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CHARACTERIZATION AND APPLICATION OF SHAKE TABLE FOR STRUCTURAL MODEL TESTING

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ABSTRACT
The present work is to finding the dynamic responses of a developed model using a shake table. The motion characteristics of the shake table were also considered as the part of study. These characteristics were evaluated in terms of acceleration components using accelerometer & FFT analyzer. The study was performed by varying the values of frequency and displacement at without load and with load conditions. The results of the present work have compared with the theoretical values & experimental values of natural frequency of the developed model & Steel framed structure. This study will helps in predicting the actual effects of earthquake on a particular structure.

The field of BCI research and development has since focused primarily on neuroprosthetics applications that aim at restoring damaged hearing, sight and movement. Thanks to the remarkable cortic al plasticity y of the brain, signals from implanted prostheses can, after adaptation, be handled by the brain like natural sensor or effector channels.

KEYWORDS: Uni-axial Shake Table, Experimental study- Dynamic analysis, Accelerometer, FFT analyzer.

INTRODUCTION
It is the fact that if we working with any instrument we have to know about its performance and permissible values of inputs may be off any kind in terms of loads , excitations etc. in this case we are actually analyzing the structural and instrumental performance of our shake table. To define its permissible values we have to perform some tests on it under characteristic loading condition. The shaking table is analyzed for their frequencies and movement amplitudes that are obtained in accordance with the mass that is excited in the platform. Dynamic testing in small-scale models always performed a very important role in the Understanding of dynamic loads in structures, it is the important to understand many of the concepts involved in experimental analysis in structures, namely in the testing of small-scale models.

The main objective of this work is to Characterization of the Shake table, to introduce improvements in the system and to suggest future interventions in the table. The shaking table is analyzed for their frequencies and amplitudes that are obtained in accordance with the mass that is excited in the platform and without mass.

The goal of this work is the characterization the instrumental and structural limitations of the shake table. Tests performed by shake tables are popular in areas of earthquake engineering, structural dynamics, testing of smart materials, actuators, and sensors. One of the interesting points of the current manufacture comes from the fact that servo motors and controller devices that are newly being used in shaking tables.

OBJECT OF THE PRESENT WORK
- To produce a detailed characterization to a common specification, of the dynamic performance of the shaking table.
- Finding the structural properties of models using shake table.
- To analyze the parameters of shake table namely acceleration under characteristic loading condition.
- To identify the advantages and Disadvantages in the present shake table.

