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THE IMPACT OF NATURAL DISASTERS ON BUILDINGS' ARCHITECTURAL STYLES

VPLIV NARAVNIH NESREČ NA ARHITEKTURNO PODOBO STAVB

Domen Kušar

In spite of endangerment because of natural disasters, especially floods and earthquakes, Ljubljana marsh is still attractive for builders.
Navkljub ogroženosti zaradi naravnih nesreč, zlasti poplav in potresov, je Ljubljansko barje še vedno privlačno za graditelje.

The impact of natural disasters on buildings' architectural styles

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ABSTRACT: Natural disasters have been part of people's lives throughout history. As a discipline that plans people's dwellings and designs their living environment, architecture has managed to cope with natural disasters and their impacts relatively successfully over the millennia. Certain disasters can be expected throughout the world, and the safety measures connected with them are similar. Nonetheless, the geographical conditions linked to natural disasters most influence the architectural style of buildings and the entire urban landscape through various factors. This paper discusses the impact of specific disasters or threats on changes in the architectural style of buildings and settlements. Special emphasis is placed on dangers or disasters that threaten the buildings in the Ljubljana Marsh. This region has long been considered inappropriate for settlement. However, because it is close to Ljubljana, it has attracted settlement, despite demanding a special construction method. The Slovenian architect Jože Plečnik, who designed the Church of St. Michael in Črna Vas in the Ljubljana Marsh, also had to deal with these issues. An analysis of the church shows that Plečnik, who lived in the nearby suburb of Trnovo, was familiar with major threats to settlements in the Ljubljana Marsh and took them into account. Unfortunately, the economic situation did not allow him to protect this building from fire as well.

KEY WORDS: geography, architecture, disasters, threats, Ljubljana Marsh, Plečnik, Slovenia.

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1 Introduction

Although high-quality architecture should take into account the features of the landscape in which it is created, the architecture of the recent past has often rejected this principle. The current globalization trend is also influential, with both positive and negative effects. The expansion of principles for building high-quality, safe buildings is certainly a major modern improvement; unfortunately, the uncritical transfer of foreign models that ignores local natural features has adverse effects.

Construction methods in the past depended on the natural features and conditions in a specific location. Changes in construction design and method were very slow because people resisted innovations out of habit; however, even more often, innovations were hindered by a poor economic situation. Natural disasters, which represented a realistic test of construction quality and adaptation to local conditions, forced people to reflect upon the necessity of changes and introduce new technologies and materials. However, disasters only rarely resulted in direct changes to construction methods; most often, this process was carried out indirectly through social, geographical, economic, and other factors.

Earthquakes, fires, and floods are the disasters that cause the most damage and thus the majority of casualties in Slovenia. This study is limited to the impact of these disasters on architecture in Slovenia. Examples from elsewhere are only cited for illustration. Special emphasis is placed on threats to the Ljubljana Marsh, which is becoming increasingly urbanized due to its vicinity to the Slovenian capital. These threats have resulted in special building requirements that should be observed in construction. The last part of this paper presents a safety analysis of the Church of St. Michael in Črna Vas in the Ljubljana Marsh, which was designed by Jože Plečnik and has been designated a cultural monument. Because this architect designed structures at various locations, this paper examines whether and how he took into account the local features of the Ljubljana Marsh.

2 Method

Architecture is a discipline that proceeds from past experience and present demands, and builds for the future. Its main task is to design exterior and interior space (Košir 2007). The research methods in studying architecture (especially its past) rely on the descriptive and historical method of studying phenomena (Kališnik 2003) because experiments are practically impossible in this discipline. Therefore, the results of this study are presented in a descriptive manner.

The description of disasters and their effects in this paper is based on studies of these phenomena in Slovenia. Thorough analyses of Slovenian earthquakes have been carried out by Sergej Bubnov (1996), Miha Tomaževič (1995a; 1995b), and Renato Vidrih (1995a; 1995b). The description of the impact of fires on architecture is based on the author's doctoral dissertation (Kušar 2005). The impact of floods is described based on the findings of a study (Gams, Kos and Orožen Adamič 1992) presented at a conference on floods in Poljče, Slovenia. Using these descriptions and an analysis of architectural features (here, the word *architecture* denotes only the discipline and not the features of a building, space, or phenomenon), the mutual relationships between individual phenomena are described.

These issues cannot be treated without explaining the concepts of »disaster« and »threat.« The terminology and concepts used in this area have already been defined by several authors, primarily to clarify certain terms and the attitude towards the translations and use of foreign words in Slovenian (Đurović, Mikoš 2008). The *Geografski terminološki slovar* (Dictionary of Geographical Terms; Kladnik et al. 2005) defines a natural disaster as a disaster caused by exceptional natural circumstances, such as earthquakes, landslides, rockfalls, floods, and so on. Because this paper discusses the impact of disasters on a built environment, the concept of disaster must be further defined. The *Standard Slovenian Dictionary* (SSKJ) describes *nesreča* 'disaster' as a state that causes emotional distress, an event in which people are injured or killed, and an event that causes great (usually material) damage to people. It defines *nevarnost* 'threat' as a possibility of a disaster, damage, or anything bad or unpleasant in general (Bajec et al. 1994). Understanding »threat« includes two components: objective and subjective. The objective component refers to the realistic possibility of a disaster and depends on the context in which it appears. Various technical disciplines deal with the objective meaning of threats. The subjective meaning of a threat refers to an individual's feeling of being threatened and thus differs from one individual to the other. The feeling of being threatened is influenced by various factors, such as knowledge of the threat and how to prevent it, the media, past experience, policy, and so on. There is a weak link between the objective and subjective threat. In a situation with the same degree of threat, some individuals are very frightened, whereas others are completely calm (Polič et al. 1994). Because of its mission, architecture deals with both the objective and subjective components of a threat. Objective threats endanger buildings' existence and function, whereas the influence of threats on people's mentality and awareness belongs more to the subjective perception of threat and safety, as well as the willingness to accept urgent changes to the living environment.

3 Examples of the impact of specific threats on architecture

Because of its location and geological structure, Slovenia's landscape is extremely diverse. It is characterized by varied relief, which was additionally shaped by exogenous factors and man. Unfortunately, this diversity also results in many natural processes with frequent harmful effects. Thus Slovenia faces more than 20 different threats (Ogroženost… 2007) and the average annual damage caused by natural disasters exceeds 2% of Slovenia's GDP. The amount of damage in the urban environment does not always depend on the scale of the disaster alone, but also on construction methods, location, and people's reactions. The threats presented in this paper (i. e., fire, earthquakes, floods, and wind) are frequent, and through history they have (both individually and jointly) altered the architectural styles of Slovenian towns and villages through various factors.

3.1 Fire

Fire is a disaster that is not always caused by a natural phenomenon. It is natural only if it is caused by lightning or some other natural process. Every year, several dozen buildings in Slovenia are affected by fire caused by lightning. In 1997, there were 65 fires of this sort (3.8% of all fires; Šipec 1998: 50). Their share in the total damage caused by fires is small (a few percent), but nonetheless the damage can be great; in Slovenia, fires represent the greatest threat to settlements with regard to the annual damage to buildings. Around 1,400 fires in Slovenia annually cause approximately €7 million in damage (Šipec 1995; Šipec 1996; Šipec 1998). It is assumed that in the past this damage was much greater because of the construction methods; therefore, the process of converting wooden buildings into fireproof buildings is briefly presented below. This process has also been strongly influenced by local, geographical, and other features.

After the collapse of the Roman Empire, timber was the primary building material for settlements in Slovenia. As a building material, timber has a number of positive properties: its basic processing does not require much expertise, skill, or many tools. Up to the 7th century, forests predominated in hilly areas, which represented a good source of timber. Later colonization reduced the forest area, but in Slovenia this reduction represented only 20% of the entire territory at most (Valenčič 1970). In Slovenia, stone or brick construction has been preserved only in the Karst region and the Koper coastal region. Wooden or straw roofing predominated. Because of the combustibility of timber, buildings or even entire settlements frequently caught fire. Today such fires are practically impossible thanks to developments in lighting and heating technology and the use of less flammable building materials.

From very early on, people sought to solve the problem of fires in various ways. Some have been recorded in the statutes of medieval towns. The main efforts of this early period were directed towards preventing the outbreak of fire and therefore people that violated these rules were severely punished (Božič 1988).

The most advanced legal regulations on fire safety were the fire safety rules and later building codes. Towns used them to regulate building construction methods; in addition, they defined the building material (especially roofing material) to be used, as well as how to warn people of fires and fight them. One important goal of these rules was to replace combustible materials with fireproof materials. At first, heating devices had to conform to these rules and, later on, entire buildings as well. A regulation from 1524 thus forbids erecting wooden buildings in Ljubljana (Božič 1988). Because towns were more densely built up, their regulations were considerably stricter than the rules relating to rural settlements.

Despite all the good intentions, regulations were implemented relatively slowly. Only the wealthy could afford to replace their roofing or heating devices, although in some places the government provided financial support for this. The share of wooden houses was largest in poor areas without a tradition of stone construction; in 1825, more than 75% buildings were made of wood in some parts of Lower Carniola. The situation was similar in the Kozje region, in Prlekija, and around Slovenj Gradec. In contrast, more than three-quarters of houses in the Postojna area, the Vipava Valley, Karst, and to some extent also in central Slovenia were made of stone or brick at that time (Vilfan 1970).

Climate also affects the number of fires. An overview of major fires in Slovenian towns shows an increasing number of fires (Krajevni leksikon Dravske banovine 1937) during the cold period from the 16th to the 19th century, also known as the »Little Ice Age.« In this case it is difficult to define whether this was a natural disaster or not. The majority of fires were sparked by heating devices as a result of carelessness or mistakes. On the other hand, the longer usage of heating devices and thus greater probability of fire was a result of a natural process – that is, longer winters and colder years. At the end of the 19th century, the number of fires decreased significantly, most likely due to changes in construction methods and the warmer climate.

In addition to fire safety reasons, the wider use of brick houses resulted from a shortage-driven increase in the price of timber. Forests were cut down because the population was growing and along with it the need for arable land. In Slovenia, the greatest deforestation resulting from colonization took place from the 10th to the end of the 14th century. At that time, the forest area was reduced by nearly a half of its initial size (Anko 1987). The advancement of mining and ore processing demanded increasingly more timber for the mines and as a source of heat in various technological processes (e. g., foundries). The authorities (both state and provincial) started reacting to the lack of timber and increased prices by imposing forest regulations. Priority for the use of timber was given to the mines and state facilities (Anko 1987).

