"ANALYSIS OF EARTHQUAKE VIBRATIONS BY THE USE OF A TUNED LIQUID DAMPER AND A BAFFLE WALL"

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Abstract

A network of very small sensor nodes is known as a wireless sensor network (WSN). Sensor nodes' processing, energy, and memory capabilities are constrained by their small size. WSN routing is complicated by the sensor nodes' limited energy and memory. Recently, clustering has increased interest in WSNs' ability to save energy. A sensor node, also known as the cluster head (CH), collects sensed data from all other sensor nodes in the cluster and acts as their representative. The load on the cluster head is greater than that of a typical sensor node, thus two types of sensor nodes are taken into consideration: the first is heterogeneous (requiring more energy than a typical sensor node), and the second is a typical sensor node. The CH should be rotated across all sensor nodes in order to balance energy consumption across the network of sensor nodes. The main source of energy consumption is the processing and communication process. The Power Efficient Hierarchical Clustering Algorithm (PEH-CA) is a suggestion made in this dissertation. Based on the sensor nodes' remaining power (energy), PEH-CA chooses CH. The network is set up in a three-tiered architecture: conventional sensor nodes are connected at the lower levels, cluster heads are located to receive data from these nodes at the middle levels, and superior nodes serve as the base station's interface at the higher levels. Long-distance data reporting to base stations in WSNs used a lot of energy, which decreased the lifetime of the network. In this research, energy heterogeneity is taken into account when choosing the cluster head in order to maximise the lifetime and stability of the network. Additionally, the cluster head's re-clustering saves energy during data reporting to the base station. The simulation findings demonstrate that, when compared to the well-known existing clustering algorithms SEP and TL-LEACH, WIoT. PEH-CA conserves more energy during data reporting. In addition, PEH-CA extends the network stability duration by 300 rounds for big areas and 2020 rounds for medium areas (compared to WIoT, TL-LEACH and SEP, respectively).

Introduction

1.1 General

This gives brief introduction and over view of the Tuned Liquid Dampers. Objective, history of the present work and basics related to earthquakes ground motion is incorporated in this chapter. Natural frequency, damping in structures and effects of sloshing liquid are also discussed. Basically, the TLD is a water tank linked to the main structure with its sloshing frequency matched to the structure's inherent frequencies. Because the damping capacity of the TLD can be controlled, the main structure's damping capacity is increased, and dynamic performance is improved. The TLD's sloshing frequency may be easily achieved by adjusting the tank's size and water depth. It is true, however, that without the help of additional energy dissipation devices, the natural damping of sloshing fluid is frequently far lower than the amount necessary for maximum TLD performance. Liquid sloshing has been utilized in the literature in Tuned Liquid Dampers (TLD), to suppress wind induced vibrations of tall structures in a number of applications. A TLD is a passive control device that can suppress structural vibrations using liquid motion. There are a number of advantages to using this device, such as low cost of manufacture and installation and low maintenance. No weight penalty to the structure exists when the design of the damper is incorporated with a storage tank for water supply. However, existing storage tanks typically have deep liquid levels that induce standing sloshing waves. It has been shown that when the tank is exposed to a sinusoidal excitation of 15Hz, 20Hz, and 25Hz with different water depths, sloshing effects in rectangular tanks with baffle walls may be evaluated using a simpler technique. Tall buildings are becoming more popular as a means of alleviating the city's ever-increasing lack of available space. As a result, the structure is more susceptible to vibration since it is comprised of light and pliable materials. In addition to increasing the likelihood of different failures, this may damage cladding and partitions and create issues in the service department. Because tall structures need functional performance, it is essential to reduce the frequency of unpleasant motion below the threshold level.

1.2 History

Anti-rolling tanks, which employ liquid dampers to stabilize ships against rocking and rolling, have been in use since the 1950s. For example, the Nutanion Dampers employed in the 1960s are based on this similar principle. Bauer first suggested using a rectangular container filled with two immiscible liquids to minimize structural response to a dynamic loading in the mid-1980s, but the notion of using TLDs to reduce structural vibration in civil engineering projects didn't catch on until much later. They were also among the first to propose the use of dampers exploiting liquid motion in civil engineering constructions, such as those proposed by Modi& Welt, Fujii, Kareem, Sun and Wakahara. Tuned Sloshing Dampers are occasionally used to refer to these dampers because of their sloshing principles of action (TSDs). The Tuned Liquid Column Damper (TLCDs), a form of liquid damper that reduces wind-induced motion by dissipating energy via the motion of liquid mass in a tube-like container equipped with an opening, is widely known.

1.2.1 Earthquakes Affecting Buildings and Earthquake Ground Motion

The dynamic response of the building to earthquake ground motion is the most important cause of earthquake-induced damage to buildings. Failure of the ground and soil beneath buildings is also a major cause of damage. However, contrary to popular belief, buildings are rarely, if ever, damaged because of fault displacement beneath a building (Fig 1).

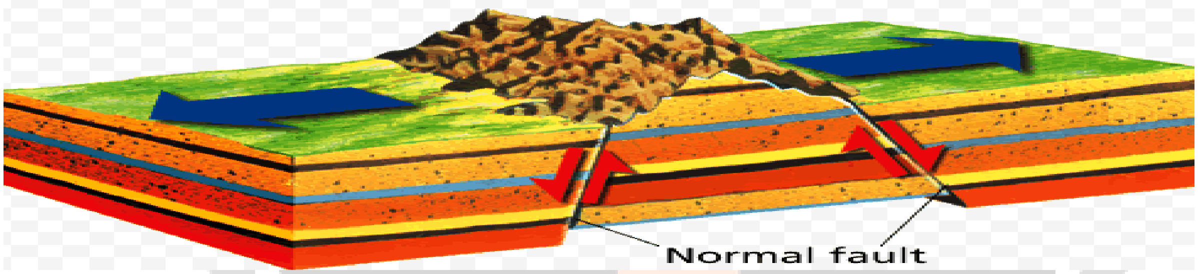

Fig.1.1 Fault within the earth crust

2. Literature Review

2.1 General

This chapter summarizes the literature on the research work carried out on TLD. The literature divided in to two categories, namely Literature review for TLD and Literature review for TLD with Baffle.

Literature Review for TLD

Pirner and Urushadze [7] investigated new type of passive tuned liquid damper (TLD) which relies on the motion of liquid inside a movable rectangular tank with two degrees of freedom (horizontal displacement and rotation), including the influence of a vessel’s horizontal motion and rotation on the damping of the vertical and horizontal vibrations of footbridges. Experimental solution consists in the determination of the magnitude of the excitation force of the shaking table required under resonance during the excitation of the vessel. The paper has shown that the sloshing damper is a device which will restrict effectively undesirable horizontal vibrations. In case of adequately selected conditions of tank support also it will restrict the undesirable torsional vibrations. The liquid vibration absorber is more advantageous, because it can be tuned easily to the actual frequency of the required vibration mode which usually differs from its theoretical value. The installation and execution of a number of tanks e.g. in the extreme box beams is easier to design than the location of a number of ball dampers.

Bhattacharjee et al. [8] Researchers have studied ho, may change and dissipate vibration energy when subjected to harmonic stimulation, and performs. By reducing structural vibrations, TLD relies on liquid movement to absorb some structural dynamic energy and so reduce structural vibrations caused by seismic action. For this project, we want a model of TLD linked to the structure to minimize structural response and investigate the impacts of different factors that influence structural response the dynamic behavior of a TLD structure exposed to harmonic base motion on a shaking table is being investigated. The present study focused on the implementation of a tuned liquid damper for mitigation of structural response. In terms of the structure's reaction to control, the rectangle TLD outperforms the square TLD. As water depth increases, the peak structural reaction often rises. TLD was discovered to be effective in regulating the structure's reaction in this investigation.

