ANALELE UNIVERSITĂȚII
"EFTIMIE MURGU" REȘIȚA
ANUL XXV, NR. 1, 2018, ISSN 1453 - 7397

The Mechanism for Actuating and Automating the Shaking Tables

Vasile Iancu

In the paper, is present the shaking table designed for the laboratory use, to simulate the earthquakes behaviors. With this equipment we can study the dynamic behavior of civil engineering structures subjected to seismic motion. The vibratory movement of the shaking table is carried out by means of an electric motor which, through a crank mechanism, moves the shaking table. The smooth start of the shaking table and its movement is accomplished through a frequency converter, FRENIC-Mini series of general use, made by Fuji Electric C. Ltd. Tests was performed using a NI application with a laser displacement sensor, in order to find out the displacement precision.

***Keywords**: shaking table, earthquake, sensor, LabVIEW program*

1. Introduction.

Now we have several different experimental techniques, to test the response of structures and to verify their seismic performance, one of this is the use of an earthquake shaking table. The shaking table is a device for shaking structural models or building components, with a wide variety of simulated ground motions, as well as reproductions of recorded earthquakes time-histories [1].

The current tables consist of a rectangular platform, which is driven in up to six degrees of freedom using servo-hydraulic systems, or actuators. The initial shaking table was made in 1893, at the University of Tokyo to classify the types of building construction [2], the motion of this shaking table was made by a simple wheel mechanism. Test models of the buildings are fixed to the up platform and shaken, often to the point of damage or failure.

The shaking tables are also used in other fields of engineering, to test and qualify different parts of the vehicles, that must respect heavy vibration requirements specifications and standards i.e. road and railway vehicles, military standards, aerospace industry, or tried and desired properties of the soil properties [3], for civil and industrial structures [4], etc.

In order to be able to solve the increasing demands for diminishing the devastating effects of earthquakes, more powerful and bigger shaking tables have been built taking into account the implementation of smaller scaling factors involving higher dynamic forces [5].

2. Construction of the shaking table.

The shaking table was made for improving the stability of the structures and their mode of operation, using different types of earthquake devices: friction pendulums [6], rubber bearings [7, 8] with different properties of the layers [9]. In the laboratory, we already use such insulators [10] for different tests [11]. The shaking table is also used for teaching the students the behavior of the structures if that are subject to seismic waves of an earthquake.

The shaking table is built from rectangular pipes having on the top a plate made from wood with a thickness of 40 mm and a steel plate with a thickness of 10 mm, the dimensions of the sliding table are 600x300x40 mm. Due to this height of the table 850 mm, the gravity center of the shaking table is bellow at 400 mm.

Due to the uniform and rectilinear movement of the sliding table, the shaking table has to more legs in order to attenuate and increase her stability Figure 1.

Figure 1. The shaking table

The circular movement of the electrical motor is transformed in rectilinear movement using a metallic gear, the connection between the sliding table and the metallic case of the shaking table, is made by a metallic ball-shaped guide Figure 2, which take the translation movements at high speeds at a low noise level.

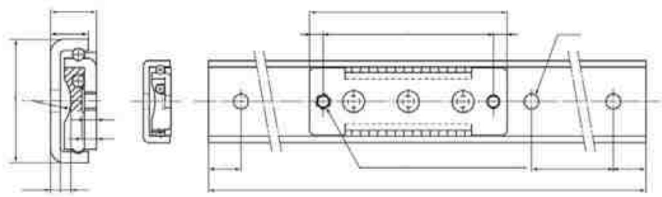

Figure 2. The metallic ball-shaped guide of the shaking table

3. The electric part of the shaking table.

The movements requirement of the sliding plate of the shaking table are from 0 to 400 rpm, for a fine translation motion it was necessary to mount a frequency converter, FRENIC-Mini series of general use Figure 3, made by Fuji Electric C. Ltd.

The characteristics of frequency convertor are: range of power (0,1 kW—2,2 kW for single phase feed and 0,4 kW—4,0 kW for three-phase power supply), output frequency max. 400Hz, breaking unit included (accept external breaking resistance), simplified torque control algorithm and energy saving function.

Figure 3. The frequency converter, FRENIC-Mini

In order to slide the plate of the shaking table, that was equipped with an electrical wiring system Figure 4, commanded from the control panel where the frequency converter is mounted Figure 5.

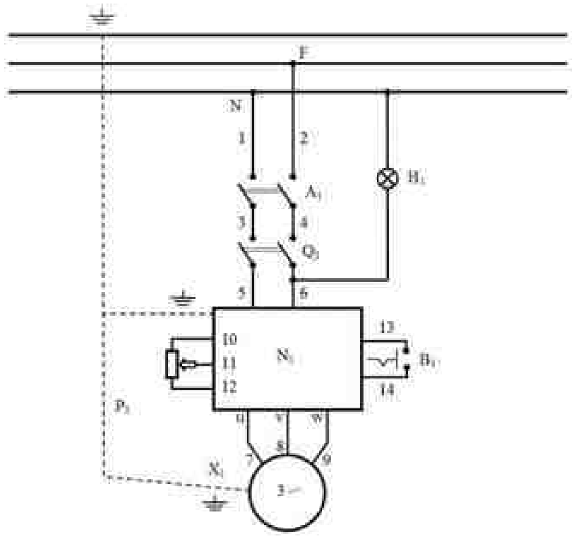

Figure 4. The wiring system of the shaking table

Figure 5. The control panel of the shaking table

4. The calibration of the shaking table.

The calibration of the shaking table was made with the LabVIEW program and the laser displacement tester, the results of the tests are in the Table 1 and the diagram of this results is presented in Figure 6. With the results of the displacement of the sliding plate I was able to determine the working frequency of the shaking table.