Despite the fact that today Slovenia is one of the most forested European countries (Areas … 2007), only two percent of Slovenia's houses are made of wood because of the several centuries of fire safety measures described above. Due to the afforestation of the cultural landscape (Kobler 2001), the danger of fires spreading from the natural to the urban environment is of current concern. Such cases occur more frequently elsewhere around the world (e. g., in California and Australia), whereas in Slovenia this is most typical of the Karst region. The situation in Karst is the result of planned planting of pine trees in the karst common land in the past and today's afforestation of meadows. In unfavorable weather conditions (i. e., strong winds), a fire that breaks out in the natural environment can spread very quickly and endanger settlements. In 2003 for example, a fire threatened Klariči and Sela na Krasu (Muhič 2005). Only carefully maintained firebreaks can prevent fires from spreading.

3.2 Earthquake

Slovenia is in the Mediterranean-Himalayan seismic belt and belongs to one of the world's most earthquakes-threatened areas. Earthquakes are natural processes that affect people frequently and severely. In 18 major earthquakes in the world that took place between 1990 and 1997 alone, 74,000 people died (Largest … 2007). Earthquakes do not directly affect people; the injuries and casualties are the result of destroyed buildings, fires, explosions, uncontrolled leakage of hazardous substances into the environment, floods, and other changes caused by the earthquake. Earthquakes destroy or damage primarily older buildings, although even structures built in line with earthquake safety regulations (Ocena potresne ogroženosti Republike Slovenije … 2007; Polič et al. 1996) can suffer severe damage. Based on historical and geological information, it is possible to predict the frequency of earthquakes and their expected magnitude.

The shaking of the ground during an earthquake loosens the supporting structure to the extent that a building may even collapse. Buildings whose supporting elements are not sufficiently connected are more threatened. The prevention of damage to buildings or their destruction follows the guidelines on earthquake-safe construction; these include specific principles that render buildings safer. Most importantly, the building's center of gravity must be as low as possible; in addition, reinforcing structures are also very important. The most vulnerable parts of buildings are their corners (Figure 1), so stone buildings have corners made of large carved stones (Bubnov 1996). Buildings' adaptation to earthquake threats depended on the building material available, technical expertise, and economic conditions. Given the available resources, people sought to do their best in order to prevent a disaster.

Wooden construction, which is seismically safer than brick or stone construction, prevailed until the 19th century in Slovenia. In the past earthquakes therefore mostly destroyed brick buildings, such as castles and churches. Greater attention to earthquake-safe construction was spurred by the 1896 Ljubljana

Figure 1: Buildings' corners are most critically affected in earthquakes (aftermath of an earthquake in the Upper Soča Valley)

earthquake, when most buildings were built of bricks. Well-constructed and well-renovated buildings survived the earthquakes in the Upper Soča Valley the best (Tomaževič, Klemenc and Lutman 1999).

3.3 Floods

Floods are a frequent disaster in Slovenia, occurring when water flows over the usual riverbeds or banks. Floods usually result from a combination of various unfavorable events; an especially significant one is a large amount of precipitation within a relatively short time. If precipitation falls onto a frozen, impermeable, or saturated surface, the riverbeds fill very quickly. Because they cannot drain the surplus water, the water flows over the river channels. Another example of how floods can occur is when dikes and dams that retain water collapse. In this case, the retained water spreads very quickly, destroying crops, infrastructure, and buildings. If the terrain is on a slope, the water has a steep gradient and therefore great destructive force. In Slovenia, waters in hilly areas cause considerably more damage than, for example, in the Ljubljana Marsh or in the dry karst poljes of Inner Carniola. Floods have also been frequent here in the past (Trontelj 1997). A large part of ancient Celeia (modern Celje) was destroyed by the Savinja River, which also changed its course. The Celje area was also affected by floods in 1550. In 1551, floods occurred in the Radlje Plain, at the Fala Crag, at Lent in Maribor, and in Ptuj. They have also occurred simultaneously throughout Slovenia, such as in 1901. On average, floods affect Slovenia or parts of it every three years (Trontelj 1997). Although floods are frequent in Slovenia, they only threaten about 5% of Slovenia's territory or 25 km^2 of urban areas (Anzeljc et al. 1995).

Floods are primarily natural events, but people can increase or decrease their effect through their own actions. The lack of implementation or partial implementation of protective measures, such as retaining structures and dams, can worsen conditions; this proved to be true in the 1990 flood in Celje (Kos 1992). Settlements were often built near water because of the advantages of such locations, such as easier transport, river crossings, and opportunities to exploit the water for energy. Because of these advantages, people have accepted the risk of floods. Although specific measures (such as retaining structures and dikes) can protect populated areas from the effects of floods today, these measures are usually too expensive. Therefore, the most appropriate method remains the selection of a suitable and safe location; in some places, damage can be reduced by erecting a building without a cellar or in an elevated location (e. g., on a dike).

3.4 Wind

Despite its geographical location and varied relief, Slovenia is not exposed to much wind (Bertalanič 2006); nonetheless, winds occasionally cause damage in Slovenia as well. The most typical strong winds are the bora and the Karawanken foehn. In addition to these two winds, strong winds may occur during local storms. The strongest gusts of wind reach up to 180 km/h and can appear throughout Slovenia (Dolinar).

Wind can be considered a natural disaster when it is unusually strong. Generally, buildings can be damaged by strong wind when the construction materials and technology are inappropriate. Recently, wind has damaged roofs covered with corrugated asbestos-cement roof panels and box-rib or corrugated metal roof panels. Both cases involve lightweight material with a large surface area. If they are not attached appropriately, the wind tears off individual panels. The predictions are that the number and force of storms will increase in Slovenia as well (Kajfež Bogataj 2007); therefore, greater attention will have to be paid to roof construction.

In Slovenia, buildings adapted to wind can be found in areas with strong bora winds There, the north and east sides of buildings have only a few small windows. Large windows are found on the south and west sides. In addition, courtyards are usually located so that the building protects them from the wind. The roofs have small cornices or none at all and are usually covered with brick tiles set in mortar and additionally weighted down with stones. A study on the bora conducted in 1970 and from 1972 to 1973 also showed a connection between the quantity of stones used to weight down the roofs in the Ajdovščina area and the force of bora winds in this area. A comparison of wind force maps and the quantity of stone on roofs demonstrates that the largest amount of stones is found in places with the strongest wind. Because this involves individual areas within the region studied, this is a very specific and notable local adaptation of buildings to natural conditions (Yoshino et al. 1976).

The map showing wind force differs from the map showing average wind velocity, on which the highest values are found in areas with mountain barriers. The average velocity and force are not so significant for construction; what is significant is the expected highest velocity (of gusts) and their strongest force in areas under construction and planned construction areas. In order to define appropriate roof forms and construction, wind maps of Slovenia (produced in line with SIST ENV 1991-2-4) are taken into account. They show that Slovenia is divided into four areas in terms of wind force. The strongest winds are found in the high mountains (wind zone D: up to 40 m/s). This area is followed by the Vipava Valley, the Karst region, and the Koper coastal region, where buildings are threatened by bora winds (wind zone B: up to 30 m/s), and the area between Jesenice and Kranj, where the karst foehn is frequent (wind zone C: up to 30 m/s). The rest of Slovenia is less windy (wind zone A: up to 25 m/s) (O vetrnih razredih … 2008).

4 Natural disaster threats to buildings in the Ljubljana marsh

The Ljubljana Marsh (Figure 2) is a tectonic basin at the junction of the pre-Alpine and Dinaric areas. It is surrounded by the Polhov Gradec Hills to the northwest, Golovec Hill to the northeast, and high Dinaric plateaus to the south. The marsh was created through slow sinking of the ground between Ljubljana, Vrhnika, and Škofljica; this sinking continues at a rate of 1 to 25 mm/year. The ground is sinking the fastest in the Ilovica area. Due to continued active tectonic activity, the southeastern part of the Ljubljana Basin in particular is one of Slovenia's most earthquakes-threatened areas (Gams 1992).

Several streams flow through the Ljubljana Marsh; they have different characters; in the past they have filled this sinking basin with various sediments, and they continue to do so today. In places, the sediment layer is up to 300 meters deep (Šifrer 1984). Argillaceous sediments with intermediate layers of sand predominate. The changes in sedimentation have been influenced by the rate of sinking and the Sava River, gravel from which has blocked the course of the Ljubljanica River several times and caused it to form a lake. In swampy areas in the Ljubljana Marsh, a layer of peat up to 6 meters thick has developed (Melik 1946).

Figure 2: Ljubljana Marsh.

Figure 3: Two-story detached houses predominate in the Ljubljana Marsh.

Although the Ljubljana Marsh is one of Slovenia's richest archeological sites, modern settlement took place relatively late, especially due to the marshy ground unsuitable for farming. Large-scale drainage at the end of the 18th and beginning of the 19th century dried out the Ljubljana Marsh to an extent enabling settlement. The first settlements in the marsh (not on or next to isolated hills or at the edge of the marsh, which had long been settled) were Volar and Ilovica along today's Ig Street (Sln. *Ižanska* cesta, built in 1827) near Ljubljana. Later on the settlements of Rakova Jelša, Galjevica, Karolinški Dvor, Črna Vas, and Lipe arose in the marshy area near Ljubljana. Elsewhere this process was less notable because the majority of new buildings were constructed in villages that had already been built away from the flood zone (Melik 1927; Kušar 1991).

Strong urbanization is taking place in southern Ljubljana and in Črna Vas and Lipe (which are the only settlements entirely in the Ljubljana Marsh). According to our findings, many people moved to this area from elsewhere in Slovenia (and other parts of the former Yugoslavia) after World War II and now live in detached houses (Figure 3). Neighborhoods with multistory apartment buildings sprang up at the edge of the Ljubljana Marsh in the suburbs of Vič and Trnovo; more recently, several apartment buildings have also been built here.