Chen and Lu [9] Introduced a wide range of applications based on the functionally enhanced passive devices idea. The functions added to their corresponding conventional passive devices (TLD, FPS, friction dampers, and TMD) include the adaptability to external disturbances, self-centering feature of friction devices, first peak reduction ability, and frequency-independent suppression of both acceleration and displacement. The performances of functionally upgraded passive devices were illustrated with the shake table tests of a building with an MVTLD. The shake table test results have shown that the MVTLD can further reduce the building acceleration by more than 10% in comparison with its corresponding TLD due to increased mass in water sloshing motion by added particles. The new damper is adaptive to external excitations as the particles in water gradually become suspended. Such a damper requires no external power to operate and thus little maintenance during their life span, but it behaves like a semi-active system.

Malekghasemi and Mercan [4] focused on sloshing type of tuned liquid dampers. In this study the accuracy of three existing models for rectangular TLDs is Bhattacharjee et al. [8] to alter a structure's dynamic properties and dissipate its vibration energy under harmonic stimulation, researchers examined the effectiveness of a unidirectional tuned liquid damper (TLD) that is dependent on the mobility of shallow liquid in a rigid tank. For this project, we want a model of TLD linked to the structure to minimize structural response and investigate the impacts of different factors that influence structural response investigations to the shaking table. The present study focused on the implementation of a tuned liquid damper for mitigation of structural response. It is seen that the square TLD is less effective in comparison with the rectangular TLD for the controlling response of the structure typically increases with increasing water depth ratio of the response of this study focuses on sloshing type of tuned liquid dampers. The main aim of this study is to check the accuracy of selected models under different conditions (i.e. Different levels of excitation frequency, amplitude etc.) And investigate the effect of selected TLD parameters that affect their response using real-time hybrid pseudo-dynamic testing method. It was shown that the where both structural displacements and accelerations decrease with the debut of the TLD According to the findings of this investigation, a well-built .

Nanda [1] has investigated TLD's ability to regulate structural vibrations effectively. The reaction of the frame model, fitted with a TLD, was studied using a numerical technique. Consideration was given to a linear TLD model. The foundation of the construction was subjected to a total of six different loading situations.. This investigation aims at studying structural model of 2D-MDOF and application of order for TLD to work properly, it must be adversely affected by under or over tuning of the TLD to the fundamental natural frequency of the structure. When the TLD is correctly tuned to the fundamental frequency of the structure, the impact is large, however the effect is relatively low when the TLD is not properly tuned. As an alternative, barriers like baffles, screens, and floating particles may be added to the TLD model so that the change efficiency can be compared.

Morsy [2] analysed the performance of TLD .The free surface is reconstructed using the Volume of Fluid technique, while obstacles are modeled using the Partial Cell Treatment method. Only harmonic excitation was considered in this study case of one screen, the solidity decreases with an increase in the maximum velocity. Decrease in structure displacement and acceleration is accompanied with increase in maximum velocities. The preliminary predictions of fluid– structure interaction identify the ability of the SPH method to accurately model the forces between a structure and sloshing absorber, when a liquid depth of 5.5mm is employed.

Banerji et al. [6]. Examined a passive tuned liquid column damper which is converted into a variable-damping semi-active system. Different semi-active algorithms based on the clipped-optimal and fuzzy control strategies are studied using numerical examples. The main objective of this paper is to study the effectiveness of different control algorithms for semi-active tuned liquid dampers for structural control applications. In this paper, a variable-damping tuned liquid column damper is studied in a semi-active framework. The numerical simulations show that semi-active strategies provide a larger reduction in response than the passive systems. The power requirements for semi-active systems are negligible and the valve can be actuated by battery power. Numerical examples show that semi-active strategies provide better response reduction than passive systems for both random and harmonic excitations. In the case of harmonic loading the improvement is about 25–30%, while for random excitation the improvement is about 10 –15%.

Marsha et al. [3] demonstrated efficacy of the use of liquid movement for structural regulation. Experimental results are contrasted to numerical predictions based on smoothed particle hydrodynamics (SPH). It is the goal of this comparison to show how well the modeling approach can replicate the features of such flows. A tuned liquid damper (TLD) can act as a damped dynamic vibration absorber. Generally, the absorber is tuned so that the frequency of sloshing normally coincides with the natural frequency of the structure. Investigating an effective means of using intentionally induced liquid sloshing for structural control applications is the primary objective of this paper the numerical work has two goals. It is important to assess the accuracy of the free surface predictions by comparing them to actual measurements.

Tam et al. [5] used a simple mechanical oscillator with a sloshing absorber represented by the container having a free liquid surface. In this study, a cap is placed above the free surface to partially restrain the surface wave to enhance the energy dissipation capability of a standing sloshing wave. The primary object of this study is to dissipate energy through plastic impacts of the rising wave with the cap Experiment was repeated for various gaps between the free surface and the cap, starting with a zero gap to a large enough value to ensure a free sloshing surface. Three different working fluids were used in the absorber. When water is used, reduction in vibrations is about 80%. Energy dissipation is accomplished severe surface breaks of descending waves. Light mineral oil and the ER fluid give their best attenuation of around 90%. Moreover, these two liquids are much less sensitive than water to the variations of the gap between the restraining cap and the free surface. With these two liquids, energy dissipation seems to take place through viscous dissipation is observed to be quite effective, with reduction in vibrations of about 85%.

Literature Review for Complicates

Hooseini and Farshadmanesh [10] presented a method based on conducting several dynamic analysis cases, by using a powerful Finite Element (FE) method for rectangular tanks with various dimensions, subjected to both harmonic and seismic excitations, and then using neural network to create simple relationships between the dominant frequency and amplitude of the base excitations and the maximum level of liquid in the tank during the sloshing and also the maximum dynamic pressure on the tank wall. Experiment was performed using multiple baffles. Using 2 to 4 vertical baffles, equally spaced rectangular tanks, can reduce the sloshing effect to a greater extent. Neural network can be used for predicting the sloshing response in tanks with satisfactory precision, and therefore it is recommended that this approach is used for studying the sloshing problem in tanks, instead of time history analysis, which is very time consuming.

3. Proposed Architecture

3.1 General

In this chapter the total experimental analysis is studied. A brief review of experimental setup is taken which consists of model details and details of the instruments. Functioning of accelerometers is also taken into consideration. Various testing cases are also studied in this chapter.

Square wave (fixed) 20 Vp-p Characteristics of output

Sine wave 5 Hz – 5,000 Hz ± 1 dB Voltage   Square wave 5 Hz – 5,000 Hz ± 0.2 dB

Hum and Noise   70 dB below rated output

Output proportional to   linear sweep

Frequency   +DC αf: 10 mV   10V Logarithmic sweep

- DC αf: -10mV   -10V

3.2 Experimental Setup

Experimentation in its broadest sense is seen in figure 3.1. The structural model is created out of mild steel, and it is meant to depict a stiff floor that is supported by mild steel pipes that are meant to represent columns. Welding is used to transmit the weight from the slab to the columns and the base of the structure. 20 Hz was determined to be the structural model's inherent frequency when it did not include a tank. On top of the model construction is where the TLD tank is located. This model is then installed on the shaking table for additional examination. The Electro-dynamically driven Vibration Generator System makes the platform on the Shaking Table, which measures 2 meters by 1 meter and travels in a single horizontal direction, shake. On each level of the model, there is an accelerometer that is attached.

