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DEVELOPMENT IN PASSIVE STRUCTURAL CONTROL IN JAPAN

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ABSTRACT

Passive structural Control devices are classified with their basic methods to reduce dynamic earthquake response. The principles of passive control are to reduce input earthquake energy to structures with base isolation and to absorb vibration energy of structures with different types of dampers. Developments of passive structural control in Japan are discussed.

Classification of Passive Structural Control

Base Isolation. In recent years, especially after the Hyogoken-Nanbu Earthquake, base isolation techniques are actively adopted in construction of buildings, bridges and other structures in Japan. Basic principle of base isolation is to reduce input earthquake energy by soft bearings and to suppress excessive displacement by damping. In Japan, many types of base isolation bearings have been used.

Tuned Mass Damper(TMD), Tuned Liquid Damper(TLD). Tuned Mass Damper(TMD)is a vibration system with mass, spring and viscous damper usually installed on the top of structures. When the structure starts to vibrate, TMD is excited by the movement of the structure. Hence, Kinetic energy of the structure goes into TMD system to be absorbed by the viscous damper of TMD. TMD is a mechanically simple system which does not need any external energy supply for operation, TMD is used in many lightly-damped towers, buildings and so on in Japan. Tuned Liquid Damper (TLD) uses water as the moving mass and restoring force is generated by gravity. Energy absorption comes form boundaries between liquid and containers and turbulence in liquid flow. Basic principle of TLD to absorb kinetic energy of the main structures is the same as TMD. TLD is used in flexible and lightly damped towers , buildings in Japan.

Yielding Metal Dampers. Inelastic hysteretic behavior of steel or lead elements absorbs energy, hence reduces structural vibration. Hysteresis loops of steel elements may be represented by bilinear models. For middle and small earthquake motion, large amount of energy absorption may not be expected because of high stiffness of the elements, but for large earthquake motion high damping effects can be expected with large hysteresis loops. Lead damper has lower stiffness than steel, and its hysteresis loops may be represented by perfectly elasto-plastic models, which shows stable energy absorbing capacity. Yielding metal dampers are used in Japan as a part of base isolation bearing, as energy absorbing braces, as a joint damper system which connects buildings with different stories.

Friction Dampers. Friction dampers absorbs energy of vibration with hysteresis loops due to friction. The cylinder type and the steel plates sandwich type devices are developed.

Viscoelastic Dampers, Fluid Viscous Dampers. A typical viscoelastic Damper consists of viscoelastic layers bonded to steel plates. Convetional fluid viscous dampers are also used to dissipate energy with velocity proportional damping.

KEYWORDS : Passive Control, Earthquake, Response, Devices, Energy Absorption, Base Isolation