4.1 Adapting buildings to flood risk in the Ljubljana marsh

The three most important watercourses in the Ljubljana Marsh are the Ljubljanica, Iška, and Gradaščica rivers. They have different catchment areas and thus also different characters. The streams of the Ljubljanica rise near Vrhnika and gather in the wide area encompassing the predominantly karst region between Vrhnika, the Bloke Plateau, the Babno Karst Field, Pivka, the Postojna Basin, Hotedršica, and Rovte. Due to the geographical features of its surface, the karst countryside along the Ljubljanica River receives a large amount of precipitation: from 1,600 mm in the Ljubljana Basin to over 3,200 mm on Mount Snežnik. The relative maximum precipitation is in early summer and late fall (Vrhovec 2002). During floods, water builds up in the karst fields, resulting in a delayed but prolonged rise in water in the Ljubljanica. Due to its karst features, the Ljubljanica River carries fine sediments rather than gravel.

The Gradaščica and Iščica (or Ižica) rivers are more subject to flash flooding. Together with the Šujica tributary, the Gradaščica's catchment area in the Polhov Gradec Hills measures around 155 km^2 (Melik 1946). The Gradaščica floods during heavy rain in the hills. Due to steep slopes and an impermeable surface, the water quickly fills the riverbeds in the valleys and causes floods in Ljubljana (cited in Trontelj 1997). According to the locals, there have been times when the Gradaščica has blocked the course of the Ljubljanica River and made it flow back towards Vrhnika. Of all the Ljubljanica's tributaries, the Gradaščica River carries the majority of sediment into the Ljubljana Marsh.

The Iška River rises on the Bloke Plateau and flows through Iška Canyon to reach the Ljubljana Marsh, where it has built up an extensive alluvial fan. Its basin measures around 83 km^2. It contains tributaries only in its upper reach and can even dry out in the Ig alluvial fan in summer. Formerly the river flowed into the Iščica (which rises in the middle of the village of Ig) near Hauptmance, but its course was redirected from Tomišelj downwards through a straight channel into the Ljubljanica River. During heavy rain, the river often rises quickly, creating large floods (Melik 1946). The floods caused by the Iška River cause less damage than the floods caused by the Gradaščica River because the water spreads over the central part of the Ljubljana Marsh, most of which is uninhabited.

In the Ljubljana Marsh a water inflow of around 790 m^3/s can be expected, whereas the runoff through Ljubljana is limited to 600 m^3/s (Godec 2005). The area of frequent floods is the largest in the west between Vrhnika, Borovnica, and Podpeč. Another flood area extends along the Ljubljanica River between Podpeč and Črna Vas. It is interesting that the area immediately adjacent to the Ljubljanica is not as frequently flooded as the area a little further away from the river. The reason for this is probably the fact that the Ljubljanica riverbed has been moved several times. During earthwork, the excavated material was probably deposited along the new or current riverbed and therefore the banks are higher than the surrounding plain. The third area of frequent floods lies in the east between Ljubljana, Ig, and Škofljica, which is practically uninhabited (Figure 4).

During major floods the flooded area is much larger, measuring 8,034 ha (Orožen Adamič 1992). The entire southern part of Ljubljana, as well as the marsh villages of Črna Vas and Lipe, are located here, in Slovenia's largest floodplain.

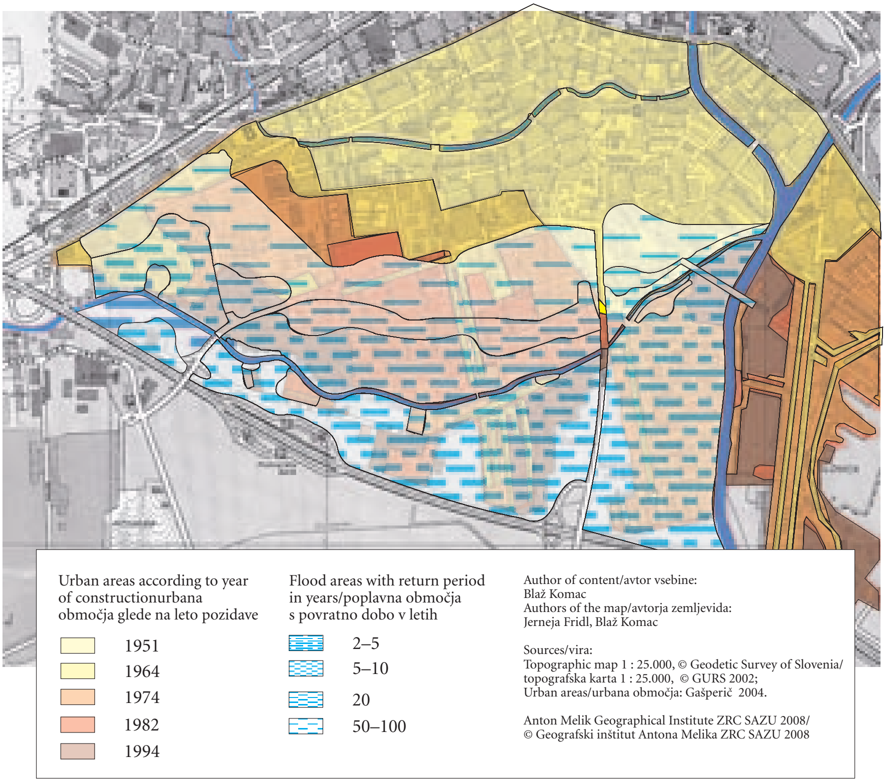

Figure 4: Map of flood threats to the Ljubljana Marsh (Komac, Natek and Zorn 2008).

Those living in the Ljubljana Marsh, especially in Črna Vas and Lipe, have adapted their houses to existing conditions by building them on the embankment above the flooding water. Therefore during floods a building and its courtyard turn into an island surrounded by floodwater. The houses have no cellars. This kind of adaptation is possible because floods in the Ljubljana Marsh (except those caused by the Gradaščica River) are not caused by torrents. Nonetheless, the inhabitants are insufficiently aware of the consequences of floods; this was also shown in a survey conducted in 1983 (Gams, Cunder 1983). Nearly 60% of respondents reported that the floor in their dwellings is less than 20 cm above ground level. The results of this survey indicate that up until that time most people that moved to the area had not yet experienced a flood.

4.2 **Earthquake risk**

The Ljubljana Marsh is an area threatened by earthquakes. In the vicinity of Ljubljana, earthquakes measuring 8 to 9 on the EMS scale can be expected. With magnitude 8 earthquakes, buildings suffer damage such as large cracks in the walls; individual buildings can collapse, and landslides can occur. With magnitude 9 earthquakes, parts of buildings collapse, cracks appear in the ground, and there can be large landslides and slippages (Kušar 2005). The anticipated earthquake intensity in the Ljubljana Marsh is no greater than that of its surroundings, but due to the geological structure of the ground the shock waves here intensify and the soil can even liquefy. Therefore, the anticipated ground acceleration in the marsh is also greater and should be taken into account in building construction (Figure 5). In areas like this, buildings

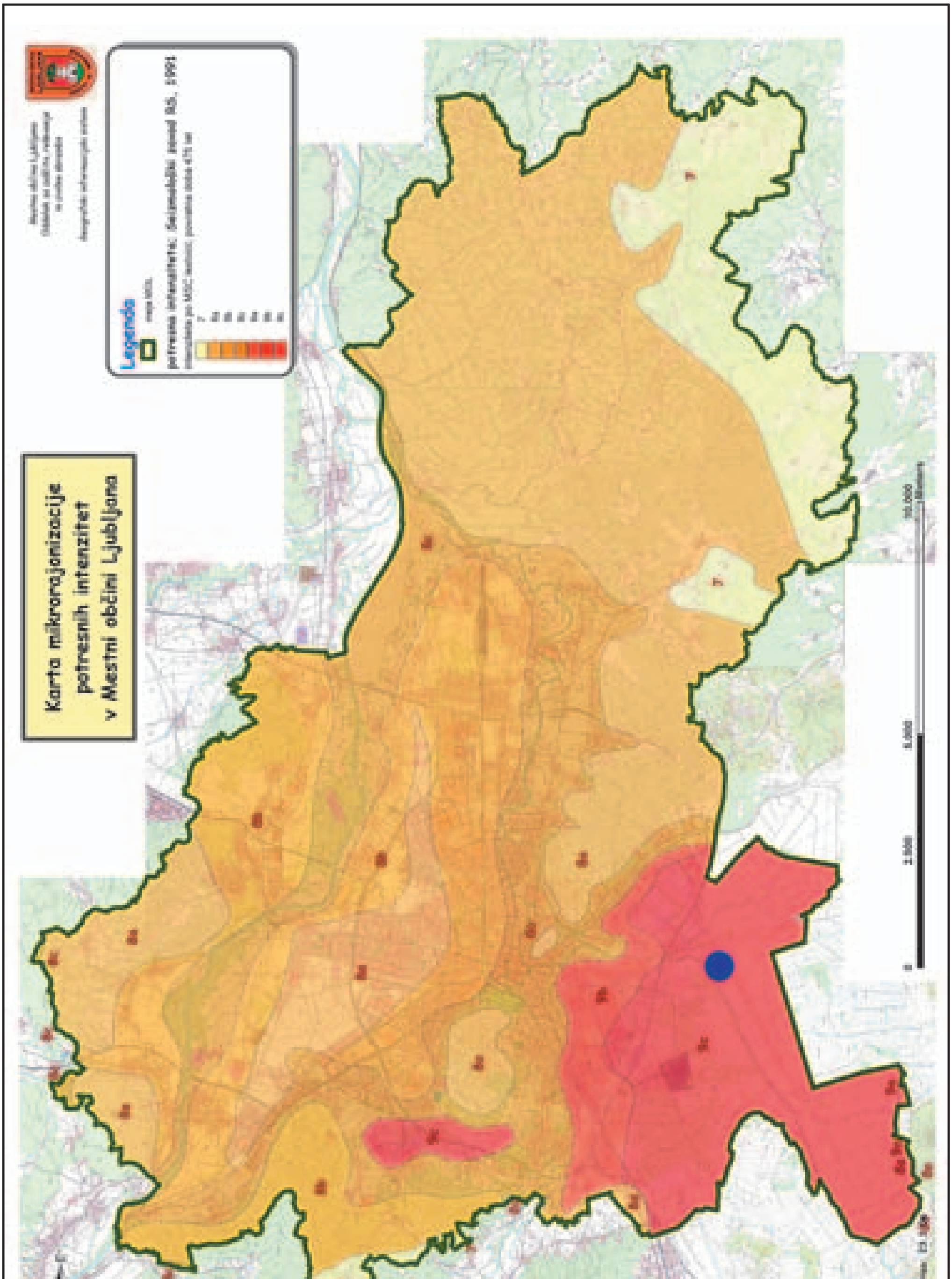

Figure 5: Micro seismic zones in the City of Ljubljana. The church is marked with a blue circle (City of Ljubljana … 2008).

