11 Machine Foundation

11.1 Introduction

- Foundations may be subjected to either static loads or a combination of static and dynamic loads; the latter lead to motion in the soil and mutual dynamic interaction of the foundation and the soil. The design of foundations subjected to dynamic forces is part of soil dynamics.
- 'Soil Dynamics' may be defined as that part of soil mechanics which deals with the behavior of soil under dynamic conditions. The effects of dynamic forces on soil are under this topic which is relatively a new area of Geotechnical Engineering.
- The sources of dynamic forces are numerous; violent types of dynamic forces are caused by earthquakes, and by blasts engineered by man. Pile driving and landing of aircraft in the vicinity, and the action of wind and running water may be other sources. Machinery of different kinds induces different types of dynamic forces which act on the foundation soil.
- Most motions encountered in Soil Dynamics are rectilinear (translational), curvilinear, rotational, two-dimensional, or three-dimensional, or a combination of these. The motion may be a periodic or periodic, and steady or transient, inducing 'vibrations' or 'oscillations. Impact forces or seismic forces cause 'shock', implying a degree of suddenness and severity, inducing a periodic motion in the form of a 'pulse' or a transient vibration. This may lead to settlement of foundations and consequent failure of structures.
- Since dynamic forces impart energy to the soil grains, several changes take place in the soil structure, internal friction, and adhesion. Shock and vibration may induce liquefaction of saturated fine sand, leading to instability. The primary aim of Soil Dynamics is to study the engineering behavior of soil under dynamic forces and to develop criteria for the design of foundations under such conditions.
- Machine foundations are subjected to dynamic forces caused by machines. Although moving parts of the machine are generally balanced, there is always some imbalance in practice which causes eccentricity of rotating parts. This produces oscillating force. The machine foundation must satisfy criteria for dynamic loading, in addition to static loading criteria.

- Machine foundations are special types of foundations required for machines, machine tools and heavy equipment which have wide range of speeds, loads and operating conditions.
- These foundations are designed considering the shocks and vibrations (dynamic forces) resulting from operation of machines.
- In the design of machine foundations, the following questions are to be answered:
    - What are the numerical limits of failure?
    - What is the relation between applied loads and quantities which are significant in the design?
    - How do we evaluate the significant quantities and what are the errors involved?
    - Finally, after the inaccuracies involved in evaluating these quantities are determined, what sort of factor of safety do we apply in the design process?

Types of Machines

1. Machines which produce a periodic unbalanced force, such as reciprocating engines and compressors. The speed of such machines is less than 600 rpm. The rotary motion of crank is converted into translational motion in these types of machines.

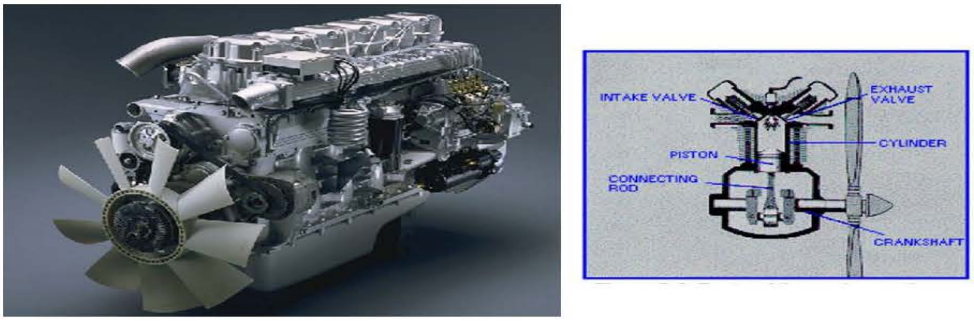


Fig: Reciprocating Engine

Fig: Compressor

2. Machines which produce impact loads, such as forge hammers and punch presses. Dynamic force attains a peak value in very short time and then dies out gradually in these types of machines. The speed is usually between 60 to 150 blows per minute.

