Experimental Study of Seismic Behaviour of Unsymmetrical Structure by Using Shake Table Test

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Abstract - Shake tables are used to test structural models and components, usually to the point of failure. These tables give the operator a wide range of seismic waves and scenarios to test against the structure's integrity. The more advanced earthquake shake tables can even recreate recorded earthquakes. One important issue in seismic response control which has not been studied to a large extent is torsionally coupled response control in asymmetric structures. If a structure has an asymmetric distribution of either mass or stiffness, a lateral seismic load can cause a response in which the torsional and lateral motions of the structure are coupled, this may cause larger responses than in a symmetric structure, resulting in severe structural damage. As a result, the structure was severely damaged due to the torsional irregularity created by the partial strengthening of the structure. One promising approach for retrofit or new construction such cases is the implementation of control systems designed to be effective for such systems. This dissertation focuses on the development and validation of control systems that can effectively reduce the seismic responses due to such torsional coupling in asymmetric building structures. Due to their attractive characteristics for seismic response control are specifically examined in the numerical and experimental studies.

***Key Words*:**ShakeTable,Seismic,earthquake,shear,amplitude,Stiffness,vibration,motion,etc

1.INTRODUCTION

Buildings are the complex system and multiple items have to be considered at the moment of designing them. Hence at the planning stage itself, architects and structural engineers must work together to ensure that the unfavourable features are avoided and good building configuration is chosen. "If we have a poor configuration to start with, all the engineers can do is to provide a band aid improve a basically poor solution as best as he can. Conversely, if we start off with a good configuration and reasonable framing system, even a poor engineer cannot harm its ultimate performance too much. But constructions can suffer diverse damages when they put under seismic excitations, although for same structural configuration, region, EQ damages in the systems are neither nor homogenous.

A desire to create an aesthetic and functionally efficient structure drives architects to conceive wonderful and imaginative structures.Sometimes the shape of building catches the eye of visitor, sometimes the structural system appeals, and in other occasions both shape and structural system work together to make the structure a Marvel. However, each of these choices of shapes and structure has significant bearing on the performance of building during strong earthquake. So the symmetry and regularity are usually recommended for a sound design of earthquake resistant structure. Earthquake resistant engineering emphasis the inconvenience of using irregular plans, recommending instead the use of simple shapes. The effects that cause seismic action in irregular structures were observed in many recent earthquakes.

In past earthquakes, collapse or severe damage too many buildings were due to asymmetry in the lateral load resisting system, or horizontal irregularity. For example, damage statistics from the September 1985 Mexico Earthquake show that up to 50% of failures could be attributed, directly or indirectly to asymmetry. During the last two decades extensive research effort has been devoted to studying the effects of asymmetry which, in brief, lead to lateral-torsional coupling of the buildings response, and to concentration of damage in some resisting elements, mainly the ones located at the edges. The last tens of years shaking table is attested as one of the most validate instrument for studying structures and sub- structures behaviour under dynamic input. If properly used, they provide effective ways to subject specimens of structural components, substructures, or entire structural systems to dynamic excitations similar to those induced by real earthquakes. On the other hand, shaking table experiments represent a good substitution for information on the behaviour of structures obtained under the effect of actual earthquakes.

2. Body of Paper

By considering all the parameters and scaling factors sample model was prepared. By some addition, alteration and removing some members other models for various asymmetry are prepared and tested.

Plan for Sample Building Model:
For Preparation of sample model we use the Aluminium Bars of size 12mm X 5mm size of various length as per the above design. For the connection bolts of 1" are used with nuts. The plan and elevation of symmetric model is as shown below.

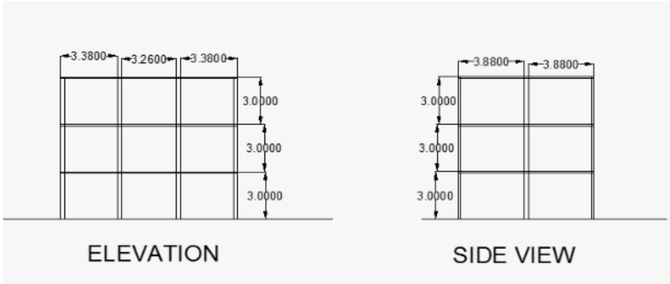
Connection for Model

We have various types of connection available with us for making of model. The types of connection are as:

1. Rigid connection
2. Pinned connection

The available rigid connections are the Welding and Gluing of the member. For the gluing of member Epoxy glue can be used. But after some study it is realise as it is not sufficient to connect them. So we decided to go with pinned connections.