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Figure 6: A sunken and tilted house indicates a lack of knowledge and observation of safe construction principles on marshy ground.

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Figure 7: Example of a compact settlement in Galjevica.

must be as low and light as possible, and solidly built. From very early on, the bearing capacity was increased by driving wooden posts or piles into the soft marshy soil under the buildings' foundations. In the past, these piles were wooden, but today concrete piles are also used. After World War II, many people that were unfamiliar with the principles of building houses on the marsh soil moved to this area. The negative effects of poorly constructed houses not adapted to the environment, which is reflected in the houses' tilting, can be seen especially in area where buildings were erected without the required permits (e. g., around Rakova Jelša) (Figure 6).

4.3 Fire risk

In contrast to other parts of Slovenia, fire risk does not have a significant impact on settlements in the Ljubljana Marsh because the swampy ground, wet meadows, and arable land with its drainage ditches prevent fires from spreading; in addition there is sufficient water for putting out fires. Marsh settlements are usually scattered, with large distances between individual buildings. Consequently, it is practically impossible for the fire to spread from one house to another and cause a large-scale disaster. An exception is new construction from the 20^{th} century in Galjevica, Rakova Jelša, and the southern part of Ig Street; however, the majority of these houses are built of noncombustible materials (Figure 7).

4.4 Winds in the Ljubljana marsh

Because Slovenia is sheltered by the Alps and because its relief is composed mostly of basins and valleys, Slovenia is not exposed to frequent winds. Slovenia has an average of 30–40% calm areas in the lowlands, with the average wind speed of only around 2 m/s (Ogrin 2002). This also applies to the Ljubljana Marsh. As shown by experience to date, stronger winds can only develop during local storms. The strongest gust of wind recorded from 1995 to 2004 by the Ljubljana weather station was 22.0 m/s (Bertalanič 2007).

5 Natural disaster threats to the church of St. Michael

The Church of St. Michael in Črna Vas near Ljubljana (Figure 8) is one of Jože Plečnik's architectural masterpieces. Aside from its artistic and architectural value, this church also reveals a few details from which

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Figure 8: The Church of St. Michael in Črna Vas in the Ljubljana Marsh.

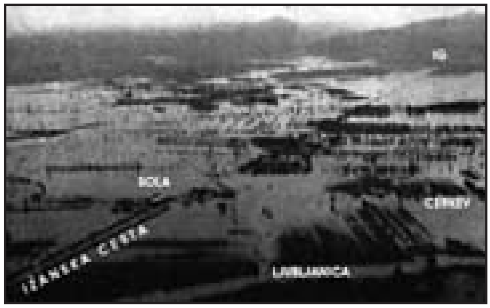

Figure 9: Ljubljanica flooded the Črna vas village also in 1963 (Lah 1965, 115).

one can discern how the architect adapted this building to natural conditions. Construction was begun in 1937. It was consecrated in 1940 and has served as a church since then.

The church stands in an area affected by frequent flooding (Figure 5 and 10). The floods in this area of the marsh are predominantly caused by the Iška and Ljubljanica rivers; in addition, they can also be caused by the springs along the southern edge of the Ljubljana Marsh, which fill the nearby ditches and channels and overflow. The land around the church has been raised, and lies around 50 cm above the surrounding meadows and arable land, which is the first to be submerged during floods. Figure 9 shows the area along Ig Street (Ižanska cesta), approximately 600 meters from the church during floods in the 1920s, when the entire area was submerged.

A further disadvantage of the area is the poor bearing capacity of the ground. This is where the marsh has the deepest sedimentation, with bedrock 117 meters deep. Down to this depth, there are alternating

DOMEN KUŠAR

Figure 10: The outer walls are made of stone and concrete, and the upper part incorporates wood and brick. Part of the monumental staircase is visible to the left, leading up to the liturgical room on the upper floor.

layers of peat, loam, sand, silt, and clay. This type of ground has poor bearing capacity. In order to increase its bearing capacity, wooden piles were driven under the church foundations, extending down to the more stable sand layer (Kušar, Slivnik and Walllner 1997; Wallner 1999; Kušar 2001).

The poor bearing capacity of the ground in this area is also an unfavorable feature in terms of earthquake risks. This is also proven by the map of earthquake threats to Ljubljana, showing that the highest ground accelerations are to be expected in the Ljubljana Marsh (Figure 5).

5.1 Church flood risk

Jože Plečnik avoided floods by building the church on raised land that had been further elevated to raise it above the level of usual floods. Thus the church stands approximately 50 cm above its surroundings. Its ground floor is made of grey Podpeč limestone and concrete (Figure 10). Its bricks and wooden elements, which are less water-resistant, appear higher up. In addition, the material selected and unplastered walls also prevent the capillary rise of water. Alongside this, the main liturgical area is on a floor 4 meters above ground, accessible by a staircase. As a result, the most important room is safe even from exceptional floods (Kušar 2005).

5.2 Church earthquake and wind risk

Jože Plečnik solved the problem of the ground's poor bearing capacity and earthquake risk through an original design and unusual use of construction elements. To make the building as light as possible, he only used solid stone and brick construction on the ground, at the corners, at the entrance, and in the sacristy. The church is built such that the proportion of heavy material, such as stone and brick, decreases with height. He even replaced the solid pillars with hollow sewer pipes. The rest of the church is made of wood. A stone church tower was built next to the church that has several perforations to make it lighter. An analysis shows that the church meets today's criteria for wind loads (Kušar, Slivnik and Walllner 1997; Wallner 1999; Kušar 2001).

5.3 Church fire risk

A fire safety analysis (Kušar 2001) revealed that the building is not fire-safe. The problem lies in the building itself and not in fire spreading from one building to another, which is practically impossible in this area. The poor fire safety condition is a result of the great amount of wood built into the church, the use of fire (i. e., candles), and problematic evacuation when a large number of people are in the church. By introducing additional measures, the building's fire safety could be improved. Similarly, the evacuation time could be shortened as well.

6 Conclusion

Settlements in Slovenia are threatened by various natural disasters. They can often be avoided by selecting the right location and a suitable construction method. Comparing old and new maps shows that in the past people knew where to build their houses to be safe from natural disasters (Komac, Zorn 2005). This behavior and safety principles were transferred through oral tradition, and later also in written form.

First and foremost, buildings are intended to protect their residents and property from destruction. Therefore, they must be adapted to natural conditions and, in places, to potential natural disasters as well. The threats and natural disasters described in this article often changed the style of settlements and thus also the external style of entire regions. Houses in the Upper Soča Valley, also known as »Bovec-style houses,« have steep roofs that prevent large amounts of snow from damaging the roof and roof construction by simply sliding off the roof. Settlements in karst fields were also built where high water cannot flood them.

Awareness of the threats of natural disasters in specific regions and their potential impact on settlements is connected with all of this. Even today one must constantly pay attention to natural conditions and observe the local features and limitations because this is the only way to prevent damage. Unfortunately, in Slovenia this awareness is insufficiently developed, with people counting far too much on state aid. The influence of insurance companies is especially small; they could play an important role and use high premiums to prevent construction in severely threatened areas. In some places abroad, insurance companies are the main drivers of safety adaptations (Oblak 2007).

An analysis of the Church of St. Michael shows that Jože Plečnik's design accounted for the flood and earthquake risks that are most typical of the Ljubljana Marsh. He also adapted the church's architectural design to these risks. Plečnik probably took all of this into account because he lived in the nearby suburb of Trnovo, which also lies in the marsh. On the other hand, this selection of materials made the church unsafe from fire from the perspective of today's criteria.

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Vpliv naravnih nesreč na arhitekturno podobo stavb

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IZVLEČEK: Naravne nesreče spremljajo človeka skozi vso zgodovino. Arhitektura kot panoga, ki se ukvarja z načrtovanjem bivališč oziroma oblikovanjem bivalnega okolja, se je skozi tisočletja bolj ali manj uspešno spopadala z naravnimi nesrečami in njihovimi posledicami. Ne glede na to, da nekatere nesreče lahko pričakujemo povsod po svetu in da so varnostni principi podobni, je vendarle geografska pogojenost naravnih nesreč tista, ki prek različnih dejavnikov v največji meri vpliva na arhitekturno podobo zgradb oziroma celotne urbane krajine. Sestavek skuša pokazati vpliv nekaterih nesreč oziroma nevarnosti na spreminjanje arhitekturne podobe stavb in naselij. Poseben poudarek je na nevarnostih (nesrečah), ki ogrožajo zgradbe na Ljubljanskem barju. Ta pokrajina je imela dolgo sloves neprimerna za bivanje. Zaradi bližine Ljubljane pa je postala zanimiva tudi za poselitev, a zahteva poseben način gradnje. S temi problemi se je moral spoprijeti tudi arhitekt Jože Plečnik, avtor cerkve sv. Mihaela v Črni vasi na Ljubljanskem barju. Analiza cerkve je pokazala, da je Plečnik, ki je stanoval v bližnjem Trnovem, dobro poznal in upošteval glavne nevarnosti, ki ogrožajo naselja na Ljubljanskem barju. Žal pa gospodarske razmere niso omogočale, da bi zgradbo naredil tudi požarno varno.

KLJUČNE BESEDE: geografija, arhitektura, nesreče, nevarnosti, Ljubljansko barje, Plečnik, Slovenija.

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Vsebina

1 Uvod

Kakovostna arhitektura naj bi upoštevala značilnosti pokrajine, v kateri nastane, vendar arhitektura bližnje preteklosti marsikje to zanika. Danes globalizacija vpliva tudi na to področje, kar ima tako dobre kot slabe strani. Širjenje principov gradnje kakovostnih in varnih zgradb je vsekakor ena od večjih pridobitev današnjega časa, žal pa nekritično prenašanje tujih vzorov brez upoštevanja krajevnih naravnih značilnosti pušča nezaželene posledice.

