_2 - z_1) = k_1 Z_0 \sin \omega t \quad \text{--- (1)}$$

$$m_2 \ddot{z}_2 + k_2(z_{2d} - z_2) = 0$$

The values of maximum amplitudes of motion are given by.

$$A_{Z1} = k_2 z_0 \frac{\frac{k_2}{m_2} \omega^2}{\omega^4 - \left[\frac{(k_1+k_2)}{m_1} + \frac{k_2}{m_2} \right] \omega^2 + \frac{k_1 k_2}{m_1 m_2}}$$

$$A_{Z2} = k_2 z_0 \frac{\frac{k_2}{m_2}}{\omega^4 - \left[\frac{(k_1+k_2)}{m_1} + \frac{k_2}{m_2} \right] \omega^2 + \frac{k_1 k_2}{m_1 m_2}}$$

→ The displacement transmissibility of the machine (T_D) is defined as the ratio of displacement amplitude of mass m_2 to the displacement amplitude of the rigid support.

Then,

$$T_D = \frac{A_{Z2}}{A_z} = \frac{\frac{k_1 k_2}{m_1 m_2}}{\omega^4 - \left[\frac{(k_1+k_2)}{m_1} + \frac{k_2}{m_2} \right] \omega^2 + \frac{k_1 k_2}{m_1 m_2}}$$

$$T_{D1C} = \frac{A_{Z2d1}}{z_0} = \frac{a_1^2 a_2^2 (1 + l_{lm})}{1 - (1 + l_{lm})(a_1^2 + a_2^2 - a_1^2 a_2^2)}$$

A_{Z2} → of permissible amplitude.

z_0 → Applied dynamic displacement.

$$\text{Ansatz: } \ddot{x} + \omega_n^2 x = (F_d - F_p) e^{j\omega t} - F_d x - F_p x$$

Isolation by location :-

→ To study and design the vibration isolation system one must first analyze and select the type of isolation technology. Based on the actual situation of the test building, the performance and application scope of common isolation technologies are as follows.

- 1) According to the stability requirement of the structure it is not advisable to use steel springs and fibreglass as the vibration isolation material.
- 2) Air springs are not suitable for vibration isolation of ordinary houses because of their complicated structure & high price.
- 3) Considering the practical use and the convenience of material processing we have selected artificial rubber for main isolation devices for the test building.

⇒ Isolation by barrier :-

→ The installation of an isolation barrier in the soil can reduce ground vibrations significantly by preventing the transmission of vibratory waves to the buildings in a determined zone behind the barrier. vibration frequencies and vehicle characteristics

Active & passive isolation test

screening of vibrations by use of open trench

① Active screening

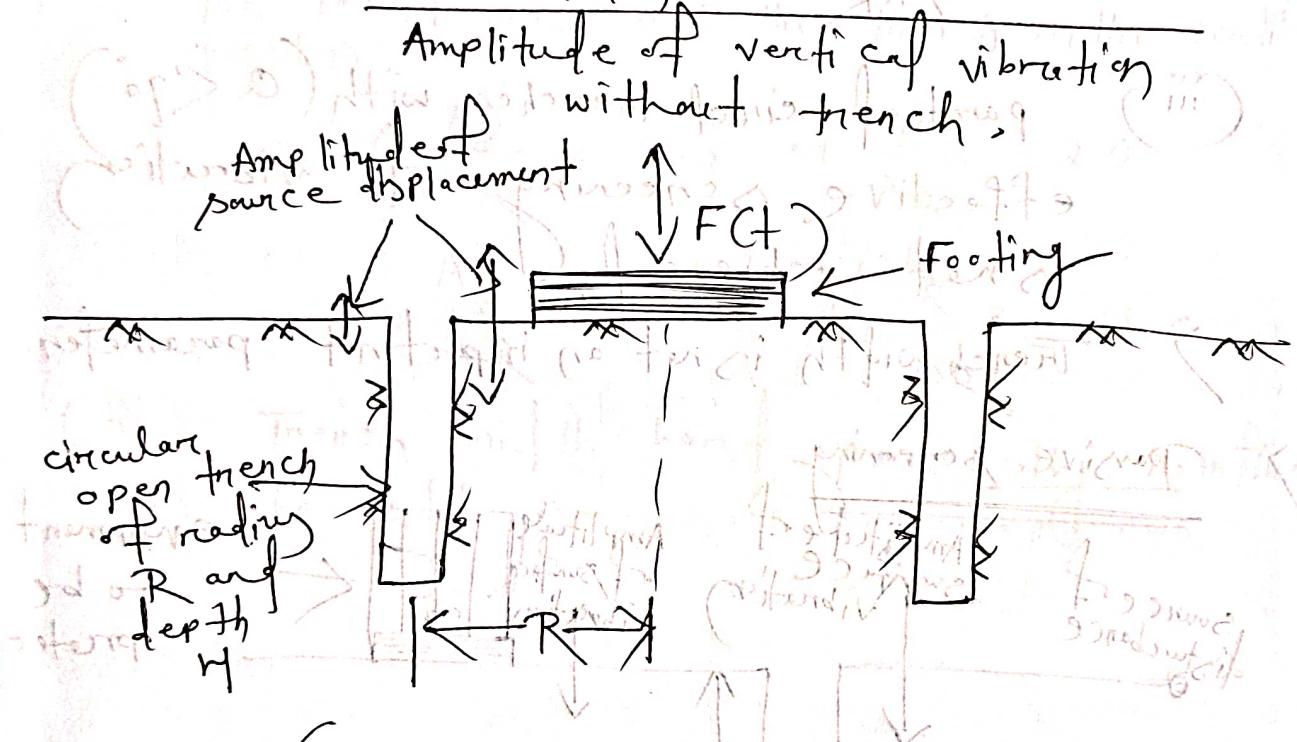
② passive screening

→ In active screening case the cutoff screening of vibrations is done near the source of vibration.

