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A SURVEY OF SUBJECTIVE OPINIONS OF POPULATION ABOUT SEISMIC RESISTANCE OF RESIDENTIAL BUILDINGS

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Abstract: The unpredictability and the seriousness of the potential earthquake consequences for people and residential buildings in Serbia imply the need for improving the resilience of local communities. The paper presents the results of a quantitative research regarding the level and factors of influence on the awareness of citizens about the seismic resistance of their residential buildings to earthquake consequences. Multiple-point random sampling was used to survey 1,018 citizens (face to face) during 2017 in 8 local communities: Kraljevo, Lazarevac, Jagodina, Mionica, Prijepolje, Vranje, Lapovo and Kopaonik. The questionnaire consisted of two segments: questions on demographic, socio-economic and psychological characteristics of respondents and questions regarding resistance of residential buildings to earthquake consequences. The results show that 35% of respondents state that they live in residential buildings that are not resistant to earthquakes, while 70.7% state that they live in buildings built of reinforced concrete, which are considered safe. Beside that 9.2% of respondents examined the resistance of their facilities to earthquake consequences. Inferential statistical analyses show that men to a greater extent than women state that their buildings are resistant to earthquake consequences. Starting from the multidimensionality of citizen vulnerability to earthquakes, it is necessary to conduct additional studies and further elucidate the sociological dimension of vulnerability and resilience.

Keywords: earthquake, survey, resistance, attitudes, buildings

Introduction

Earthquakes that represent a sudden rupture process in the Earth's crust or mantle caused by tectonic stress produce unimaginable consequences for humans and their material goods (Kanamori, 1994). According to EM-DAT in the period between 1900 and 2013, the largest number of earthquakes occurred in Asia (54.71%), then America (21.74%), Europe (12.97%), Africa (6.38%) and finally Oceania (4.20%). On the other hand, Serbia belongs to the area of moderate seismic activity and during the period from 1956 to 2009, 7,407 earthquakes were registered with an intensity of IV on the MCS-64 scale, 284 earthquakes had an intensity of V, 115 earthquakes had an intensity of VI, 20

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earthquakes had an intensity of VII and 4 earthquakes had an intensity of VIII on the MCS-64 scale (Abolmasov, Jovanovski, Ferić, & Mihalić, 2011). Severe earthquakes were recorded in Rudnik, Lazarevac, Juhor, Krupanj, Svetozarevo, Vranje, Vitina and after 1970, three moderate quakes in Kopaonik, Mionica and Trstenik (Marović et al., 2002). Due to the impossibility of accurate forecasting the occurrence and the intensity of earthquakes, the citizens need to improve their resilience to such events. According to the International Strategy of Disaster Risk Reduction (United Nations, 2004), resilience is the ability of a system, community or society exposed to hazards to resist, absorb, respond to the consequences of hazards in a timely and effective manner and to recover from it, including preserving and restoring its essential basic structures and functions. On the other hand, resistance is the ability of materials to return to their original shape after bending. In order to increase earthquake resilience, it is necessary to assess the risks, that is, the likelihood of the occurrence and the consequences of earthquakes in different parts of Serbia; to examine the ability of the built environment and human systems to resist to negative impacts; to define interventions in order to improve and reach the desired level of resistance; to develop mechanisms for gathering and cooperation of decision-makers and disaster experts (Petak, 2002). The first building regulations in seismically endangered areas were made in 1964 after the earthquake in Skopje that occurred in 1963. After that, a Rulebook on technical norms for the construction of high-rise buildings in seismic areas (Official Gazette of the SFRJ, 31/1981, 49/1982, 29/1983, 21/1988, 52/1990) was adopted, defining technical norms for the construction of high-rise buildings in the seismic areas of VII, VIII and IX degrees of seismicity according to the MCS scale. According to the rulebook, high-rise buildings were classified into the following categories: outside any category, I, II, III and IV.

