DELIVERABLE D.T1.3.2

PILOT SITES IDENTIFICATION

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With contribution of all partners

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INTRODUCTION

On the basis to the identified risk prone areas, on the cultural/historic value of the site and considering the outputs from previous local, national, transnational and European projects seven pilot heritage sites have been selected and gathered in the following table:

Table 1. Selected pilot sites and Project Partners of reference.

Pilot Site	Project Partner (PP)
1. Bielsko-Biala, Poland (PL)	– PP4 Bielsko – Biala District (BBD) – PP5 Regional Development Agency Bielsko-Biala (ARRSA)
2. Ferrara, Italy (IT)	– PP6 Municipality of Ferrara (MUF)
3. Kaštela, Croatia (HR)	– PP9 City of Kastela (COK)
4. Kočevje, Slovenia (SI)	– PP10 Municipality of Kocevje (MOK)
5. Krems, Austria (AT)	– PP3 University for Continuing Education Krems Danube University Krems (DUK)
6. Pècs, Hungary (HU)	– PP8 Government of Baranya County (GBC)
7. Troja (CZ)	– PP2 Municipal District Praha – Troja – PP7 Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences (ITAM)

Furthermore, according to the actions that should be necessary to be adopted at the sites, they are divided in two groups:

1. Pilot Actions 1-3, 6 (see WT4, A.T4.1): **Preparedness strategies** for monumental complexes in historic city centres for the following events:
    a. Flood events in large basin:
        i. Troja (CZ) - Pilot action 1
        ii. Krems (AT) - Pilot action 2
    b. Heavy rain:
        i. Ferrara (IT) - Pilot action 3
        ii. Pècs (HU) - Pilot action 6
2. Pilot Actions 4, 5, 7 (see WT4, A.T4.1): **Emergency plans** for evacuation in emergency phase in historic buildings for the following events:
    a. Sea flood:
        i. Kaštela (HR) - Pilot action 5
    b. Fire due to drought:
        i. Kaštela (HR) - Pilot action 5
    c. Heavy rain:
        i. Kaštela (HR) - Pilot action 5
        ii. Bielsko-Biala (PL) - Pilot action 7
        iii. Kočevje (SI) - Pilot action 4

In the following chapters, the selected case studies are described, listed in alphabetical order.

1. Bielsko-Biala (PL)

2. ACTION	EVENT	ICON
Pilot action 7: **Evacuation plans** in emergency phase in museum at historic buildings	Heavy rain	

SITE LOCATION	
Lat: 49.908611	**Long: 19.113996**

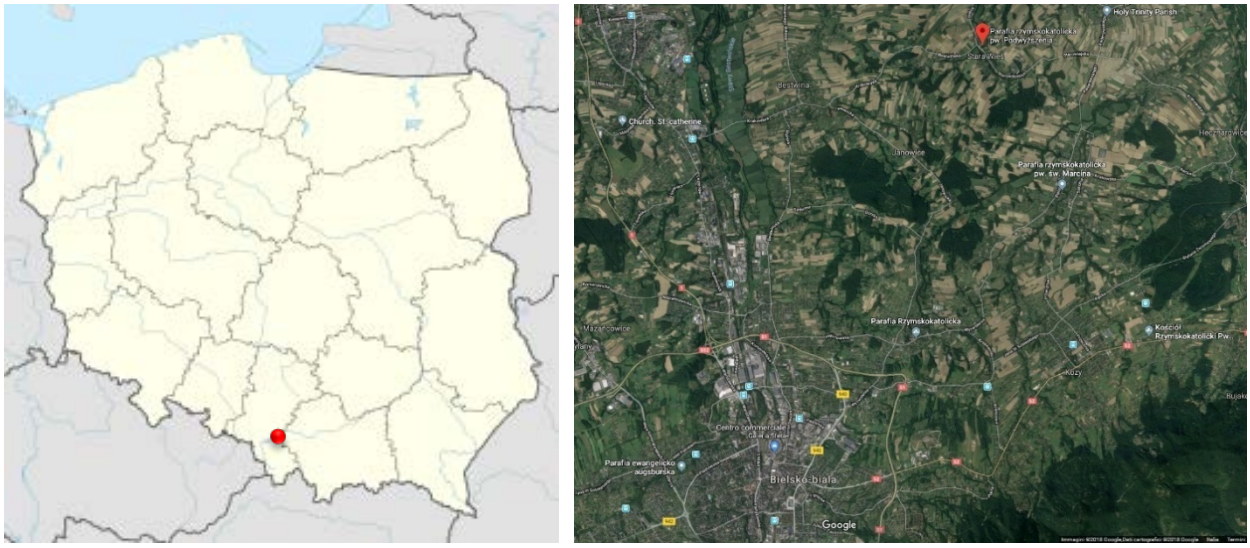

Figure 1.1. On the left, highlighted with a red dot Bielsko-Biała city; on the right, the location of the Roman Catholic Church of the Exaltation of the Holy Cross in Stara Wieś.

In Poland, the pilot site is located in Stara Wieś, a village within Bielsko District, in southern Poland (Fig. 1.1). Specifically, this village is 10 km far from Bielsko-Biała city, in the north direction, while it lies 40 km south of the regional capital Katowice.

SITE DESCRIPTION

The site pertains to the parish church dedicated to the Exaltation of the Holy Cross erected in 1522. Entry in the register includes the building of the church and the immediate surroundings, i.e. the so-called church cemetery with trees.

The church is made of fir wood on the oak foundation. Dendrochronological research carried out in 2011 showed that the presbytery, nave and tower were built in the same year (1522) and the original shape has survived to this day. The wooden church is situated on a hill (probably the former pre-Christian burial site and Stave church) surrounded by an old tree stand - a nature monument. It is an extremely high object (tower 30 m, nave 20 m) with a very interesting architectural structure, with a preserved Gothic shape, which is very rarely to be found in medieval wooden architecture. Oriented temple, skeletal construction with a pole tower. The tower -square from the west with inclined walls with a belfry and an onion-shaped dome with a lantern. Roof covered with shingles. Surrounded by “soboty” (low arcades), where Stations of the Cross are located. From the very beginning, the church is called the Exaltation of the Holy Cross, which is indicated by the miniscule inscription on the quire arc:

"ITA (! Sic) ECCELESIA AEDIFICATA IN HONOREM DEI ET BEATE DEI GENITRICIS MARIE ET HONOREM SANCITE CRUCIS".

(*This church was built in honor of God and His Mother Mary and in honor of the Holy Cross.*)

The church's decorations are:

- Renaissance polychrome of ceilings;
- Baroque wall polychromy with numerous paintings;
- Wooden, richly decorated, baroque altars from the 14th and 15th century with paintings;
- Wooden, baroque pulpit and baptismal font, eleven-voice Rococo organ with a beautiful sound;
- A historic confessional.

In the church tower, a St. John bell was hung that dates to 1748. In the 17th century, thanks to the Dominican missions, the church receives the second name of the Rosary Virgin Mary for the worship of which the late-baroque wooden side altar is made with the medieval painting of the Virgin Mary and baby Jesus still enjoying the cult as the Mother of God Starowiejska and local church services. At the main entrance of the church there are two stone stoups.

The act of consecration of the church written on parchment was discovered in 1996 in the main altar *mensa*, where it was embedded. It was found in a tin container from the 13th century, sealed with a wax seal.

The parish also is in possession of a richly equipped museum of sacred art.

In proximity of the church, there is a wooden historical building in which there used to be a school. Currently, it houses the Regional Chamber.

The building was erected in 1787. In the 19th century, the building was taken away from the church. In 1862, the school was thoroughly rebuilt, as evidenced by the inscription engraved on the ceiling beam of the school room. Since then, it has survived to this day almost unchanged. In 1910, a new school was put into use, nevertheless, the classes in the historic building were still held until the late 50s of the XX century. The old building was also used as the seat of the village administrator at that time. It served as a place for various meetings, courses sometimes as rented rooms for tenants.

In 1971, at the initiative of the Polish Tourist and Sightseeing Society, a regional chamber was organized in the old school building. It quickly became a big tourist attraction. At the beginning of the 1990s due to political and economic changes PTTK, being in a difficult financial and organizational situation, gradually ceased to deal with the chamber and the conservation of exhibits. On its own initiative Monuments Protection Committee established at the parish in 1992 started to take care of all exhibits. In1994, the building was passed back into ownership of the local parish, which now deals with the running of the museum facility.

For the presentation of the collections of the chamber, which are primarily of ethnographic character, two chambers are used. The first one, smaller, was arranged like a peasant's room. There is a fireplace, chests, sideboard, wardrobe, table, chairs and kitchen tables, as well as folk costumes - in short, everything that was needed by former residents in everyday life. In the second room, the former school room, a rich collection of farm equipment is presented. On the door of the chamber there is also information about the history of Stara Wies.

In front of the old school building there is an exhibition of traditional bee hives.

MAIN RISKS IMPACTING THE SITE

The selected CH complex is most threatened by the negative effects of heavy rain. It is located on the escarpment, causing overflowing water to overflow through the complex during the downpour. In addition, heavy rains can cause landslides and the movement of the ground on which the CH are located.

RECORDED PAST EVENTS

- July 1997 - gentle landslides from the cemetery area and the threat of land movements from under the church and the old school building, which are located above the cemetery.
- July 1997 - flooding of the church grounds, cemetery and the old school building.
- May / June 2010 - flooding of the church grounds, cemetery and the old school building. Water penetrated into the church due to a leaky roof.
- June 2013 - flooding of the church grounds, cemetery and the old school building. Repeated landslides from the cemetery area and the threat of land movements from under the church and the old school building, which are located above the cemetery.
- May 2014 - flooding of the church grounds, cemetery and the old school building.

ADOPTED MEASURES

Technical/Physical interventions, restoration works, etc.

- XVIII century, realized cloisters around the church, which were also protection against meteorological conditions,
- Before the Second World War – water drainage system in the fields above the pilot site. About 25 years ago, they carried out a test checking their patency for obtaining a permit to create a new cemetery there,
- Around 1997 - construction of retaining walls at the bottom of the cemetery to prevent landslides due to intense rainfall,
- Approx. 1997 - execution of surface drainage (channels) at the church and the old school building,
- Approx. 15 years ago - asphalting the road running over the pilot site together with water drainage system, to change the path of water flow in case of heavy rainfall,
- 2012 - roof repair,
- Currently, the renovation of the main steps from the church to the cemetery along with the construction of drainage channels is being carried out.

