INTERNATIONAL JOURNAL OF TECHNICAL AND NATURAL SCIENCES

A case study – the General Urban Plan of City of Skopje in Context of Seismic Risk

DOI: https://doi.org//10.69648/FNIE9695

International Journal of Natural and Technical Sciences (IJTNS), 2024; 4(2): 33-44

ijtns.ibupress.com

Online ISSN: 2671-3519

Application: 02.11.2024

Revision: 07.12.2024

Acceptance: 17.12.2024

Publication: 31.12.2024

Edip, K. (2024). A Case Study – the General Urban Plan of the City of Skopje in the Context of Seismic Risk. International Journal of Natural and Technical Sciences, 4(2), 33-44.

https://doi.org//10.69648/FNIE9695

Kefajet Edip

Kefajet Edip, PhD

International Balkan University, Skopje, North Macedonia

https://orcid.org/0009-0003-4241-9897

Paper was presented at International Conference of Applied Sciences, Engineering, Mathematics and Architecture (ICASEMA), Skopje, North Macedonia. The author declares no conflicts of interest.

Correspondence concerning this article should be addressed to Kefajet Edip.

Email: k.edip@ibu.edu.mk

Abstract

Skopje and its surrounding areas have developed in a seismically active region. The measures for mitigating seismic risk are classified as structural and non-structural. Application of seismic design codes is the most crucial structural measure for reducing seismic risk. Among non-structural seismic risk mitigation measures, urban planning is recognized as a very important instrument.

To find out the contribution of the urban planning to seismic risk mitigation in Skopje, this study focuses on the General Urban Plan (GUP) prepared for the City of Skopje with plan period of 2012-2022. The content of the GUP is analyzed in context of seismic risk by searching for information which is related to seismicity and measures suggested by the plan to reduce the negative consequences of earthquakes.

Within the plan documentation of GUP there is an annex with seismic hazard maps. Also, in the textual part of the plan there is a section devoted to seismic hazard. However, the guidelines for mitigating the seismic risk are limited to selection of locations based on seismic hazard information, while the vulnerability to seismic risk of the existing urban areas is not considered.

Mitigating seismic risk at urban scale requires multidisciplinary approach. This to be achieved it is required to establish a collaboration between the earthquake engineers, seismologists and urban planners.

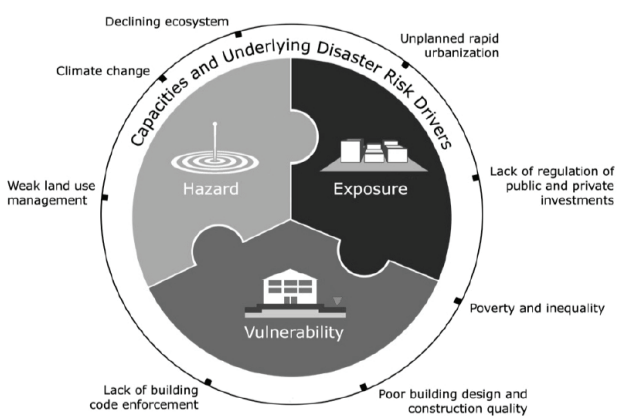
Keywords: GUP of Skopje, seismic hazard, seismic risk, urban planning, seismic risk mitigation

Urban Planning and Seismic Risk

The earthquake is a geophysical phenomenon and cannot be predicted when it will happen; however, the potential seismic hazard with its spatial dimensions can be identified with the seismic microzonation studies. In seismic regions, the seismic microzonation maps are used to have insight into the seismic hazard information, and they can serve as a guide to urban planners in planning and decision making about future urban development areas (Ansal et al., 2009). Earthquakes can have devastating effects on urban environments with high densities of buildings and population, which are vulnerable to seismic risk (Edip & Apostolska, 2024). For urban planning of the existing urban areas, it is important to take into consideration the seismic risk and take actions to mitigate it (Edip, 2023). According to the Sendai Framework for Disaster Risk Reduction, risk (Figure 1) can be defined as the product of the interdependent components of hazard, exposure, and vulnerability (United Nations, 2015). In the context of seismic risk, earthquake represents the hazard component, entities exposed to the earthquake, such as people, buildings, infrastructure, etc., make up the exposure component, and the exposed entities show different levels of susceptibility to damage or loss, which is defined as the vulnerability component (Edip, 2023).

