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RESPONSE OF THE BUILDING IN AGGREGATES ACCORDING TO THE INTERCONNECTED DIFFERENT PARAMETERS

Maja Mrkonjić [(1)], Josip Atalić [(2)]

[(1)] *Professional associate, Faculty of civil engineering in Zagreb, maja.mrkonjic@grad.unizg.hr*
[(2)] *Associate professor, Faculty of civil engineering in Zagreb, josip.atalic@grad.unizg.hr*

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1. Introduction

On March 22, 2020, Zagreb, Croatia, was struck by a devastating earthquake, severely damaging many buildings, particularly those in the city center built during the Austro-Hungarian period (19th century). Standalone family homes near the epicenter also suffered significant damage.

2. Research Objective and Database as an Information Source

The aim of the research is to conclude how the response of a building in aggregate is influenced by neighboring buildings, considering their interconnection (shared or separate gable walls) and the different or identical arrangement of various parameters.

Following the earthquake, volunteer engineers conducted rapid inspections, leading to a crucial database with over 25,000 damage assessments. This database provides essential data for analyzing building damage and usability. It is based on ArcGIS – a Geographic Information System (GIS), a software tools for collecting, managing, analyzing, and visualizing spatial data, developed by the company Esri (Environmental Systems Research Institute).

3. The First Phase of Systematization

Donji Grad, the observed area, spans 3.50 km² of Zagreb. It is bordered by Ulica Republike Austrije to the west, Ulica Vjekoslava Heinzela to the east, Ilica to the north, and a railway line to the south. This district, consisting of 168 blocks composed of buildings in aggregates [1]: Fig. 1 a). Due to damage reports (2,059 buildings out of 6,396) [2] following the earthquake, nearly 3,000 rapid inspections were conducted in this area: Fig. 1 b). Systematization began with Block 19, as existing data [3] enabled a comparative study. This block includes 35 buildings in aggregate. A total of 58 inspections (41 buildings including those in courtyard) were conducted in this block after the Zagreb earthquake (March 2020), with eight additional inspections following the Petrinja earthquake (December 2020).

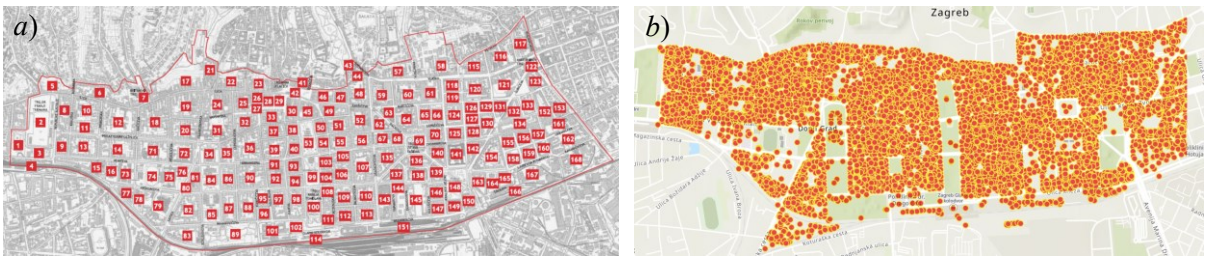

Figure 1. Donji grad a) Block index; b) ArcGIS map showing inspected buildings.

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4. Conclusion

One approach to assessing building vulnerability is the empirical method, which involves analyzing statistical data gathered from damage assessments conducted after earthquake. The goal of this research is to process the collected information (attributes) and adapt it to the available parameters following the methodologies of [4] and [5]. The obtained results will be evaluated based on the criterion of recorded damage.

This paper analyzes the aforementioned parameters and draws conclusions regarding the vulnerability level caused by the same factors. The parameters observed were assigned a certain (different) number of interpolated subcategories: attributes of the structural typology (4), number of storeys (8), height ratio of adjacent buildings (6), floor plan (2) and vertical irregularities (2), height position of the ceiling structure of adjacent buildings (3), and openings arrangement (5). However, the subcategories value is interpolated to compensate those different number for individual attributes. The exception was the typology attribute that was assigned a higher value. The results: Fig. 2 were compared with the position of the building in aggregate (plan interaction classes) and with the detailed inspection conclusions (usability) after the earthquake.