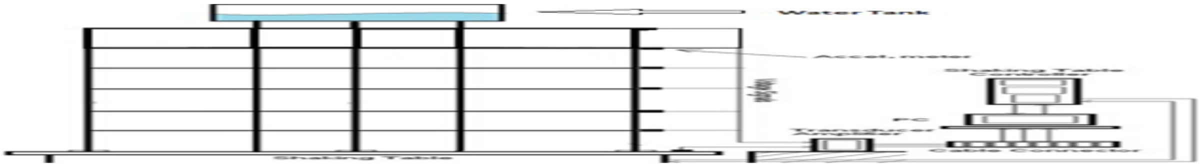

Fig: 3.1 Experimental setup

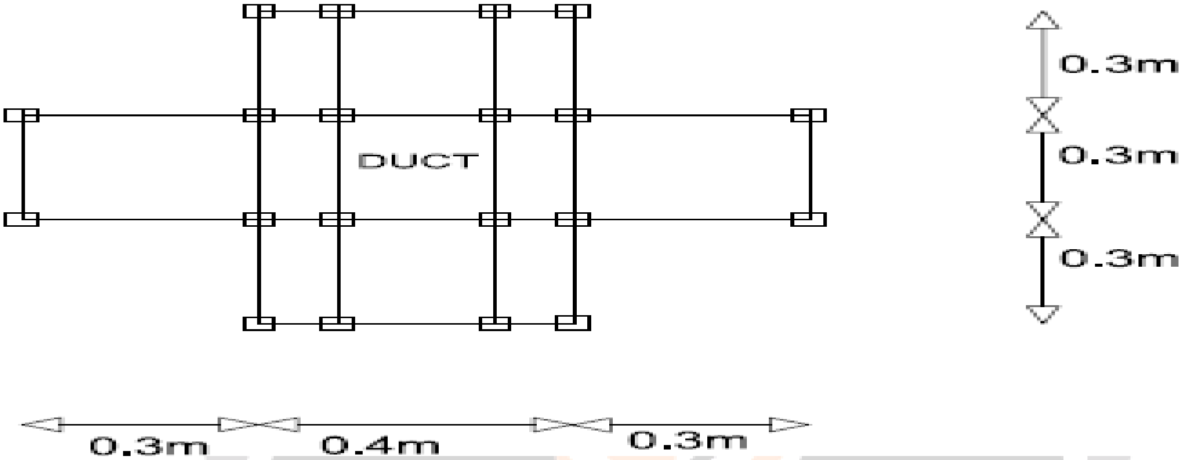

Fig: 3.2 Actual plan of the building

3.3 Model Details

Scale model of a G+5-story skyscraper subjected to experimental study.

a) What kind of structure does it have? A multi-story, rigidly joined frame. Six storeys (G+5),

(b) cm x mm d) in the longitudinal direction of the columns and beams.

(c) Material utilized and its properties

(d) Thickness of the slab is 100 mm;

1) Dimensions 15 mm x 15 mm for Beams/Columns (mild steel square sections)

2) Thickness of 1.5 mm for Slab (Mild Steel Sheet)

Details about Instruments

Shaking Table

Fig: 3.3 Shaking Table [15]

Vibration Generator Model ASE – 385Force Rating 670 Kg.Frequency Range 5 Hz to 3000 Hz

Vibration range Displacement 25 mm (p-p)

Acceleration 120 gunder no-load conditionTable Size 180 mm diameter

Weight of Moving Part Approx. 5.9 Kg

Armature Suspension Half loop roll beryllium copper flexures with axial stiffness of 59 Kg per cm

Stray Magnetic Field Less than 5 gauss 150 mm above table

Table Size 782W x 490 D x 793 H mm (Approx.)

Weight 550 Kg (Approx.)

3.4.1.1 Power Amplifier Model ASB-8002

Amplification System Direct coupled solid state amplifier system Power Output 4 KVA (Max)

Frequency Characteristic 5 Hz to 6,000 Hz (+- 3dB)

Output Adjustment Zero to Max. Continuously variable

Cooling Method Water cooling 15 liters/min 350C or less 2Kg/cm2= - 5 Kg/cm2

Hum and Noise 60 dB below rated output

Wave form Distortion Sine wave less than 5%

Protective Devices Protective Devices of excess displacement and excess output current and excess input current, over heat cooling, water stop

Power Requirements 3 phase 440V 50 Hz 15 KVA

Sine Wave Vibration Control Center Model SCO-100

3.4.2.2 Frequency Oscillating Unit

Because of the adoption of voltage control type oscillation which is different from beat oscillation or CR oscillation, this unit has the following distinctive features.

Frequency is indicated by a highly accurate wide-angle meter.

As frequency can be varied by the voltage system, sweep by the external voltage is possible.

Outputs of not only sine wave but also square and triangular waves can be obtained.

The frequency scale is of the logarithmic and linear type. The specifications for this unit are as follows:

Frequency range 5 Hz to 5,000Hz Logarithmic scale 100 Hz to 5,000Hz Linear scale

Scale Accuracy ± 3% of indication,± 0.5Hz Logarithmic scale

Frequency stability ± 2% of full scale, linear scale ± 0.5 Hz or ± 1%/ 8 hour

Output voltage Sine wave (fixed) 1 Vrms

Sine wave is continuously variable. 0 – 6 Vrms

3.4.3 Vibration Measuring Unit

This unit is designed to read the vibration displacement, acceleration and velocity of the shaking table of the shaker and is also used as a level setting

Meter in case of program control. The distinctive features of the unit are as follows:

Indication is made by two meters; a displacement / acceleration meter and a velocity/ acceleration meter.The meter range can be changed over even during the operation of automatic vibration control.

A charge/ voltage amplifiers are installed as input amplifiers. The specifications for this unit are as follows: Displacement meter Range 1/3/10/30/100/300 mm p-p

Frequency 5 Hz -- 2,000 Hz

Accuracy Displacement input ± 3% of indication

± 2% of full scale Velocity input

± 4% of indication

± 2% of full scaleAcceleration input

± 5% of indication

± 2% of full scaleVelocity Meter Range

30/100/300/1,000/3,000/10,000mm/sec

Frequency 5 Hz – 2,000 Hz

Accuracy velocity input±3% of indication

± 2% of full scaleAcceleration input

± 4% of indication± 2% of full scale

3.4.4 Safety Device

When the button or switch that should not be operated or changed ever during vibration control is operated, the safety device is actuated to protect the shaker and the specimen, thus reducing the control output to zero and stopping excitation. The safety device is operated in the following cases.

When the frequency or feedback signal is suddenly changed.

When the following switch is changed over during vibration control :

Sweep function switch

Constant vibration control switch

VAR/STD switch

Two – for -two switch

Filter In/out switch

When the constant vibration servo loop opening detecting circuit is actuated.

When the protective circuit of the shaker is actuated.

3.4.5 Various Terminals

Various terminals as described below are attached.

Output terminals to automatically raise and lower the pen of an X-Y recorder to be used in case of recording the frequency characteristics of specimen and shaking plate.

Output terminal which permits a multi-transfer frequency control by connecting a multi-level programming device.