Figure 1

The components of risk.



Source: UNISDR, 2017

Mitigation of seismic risk can be achieved with structural and non-structural measures. While the application of up-to-date seismic design codes in the design and construction of buildings is crucial for the seismic stability of buildings as a structural method, it is important to achieve the seismic stability at the urban scale (Edip & Apostolska, 2024). Recent studies have proven that urban planning can be used as a non-structural seismic risk mitigation tool (Bahrainy & Bakhtiar, 2022). In the Sendai Framework for Disaster Risk Reduction (United Nations, 2015), the importance of including disaster risk assessments in urban planning is emphasized.

Skopje and its broader territory are considered a region with relatively high seismicity. One of the biggest natural catastrophes in the history of Skopje was the 1963 earthquake with a magnitude of 6.2 (Milutinovic et al., 2017). By that time, there were no seismic design codes adopted yet, and buildings were designed and constructed without taking into consideration the seismic forces. The first seismic design codes were introduced in 1964, and the modern seismic design codes were adopted in 1981. In the aftermath of the 1963 earthquake, many buildings were significantly damaged and some collapsed, which caused the death of 1.070 citizens, and more than 3.300 were injured. Because of the damaged housing stock, there were also many homeless people (Milutinovic et al., 2017). While some buildings were heavily damaged and collapsed, some of the extensively damaged buildings, due to safety precautions, were demolished by the city authorities (United Nations, 1970). In 2016, a series of earthquakes shook the territory of Skopje with intensity between VI-VII according to the European Macro-Seismic scale. While minor structural damages and extensive non-structural damages were observed at buildings built before 1963, the buildings constructed according to seismic design codes had almost no structural damages, and non-structural damages were insignificant (IZIIS, 2016). Small intensity earthquakes happen more often, but they do not have much impact on the environment.

Being a city with a long history, the urban tissue of Skopje consists of buildings built in different periods, before and after the introduction of seismic design codes. The presence of buildings constructed without the use of seismic design codes in the urban structure can increase the seismic vulnerability at the urban scale because there is no information about the vulnerability characteristics of such buildings (Edip, 2023).

The Urban Planning System of North Macedonia

The first urban plan for the City of Skopje was prepared back in 1914 by Dimitrije Leko. With this urban plan, the modern history of urban planning of Skopje started, which contained the influences of European urban planning. The earthquake of 1963 greatly influenced the future development of the city. In 1964, a new urban plan was adopted, which was prepared by the United Nations' experts, among whom the leading role was played by urban planners from Greece (Doxiadis Associates), Poland (Polservice), and the UK (Wilbur Smith and Associates) (Stefanovska & Kozelj, 2012).

The 1970s marked the beginning of the establishment of the Spatial Planning Agency. By then, a Directorate for Spatial Planning was formed in Ohrid, followed by the establishment of its Working unit in Skopje in 1973. In 1988, the Directorate of Spatial Planning changed into the Institute for Spatial Planning with its headquarters in Skopje. Between 1991 and 1995, the Institute for Spatial Planning ceased to exist. In 1995, the spatial planning system was re-established under the leadership of the Ministry of Urban Planning, Construction, Transportation, and Ecology, and the Public Enterprise for Spatial and Urban Planning developed the spatial plans. The Agency for Spatial Planning was established as a professional institution in 2005 as a continuation of the Public Enterprise for Spatial and Urban Planning (SPA, 2024).