Regarding the site management, considering the plans, strategies, projects (local, national, EU, etc.) always included in DT1.1.1 (ANNEX), here are indicated if any of them have been produced and/or adopted at the here presented pilot site:

- *Spatial Development Plan of the Silesian Voivodship* – The plan is a general document in order to shape the voivodeship area, defining the concept of the basic elements of the future spatial structure of the voivodeship and functional links between these elements. Wilamowice commune with the village of Stara Wies are located in the voivodeship.
- *District Crisis Management Plan for Bielsko-Biala District* - Document with procedures and information about communes forces and resources that can be used in crisis situation in the territory of Bielsko-Biala District.
- *Flood Control Plan for the Bielsko-Biala District* - Document defining of activities entities engaged in flood prevention, since the occurrence of a flood hazard until the effects of the flood are removed.
- *District Plan of Monuments Protection in case of armed conflict and crisis situation* - Document describing all of cultural heritage from territory of Bielsko-Biala District and procedures of their protection and actions to be taken in the event of an armed conflict or a crisis situation.

2. Ferrara (IT)

ACTION	EVENT	ICON
Pilot action 3: **Preparedness strategies** for monumental complexes in historic city centres	Heavy rain	

SITE LOCATION	
Lat: 44.835656	**Long: 11.620270**

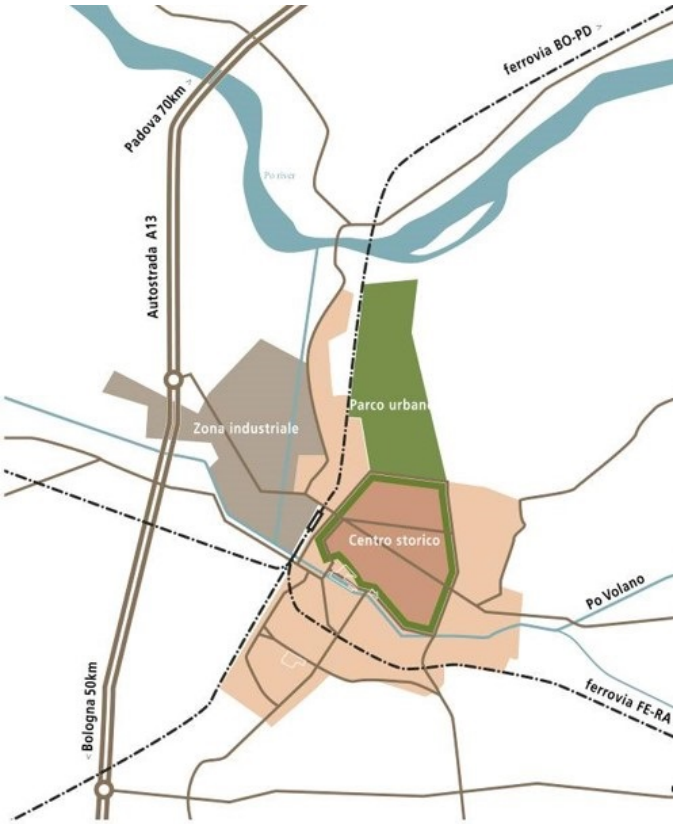

Figure 2. 1. On the left: City of Ferrara and its province; On the right: Urban structure (from: Masterplan per Ferrara. Aree ex Mof, Darsena, ex Amga ed ex Direzionale Pubblico di via Beethoven", September 2008, by Behnisch Architekten in collaboration with Politecnica Ingegneria e Architettura).

The city of Ferrara is located in the Emilia-Romagna region, in the Northeast of Italy (Fig. 2.1).

SITE DESCRIPTION

The city and its province has been inscribed in the World Heritage List since 1995, with an extension in 1999, including also the territory of the river Po Delta[1].

In particular, the case study includes the Cathedral Square and the Trento Trieste Square, where the Cathedral of Saint George the Martyr is located. In particular, the façade of the Cathedral, West oriented, faces the Cathedral Square (Fig. 2.2), while the South side of the church faces Trento Trieste Square (Fig.2.3)

Figure 2. 2. The main façade of the Ferrara Cathedral, West oriented, faces the Cathedral Square ® Google Maps.

Figure 2. 3. The south side of the church and the bell tower face the Trento Trieste Square ® Google Maps.

The cathedral of Ferrara dates from the 12th century and bears witness to all the historical periods of the city. The outstanding façade, divided into three sections, was begun in Romanesque style, still visible in the lower part (Fig. 2.4). Note the St. George and the scenes from the New Testament above the central door, the work of the sculptor Nicholaus (1135). The upper part was built some decades later in a Gothic style and besides the numerous small arches and the splayed mullioned windows presents an extraordinary Last Judgment by an unknown sculptor over the central loggia. The side facing Piazza Trento e Trieste is

[1] https://whc.unesco.org/en/list/733

decorated with two galleries and small columns of various shapes. At ground level, there is the Loggia of the Merchants, occupied by shops since Medieval times. Half way along the south side what remains of the "Porta dei Mesi", demolished in the 18th century can still be seen; some of its sculptures are conserved in the Cathedral Museum. The imposing Renaissance campanile, in pink and white limestones, mainly coming from the Veneto Region (in particular from Verona) and Istria, is an unfinished work attributed to Leon Battista Alberti. The brickwork apse, whose sober design is lightly embellished by terracotta arches and marble capitals, is the work of Ferrara's top architect and town planner, Biagio Rossetti.[2]

Figure 2. 4. Main façade of the Cathedral of Ferrara.

The interior of the cathedral was completely refurbished in the 17th century in a grandiose classical style (Fig.2.5). Along with the ostentatious pictorial decoration older works can be admired such as the bronze statues of the Crucifixion and of Saints George and Maurilius, by Nicolò Baroncelli and Domenico di Paris (15th cent.) in the right transept; on the altar alongside, the splendid canvas of the Martyrdom of St Lawrence/by Guercino (17 cent.) is to be seen. The bowl-shaped apse is vaulted with the grandiose Last Judgment by Bastianino (16th cent.). In what is his masterpiece the artist displays great dramatic force, imagination and unconventionality in this work clearly inspired by Michelangelo[3].

Figure 2. 5. Particular of the Cathedral's interior.

[2] http://www.ferraraterraeacqua.it/en/ferrara/discover-the-area/art-and-culture/churches-baptisteries/cathedral

[3] http://www.ferraraterraeacqua.it/en/ferrara/discover-the-area/art-and-culture/churches-baptisteries/cathedral/interno-della-cattedrale

MAIN RISKS IMPACTING THE SITE

Ferrara is taken into account as a case study for the heavy rain phenomena that affect the town.

RECORDED PAST EVENTS & ADOPTED MEASURES

In the past, the area underwent to flood events, in particular the area in front of the Cathedral Façade after heavy rains events result flooded (Fig.2.5). Even if no specific damages occurred to the cathedral after the flood, it has to be considered.
Other events that has to be considered are:

1. In May 2012**,** an earthquake damaged private and public buildings (churches and old houses in the historic centre), people, factories, commercial buildings.
Adopted Measures
Intermunicipality Plan of the Civil Protection, Communication campaign of safeguarding, restoring of private, public and religious damaged buildings.

2. Flooding due to the heavy rain and to the insufficiency of the drainage network and the sewage system. Flooding are always associated to extreme weather phenomena which, with the ongoing climate change, are more and more frequent and of particular intensity.
Adopted Measures
- Periodic cleaning of the storm drains, streets and squares to avoid their obstruction
- Weather alert communication on the web and social network

3. Among the sensitive elements, in addition to those mainly of socio-economic interest, large relevance assume the road network and the underpasses that can actually constitute, in case of flooding, a danger to the safety of people: no reference is included for the Cultural heritage protection.
Adopted Measures
Installation of traffic lights near the underpasses to prevent transit of vehicles in the road in case of flooding.

Figure 2. 6. *On the left:* "Padimetro" of Ferrara. This monumental water gauge indicates the different heights and corresponding years of Po River level at Pontelagoscuro, a locality few kilometers distant from Ferrara city center. It is showed on a coloumn near the Cathedral square. *On the right:* the flooded area in front of Ferrara Cathedral.

3. Kaštela (HR)

ACTION	EVENT	ICON
Pilot action 5: **Evacuation plans** in emergency phase in museum at historic buildings	Sea flood	
	Fire due to drought	
	Heavy rain	

SITE LOCATION		
Reference Point	**Lat: 43.55**	**Long: 16.383333**
Kaštel Sućurac	Lat: 43.545854	Long: 16.425540
Kaštel Gomilica	Lat: 43.547391	Long: 16.395452

Figure 3. 1. On the left: the location of Kaštela in the Splitsko-dalmatinska County, in Croatia. On the right: map showing Kaštela Bay and indicating the locations of the seven castles.

Croatia is a Central European and Mediterranean country, and according to an official statistics of number of inhabitants in 2011, it has 4 million and around 200 thousand citizens. Croatia is popularly referred as a land with thousand islands because it has one of the most indented coasts that counts over 1,200 larger and smaller islands, cliffs and ridges.

The city of Kaštela is located in the eastern Adriatic coast of Croatia, in Central Dalmatia (lat. Dalmatia), Splitsko-dalmatinska County. In particular, this site is located under a mountain, Kozjak, northwest of the city of Split, west of Solin and east of Trogir (Fig.3.1).

SITE DESCRIPTION

The uniqueness of Kaštela town lies in the fact that the city has developed itself around 7 castles (Kaštel Sućurac, Kaštel Gomilica, Kaštel Kambelovac, Kaštel Lukšić, Kaštel Stari, Kaštel Novi, Kaštel Štafilić), built during the time of Turkish pressure in Dalmatia, and around which the present day settlements gradually developed.

All the settlements of the town are presented in picture "geographical display Kastela bay", shown at fig. 3.1., on the right side.

The history of Kaštela goes far into the past, because of the remains of prehistoric times, some remains from parts of the Illyrian period, as well as the ruins of antique villas. During the 15th and 16th century the Trogir's and Splits rich class people together with the Church built castles to protect the estate and the population from the Turks attack. The walls of the fortress facing the sea were built in Renaissance style.

