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Program: B-Tech Civil

Subject: Introduction to  
Earthquake engineering

Semester# 05

Assignment# ...0.2...

Submitted to: Engineer  
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## What is tuned mass damper (TMD)?

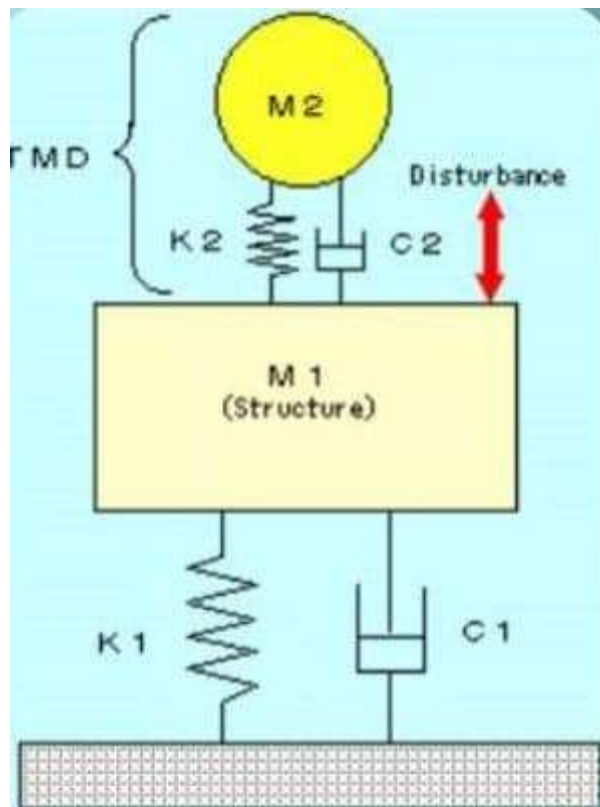
Tuned mass damper (also called vibration absorbers or vibration dampers) is a device mounted to a specific location in a structure, so as to reduce the amplitude of vibration to an acceptable level whenever a strong lateral force such as an earthquake or high winds hit.

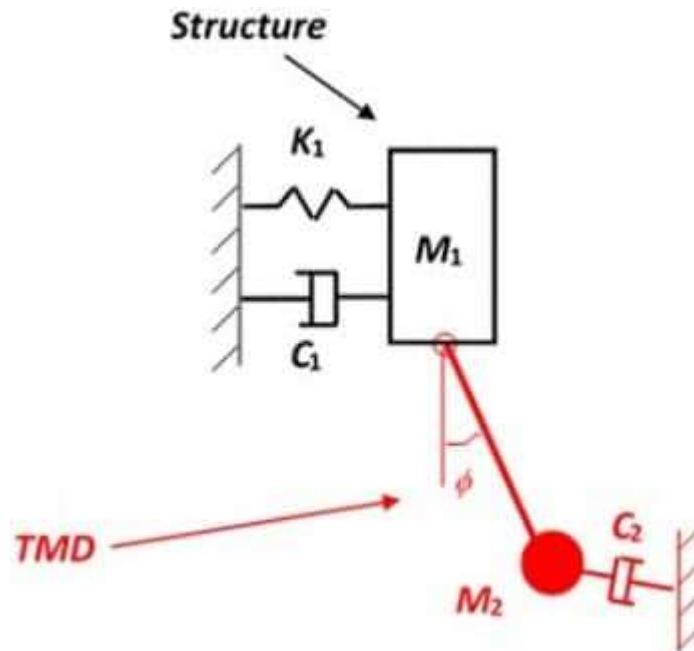
Consequently, discomfort, damage, or outright structural failure caused by vibration in the structure will be prevented. This article presents different aspects of tuned mass damper and its applications.

### Component of tuned mass damper:

- Spring ( $K_2$ )
- Oscillating Mass ( $M_2$ )
- Viscodamper ( $C_2$ )

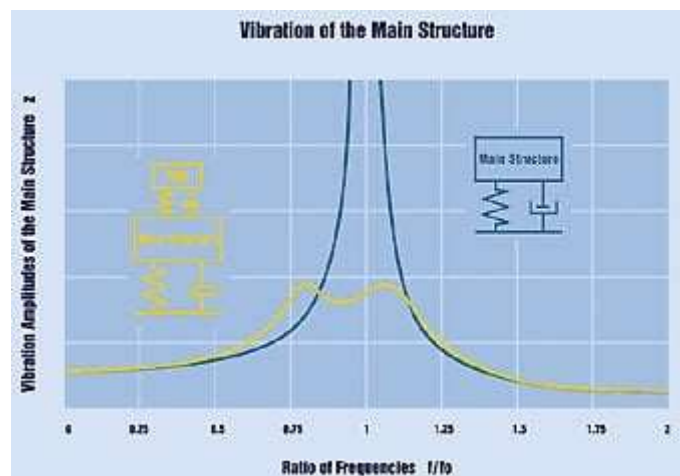
(Fig 1)





Pendulum Tuned Mass Damper (Fig2)

The value of  $K_2$  and  $M_2$  are specified so that the moving part of damper system can be tuned to the frequency of the structure. Fig. 3 shows curves for the two structures with and without the use of tuned mass damper.



