DinEst 2024
Third Conference on Structural Dynamics
Seville, Spain, 12–13 September 2024

PHYSICAL PROPERTIES TRACKING OF A LABORATORY-SCALED TWO-STOREY BUILDING MODEL

Alvaro Magdaleno[1*], Alvaro Iglesias-Pordomingo[1], Lara del Val[1], Emiliano Pereira[2] and Antolin Lorenzana[1]

[1] ITAP. Universidad de Valladolid
Paseo del Cauce, 59, 47011 Valladolid
e-mail: {alvaro.magdaleno, alvaro.iglesias, lara.val, antolin.lorenzana}@uva.es

[2] Department of Signal Processing and Communications. Universidad de Alcalá
Ctra. Madrid-Barcelona, km 33.600, 28805 Alcalá de Henares
e-mail: emiliano.pereira@uah.es

Keywords: Modal identification, physical properties, two-storey building, structural health monitoring

Abstract. Structural health monitoring is a topic that has gained much interest in the last decades. It is devoted to mitigating the effects of the natural ageing of structures among other aims. Data acquisition systems are deployed on structures and ambient vibration data is stored and processed to assess the actual structural state and foresee potential issues [1, 2]. Natural frequencies are one of the most commonly estimated properties and, by means of a variety of algorithms, which usually involve computational models, damage can be detected [3, 4].

In this work, a methodology is proposed to track the evolution of the physical properties of a two-storey structural model that represents a slender shear building. As shown in Figure 1a, it is composed of two rigid, thick plates that represent the floors connected via several thin aluminium sheets that represent the columns. This element disposal restraints the movement of the model to one vertical plane. In addition, these materials confer the resulting model a set of interesting dynamic properties, such as low damping and low natural frequencies, which are very adequate for the purposes of this work. The modal properties of this model are estimated through operational modal analysis (OMA) techniques. The acceleration of both storeys is measured by means of two accelerometers one on each floor connected to a data acquisition system. This system automatically records a set of data every hour and records it in a computer. In parallel, a Python script runs periodically to check the presence of new data files and process them. This script is responsible for pre-processing the data, performing the operational modal analysis to estimate the modal properties of the model, tracking its physical properties and storing the results in an online time-series database (TSDB).

The OMA algorithm used in this work is the well-known covariance-driven stochastic subspace identification method (SSI-cov), that provides accurate estimates of natural frequencies, damping ratios and unscaled mode shapes. By means of these modal properties, an estimation of the evolution of the physical properties is obtained. To do so, first the structure is assimilated to a specific model such as the one shown in Figure 1b. This model is composed of two degrees of freedom, so two concentrated masses (m_1 and m_2), two spring constants (k_1 and k_2) and two

damping coefficients (c_1 and c_2) need to be determined. The algorithm, however, does not provide with the specific values of the physical properties. Instead, for each measurement, the variation of each property is calculated with respect to the previous one and tracked over time. The variation ratio of the six properties (which equals to 1 if that property does not change from one measurement to the next) is finally stored in an online database, which is easily queried via web. Finally, several scenarios are presented to show the usefulness of the tracking algorithm. In these scenarios, both masses and stiffness coefficients are alternatively modified. These modifications are tracked, and the obtained variations compared to the true values.

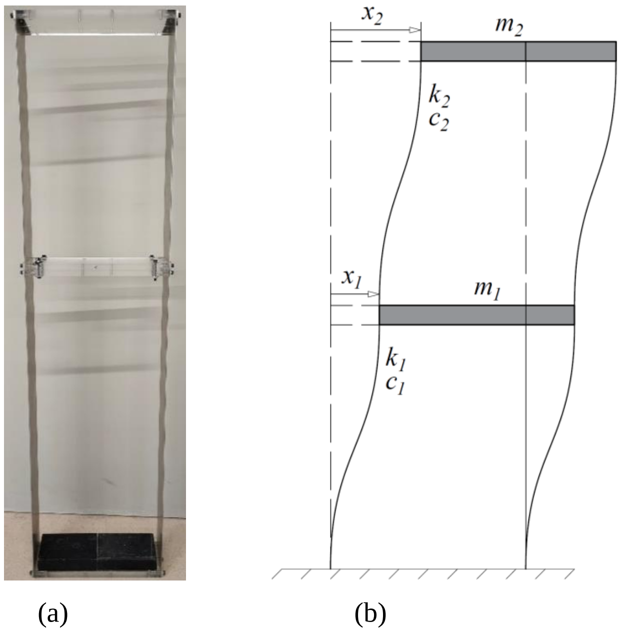

Figure 1. (a) Picture of the structural model and (b) its conceptual model

Acknowledgements

The authors wish to acknowledge to the AEI, Spanish Government (10.13039/501100011033), and to "ERDF A way of making Europe", for the partial support through the grant PID2022-140117NB-I00.

References

[1] Zhang, C.W. et al. (2022) Vibration feature extraction using signal processing techniques for structural health monitoring: A review. *Mechanical Systems and Signal Processing*, 177, 109175. DOI: 10.1016/j.ymssp.2022.109175

[2] Deng, Z.H., Huang, M.S., Wan, N. and Zhang, J.W. (2023) The current development of Structural Health Monitoring for bridges: a review. *Buildings*, 13(6), 1360. DOI: 10.3390/buildings13061360

[3] Burgos, D.A.T. et al. (2020) Damage identification in Structural Health Monitoring: A brief review from its implementation to the use of data-driven applications. *Sensors*, 20(3), 733. DOI: 10.3390/s20030733

[4] Palma, P. and Steiger, R. (2020) Structural health monitoring of timber structures – Review of available methods and case studies. *Construction and Building Materials*, 248, 118528. DOI: 10.1016/j.conbuildmat.2020.118528