We single out the place of Kaštel Sućurac and Kaštel Gomilica, but taking into consideration the other settlements as well, refereeing the fact that all settlements of the City of Kaštela developed around fortresses, positioned on the coast, nearby sea.

KAŠTEL SUĆURAC

Figure 3. 2. Aerial view of Kaštel Sućurac.

Kaštel Sućurac is the oldest established settlement on the Kaštela coast (Fig.3.2).

In ancient times, in this area, Salonitans built their summer houses, and the most representative palace in the place is the archbishop's mansion built to protect the villagers of Putalj, located on the slopes of Kozjak, around the church of St. Juraj. Over time, with the additional activities on the tower, it became a settlement by the sea. Nowadays, Kaštel Sućurac hosts the Museum of the Kaštela city.

The area on which settlement is built represents embankment in the sea made in XVI century. Embankment spreads deeper in the sea as the number of citizens grow as a result of migrations due to war threats by Turks. According the report made by count Nikoa Correr 1583, there were 226 citizens in 54 houses, well protected by the defensive wall but unprotected by the seaside. The great number of houses from that area are still populated.

In the following images, collected in a publication of Bijaći-društvo za očuvanje kulturne baštine Kaštela, and TZ-Grada Kaštela (1999), the development through centuries of Kaštel Sućurac is represented (Fig. 3.4-3.7).

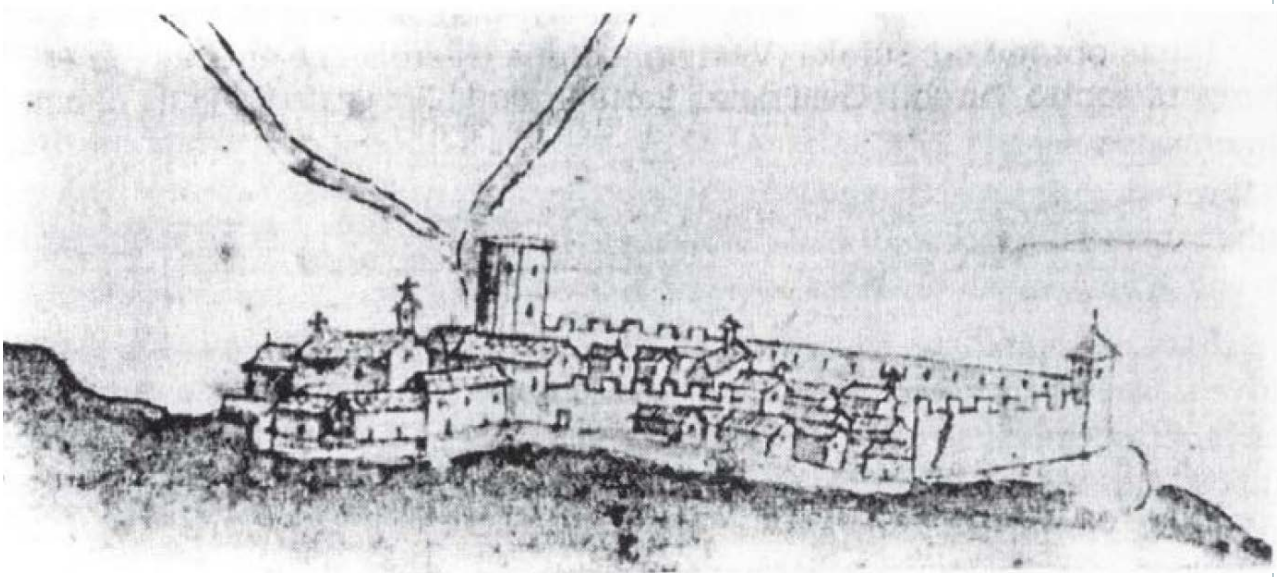

Figure 3. 3. Perspective drawing of Kaštel Sućurac from 1726 (A. Barbieri).

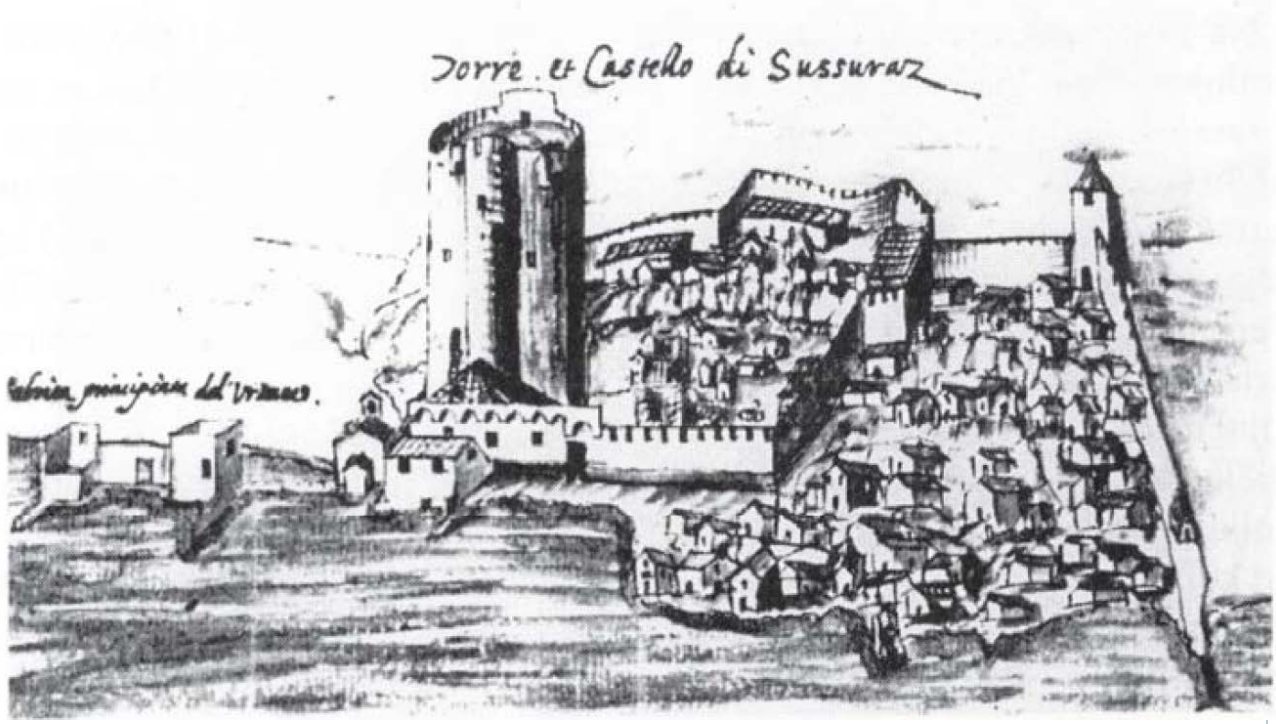

Figure 3. 4. Ancient drawing of Kaštel Sućurac by the end of XVI c. (Archivio di Stato Venezia).

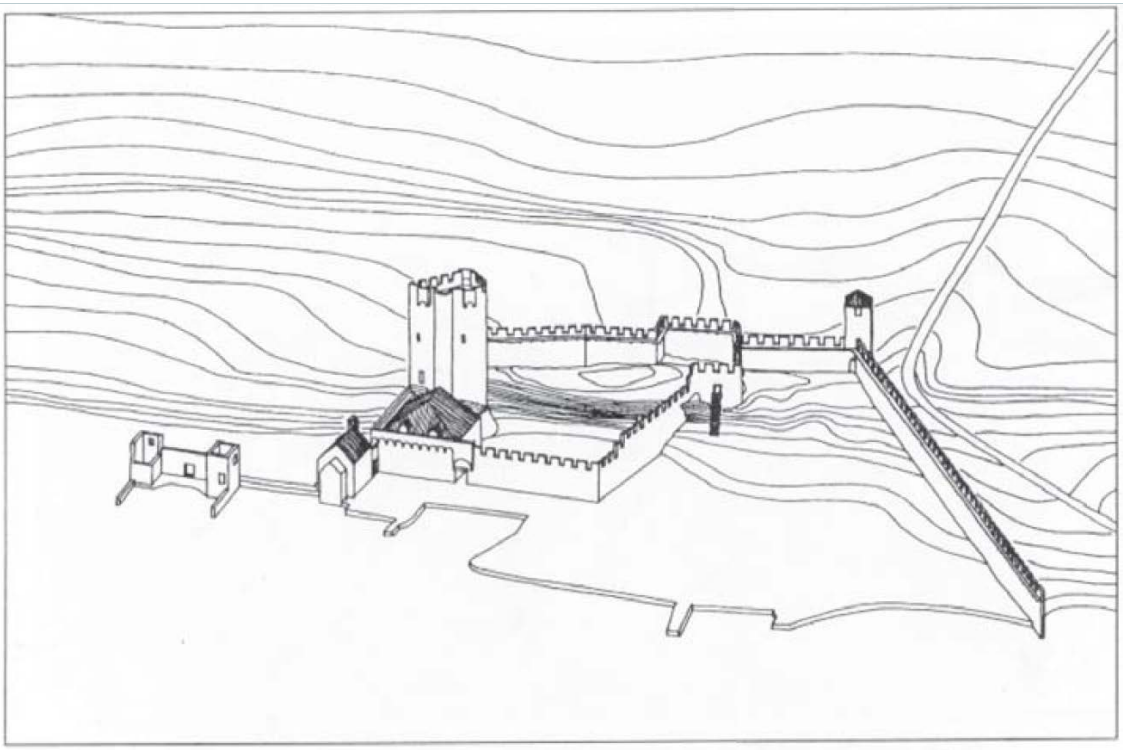

Figure 3. 5. Perspective drawing of Kaštel Sućurac, assumed appearance at the end of XVI c., view from the south (Katja Marasović).

