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Seismic Dampers (Mass Damper)

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ABSTRACT

Although the incidence of floor vibration problems appears to be on the rise, the use of mechanical damping devices to control vibrations is limited. In a recent survey of vibration control methods, Murray reports that passive-mechanical damping methods, including viscous damping, visco-elastic damping, and tuned-mass dampers, have often gone untried outside the laboratory or have had marginal impact in actual buildings. This is particularly unfortunate because mechanical dampers can sometimes control floor vibrations more cheaply than structural stiffening, and are often the only viable means of vibration control in existing structures. Successful implementation of Tuned Mass Damper used in Taipei 101 uses a 800 ton TMD which occupy 5 of its upper floors (87 – 91).Which cost all most about $700 millon for construction of 101 floors which is economical as compere to constructing structure consisting of high grade steel which may have indirectly affected the cost of construction and alternately affected the safety of people

INTRODUCTION

The most of structural system designed to carry vertical load may not have the capacity to resist lateral load even if it has design of lateral load will increase the structural cast substantially with increase in number of storey.As the seismic load acting on a structure is a function of self weight of structure,this structures are made comparatively light and flexible which have relatively low natural dumping. results makes the structure more vibration prone under wind, earthquake loading.New generation high rise of building is equipped with artificial dumping device for vibration control of energy dissipation.the various vibration control methods include passive ,active ,semiactive. Various factors that affect the selection of particular type of vibration control device are effectively, compactness and weight, capital-cost,operation cost,maintaince requirements and safetyTuned mass damper is to a main structure a passive damping system which utilizes a secondary mass to a main structure normally through spring and dashpot to reduce the dynamic response of the structure. the secondary mass system is designed to have the natural frequencywhich is depended on its mass and stiffness tuned to that of the primary structureWhen the particular frequency of the structure gets excited the imd will resonate out of phase with the structural motion and reduces its response. then the excess energy that its built up in the structure can be transferred to a secondary mass and is dissipitated by the dashpot due to secondary system as particular earthquake contains a large number of frequency content

Now a day multiple storey building are coming with tuned mass damper as a alternative resistancy system for wind and earthquakes

India is a country wherein 60% of our land is seismically prone and is being visited by earthquakes time and again incurring socio-economic losses in huge proportion and at the same time reminding the need of Seismic design.

Need of the Project:

Earthquakes have become a fear for many people and to accommodate this many construction companies are building structures which can withstand earthquake to a certain degree.

In a single year, earthquakes ruin thousand of homes and kill millions of people. They occur naturally on the earth's surface due to movement of plates which are located below the earth's crust. The vibrations caused by the earthquake have the potential to cause massive destruction and even ruin entire cities.

Earthquake occur due to two reasons. Firstly, it occurs when a volcano erupts suddenly and secondly due to the movements of plates which can happen due to cracks in plates or crust waves. Moreover, earthquake can also arise on the ocean floor and produce ground movements. In the recent years, majority of the earthquakes have occurred at the boundary of the continental plates of North and South America, South Asia and Pacific Ocean. It is believed that stress on the boundary of the plates creates pressure towards the middle and leads to movement of the Earth.

The major consequences of such natural disasters are the loss of human life. The location and magnitude of the earthquake is a major factor which determines the number of lives that will be lost and the number of structures that will be damaged. A huge number of deaths can be caused by collapse of structures which were constructed from heavy and weak materials. Other economic and social consequences include trauma, cost of damage, loss of jobs, loss of housing, business interruptions, waste of energy and material.

However, we strategies so as to limit the effect of such natural disasters to some extent. The planning includes minimizing the use of land that has already gone through ground damages, shaking, landslides and fault rupture. The basic aim is to reduce the number of lives that are lost each year due to earthquakes and disasters related to earthquakes and to reduce the damage done to the structures and the natural environment. To achieve these goals we are designing a structure which can withstand the devastating effects of earthquakes.