Resilience of local communities to disasters is the basic precondition for mitigation, planning and recovery from such events (Paton & Johnston, 2001; Rose, 2004). Thereby, a major challenge for researchers is to measure the level of resilience to certain disasters (Paton & Johnston, 2001; Cvetković, 2017). A large number of previous studies emphasized that most of the consequences were directly related to unsafe, that is, inadequately designed structures (Alexander, 1993; Coburn & Spence, 2003). For example, although Turkey has a large number of seismic building design regulations, which are predominantly of lower or middle size, a large number has not been built up respecting the mentioned standards (Korkmaz, 2009). Also, Iranian school facilities have shown weak performance throughout past earthquakes (Azizi-Bondarabadi, Mendes, Lourenço, & Sadeghi, 2016). A lot of research have been carried out about the damage analysis of building structures under repeated ground motions

(Meroni et al., 2017; Kojima & Takewaki, 2016; Sharma, Deng & Noguez, 2016; García-Torres, Kahhat, & Santa-Cruz, 2017).

Research shows that building owners would not face such serious consequences of earthquakes that they complied with construction regulations in seismic areas (Irtem, Turker, & Hasgul, 2007; Wenk, Lacave, & Peter, 1998). In accordance with the high level of vulnerability of buildings to earthquakes in Turkey, a large number of citizens took concrete structural measures to reinforce the existing structures of the facilities they live in. On the other hand, many damaged or demolished buildings have been reconstructed or constructed in accordance with the standards of improved seismic resistance (Korkmaz, 2009). Maqsood et al. (2016) highlighted that the vulnerability of buildings implies a relationship between the loss (Damage Index) caused by earthquakes and a measure of the ground motion intensity. Citizens who are at a low socio-economic level represent a particularly vulnerable category of people who tend to build in seismic areas or to ignore construction regulations (Paul, 2011). Bruneau et al. (2003) developed a conceptual framework for the seismic resistance of a local community that includes quantitative measurements focused on four dimensions, such as technical, organizational, social and economic.

Methodology of research

For the purpose of the research, a survey was conducted using the strategy of surveying in households. Using multiple random sampling, local communities were determined where the survey was conducted: Kraljevo (330 — 34.4%), Lazarevac (190 — 19.8%), Jagodina (150 — 15.6%), Mionica (50 — 5.2%), Vranje (80 — 8.3%), Prijepolje (100 — 10.4%), Lapovo (60 — 6.2%) and Kopaonik (58 — 6.5%). After determining the parts of the communities in which the survey would be conducted, the streets and households in those parts were selected. On that occasion, the survey was conducted in every other household on the right side from the beginning to the end of the street. In specific households, male and female family members were surveyed according to the principle of the next birthday. By applying the mentioned procedure, 1,018 respondents were interviewed by conducting a personal interview (face to face). Out of the total number of respondents, the sample covered 46.9% of women and 50.1% of men (97% fully completed the interview-based questionnaire). The average age of the respondents is 36 years (minimum 18, maximum 75) and most of the respondents are in the category of younger persons (474 — 46.6%). Most of the respondents (28.9%) have completed secondary education, followed by faculty (19.1%), college (10%) and a few of them have only primary school (1.2%). Married respondents make 45%, widowed (0.4%) and singles (2.9%).

Table 1. Basic demographic and socio-economic characteristics of the respondents (n=1,018)

Varible	Category	Absolute number	%
Gender (n = 1016)	Male	476	46.9
	Female	540	50.1
Age (n = 1018)	18–28	474	46.6
	29–38	90	8.8
	39–48	212	20.8
	49–58	142	13.9
	Above 59	100	9.8
Education level (n= 644)	Elementary	12	1.9
	Secondary	294	45.7
	College	102	15.8
	Faculty	194	30.1
	Postgraduate	42	6.5
Marital status (n= 786)	Single	294	37.4
	Married	458	58.3
	Divorced	30	3.8
	Widowed	4	0.5
House/apartment ownership (n=1,014)	Personal	302	29.8
	Family member's	622	61.3
	Rented	90	8.9
Employment status (n=1,014)	Employed	442	43,4
	Unemployed	572	56,2
Monthly household income (RSD) (n=968)	Up to 25,000	152	15.7
	Up to 50,000	304	31.4
	Up to 75,000	382	39.5
	Up to 90,000	130	13.4

* 1 US Dollar = 115.90 RSD (The World's Trusted Currency Authority retrieved on 30/01/2017)

The largest number of respondents are unemployed (56.2%) and respondents with household income above RSD 75,000 (37.5%). The highest number of respondents (61.1%) live in the home/apartment owned by family member, followed by personal ownership (29.7%) and rented (8.8%) (Table 1).