Output terminal for sweep of tracking filter

Input terminal for sweep of frequency from an external source

4. Results and discussion

This chapter deals with the readings and their respected graphs for each and every test performed on the scales model. Also the results for each case is evaluated in this chapter. The results are calculated in the form of amplitude of acceleration at the top storey of the structure for the sinusoidal excitations. Lastly the discussion of results ends this chapter.

4.1 General

Fig's 4.1, 4.2 and 4.3 represents Fig's 4.4, 4.25 and 4.6 represents whereas the Fig's 4.7, 4.8 and 4.9 to the TLD by using a shake table. Shows the acceleration at top storey for 20 Hz frequency for various water depths like 50mm, 70mm, 90mm and 110mm. Our finite element studies in this area include two different kinds of high and medium-rise structures. Two separate damping mechanisms, namely friction and VE diagonal dampers, make up the first kind of shear wall construction. A total of eleven dampening devices were fitted inside shear wall cutouts. At a period, just one damper type and one location were used for seismic assessments. In order to evaluate the effectiveness of these dampening technologies, four earthquakes were used. In order to test the viability of the method, this was the first building to be examined. The fundamental contribution of this study was to demonstrate that the use of dampers implanted in cutouts of the shear wall may be used to mitigate the effects of earthquakes on building structures. This is a revolutionary technique to seismic control, and it has been tested and shown to work in a number of scenarios. The tip deflection offers an overall evaluation of the structure's seismic reaction, which may be used to safeguard buildings against earthquakes. The greatest results may be achieved by using dampening systems that are specific to the construction of the building. However, the findings of this research show that there are certain commonalities across the structures studied. As a consequence, the outcomes of this investigation were significant.

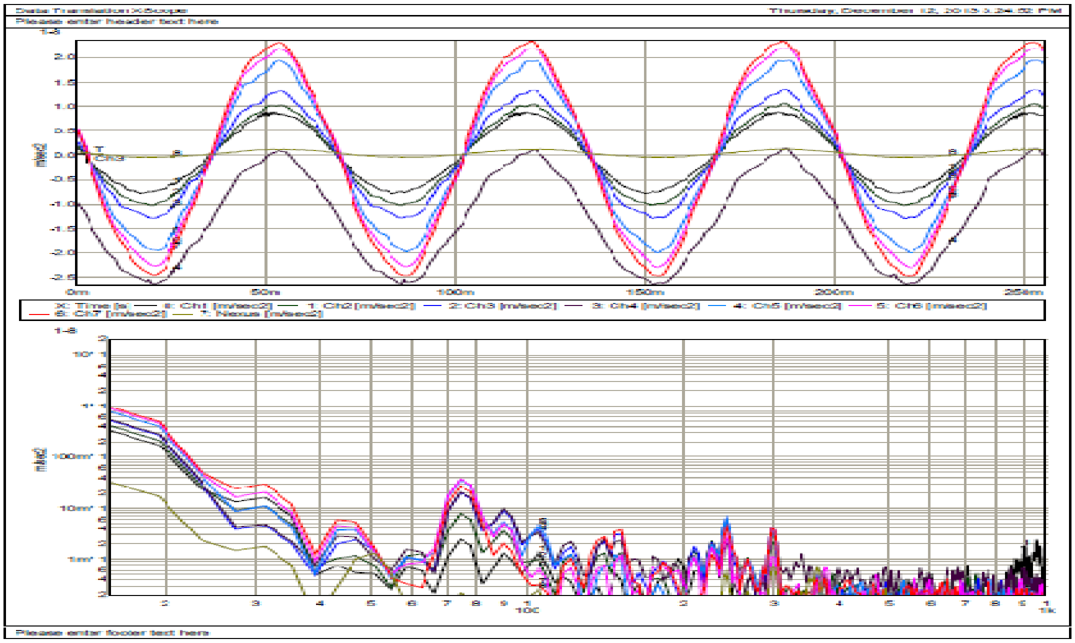

Fig. 4.1: The building's top floor's reaction to sinusoidal ground acceleration at 15 Hz without TLD

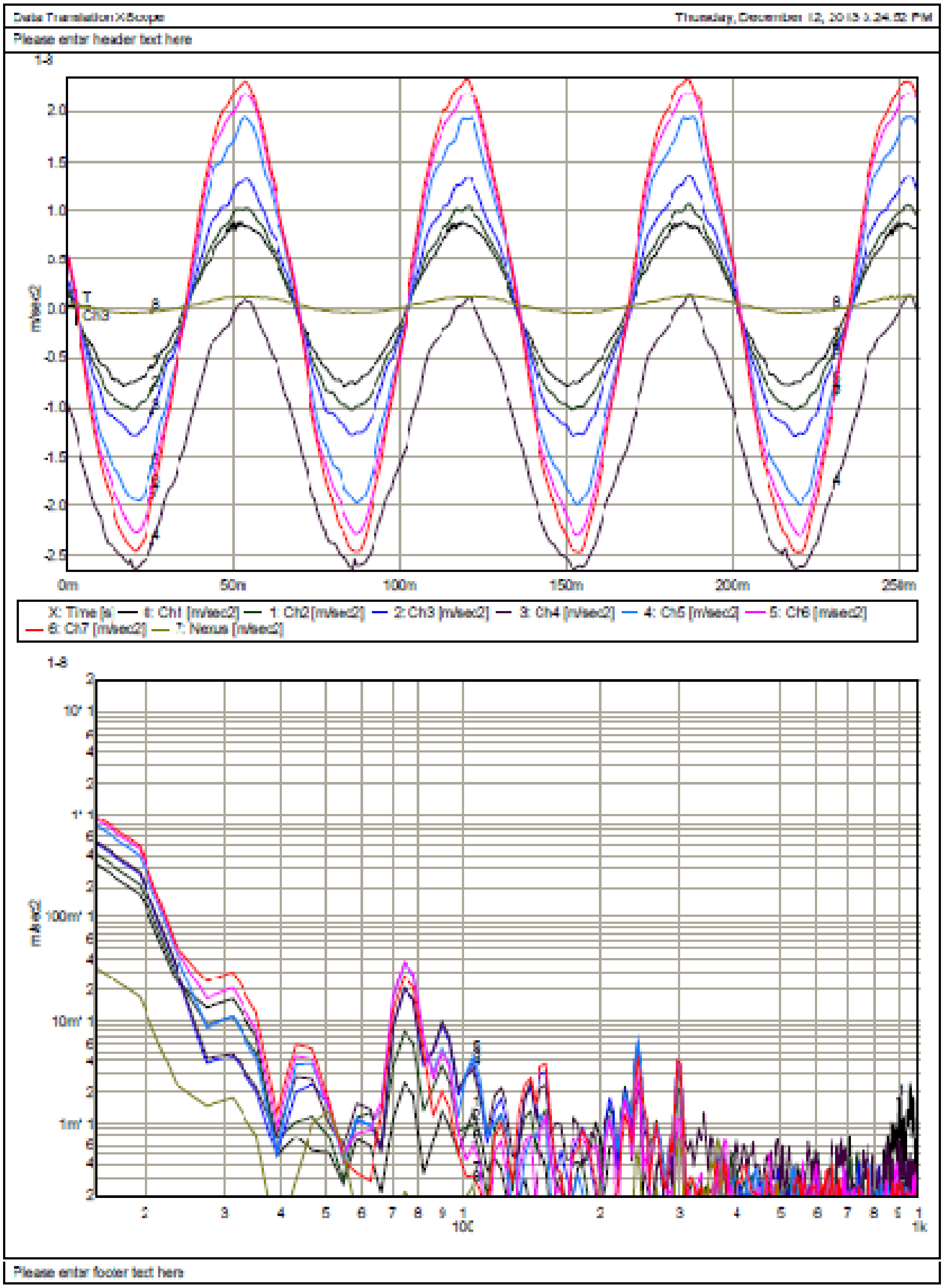

Fig. 4.2: The structure's top floor's reaction to sinusoidal ground acceleration at 15 Hz