New technologies and refined methods of analysis permit the design and construction of more slender, and hence, in many cases more vibration-prone structures with rather light damping. One effective measure to protect buildings against excessive large vibration amplitudes is the installation of Tuned Mass Dampers (TMDs). A TMD is a control device with a single-degree-offreedom (SDOF) of either mass-spring-dashpot type, or a pendulum-dashpot system. The Tuned Liquid Column Damper (TLCD) is a variety of the TMD, which is based on the same mode of operation [1]. The natural frequency of the TMD is tuned closely to the dominant mode of the vibration-prone structure. Thus, the kinetic energy is transferred from the vibrating main structure to the TMD, where it is subsequently dissipated by its viscous element. Optimal design of TMDs is discussed in various papers, e.g. [2 - 6]. TMDs have been proven to be effective in reducing the dynamic response of structures induced by narrow-band periodic excitation such as wind and traffic loads. However, the effectiveness of TMDs to mitigate earthquake induced vibrations is still a topic of controversial discussion. For example, [7] reports about weak seismic performance of TMDs with very small mass ratios. On the other hand, in [6] it is shown that for a large mass ratio TMDs become very effective in minimizing the structural response. In this paper the seismic performance of TMDs, i.e. their effectiveness and robustness, is assessed. The presented parametric study of SDOF structures covers a wide range of structural periods between 0.05s and 5.0s, and mass ratios between 2% and 8%. The results are based on a set of recorded ordinary ground motions.

Objectives of our project are:

- Studying the use of tuned mass damper

- Use of TMD in New ATC tower delhi

Conclude the research with appropriate results of product durability.

Types of Mass Damper

Friction Damper

In this type of damper, seismic energy is spent in overcoming friction in the contact surfaces. Among other features of these dampers can be classified as avoiding fatigue in served loads(due to the non-active dampers under load) and their performance independent to loading velocity and ambient temperature. These dampers are installed in parallel to bracing.

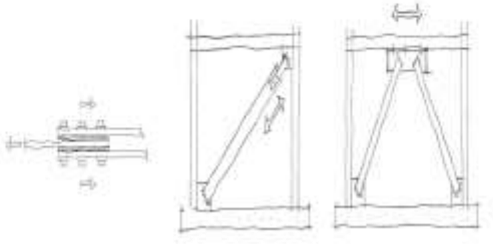
Friction Dampers are normally modeled directly in structural design software either directly (with a rectangular hysteretic loop) or more commonly, as a fictitious yielding element (how to model friction dampers). The two main outputs of the structural design being the required slip load and travel. With these two parameters, Quaketek can provide Dampers ranging from 0.5kip (2kN) to 350kips (1500kN) per damper with travels commonly between 0.5inches (12mm) and 12inches (300mm). Larger loads can be generated by connecting the dampers in parallel, generating in excess of 1,400kips (6,000kN)

Dampers can be designed for indoor or outdoor applications as the finishes can be adapted for different environments.

Friction based dampers are formed of steel plates tightened together by means of high strength bolts with either axial or rotational deformation mechanism leading to transformation of kinetic energy to thermal one.

Friction dampers are designed to have moving parts that will slide over each other during a strong earthquake. When the parts slide over each other, they create friction which uses some of the energy from the earthquake that goes into the building.

Rotational friction damper compared to other dampers Damptech rotational friction damping system is protected by a patent originally granted in 1999, and most recently in 2014, and registered in many countries around the world. The rotational friction mechanism is exclusively under the ownership of Damptech. The rotational friction dampers present an advanced technology, with high reliability and economic and technical advantages. Not surprisingly, the Japanese construction industry, which is one of the leaders in implementation of seismic-protective technologies has chosen Damptech dampers for installation in large-scale domestic projects. In the following, a broad comparison between the rotational friction dampers and other damper types is made:



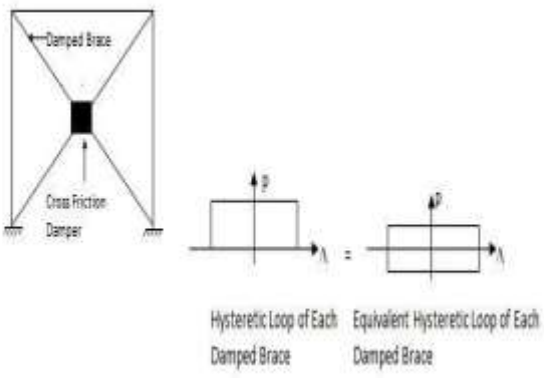
Linear friction dampers Linear (unidirectional) friction dampers are conceived as the older generation friction dampers, in which prestressed bolted connections with slotted holes are used. Grigorian and Popov (1993), Giacchetti, Whittaker et al. (1989) and Fitzgerald (1989) reported studies on this type of dampers. The linear friction dampers offer certain advantages such as high energy-dissipation capacity and stable cyclic behavior, which are considered the core advantages of all friction damper types, including the rotational friction dampers. Despite of these positive properties, the linear friction dampers suffer from some disadvantages such as: the variation in their behaviour due to corrosion on the steel plates (frictional interfaces). If the• engineer cannot predict the friction coefficient, the device cannot provide reliable friction. dimensional limitations for the projects that require high deformation capacities. Most national• codes limit the length of slotted holes, since the steel plate can be weakened. This limits the allowed displacement of linear friction dampers, and there is a risk that the damper will "lock" if the damper bolts hit the end of the slotted holes during an earthquake

Pall Friction Damper

Another type of friction damper is Pall friction damper. This damper includes a bracing and some steel plate with friction screws. And they should be installed in the middle of bracing. Steel sheets are connected to each other by high strength bolts and they have a slip by a certain force, to each other.

Design of these dampers have been first proposed by the Canadian researchers, Pall and Marsh (1982).This system basically consists of a series of steel plates which can be connected together by highly resistant steel bolts and are allowed to slip under a predetermined load. When an earthquake occurs, friction dampers slip for a predetermined load before the frame is damaged or collapses. This will allow the major part of the seismic energy to be depreciated via friction. Actually, buildings remain in the elastic range and are able to bear the disastrous seismic forces

Pall friction mechanism shift curve whose rectangular form indicates high energy absorption by the system.



The Pall friction damper is made of a set of special steel plates, which can create the convenient frictional performance. These plates are bolted together with a high strength screws and they are designed not to slip during wind. These dampers slide over each other at the determined optimum slip load prior to yielding of structural members and dissipate the big portion of the earthquake energy. This makes the structure remain in the elastic range or delay the yielding of the structural member during major earthquake.

A Pall damper is installed in the intersection of cross, chevron and single diagonal bracings . This type of damper has been used in countries such as Canada, India, USA and China.

Pall damper is considered better than other energy dissipation systems because 1) it is easy and cost-effective to build a Pall damper, 2) a Pall damper performs reliably against an earthquake, 3) energy dissipation is very high in a Pall damper due to its large hysteresis loop, 4) this damper performs independently from changes in velocity and temperature, 5) Pall dampers do not usually require considerable repair after the earthquake, 6) they can be hidden in blades, 7) due to rectangular hysteresis loop, these dampers are easily modelled in a computer [1]. In [8], authors introduced a new type of Pall damper which is used in cross bracings. These dampers are similar to PFDs, with a difference that their central core is Tshaped. This type of damper was called an Improved Pall Friction Damper (IPFD). A schematic can also be found in [7]. The mechanical performance of both dampers is entirely similar and they both absorb an equal amount of energy. Most of Pall’s assumptions for PFD are true for IPFD. However, IPFD is considered better than PFD because 1) its configuration is easier, 2) its motor function is better, 3) its analysis is simpler, and 4) its construction costs lower.

Mass Dampers

Mass is placed on a fulcrum which acts as a roller. And it allows to mass with move as a transfer-lateral movement to the floor. Springs and dampers are placed between mass and anchor members to the floor and frame and they are placed relative in “opposite phase” and sometimes are adjacent vertical. And these anchor members transmits structural lateral force. Bidirectional transfer dampers are made as a spring-damper in two vertical directions. And they provide controlling the structure movement in two vertical structures.

Tuned mass dampers stabilize against violent motion caused by harmonic vibration. A tuned damper reduces the vibration of a system with a comparatively lightweight component so that the worst-case vibrations are less intense. Roughly speaking, practical systems are tuned to either move the main mode away from a troubling excitation frequency, or to add damping to a resonance that is difficult or expensive to damp directly. An example of the latter is a crankshaft torsional damper. Mass dampers are frequently implemented with a frictional or hydraulic component that turns mechanical kinetic energy into heat, like an automotive shock absorber.