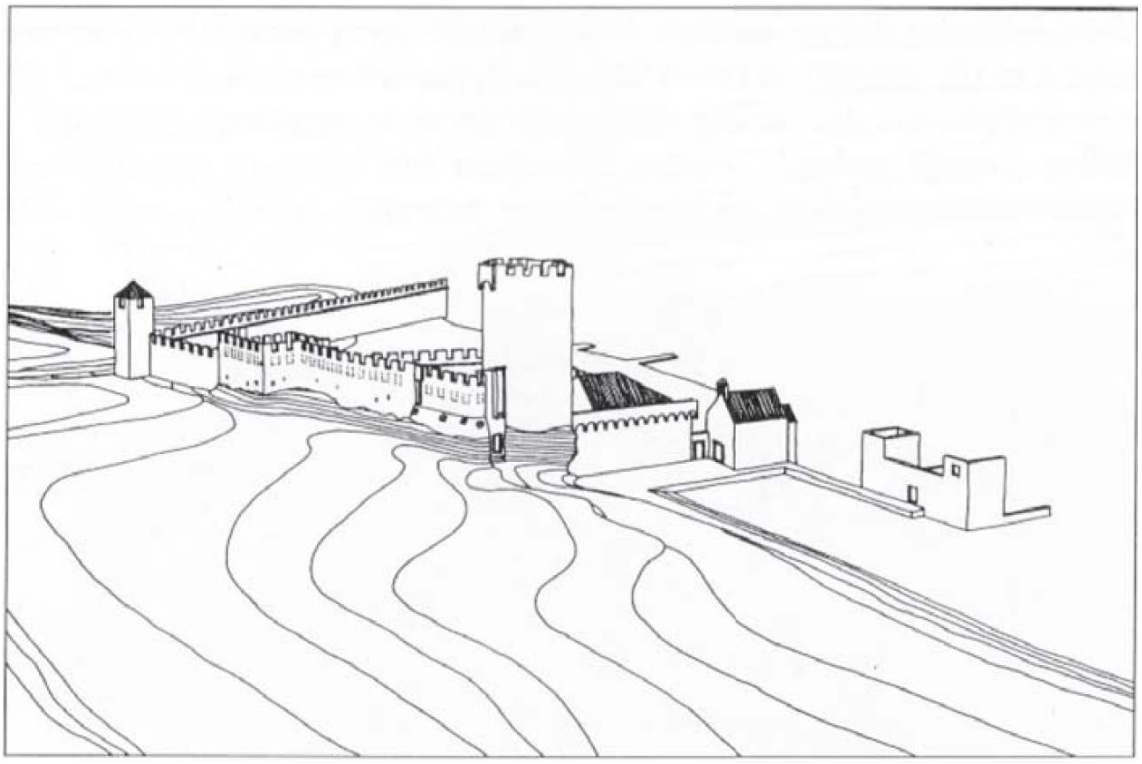

Figure 3. 6. Perspective drawing of Kaštel Sućurac, assumed appearance at the end of XVI c., view from the northwest (Katja Marasović).

SITE DESCRIPTION

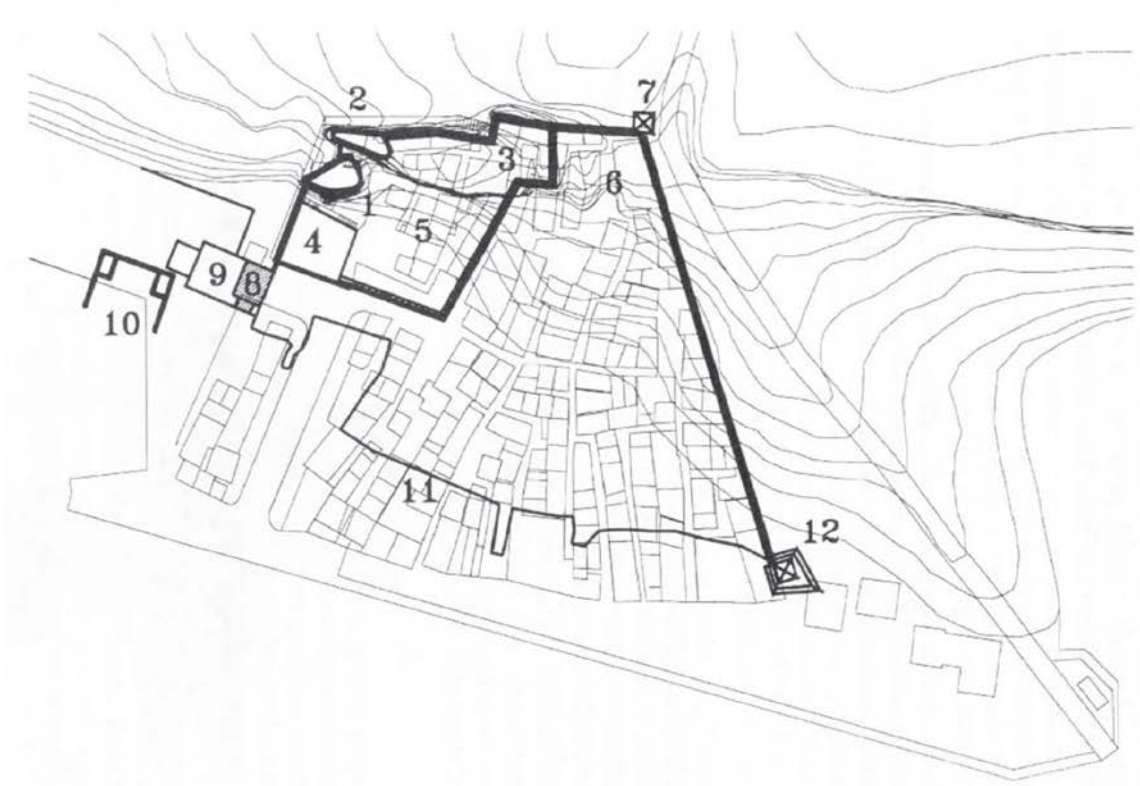

Figure 3. 7. Plan of Kaštel Sućurac, fortification scheme: 1. Fort from 1392 year; 2. Medieval building; 3. Shelter on the ridge; 4. Archbishop`s palace; 5. Settlement from the 1488 year; 6. Walls from 1509 year; 7. Nović tower; 8. St.Luka church, XVI c.; 9. St. Juraj church, 1961 year; 10. Unfinished building started by archbishop Zane; 11. Coastline at the end of XVI c.; 12. Fortin.

ADOPTED MEASURES

In the middle of the 20th century, a protective dam with a road was built as an attempt to reduce the sea impact. Since the settlement is sea level, the existing drainage system is inadequate in situation of high tide or heavy rain when public place and private homes are endangered. Although all house are stone made (limestone), water penetration was recorded through foundations and in the later period capillary in the wall of the houses that contributes to growth of the fungi and mold.

The "Assessment of population vulnerability, material and cultural goods and the environment of the City of Kaštela" and "Disaster risk assessment for Republic of Croatia" have been developed and they represent key documents for developing the "Rescue plan for the city of Kaštela".

SITE DESCRIPTION

KAŠTILAC, KAŠTEL GOMILICA

Figure 3. 8. Aerial view of Kaštel Gomilica.

Kaštel Gomilica is a part of the city of Kaštela, the second settlement from the direction of Split towards Trogir, located along the coast of the Kaštela Bay, as all Kaštela settlements are.

Kaštilac is the Fortress built by the Benedictine nuns from Split in 1529, on the small island called Gomile (meaning "a pile" of stones) (Fig.3.8) Based on the name of the island the castle and the settlement got its name, which is present until today.

On the underwater cliff, about 40 meters from the shore, a fortress of a square ground floor was build (Fig.3.9, Bijaći-društvo za očuvanje kulturne baštine Kaštela, and TZ-Grada Kaštela, 1999). The castle is connected to the land by a stone bridge, which is still present nowadays. The castle has a high tower in the middle of the northern wall over the entrance to the fort. His defensive function was lost in the 17th century.

The settlement is populated and it is facing the same problems as Kaštel Sućurac due to fact that it is built on an embankment. During the centuries, the sea impact has caused erosion of the foundation, cracks on buildings and penetration of the seawater when the tide level is high. For the location, the documentation for structural repair is currently under construction, but it does not resolve problem of high tide threat and sea flood impact.

The locality of Kaštilac is one of the most beautiful and its castle is one of the most photographed in Croatia. Indeed, Kaštilac is one of the favorite subjects of the majority of painters visiting Kaštela. In 2009, pictures and presentation of Kaštilac were utilized as content within a commercial promotion campaign of Croatia, realized by the Croatian Tourist Board, therefore the presentation of Kaštilac has "travelled the world".

Figure 3. 9. Time line of the development of the Kaštel Gomilica: a. Natural ground; b. XVI c.; c. XVII c.; d. XVII c.; e. 1831 year; f. 1964 year; g. 1985 year.

RECORDED PAST EVENTS

FIRE

Kaštela

- *July 27, 1971*. A serious, harmful fire on the Kozjak hill, which surrounds the city of Kaštela from the north side, happened on July 27, 1971.The southern slope of the Kozjak hill is very steep and the northern rocky slopes gradually cross over to the wavy plateau of Zagora (area involving the middle and a part of north Dalmatia).The fire caught the southern slopes of Kozjak Hill, the area opposite of locality Kaštel Sućurac and the huge spreading fire flame lasted for four hours.
- *August 22, 2010*. - "The biggest fire in the Split-Dalmatia County this summer. The hot flaming wave from Split and Solin edge areas, with a very rapid spread (16 meters per minute), came into Kaštela City. That day the fire caught large parts of green areas, the smoke and the ash, hid the sky above Kaštela. "(Book Volunteer Fire Department "Mladost", K. Sućurac, Gajdek Đ., 2014)
  "In just an hour, a fire strike worn with a heavy wind swallowed more than a hectare and a half of a forest on the hill Kozjak. On Friday at about 5.30 pm, fire in the Gaj area in Kaštel Sućurac caused a fire which was difficult to fire due to the wind "bura", as the main firefighter commander Kaštela, Milivoj Taslak, told us that the fire was under control at about 18.30. There were about 60 firefighters in the field with more than 20 firefighters." (Local main newspapers - Slobodna Dalmacija, 06. 03. 2015.)

Fire uphill of Kaštel Sućurac

Above Kaštel Sućurac there is the settlement Church of Croatian prince Mislav (835-845), who gave it for constructing in 839. The name Kaštel Sućurac derived from the name of the church. The church of St. Juraj together with all the properties of this church was given to Split Archbishop Peter as a counterfeit that he borrowed silver for making church utensils. This was the most important possession of the Split Archbishop.