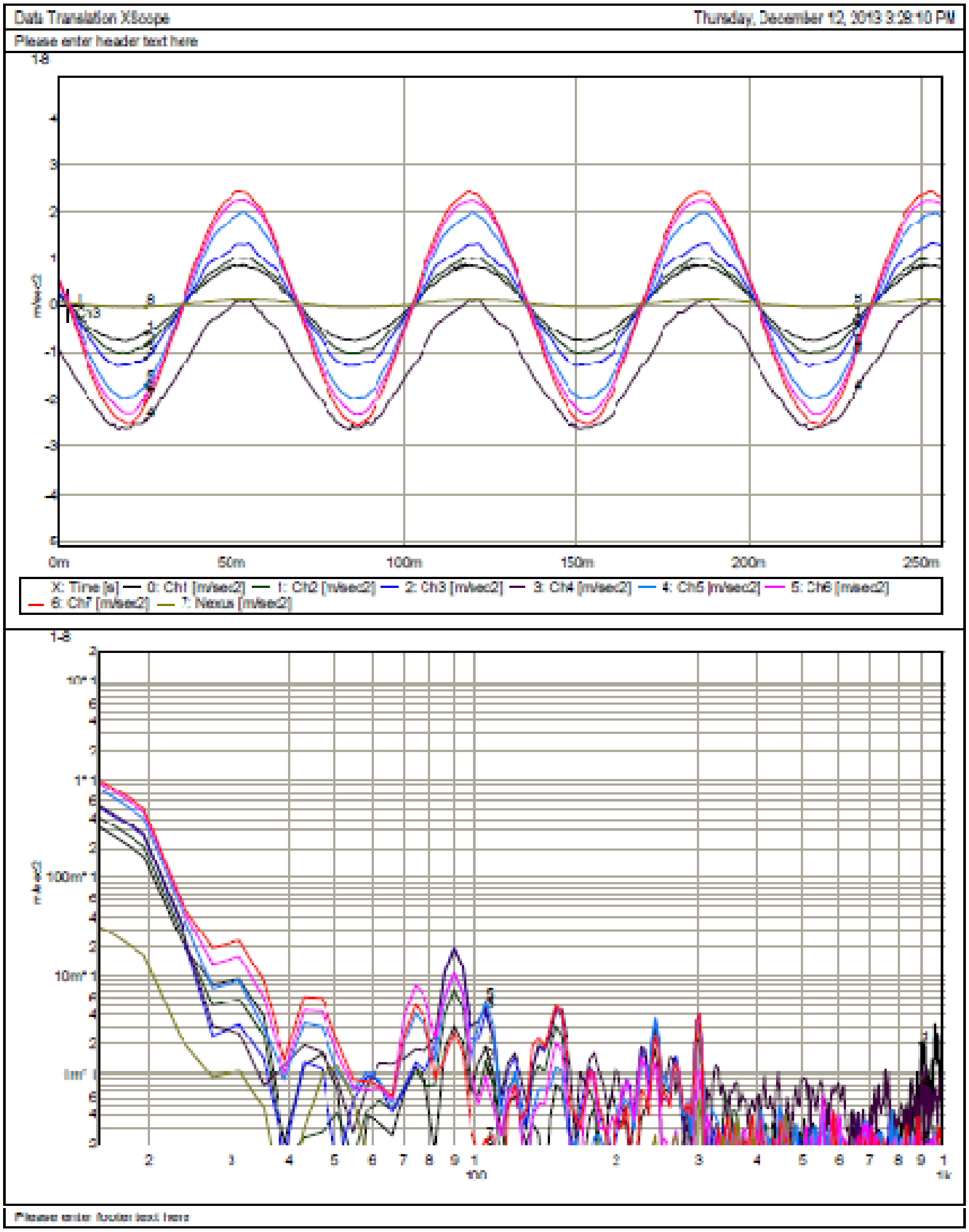

Fig: 4.3 The response of the structure's top floor to sinusoidal ground acceleration at 15 hertz with TLD for single baffle