Našim prednikom so način gradnje pogojevale naravne danosti in razmere v določenem kraju. Spremembe v oblikovanju in načinu gradnje so bile zelo počasne, saj so se ljudje novostim upirali iz navade, še večkrat pa so to preprečevale ekonomske zmožnosti. Naravne nesreče, ki so bile realni preizkus kakovosti gradnje in prilagoditve lokalnim razmeram, pa so bile tisti močan vzvod, ki je silil ljudi k razmišljanju o nujnosti sprememb ter k uvajanju novih tehnologij in materialov. Vendar so nesreče le redko neposredno vplivale na spremembo v načinu gradnje, največkrat je bil ta proces posreden prek družbenih, geografskih, ekonomskih in drugih dejavnikov.

Potres, požar in poplava spadajo med nesreče, ki v Sloveniji povzročijo največ škode ter posledično tudi žrtev. Raziskavo o vplivu teh nesreč na arhitekturo smo geografsko omejili na Slovenijo. Nekateri primeri od drugod bodo predstavljeni le za boljšo ilustracijo. Posebno pozornost smo posvetili nevarnostim, ki so povezane z Ljubljanskim barjem, ki je zaradi bližine prestolnice čedalje bolj urbanizirano. Te nevarnosti so vplivale na posebne zahteve za gradnjo, ki bi jih morali upoštevati pri gradnji stavb. V zadnjem delu članka je predstavljena varnostna analiza cerkve sv. Mihaela v Črni vasi na Ljubljanskem barju, ki jo je projektiral Jože Plečnik in je kulturni spomenik. Glede na to, da je arhitekt projektiral na različnih krajih, je bilo zanimivo ugotoviti, ali je in kako je upošteval krajevne značilnosti Ljubljanskega barja.

2 Metoda

Arhitektura je veda, ki izhaja iz preteklih izkušenj in sedanjih potreb ter gradi za prihodnost. Poglavitna naloga arhitekture je oblikovanje (zunanjega in notranjega) prostora (Košir 2007). Znanstveno-raziskovalne metode v preučevanju arhitekture, posebno še njene preteklosti, se opirajo na opisno in zgodovinsko metodo preučevanja pojavov (Kališnik 2003), saj so eksperimenti v tej stroki praktično nemogoči. Zato bodo rezultati predstavljeni opisno.

Opisovanje nesreč in njihovih posledic bomo naslonili na dognanja avtorjev, ki se ukvarjajo s preučevanjem teh pojavov pri nas. Potrese so pri nas dobro analizirali Bubnov (1996), Tomaževič (1995a; 1995b) in Vidrih (1995a; 1995b). Opis vpliva požarov na arhitekturo temelji na avtorjevi doktorski disertaciji (Kušar 2005). Za oris vpliva poplav smo se naslonili na izsledke raziskav (Gams, Kos, Orožen Adamič), ki so bili predstavljeni na posvetu na temo poplav v Poljčah, leta 1992. S pomočjo teh opisov ter analizo arhitekturnih značilnosti [nam beseda arhitektura označuje le vedo, ne pa lastnosti stavbe, prostora ali značilnosti pojava] bomo opisali medsebojna razmerja med enim in drugim pojavom.

Obravnava te problematike ne more iti mimo razlage pojma nesreče in pojma nevarnosti. Izraze in pojme s tega področja je opredelilo že več avtorjev, predvsem z namenom razjasniti nekatere pojme in odnos do prevodov in uporabe tujih besed in tujk v Slovenščino (Đurović, Mikoš … 2008). Geografski terminološki slovar (Kladnik in ostali 2005) opredeli naravno nesrečo kot nesrečo, ki jo povzročijo izjemne naravne okoliščine, npr. potres, zemeljski plaz, podor, poplava itd. Glede na to da sestavek obravnava njihov vpliv na grajeno okolje, je potrebno pojem nesreče opredeliti tudi širše. Slovar slovenskega knjižnega jezika opiše nesrečo kot stanje, ki povzroča duševne bolečine, dogodek, pri katerem je človek poškodovan ali mrtev, dogodek, ki človeka zelo prizadene, navadno materialno (Bajec in ostali 1994). Nevarnost pa opredeljuje kot možnost nesreče, škode ali česa slabega, neprijetnega sploh (Bajec in ostali 1994). Dojemanje nevarnosti ima dve komponenti, objektivno in subjektivno. Objektivna se nanaša na realno možnost nastanka nesreče in je odvisna od konteksta, v katerem se pojavlja. Z objektivnim pomenom nevarnosti se ukvarjajo različne, predvsem tehnične stroke. Subjektivni pomen nevarnosti pa se nanaša na občutek ogroženosti pri posamezniku in se zato razlikuje od človeka do človeka. Na občutek ogroženosti vplivajo različni dejavniki: poznavanje same nevarnosti in načina preprečevanja, mediji, pretekle izkušnje, politika idr. Med objektivno in subjektivno nevarnostjo je šibka zveza. V situaciji z isto stopnjo nevarnosti so nekateri posamezniki zelo prestrašeni, drugi pa se obnašajo popolnoma brezskrbno (Polič in ostali 1994).

Arhitekturna stroka se zaradi svojega poslanstva srečuje tako z objektivno kot s subjektivno komponento nevarnosti. Objektivne nevarnosti ogrožajo obstoj in funkcijo stavb, medtem ko vpliv nevarnosti na mišljenje in zavest ljudi že sodi bolj v kontekst subjektivnega dojemanja nevarnosti in varnosti ter hkrati na pripravljenost sprejeti nujne spremembe bivanjskega okolja.

3 Vpliv nekaterih naravnih nevarnosti na arhitekturo

Slovenija je zaradi svoje lege ter geološke sestave pokrajinsko zelo pestra dežela. Zanjo je značilen razgiban relief, ki so ga dodatno oblikovali tudi eksogeni dejavniki ter nenazadnje človek. Žal pa so posledica pestrosti tudi številni naravni procesi, ki pogosto prizadenejo človeka. Tako Slovenijo ogroža več kot 20 različnih nevarnosti (Ogroženost … 2007), letna škoda, ki jo naravne nesreče povzročijo, pa povprečno presega 2 % BDP Slovenije. Višina škode v urbanem okolju ni vedno odvisna samo od jakosti nesreče, pač pa tudi od načina gradnje, lokacije/lege, reakcij ljudi. V članku predstavljene nevarnosti (požar, potres, poplava in veter) se pogosto pojavljajo in so skozi zgodovino skupaj ali posamič prek različnih dejavnikov spreminjale arhitekturno podobo naših krajev.

3.1 Požar

Požar je ena od nesreč, katerega vzrok ni vedno naraven pojav. Naravni pojav je le, če je požar posledica strele ali kakega drugega naravnega procesa. Požarov na objektih, ki so posledica strele je v Sloveniji vsako leto nekaj deset. Leta 1997 je bilo takih požarov 65 (3.8 % vseh požarov) (Šipec 1998: 50). Njihov delež v celotni škodi zaradi požarov je sicer majhen (nekaj odstotkov), vendar pa je škoda kljub temu velika, saj so pri nas požari največja nevarnost v naseljih glede na letno povzročeno škodo na stavbah. Lahko rečemo, da je pri nas na leto okoli 1400 požarov, ki povzročijo za okoli 7 milijonov evrov škode (Šipec 1995; Šipec 1996; Šipec 1998). Domnevamo, da je bila škoda v preteklosti zaradi načina gradnje še veliko večja, zato v nadaljevanju na kratko predstavljamo proces preoblikovanja lesenih stavb v bolj ognja varne stavbe, na katerega so močno vplivale tudi krajevne, geografske in druge značilnosti.

Za gradnjo naselij so po propadu Rimskega imperija na območju Slovenije uporabljali predvsem les, ki ima kot gradbeni material vrsto dobrih lastnosti. Osnovna obdelava ne zahteva veliko znanja, spretnosti in orodja. Za čas do okoli 7. stoletja je možno domnevati, da so v gričevnatem in hribovitem svetu prevladovali gozdovi, ki so pomenili vir lesa. Kasnejša kolonizacija je zmanjšala površino gozdov, vendar naj bi to zmanjšanje na območju Slovenije predstavljalo največ 20 % celotne površine. (Valenčič 1970). Kamnita oziroma opečna gradnja se je pri nas ohranila le na Krasu in v Koprskem primorju. Prevladovala je lesena ali slamnata kritina stavb. Zaradi gorljivosti lesa, so požari zelo pogosto prizadeli stavbe ali celotna naselja. Danes so taki požari praktično nemogoči, kar je posledica razvoja tehnike na področju razsvetljave in ogrevanja ter uporabe manj vnetljivih gradbenih materialov.

Problema požarov so se ljudje že zgodaj poskušali rešiti na različne načine. Nekateri so zapisani v statutih srednjeveških mest. Glavni napor tega zgodnjega obdobja je bil usmerjen v preprečevanje izbruha požara, zato so kršilce teh zapovedi tudi ostro kaznovali (Božič 1988).

Naprednejšo zakonsko regulativo na področju požarne varnosti so pomenili požarni redi in kasneje stavbni redi. Z njimi so mesta urejala način gradnje hiš, določala so gradbeni material (zlasti za strehe) in način opozarjanja pred požari ter njihovega gašenja. Navadno so bili povod za sprejetje požarnih redov večji požari. Eden od pomembnejših ciljev teh redov je bil zamenjava gorljivih gradbenih materialov z negorljivimi. Najprej so morale biti tako urejene ogrevalne naprave, kasneje pa celotne zgradbe. Tako predpis iz leta 1524 prepoveduje postavljanje lesenih zgradb v Ljubljani (Božič 1988). Zaradi gostejše pozidanosti so bili predpisi za mesta bistveno strožji kot za podeželska naselja.

Kljub dobronamernosti so se predpisi uveljavljali bolj počasi. Zamenjavo kritine ali kurilnih naprav so si lahko privoščili le bogati, čeprav je država ponekod to finančno spodbujala. Delež lesenih hiš je bil največji v revnejših predelih brez tradicije kamnite gradnje, tako je bilo leta 1825 ponekod na Dolenjskem več kot 75 % zgradb lesenih. Podobno stanje je bilo na primer tudi na Kozjanskem, v Prlekiji, v okolici Slovenj Gradca. Nasprotno pa je bilo na Postojnskem, v Vipavski dolini in na Krasu ter deloma v osrednji Sloveniji že takrat več kot tri četrtine hiš zidanih (Vilfan 1970).