Passive Tuned Mass Damper (PTMD)

Whenever the term TMD is mentioned in the field of vibration control of structures, it refers to the passive type which can have several different configurations. Typically, a TMD is a structural control device that consists of an inertial mass attached to the structure at the location of higher frequency, usually near the top, via spring and damping mechanisms, normally viscous or viscoelastic dampers,. Tuning is the action of substantially matching the natural frequency of the attached TMD to that of the structure by selecting the appropriate TMD parameters (stiffness, damping, and mass). The TMD will resonate out-of-phase when it is properly tuned to the fundamental (first) mode of the structure (the lowest natural frequency), which most of the time carries the highest vibrational energy of the structure, and the resulted energy will be dissipated to the environment as heat by the damper .

The concept of the tuned mass damper (TMD) was first applied by Frahm in 1909 to reduce the rolling motion of ships as well as ship hull vibration. Later, Ormondroyd and Den Hartog (1928) presented the theory of the TMD, followed by a detailed discussion of optimal tuning and damping parameters in Den Hartog's book on mechanical vibrations (1940). Since then, tuned mass damping has become one of the most investigated fields in structural vibration control

There are some significant factors (constraints) that need to be considered when designing a TMD. The major and chief of which is the size and amount of mass that can be practically placed on the top of a building. Space restriction due to the relative motion of the TMD to the building is another design factor as well as low friction bearing surface which enables the mass to respond to the building motion at low levels of excitations. Friction is a major engineering issue that is associated with a sliding mass arrangement of traditional TMD configurations which become more important when the TMD is utilized as an additional damping to increase the serviceability of the building Another limitation is the lack of adaptation to detuning conditions, and as a consequence, passive TMD efficiency depends on the accuracy of its primary tuning TMDs are typically effective through the use of multiple TMD configurations, which consist of a collection of several mass dampers with distributed natural frequencies under random loading, leading to more effective and dynamic responses of the structure.

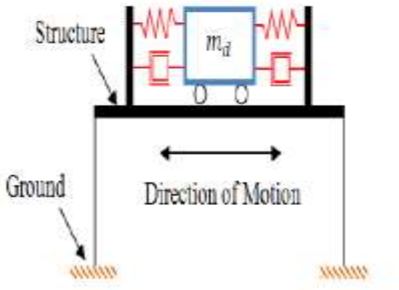
However, in many cases, space constraints will not allow for the use of traditional TMD configurations which occupy large areas of the building rather than requiring the installation of an alternative configuration, such as a pendulum TMD which occupies less space and can have a bigger mass that moves freely in the space, to accommodate the TMD in the structure

Currently, there are several TMD configurations installed in tall buildings, bridges, towers, and smoke stakes for dynamic response control primarily against wind-induced motion. As of today, most TMD applications have been made to mitigation wind-induced motion Despite the restrictions that have been mentioned previously, passive TMDs are still the favorable vibration absorber for structure engineering because they are relatively inexpensive systems that perform effectively when properly tuned to the specified modeThe two common types of passive TMDs are translational TMDs and pendulum TMDs.

Translational TMD

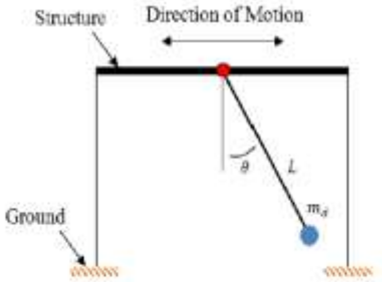
The two typical types of translational TMD systems are unidirectional systems and bidirectional systems The motion of the TMD mass in a unidirectional system is constrained to one direction by putting the mass on roller bearings or a set of rails that function as a roller, permitting the mass to slide laterally, out-of-phase, and relative to the floor as depicted in Figure. On the other hand, the mass can move in two orthogonal directions which helps control the motion of a structure in two cross coordinate axes. This system is called a bidirectional system. In both systems, a set of springs and dampers are located between the TMD mass and vertical support structure, which transfer the lateral damping force to the structural frame

Some existing examples of early installed versions of translational TMD systems include the Washington National Airport Tower, the John Hancock Tower in Boston, the Chiba Port Tower in Japan, Citicorp Center in Manhattan, New York City, and the Canadian National Tower in Toronto.