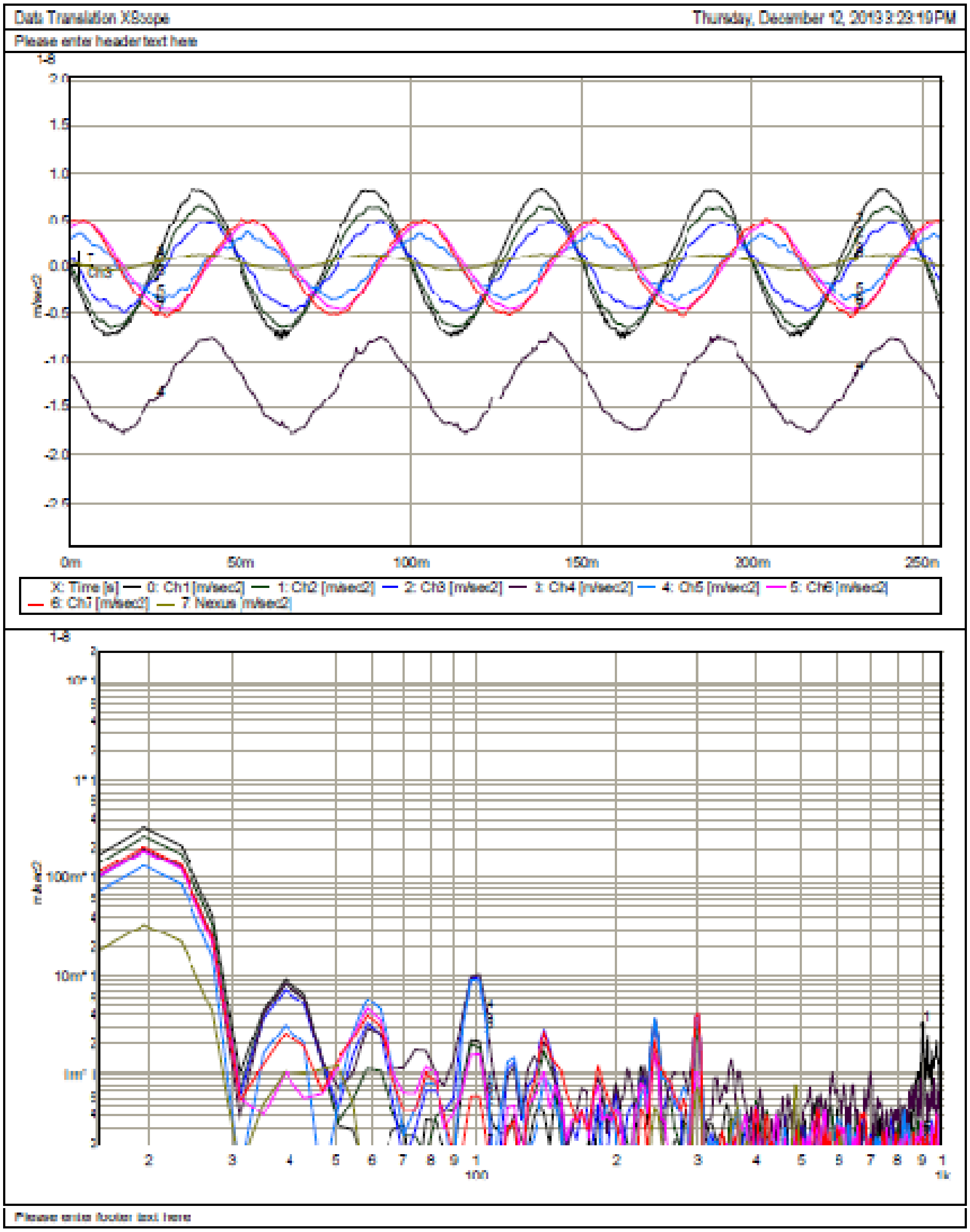

Fig: 4.4 Top floor reaction to 20 Hz sinusoidal ground acceleration without TLD

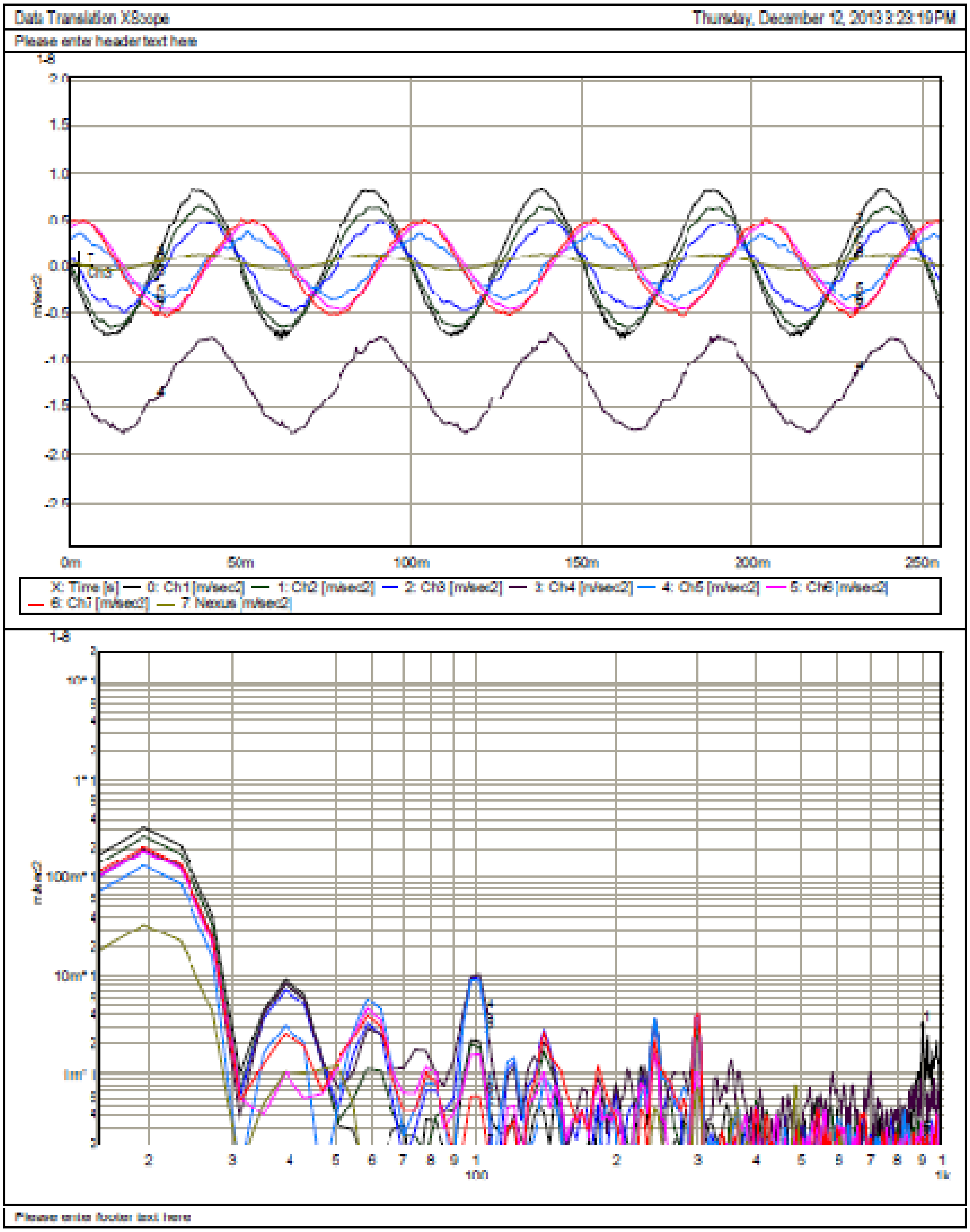

Fig: 4.5 The response of the structure's top floor to the sinusoidal ground acceleration at a frequency of 20 hertz