- In 2017, a great fire occurred in place Plano (the hill area between city of Trogir and Kaštel Štafilić), at the entrance of the city of Trogir and above the last kaštel, Kaštel Štafilić. The fire was seriously threatening inhabited area, and strong wind, which is usual appearance in Dalmatia, which made the situation difficult completely for fire department squad. The critical situation was successfully solved; one house was unfortunately damaged and burned into flames, but no other lives or houses were damaged because of the fire.

When fire occurs, Kaštela's houses and people are always in danger, because fire is usually spreading along the hill Kozjak, and it can easily threats the nearby houses, causing a real danger to people's lives. Regarding the fact that Kaštela is a city, it can spread uphill of Kozjak.
In addition, it has to be mentioned that another possible cause of fire ignition can be attributed to the sparkles from rail road which is passing by the Kozjak hill. Especially during the summer period, sparkles produced by the train can easily cause a fire when the grass is dry around the railroad, as it was the case many times as well.

FLOODS

RECORDED PAST EVENTS

- *January 02, 2005*. – Heavy rain and heavy cold blowing wind (Bura) did not pass over the city of Kaštela. Broken trees, blocked streets, raised house roofs, broken commercial posters and billboards on metal and wood columns, could be seen almost in every street in Kaštela. (The title of the Croatian daily newspaper Slobodna Dalmacija, article from January 2, 2005)
- *October 12, 2012*. "In a few hours, most of the streams flooded. Manholes could not collect all the water that came up, so the inhabitants of Kaštela had to deal with serious issues, unexpected and large amounts of water flooding all over the streets of Kaštela city. Assistance of those in charge of duty, especially particular members of the Kaštela voluntary fire bridges contributed a lot with large amount of effort. Over 137 liters of rain per square meter fell in the area. With all rainfalls and floods on that day, between 15:00 and 16:00 h (in only one hour), around 90 liters of rainfall occurred in the city. Large amount of rain that day caused flooding across the whole city. "(Book Volunteer Fire Department Mladost, K. Sućurac, author Gajdek Đ., 2014)
- *September 12, 2014*. - From the Report of the Croatian State Meteorological Institute, located on the area of Kaštela Airport - "In the last 24 hours, 74 liters of rain per square meter fell in the area, but if judged according to the appearance of castles, gardens, and some residential and business facilities, in parts of Kaštela the amount of rain was much more higher."
- According to the official and starting document for creation of official Rescue Plan of the City of Kaštela "Assessment of population vulnerability, material and cultural goods and the environment of the City of Kaštela"- (document holder - State Protection and Rescue Directorate) in Kaštela area there are no permanent natural watercourses, they act as streams after abundant precipitation. Short-term and very intense rains cause rapid drainage from the basins, creating flow of water in dry reeds at those times, which is resulting with formation of streams, as a watercourse with enormous erosive power. Thus, according to "Assessment of population vulnerability" in most cases, apart from the flow of water that comes shortly after rain, the area is in most cases contaminated with material transmitted by the streams, mud, stones, and other impurities from the water flows.
- Exposure of the old town core in Kaštela to tidal waves and drifts that occur under the influence of air and wind pressure is present, especially in a case of strong south wind, which suppresses the water mass towards the closed end of the Kaštela's bay raising the sea level. For the Kaštela area, the rise of the sea level caused by the south wind in average ratios is about 4-8 mm, the residual height of the sea in 1996.; Kaštela, was between -50 and 25cm. (Source: Buljan, M., Zore - Armanda, M., 1976. Oceonographic Properties of the Adriatic Sea, Oceanography and Biological Biology - Annual Review, 14th).
- This exposure is also due to the sea level rise caused by climate change, this area is at risk of tidal waves and flooding of the coast. The tidal wave formed during the tide most often occurs in narrow and long bays such as the Kaštela Bay. It often occurs as a result of the weather, and at its height it prolongs the flood time of the affected area and creates the effect of a sudden rise in water level which is not common.

HEAVY RAIN

Each heavy rain in the town of Kaštela provokes the flooding of the old city cores, and every Kaštel in all settlements, because of the tidal waves in those moments is threatened.

ADOPTED MEASURES

The "Assessment of population vulnerability, material and cultural goods and the environment of the City of Kaštela" and "Disaster risk assessment for Republic of Croatia" have been developed and they represent key documents for developing the "Rescue plan for the city of Kaštela".

4. Kočevje (SI)

ACTION	EVENT	ICON
Pilot action 4: **Evacuation plans** in emergency phase in museum at historic buildings	Heavy rain	

SITE LOCATION	
Lat: 45.642961	**Long: 14.859383**

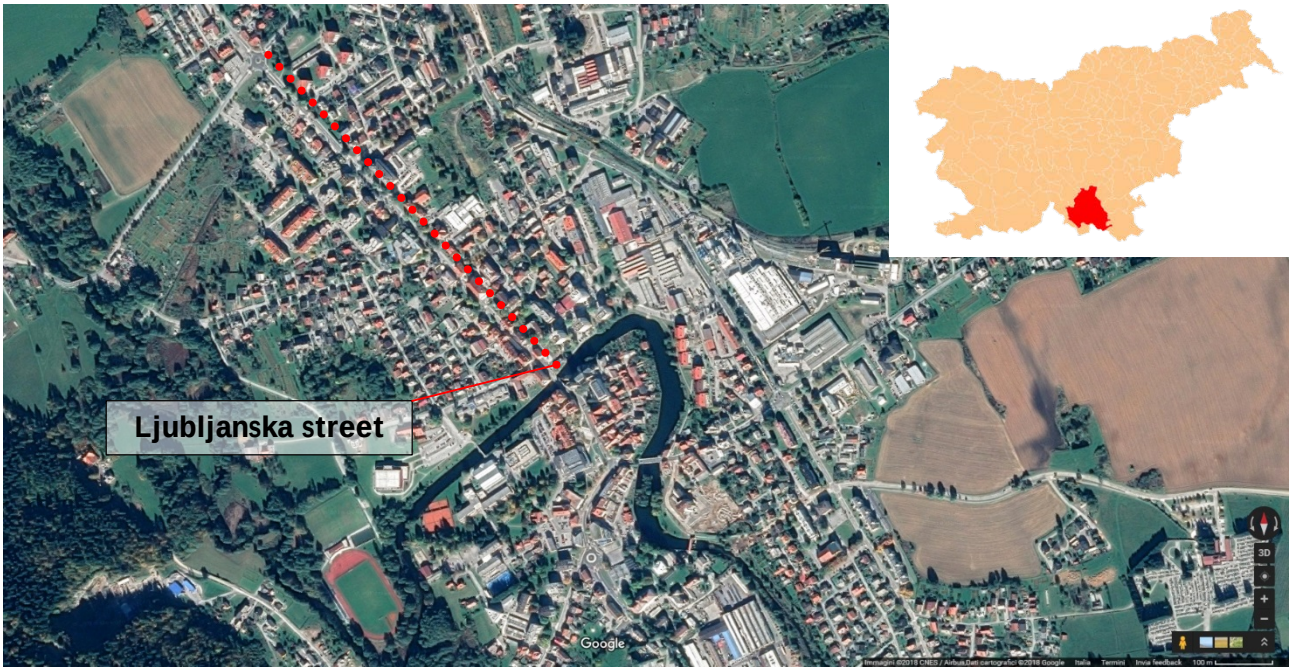

Figure 4. 1. On the top, the municipality of Kočevje highlighted in red, in southern Slovenia. On the bottom highlighted in dotted red line Ljubljanska street.

Kočevje is a municipality in southern Slovenia, located between the Cherca and Kolpa Rivers. In particular, the town hosts the majority of its historical buildings in the in the city centre along Ljubljanska street (Fig. 4.1), representing the built heritage of the city.

SITE DESCRIPTION

INTRODUCTION

In the process of recording the cultural heritage and state of structures in terms of the level of preservation of cultural heritage in the changing environment and environment-related climate change, the investor decided to include structures positioned along the Ljubljanskacesta and owned by the Municipality of Kočevje. Locations and house numbers of respective structures are listed in the following sub-chapters.

Ljubljanskacesta falls under types of urban areas characteristic of Ljubljana, and even more prominently seen in arrangements and planning of urban areas after earthquakes. In Kočevje, design trends typical of Secession architecture were introduced. It was thus a fashionable flirt with an idea that corresponded with the views of the emerging middle class. By placing these buildings into the Ljubljanskacesta area, a new urban design unbeknownst to Kočevje was formed in the urban locality – a city garden street. In this type of designing, a green area in front of the building has completely equal role to the building itself. Within a wider meaning of Secession architecture, the respective buildings importantly contributed to designing urban fabric.
All addressed buildings typically represent "middle-classed village houses" built in the late 19th and early 20th century. What the respective buildings have in common is their relatively moderate exterior with the most prominent element being the architectonics of windows and window frames. The buildings are of historical and cultural value for the Municipality of Kočevje. In the past, these were the places of inns, villas, homes and also a grammar school. Some buildings have preserved their function (grammar school), while others have been renovated to pursue business and tourist activities. A special example is Marijindom (today the main building of the Municipality of Kočevje) located at Ljubljanska cesta 26. It was once a cloister, and between the First and the Second World War also served as a hospital. There is also the RÖTHEL Villa (today the Social Work Centre building) at Ljubljanska cesta 9 which is one of more significant representatives of Secession architecture in Kočevje. It was commissioned by Dr Erich Schreyer. After he moved away in 1909, the Villa was bought by Dr Georg Röthel.

BUILDINGS

The respective buildings are located at the addresses along Ljubljanska cesta in the town centre of the Municipality of Kočevje, namely (Fig. 4.2):

- Ljubljanska cesta 3
- Ljubljanska cesta 6
- Ljubljanska cesta 7
- Ljubljanska cesta 8
- Ljubljanska cesta 9
- Ljubljanska cesta 26

Figure 4. 2. Image 1: Orthoimage of the town centre with the marked locations of buildings (note by the author: the number represents the house number of the building).