Pendulum TMD

In pendulum TMDs, the mass is hung by cables to the floor, as shown in Figure, instead of sitting on roll bearings or rails, enabling the system to act as a pendulum, which hence eliminates the problems associated with bearings in translational TMDs as depicted in Figure. When the pendulum gets excited by the structure motion, it generates a horizontal force that counteracts the floor motion and reduces the structure's vibration. The behavior of both the pendulum and the translational TMDs can be modeled by an equivalent single degree of freedom (SDOF) system attached to the structure as shown in Figure

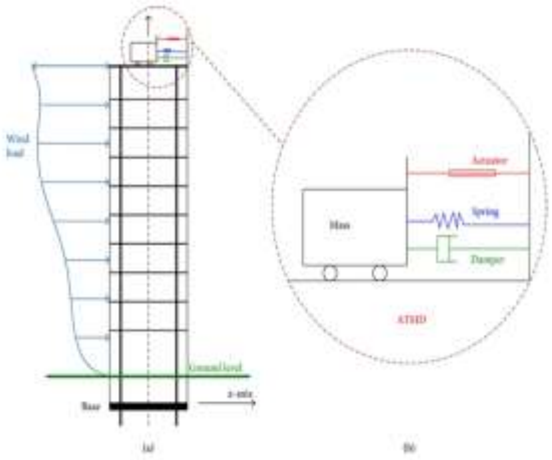


There are several parameters that make pendulum TMDs favorable over translational TMDs. They include the absence of bearings, they can use larger masses, multi-directionality, they occupy less space, and have longer life. Utilizing bearings for translational TMD as a support is expensive, because it involves many mechanical systems such as rail and brake systems, and can lead to wear over time. Examples of early versions of PTMD applied to structures include Crystal Tower in Osaka, Japan, Higashiyama Sky Tower in Nagoya, Japan, and Taipei 101 in Taipei, Taiwan

Active Tuned Mass Damper (ATMD)

Passive TMDs are favoured for their simplicity and reliability, but these devices are incapable of adjusting to the variation in system parameters, due to the change in the operational environment. As a result, mistuning problems occur, which is the sensitivity to the fluctuation in tuning the frequency of TMDs to the controlled frequency of the structure, and significantly reduces the effectiveness of the TMD. Clearly, more efficient and swifter TMD systems could be reached with the ability to respond actively to changes in structure parameters and, thereby, would allow absorption of broadband vibrations. Such a vibration absorbers is called active tuned mass damper (ATMD) which is really a traditional TMD with an external hydraulic or electro-mechanical actuator inserted between the primary structure and the auxiliary mass as shown in Figure.

The appropriate control force provided by actuator systems counteracts the dynamic response of the structure. The actuators are driven by an appropriate algorithm such as a closed loop (feedback), in which the control forces are determined by the feedback response of the structure.



The selection of the vibration absorber type for high rise buildings and structures depends on several major factors including efficiency, size and compactness of the structure, capital cost, operation cost, maintenance, and safety. The use of Active TMDs as vibration absorbers has several major advantages in mitigation of structural vibration over passive TMDs. They include the ability to reduce vibration in multiple modes (even in different directions) with one TMD, requiring less space (by using one rather than multiple TMDs), increasing the effectiveness by utilizing the control force, self-tuning to the changing structure's frequency, using a smaller mass than an equivalent passive TMD, and higher efficiency. Whereas the regular TMD can add 3% to 4% additional damping of the critical damping, the active TMD can add 10% or more Also, ATMDs can reduce the dynamic response of the structure by 40 % to 50% or more ATMDs, unlike some other active control devices, can be installed in different types of structures such as buildings, towers, bridges, and stacks

Increasing the effectiveness is the major feature of utilizing active control in TMD, in which a relatively small mass with control force can be used to subdue the dynamic response of the structure. To reach the highest possible effectiveness of ATMD, it is advised that an optimal active control force be determined using an appropriate control strategy. The issue associated with the selection of a control technique is how to operate the active TMD most effectively in order to mitigate the response of the main structure , Control performance depends on the properties of the controller, the targeted structure to be damped, and the operation environment. Therefore, control system design strategies and control performances of different active control techniques should be studied and investigated to find out the appropriate control method for structural control.