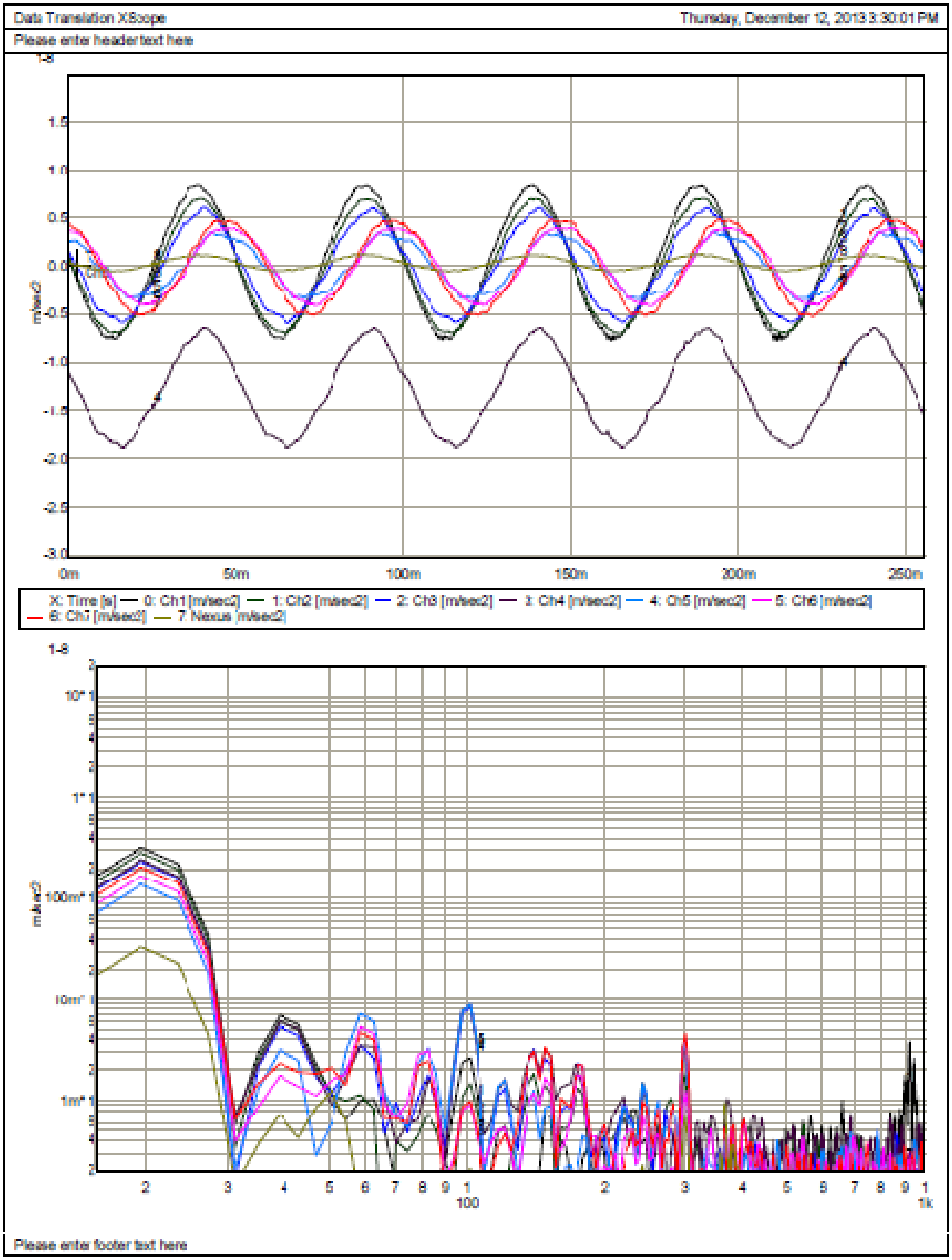

Fig: 4.6 Top floor reaction to 20 Hz sinusoidal ground acceleration with TLD for single baffle

4.3 Readings

Table 4.1gives the readings of the accelerations for structure without Tuned Liquid Damper

Table 4.1: Readings for structure without TLD

Ch.No.	Position	Frequency & Acceleration					
		15Hz	Accl..	20Hz	Accl..	25Hz	Accl.
CH1	Ground	14.988	1.6217	20.032	2.5758	25.1	1.4694
CH2	1st	15.097	1.9201	20.259	1.4841	25	1.4666
CH3	2nd	14.357	2.32	20.227	1.0578	23.992	1.5733
CH4	3rd	14.952	2.8093	20.358	2.3866	25.202	3.8938
CH5	4th	15.115	3.236	20.227	4.509	24.131	5.0971
CH6	5th	15.188	3.6309	20.425	5.9892	24.319	7.603
CH7	6th	15.078	3.8833	20.525	6.655	24.857	9.5004

Table 4.2 gives the readings of the accelerations for structure with tuned liquid damper for different frequencies .

Table 4.2: Readings for structure with TLD

Water Depth	Freq 15Hz	Accl..	Freq 20Hz	Accl..	Freq 25Hz	Accl.L.
50mm	15.078	1.8079	19.936	1.3679	24.851	1.4638
	15.06	2.1829	20.194	0.704	24.752	0.728
	15.078	2.7407	20.194	0.5718	26.483	0.4
	15.152	3.35	19.501	1.4761	24.851	1.8117
	15.244	3.8624	18.997	2.6861	24.802	2.651
	15.225	4.4128	19.968	3.5803	24.9	4.0678
	15.133	4.6853	19.968	3.9718	24.655	5.1335
	15.225	0.191	19.35	0.1605	24.95	0.1745
70mm	15.006	1.7007	20.096	1.6133	24.9	1.4835
	14.988	2.0903	20.627	1.0989	26.767	0.7704
	15.006	2.6696	20.227	0.6281	24.95	0.2844
	15.133	2.8062	21.151	0.665	24.407	0.3418
	14.863	3.7951	20.032	1.5332	24.802	2.2764
	14.988	4.264	20.492	2.1083	25.202	3.52
	15.024	4.522	20.064	2.3441	25	4.4436
	14.269	0.1693	20.129	0.1718	24.665	0.1672
90mm	15.042	1.6866	20.259	1.6246	24.752	1.4807
	15.625	2.0694	20.292	1.3199	24.414	0.931
	14.81	2.64	20.227	0.9985	24.752	0.3052
	14.881	2.8062	20.458	1.041	25.202	0.3978
	15.263	3.9326	19.936	0.7461	24.95	1.6035
	15.078	4.4951	20.392	0.9433	24.752	2.6306
	14.988	4.8091	20.392	1.0379	25	3.4882
	15.263	0.1654	19.142	0.1754	24.319	0.1715

Table 4.3 gives the readings of the accelerations for structure with tuned liquid damper with baffle for frequencies 15Hz, 20Hz and 25Hz for various water depths 50mm, 70mm, 90mm and 110mm.

1. It can be seen that without installing TLD, the accelerations was found to be 6.655 m/sec2.

Table 4.4: Acceleration at 20 Hz (Top storey)

Acceleration at 20 Hz (Top storey) (mm/s2)			
Water Depth	Without TLD	With TLD	TLD +1 Baffle
50 mm	6.655	3.9718	3.4469
70 mm	6.655	2.3441	1.9992
90 mm	6.655	1.9556	0.99
110 mm	6.655	2.0463	2.2793

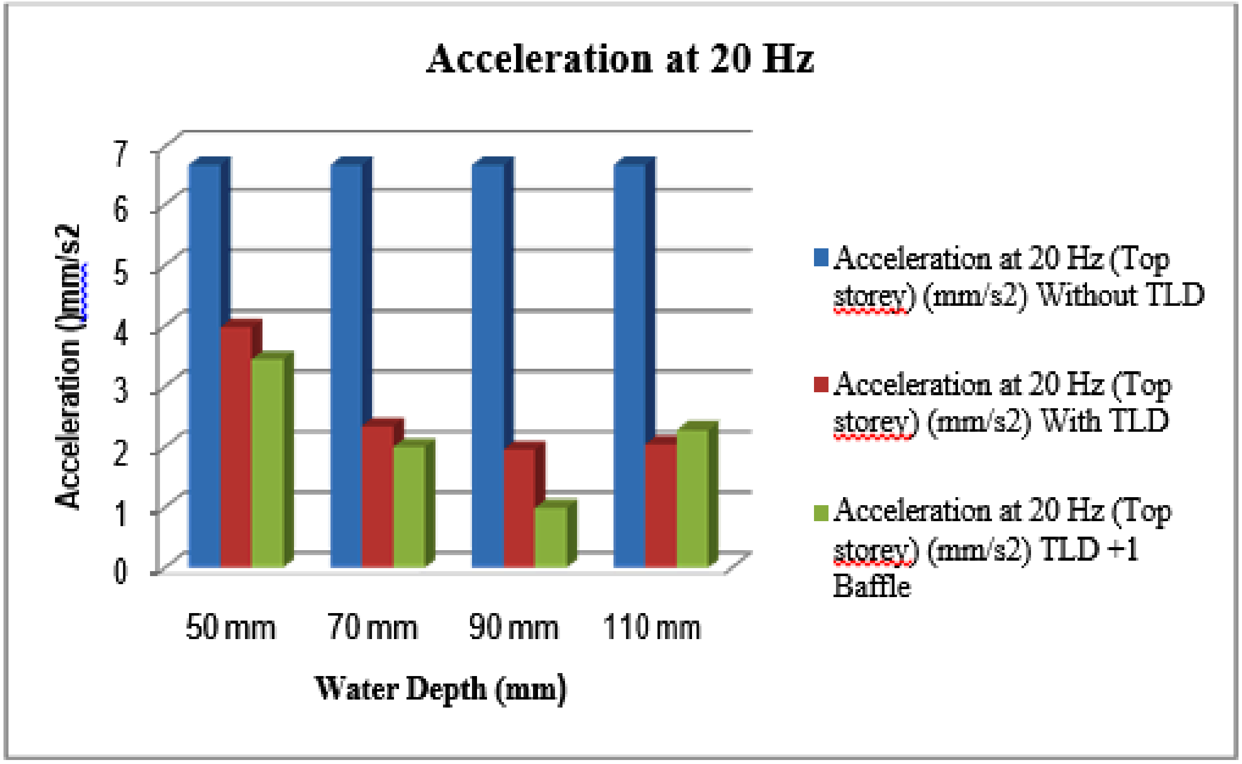

Fig 4.10: Acceleration At 20 Hz for different cases

4.4. Comparison of results

The response of the structure for various water depth by Bhatacharjee et al. (2013) and present study is shown in fig 4.11 and fig 4.12 respectively. Present results obtained for the acceleration are compared with the results obtained by Bhattacharjee et al (2013). It is observed that the reduction in the acceleration is found to be linear with increase in water depth ratio for both the results.

