Proceedings of the 2nd Croatian Conference on Earthquake Engineering - 2CroCEE
Zagreb, Croatia - March 22 to 24, 2023

DOI: https://doi.org/10.5592/CO/2CroCEE.2023.57

FRIBAS: A PARAMETRIC DATABASE OF BUILDING AND SOIL FEATURES INCLUDING THE FUNDAMENTAL FREQUENCY OF RESONANCE

Chiara Scaini [1], Bojana Petrovic [2], Maria Rosaria Gallipoli [3], Giuseppe Calamita [4], Nicola Tragni [5], Carla Barnaba [6], Marco Vona [7], Stefano Parolai [8]

[1] *Researcher, Seismological Research Center, National Institute of Oceanography and Applied Geophysics - OGS, cscaini@ogs.it*
[2] *Research fellow, Seismological Research Center, National Institute of Oceanography and Applied Geophysics - OGS, Italy, bpetrovic@ogs.it*
[3] *Researcher, National Research Council - CNR, Institute of Methodologies for Environmental Analysis (IMAA), Tito Scalo (PZ), Italy, email: mariarosaria.gallipoli@imaa.cnr.it*
[4] *Researcher, National Research Council - CNR, Institute of Methodologies for Environmental Analysis (IMAA), Tito Scalo (PZ), Italy, email: giuseppe.calamitra@imaa.cnr.it*
[5] *Research fellow, National Research Council - CNR, Institute of Methodologies for Environmental Analysis (IMAA), Tito Scalo (PZ), Italy, email: nicola.tragni@imaa.cnr.it*
[6] *Researcher, Seismological Research Center, National Institute of Oceanography and Applied Geophysics - OGS, cbarnaba@ogs.it*
[7] *Professor, School of Engineering, University of Basilicata, Potenza, Italy, email: marco.vona@unibas.it*
[8] *Professor, Università degli Studi di Trieste, Italy and Seismological Research Center, National Institute of Oceanography and Applied Geophysics - OGS, Italy, stefano.parolai@units.it, sparolai@ogs.it*

Keywords: period-height relationship, ambient noise measurements, building dynamic behavior, soil-structure interaction.

The fundamental period of vibration of buildings is an important parameter for assessing their behavior during earthquakes. It can be estimated using analytical [1] and empirical [2,3] approaches. In engineering practice, it is often estimated using simplified period-height relationships (e.g. [4]). The empirical determination of the fundamental period of buildings is extremely important to validate existing simplified period-height relationships and to develop new ones. Several parameters, apart from building height, might also influence the fundamental period of built structures. Currently, however, there are no empirical period-height relationships that account for building characteristics other than height (e.g. foundation soil type). In addition, there are very few empirical studies that provide both the fundamental period of buildings together with their main characteristics.

The FRIBAS database contributes to filling this gap by providing information on the fundamental period of vibration and characteristics of more than 300 reinforced concrete and masonry buildings. The studied buildings are located in northeastern Italy and in three towns of southern Italy (Matera, Potenza and Villa D'Agri, Fig. 1). To the best of our knowledge, FRIBAS is the first database that collects various building characteristics, including structural and geometric features, such as the age of construction, the construction material, storey number and other data regarding the such as geometric features (e.g. shape) and construction details (e.g. roof type, floor types). These characteristics were inferred from external and sometimes internal building inspections, and combined with information provided by residents. In addition, FRIBAS includes the fundamental period of buildings and foundation soil, which were empirically estimated using single station ambient noise measurements. The database was assembled based on data collected separately in northeastern and southern Italy (Fig.1) for different building types (including both low to mid-rise historical and modern masonry and low to high-rise reinforced concrete buildings). The buildings were chosen also based on the possibility of accessing the interior and performing measurements. The data were harmonized into 37 fields that allow for a general classification of building and soil parameters.

