Gruppo Nazionale di Geofisica della Terra Solida

BOOK OF ABSTRACTS
41st NATIONAL CONFERENCE

7-9 FEBRUARY 2023

BOLOGNA

OGS
Istituto Nazionale
di Oceanografia
e di Geofisica
Sperimentale

EAGE
EUROPEAN ASSOCIATION OF GEOSCIENTISTS & ENGINEERS
SEG
SOCIETY OF EXPLORATION GEOPHYSICISTS
SEZIONE ITALIANA

22° CONVEGNO NAZIONALE

Gruppo Nazionale di Geofisica della Terra Solida

BOOK OF ABSTRACTS
41st NATIONAL CONFERENCE

7-9 FEBRUARY 2023

BOLOGNA

OGS
Istituto Nazionale
di Oceanografia
e di Geofisica
Sperimentale

EAGE
EUROPEAN ASSOCIATION OF GEOSCIENTISTS & ENGINEERS
SEG
SOCIETY OF EXPLORATION GEOPHYSICISTS
SEZIONE ITALIANA

22° CONVEGNO NAZIONALE

41st GNGTS National Conference

GNGTS TECHNICAL SCIENTIFIC COMMITTEE

Alessandro Rebez, President
National Institute of Oceanography and Applied Geophysics – OGS
arebez@ogs.it

Daniela Di Bucci
Representing the Civil Protection Department
Daniela.DiBucci@protezionecivile.it

Claudia Piromallo
Representing the National Institute of Geophysics and Volcanology - INGV
claudia.piromallo@ingv.it

Massimiliano Moscatelli
Representing the National Research Council - CNR
massimiliano.moscatelli@igag.cnr.it

Paolo Gasperini
Representing the Universities
paolo.gasperini@unibo.it

Andrea Tognarelli
Representing the EAGE-SEG Italian Section
andrea.tognarelli@unipi.it

Angelo Masi
Representing ReLUIS Consortium
angelo.masi@unibas.it

ORGANISING COMMITTEE

National Institute of Oceanography and Applied Geophysics – OGS
Giulia Massolino
William Toson
Alessandro Asta
Maria Zanenghi

Editors: Alessandro Rebez and Giulia Massolino

DOI: 10.13120/2tf2-1j75

Seismic vulnerability analysis of historic centres towards risk mitigation strategies. Remarks on the sister cities of Faenza (Italy) and Timisoara (Romania)

C. F. Carocci[1], C. Circo[1], V. Macca[1], M. Mosoarca[2], I. Onescu[2]

[1] *Department of Civil Engineering and Architecture, University of Catania*
[2] *Research Center in Urban Planning and Architecture, Faculty of Architecture and Urban Planning, Politehnica University of Timisoara*

Introduction

Heritage buildings represent a valuable part of historic cities and need to be protected through comprehensive preservation strategies to ensure the authenticity and spirit of the place. The base of any preservation policy is the knowledge that can be improved following vulnerability assessment methodologies.

The paper briefly illustrates two distinct studies that deal with the assessment of the seismic vulnerability of the historic core of the sister cities of Faenza and Timisoara.

The research on the Italian city was developed by the Dept. of Civil Engineering and Architecture of the University of Catania (UniCT) in agreement with Faenza Municipality. The study – whose purpose was the establishment of guidelines for mitigating the vulnerability of the historic urban fabric – was part of the broader framework of the development of the city's master plan.

The research on the Romanian city was developed by the Dept. of Architecture of the Polytechnic University of Timisoara (UPT). The study aimed to develop a simplified assessment methodology, adapted for the local conditions and easy to apply at the urban scale, as part of the wider prevention policies for a sustainable development of the city. The research proposal is under the concerns of ICOMOS, which encourage a multidisciplinary assessment of historic buildings, aims to reduce the seismic risk, and protect the cultural heritage and local communities. The originality of the proposals is also dictated by intertwining the field of civil engineering with that of architecture, urban planning, and socio-economic studies, focusing also on the cultural and artistic features.

The studies that have been carried out independently in the respective universities in Italy and Romania are briefly illustrated in the following to highlight differences in terms of the objectives

and methods of analysis used, in perspective to initiate a new coordinated resumption of the two studies themselves.