Fig: Forge Hammer

Fig: Punch Presses

3. High speed machines, such as turbines and rotary compressors. The speed of such machines is very high up to 3000 rpm.

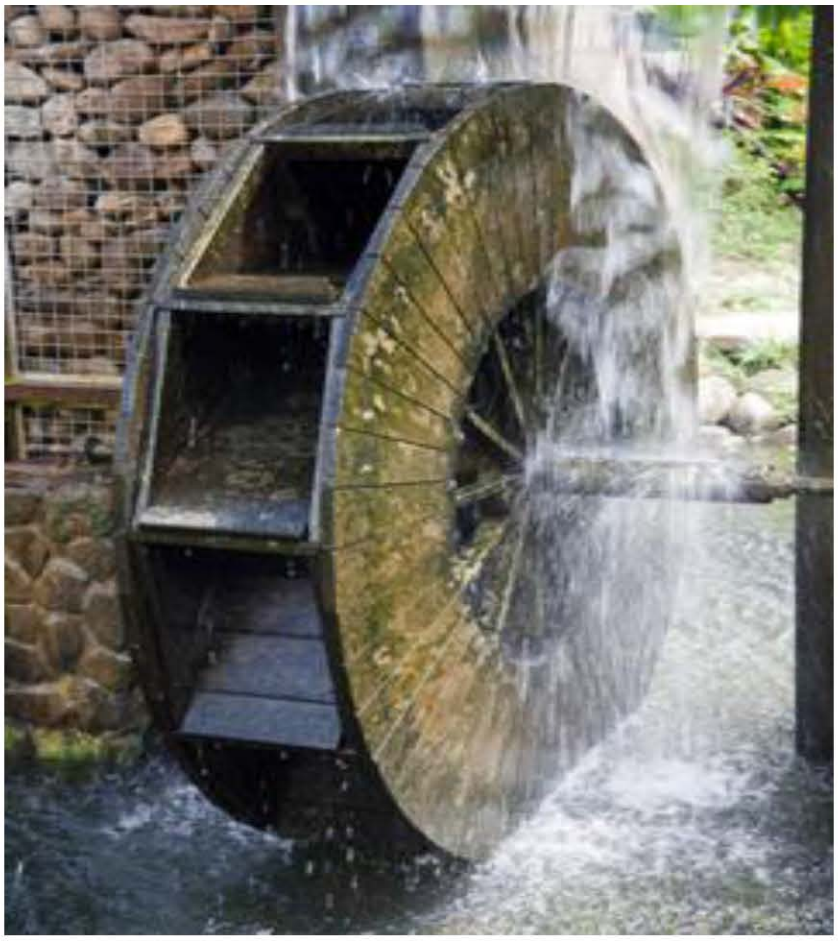
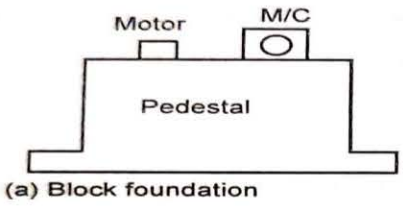


Fig: Turbine

11.2 Types of Machine Foundations

1. Block Type Machine Foundation:

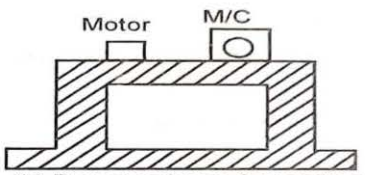
This type of foundation consists of a pedestal resting on a footing have has large mass and a small natural frequency.



(a) Block foundation

2. Box Type:

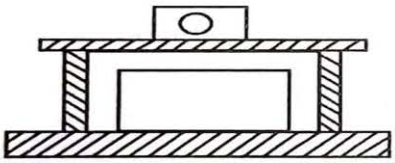
This foundation consists of a hollow concrete block. The mass of the foundation is less than that of block type but natural frequency is higher.



(b) Box or caisson foundation

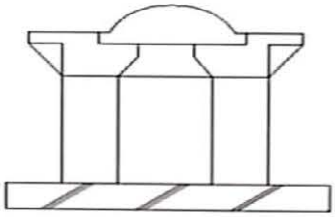
3. Wall Type:

The wall type of foundation consists of a pair of walls having a top slab. The machine rests on the top slab.


(c) Wall foundation

4. Framed type:

This type of foundation consists of vertical columns having a horizontal frame at their tops. The machine is supported on the frame.


(d) Framed-type

Suitability of Machine Foundations

- Machines which produce periodical and impulsive forces at low speeds are generally provided with block type foundations.
- Machine of category (2) above may also be supported on block-type foundations, but these are made to rest on springs or suitable elastic pads to reduce their natural frequencies.
- Framed foundations are generally used for the machines working at high speeds and those for rotating types.
- Some machines such as lathes, which induce very little dynamic forces, do not need any foundations; such machines may be directly bolted to the floor.

General Criteria for Design of Machine Foundations

Good machine foundation should satisfy following criteria:

1. It should be safe against shear failure caused by imposed loads and settlements should be within safe limits.
2. There should be no possibility of resonance. The natural frequency of foundation should be either greater than or smaller than the operating frequency of machine.
3. The amplitude should be under permissible limits.
4. The combined center of gravity of the machine and the foundation should be on vertical line passing through the CG of the base plane.
5. Machine foundation should be taken to lower level than the foundation of adjacent building.
6. The vibrations induced should not be annoying.
7. The depth of ground water table should be at least one-fourth of the width of the foundation below the base plane.

Fundamental Frequency

$$F_0 = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

k ← Stiffness

m ← Mass