Proceedings of the 2nd Croatian Conference on Earthquake Engineering - 2CroCEE
Zagreb, Croatia - March 22 to 24, 2023

DOI: https://doi.org/10.5592/CO/2CroCEE.2023.57

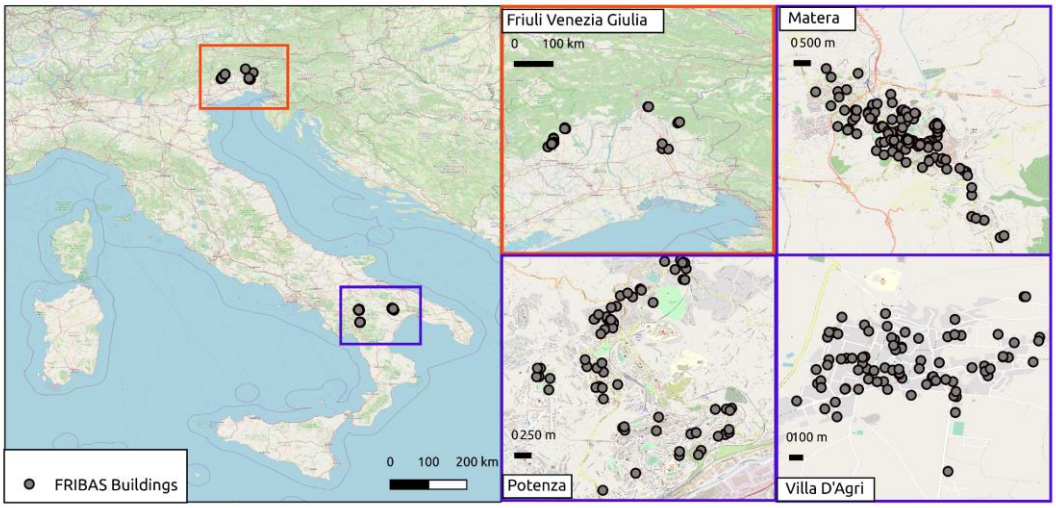

Figure 1: Map of the location of buildings where ambient vibration measurements were carried out.

FRIBAS was assembled with the specific goal of analyzing how different building parameters affect structural behavior (in particular, the fundamental vibration period). The database is available online in open access mode under the CC 4.0 license available at this link: https://doi.org/10.5281/zenodo.6505442. The first explorative analysis was focused on the period-height experimental relationship obtained from the entire dataset. Fig. 2 shows the period-height relationship obtained for this study in comparison with those developed by other authors and those prescribed by Eurocode 8. The plot shows that substantial differences between the empirical relationships and the Eurocode formula exist.

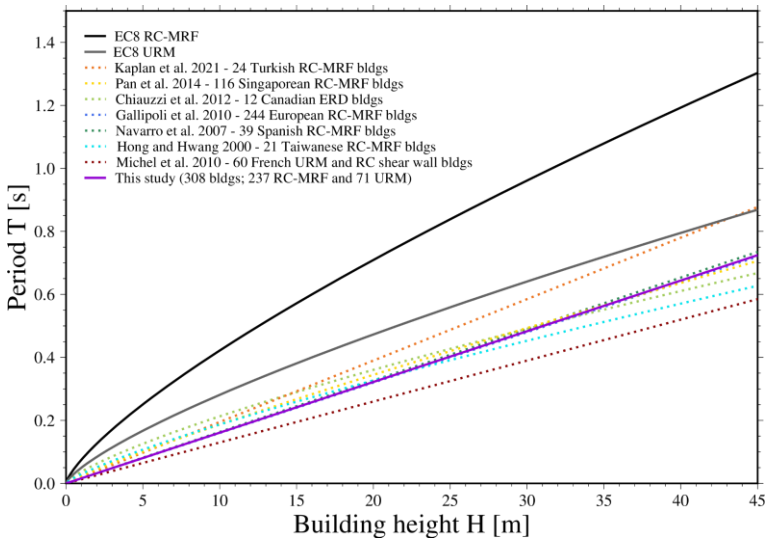

Figure 2: Period-height relationship derived from the FRIBAS database (violet solid line) in comparison with other relationships from literature and with the EC8 relationships proposed for RC and URM buildings.