In an effort to enhance the effectiveness of a TMD system, Chang and Soong (1980) , and Isao (1992) , introduced an active control force to act between the structure and TMD system, thereby, increasing the effectiveness of the TMD. It has been proven by Chang and Soong that the effectiveness of TMDs can be considerably increased by the addition of an active actuation. The appropriate control forces were calculated using an optimization process. Numerical results using realistic parameter values show that significant reduction in building displacement and acceleration can be reached when the TMD system is actively operated. Moreover, reduction in TMD strokes or the mass ratio can also be achieved. Another important finding based on the numerical results is that the TMD can become ineffective when high frequency excitations are encountered; however, by adding active control force, this situation can be better improved. Further study for designing an effective active TMD to control a tall building subjected to stationary random wind forces was proposed by Abdel-Rohman (1984) using the pole assignment method.

The numerical results of an example indicate that the design of an optimal ATMD required at least a parametric study to select the ATMD parameters.

Chang and Yang proposed a form of a closed-loop complete feedback control algorithm to control a building (MDOF system) using an ATMD. The building is assumed to be under stationary Gaussian white noise ground excitation. The control force is computed from classical feedback control of the acceleration, velocity, and displacement of the building. The passive properties and the gain coefficients of the actuator were derived by minimizing the displacement variance of the building. After the simulation has been performed to evaluate the ATMD, the results show that the control efficiency of the ATMD, based on velocity feedback, depends on the properties assumed for the passive device. Also, for the same level of reduction in structural displacement, the control force required is smaller using complete feedback. Another similar study was presented by Seshasayee and Yang for the design of ATMD to suppress the first mode of a tall building subject to wind loads, which was assumed as white noise excitation. In their study, the control force was generated based on complete feedback (of displacement, velocity, and acceleration). Two examples are studied, one is a 162 m tall planar frame and the other is 400 m tall, to evaluate the control procedure and effectiveness of ATMD

Active Pendulum Tuned Mass Damper and Structure Model

Suspended mass, as shown in Figure, is possibly the simplest form of TMDs. By involving viscous damping elements in their design, they can suppress structural vibrations effectively and increase the serviceability of high-rise buildings. Such TMDs are called Pendulum TMDs, or PTMDs. The typical schematic geometry is shown in Figure. PTMDs are commonly suggested for tall structures with large masses and low natural frequencies . The motivation in this work is to develop and investigate a single active PTMD that a) can be simultaneously tuned to multiple modes of high rise structure and mitigate their corresponding vibrations and b) have a smaller mass than an equivalent passive PTMD, by improving its effectiveness using a modern control theory

Active PTMD (APTMD)

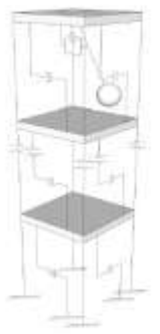
Viscous dampers in passive PTMDs, which are connected to the mass from one end and to the vibrating structure at the other, as it appears in Figure are responsible for the energy dissipation from the damped structure. Several reasons make active PTMDs of interest to civil engineers in the case of vibration control of tall buildings because they:

Eliminate the need for using multiple traditional translational TMDs tuned to multiple frequencies

Provide higher damping effectiveness than an equivalent passive PTMD of an equal size

Provide as much damping, using a smaller mass, as an optimally designed passive TMD with substantially larger mass. This is of interest when the vibrating structure, e.g., the high-rise, cannot support the weight of a massive passive PTMD.

Occupy less space than a passive type.