Na število požarov vpliva tudi podnebje. Pregled večjih požarov v mestih na območju Slovenije kaže na povečano število požarov (Krajevni leksikon Dravske banovine 1937) v hladnem obdobju med 16. in 19. stoletjem, tako imenovano malo ledeno dobo. Opredelitev ali gre za naravno nesrečo ali ne je v tem primeru zapleteno. Večina požarov je nastala v kurilnih napravah kot posledica nepazljivosti ali napak. Po drugi strani pa je bila daljša sezona uporabe kurilnih naprav in s tem večje možnosti nastanka požara, posledica naravnega dogajanja, to je obdobja daljših zim in bolj mrzlih let. Število požarov je močno upadlo na koncu 19. stoletja, po vsej verjetnosti zaradi sprememb načinov gradnje in toplejšega podnebja.

Na večjo razprostranjenost zidanih stavb pa je poleg požarnovarnostnih razlogov vplivalo tudi naraščanje cene lesa, ki je bilo posledica njegovega pomanjkanja. Zaradi naraščanja števila prebivalstva in s tem povezane potrebe po obdelovalnih površinah so gozdove izsekavali. Največje izsekavanje gozdov kot posledica kolonizacije, se je pri nas vršilo od 10. do konca 14. stoletja. V tem času se je obseg gozda zmanjšal za približno polovico svojega prvotnega obsega (Anko 1987). Naraščajoče rudarstvo in predelava rud je zahtevala čedalje več lesa za rudnike in kot vir toplote v različnih tehnoloških procesih (fužine). Posledično pomanjkanje lesa in višanje cene je začela zavirati oblast (državna in deželna) z gozdnimi redi. Pri tem je dajala prednost uporabi lesa za rudnike in državne objekte (Anko 1987).

Kljub dejstvu, da je danes Slovenija ena od najbolj gozdnatih držav v Evropi (Areas … 2007), sta zaradi opisanih večstoletnih dejavnosti na področju protipožarnega varstva v Sloveniji le dva odstotka hiš lesenih. Zaradi zaraščanja kulturne pokrajine (Kobler 2001) je danes aktualna nevarnost širjenja požarov iz naravnega okolja v urbano. Takih primerov je več drugod po svetu (Kalifornija, Avstralija), pri nas pa predvsem na Krasu. Stanje na Krasu je posledica načrtnega sajenja borov po kraških gmajnah v preteklosti ter zaraščanja travnikov v sedanjem času. Požar, ki nastane v naravnem okolju, se lahko ob neugodnih vremenskih razmerah (veter) hitro razširi ter ogrozi naselja. Leta 2003 je na primer požar ogrožal Klariče in Sela na Krasu (Muhič 2005). Širjenje požara lahko preprečimo le s skrbno vzdrževanimi požarnimi posekami.

3.2 Potres

Slovenija, ki leži v potresnem sredozemsko-himalajskem pasu, spada med potresno najbolj ogrožena območja sveta. Potresi so naravni pojav, ki zelo pogosto in zelo močno prizadenejo človeka. V le osemnajstih večjih potresih v svetu med letoma 1990 in 1997 je umrlo kar 74.000 ljudi (Largest … 2007). Potresi sami neposredno ne vplivajo na ljudi, zato so poškodbe in smrtne žrtve posledica porušitve zgradb, požarov, eksplozij, nenadzorovanega uhajanja nevarnih snovi v okolje, visokih voda in drugih sprememb, ki jih povzroči potres. Potresi porušijo ali poškodujejo predvsem starejše zgradbe, čeprav lahko utrpijo hude poškodbe tudi zgradbe, ki so bile zgrajene v skladu s predpisi o potresno varni gradnji (Ocena potresne ogroženosti Republike Slovenije … 2007; Polič in ostali 1996). Na temelju zgodovinskih in geoloških podatkov je možno napovedati pogostost potresov ter njihovo največjo pričakovano moč.

Tresenje tal ob potresu zrahlja nosilno konstrukcijo do te mere, da se zgradba celo poruši. Pri tem so bolj ogrožene zgradbe, katerih nosilni elementi niso dobro povezani med seboj. Preprečevanje nastanka poškodb ali porušitve zgradb sledi smernicam za protipotresno varno gradnjo; te zajemajo določene principe, ki naredijo zgradbo bolj varno. Predvsem mora biti težišče zgradbe čim nižje, pomembne so tudi ojačitve zgradb. Najbolj ranljiva mesta stavb so vogali (slika 1), zato imajo kamnite zgradbe vogale iz velikih izklesanih kamnov (Bubnov 1996). Prilagoditev zgradb potresni nevarnosti je bila zlasti odvisna od: gradbenega materiala, ki je bil na voljo, tehničnega znanja in ekonomskega stanja. V okviru danih možnosti so prebivalci skušali storiti največ, kar je bilo v njihovi moči, da bi preprečili nesrečo.

Slika 1: Vogal je ob potresu kritično obremenjen element zgradbe (primer posledic potresa v Posočju).
Glej angleški del prispevka.

Na ozemlju Slovenije je do 19. stoletja prevladovala lesena gradnja, ki je potresno varnejša od zidane. Tako so potresi v preteklosti rušili predvsem zidane stavbe, kot so gradovi ali cerkve. Večjo skrb za protipotresno gradnjo je povzročil Ljubljanski potres leta 1895, ko so bile zgradbe že pretežno zidane. Potrese v Zgornjem Posočju so najbolje prestale kvalitetno zgrajene ali obnovljene zgradbe (Tomaževič, Klemenc, Lutman 1999).

3.3 Poplave

Pogosta nesreča pri nas so poplave, ki nastopijo, ko se voda razlije čez mejo običajnih strug oziroma bregov. Poplave so največkrat posledica vsote različnih neugodnih dogodkov. V prvi vrsti gre za veliko količino padavin, ki pade v razmeroma kratkem času. Če padavine padejo na zmrznjeno, neprepustno ali dobro namočeno podlago, hitro pride do napolnitve strug vodotokov. Ker ti ne morejo odvajati povečane količine vode, se ta razlije zunaj strug. Drugi primer poplav so porušitve nasipov in jezov, ki zadržujejo vodo. V tem primeru se zadržana količina vode hitro razlije naokrog in pri tem uničuje poljščine, infrastrukturo in zgradbe. Če je teren nagnjen, ima voda velik padec in tudi veliko razdiralno moč. Tako pri nas voda v hribovjih povzroči bistveno večjo škodo kot na primer na Ljubljanskem barju in na Notranjskih kraških poljih. Poplave so bile v Sloveniji pogoste tudi v preteklosti (Trontelj 1997). Tako je velik del antične Celeje uničila Savinja, ki je ob tem spremenila tudi svoj tok. Poplave na Celjskem so bile tudi 1550, na Radeljskem polju, Falski pečini, na Lentu v Mariboru in na Ptuju 1851 ter na območju celotne Slovenije na primer leta 1901. Večje ali manjše poplave prizadenejo Slovenijo ali njen del povprečno na tri leta (Trontelj 1997). Kljub temu da so poplave pri nas pogoste, ogrožajo le približno 5 % ozemlja Slovenije oziroma 25 km^2 urbanih površin (Anzeljc in ostali 1995).

Poplave so povečini naravni pojav, človek pa lahko s svojim delovanjem njihov učinek poveča ali zmanjša. Tako lahko neizvedeni ali delno izvedeni varovalni ukrepi, kot so zadrževalniki ali jezovi, še poslabšajo razmere, kot se je izkazalo v primeru poprave v Celju leta 1990 (Kos 1992). Naselja so pogosto nastala ob vodi zaradi prednosti, ki jih je takšna lega prinašala: lažji transport, možnost prehoda, izkoriščanje energije. Ljudje so tako zaradi drugih prednosti sprejeli tveganje zaradi poplav. Kljub temu, da je danes z določenimi ukrepi (zadrževalniki, nasipi) možno obvarovati poseljeni prostor pred učinki poplav, so ti ukrepi navadno predragi. Zato ostaja najprimernejša metoda gradnje izbira ustrezne in varne lokacije, ponekod pa je škodo mogoče zmanjšati tako, da zgradimo stavbo brez kleti ali na dvignjenem mestu – na primer nasipu.

3.4 Veter

Čeprav je Slovenija zaradi svoje zemljepisne lege in razgibanosti površja razmeroma slabo prevetrena dežela (Bertalanič 2006), se tudi pri nas občasno pojavljajo vetrovi, ki povzročajo škodo. Najznačilnejša močna vetrova sta burja in karavanški fen. Poleg njiju so možni močni vetrovi ob lokalnih neurjih. Največji zabeleženi sunki vetra dosegajo 180 km/h in se lahko pojavijo kjerkoli po državi (Dolinar 2008).

O vetru kot naravni nesreči lahko govorimo takrat, ko je neobičajno močan. Škodo na zgradbah pa lahko povzroči tudi običajno močan veter, če so materiali in tehnologija za gradnjo napačno izbrani. V zadnjem času veter razkriva zlasti strehe, ki so krite s salonitnimi ploščami in s tako imenovano trapezno oziroma valovito pločevino. V obeh primerih gre za elemente, ki imajo veliko površino in majhno maso. Če niso ustrezno pritrjeni, veter posamezne elemente odtrga. Glede na napovedi, ki pravijo, da se bo povečalo število in moč neurij tudi pri nas (Kajfež Bogataj 2007), bo treba gradnji strehe posvečati čedalje večjo skrb.

Primer prilagoditve bivališč na veter so pri nas na območjih z močno burjo. Tam imajo stavbe na severni in vzhodni strani malo oken majhnih dimenzij. Večja okna so na južni in zahodni strani. Prav tako so dvorišča večinoma locirana tako, da jih stavba varuje pred vetrom. Strehe imajo majhne napušče ali so brez njih in so običajno krite z opečnimi korci, položenimi v malto ter še dodatno obteženi s kamni. Raziskava o burji v letih 1970 in 1972–1973 je pokazala tudi povezavo med količino kamna za obtežitev streh na področju Ajdovščine ter močjo burje na tem območju. Primerjava kart moči vetra in količine kamna na strehah kaže, da je na krajih, kjer je moč vetra največja, tudi količina kamna na strehi največja. Ker gre za posamezna področja znotraj obravnavanega področja, kaže na zelo specifično in izrazito lokalno pogojeno prilagoditev bivališč naravnim razmeram (Yoshino in ostali 1976).