FRIBAS also supports the definition of different period-height relationships based on construction material and soil types. Period-height relationships were developed for RC and URM buildings on rigid and soft soil, respectively [5]. Rigid and soft soils were defined using a simplified classification based on the geological map available for each town: outcropping bedrock and clean coarse gravels of northeastern Italy were classified as rigid soils, while all the other sediments were considered as soft soils. The results show that for the analyzed URM buildings the fundamental period differs by about 20% between buildings located on rigid respect to those on soft soil. The difference is smaller (11%), but still not negligible for RC buildings.

Proceedings of the 2nd Croatian Conference on Earthquake Engineering - 2CroCEE
Zagreb, Croatia - March 22 to 24, 2023

DOI: https://doi.org/10.5592/CO/2CroCEE.2023.57

Results of the analysis highlight that soil type should be accounted for when developing simplified period-height relationships. In addition, they point out the need for characterizing the dynamic behavior of different building typologies, in particular to account for the variability of masonry building types. Empirical period-height relationships developed for specific building typologies and soil types can potentially improve damage assessment strategies and provide more realistic results. The fundamental period is, in fact, a crucial parameter for evaluating the expected impacts of seismic events For example, [6] apply a simplified approach to estimate the expected damage on selected building typologies. The method uses the fundamental period obtained from experimental period-height relationships for buildings of different construction materials and located on different soil types ([5],[7]). In addition, soil-building resonance phenomena can be identified based on experimental measurements of fundamental frequency on buildings and foundation soils (Gallipoli et al., 2020). Damage assessment methods can therefore benefit from datasets such as FRIBAS, which provides useful data for the development of new period-height relationships.

Acknowledgements

During the preparation of this study, Bojana Petrovic was supported by a research fellowship from the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG, PE 2891/1-1, Projektnummer 428372009).

References

[1] Kwon, O.S., Kim, E.S. (2010). Evaluation of building period formulas for seismic design, *Earthquake Engineering and Structural Dynamics, 39(14):1569-1583*.

[2] Gallipoli, M.R., Mucciarelli, M., Šket-Motnikar, B., Zupančić, P., Gosar, A., Prevolnik, S., Herak, M., Stipcević, J., Herak, D., Milutinović, Z., Olumćeva, T. (2010). Empirical estimates of dynamic parameters on a large set of European buildings, *Bulletin of Earthquake Engineering 8:593–607.*

[3] Michel, C., Gueguen, P., Bard, P.Y. (2008). Dynamic parameters of structures extracted from ambient vibration measurements: an aid for the seismic vulnerability assessment of existing buildings in moderate seismic hazard regions, *Soil Dyn Earthq Eng 28:593–604.*

[4] Crowley, H., Pinho, R. (2006). Simplified equations for estimating the period of vibration of existing buildings, *First European Conference on Earthquake Engineering and Seismology (a joint event of the 13th ECEE & 30th General Assembly of the ESC), Geneva, Switzerland, 3-8 September 2006, Paper Number: 1122.*

[5] Gallipoli, M.R., Petrovic, B., Calamita, G., Tragni, N., Scaini, C., Barnaba, C., Vona, M., Parolai, S. (2022). FRIBAS database for better characterization of RC and URM buildings: Towards specific T-H relationships, *Bulletin of Earthquake Engineering, under review.*

[6] Petrovic, B., Scaini, C., Parolai, S. (2022). Applying the damage assessment for rapid response approach to the august 24 M6 event of the seismic sequence in central Italy (2016), *Front. Earth Sci., Sec. Geohazards and Georisks, Research Topic New Challenges for Seismic Risk Mitigation in Urban Areas, https://doi.org/10.3389/feart.2022.932110*

[7] Gallipoli, M.R., Calamita, G., Tragni, N., Pisapia, D., Lupo, M., Mucciarelli, M., Stabile, T.A., Perrone, A., Amato, L., Izzi, F., La Scaleia, G., Maio, D., Salvia, V. (2020). Evaluation of soil-building resonance effect in the urban area of the city of Matera (Italy), *Engineering Geology 272, 2020, https://doi.org/10.1016/j.enggeo.2020.105645*.