LITERATURE REVIEW

J.S Hwang compared the dynamic performance of shake table by introducing two separate input programme signal and measured acceleration and displacement of known earthquake records**. G.Carydis** compared four large capacities shaking tables each of one, three and six degree of freedom been studies and their dynamic characteristics were identified. The paper presents a characterization of the shake table study. It shows a very good match of the required acceleration, velocity and displacement and time histories was achieved for both rigid and flexible payloads once sufficiently complex and control algorithms were used. Shaking table provides a test facility that will continue to be important is dynamic and seismic testing fields. **Abdolhossein Fallahi** has done test on an SDOF model steel structure using target earthquake. He presented that according to Japan Road Bridges code, it is better to employ some 3 acceleration records, and use average of the corresponding responses in seismic check, which is based on the fact that expected earthquake ground motions on a specific site would be different with each other considering different characteristics of earthquakes, and that earthquake inputs are uncertain even with the present knowledge and it does not appear easy to predict forth coming events precisely both in time and frequency contents. By free vibration test the natural period (0.2 s) of the model was confirmed and the damping ratio (2%) was determined. The simulation was conducted by the product of artificial wave generated from modified power spectral density (PSD) function and envelope function at consecutive time intervals of target. The modification was performed by amplifying the PSD graph of target at each time interval in a specified width corresponding to the structural response and reducing it in the other parts in which the areas under the PSD-frequency diagrams in the original and modified ones to be same. **Seug-eock** had experimental work test of a two storey unbraced steel framed structure. This paper presents some shaking table tests for a one-bay, two-story steel frame under simulated earthquake loading. The test frame was designed to be capable of showing the second-order inelastic behavior under the earthquake loads and to avoid lateral torsion buckling of a single member. The descriptions of test specimen, instruments, set-up procedures, and results are presented. A comparison of the results obtained from experiment and numerical analysis using beam element model of the ABAQUS program was done. The experiment aims to clarify the inelastic behavior of steel frames subjected to earthquake load and its results can be used to verify the validity of second-order inelastic dynamic analysis techniques of steel frames. **O. Ozcelik1** has done Experimental characterization, modeling and identification of the shake table system. He presented the experimental characterization of the shake table and proposed a simple conceptual mathematic model for the mechanical components of the NEESUCSD large high performance outdoor shaking table and focuses on finding the displacement, acceleration, and velocity of the present work. The effectiveness of the proposed conceptual models verified through a comparison of analytical results with the experimental results for various tests conducted on the system. An identification approach based on the measured hysteresis response is used to determine the fundamental model parameters including the effective horizontal mass, effective horizontal stiffness of the table, and the coefficient of the classical coulomb friction and viscous damping element representing the various dissipative forces in the system. **C. S. Sanghvi,** worked on the development of low cost shake tables. He showed "development in the field of earthquake engineering, experimental study is required" To study the effects of earthquake, laboratory facilities are needed. The development has reached to a stage where earthquake simulation is achieved in laboratory. Shake table is used to provide earthquake simulation and to test the prototype and scaled model of the structure. In order to reproduce actual earthquake data, a six-degree of freedom electro-hydraulic shaking table is essential. They are very expensive and require high maintenance and operational costs. There exists a need to developed suitable teaching and learning aids to augment the classroom teaching. One of the most effective ways to achieve this is to develop simple experimental setup with suitable shake table. Development of shake table for the Earthquake Engineering laboratory to test models is a challenge the law cost shake table. Single translation (horizontal) degree of freedom shaking tables is useful for laboratory testing to study behavior of structural models. From this perspective, low cost uni-axial shaking tables were designed & fabricated at L.D College of Engineering. These low cost shake tables will be used to study behavior of structure through models under harmonic as well as random excitation. Shake tables prepared by L.D College of Engineering (L.D.C.E) are Uni-axial Electro-mechanical Shaking tables. These shaking tables are assembly of various steel sections that forms a table on which a plate is supported. The movement of this plate is considered as shaking of ground due to earthquake. The term Uni-axial means movement in one horizontal direction only. **Hakim Bechtoula,** worked on the Performance and overview of the new 6 DOF Shaking Table. The research paper had activity of laboratory will include the development of experimental research in field of earthquake engineering, dynamic qualification test of industrial equipment, conduct a collaborative research project with and international institutions. This laboratory is located at Algiers ant it is composed of a six degree of freedom shaking table of 6.1x6.1m, a reaction wall of 13x15m and a strong floor of

13x32m. In this laboratory is equipped with an advanced hydraulic distribution system, a series of high performance actuators are used and 128-channel data acquisition system and two high-capacity bridge cranes of 10 and 32t. The shaking table is capable of simulating earthquake events and other ground vibration with displacements of ±150 mm and ±250mm in the horizontal directions and ±100mm in the vertical direction. Accelerations of ±1.0 for horizontal directions and ±0.8 g for vertical direction are possible with maximum test specimens of 60tons. Performances of the shaking table were checked using 4 specimens. It was observed that the achieved and the target performance envelope are in good agreement for all frequencies of operation. The error in peak value between achieved and target signal did not exceed in the worst case 1% in displacement control and 2% in acceleration control. This result indicates that the CGS shaking table is performing to its design specifications criteria. The dynamic testing facility can be used reliably for the type of experiments that it was designed for.