Zemljevid, ki prikazuje moč vetra, se razlikuje od zemljevida, ki prikazuje povprečne hitrosti vetrov, na katerem so najvišje vrednosti na območjih gorskih pregrad. Za gradnjo stavb namreč nista toliko pomembna povprečna hitrost in moč pač pa pričakovana največja hitrost (sunkov) in njihova največja moč na območjih, kjer se gradi oziroma se gradnjo načrtuje. Za določitev primerne oblike in konstrukcije streh se zato upošteva tako imenovane vetrovne karte Slovenije (narejene v skladu s standardom SIST ENV 1991-2-4). Z njih je možno razbrati, da je Slovenija glede moči vetra razdeljena na štiri območja. Največja moč vetra je v območju visokogorja (vetrna cona D: do 40 m/s). Temu sledita območji Vipavske doline, Krasa s Koprskim primorjem, kjer stavbe ogroža burja (vetrna cona B: do 30 m/s) in območje med Jesenicami in Kranjem, kjer je pogost tako imenovani karavanški fen (vetrna cona C: do 30 m/s). Na preostalem delu Slovenije je moč vetrov manjša (vetrna cona A: do 25 m/s) (O vetrnih razredih … 2008).

4 Ogroženost naselij na Ljubljanskem barju zaradi naravnih nesreč

Ljubljansko barje (slika 2) je tektonska udornina, ki leži na stiku predalpskega in dinarskega sveta. Na severozahodnem delu jo omejujejo Polhograjsko hribovje, na severovzhodnem delu Golovec in na jugu visoke dinarske planote. Nastala je s počasnim ugrezanjem ozemlja med Ljubljano, Vrhniko in Škofljico, ugrezanje še vedno poteka s hitrostjo od 1 mm/leto do 25 mm/leto. Najhitrejše grezanje je v na območju Ilovice. Zaradi še vedno aktivne tektonske dejavnosti je zlasti jugovzhodni del Ljubljanske kotline med potresno najbolj ogroženimi deli Slovenije (Gams 1992).

Po Ljubljanskem barju teče več vodotokov, ki imajo različen značaj in so v preteklosti in še danes zasipavajo ugrezajočo se kotlino z različnimi sedimenti. Plast sedimentov je ponekod globoka 150–160 m, predvideva pa se, da bi bila največja globina lahko celo 300 m (Šifrer 1984). Prevladujejo glinasti in ilovnati sedimenti z vmesnimi plastmi peska. Na menjavo sedimentacije sta vplivala hitrost ugrezanja ter reka Sava, ki je s prodom večkrat zaprla pot Ljubljanici in povzročila ojezeritev. Na močvirnih območjih se je na barju razvila do 6 m debela plast (Melik 1946).

Slika 2: Ljubljansko barje.
Glej angleški del prispevka.

Čeprav velja Ljubljansko barje za arheološko enega bogatejših delov Slovenije, se je poselitev v novejšem času odvijala relativno pozno, predvsem zaradi neprimernosti barjanskih tal za uspešno kmetovanje. Z velikimi izsuševalnimi deli konec 18. in v začetku 19. stoletja, so Ljubljansko barje toliko izsušili, da je bila možna naselitev. Prva naselja na barjanskih tleh (ne na in ob osamelcih in robovih barja, ki so bili že dolgo poseljeni), so bila Volar in Ilovica ob današnji Ižanski cesti (narejeni 1827) pri Ljubljani. Kasneje so v bližini Ljubljane, vendar že na barjanskih tleh nastala naselja Rakova jelša, Galjevica, Karolinški dvor, Črna vas in Lipe. Drugod je bil ta proces manj izrazit, saj je večina novogradenj bila zgrajenih na območjih vasi, ki so bile že v preteklosti postavljene stran od poplavnega pasu (Melik 1927; Kušar 1991).

Danes je na jugu Ljubljane ter v Črni vasi in Lipah (ki sta edini v celoti na Ljubljanskem barju ležeči naselbini) izredno močna urbanizacija. Po naših ugotovitvah se je po drugi svetovni vojni veliko ljudi na to območje priselilo iz drugih delov Slovenije (in nekdanje Jugoslavije) in žive v individualnih hišah (slika 3). Blokovska naselja so nastala na robu Ljubljanskega barja na Viču in Trnovem, v zadnjem času pa je bilo zgrajenih tudi nekaj večstanovanjskih objektov.

Slika 3: Individualna stanovanjska gradnja (P + 1) prevladuje na Ljubljanskem barju.
Glej angleški del prispevka.

4.1 Prilagoditev bivališč zaradi poplavne ogroženosti Ljubljanskega barja

Na Ljubljanskem barju so trije pomembnejši vodotoki: Ljubljanica, Iška in Gradaščica. Zaradi raznolikih porečij imajo tudi vodotoki različen značaj. Vode Ljubljanice, ki izvirajo pri Vrhniki se zbirajo na obsežnem območju, ki obsega pretežno kraški svet med Vrhniko, Blokami, Babnim poljem, Pivko, Postojnsko kotlino, Hotedršico in Rovtami. Kraško zaledje Ljubljanice dobiva zaradi geografskih značilnosti površja veliko padavin: od 1600 mm v Ljubljanski kotlini do več kot 3200 mm na Snežniku. Relativni višek padavin je zgodaj poleti in pozno jeseni (Vrhovec 2002). Ob poplavah voda zastaja na kraških poljih, zato se visoke vode na Ljubljanici pojavijo z zamikom, vendar trajajo dlje časa, kot bi sicer. Ljubljanica zaradi kraškega značaja tudi ne nosi proda pač pa drobne sedimente.

Gradaščica in Iščica pa imata hudourniški značaj. Porečje Gradaščice v Polhograjskem hribovju meri skupaj s pritokom Šujico okoli 155 km^2 (Melik 1946). Gradaščica poplavlja ob hudih nalivih, ki nastanejo v hribovitem svetu. Zaradi velikih strmin in nepropustne podlage vode hitro napolnijo struge dolin in povzročijo poplave v Ljubljani. [iz Trontelj 1997 – kdaj so bile poplave Ljubljane] Po pripovedovanju domačinov se je že zgodilo, da je Gradaščica zaprla pot Ljubljanici, tako da je reka tekla nazaj proti Vrhniki. Danes Gradaščica na Ljubljansko barje prinese največ naplavin med vsemi pritoki Ljubljanice.

Iška izvira na Blokah in skozi sotesko Iškega Vintgarja doseže Ljubljansko barje, kjer je ustvarila obsežen vršaj. Porečje meri okoli 83 km^2. Pritoke ima le v zgornjem delu, poleti pa lahko na Iškem vršaju celo presahne. Prvotno se je reka izlivala v Iščico (ta izvira sredi vasi Ig) pri Hauptmancah, ob regulacijskih delih pa so njen tok od Tomišlja navzdol speljali z ravnim kanalom neposredno v Ljubljanico. Reka ob obilnih padavinah pogosto hitro naraste in se razlije v silovite povodnji (Melik 1946). Poplave Iške povzročijo manjšo škodo kot poplave Gradaščice, saj se razlijejo po večinoma neposeljenem srednjem delu Ljubljanskega barja.

Na Ljubljanskem barju lahko pričakujemo okoli 790 m^3/s dotoka vode, odtok skozi Ljubljano pa je omejen na 600 m^3/s (Godec 2005). Obseg pogostih poplav je največji na zahodnem delu med Vrhniko, Borovnico in Podpečjo. Drugo tako območje se razteza ob Ljubljanici med Podpečjo in Črno vasjo. Pri tem je zanimivo, da predel tik ob Ljubljanici ni tako pogosto poplavljen kot malo bolj odmaknjeno ozemlje. Razlog zato je verjetno dejstvo, da je bila struga Ljubljanice večkrat prestavljena. Ob zemeljskih delih so izkopano gradivo najverjetneje nasipali ob novi – sedanji strugi, zato so bregovi višji od okoliške ravnine. Tretje območje pogostih poplav je na vzhodnem delu med Ljubljano, Igom in Škofljico. V teh primerih gre za praktično neposeljena območja (Slika 4).

Ob večjih poplavah je poplavno območje dosti večje, in meri 8034 ha (Orožen Adamič 1992). Na tem največjem poplavnem območju v Sloveniji ležijo ves južni del Ljubljane ter barjanski vasi Črna vas in Lipe.

Prebivalci Ljubljanskega barja so zlasti v Črni vasi in Lipah svoja bivališča prilagodili razmeram tako, da so zgradbe postavili na nasipu, ki je nad poplavno vodo. Tako je zgradba z dvoriščem ob poplavah otok, obdan s poplavno vodo. Vse hiše so brez kleti. Takšna prilagoditev stavb je možna, ker poplav na Ljubljanskem barju (razen v primeru Gradaščice) ne povzroča deroča voda. Kljub temu pa se prebivalci le slabo zavedajo posledic poplav, kot je pokazala tudi anketa leta 1983 (Gams, Cunder 1983). Slabih 60 % anketiranih je odgovorilo, da imajo tla v stanovanju manj kot 20 cm visoko glede na okolico. Rezultat ankete kaže na to, da do takrat večina priseljencev še ni imela izkušnje s poplavo.

Slika 4: Karta poplavne ogroženosti Ljubljanskega barja (Komac, Natek in Zorn 2008).
Glej angleški del prispevka.