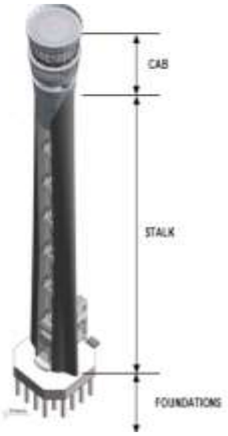


Schematic of a MDOF flexible main structure equipped with a PTMD

ATC Tower Delhi

The Delhi Air Traffic Control Tower: Engineering, Architecture and Design with TMD for the Tallest ATCT in India

The 100m tall air traffic control tower function is split into the “stalk” which is approximately 10m wide by 22m long and at the top of this is a 6 storey high (excluding roof) “cab”. The stalk is to be built of insitu concrete



The cab houses various rooms and facilities including the visual control room which lies approximately 95m above ground level and 5m below roof level. The upper 2-storeys of the cab are steel framed, in order to achieve small light weight vertical columns, minimising visual obstruction for the visual control room operation and offering 360 degrees panoramic views, required for air traffic control operations. The lower 4-storeys of the cab are concrete frames, supported by the stalk below. The main function of the stalk is to lift the cab section to a high level, and to house a fire lift, a passenger lift, a stair well and services & avionics risers for vertical transportation to the cab. The architectural design dictates that the stalk is split into two ‘legs’ as cores, connected by crosslandings (bridges) at 10.5m spacing. The two cores perform largely as independent cantilevers, although the landings do offer some benefits of lateral load sharing and some torsional connectivity between the cores.

Tuned Mass Damper Design

The air traffic control tower, being a slender light building, is responsive to dynamic load, that is to say it will move perceptibly when loads are changed, such as changing wind load. This horizontal movement or acceleration needs to be limited to within occupancy comfort levels as to prevent an uncomfortable working environment. To deal with this a tuned mass damper is being used and will be located at the highest location in the tower it can be fitted.

The tuned mass damper works by providing additional mass that is controlled by a combination of springs and dampers. As the tower is pushed and moved by wind loading the additional mass of the tuned mass damper counteracts the actual mass of the tower preventing the tower from swaying side to side and limiting the floor accelerations. Floor accelerations have been limited to a maximum of 15millG under wind excitation for occupancy comfort, which is within the human perceptible range, avoiding the annoying range.

The evaluation and limitation of accelerations on frequent recurrence intervals (such as one year) is of utmost importance in wind environments driven by synoptic and thunderstorm events such as that of Delhi. This shorter recurrence interval is most relevant to occupants’ daily working life. Synoptic gales, monsoons, cyclones and thunderstorm winds are all extreme wind events that need to be considered when designing for occupant comfort; however the nature of these events can be quite different depending on geographical location. In areas such as Delhi, where synoptic gales or thunderstorms are dominant, there is a strong relationship between regularly occurring accelerations in towers and higher levels of vibration occurring during extreme wind events. The frequency dependent guidelines given in the International Organization for Standardization (ISO10137) document are the most internationally recognized criteria for assessing the acceptability of building motions in a wind climate such as that of Delhi. This standard provides recommended limiting accelerations based on occupancy type for accelerations occurring on a 1-year recurrence interval. Acceleration studies were carried out on the tower based on the wind load desk study. As such the results are somewhat approximate and will need to be checked again once the wind tunnel test results are available. The acceleration studies were done in absence of TMD to show it was required, and was required in both directions. Options involved looking at one or two masses, however one proved sufficient. Approximately one single value of tuning was sufficient for early analysis for both the two directions: increasing effective damping from 1% to around 7% in one direction and around 4% in the other. The optimum position is clearly as high as possible up the tower to gain maximum effectiveness of the damper, but has to be below the visual control room and coordinated work with HOK International led to best position according to a wide range of constraints and building functionality

Taipei 101 - A case-study

TAIPEI 101 - A structural marvel created by combining the best of all structural systems.

TheThe Taipei 101 uses a 800 ton TMD which occupy 5 of its upper floors (87 – 91). The ball is assembled on site in layers of 12.5-cm-thick steel plate. It is welded to a steel cradle suspended from level 92 by 3” cables, in 4 sets of 2 each.

Eight primary hydraulic pistons, each about 2 m long, grip the cradle to dissipate dynamic energy as heat.

