ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Study of Dynamic Behaviour of a Multistoried RCC Structure with Water Tanks as Liquid Dampers

Syed Ahmed Uddin
Roll-No: 1603-13-741-018
Department of Civil,
Deccan College Of Engineering And Technology.

Hashim Mohiuddin
Professor,
Department of Civil,
Deccan College Of Engineering And Technology.

ABSTRACT:

Sloshing liquid dampers (SLDs), popularly known as tuned liquid dampers (TLDs), are used as passive control devices for reducing structural vibrations resulting from wind and earthquake ex-citations in tall buildings and high-rise structures. In the present investigation, effectiveness of these TLDs has been studied for a building. A twenty-storied building has been considered as a representative of the structure. It is shown that the liquid sloshing is the most important design parameter, rather than, tuning of the fundamental sloshing frequency to the structure frequency for the liquid damper to be effective. Furthermore, the liquid damper design for multistory buildings is different from that for Single Degree Of Freedom (SDOF) structures, where not only the optimal tuning ratio of the liquid damper is different, but multiple dampers located at critical locations are required for effective control of floor accelerations. The investigation is performed using the linear dynamic analysis. Response spectrum method is used for analysis of the structure under dynamic loading. This is very useful tool of earthquake engineering for analyzing the performance of structures and equipment in earth-quakes, since many behave principally as simple oscillators. Thus, if you can find out the natural frequency of the structure, then the peak response of the building can be estimated by reading the value from the ground response spectrum for the appropriate frequency. In most building codes in seismic regions, this value forms the basis for calculating the forces that a structure must be designed to resist. Finally, it is illustrated that TLDs, if appropriately designed, can be very effective in reducing overall forces, moments, base shears, time period and deformation of building structures for earthquake type base excitations.

To perform this type of analysis the software used here is SAP. From its 3D object based graphical modeling environment to the wide variety of analysis and design options completely integrated across one powerful user interface, SAP2000 has proven to be the most integrated, productive and practical general purpose structural program on the market today. This interface allows us to create structural models rapidly without long delays. Complex Models can be generated and meshed with powerful built in templates. Integrated design code features can automatically generate loads with comprehensive automatic steel and concrete design code checks per design standards.The model is subjected to dynamic loads and the results compared are base shear, roof displacement, Time period. The selected modelwere subjected to linear dynamic analysis with and without TLD. Results obtained from calculations, analysis and investigations are the lateral roof displacements, base shears & time period. Base shear was found to be 15% less when a TLD is used, similarly lateral displacement and time period was found to be 14% and 8% less respectively when a TLD was applied on the structure.

INTRODUCTION:

Starting from the very beginning of civilization, mankind has faced several threat of extinction due to invasion of severe natural disasters. Earthquake is the most disastrous among them due to its huge power of devastation and total unpredictability. Unlike other natural catastrophes, earthquakes themselves do not kill people, rather the colossal loss of human lives and properties occur due to the destruction of man-made structures. Building structures are one of such creations of mankind, which collapse during severe earthquakes, and cause direct loss of human lives.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Numerous research works have been directed worldwide in last few decades to investigate the cause of failure of different types of buildings under severe seismic excitations. Massive destruction of high-rise as well as low-rise buildings in recent devastating earthquake of Nepal in April, 2015 proves that also in developing counties, such investigation is the need of the hour. Conventionally reinforced concrete tanks have been used extensively in residential and industrial facilities for several decades. The design of these structures is also being given attention considering parameters such as strength requirements and serviceability requirements. Conventional design is followed till date for the design of high rise structures with water tanks. Seismic activity prone countries across the world rely on "codes of practice" to mandate that all the constructions fulfill at least a minimum level of safety requirements against future earthquakes.

The devastation caused by recent earthquakes highlights the necessity of adequate protection in buildings against earthquake damage. One effective way of providing earthquake protection for buildings is the use of external structural control devices. Unfortunately, widespread use of these devices in developing countries is prevented due to the prohibitive additional cost of these devices, relative to the cost of construction of a typical building. Thus, research focus is shifting towards the study of effective and economic control devices for earthquakes. The behavior of a building during earthquakes depends critically on its overall shape, size and geometry in addition to how the earthquake forces are carried to the ground. Design of civil engineering structures is typically based on prescriptive methods of building codes. Normally in the static case, the loads on these structures are low and result in elastic structural behavior. However, under a strong seismic event, a structure may actually be subjected to forces beyond its elastic limit. The devastation caused by recent earthquakes highlights the necessity of adequate protection in buildings against earthquake damage.