Results and discussion

Perception of houses resistance

People's perception of the resistance of their houses plays a decisive role in taking preventive measures to mitigate consequences of earthquakes. Thereby, perception is the cognitive function of the process of seeking, receiving, selecting and processing various irritations that affect the human senses and their nervous system. Perception is not a simple process, but a large number of factors affect it (Slovic & Weber, 2002). It is very important for people to be familiar with the seismic risks of the area in which their house is located, the quality and the resistance of the structure, the safe places within the building. Citizens' preparedness for earthquakes is conditioned by correct perceptions (Slovic, 1993) and an adequate level of familiarity with risks (Slovic, Fischhoff, & Lichtenstein, 1980).

In order to determine the perception of the respondents about the resistance of their houses, they were asked whether they consider their houses resistant to earth tremors. According to the obtained results, the majority of respondents (38.3%) believe that their houses are neither resistant nor non-resistant (Figure 1). Observed on Likert's five-step scale, the recorded mean value of the houses resistance is 3.20, of which 20% of respondents point out that their houses are absolutely resistant to the earthquake consequences, while only 8.6% state that their houses are absolutely frail. The obtained results indicate that majority of respondents are not sure about the resistance of their houses and this represents a real situation. It can be assumed that a large number of citizens do not even think about the impact of earthquakes on their facilities. The reasons for the low level of awareness among citizens about the necessity of knowing the resistance of their facilities should be sought in not so much represented stronger earthquakes in the territory of Serbia. However, the earthquake that occurred in Kraljevo in 2010 caused serious consequences when the couple died in Grdica because of the demolition of the roof of the family house.

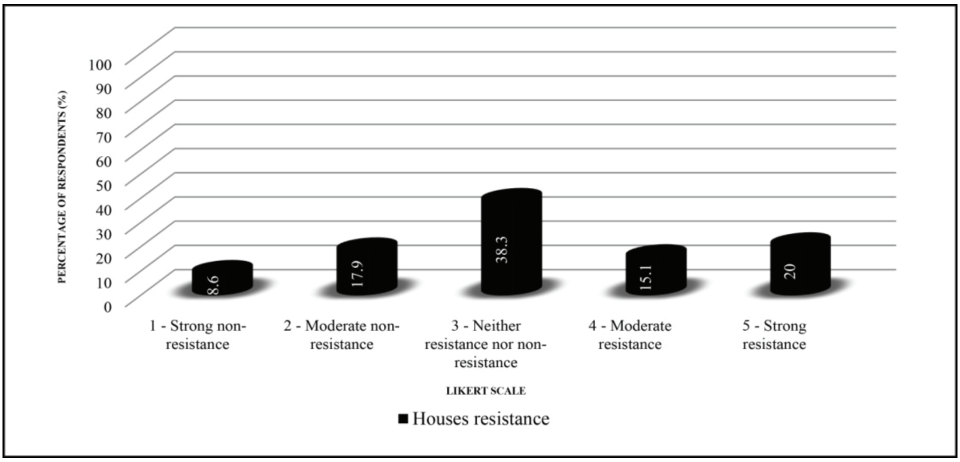

Figure 1. Percentage of respondents about houses resistance

The perception of people about the resistance of their houses to the consequences of earthquakes can be influenced by various factors. The results of inferential statistical analyses show that certain groups state to higher degree that their houses are resistant to earthquakes: men (37%) than women (30%); the younger (38.9%) than the elderly (8.4%); citizens with secondary school (23.8%) compared to citizens with primary school (15%); the widowed (50%) compared to citizens who are single (30%); citizens living in a house owned by a family member (29.6%) compared to those living in a house that is their personal property (21.2%); the unemployed (39.7%) compared to the employed (9.9%); citizens with low incomes (39.8%) compared to those with high incomes (27.7%) (Table 2).