LJUBLJANSKA CESTA 3

SITE DESCRIPTION

The building is a typical representative of a "middle-classed village house" and was built in 1831, according to the year engraved into the stone portal (Fig. 4.3-4.4). It is of a rectangular shape with a floor area of 19.25 x 16.02 m. The building has the groundfloor, one storey, a mansard and an attic. The groundfloor comprises three small business premises suitable for pursuing different service activities or a shop for non-food products, and common premises of apartments located on the first floor and mansard. The main entrance is facing Ljubljanskacesta and organised through central portal and vestibule. The attic of the building is empty and is used as a drying room for clothes or an additional storage facility.
In 2008, the building was completely reconstructed pursuant to the project documentation drawn up by the AG Inženiringd.o.o. company and the "Inspection report of the Ljubljanskacesta 3, Kočevje business and residential building,evaluation of earthquake resistance and proposal for structural rehabilitation and reinforcement, no. DN 461196/2001" prepared by the Building and Civil Engineering Institute ZRMK Ljubljana.

Figure 4. 3. Building viewed from Ljubljanskacesta

Figure 4. 4. View of side and front façade

Structural Design

Foundations and foundation walls are made of stone. Outer and inner supporting walls are built of stone or a combination of stone and full brick. Ceiling structures are executed as reinforced concrete plates or brick arches with an addition of reinforced screed. The roof support structure is made of wood.

RECORDED PAST EVENTS & ADOPTED MEASURES

According to the project of the AG Inženiring d.o.o., the rehabilitation of the building (2008) comprised the rehabilitation of foundation walls, groundfloor walls and ground plate against the excessive moisture levels in structures through capillary absorption of groundwater (Fig. 4.5-4.6). Supposedly, the performed rehabilitation works comprised a new drainage around the building, homogenisation of walls with systematic hydrophobic shotcrete, horizontal hydrophobic barrier, replacement of plaster on the groundfloor by new hydrophobic plaster, while the execution of vertical hydro-insulation of the building was also foreseen. Despite structural interventions performed, the outer walls on the groundfloor and in semi-basement show the signs of excessive moisture level caused by capillary absorption of groundwater, or probably due to sudden increasing volume of underground water due to heavy rainfall. A submersible pump is also installed in the semi-basement where storage facilities of residents and a heating station of the building are located. The pump is used to discharge groundwater and rainwater penetrating the building.

Figure 4. 5. Visible damp on inner plaster

Figure 4. 6. Visible damp on inner plaster.

LJUBLJANSKA CESTA 6

SITE DESCRIPTION

The building is a typical representative of a “middle-classed village house”. Initially, the house was probably similar to houses at Ljubljanska cesta 3 and 4. In 1938, Ivan Cetinski, a wine merchant from Morava, built a new house in the pre-war functionalism style at this location. It is of a rectangular shape with a floor plan of 12.00 x 27.40 m. The building comprises basement, groundfloor, first and second floor and a mansard. The building used to be a town and school library and has been unoccupied for several years now. Its exterior design is very moderate, with the architectonics of windows being the most prominent element. In the past, the extension to the building was constructed which ended with a terrace on the first floor.

Structural Design

The building has standard construction, its basement walls are executed in a combination of full brick and stone. The plates between the floors are mainly made of wood. An arched brick ceiling combined with concrete fillers is executed at the location of the main stairway. The building is founded on a brick and stone structure cemented by deteriorated mortar or soil. The roof support structure is made of wood. The supporting walls arewithout any appropriate hydro-insulation barriers. Local damage caused by leaking (through the roof and damaged façade plaster) and capillary absorption from the terrain is visible on the surface of façade walls (Fig. 4.7-4.8). The basement floor is completely flooded with groundwater which causes the load-bearing elements to deteriorate and also structural instability of the entire building.

The building has no circumferential drainage and appropriate drainage of rainwater arranged.

The exterior has not been significantly modified since its construction (except for the above-mentioned extension).

Due to leaking of rainwater through roof coverings, parts of wooden roof supporting structure have a high level of moisture, also the occurrence of dry rot is possible. The leaking roof also causes the wooden ceiling structure between the second floor and the mansard to deteriorate.


a.

b.

Figure 4. 7. Images a. and b.: Completely flooded basement floor of the building.

Figure 4. 8. Mildew on outer walls due to water leaking through façade and capillary absorption through non-insulated foundations of the building.

Figure 4. 9. Building depicted In a post-war postcard

Figure 4. 10. View of the building from 2013 (before the placement of a façade scaffold)

ADOPTED MEASURES
Recently, its exterior has been protected by a façade scaffold and jute, since the building presents risk to its immediate vicinity due to deterioration and falling elements.

LJUBLJANSKA CESTA 7

SITE DESCRIPTION

It is a 100-year-old, multi-apartment one-storey building without a basement which was several decades ago raised to include the mansard floor (Fig.4.11-4.12). Currently, the building is unoccupied, while in the past it was used by:

- Območno združenje Rdečega križa Novo mesto (Regional Red Cross association, Novo mesto)
- Local community
- Energy service office
- Fispat d.o.o. accounting service
- Društvo varnega zavetja (Safe Shelter Association)
- Social Work Centre
- Kočevje Student Club

An innkeeper, Ernest Petsche, constructed the building around 1908. The main façade of the former Sun Hotel (ZurSonne) is richly decorated with typical decorative and stylised Secession elements. After 1945, the building housed the registered office of the Kočevje Committee of the League of Communists of Slovenia and thus the building was known as "the Committee" or "the Red House".

The building is located in Kočevje, next to the Kočevje Grammar School. It was initially intended as quiet office premises for various local societies. The building has three floors (groundfloor, first floor, mansard) and no basement. Each floor comprises offices, toilets, hallway and staircase. A room for thermal energy supply using a thermal station of the district heating is located on the groundfloor.

Figure 4. 11. Building viewed from Ljubljanskacesta

Figure 4. 12. Building viewed from the yard

Structural Design

The respective building was built in 1910. Vertical load-bearing structures (walls of the building) are made of brick. On the other hand, horizontal load-bearing structures between floors are wooden (roof beams with filler and ground and ceiling processing). The load-bearing structure of the staircase is made of steel bars, concrete and brick fillers. The building is founded on a brick and stone structure cemented by deteriorated mortar or soil. The roof support structure is made of wood.

The supporting walls arewithout any appropriate hydro-insulation barriers. Walls have no visible cracks due to differential subsidence of the building. However, local damage caused by leaking (from the roof and through damaged façade plaster) and capillary absorption from the terrainis visible on the surface of façade walls (Fig. 4.13-4.19). The wooden ceiling structure above the first floor is partially in very poor condition due to leakage. There are visible deteriorations of roof watershoot due to dry rot in the damaged areas of the upper cornice. The roof support structure facing Ljubljanskacesta is also degenerated due to fire.

The building has no circumferential drainage and appropriate drainage of rainwater arranged.

The exterior has not been significantly modified since its construction.

Figure 4. 13. Falling plaster and visible leaking façade

Figure 4. 14. Falling plaster and visible leaking façade

Figure 4. 15. Inappropriate execution of installations on the façade – possibility of leaking

Figure 4. 16. Visible leaking in the mansard due to inappropriate execution of the roof and wear and tear of structure

a.

b.

Figure 4. 17. Images a. and b.: Mildew on outer walls due to water leaking through façade and capillary absorption through non-insulated foundations of the building

Figure 4. 18. Presence of mildew on outer walls due to leaking façade

Figure 4. 19. Deteriorated and old construction joinery

LJUBLJANSKA CESTA 8

SITE DESCRIPTION

It is a type of a “middle-classed village house” from the mid-19th century.The building belongs to a type of architecture that can be designated as Bidermeier architecture having a very moderate exterior design with the most prominent element being the architectonics of windows (Fig.4.20). The special feature of the house is its yard-facing façade which opens with arched passages on the groundfloor and on the first floor (Fig.4.21). The building has four levels (basement, groundfloor, first floor and mansard). The basement is used as an inspectorate archive. The inspectorate offices are located on the groundfloor. The first floor and mansard are designed for residential purposes.

Figure 4. 20. Building viewed from Ljubljanskacesta

Figure 4. 21. Building viewed from the backyard

Structural Design

The respective building was constructed in the mid 19th century. Vertical load-bearing structures (walls of the building) are made of brick. On the other hand, horizontal load-bearing structures between floors are wooden (roof beams with filler and ground and ceiling processing). The load-bearing structure of the staircase is made of steel bars, concrete and brick fillers. The building is founded on a brick and stone structure cemented by deteriorated mortar or soil. The roof support structure is made of wood.

In 2010, the building was significantly reconstructed pursuant to the project documentation drawn up by the Zasnova gradbeni biro, Lovšin Tone s.p.

The outer walls of the basement are without any appropriate hydro-insulation barriers. No cracks caused by differential subsidence of the building are visible on walls. However, basement walls are damaged due to leaking groundwater and rainwater. The wall structure in the basement has a high level of moisture, mortar and hydrophobic plaster with drying function are deteriorated and fall off in places (Fig. 4.22-23). The high level of moisture on basement walls also affects the static and mechanical stability of the building.

The building has no circumferential drainage and appropriate drainage of rainwater arranged.

a.

b.

Figure 4. 22. Images a. and b.: High volume of rainwater and groundwater in the basement and deterioration of walls


a.

b.

Figure 4. 23. Images a. and b: High volume of rainwater and groundwater in the basement and deterioration of walls

LJUBLJANSKA CESTA 9

SITE DESCRIPTION

It is a more than 100 years old middle-class building with a basement and currently houses the Social Work Centre. In the Municipality of Kočevje, the building is known as the Röthel Villa and is one of the most important representatives of Secession architecture in Kočevje (Fig. 4.24-4.25). It was commissioned by Dr Erich Schreyer. After he moved away in 1909, the Villa was bought by a retired grammar school senior teacher Krauland, and was then inherited by Dr Georg Röthel. During the most recent renovation in 2012, a decorative ceiling painting was discovered on the ceiling above the internal staircase.
The building has four levels (basement, groundfloor, first floor and mansard). Each floor comprises offices, toilets, hallway and staircase. A room for thermal energy supply using a thermal station of the district heating is located in the basement.