Moreover, the present contribution aims to underline how the results of preventive seismic vulnerability analysis studies can provide information capable of fostering the activation of seismic risk prevention measures in ordinary urban governance.

Faenza's historical core

The study of the historical centre of Faenza lies within the path of seismic risk prevention pursued by Emilia Romagna. Regional Law no. 19/2008 entrusts municipalities with assessing their instruments to reduce seismic risk by adapting their Urban and Building Code (UBC) and updating the Civil Protection Plan. The Municipality of Faenza started the design of its UBC, involving the Department of Civil Protection to test a methodology for assessing vulnerability at the urban scale and the University of Catania to carry out a qualitative vulnerability assessment of the historic core. Moreover, for the first time in Italy, the Technical Office tested the Emergency Limit Condition (ELC) introduced by the Italian Government Ordinance (OPCM n. 4007/2012). The ELC is a municipal scale analysis set up based on the Civil Protection Plans and aimed at guaranteeing the functioning of the emergency management system in the post-earthquake phase.

The work on the historical core was carried out in three consecutive phases: (i) the mapping of the seismic vulnerabilities extended to the whole historical centre; (ii) the definition of a survey procedure and its testing on a sample block; (iii) the elaboration of guidelines for the mitigation of buildings' vulnerability in the historical urban fabric.

The analysis of the whole historical centre aimed at the identification of the recurring seismic weaknesses of the urban fabric and the qualitative evaluation of its susceptibility to being damaged by an earthquake. It was performed trying to detect all the factors (constructive, typological, transformative) able to affect, positively or negatively, the seismic behaviour of the urban fabric in its current configuration. The analysis was carried out in four distinct steps: the collection of basic information; the division of the building fabric into aggregates; the on-field survey; and the elaboration of synthesis maps.

In a preliminary phase, the information from bibliographic sources revealed some key aspects of the history of Faenza, especially the reconstruction after World War II. Moreover, the cartography provided by the Administration was analysed – compared with aerial photos available on the web – with the twofold objective of identifying the "aggregates" (i.e., blocks) and preparing the base maps necessary for the retrieval of information during the fieldwork.

The division of the built fabric into "aggregates" (121 in total) followed the approach of the Italian technical regulations (Min&Inf. 2008), adapting the code's criteria to the actual situations detected in Faenza. For each aggregate, the on-field survey has been carried out to identify the vulnerability and strength factors of the urban fabric concerning seismic actions, distinguishing between "intrinsic vulnerabilities" (those associated with the original buildings) and "transformation vulnerabilities" (associated to subsequent interventions) (Carocci 2013).

The vulnerability factors related to the original construction of Faenza buildings are, for example, the presence of windows too close to the top of the walls with the consequent weakening of a very critical portion of the building. The vulnerabilities deriving from transformations are the interventions realized with incongruous materials such as r.c. balconies. The strength factors are first identifiable with traditional anti-seismic devices, such as metallic tie-rods and buttresses, and secondly with an average good quality of the wall texture (mostly made of brick elements). Failures resulting from ground settlements have been systematically observed: they interact with the vulnerability and strength factors by increasing the former's harmfulness and reducing the latter's effectiveness.

The results of the on-field survey have been included in a map in which all the factors observed are indicated in each aggregate (Fig. 1). In this way, the map not only allows a preliminary evaluation of the vulnerability conditions of all the aggregates but can also help to identify the priorities for strategic interventions to be promoted by the public authorities.

The procedure for defining seismic vulnerability mitigation criteria for Faenza's historical centre was tested on a sample block performing the so-called "critical survey" (Carocci 2013). This latter was chosen as representative of the characters of the historical built-up context of Faenza and confirmed and clarified the indications deriving from the survey of the whole historical centre. This phase of the study aimed at carrying out an in-depth analysis of the constructional features of the whole urban fabric to identify general design criteria for the conservation and seismic safety of the entire historical centre.

Knowing vulnerabilities and strengths at the two levels (comprehensive and detailed) allowed us to identify for the specific recognized problems intervention categories that are explicitly performance-based. They define design criteria – and not technical solutions – to pursue a vulnerability reduction strategy within a conservative approach that is respectful of the original nature of historical masonry structures.

Figure 1. Map of the historical core of Faenza in which the type and the number of vulnerabilities and strengths factors are identified for each aggregate.