ZGRADA	IME	ULICA	UPORABLJIVOST	POLOŽAJ U BLOKU/NIZU	TIPOLOGIJA	KATNOST	ODNOS VISINA SUSJEDNIH ZGRADA	TLOCRTNA NEPRAVILNOST	VERTIKALNA NEPRAVILNOST	VISINSKI POLOŽAJ STROPNE KONSTRUKCIJE SUSJEDNIH ZGR.	POLOŽAJ I RASPORED OTVORA	ZBROJ OCJENA	PONDIRANA OCJENA
14	Zgrada Zemaljskog …	Dalmatinska 12	PN2	U BLOKU	1,00	0,43	1,00	1,00	0,00	1,00	1,00	5,43	0,84
23	Kuća Rossipal	Medulićeva 3	PN2	U BLOKU	1,00	0,43	1,00	1,00	0,00	0,50	0,75	4,68	0,75
7	Dramsko kaz. Gavella	Frankopanska 10	N1	U BLOKU	1,00	0,29	0,33	1,00	1,00	1,00	1,00	5,62	0,75
6	Kuća Kaufmann	Frankopanska 8	PN2	U BLOKU	1,00	0,29	1,00	1,00	1,00	0,50	0,50	5,29	0,75
1	Kuća Honigsberg	Frankopanska 2 / Ilica 41	PN2	UGLOVNICA	1,00	0,43	1,00	1,00	1,00	0,50	0,00	4,93	0,70
25	Kuća Rath	Ilica 55	N2	U BLOKU	1,00	0,29	0,00	1,00	1,00	1,00	1,00	5,29	0,69
3	Kuća Jeršić	Frankopanska 2b	PN2	U BLOKU	1,00	0,29	0,33	0,00	1,00	1,00	1,00	4,62	0,69
2	Kuća Zimmermann	Frankopanska 2a	PN2	U BLOKU	1,00	0,29	0,67	1,00	1,00	0,50	0,50	4,95	0,69
33	Kuća Pečić s ljekarnom K Svetom	Ilica 43	U2	U BLOKU	1,00	0,43	0,00	1,00	1,00	1,00	0,75	5,18	0,68
8	Kuća Hribar-Penić	Frankopanska 12	U2	U BLOKU	1,00	0,29	0,67	0,00	1,00	0,50	0,75	4,20	0,67
11	Kuća Beniger	Dalmatinska 6	U2	NA KRAJU NIZA	1,00	0,43	0,00	1,00	0,00	1,00	1,00	4,43	0,66
12	Kuća Kosirnik	Dalmatinska 8	U2	U BLOKU	1,00	0,43	0,67	1,00	0,00	0,50	0,50	4,10	0,66
35	Kuća Friedmann – Švarc	Ilica 41a	U2	U BLOKU	1,00	0,43	0,67	0,00	1,00	0,50	0,50	4,10	0,66
24	Kuća Rossipal	Medulićeva 1 / Ilica 57	N2	UGLOVNICA	1,00	0,29	0,00	1,00	1,00	1,00	0,75	5,04	0,65
34	Radionica i skladište božićnog nakita	Ilica 43/1 (dvorište)	U2	NA KRAJU NIZA	1,00	0,29	0,00	1,00	0,00	1,00	1,00	4,29	0,63
19	Kuće Grahor	Medulićeva 11–13	PN1	U BLOKU	1,00	0,29	0,67	1,00	0,00	0,50	0,50	3,95	0,63
4	Kuća Schneider	Frankopanska 4	U2	U BLOKU	1,00	0,29	0,00	1,00	1,00	0,50	0,75	4,54	0,61
5	Kuća Uhrl	Frankopanska 6	N1	U BLOKU	1,00	0,29	0,00	1,00	1,00	0,50	0,75	4,54	0,61
9	Kuća Pavelić	Frankopanska 14 / Dalmatinska 2	PN2	UGLOVNICA	1,00	0,43	0,00	1,00	1,00	0,50	0,50	4,43	0,60
16	Kuća Pettko	Dalmatinska 14	U1	U BLOKU	1,00	0,43	0,33	1,00	0,00	0,50	0,50	3,76	0,60
20	Kuća Deutsch	Medulićeva 9	PN2	U BLOKU	1,00	0,43	0,33	1,00	0,00	0,50	0,50	3,76	0,60
10	El.strojarska radionica	Dalmatinska 4	0	NA KRAJU NIZA	1,00	0,00	0,33	0,00	0,00	1,00	1,00	3,33	0,58
32	Hotel »Park 45« (danas)	Ilica 45	0	U BLOKU	1,00	0,29	0,00	1,00	1,00	0,50	0,50	4,29	0,57
17	Kuća Smodek	Dalmatinska 16	U2	U BLOKU	1,00	0,43	1,00	0,00	0,00	0,00	0,00	2,43	0,54
26	Svjetlotiskarski zavod Rudolfa Mosingera	Ilica 55/3 (dvorište)	PN1	DVORIŠNA ZGRADA U BLOKU S ANEKSIMA	1,00	0,14	0,33	1,00	1,00	0,00	0,25	3,73	0,52
18	Kuća Grahor	Dalmatinska 18	PN1	UGLOVNICA	1,00	0,43	0,33	1,00	0,00	0,00	0,25	3,01	0,51
13	Kuća Spevec	Dalmatinska 10	PN2	U BLOKU	1,00	0,29	0,33	0,00	0,00	0,50	0,50	2,62	0,51
27	Kuća Honigsberg	Ilica 51–53–53a	PN2	U BLOKU	1,00	0,29	0,33	1,00	1,00	0,00	0,00	3,62	0,51
22	Kuća Šašel	Medulićeva 5	U2	U BLOKU	1,00	0,29	0,33	1,00	0,00	0,00	0,25	2,87	0,49
29	Matica hrvatskih obrtnika	Ilica 49	U2	U BLOKU	0,00	1,00	0,33	1,00	1,00	0,50	0,50	4,33	0,48
31	Kuća Vulaković	Ilica 47/2 (dvorišna zgrada)	PN1	U BLOKU	1,00	0,43	0,00	1,00	1,00	0,00	0,00	3,43	0,48
30	Kuća Angerer	Ilica 47	N2	U BLOKU	1,00	0,29	0,00	1,00	1,00	0,00	0,00	3,29	0,45
8a	Tiskara - Studij dizajna	Frankopanska 12 (dvorište)		U BLOKU	1,00	0,29	0,33	1,00	0,00	0,00	0,00	2,62	0,45
21	Kuća Balaško	Medulićeva 7	PN2	U BLOKU	1,00	0,29	0,33	0,00	0,00	0,00	0,00	1,62	0,39

Figure 2. Block 19 buildings ranking following analysis.

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