Figure 4. 24. Building viewed from Ljubljanskacesta

Figure 4. 25. Building depicted on the postcard

Structural Design

The building walls are founded on stone structures and concrete foundation installed in the homogeneous clay surface. Foundation footings in the basement area are shallowly buried under the basement floor level. Stone foundations are built with lime mortar and continue to the basement wall. Foundations and walls are not separated with a hydro-insulation material. No plaster with drying-function is applied on the basement walls. In addition, the execution of horizontal and vertical hydro-insulation barriers is also problematic. The basic structure of the outer basement section varies in thickness and is executed as a stone wall in combination with full brick. Walls built above the level of the surrounding terrain are made of brick (full brick). Also thin partition walls are made of the same material. Some walls, in particular in the loft, are made of wood and include a layer of thermal insulation. In 2013, the entire building was thoroughly renovated.

Despite the executed interventions, intensive dampness is visible on the outer walls of the basement due to the absorption of capillary moisture and the ingress of groundwater. The high level of moisture most likely affects the static and mechanic resistance of the entire building, since the deterioration of outer load-bearing walls in the basement is visible (Fig. 4.26-4.28).

a.

b.

Figure 4. 26. Images a. and b.: Dampnesson outer walls of the basement

Figure 4. 27. Groundwater in the basement

a.

b.

Figure 4. 28. Images a. and b.: Visible deterioration of basement walls

LJUBLJANSKA CESTA 26

SITE DESCRIPTION

According to some information, the building was constructed in 1887, and in the period between 1895 and 1899 it was redesigned in Marijindom. After the Second World War, the attic was rearranged in 21 apartments and offices were designed on the lower floors. Currently, the building houses the offices of the Municipality of Kočevje, administrative unit, court and some local societies.

The building consists of the groundfloor, first and second floor and mansard, and is covered by the hip roof (Fig. 4.29-4.32). It is rectangular in the ground plan view withNW-SE orientation and is located by Ljubljanskacesta. It is 50.10 m long and 18.81 m wide. The building has the basement only in its eastern ground plan section (over a quarter of the building's ground plan).

The main entrance is facing south-west (towards Ljubljanskacesta), while there is asphalt car park and a back entrance at the back).

Figure 4. 29. View of the main façade facing the street

Figure 4. 30. View of the façade facing the yard

Figure 4. 31. View of the side façade

Figure 4. 32. View of the side façade

Structural Design

The data provided below are taken from the "Report no. P 258/10-650-1 on the review, inspections and analysis ofthe load-bearing structure and measurements of moisture in the Kočevje municipality and administration building, Ljubljanskacesta 26, withguidelines for rehabilitation and other measures", drawn up by the Slovenian National Building and Civil Engineering Institute, Department of Constructions, 28 May 2010.

The load-bearing structure includes strip footings, load-bearing walls, ceiling structures and wooden roof support structure.

The foundations are strip-stone foundation walls. In the section with no basement, the bottom of foundations is 2.0 m deep at the angle of the terrain, while in the section with the basement at the depth of 2.6 m. The foundations are made of stone blocks joined withlime mortar**. Up to the depth of 2.0 m, the mortar is hard, while below it is muddy and viscous due to water penetration.**

The load-bearing walls are built and relatively accurate in their arrangement in terms of the ground plan and the height of the building.In addition toouter walls, the building has inner longitudinal walls in two axes along the central hallway. Since the hallway runs across thecentral part of the building, the

arrangement of walls is symmetric in the longitudinal direction. Arrangement and thickness of transverse walls is somewhat less accurate.

Several inner walls of the basement are entirely made of full bricks laid on lime mortar, some walls are entirely made of stone, while some of them have layers of bricks at different levels. Some transversal walls have their central part built of full brick – these are most probably initial openings walled-up.

The thickness of inner basement walls ranges between 85 and 110 cm (plaster included).

The load-bearing wallsare made of brick on the groundfloor and the first and second floor. They are made of full bricks of old layout in lime mortar. Outer and inner longitudinal walls, which mainly support the ceiling structure, are 70 cm thick from the groundfloor to the second floor (plaster included), or about 60 cm without plaster according to dimensions of old brick layout. The structure thickness of inner transversal load-bearing walls is 30, 45 or 60 cm.

In addition to load-bearing walls, the building has partitions, mostly transversally oriented, while some of them are also arranged in the longitudinal direction of the building. Upon inspecting wooden ceiling structures above the first floor it has been established, that partition walls are also made of bricks of old layout, but are only 15 cm thick. On the second floor, the transversal partition walls are built on one of the wooden ceiling beams above the first floor. The wall axis is not aligned with the beam axis. The wall linked to the beam is built eccentrically. Longitudinal partition walls also directly apply pressure on wooden ceiling beams.

Given the age and visible damage, the walls are most probably not connected with wall links.

Structures above the basement are brick arches, while above the groundfloor they are mainly brick arches, partially levelledwooden ceilings. Above the first floor, the arches are only designed next to the staircase, while the other rooms have wooden ceiling. Above the second floor, the ceilings are wooden. Arches above the majority of offices are built using intermediate supporting steel girders of I profile. These girders are mostly laid from the external to the internal longitudinal wall, with arches built in between.Only in arches above the first floor, the girders are laid in the longitudinal direction of the building. Arches above hallways and some offices or rooms on the groundfloor are built in one arch from one to the other supporting wall.

The basement is exposed to constant ingress of water causing the load-bearing elements in the basement to deteriorate. Outer and inner load-bearing walls of the basement are mostly degenerated which affects the structural stability of the entire building.

Due to leaking of rainwater through roof coverings, **parts of wooden roof supporting structure have a high level of moisture**, also the occurrence of **dry rot** is possible. The leaking roof also causes the **wooden ceiling structure** between the second floor and the mansard to **deteriorate**.

On the surface of outer walls of the building, **local damage caused by leaking** (through the roof and damaged façade plaster) and **capillary absorption from the terrain** are visible (Fig. 4.33-4.37).


a.


b.

Figure 4. 33. Images a. and b.: Falling plaster and visible leaking façade


a.


b.

Figure 4. 34. Images a. and b.: Falling plaster and visible leaking façade


a.


b.

Figure 4. 35. Images a. and b.: High volume of rainwater and groundwater in the basement and deterioration of walls


a.


b.

Figure 4. 36. Images a. and b.: High volume of rainwater and groundwater in the basement and deterioration of walls


a.


b.

Figure 4. 37. Images a. and b.: Visible leakage of the existing roof coverings and damage on the wooden roof supporting structure and structure between floors

5. Krems (AT)

ACTION	EVENT	ICON
Pilot action 2: **Preparedness strategies** for monumental complexes in historic city centres	Flood events in large basin	

SITE LOCATION	
Lat: 48.407603	**Long: 15.596460**

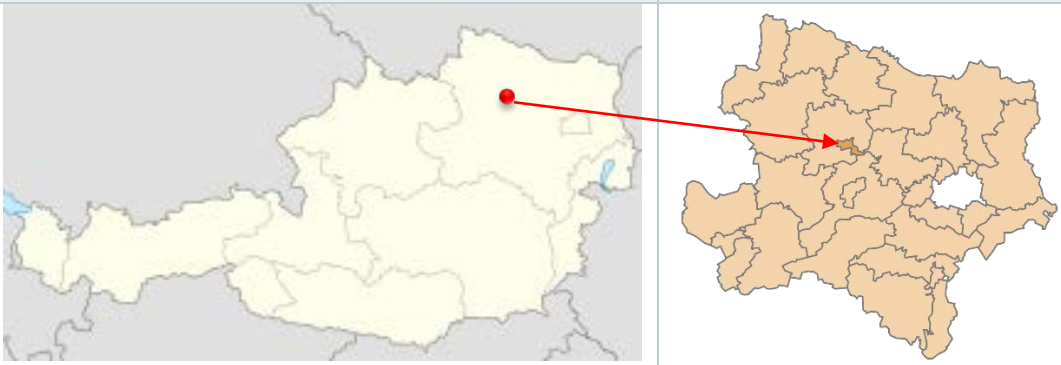

Figure 5. 1. On the left: Krems location within Austria; on the right: Map of the Austrian State Lower Austria highlighting Krems.

Krems an der Donau rises on the eastern Wachau, a stretch of the Danube Valley between Melk and Krems in Austria, which is included in the World Heritage List for its importance and high visual quality as cultural landscape[4] (Fig.5.1).

[4] https://whc.unesco.org/en/list/970

Figure 5. 2. Panoramic view of Stein an der Donau (https://de.wikipedia.org/wiki/Datei:Stein_a_d_Donau_Panorama.jpg)

Krems and Stein are twin towns on the north bank of the Danube (Fig.5.2). Both owe their development and historic significance to their location along the main route from East to West along the Danube and their function as a point of reloading from river to land traffic, the cultivation of grapevine and the resulting trade (Bundesdenkmalamt/ REPUBLIC OF AUSTRIA, 1999).

Krems and Stein, which is part of the municipality of Stein but a former independent city, both hat old towns that date back to the Middle Ages, complete with parts of the old city walls and gates. Both old town centres are protected by the Austrian monuments protection law and listed on the list of cultural property protected under the Hague Convention of 1954 (CPP) (Fig. 5.3-5.4). Krems and Stein are also part of the UNESCO World Heritage Region Wachau, in the buffer zone.

Krems and Stein own their importance and riches to the river Danube and the trade on and along the river side in former times.

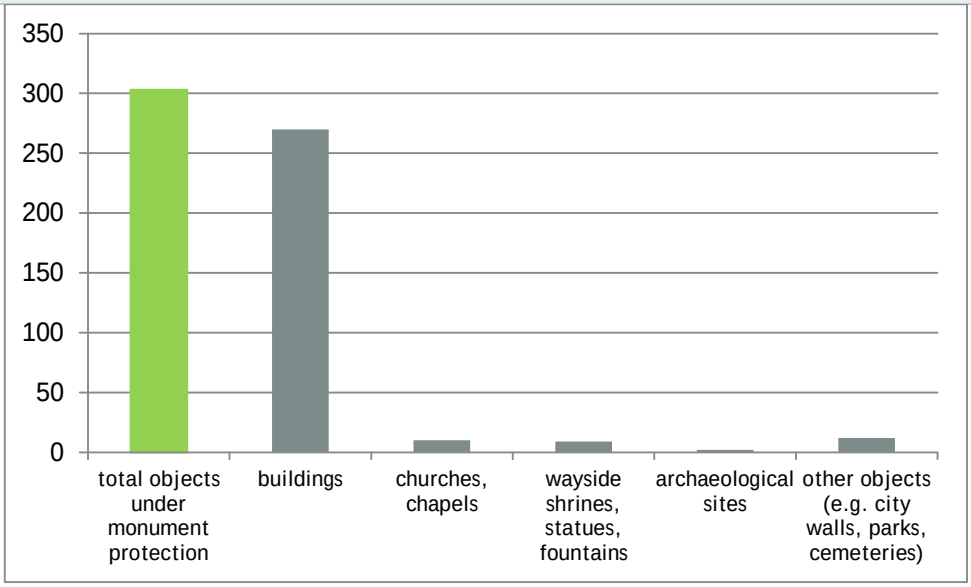

Figure 5. 3. Krems has in total 303 objects protected by the Austrian monuments protection law.

