CHAPTER 3

VIBRATION CONTROL SYSTEMS

3.1 INTRODUCTION

Vibrations can be controlled by three different ways, namely, (i) Vibration control at source (The cause of the vibration is identified and rectified at the source level itself). The examples are balancing of inertia forces in rotating and reciprocating machinery, and smoothening of fluid flow to reduce the vibration level. (ii) System modification in which modification of structural parameters such as inertia, damping and stiffness are properly chosen or modified to reduce the vibration to a specified level. The use of energy dissipation systems i.e. supplemental damping devices belong to this type. (iii) Modification of vibration transmission path from source to the structure. In this method the transmission path of vibration is modified by means of isolators or suspension systems located in the path of vibration transmission from source to structure.

Among the three ways of vibration controlling technique, the most efficient way of controlling structural vibration is the use of energy dissipation systems (System modification) in civil engineering structures. The four major classes of vibration control systems are passive, active, semi-active and hybrid vibration control systems. The Schematic diagram of conventional structure without any passive and active vibration control devices is shown in the Figure 3.1.
3.2 PASSIVE CONTROL SYSTEMS

A passive control system may be defined as a system which does not require an external power source for operation and utilizes the motion of the structure to develop the control forces. Control forces are developed as a function of the response of the structure at the location of the passive control system. Flow diagram of passive control systems is shown in Figure 3.2. Passive energy dissipation systems encompass a range of materials and devices for enhancing damping, stiffness and strength of structures.

The objective of these systems is to absorb a significant amount of the seismic input energy, thus reducing the demand on the structural system. The various passive energy dissipation devices are metallic yield dampers, friction dampers, viscoelastic dampers, viscous fluid dampers and tuned liquid dampers.
Another type of passive energy dissipation devices are seismic isolation systems in which a flexible isolation system is introduced between the foundation and superstructure so as to increase the natural period of the system. The increase in flexibility typically results in the dissipation of a major portion of the earthquake energy and reducing accelerations in the superstructure while increasing the displacement across the isolation level. In Japan, the Atami Korakuen Hotel which is a twenty storey building was built with passive control system (192 friction dampers) for suppression of earthquake vibration.

3.3 **ACTIVE CONTROL SYSTEMS**

An active control system may be defined as a system which typically requires a large power source for operation of electro-hydraulic or electro-mechanical actuators which supply control forces to the structure. Control forces are developed based on feedback from sensors that measure the excitation and/or the response of the structure. The primary effect of active control systems is to modify the level of damping with a minor modification of stiffness. The flow diagram of the active control systems is shown in Figure 3.3. The examples for active control are Active Mass Damper and Active Brace System. An Active Mass Damper of mass weight 480 tonnes was attached to the Applause Tower of 38 floors in Osaka to suppress the building vibration due to strong winds or medium/small earthquakes.

![Flow diagram of active control system](image-url)
3.4 SEMI-ACTIVE CONTROL SYSTEMS

A semi-active control system may be defined as a system which typically requires a small external power source i.e. a battery for operation and utilizes the motion of the structure to develop the control forces, the magnitude of which can be adjusted by the external power source. Control forces are developed based on feedback from sensors that measure the excitation and/or the response of the structure. The feedback from the structural response may be measured at locations remote from the location of the semi-active control system.

Semi-active controllers combine the desirable features of both active and passive control systems. Schematic diagram of semi-active control systems are as shown in the Figure 3.4. A semi-active control system generally originates from a passive control system which has been subsequently modified to allow for the adjustment of mechanical properties. As in an active control system, a controller monitors the feedback measurements and generates an appropriate command signal for the semi-active devices. As in a passive control system, however, the control forces are developed as a result of the motion of the structure itself. The control forces are developed through appropriate (based on a pre-determined control algorithm) adjustment of the mechanical properties of the semi-active control system. Furthermore, the control forces in many semi-active control systems primarily act to oppose the motion of the structural system and therefore promote the global stability of the structure.
3.5 HYBRID CONTROL SYSTEMS

Hybrid control systems consist of combined passive and active devices or combined passive and semi-active devices. Schematic diagram of Hybrid control systems are as shown in the Figure 3.5. The combined use of active and passive, or hybrid control can alleviate some of the limitations that exists for either the passive system or the active system operating singly, thus leading to an effective protective system.