Among the all we are going to adopt Bolting connection for making of model. Which is best suited for model flexibility. So are going to provide flat headed bolts of varying diameter and length for connections. We are also provide Cleat Angles for the connection of member to the base. Some extra connection holes are provided in the Model so as to it can be utilised for different plan configuration also.The material used as member of model is: 12mm X 5mm Bar of Aluminium The bolt used for model making are as: 4mm Diameter Nut & Bolts



Input to Shake Table:

1. Setup the Equipment Assembly and the Input Assembly as per diagram above.
2. Start the Application 'TESTLAB SHAKE TABLE'.
3. Give IP address as 192.168.2.12
4. Adjust the equipment to Starting point by using MANUAL MODE.
5. There are 3 modes for application of excitations, are as follows,
    1. Manual Mode
    2. Cycles Mode
    3. Earthquake mode
6. Under manual mode we can give a displacement and the velocity for it.
7. Under Cycles Mode we can give excitation in the form of frequency, Amplitude & Cycles of vibrations.

8. Under Earthquake mode we can put the time history of past earthquake data and run the same simulation of earthquake with required scale.
9. Then start application KAMPANA.
10. Make filter on and change setting of lower PB adjust it to the twice of frequency which is going to check. For working with EARTHQUAKE mode use maximum limit of PB as 50.
11. And start the recording of data.
12. Then again go to the Application TESTLAB SHAKE TABLE and give input data for seismic excitation as per the need.
13. In the cycle mode when output frequency comes closer to the input frequency click on Log mm/Hz so it record the all the accelerometers data in X, Y & Z direction.
14. Then stop the recording of data as stop the recording excel file of Frequency verses displacement is created load it and view in the excel sheet.
15. In the Earthquake mode after completion of time history stop the recording and go to the require channel and by exporting we can get the data as in the form of Frequency verses Acceleration, Velocity or Displacement with each 0.01 sec. accuracy.

Terminology:-

Acceleration:-

Acceleration is the rate of change of Velocity of an object.

Amplitude:-

Amplitude is the maximum displacement or distance moved by point on a vibrating body or wave measured from its equilibrium position.

Frequency:-

Frequency is the number of occurrences of repeating event per unit time.

Natural Frequency:-

Natural frequency is the frequency at which a system tends to oscillate in the absence of driving or damping force.

Period:-

The period is the duration of time of one cycle in repeating event.

Stiffness:-

Stiffness is the rigidity of an object the extent to which it resists deformation in response to an applied force.

Velocity:-

Velocity is the rate of change of displacement of an object.

Stiffness Irregularity:-

This is considered to exist when the lateral stiffness of the SFRS in a story is less than 70% of any adjacent storey, or less than 80% of the corresponding average stiffness of the three storey above or below.

Checking the effect of seismic excitations on the structure on the basis of Stiffness Variations; 4 models are prepared and tested under their respective natural frequencies.

Stiffness irregularities in the model are introduced by addition, alteration and removal of members at various levels. The models are tested for the natural frequencies and respective displacements, velocities and accelerations are calculated.

Plan Irregularity **:-**

This is considered when floor diaphragms are rigid in their own plan in relation to the vertical structural elements that resist the lateral forces. Torsional irregularity to be considered to exist when the maximum storey drift, computed with design eccentricity, at one end of the structures

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transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structure and if plan configurations of a structure and its lateral force resisting system contain re-entrant corners, where both projections of the structure beyond there-entrant corner are greater than 15 percent of its plan dimension

Checking the effect of seismic excitations on the structure on the basis of Plan Variations; 3 models of plan configuration C, T & L are prepared and tested under their respective natural frequencies.

Plan irregularities in the model are introduced by addition, alteration and removal of members at various levels. The models are tested for the natural frequencies and respective displacements, velocities and accelerations are calculated.

Mass Irregularity :-

Mass irregularity shall be considered to exist where the seismic weight of any storey is more than 200 percent of that of its adjacent store's. The irregularity need not be considered in case of roofs.

Checking the effect of seismic excitations on the structure on the basis of Mass Variations; 3 models are prepared and tested under the various frequencies.

Mass irregularities in the model are introduced by addition, alteration and removal of members at various levels. The models are tested for the natural frequencies and respective displacements, velocities and accelerations are calculated.

Vertical Irregularity :-

Vertical geometric irregularity shall be considered to exist where the horizontal dimension of the lateral force resisting system in any storey is more than 150 percent of that in its adjacent storey

Checking the effect of seismic excitations on the structure on the basis of Vertical Variations; 4 models are prepared and tested under the various frequencies.

Vertical irregularities in the model are introduced by addition, alteration and removal of members at various levels. The models are tested for the natural frequencies and respective displacements, velocities and accelerations are calculated.