Timisoara historical districts

The study on Timisoara is based on a multidisciplinary approach, as the heritage structures cannot be analysed by only structural features and state of conservation, but also by more complex characteristics which are related with the architectural and urban context, as well as with the historic and cultural value. The subject of seismic vulnerability assessment of historic urban areas is very common nowadays, as many multidisciplinary teams in the world are involved in research in the field. Despite this high interest, most of the research works focus on the structural features, while the cultural components are insufficiently investigated.

Timisoara is the most important city from the western part of Romania, located in Banat seismic region. The history of the city is very complex, with several external administrations, such as the Ottoman and the Habsburg. Since 1177, when the city was first recognized, the urban pattern changed several times, leaving behind valuable urban districts in Secession, Art Nouveau, Baroque and Eclectic architectural style. The buildings are distributed into aggregate condition, forming closed contours around the street path, with interior courtyards. The historical buildings are made in brick masonry, of burnt clay brick and lime. The exterior walls in both longitudinal and transversal directions are massive, with thicknesses up to 80 centimeters. There is usually another thick wall in the longitudinal direction, parallel with the main façade. The transversal walls are thin, contributing only to the rigidity of the building, and are not connected with the façade walls in the majority of the cases (Mosoarca et. Al., 2019).

The seismicity of Banat area is characterised by shallow earthquakes of crustal type. The focal depths are small and the magnitudes in the area were maximum (registered) Mw=5.6. According to several seismic scenarios obtained for Timisoara city, the most probable macroseismic intensity would be IX EMS-98. The investigation starts from a methodology developed by Onescu and Mosoarca and a previous investigation of the historical buildings in the main districts of Timisoara. The analysis that was made in the past was hybrid, combining the advantages of mechanical and empirical techniques (Mosoarca et. Al., 2020).

Starting from this investigation, the analysed area is extended to consider an entire aggregate. Based on the original seismic vulnerability assessment that also considers the cultural value , by adding to the original investigation form parameters regarding the value of the architectural-artistic, urbanistic, and existing socio-economic elements (Onescu, 2020), it is possible to determine the most probable damage states for each of the buildings in the aggregate, as well as for the aggregate itself. The most probable damage state is determined considering possible seismic scenarios for the city, previously determined, which indicated the most probable IX-EMS98 macroseismic intensity for the area. The main historical districts of Timisoara city are presented in Figure 2a, while the damage assessment performed on Iosefin historic area is shown in Figure 2b.

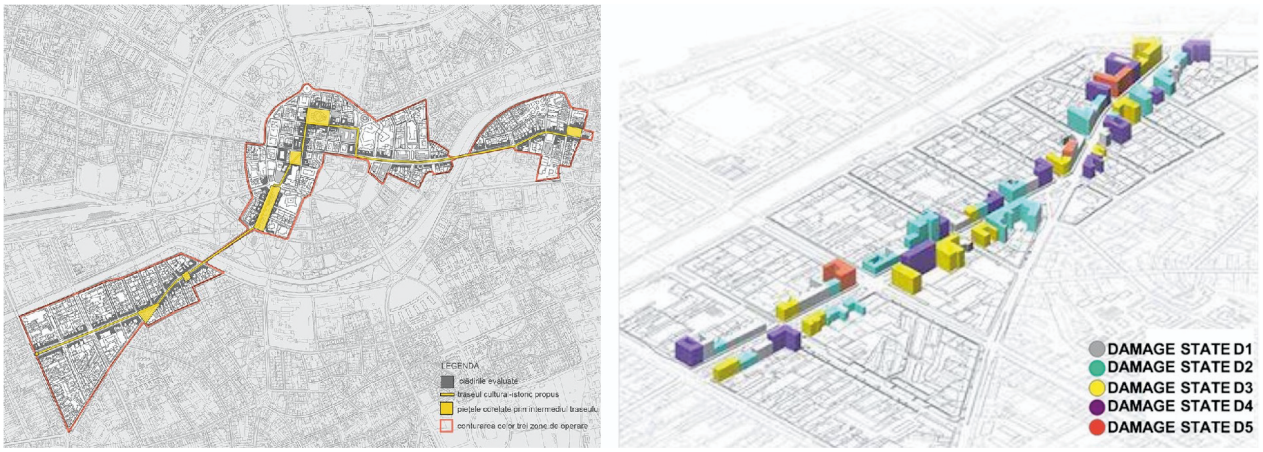

Figure 2. a) Map of the historical districts of Timisoara in which historical buildings are identified; b) Damage assessment of the investigated buildings from Iosefin historical districts