Table 1

Step	Frequency (Hz)
0	0
1	0,323
2	0,657
3	0,995
4	1,320
5	1,650
6	1,980

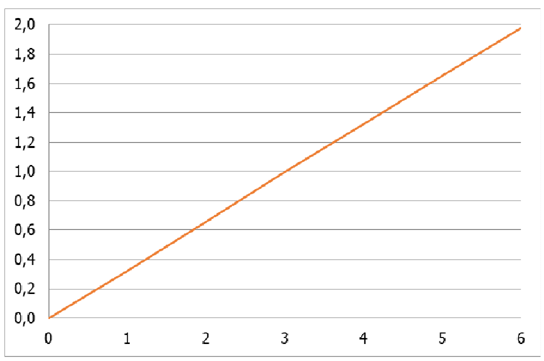

Figure 6. The frequency diagram of the shaking table.

4. Conclusions.

After the tests, we have concluded that, for a safe operation at high levels the shaking table must be reinforced by lowering the center of gravity, for that at the bottom of the table a metal plate was mounted.

The measurements made by LabVIEW program from National Instrument reveal some parasitic frequencies aspects of the cinematic chain and the metallic ball-shaped guide, these will be mitigated by using some elastomeric materials.

References.

[1] Iancu V., Galuska I., Manescu T., *Shaking table for the analysis of pillars with top mass*, Acoustic and Vibration of Mechanical Structures, Springer Proceedings in Physics (SPPHY, volume 198), Timisoara, May 25-26, pp 405-410, 2017.

[2] Reitherman R., *Earthquakes and Engineers: An International History*, Reston, VA: ASCE Press, pp 126–127, 2012.

[3] Prasad S.K., Towhata I., Chandradhara G.P., Nanjundaswamy P., *Shaking table tests in earthquake geotechnical engineering*, Current Science, Vol. 87, Issue 10, Special Section: Geotechnics and Earthquake Hazards, pp 1398-1404, 2004.

[4] Weixiao X., Jingjiang S., Weisong Y., Ke D., *Shaking table comparative test and associated study of a stepped wall-frame structure*, Earthquake Engineering & Engineering Vibration, Vol. 13, Issue 3, pp 471-485, 2014.

[5] Bairrao R., Zav C.T., *Shaking table testing of civil engineering structures - the LNEC 3D simulation experience*, 12th World Conference on Earthquake Engineering, Auckland, New Zeeland, 2000.

[6] Gillich G.R., Amariei D., Iancu V., Jurcău C.Ş., *Aspects behavior of bridges which use different vibration isolating systems*, 10th WSEAS International Conference on Automation & Information (ICAI'09), pp 140-145, Praga, 2009.

[7] Iancu V., Gillich G.R., Iavornic C.M., Gillich N., *Some Models of Elastomeric Seismic Isolation Devices*, 12 International Symposium AVMS' 2013 - Timişoara, 2013.

[8] Gillich G.R., Bratu P., Frunzăverde D., Amariei D., Iancu V., *Identifying mechanical characteristics of materials with non-linear behavior using statistical methods*, Harvard Univ., Cambridge, USA, 2010.

[9] Jurcău C.Ş., Gillich G.R., Iancu V., Amariei D., *Evaluation and Control of Forces Acting on Isolated Friction Pendulum*, The 3rd WSEAS International Conference (EMESEG '10), pp 220-225, Corfu Island, Greece 2010.

[10] Iancu V., Vasile O., Gillich G.R., *Modelling and Characterization of Hybrid Rubber-Based Earthquake Isolation Systems*, Revista Materiale Plastice, 49(4), 2012, pp. 237-241.

[11] Negru I., Gillich G.R., Praisach Z.I., Tufoi M., Gillich E.W., *Nondestructive evaluation of piers*, Proc. SPIE 9438, Health Monitoring of Structural and Biological Systems 2015, 943817, San Diego, USA, March 23, 2015.

[12] Gillich G.R., Samoilescu G., Berinde F., Chioncel C.P., *Experimental determination of the rubber dynamic rigidity and elasticity module by time-frequency measurements*, Materiale Plastice, 44(1), 2007, pp. 18-21.

[13] Gillich G.R., Gillich N., Chioncel C.P., Cziple F., *Legal aspects concerning the evaluation of pollution effects due to vibrations in urban areas*, Journal of Environmental Protection and Ecology, 9(2), 2008, pp. 465-473.
[14] Iavornic C., Praisach Z.I., Vasile O., Gillich G.R., Iancu V., *Study of Stress and Deformation in Elastomeric Isolation Systems Using the Finite Element Method*, 11th WSEAS International Conference on Systems Theory and Scientific Computation, 2011, pp 239-244.
[15] Ghita E., Gillich G.R., Bordeasu I., Voda M., Troi C., *Aspecte ale comportarii polimerilor la solicitãri de tractiune*, Materiale Plastice, 44(2), 2007, pp. 158-162.
[16] Berinde F.C., Gillich G.R., Chioncel C.P., *Structure monitoring and evaluation using vibro-acoustic method supported by the Wigner-Ville Distribution*, Romanian Journal of Acoustics and Vibration, 7, 2006, pp. 61-65.

Address:

- Asist. Prof. Dr. Eng. Vasile Iancu, "Eftimie Murgu" University of Reşiţa, Piaţa Traian Vuia, nr. 1-4, 320085, Reşiţa, v.iancu@uem.ro