4.2 Potresna ogroženost

Barje je potresno ogroženo področje. V okolici Ljubljane lahko pričakujemo potrese VIII. do IX. stopnje EMS potresni lestvici. Pri VIII. stopnji že nastanejo poškodbe objektov, kot so večje razpoke v zidovih, posamezne stavbe se lahko porušijo, sprožijo se zemeljski plazovi. Pri IX. stopnji pa se podirajo deli hiš, nastanejo razpoke v tleh, in veliki zemeljski plazovi ter usadi (Kušar 2005). Pričakovana intenziteta potresov na Ljubljanskem barju sicer ni nič večja kot v bližnji okolici, vendar se na barjanskih tleh zaradi geološke sestave potresni valovi okrepijo, lahko pride do utekočinjenja tal. Zato se območje največje intenzitete potresa na območju mestne občine Ljubljana praktično v celoti prekriva z območjem barja, kar moramo upoštevati pri gradnji stavb (slika 5). Zgradbe morajo biti na takih območjih čim nižje, čim lažje ter trdno povezane. Nosilnost so že zgodaj začeli povečevati z zabijanjem lesenih kolov – pilotov pod temelje zgradb v mehka barjanska tla. V preteklosti so bili piloti le leseni, danes pa so tudi betonski. V času po II. svetovni vojni se je na to območje priseljevalo veliko ljudi, ki niso poznali principov gradnje na barjanskih tleh. Posledice nekakovostno zgrajenih in neprilagojenih hiš okolju, ki se kažejo v nagnjenosti hiš, je moč videti zlasti na področjih, kjer so bile stavbe postavljene brez dovoljenj (npr. v predelu Rakove jelše; slika 6).

Slika 5: Mikrorajonizacija potresnih intenzitet za območje mestne občine Ljubljana. Lokacija cerkve je označena z modrim krogcem (Mestna občina … 2008).
Glej angleški del prispevka.

Slika 6: Pogreznjena in nagnjena hiša kaže na nepoznavanje ali neupoštevanje principov varne gradnje na barjanskih tleh.
Glej angleški del prispevka.

4.3 Požarna ogroženost

Požarna nevarnost za razliko od drugih delov države na Ljubljanskem barju nima posebnega vpliva na naselja, saj močvirna tla, mokri travniki ter njive z melioracijskimi jarki onemogočajo širjenje požarov pa tudi vode za gašenje požarov je dovolj. Za barjanska naselja je značilno, da so razložena oziroma so med stavbami velike razdalje. Tako je preskok ognja iz hiše na hišo ter nastanek požara večjih razsežnosti praktično nemogoč. Izjema so le nekatere novogradnje iz prejšnjega stoletja na Galjevici, v Rakovi Jelši in na južnem delu Ižanske ceste, vendar so tudi te hiše grajene iz večinoma negorljivih materialov (slika 7).

Slika 7: Primer zgoščene gradnje na Galjevici.
Glej angleški del prispevka.

4.4 Vetrovi na Ljubljanskem Barju

Za Slovenijo je značilno, da je zaradi lege v zavetju Alp in pretežno kotlinsko dolinskega površja slabo prevetrena. V nižinskem svetu je povprečno 30–40 % tišin, povprečna hitrost vetra pa le okoli 2 m/s (Ogrin 2002). Ta ugotovitev velja tudi za Ljubljansko barje. Kot kažejo dosedanje izkušnje, se lahko močnejši vetrovi razvijejo le ob lokalnih neurjih. Meritve na vremenski postaji v Ljubljani so tako v letih 1995–2004 zabeležile največji sunek vetra 22.0 m/s (Bertalanič 2007)

5 Ogroženost cerkve sv. Mihaela zaradi naravnih nesreč

Cerkev sv. Mihaela v Črni vasi pri Ljubljani (slika 8) je eden od arhitekturnih biserov Jožeta Plečnika. Ne glede na umetnostno in arhitekturno vrednost cerkev kaže tudi nekaj detajlov, iz katerih je mogoče razbrati, kako je arhitekt zgradbo prilagodil naravnim razmeram. Graditi so začeli 1937, blagoslov cerkve pa je bil leta 1940. Od tedaj naprej služi svojemu namenu.

Cerkev leži na poplavnem območju (slika 5 in 10). Na poplavo tega dela barja najbolj vplivata Iška in Ljubljanica, nekaj malega pa prispevajo tud izviri ob južnem robu Ljubljanskega barja, ki napolnijo bližnje jarke in kanale ter se razlijejo iz svojih strug. Zemljišče okoli cerkve je nasuto, tako da je približno 50 cm nad okoliškimi travniki in tudi njivami, ki so ob poplavah najprej pod vodo. Slika 9 prikazuje območje Ižanske ceste v oddaljenosti približno 600 m od cerkve ob poplavah v dvajsetih letih prejšnjega stoletja, ko je bilo celotno območje pod vodo.

Druga slaba lastnost je majhna nosilnost podlage. Na tem območju je barjanska udornina najglobja, matična kamenina je 117 m globoko. Do te globine pa se menjavajo plasti šote, ilovice, peska, melja in gline. Taka podlaga je slabo nosilna. Za povečanje nosilnosti so pod temelje cerkve zabili lesene pilote, ki segajo do stabilnejše plasti peska (Kušar, Slivnik, Walllner 1997; Wallner 1999; Kušar 2001).

Nizka nosilnost podlage na tem območju je neugodna tudi z vidika potresne ogroženosti. To dokazuje zemljevid potresne ogroženosti Ljubljane, kjer so največji pričakovani pospeški tal ob potresu prav na območju Ljubljanskega barja (slika 5).

Slika 8: Cerkev sv. Mihaela v Črni vasi na Ljubljanskem barju.
Glej angleški del prispevka.

Slika 9: Ljubljanica je Črno vas poplavila tudi leta 1963 (Lah 1965, 115).
Glej angleški del prispevka.

5.1 Poplavna ogroženost objekta

Jože Plečnik se je poplavam ognil tako, da je stavbo postavil na dvignjeno zemljišče, ki so ga tudi nasuli, da je bilo nad koto običajnih poplav. Tako je stavbišče cerkve približno 50 cm nad okoliškimi zemljišči. Zgradba je v pritličju zgrajena iz sivega podpeškega apnenca in betona (slika 10). Na vodo manj odporna opeka in leseni deli se pojavijo višje. Prav tako izbrani material ter stene brez ometa tudi preprečujejo kapilarni vlek vode. Poleg tega je glavni bogoslužni prostor cerkve v nadstropju približno 4 m nad podlago in je dostopen s stopniščem. Tako je najpomembnejši prostor varen tudi pred izjemnimi poplavami (Kušar 2005).

Slika 10: Strukturo obodnih sten sestavljata kamen in beton, zgornji del pa še les in opeka. Na levi vidimo del monumentalnega stopnišča, ki vodi v bogoslužni prostor v zgornjem nadstropju.
Glej angleški del prispevka.

5.2 Potresna ogroženost in ogroženost objekta zaradi vetra

Problem slabe nosilnosti tal in potresne ogroženosti je arhitekt rešil z izvirno zasnovo in nevsakdanjo uporabo gradbenih elementov. Da bi bila zgradba čim lažja, je masivno gradnjo v kamnu in opeki uporabil le pri tleh, v vogalih, pri vhodu in v zakristiji. Cerkev je zgrajena tako, da se delež težjega gradiva, kot sta opeka ali kamen, z višino manjša. Masivne stebre je celo nadomestil z votlimi kanalizacijskimi cevmi, ostali deli stavbe pa so leseni. Ob cerkvi je postavljen kamnit zvonik, ki pa je zaradi manjše teže večkrat prevotljen. Analiza je tudi pokazala, da zgradba ustreza današnjim kriterijem obremenitev zaradi vetra (Kušar, Slivnik, Walllner 1997; Wallner 1999; Kušar 2001).

5.3 Požarna ogroženost objekta

Analiza požarne varnosti (Kušar 2001) je pokazala, da zgradba ni požarno varna. Tu gre za problem same zgradbe in ne problem širjenja požara iz objekta na objekt, ki je na tem področju praktično nemogoče. Slabo stanje na področju požarne varnosti je posledica velike količine vgrajenega lesa, uporabe ognja (sveče) in problematične evakuacije pri velikem številu ljudi. Z uvedbo nekaterih dodatnih ukrepov bi se požarna varnost zgradbe izboljšala. Prav tako bi se dalo skrajšati čas evakuacije.

6 Sklep

Naselja v Sloveniji ogrožajo različne naravne nesreče. Pogosto se jim je mogoče izogniti s pametno izbiro lege in ustreznim načinom gradnje. S primerjavo starih in novih zemljevidov lahko ugotovimo, da so ljudje v preteklosti vedeli, kje postaviti hiše, da bodo na varnem pred naravnimi nesrečami (Komac, Zorn 2005). To vedenje in varnostni principi so se najprej prenašali z ustnim izročilom, kasneje pa tudi pisno.

Zgradbe so v prvi vrsti namenjene zaščiti prebivalcev in lastnine pred uničenjem. Zato pa se morajo prilagajati naravnim razmeram in ponekod tudi morebitnim naravnim nesrečam. V članku opisane nevarnosti in naravne nesreče so pogosto spremenile podobo naselij, s tem pa tudi zunanjo podobo celotnih pokrajin. Hiše v zgornjem Posočju, tako imenovan tip »Bovške hiše«, imajo tako strme strehe, ki omogočajo, da velika količina snega ne poškoduje strehe in strešne konstrukcije temveč zdrsne s strehe. Tudi naselja na kraških poljih so nastala tam, kjer jih visoka voda ne more zaliti.

S tem je povezano zavedanje o nevarnosti naravnih nesreč v določenih pokrajinah in njihovih možnih posledicah na naselja. Tudi danes moramo biti nenehno pozorni na naravne razmere in upoštevati krajevne danosti in omejitve, saj le tako lahko preprečimo škodo. Žal je ta zavest pri nas še premalo razvita in se vse preveč računa na pomoč države. Zlasti je premajhen vpliv zavarovalnic, ki bi pri tem lahko igrale pomembno vlogo in z visokimi zavarovalnimi premijami preprečevale gradnjo na močno ogroženih področjih. Ponekod v tujini so namreč zavarovalnice glavni generator sprememb na področju varnosti. (Oblak 2007).

Z analizo ogroženosti cerkve sv. Mihaela smo ugotovili, da je arhitekt Plečnik pri načrtovanju cerkve upošteval poplavno in potresno nevarnost, ki sta najbolj značilni za področje Ljubljanskega barja. Temu je prilagodil tudi arhitekturno zasnovo cerkve. K upoštevanju tega je gotovo pripomoglo dejstvo, da je arhitekt Plečnik stanoval v bližnjem Trnovem, ki prav tako leži na barjanskem terenu. Po drugi strani pa je ravno izbira materiala naredila cerkev po današnjih merilih požarno nevarno.

7 Literatura

Glej angleški del prispevka.