One effective way of providing earthquake protection for buildings is the use of external structural control devices. Unfortunately, widespread use of these devices in developing countries is prevented due to the prohibitive additional cost of these devices, relative to the cost of construction of a typical building. Thus, research focus is shifting towards the study of effective and economic control devices for earthquakes. The vibration control system, named Tuned Liquid Damper (TLD), has been widely recognized as an effective damper for reducing the structural vibration due to earthquake, strong wind and other dynamic loadings (Modi., 1987 and Fujino., 1988). In this damper, the sloshing period of the TLD is tuned to the fundamental period of the structure. This damper exploits the hydrodynamic force of the liquid (water) to control the vibration of the structure.

Seismic Base Isolation:

Seismic base isolation is an old design idea, and has wider applications with mature technology. It is based on the principle of decoupling the structure or part of it, or even of equipment placed in the structure, from the damaging effects of vibrations caused by seismic forces or ground accelerations. Seismic isolation aims:

(i) to alter the fundamental frequency of the structure by shifting away from the dominant frequencies of earthquake ground motion (Fig. 1), and

(ii) to control the displacement by addition of adequate amount of damping (Fig. 3.2).

Principle underlying seismic isolation may be explained by Figs 1 and 2. Period shift of structure reduces the acceleration transmitted to the isolated structure. In its effective form the structure approaches near stationary state whereas the supporting ground vibrates under excitation (Fig.1). But increase in time period also increases the displacement. The displacement is controlled by inclusion of damping material in isolators such as lead (Fig. 3 & Fig. 4) (iii)The base isolators inserted at founding level or at first floor level filter the horizontal components of the seismic vibrations from soil, which are most dangerous when entering the structure.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Seismic base isolation permits large lateral movement (from 20-40 cm in Italy, even 80 cm in California and Japan) of the structure but quite slowly (typically with periods of 2 s or more), a nd practically as a rigid body. This makes seism ic isolation particularly adequate f or the strategic and criticall y important constructions ensuring their functio nality again st severe seismic events.

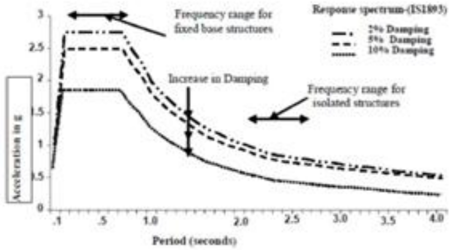

Fig. 1 Reduced response due to frequency shiftth rough base isolation.

The most commonly used seismic isolation devices are made of rubber called rubber bearings (RBs) as shown in Fi.3. With, insertion of lead plugs (LRB or PB) or the high damping rubber bearings (HDRB) a damping coefficient more than 10 per cent (Dolce et al. 2005) may be achieved. Thereby the lateral movement is limited to a reasonable value as illustrated in Fig. 4. Important parameter to be considered in the choice of an is lation system, apart from its general a bility of shifting the vibration period and adding damping t o the structure is its capacity of selfcntering, which is accom plished by he RBs and friction pendulums. In the USA a steelteflon recentring sliding system known as Friction Pendulum S stem (FPS) has been appled alone and performed satisfactorily. The sliding isolatio n system is based on the concept of sliding friction.

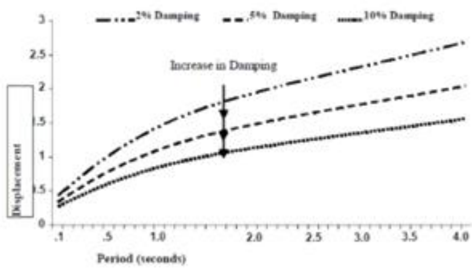

Fig. 2 Reduced displacement du e to increase in damping.

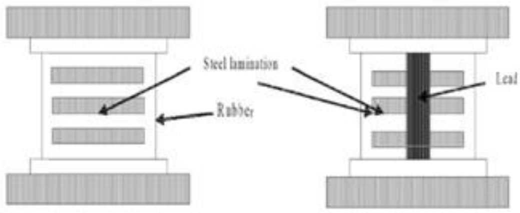

Fig. 3 & Fig. 4 Laminated Rubber Bea ring and Laminated Lead Rubber

CONCLUSION:

1.The percentage difference in base shear obtained from response spectrum for empty tank and full tank case is 15 percent.

2. The percentage difference in Joint displacements obtained from response spectrum for empty tank and full tank case is 14 percent.

