Swing Column, an Emerging Base Isolation Technique: Drawing Board to Prototype

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Abstract—During an earthquake the principal attack on a structure is by horizontal force in different directions. The resistance of the structure against earthquake depends on elastic strength, inelastic deformability, damping capacity or a combination of all. In recent years there is a considerable research and development of structural control devices to control seismic response of buildings. Base isolation is a passive vibration control system. A base-isolation system reduces ductility demands on a building, minimizes its deformations, improves building performance and permits freedom to select different structural type. Swing Column is one of the Base Isolation techniques.

Keywords —Base Isolators, Seismic energy, Dissipation, Earthquake, Structure, Swing Column, Base Isolation, Active, Passive.

I. INTRODUCTION

Earthquake is a natural disaster which may cause harm to many living beings. It mainly occurs due to the motion of tectonic plates under the earth surface. It releases seismic vibrations on ground surface of very high magnitude, which is maybe not sustainable for living lives. So, as being civil engineers, our duty is to minimize these effects of the natural disaster and ensure safety to human lives. To fulfill this purpose, many methods are introduced in structural and earthquake engineering fields.

All these methods are mainly classified into following categories:

1) Classification based on Basic Principles of Dynamics:
   (a) A method to control & adjust restoring forces characteristics.
   (b) A method to control & adjust damping.
   (c) A method to control & adjust mass.
   (d) A method to adjust input motion (combination)

2) Classification based on Energy Realization Procedure:
   (a) Passive way
   (b) Active way

3) Classification based on Installed Location:
   (a) External types
   (b) Internal types

Among all these methods, we consider here mainly two types which are, Active way & Passive way. Classification based on energy realization procedure can be elaborated as under:

1) Passive control: No external source of energy required
2) Active control: Activated by external force/energy
   and two more can be added in the form of:
3) Semi-Active: Combination of Passive and Active control
4) Hybrid: Combining two active or two passive techniques.

II. BRIEF DESCRIPTION OF SYSTEMS

A. Active way System:

In active way system, some external load is required to resist the seismic vibrations coming from the ground. They sense incoming vibrations and react to them.

There are two general types of active vibration cancellation systems:

1) Feed forward and 2) Feed backward systems.

1) Feed-forward systems are specifically programmed to compensate for regular periodic vibrations.
2) Feed backward systems continually sense and react to incoming vibrations.

The different types of dampers, different types of bracings etc. falls in active way system.

B. Passive way System:

There is no need of any external forces to reduce the seismic vibration in this method. It ensures more safety than active methods by means of detaching the superstructure from the sub-structure. All types of isolators fall in this category of system, which are explained in detail afterwards.

TABLE I

PASSIVE VS. ACTIVE - Comparison Table

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>PASSIVE</th>
<th>ACTIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation Range</td>
<td>&gt;5Hz</td>
<td>&gt;.7Hz</td>
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III. BASE ISOLATION TECHNIQUE

Base isolation system is widely used isolation techniques now-a-days. It is a passive way of system to control the seismic vibrations during earthquakes. The main feature of base isolation technique is, it introduces flexibility to the structure.

A. Concept:

The main concept of base isolation is that it decouples the sub-structure to the super-structure. So, when seismic vibrations of high magnitude occurs, it absorbs the energy at ground level & so there is no or less harm to the super structure. Also the structure becomes more flexible.

i. Requirement of Base isolation devices\(^{(4)}\):

1) Isolating the building from the ground
2) Supporting the weight of building
3) Damping of response amplitude
4) Restoring the original position after an earthquake

ii. Types of Base Isolation Technique\(^{(3)}\):

The different types of base isolation technique are:

1) Elastomeric Bearings:
   (a) Lead Rubber Bearing
   (b) Laminated Rubber Bearing

2) Sliding Bearings:
   (a) Flat Sliding Bearing
   (b) Spherical Sliding Bearing

3) Swing Column Technique
4) Friction pendulum System

B. Elastomeric Bearing:

It is very commonly used technique in the field of base isolation. It consists of natural or artificial rubber layers between the steel plates. The rubber absorbs seismic vibrations efficiently when the steel plates provides support to rubber layer. And thus, provide good safety against the vibrations.

Characteristics of rubber bearings:

This isolation system works with the principle that a rigid mass is isolated from a flexible supporting structure, which are mainly depends on:

1. Load capacity and size of rubber bearings
2. Absorption
3. Durability under cyclic loading

There are mainly two types of rubber bearings:

i. **Lead Rubber Bearings (LRB):**

In this type of elastomeric, thin layer of low damping natural rubber is placed between the alternate two steel plates. A lead cylindrical plug is fixed at the center.

![Lead rubber Bearing](image1)

**Fig. 1: Lead rubber Bearing\(^{(7)}\)**

ii. **High Damping Rubber Bearing: (HDRB)**

In this type of elastomeric bearing, the thin layer of high damping laminated rubber and steel plates are used alternatively to absorb the vibrations. The additional internal steel plates increases the vertical stiffness of the bearing several hundred times more than the horizontal stiffness.

![High Damping Rubber Bearing](image2)

**Fig. 2: High Damping Rubber Bearing (HDRB)\(^{(5)}\)**

Basic functions of Elastomeric Bearing:

(1) Load supporting function
(2) Horizontal elasticity function
(3) Restoration function
(4) Damping function

C. Sliding Bearing:

For large scale isolation systems, sliding bearings are used instead of rubber bearings. In this type of bearing, a sliding material is arranged in the way that it can move on the flat or spherical sliders. If the flat plate slider is provided, it is named as flat sliding bearing & if the spherical slider if provided, it is called as spherical sliding bearing. So, when the seismic vibration occurs, the material moves on the sliders instead of being stiff, which can absorbs the energy and gives protection to the vibrations.

To modify the effect of sliding bearings, it is also used with multilayer rubber bearings, which is called as Sliding support with rubber-pad (SSR).

Advantages of such bearings are:

1) SSR can provide vibration isolation for light loads as well as large deformation performance like a large-scale isolation system.
2) It provides protection against a wide range of tremors from small vibrations to major earthquakes.
3) It can be used in conjunction with other isolation systems such as LRB, and HDRB.

For complete protection of building during earthquake, minimum four swing columns are needed at all four piers of building, in tri-axial direction.

A. Preparation of Design Drawings:

(All dimensions are in mm unless otherwise specified)

Fig. 1: Walled Base Plate

Fig. 2: Walled Base Column

Fig. 3: Plate Racks for Base Columns

Fig. 4: Swing Plates

IV. SWING COLUMN TECHNIQUE

It is a developing technique of base isolators. In this type on isolators, the column is fabricated by the steel swing plates and base. A swing column consists of three swing devices in tri-axial direction.

In this mechanism, the walled base is rigid, on which swing plates are attached with joints and they are covered with walled top. Thus, swing plates are free to move between the walled plates. So, when the earthquake comes, the swing plates swings in the direction of seismic vibration and comes at their original place. In his way, swing column absorbs the energy and provide safety to the super structure.
C. Testing of prototype:

During the initial testing it was found that all swinging plates are not at a same bottom or top level, and hence it was touching the cover plate.

The rectification procedure was carried out by filing the swing plates at required places.

Four sets are prepared so that each can be placed under one column of prototype building having four columns.

V. CONCLUSION

The swing column technique is an emerging base isolation technique and is considered as a revolutionary one. After initial testing, it was found that if Swing Columns are used along with simple bracings, the balance between flexibility and Stiffness of the structure can be maintained and the effect of earthquake can be reduced substantially.

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