Table -1: Engineering Properties of Various Material

MATERIAL	Type	Cost ($/kg)	Density (ρ, Mg/m^3)	Young's Modulus (E, GPa)	Shear Modulus (G, GPa)	Poisson's Ratio (ν)	Yield Stress (σ_Y, MPa)	UTS (σ_f, MPa)	Breaking strain (ε_f, %)	Fracture Toughness (K_c, MN m$^{-3/2}$)	Thermal Expansion (α, 10^{-6}/C)
Alumina (Al_2O_3)	ceramic	1.90	3.9	390	125	0.26	4800	35	0.0	4.4	8.1
Aluminum alloy (7075-T6)	metal	1.80	2.7	70	28	0.34	500	570	12	28	33
Beryllium alloy	metal	315.00	2.9	245	110	0.12	360	500	6.0	5.0	14
Bone (compact)	natural	1.90	2.0	14	3.5	0.43	100	100	9.0	5.0	20
Brass (70Cu30Zn, annealed)	metal	2.20	8.4	130	39	0.33	75	325	70.0	80	20
Cermets (Co/WC)	composite	78.60	11.5	470	200	0.30	650	1200	2.5	13	5.8
CFRP Laminate (graphite)	composite	110.00	1.5	1.5	53	0.28	200	550	2.0	38	12
Concrete	ceramic	0.05	2.5	48	20	0.20	25	3.0	0.0	0.75	11
Copper alloys	metal	2.25	8.3	135	50	0.35	510	720	0.3	94	18
Cork	natural	9.95	0.18	0.032	0.005	0.25	1.4	1.5	80	0.074	180
Epoxy thermoset	polymer	5.50	1.2	3.5	1.4	0.25	45	45	4.0	0.50	60
GFRP Laminate (glass)	composite	3.90	1.8	26	10	0.28	125	530	2.0	40	19
Glass (soda)	ceramic	1.35	2.5	65	26	0.23	3500	35	0.0	0.71	8.8
Granite	ceramic	3.15	2.6	66	26	0.25	2500	60	0.1	1.5	6.5
Ice (H_2O)	ceramic	0.23	0.92	9.1	3.6	0.28	85	6.5	0.0	0.11	55
Lead alloys	metal	1.20	11.1	16	5.5	0.45	33	42	60	40	29
Nickel alloys	metal	6.10	8.5	180	70	0.31	900	1200	30	93	13
Polyamide (nylon)	polymer	4.30	1.1	3.0	0.76	0.42	40	55	5.0	3.0	103
Polybutadiene elastomer	polymer	1.20	0.91	0.0016	0.0005	0.50	2.1	2.1	500	0.087	140
Polycarbonate	polymer	4.90	1.2	2.7	0.97	0.42	70	77	60	2.6	70

3. CONCLUSIONS

1. Realistic Experimental setup and modelling of structure is possible and it is possible to determine the behaviour of asymmetric structure and able to compare with normal structure.
2. As the stiffness decreases respective acceleration also goes on decreasing which results in increase in fundamental time period.
3. As stiffness goes on decreasing model becomes flexible which is much safer in resisting earthquake.
4. In the plan irregularity the maximum response was observed by the L shape building. So it must be avoid in the vicinity of seismic excitation zone.
5. The response observed in the Y and Z direction is much higher for C, T and L shape structures which occurs due to twisting effect in the structure.
6. It is also observed that in mass asymmetry there is response in Y and Z direction also. This may be due to twisting effect due to uneven distribution of mass at various floor levels.
7. Vertical irregularity in the form of slender columns are shows reduction in the accelerations in all the floor levels as compared to the normal structure decreasing which results in increase in fundamental time period.

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REFERENCES

1.Khante.S.N ,Lavkesh R.Wankhade *"Study of seismic response of symmetric and asymmetric base isolated building with mass asymmetry in plan"* international journal of civil and structural engineering volume x, no x, 2010

2.Weixing SHI *"Shaking table experimental study of reinforced concrete high-rise building"* Structural Engineering Institute, pp1015-1020.

3.T. Trombetti, P. Barrasso, A. Crewe, M. De Stefano, G. Gasparini, R. Nudo, A. Rutenberg, S.Silvestri, C. Taylor "*Shaking table testing of symmetric and asymmetric three-store steel frame structures"* 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada (August, 2004) Paper No. 1248

4.Corbib Z.T. Rakicevic *"Shaking Table Testing for Structural Analysis"* international journal of mechanics, issue 4, volume 7, 2013,pp459-466

5.H. Hao, I Member, ASCE, and X. N. Duan *"Seismic response of asymmetric structures to multiple ground motions"* ASCE

Books:

1. **S.K. Duggal** *'Earthquake Resistant Design of Structure'.*
2. **Pankaj Agarwal & Manish Shrikhande** *'Earthquake Resistant Design of Structure'.*