MODULE – 5

Machine Foundations
Types of Machine Foundations

There are 3 Major categories:

1. Reciprocating Machine
2. Impact Type Machine
3. Rotating Machine

Types of Machine Foundations (contd.)

1. Reciprocating Machine
   - Produces periodic unbalanced force,
   - Examples ---- Compressor, Reciprocating engine etc.
   - Operating frequency < 600 rpm
   - For analysis unbalanced force can be considered as sinusoidal
Types of Machine Foundations (contd.)

2. Impact Type Machine
   - Produces Impact load,
   - Example ---- Forge hammer.
   - Operating frequency 60 to 150 blows/min
   - Dynamic loads attain peak in a very short time and then die out

3. Rotating Machine
   - Example ---- High speed machines like Turbo generator, Rotary compressor.
   - Operating frequency 3000 – 10000 rpm
Basic Design Criteria for Machine Foundations

A. For Static Load:
   - No shear / bearing capacity failure.
   - No excessive settlement.

B. For Dynamic Load:
   - No resonance (Operating frequency and natural frequency should not match)
   - Amplitude must not exceed the permissible limit
   - The vibration must not be annoying to the person working in the environment and it should not damage the adjacent structures.

Methods of Analysis for Machine Foundations

A. MSD model:
   - Mass-Spring-Dashpot model

B. EHS theory:
   - Elastic Half Space model based on linear theory of elasticity

C. Tschebotarioff’s reduced natural frequency method (1953)
   - Semi-empirical method
   - It can also be used for any earth retaining structures
Typical Types of Machine Foundations usually designed

1. Block type

1. Box or caisson type

1. Wall or frame type

Typical Types of Machine Foundations usually designed (contd.)

1. Block type
Typical Types of Machine Foundations usually designed (contd.)

2. Box or caisson type

![Diagram of Box or Caisson Type Foundation]

3. Wall or frame type

![Diagram of Wall or Frame Type Foundation]
SOIL DYNAMICS

Degrees of Freedom for Machine Foundations

Design of Machine Foundations as per IS:2974 (Part-1)-1969

- Dimensional criteria
- Vibration criteria
- Displacement criteria
Design of Machine Foundations as per IS:2974 (Part-1)-1969 (contd.)

**Dimensional criteria:**

1. **Area of the block:**
   - **I.** Size of the foundation block must be larger than base plate.
   - **II.** Minimum all-round clearance of 150 mm must be provided.
   - **III.** Foundation block should be placed deep enough on a good bearing strata.

2. **Combined C.G. of machine + Foundation block should be as far below the top of the foundation as possible.**

3. **Eccentricity should not exceed 5% of the least width or horizontal dimension**

Vibration criteria:

It is expected to have a foundation which is having natural frequency much higher or lower than the operating frequency of the machine.

- **UNDER TUNED** → \( \frac{\omega}{\omega_n} \leq 0.5 \) for important machine
  - \( \leq 0.6 \) for less important machine

- **OVER TUNED** → \( \frac{\omega}{\omega_n} \geq 2 \) for important machine
  - \( \geq 1.5 \) for less important machine
Design of Machine Foundations as per IS:2974 (Part-1)-1969 (contd.)

Displacement criteria:

- Permissible displacement of the machine foundation system must be < 0.2 mm
- Permissible displacement should be also checked using Richart’s chart, so that it should not become annoying to the workers.

Richart’s Chart
Tschebotarioff’s “Reduced Natural Frequency” ($f_{nr}$) method (1948, 1953)

very handy, fast and simple method.

proposed by Tschebotarioff and Wood (1948) and Tschebotarioff (1953).

based on DEGEOO expression (developed during World War II at Berlin).

\[ f_n = \frac{1}{\sqrt{q_0}} f_{nr} \]

where,

\( K \) = dynamic modulus of subgrade reaction (lb/ft²)
\( A \) = area of the base of the foundation (ft²)
\( m \) = mass of the foundation block + machine
\( m_s \) = mass of the soil

so,

\[ f_n = \sqrt{\frac{A}{W}} \frac{1}{2\pi} \left( \frac{KW}{m + m_s} \right) \]

\[ = \sqrt{\frac{A}{W}} \frac{1}{2\pi} \left( \frac{K mg}{m + m_s} \right) \]

\[ = \sqrt{\frac{A}{W}} \frac{1}{2\pi} \frac{1}{1 + \left( m_s / m \right)} \]

where, \( q_0 = \frac{W}{A} \) = contact pressure

\[ f_n = \frac{1}{\sqrt{q_0}} f_{nr} \]