INSTRUMENTAION

a) Uniaxial shake table- uniaxial shake tables move in the single direction a servomotor driven tables are cleaner and less noisy than servo-hydraulic tables and require no special maintenance training. However, they have limited payload mass capacity and can be more expensive than servo-hydraulics for larger tables.

b) FFT analyzer- The fast Fourier transform decomposes a function of time a signal into the frequency that make it up, similarly to has a musical chord can be expressed as the amplitude of its constituent notes. The Fast Fourier Transform of a function of time itself is a complex valued function of frequency the Fast Fourier Transform is called the frequency domain representation of the original signal.

c) Accelerometer- At is device that measures proper acceleration is a built in electronic and component that measure motion at is used to detect and monitor vibration in rotating machinery. An acceleration is an electromechanical device that will measure acceleration forces may be static like the constant force of gravity pulling at you feet of they could be dynamic caused by moving or vibrating the accelerometer. Measuring and recording dynamic change in mechanical variables including shock and vibration. We are using the piezoelectric accelerometer single axis.

EXPERIMENTAL PROCEDURE AND METHODOLOGY

a) Characterization of the Shake Table- We had we checked the behavior of the shake table with or without loading condition.

- The accelerometer is attached at the midpoint of the shake table.
- Accelerometer is connected with on FFT analyzer & FFT connecting it with the computer.
- The control software is used "NVGATE" the hardware control and provide much more accurate control over the table motion. In use at the four sites does this by recoding the table motion achieved during a seismic test and correcting the drive signal the time histories are segmented into overlapping blocks and converted to the frequency domain using the Fast Fourier Transform (FFT).
- The experiment performed under the three following condition: - No load, 250 Load & 450 Kg load.
  Apply frequency of 5Hz, 15Hz, 25Hz and displacement of 10mm, 30mm, 50mm, in all the three conditions.
- After the above step, we determined the behavior of the shake table.
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Fig.4.1. Uniaxial shake table without load.

Fig.4.2. Uniaxial shake table with load.

b) Single storey steel framed structure- The structure is fixed on the shake table and base excitation started.

- We varied the height and load of the structure and frequency is calculated by the proposed methodology.
- After the above step we determined the natural frequency of the structure experimentally and theoretically match.
- The accelerometer is attached at the midpoint of the shake table.
- Accelerometer is connected with on FFT analyzer & FFT connecting it with the computer.
- The control software is used “NVGATE” the hardware control and provide much more accurate control over the table motion. In use at the four sites does this by recoding the table motion achieved during a seismic test and correcting the drive signal the time histories are segmented into overlapping blocks and converted to the frequency domain using the Fast Fourier Transform (FFT).

Fig.4.3. Experimental setup steel framed structure

RESULTS AND DISCUSSION

***Characterization and Performance of the shake table*:**

There will be a description of all essential aspects lead to its functionality and it will be provided an analysis of its performance in terms of ability of generating shaking frequencies on mass bodies placed on the platform. In the uni-axial shake table the frequency applied to the shake table is 5, 15, and 25 Hz. In each frequency applied to the shake table the displacement provided are 10, 30, and 50mm.

➢ ***Without load condition***

Firstly you can see we had attached Accelerometer (measure motion at is used to detect and monitor vibration in rotating machinery) with shake table with Wax and this accelerometer is attached with the (FFT) analyzer. This was our setup to get the results and after than we will provides Various frequencies and various displacements to get the best results from all of them.

Table 5.1: Calculation of steel frame structure

S. No	Height (mm)	Mass (Kg)	Moment of inertia $\frac{\pi D^4}{64}$ (mm4)	Modulus of elasticity (N/mm2)	Stiffness $K = 12EI/L^3$ (N/m)	Natural frequency $f = \frac{1}{2\pi}\sqrt{k/m}$ (Hz)
1	202	4.79	20.12	210000	24605	11.41
2	202	8.79	20.12	210000	24605	8.42
3	202	10.79	20.12	210000	24605	7.60
4	340	4.79	20.12	210000	5159	5.22
5	340	8.79	20.12	210000	5159	3.86
6	340	10.79	20.12	210000	5159	3.48
7	450	4.79	20.12	210000	2225	3.43
8	450	8.79	20.12	210000	2225	2.52
9	450	10.79	20.12	210000	2225	2.29