3. The percentage difference in time periods obtained from response spectrum for empty tank and full tank case is 8-9 percent.

4. Based on the results it can be concluded that when water tank sloshing load is analyzed and considered as a TLD in application on the structure against the earthquake load it effectively reduces the overall behavior of the structure resulting in economic and safe design.

5.From this study, it has been found that TLD can successfully be used to control the response of the structure. During the life of the building, if there is no seismic activity, the structure will behave as an elastic system, unaffected by the presence of the dampers.

6. The water tank lies at the roof of the structure, and as they require no extra space they can be used without any problem. Inspection and periodic testing are not required. When there is no seismic activity there is no action in the tank, which can support its design static load indefinitely, so there are no problems of wear or fatigue.

7. Particular water level is to be maintained in the water tank by placing the exit pipe at some elevation which makes sure that required water level for damping is always available.

8. Apparently, TLD is a very attractive proposition for structural response control during a seismic event, but the major limitations hindering the application of TLDs are:

i) The physical phenomenon of water sloshing is not fully understood. Effects of wave breaking in the process of sloshing may be a potential source of analytical and design error; and

ii) Prevalent methods for TLD design involve many approximations, which should be addressed through rigorous analytical and experimental studies.

9)The major advantages which may be attributed to the tuned liquid dampers are:

i) Low initial cost;

ii) Low or no maintenance cost;

iii) Ease of frequency tuning;

iv) No limit for vibration amplitude ;

v) Easy applicability for existing buildings and;

vi) No mass or weight addition to the structure as water required for building purposes may also serve the damping requirement.

REFERENCES:

1.A. Doğangün , and r. Livaoğlu (2008). "A comparative study of the seismic analysis of rectangular tanks according to different codes"

2.A. Samanta and p. Banerji (2008). "Structural control using modified tuned liquid dampers."

3.ACI 350 (2001), Seismic Design of Liquid-Containing Concrete Structures (ACI 350.3-01) and Commentary (350.3R-01), ACI. USA.

4.Banerji P, Murudi M, Shah AH, Popplewell N. (2000) "Tuned liquid dampers for controlling earthquake response of structures." Earthquake Engineering Structural Dynamics 2000; 29: 587-602.

5.Baratta A, Corbi O, Orefice R (2004), Tuned Liquid Dampers for structural Applications:Experimental Evidence, Proceeding of the 4th International Conference on Engineering Computational Technology, Lisbon, 2004.

6.Bhosale Dattatray, G. R. Patil, Sachin Maskar (2014), "Use of Overhead Water Tank to Reduce Peak Response of the Structure", ISSN: 2278-3075, Volume-4 Issue-2

7.Chaiseri, P., Fujino, Y., Pacheco, B.M. and Sun, L.M. (1989). Interaction of tuned liquid damper and structure: theory, experimental verification and application. J. Structural Engg./Earthquake Engg. Proc. JSCE 6:2, 273-282.

8. Doğangün A, Livaoğlu R, (2004), "Hydrodynamic pressures acting on the walls of rectangular fluid containers", Structural Engineering and Mechanics, vol:17, 2, 203-214.

9."Emili Bhattacharjee, Lipika Halder and Richi Prasad Sharma (2013), ""An experimental study on tuned liquid damper for mitigation of structural response"", Structural Engineering 2013, 5:3"

10.Epstein, H.I (1976), "Seismic design of liquid storage tanks", J.Struct. Div. ASCE, 102,1659-1673.

11.Fujino y, sun lm, pacheco bm, chaiseri p (1992). "tuned liquid dampers (tld) for suppressing horizontal motion of structures." Journal of engineering mechanics, asce 1992; 118(10): p. 2017-30.

12.G. P. Mavroeidis, b. Zhang, g. Dong, a. S. Papageorgiou, u. Dutta, and n. N. Biswas (2008). "The great 1964 prince william sound, alaska, earthquake": estimation of strong ground motion.

13.H.kosaka, t.noji, h.yoshida, e.tatsumi, h.yamanaka&a.k.agrawal (2010). "Damping effects of a vibration control damper using sloshing of water", vol 4.

14.Hanson, R. D. (1973). "Behavior of liquid-storage tanks, in The Great Alaska earthquake of 1964: Engineering", National Academy of Science, Washington D.C., 331-339.

15.Hous ner, G.W. (1957). Dynamic pressures on accelerated Fluid Containers.

16.Housner, G.W. (1963), "Dynamic behaviour of water tanks", Bull. Seism. Soc. Am., 53,381-387.