In North Macedonia, spatial plans are regulated within the Ministry of Living Environment and Spatial Planning, while the urban plans are in the responsibility of the Ministry for Transportation and Communications (Ivanisevic et al., 2021). There is a National planning agency – the Spatial Planning Agency (SPA), which prepares the regional level plans, such as spatial plans, and the city level plans, the General Urban Plans. As a higher-tier plan, the spatial plans define the conditions for urban planning, which give guidelines for the General Urban Plans. The urban planning system of North Macedonia consists of urban plans prepared for different land use governance levels and scales of territories that are subject to urban planning (Official Gazette No. 32/2020).

The urban plans can be categorized into the following five categories (Official Gazette nr 78/2006):

- General Urban Plan
- Detailed Urban Plan

- Urban Plan for Village
- Urban Plan for Rural Area
- Urban Plan for the province and buildings of National importance

The General Urban Plan (GUP) is prepared at the City level in scales 1:10.000, 1:5.000, and 1:2.500 depending on the area of the territory. The zones and land uses within the zones are defined in the GUP. The plan period of the GUP is ten years. Once the plan period is over, a new GUP should be adopted (Official Gazette, No. 32/2020). Currently, for the City of Skopje, the GUP with a plan period of 2012-2022 is still in use because the new GUP with a plan period of 2022-2032 is still in the process of preparation (Edip, 2023). At the municipality level, Detailed Urban Plans (DUP) are prepared for smaller segments of the municipality. Usually, the scale of a DUP is 1:1.000 and 1:500. In the DUP, more detailed information is presented regarding the division of building lots, the urban parameters regarding the buildings, and the density of population. The plan period of the DUP is five years. Urban plans are also prepared for villages and rural areas. Urban Plan for Village is prepared on a scale of 1:2.500 with a plan period of five years. The Urban Plan for the Rural area is prepared on a scale of 1:1.000 and it has a plan period of ten years. For provinces and buildings of National importance, there is a special urban plan with a plan period of ten years, which is prepared on different scales depending on the area of the subject territory (Official Gazette, No. 32/2020).

All of the urban plans in the planning system of North Macedonia consist of textual documentation and plan documentation (graphical part). For a certain territory that is subject to urban planning, the textual documentation contains information about the existing conditions and projections for future developments based on analysis. The plan documentation contains the graphical information prepared in accordance with the planning provisions (Official Gazette, No. 78/2006).

Methodology

This research paper analyzes the seismic risk mitigation measures which are included in urban planning and as a case study is taken the General Urban Plan (GUP) of City of Skopje for plan period of 2012-2022.

In North Macedonia, the importance of spatial and urban planning in seismic risk mitigation was recognized in 1973. Consequently, the seismic zoning and micro zoning maps became part of the spatial plans prepared at the country and regional

levels as well as urban plans prepared for the city level (Milutinovic et al., 2017). According to the urban planning law, data related to natural hazards, among which earthquakes, are mandatorily part of the urban planning documentation (Official Gazette No. 32/2020).

The complete documentation of the General Urban Plan (GUP), taken as a case study, was analyzed to find out what information it contains related to seismic risk. The documentation of the GUP for Skopje with plan period of 2012-2022 consists of four books with textual data, one book with plan drawings (graphical data) and an annex which contains graphical information about the natural hazards present in the territory of Skopje.

The first book consists of general information about the plan (such as historical development of the city, subject of the plan, and methodology of preparation of the plan). Then follows the information about the geographic and geodetic definition of the territory, which is the subject of planning. In chapter 3 of the first book, there is a review of the history of planning and organizing the provision of previous plans (SPA, 2011).

Chapter 4 is dedicated to the natural hazards that have the potential to interfere with the development of the territory subject to planning. Among the natural hazards, the following are considered:

- Geological base (fault lines and tectonic zones) and seismic hazard information
- Climate and microclimate conditions
- Hydrography and hydrology
- Protected zones

Chapter 5 analyses the existing situation in the territory that is subject to planning, where the regions and zones of the city are defined. The dispersion of land use types within the city, demographic analysis of Skopje, and occupancy type "housing" are analyzed in this chapter (SPA, 2011).