A roughly 60-cm-dia pin projecting from the underside of the ball limits its movement to about 1 m even during times of the strongest lateral forces.

The 60m high spire at the top has 2 smaller ‘flat’ dampers to support it.

Conclusion And Discussion

The Project Appealed To Us After We Realize The Necessity Of Earthquake Resistant Structure. Seismic Analysis Of Buildings Still Needs Adequate Attention In India In Spite Of The Fact That The Single Most Importance Factor Of Contributing Maximum Damage And Casualties In Past Earthquake Is The Collapse Of Building.

Thus, Shear Wall Are One Of The Most Effective Building Elements In Resisting Lateral Forces During Earthquake. By Constructing Shear Walls, Damages Due To Effects Of Lateral Forces Due To Earthquake And High Winds Can Be Minimized. Shear Wall Construction Will Provide Larger Stiffness To The Buildings Thereby Reducing The Damage To Structure And Its Contents.

We Came Across Many New Facets Related To The Project And It Was A Great Learning Experience Throughout For Us.

To Solve Numerous Issues With The Building Dynamics And Controlling The Accelerations To Ensure The Occupancy Comfort. The Time Demands Light Weight And Tall Structures. Which Hinders The Safety And Stability Of Structure .Dampers Are The Devices Which In Turn Can Be Used As A Safety Devices As It Resist The Vibrations And Dissipate Energy In Terms Of Fluid Damper.

Skyscrapers And Other Structures Do Move To A Certain Extent. During Seismic Events Or Strong Winds, The Tallest Skyscrapers Can Sway Up To Almost A Metre On Each Side! The Building May Be Structurally Fine, But That Magnitude Of Movement Together With Any Induced Vibration May Cause Severe Discomfort, Airsickness, Nausea Or Even Shock To The Building Occupants. Thus, Lateral Deflection (Also Known As Sway Or Drift), Vibration And Building Acceleration Are Significant Criteria That Structural Engineers Carefully Assess In The Design Of High Rise Structures.

There Are Several Ways Of Reducing The Sway And Vibration Of Structures In Order To Reach The Acceptable Level Of Human Comfort. First, Vertical Elements Such As Columns And Walls May Be Stiffened By Providing Larger Dimensions Or Thicknesses. However, Architects Usually Prefer This To Be The Last Option As Far As Is Possible, So Engineers May Need To Step Back And Look More Unconventional Approaches. One Of Which Is To “Tune The Building Like A Guitar”! Yes, You Can Fine Tune A Building Similar To Everyone’s Favourite Musical Instrument. How? The Answer Is Through The Use Of A Tuned Mass Damper Or Tmd.

Tmds Are The Very Effective Tools To Protect The Structure From Various Lateral Forces, Like Wind Forces, Earthquake Effect, And Thereby It Can Save Our Property And Priceless Lives.The Structure Can Be Made Light And Taller Just By Adding The Damping Device .The Damping Device Resists The Vibrations.

REFERENCE

1. Shimazu T. “Evaluation of base isolation systems based on recorded and predicted responses of actual buildings under recent earthquakes.” Proceedings of the 2nd world conf. on structural control, John Wiley & Sons: 1145-1152, 1999.
2. Mualla I., Nielsen L. O., Chouw N., Belev B., Liao W. I., Loh C. H., Agrawal A. “Enhanced response through supplementary friction damper devices.” Proceedings of the 3rd int. workshop WAVE2002 on wave propagation, moving load and vibration reduction, Lisse: A. A. Balkema, 121-127, 2002.
3. Villaverde R., Mosqueda G. “Aseismic roof isolation system: analytic and shake table studies” Earthquake Engineering and Structural Dynamics 1999; 28: 217-234.
4. Villaverde R. “Seismic control of structures with damped resonant appendages” Proceedings of the 1st world conference on structural control, Los Angeles, 1994, wp4-113-wp4-121.
5. Soto-Brito R., Ruiz S. E. “Influence of ground motion intensity on the effectiveness

of tuned mass *dampers* ” Earthquake Engineering and Structural Dynamics 1999; 28: 1255-1271.