A circular trench of radius 'R' and depth (H) which surrounds the machine foundation that is the source of disturbance.

→ Amplitude reduction factor (ARF)

$= \frac{\text{Amplitude of vertical vibration with trench}}{\text{Amplitude of vertical vibration without trench}}$



(Vibration screening using a circular trench surrounding the source of vibration)

The field tests of woods they correspond to

$$\frac{\lambda}{\lambda_R} = 0.222 - 0.910 \text{ and}$$

$$\frac{H}{\lambda_R} = 0.222 - 1.82$$

→ For satisfactory screening of vibrations, woody recommended that ARF should be less than or equal to 0.25.

(i) Full circle trench ($\alpha = 360^\circ$)

$$\frac{H}{\lambda_R} = 0.6$$

(ii) For partial circle trench ($90^\circ < \alpha < 360^\circ$)

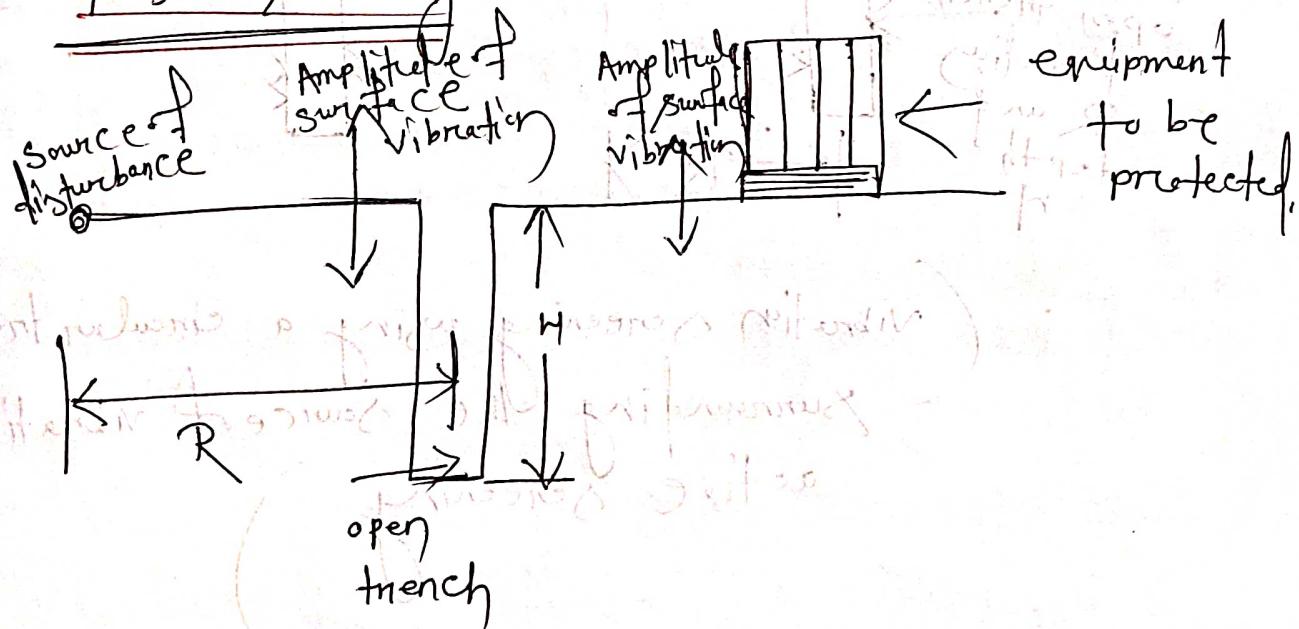
$$\frac{H}{\lambda_R} = 0.6$$

(iii) partial circ. trench with ($\alpha < 90^\circ$)

effective screening of vibration
is not achieved.

→ Trench width is not an important parameter.

⇒ Passive screening



→ Woods has also ~~been~~ performed field test to study the effectiveness of open trench in passive screening.

- Frequency excitation varied from 200 to 350 Hz.
- The values of $\frac{A_T}{\lambda_R^2}$ varied from 0.444 to 3.64
 $\frac{R}{\lambda_R}$ from 2.22 to 7.10.
- The conclusions made on the basis of this field study to keep ARF ≤ 0.25 .

(i) $\frac{A_T}{\lambda_R^2}$ should be atleast 1.33

(ii) To maintain the same degree of screening, the least area of the trench in the vertical direction.

$$\frac{A_T}{\lambda_R^2} = 2.5 \text{ at } \frac{R}{\lambda_R} = 2.0$$

$$\frac{A_T}{\lambda_R^2} = 6.0 \text{ at } \frac{R}{\lambda_R} = 7.0$$

(iii) Trench width have practically no influence on the effectiveness of screening.