Table 2. Cross–tabulation of houses resistance perception

Variables	**Houses resistance perception**	
	Value	p
Gender	9.7	.046*
Age	263.2	.000*
Education level	132.5	.000*
Marital status	146.8	.000*
Ownership of house	90.6	.000*
Employment status	114.1	.000*
Households income	76.5	.000*

*Significant correlation from chi–square test

Men compared to women in Serbia traditionally perform harder physical jobs, including the construction of various residential buildings. It can be assumed that this also affects their better understanding of the resistance of certain constructed structures. Also, the paper found that younger respondents, followed by those with secondary education, live in houses owned by family members, the unemployed and those with low incomes recorded a higher level of resistance of their housing units. When it comes to the age of the respondents, it can be assumed that the younger respondents are more confident or insufficiently informed and accordingly they emphasize that their facilities are resistant. On the other hand, the unemployed and respondents with low incomes are too preoccupied with everyday existential problems, and they do not even think about it. Certainly, the above premises are also recommendations for future research that should be carried out in order to better understand the factors that influence the awareness of citizens about the resistance of their buildings.

Testing houses resistance

The unpredictability of the earthquake and its severe and devastating consequences can be prevented only by compliance with the regulations on the construction of aseismically resistant buildings. Regardless of the significance of such measures, a certain number of citizens, in order to reduce the construction costs, do not comply with the envisaged standards. Therefore, in order to improve the safety of citizens, it is necessary, within each household, to examine the resistance of the residential building and, in accordance with the factual state, to reinforce it or to reconstruct it. There are many reasons why people are not interested in raising resistance of their houses to earthquakes: they underestimate the likelihood of occurrence, they believe that this will not happen to them, there are budget constraints, they do not want to change their behavior, etc. (Kunreuther, 2006). In order to determine the opinions of population about seismic resistance of residential buildings, respondents were asked whether they checked the resistance of their houses. Out of the total number of respondents, only 9.2% tested the resistance of their residential buildings. The above data indicate serious shortcomings in the preparedness of citizens to earthquakes. Thus, the obtained data indicate the need for further research in terms of testing factors that influence on such a low level of testing the resistance. It can be assumed that citizens tend not to check the resistance of their facilities because they think that this will not happen to them, they do not have enough financial resources, they did not think about it at all. In order to examine the aforementioned premises, it is necessary to carry out further research to examine the reasons or the barriers of non-checking the resistance of their objects.

Table 3. Cross–tabulation of testing house resistance

Variables	Testing house resistance	
	Value	p
Gender	15.3	.000*
Age	39.8	.000*
Education level	15.2	.004*
Marital status	41.9	.000*
Ownership of house	13.5	.001*
Employment status	3.5	.060
Households income	18.9	.000*

*Significant correlation from chi–square test

The results of Chi square statistical analyzes show that certain groups are more likely to check whether the house is resistant to the consequences of the earthquake: women (12.6%) compared to men (5.5%); younger citizens (14.8%) compared to the elderly (0.5%); university-educated citizens (14.4%) compared to those with elementary school (0.3%); citizens who are in a relationship (17.7%) compared to those who are divorced (1.2%); citizens living in an object owned by a family member (11.9%) compared to those living in their own house (4.6%); the unemployed (10.8%) compared to the employed (7.2%). Judging from the collected results, respondents such as women, the younger, university-educated, in a relationship, those who live in a family member's house and the unemployed have recorded a higher level of checking the resistance of houses to the consequences of earthquakes. It can be assumed that the mentioned categories of respondents are more cautious about their safety, or more informed on the consequences of earthquakes to the constructed structures. Surely, further research needs to be carried out to examine in more detail the factors influencing the decision-making on testing the seismic resistance of residential buildings (Table 3).

Reinforced houses

The existence of awareness among citizens about the necessity of testing the resistance of their residential buildings to the consequences of earthquakes is a prerequisite for their reinforcement. Reinforcement of the building can greatly influence the reduction of the risks of such events (Takewaki, Moustafa, & Fujita, 2012). Although it is impossible to predict in a timely manner where the next earthquake will occur, scientists around the world are developing constructive solutions to mitigate the tremors of buildings. Air Dashin Systems has designed a system that is built on existing houses that allow the construction to rise when the ground is shaken. Very simply, seismic sensors register a tremor, after which the compressors are activated which, in less than one second, raise the house about 3 centimeters, allowing it to levitate above the earthquakes (Rikhari, 2015). In addition to such a system, there are many other systems, such as sliding of the house on steel bearings that reduce the impact of horizontal forces and reduce damage to the building. The significance of reinforcing the construction in seismically endangered areas is also indicated by the fact that during the earthquake in 1999 in Turkey, almost 50% of the buildings were seriously damaged. However, with the appropriate interventions of the relevant construction services, structural reconstructions have been undertaken in order to improve their resistance (Donmez & Pujol, 2005). According to Turnić (2009), when designing seismically resistant buildings, consideration should be given to: selection of materials to make the constructions firm and deformable; necessity of providing more vertical stiffening's; influence of types of ground and foundation on the building; elements necessary for the good behavior of the structure: simplicity, symmetry, sufficient stiffness, etc. In doing so, the respondents were asked to answer whether they live in reinforced housing. The results show that 70.7% of the respondents live in such facilities, while 29.3% do not. Of course, the question may arise as to whether their reinforcements are adequate, seen from the perspective of impartial expert and engineering assessments. Apart from their statements, experts did not check the housing units using the method of direct observation, whose findings would be more relevant. Recommendation for future research would refer to conducting research with taking pictures of housing units, included by random sample method, and on that occasion assessing their real resistance. This would undoubtedly determine the difference between subjective and objective perceptions of building resistance.