In the second documentation book, chapter 5 from the previous book continues with information about other occupancy types, tourism and hospitality, spatial development of the industry, public functions (education, health, culture, governmental institutions), green areas, and sports facilities. Additionally, there is information about the system of spatial centers, economic perspectives, communal infrastructure, and protection of the living environment (SPA, 2011).

The third book also continues with chapter 5 segments, which contain information about cultural heritage and methods of protection and rescue. Chapter 6 refers to the inventory of recorded building stock and infrastructure according to the occupancy types. In chapter 7, there is information regarding the existing heritage, buildings with cultural-historical value, and cultural regions. Chapter 8 contains information about the communal infrastructure (water supply system, wastewater system, transportation system, electrical and telecommunication networks and etc.). In the fourth book, there is an analysis of the previous plan and how much of it has been realized. The problems in the existing plan are analyzed from different perspectives. Chapter 10 makes an analysis of possible improvements in spatial development. In chapter 11, there is a reference to planning conditions defined in the higher-tier plan, the Spatial Plan of the Republic of North Macedonia. The numerical data regarding the urban planning parameters are presented in Chapter 12 (SPA, 2011).

Book 4 of the GUP documentation is organized in two parts: letters sent to and received from different institutions, communal organizations, religious associations, and municipalities. The graphical part of the GUP is presented in Book 5. It consists of the following plans (SPA, 2011):

- Extract of GUP of Skopje for the plan period of 2001-2020, scale 1:10.000 (Figure 2)
- Up-to-date geodetic base of the primary traffic network, scale 1:10.000
- Inventory of recorded building stock and physical infrastructure, scale 1:10.000
- Inventory of recorded communal infrastructure, scale 1:10.000
- Inventory of recorded cultural heritage, buildings with cultural and historical value, and cultural regions in scale 1:25.000

Figure 2

Extract of GUP of Skopje for the plan period of 2001-2020

Source: SPA, 2011a

Results

The first book of GUP chapter 4, which is dedicated to natural hazards that influence the territorial development of the plan, contains broad information about natural hazards, including geological hazards such as earthquakes. The geological base, the fault lines and the tectonic zones, and overall the seismic hazard information are considered in the first book in chapter 4.

In this chapter, the planners are also given directions about the suitability of the terrain for the development of urban settlements. The suitability of the terrain is classified into the following four categories:

- Optimally suitable terrain: mainly consisting of rocks with a slope less than 5°
- Suitable terrain: stable terrain made up of stone and rocks with a slope of less than 10°
- Conditionally suitable terrain: made up of consolidated and connected rocks with a slope less than 10°

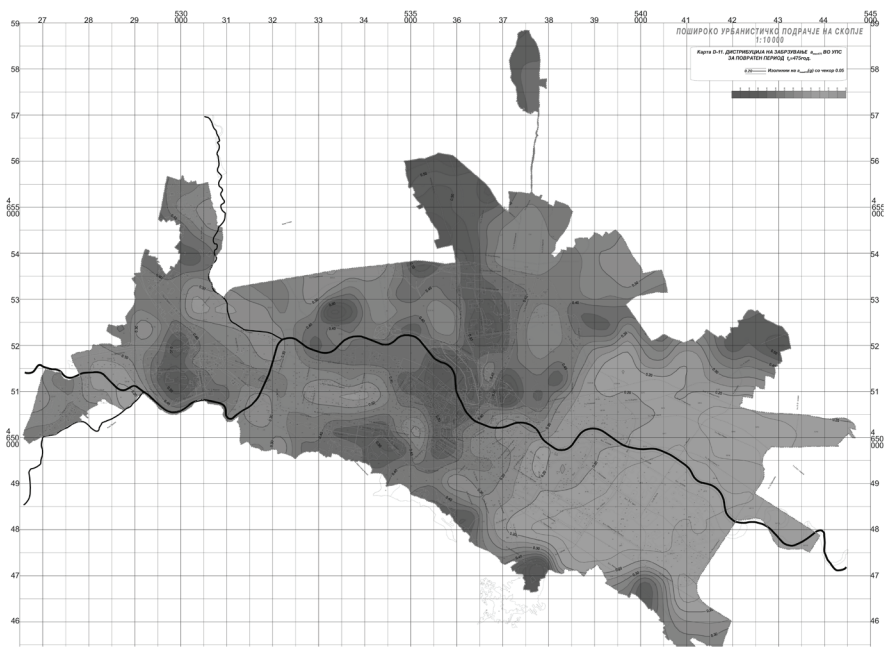
- Unsuitable terrain: unstable, made up of unconsolidated and weakly connected sediments, surface slope bigger than 10°