Conclusions

The study on Faenza was finally included in the UBC regulation and in the document named "Seismicity City Plan" (SCP) – enclosed to the UBC as a document of mandatory consultation – becoming the basis for promoting strategies aimed at implementing preventive strengthening interventions on the buildings of the historical centre. The SCP is a valuable tool to guide choices in ordinary land management and affect seismic risk reduction actions and interventions. For example, the studies contained therein support the definition of: indications and rewards for interventions in the historic centre; increased urban planning incentives for the strengthening of buildings facing strategic axes; the definition of public intervention priorities identified by the overlap with ELC and supported by economic assessments (Giuffrida et al., 2020).

The study on Timisoara is not part of any local regulations but is part of one national research contract, the "Multidisciplinary seismic risk assessment for heritage buildings in Timisoara, European Capital of Culture 2023", financed by the Academy of Romanian Scientists. Moreover, another international research contract Ctos Action was proposed considering Timisoara as one of the main case study cities, under the name of "Fostering multi-risk Participatory Planning to enhance resilience and sustainable urban development". The research work is a multi-, inter- and transdisciplinary work which highlights that besides understanding the structural behaviour of heritage buildings, a series of factors must also be taken into consideration. Only after such a comprehensive analysis, the possible preventing intervention solutions can be structurally evaluated and decisions and strengthening measures, if necessary, taken. The project represents a first tool in the process of seismic vulnerability assessment for the western part of Romania and can be applied by several categories of professionals, and by the owners of the building. The procedure can be easily understood and applied, so anyone can learn it in little time. In the absence of financial funds and limitations of time to conduct detailed technical expertise reports for each building, the proposed methodologies represent a simple way to perform a preliminary yet fast and cost-efficient assessment of a wider array of buildings, enabling to raise the awareness

of the risk to which European centers are exposed and to prioritize future interventions and extensive structural analysis.

The two studies just illustrated represent an essential enrichment for urban planning tools aimed at preventing seismic risk. In Faenza, the approach - tested in different historical contexts in both ordinary and damaged conditions - is based on an in-depth knowledge of the built reality to formulate a qualitative assessment of vulnerability. In Timișoara, on the other hand, the study attempts to define general and quantitative risk indicators on the current historical fabric. However, both studies aim at the same objective: to provide criteria for preventive intervention. These preliminary observations highlight the opportunity to develop a common methodology to assess the vulnerability of a historical urban area in a multidisciplinary way that overcomes the limitations of each individual method.

References

Carocci C. F.; 2013: Conservazione del tessuto murario e mitigazione della vulnerabilità sismica. Introduzione allo studio degli edifici in aggregato, in: Blasi C. (Ed), Architettura storica e terremoti. Protocolli operativi per la conoscenza e la tutela, Wolters Kluwer Italia, pp. 138-153.

Min. Infr. & Trasp.; 2008: Decreto del Ministero delle Infrastrutture e dei Trasporti del 14/01/2008. Norme Tecniche per le Costruzioni.

Giuffrida S., Carocci C., Circo C., Giuffrè M., Trovato M.R. and Ventura V.; 2020: Axiological strategies in the old towns' seismic vulnerability mitigation planning. Valori e Valutazioni, 2020, 25, pp. 99-106.

Mosoarca M., Onescu I., Onescu E., Azap B., Chieffo N., and Szitar-Sirbu M.; 2019: "Seismic vulnerability assessment for the historical areas of the Timisoara city, Romania" Eng. Fail Anal., vol. 101, pp. 86–112, Jul., DOI: 10.1016/J.ENGFAILANAL.2019.03.013.

Apostol I. (Onescu); 2020: "Seismic vulnerability assessment of historical urban centres," Ph.D., Politehnica Timisoara.

Mosoarca M., Onescu I., Onescu E. and Anastasiadis A.; 2020: "Seismic vulnerability assessment methodology for historic masonry buildings in the near-field areas" Eng Fail Anal.

Corresponding author: Chiara Circo, chiaracirco@unict.it