Amplitude – Frequency response of a low damped system without (blue) and with (yellow) tuned mass damper (Fig3)

## Types of Tuned Mass Damper (TMD)

### Horizontal Tuned Mass Damper:

It is normally found in slender buildings, communication towers, spires and the like. Horizontal tuned mass damper (TMD) as shown in Fig. 1 composed of viscodampers and leaf springs or pendulum suspensions. It eats horizontal and torsional excitations.

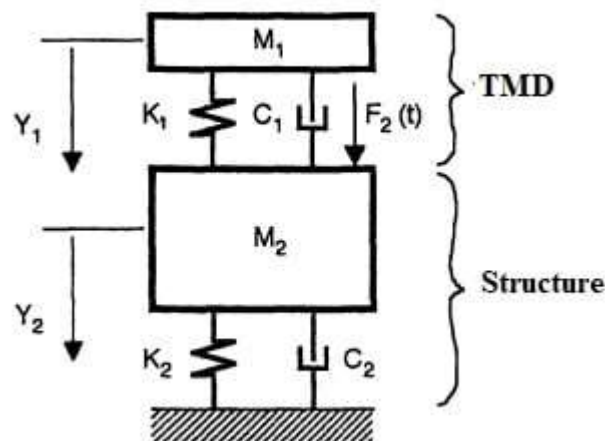
### Vertical Tuned Mass Damper:

It is usually applied in long span horizontal structures such as bridges, floors and walkways. Vertical tuned mass damper (TMD) as shown in Fig. 2 is a combination of coil springs and Viscodampers and it declines vertical vibrations.

Both types have similar functions, though there might be slight differences in terms of mechanism.

### How Tuned Mass Damper Work?

A tuned mass damper (TMD) consists of a mass ( $m$ ), a spring ( $k$ ), and a damping device ( $c$ ), which dissipates the energy created by the motion of the mass (usually in a form of heat). In this figure,  $M$  is the structure to which the damper would be attached.



Tuned mass damper operating principles (Fig4)

From the laws of physics, we know that  $F = ma$  and  $a = F/m$ . This means that when an external force is applied to a system, such as wind pushing on a skyscraper, there has to be acceleration.

Consequently, the people in the skyscraper would feel this acceleration. In order to make the occupants of the building feel more comfortable, tuned mass dampers are placed in structures where the horizontal deflections from the wind's force are felt the greatest, effectively making the building stand relatively still.

When the building begins to oscillate or sway, it sets the TMD into motion by means of the spring and, when the building is forced right, the TMD simultaneously forces it to the left.

Ideally, the frequencies and amplitudes of the TMD and the structure should nearly match so that EVERY time the wind pushes the building, the TMD creates an equal and opposite push on the building, keeping its horizontal displacement at or near zero.