Table 4. Cross–tabulation of reinforced houses

Variables	**Reinforced houses**	
	Value	p
Gender	20.4	.000*
Age	56.5	.000*
Education level	44.5	.000*
Marital status	34.1	.000*
Ownership of house	93.9	.000*
Employment status	16.6	.000*
Households income	4.8	.185

*Significant correlation from chi–square test

The results of Chi square statistical analyzes show that certain groups have reinforced their houses to the consequences of earthquakes to higher degree: women (77%) compared to men (64%); younger citizens (86.7%) compared to the elderly (44%); citizens with post-graduate studies (95.2%) compared to those with secondary education (56.8%); citizens who are single (76.9%) compared to the widowed (50%); citizens living in a house owned by a family member (81.6%); the employed (77.4%) compared to the unemployed (65.6%); citizens with a higher level of incomes (78.5%) compared to those with lower incomes (68%) (Table 4). According to the obtained results, the respondents of the following characteristics: women, with postgraduate studies, single, living in a house owned by a family member, the employed and with higher incomes indicate to a greater extent that they have reinforced their housing structures in order to mitigate the consequences of earthquakes. It can be assumed that women and respondents with post-graduate studies are more informed about the necessity of reinforcing the structures, while on the other hand it can be assumed that respondents who are employed and have a higher level of incomes are more relaxed relating to their budget constraints.

Conclusion

Due to experiences with devastating earthquakes, people have generally taken all structural and non-structural measures to protect themselves from the negative consequences of such events. In parallel with the development of science that would enable at least some predictions of events and intensities, great urbanization and poor preparedness of citizens for earthquakes, greatly increased the vulnerability of people. A special problem that contributes to the higher level of vulnerability of people to earthquakes concerns also not using aseismic construction standards in order to achieve certain savings or simple failure to comply with the regulations on the necessity of such construction. Although Serbia belongs to the moderate seismic region, the buildings are not predetermined for stronger earthquakes, and it is very important to raise citizens' awareness about it. In addition to the very buildings in which people live, it is important to point out that citizens are most often injured by objects that are hung on the wall or on the ceiling and which, due to tremors, fall on them, causing minor to severe injuries. Starting from the fact that in Serbia there is no evidence of the resistance of all objects to the consequences of earthquakes, the authors tried to indirectly obtain initial empirical data on the perception of resistance of objects, their testing and eventual reinforcement using quantitative research tradition. The results show that only 35% of respondents state that they live in objects that are not resistant to earthquakes, 70.7% state that they live in objects that are reinforced and only 9.2% of the respondents checked the resistance of their buildings. Starting from the fact that almost one third of the respondents pointed out that they lived in unsafe objects, and that only one tenth of the respondents really checked the state of their facilities, it is necessary to immediately influence on decision-makers in Serbia to form independent municipal teams of experts who would visit all households and objectively determine the degree of their resistance. After that, risk maps with potential damage to buildings in the areas of local communities could be developed, which would certainly contribute to raising the awareness of citizens about their possible consequences due to earthquakes. The research results should also be used in the context of creating specific programs for improving the preparedness of citizens for earthquakes in which the possible consequences would be clearly outlined if certain preventive measures are not taken in time. In the following period it is necessary to carry out research which should explain in more detail the nature of the influence of certain factors on the awareness of citizens on the necessity of examining the seismic resistance and the barriers to their improvement.

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