The suitability of the terrain is presented in the form of a map in the annex, and the areas are identified according to the category of the terrain suitability for urban development.

The annex part of the GUP also contains seismic hazard maps prepared for different intensities of earthquakes represented with return periods, such as 95,145, 475, 975, and 2475 years. The seismic hazard presenting the peak ground acceleration for a return period of 475 years for the territory of Skopje is presented in Figure 3.

Figure 3

Seismic hazard map showing the peak ground acceleration for return period of 475 years



Source: SPA, 2011b.

In chapter 4 there is data obtained from analysis of the local amplification of sites. The amplification of the soil influences the transmission of seismic movements; accordingly, in urban planning, it is important to consider the amplitude parameters of the movement of the soil based on the typology of the soil (SPA, 2011).

In this section guidelines provided for planning are as follows:

- Selection of the location for different occupancy type of buildings depending on their importance to function on regular days as well as in crisis
- For the buildings which contain technological processes and may pose ecological danger for the area in the short and long term, the location should be selected with special attention.
- Buildings of special importance in case of a devastating earthquake and buildings which provide a lifeline to the region should be correctly planned and situated to be safe and accessible
- The depth of foundations should be carefully chosen to reduce the peak ground acceleration of the soil.
- The shallow layer of deposit which causes high amplification should be removed to reduce the peak ground acceleration.
- In regions with high values of peak ground acceleration or with high risks the density of buildings and population should be carefully planned.

Discussion

The results obtained by analyzing the content of the GUP of Skopje for plan period of 2012-2022 show that the seismic hazard information is considered both in textual part as well as maps present in the annex part. While the seismic hazard information is very important for urban planning the seismic risk information is required for a comprehensive approach in urban planning. This is especially important for the existing urban areas like the example of Skopje, a city with a very long history where there are buildings built in different periods. The buildings constructed prior to the introduction of the seismic design codes are vulnerable to seismic risk because in their design the seismic forces have not been considered. In order to determine the seismic risk level of an urban area, all the components of risk should be identified and then seismic risk assessment should be conducted. Seismic risk information can be mapped in similar way to the seismic hazard maps and can serve to urban planners for decision making about the future development of the existing urban areas (Edip, 2023). Having a lot of information which should be considered simultaneously requires use of same scale of the graphical maps. Recent research suggests the use of GIS software for urban planning as it provides option to have insight into natural hazard information and urban plans (Bathrellos et al., 2017).

Conclusions

Dealing with natural hazards requires multidisciplinary approach (Menoni, 2020). In order to mitigate seismic risk at urban level it is required to have collaboration between the urban planners, earthquake engineers and seismologists. Seismic risk mitigation measures applied in the urban planning of North Macedonia was analyzed through the case study of GUP for Skopje. The GUP contains all the required information regarding the seismic hazard and provides guidelines to urban planners which are mainly in domain of selecting areas for future urban developments. However, beside the seismic hazard it is important to identify also the other components of risk, the exposure and the vulnerability of the exposed entities. It is crucially important to consider the seismic risk level of the existing urban areas. Seismic risk assessment information can serve to urban planners for decision making which can improve the seismic safety level in urban settlements developed in seismically active regions (Edip, 2023).

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