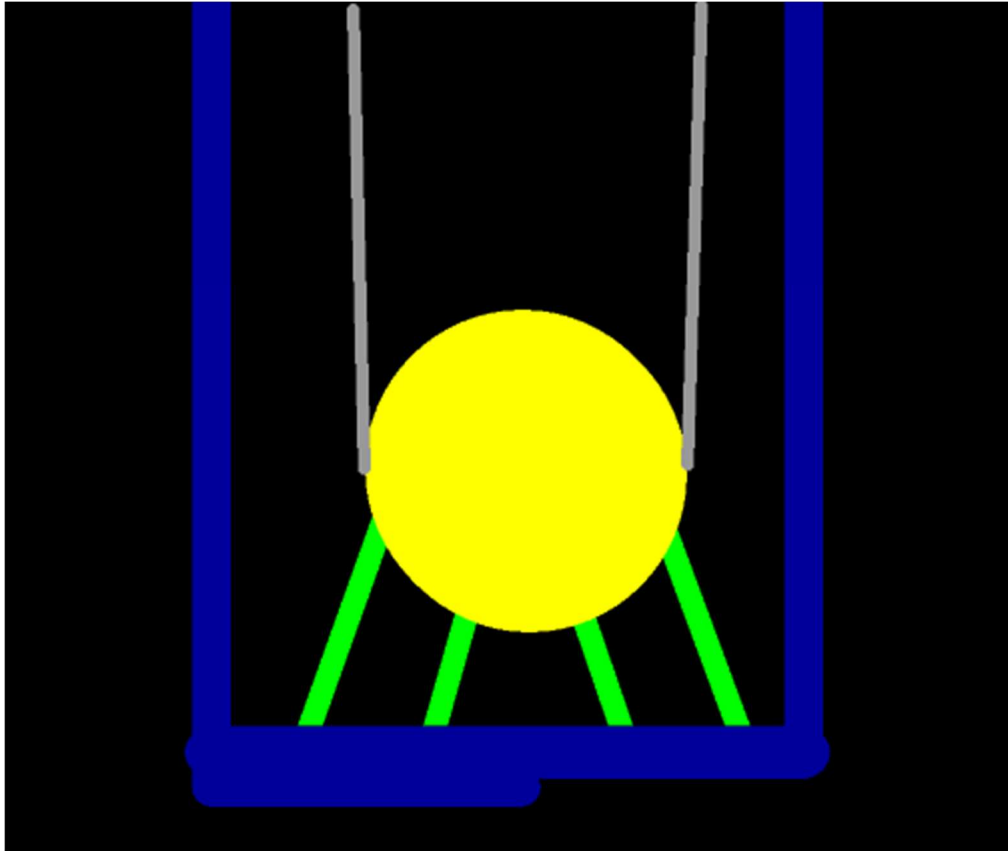
If their frequencies were significantly different, the TMD would create pushes that were out of sync with the pushes from the wind, and the building's motion would still be uncomfortable for the occupants.

If their amplitudes were significantly different, the TMD would, for example, create pushes that were in sync with the pushes from the wind but not quite the same size and the building would still experience too much motion.

The effectiveness of a TMD is dependent on the mass ratio (of the TMD to the structure itself), the ratio of the frequency of the TMD to the frequency of the structure (which is ideally equal to one), and the damping ratio of the TMD (how well the damping device dissipates energy).

Wide span structures (bridges, spectator stands, large stairs, stadium roofs) as well as slender tall structures (chimneys, high rises) tend to be easily excited to high vibration amplitudes in one of their basic mode shapes, for example by wind or marching and jumping people.

Low natural frequencies are typical for this type of structures, due to their dimensions, as is their low damping. With GERB Tuned Mass Dampers (TMD), these vibrations can be reduced very effectively.



Tuned Mass Damper operations (Fig5)

**Application of Tuned Mass Dampers:**

**Tuned mass dampers are mainly used in the following applications:**

- Tall and slender free-standing structures (bridges, pylons of bridges, chimneys, TV towers) which tend to be excited dangerously in one of their mode shapes by wind,
- Stairs, spectator stands, pedestrian bridges excited by marching or jumping people. These vibrations are usually not dangerous for the structure itself, but may become very unpleasant for the people,
- Steel structures like factory floors excited in one of their natural frequencies by machines , such as screens, centrifuges, fans etc.,
- Ships excited in one of their natural frequencies by the main engines or even by ship motion.

Tuned Mass Dampers may be already part of the structure's original design or may be designed and installed later.

## **Advantages & Disadvantages of Base Isolation.**

- **Advantages of Base Isolation :**
  - ✓ Apart from protecting structures from seismic activities, base isolation also protects them from GSA blast loads as the ability to move reduces the overall impact of the blast on the structures.
  - ✓ Base isolated structures are predictable, hence reliability of them is very high as compared to conventional structural components.
  - ✓ Need of strengthening measures such as frames, bracing and shear walls is cut down by reducing the earthquake forces transmitted to the building.
  - ✓ Simplification of seismic analysis as compared to the conventional structures by allowing reduction in structural elements.
  - ✓ In case of large unexpected seismic activities, damage is only concentrated in isolation system, where elements can be easily substituted.
  - ✓ Base isolation can also be retrofitted to suitable existing structures. Moreover, the building can remain serviceable throughout the construction
- **Disadvantages of Base Isolation:**
  - ✓ Base isolation can't be done on every structure, for example: it is not suitable for structures resting on soft soils.
  - ✓ Becomes less efficient for high rise buildings.
  - ✓ Unlike other retrofitting base isolation cannot be applied partially to the structure.
  - ✓ Implementation in efficient manner is difficult and often requires highly skilled labors and engineers.