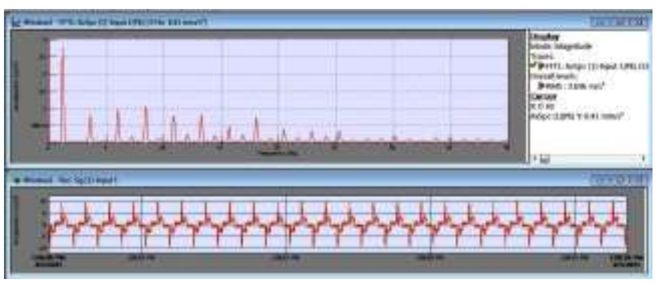

Fig.5.1 Performance the shake table without load

➢ ***With load condition***

As you seen above that the characterization and performances with load condition and now you will see that characterization with 250kg and 450kg load. Same frequency and same displacement are applied. As now you see that our design is prefect as both the results are same with load and without any load.

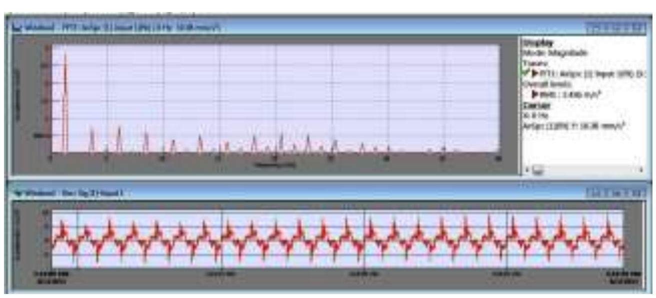

Fig.5.2 Performance the shake table with load

STEEL FRAMED STRUTURE

The Vibration characteristics (natural frequency) of single story steel framed building of length 450mm, 340mm & 202mm and varying load 4.79kg, 8.79kg &, 10.79kg and constant dia (4.5mm) have been determined by spectrum graphs between amplitude in terms of displacement and excitation frequency. We have calculated the natural frequency. The FRF obtained using NVGATE software for steel framed structure of same length.

The results of the above study can be seen in the Table 5.1 for different heights and for different loading conditions and having different mass of each of the element. The material on which the study is carried out is of stainless steel and the

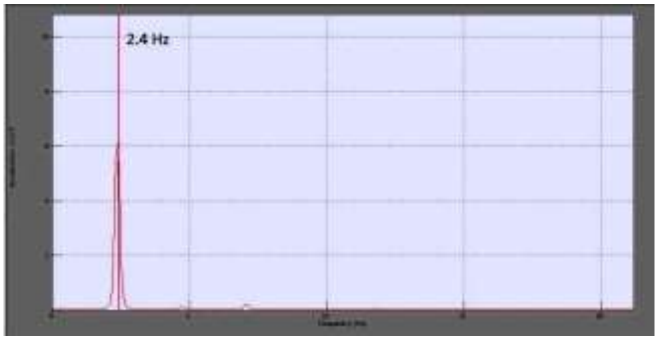

Fig.5.3. 450mm height and mass 10.79Kg

As displayed fig.5.3.The natural frequency corresponds to the peak response can be seen to be 2.4Hz.and the theoretical value calculated was 2.29 Hz, the values are nearly same.

CONCLUSION

The main objective of the present work is to study the Characterization and application of the shake table for structural model testing. Analysis and performance of shake table by Collection of the limiting values under various conditions like with load and without load. Collection of the data based on excitation frequency using free vibration, force vibration technique and comparison with the theoretical results had done. The single storey building steel frame structure.

Shake table is exclusively used for testing earthquake resistance on the prototypes and models of neither the structures nor the whole structure or the building is tested on it as it is not possible to test the whole structure practically.

The experiment performed on the shake table gave satisfactory results, there were too many peak points obtained as shown in fig that occurred due to the servo motor used in the shake table. If electrical or mechanical motor were used there will be only one peak point in the graph but in that particular case due to the use of servo motor different peaks and modes were obtained. It can also be seen in the Figure no. 5.1. & 5.2

As displayed in the Table.5.1, there is increase in natural frequency as the height of (steel framed) model is decrease. Which conclude that the natural frequency increase with decrease in height of frame structure and vice versa. And other concludes that the natural frequency also decrees in varying the load of the structure.

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