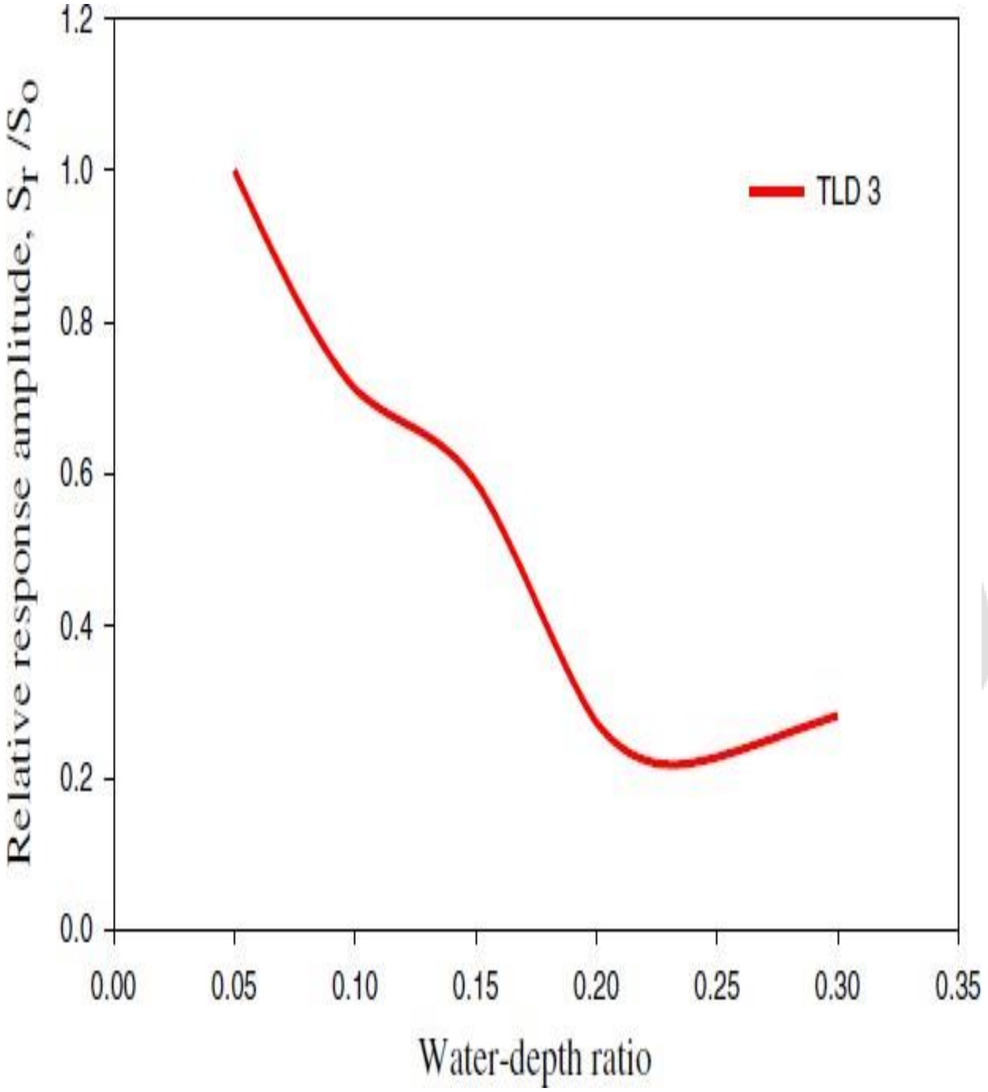

Fig 4.11 Response of the structure for changing water depth of Bhattacharjee (2013)

The present results are obtained for the performance of the structure without TLD, with TLD and TLD with baffle wall, whereas the Morsy (2010) obtain the results for performance of the structure without TLD, with TLD and TLD with screen. The Present results obtained for the acceleration are compared with the results obtained by Morsy (2010). Table 4.5 gives this comparison. It is observed that the present results are well in agreement with the results obtained by Morsy (2010).

Table 4.5 Camparision between Present study with Morsy (2010)

Morsy (2010)		Present Study	
Testing cases of the structure	Percentage reduction in the amplitude of the acceleration (%)	Testing cases of the structure	Percentage reduction in the amplitude of the acceleration (%)
Structure without TLD	0	Structure without TLD	0
Structure with TLD	71	Structure with TLD	70
Structure with TLD plus screen	92	Structure with TLD plus baffle wall	85

The Present results obtained for the amplitude of the acceleration are compared with the results obtained by Banerji (2000). Table 4.6 shows the comparison between the present studies with Banerji (2000). It is observed that the present results are well in agreement with the results obtained by Banerji (2000).

Table 4.6 Comparison between Present studies with Banerji (2000)

Banerji (2000)		Present Study	
Water depth ratio (%)	Percentage reduction in the amplitude of the acceleration (%)	Water depth ratio (%)	Percentage reduction in the amplitude of the acceleration (%)
0.15	40	0.16	40.31

5. CONCLUSION

5.1 General

This chapter discusses the important finding of the work and gives recommendations and suggestions for further work. It discusses the conclusions and possibilities of further work are indicated under the title ‘future scope’.

5.2 Conclusions

1. From this study, it has been found that TLD can be successfully used to control vibrations of the structure.

2. Based on experimental study, it is determined that TLD is most effective when employed, and that one baffle placed in the middle of the tank increases efficiency.

3. It was also noted that the one baffle wall and 90 mm of water depth produced the greatest acceleration decrease. With one baffle in place and a 90 mm depth of water, the acceleration at the top story was reduced by around 85%.

4. The acceleration was significantly reduced up to a depth of 90 mm and progressively increased at a depth of 110 mm.

5. For water depths of 50 mm, there was a roughly 40 percent decrease in acceleration at the top storey; for depths of 70 mm, there was a 65 percent reduction; for 90 mm, there was an 85 percent reduction; and for 110 mm, there was a 69 percent reduction.

6. As a result, it is also noted that the largest acceleration decrease was discovered to occur at a water depth of 90 mm. At 90 mm of water depth, there was an acceleration decrease of nearly 85% at the top floor. As a result, it was discovered that a water depth of 90 mm was ideal for effectively reducing earthquake vibrations.

5.3 Future scope

Screens and floating particles are two examples of potential new additions to the tank that might alter the control performance and so provide new insights for the investigation.

The two-dimensional model of the structure and damper presented here may be expanded upon to incorporate a three-dimensional model of the structure and a damper liquid model.

The use of TLD to manage movements other than horizontal ones.

Fourth, the scope of the research may be broadened to investigate the impact of varying tank geometries, such as tank form and bottom material.

5. Determine the maximum dynamic pressure on the tank wall using a neural network implemented in a tuned liquid damper.

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