SITE DESCRIPTION

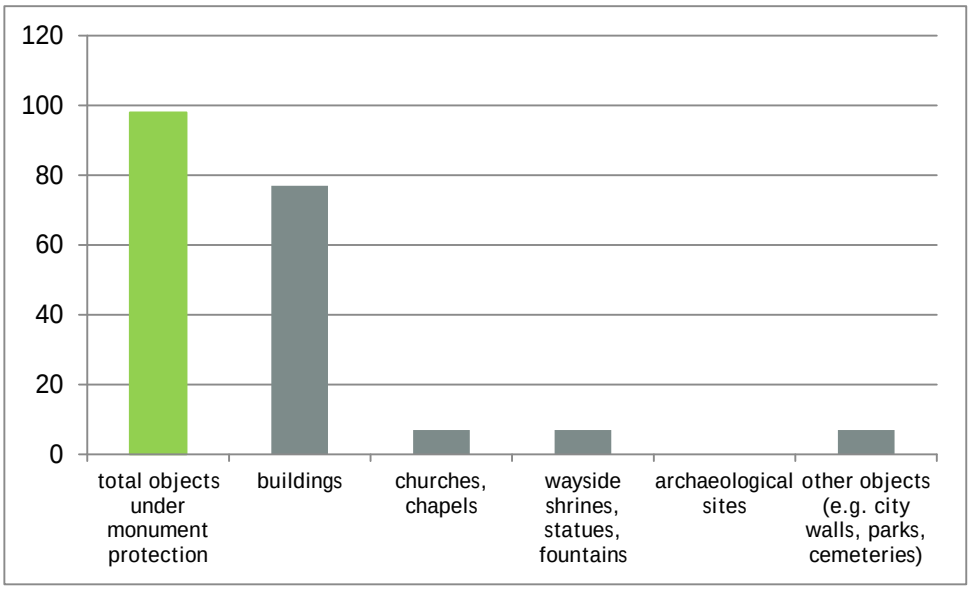

Figure 5. 4. Stein has in total 98 objects protected by the Austrian monuments protection law.

MAIN RISKS IMPACTING THE SITE

Figure 5. 5. The hora.gv.at maps do show the risk areas for flood in Austria. Both Krems and Stein are included.

The main risks posed to Krems and Stein are floods by the river Danube and rivers and rivulets flowing into the Danube, as is to be seen on the map from the hora.gv.at system (Fig. 5.5). Fire is recognised as big risk for the old towns since the roofs of the buildings often are immediately connected. The fire brigades of Krems and the whole region are adapting their firefighting plans at the moment and updating the so called "Case Zulu" which is fire in the old towns of Krems and Stein.

In the more recent past no big fire has been reported in the old towns of Krems and Stein, but Danube river floods have damaged buildings especially in the old town of Stein, which is located immediately on the shores of the Danube. The old town of Krems lies a bit inland and higher up, wherefore it was not flooded as often as Stein. The mobile flood protection system is currently up and working. In 1991 the old town of Stein was flooded huge style for the last time. Other parts of Krems and Stein were flooded in 2002 as well.

MAIN RISKS IMPACTING THE SITE

The old towns of Krems and Stein are medieval in their structures. Bricks, stones and wood are the main building materials. Wood especially in the roof constructions and first floors. In Stein, immediately on the shores of the Danube, the ground floors are built slightly sloping towards the Danube in order that when the flood was dropping the withdrawing water transported all the Danube mud and slime out of the buildings automatically.

Krems and Stein boast a number of museums. The most important are marked on the map (Fig. 5.6). Amongst them is the Landesgalerie Niederösterreich, being constructed at the moment. Some of them are built in the immediate flooding zone (at the moment protected by the mobile flood barriers). They house all kinds of collections, from paintings, books, statues of different materials, to technical exhibits.

Figure 5. 6. View of Krems and main monuments and museums locations.

RECORDED PAST EVENTS

Krems-Stein has been affected by floods several times, as shown in a monumental water gauge (Fig. 5.7), reporting their dates: 1830, 1776, 2002, 1795, 1799, 1740, 1880, 1899, 1893, 1897, 1991, 1954, 1862, 1883, 1892, 1888, 1730, 1803 and 1890 (listed from the highest to the lowest).

Furthermore, a more recent flood event was registered in 1954.

Figure 5. 7. Flood marks of past flood events in Krems-Stein, represented from the highest to the lowest on the marker.

Flood Krems-Stein June 2013

RECORDED PAST EVENTS

Figure 5. 8. Erection of the flood prevention system–Flood Stein 2013. The mobile flood prevention system held, Stein was not flooded in 2013.

Figure 5. 9. Local residents and members of the fire brigade filling sandbags to secure building structures–Flood Stein 2013.

Figure 5. 10. Flood defense systems build up for local shops–Flood Stein 2013.

Flood Krems-Stein August 2002

Figure 5. 11. Construction of the mobile flood protection system. The district Stein was defended against the high flood.

RECORDED PAST EVENTS

Figure 5. 12. In the district Mitterau the flood couldn´t be prevented and caused major damage to streets and bridges as never seen before.

Flood Krems-Stein August 1991

Figure 5. 13. The historical part of Stein itself was flooded in 1991. Gangplanks were erected to provide the residents a dry passage from the first floor.

Figure 5. 14. Peak level before the mobile flood protection was proposed.

ADOPTED MEASURES

Plans and strategies for firefighting in the old towns of Krems and Stein do exist and are currently updated, following up on lessons learned from a big fire in the outskirts of Krems in August 2017.

At the moment the emergency plan foresees 40 firefighting squads, all together 200 persons, with their standard equipment and three turntable ladders. Coping mechanisms and processes with the executive are developed, as are assembly areas for civilians, injured persons, the staff personnel, reserve units, and media.

The following projects related to the old towns of Krems and Stein are currently in the process of updating:

- Update of water intake points and maintenance plans

- Assessment of hydrants

- Fire authority assessment of the buildings in the old towns

- Update of the emergency plans for the old towns

- New methods and assessment of dealing with roof fires

- Asymmetrical threats (together with the Austrian Armed Forces)

The main risk in Krems-Stein is flooding from the river Danube and rivulets flowing into the Danube. From 1994 until 1996 the mobile flood protection Krems-Stein was constructed. Before that the existing dams only could prevent floods lower than the one occurring every 17 years on average. The mobile flood protection was built to withstand floods occurring every 100 years on average. One of the demands of the flood protection was not to lose sight of and connection to the Danube. Therefore, it was constructed as a mobile flood protection that can easily be erected in case of flooding. When flood threatens the mobile system consisting of steel pillars which can house the mobile aluminium stop logs is erected. The aluminium stop logs are raised to a height according to the flood threat. It can be raised up to 1.60 metres (not including the permanent wall), the calculated height of a flood occurring every 100 years on average. It managed the flood of 2002 well enough but only barely withstood the flood of 2013, during which the mobile flood protection had to be made higher with sand bags piled on top of the aluminium stop logs. Stone-clad flood control walls and dams, together with a drainage network with a flood control pumping station, complete the flood protection system. The overall length of the flood protection system for Krems-Stein is 1670m. It consists of 247 steel pillars and ca. 2600 aluminium stop logs, which are stored with the fire brigade in Krems. It is the fire brigades which erect the barrier, if necessary support by the Austrian Armed Forces. The pictures below show a demonstration of the system in January 2018 (Fig. 5.15).

https://www.hydro-ing.at/krems-stein-598.html

Figure 5. 15. A demonstration of the mobile flood protection system in January 2018.

6. Pècs (HU)

ACTION	EVENT	ICON
Pilot action 6: **Preparedness strategies** for monumental complexes in historic city centres	Heavy rain	

SITE LOCATION	
Lat: 46.07125	**Long: 18.23311**

Figure 6. 1. On the left: location of Pècs respect Hungary; on the right: aerial view of Pècs.

The historical downtown of Pécs lies at the southern hills of the Mecsek, in Hungary (Fig.6.1).

SITE DESCRIPTION

Pécs lies at the southern hills of the Mecsek. The different cultural layers of the city stratified on each other through specific periods of history. The very foundation of this multicultural structure lies 3 meters below the surface, where the Roman city Sopianae – the administrative centre of Valeria - lived its flourishing life. It is the very epoch from which the unique collection of early Christian burial buildings derives from, which was acknowledged by the UNESCO World Heritage Convention 2001. Nine, out of the nearly 27 discovered burial buildings, is open to the public, including the Mausoleum and the Cella Septichora .

The next formative period of the city came after the "Magyars" settled in the Carpathian Basin and founded the Hungarian kingdom in 1000. St. Stephen the first king founded the Christian state and nine Bishopric as well.

The next major cultural influx came along with the political ambitions of the Ottoman Empire in 1541, leaving behind a surprisingly rich collection of Islam architecture. The Mosque of Pasha Gázi Kászim in the main square of Pécs was turned later back spiritually to a Catholic Church but it still preserves the features of Islam architecture. The Mosque of Pasha Jakovali Hassan at the western gates of the historical downtown however, provides again religious services for the local Muslim community.

SITE DESCRIPTION

The Cella Septichora Visitor Center, presenting the ancient Christian (Early Christian) relics/remains, opened its doors in March 2007 (Fig. 6.2). The unique, visitable late Roman tombs/sepulchral structures - which have been part of the World Heritage since 2000 - have been featured in a single complex. The Early Christian Mausoleum and the Apáca street Tombs/Sepulchral constructions form a separate island in the area of the World Heritage Site.


Figure 6. 2. Images of Cella Septicora Visitin Center.

MAIN RISKS IMPACTING THE SITE

The historical center of Pécs basically has a rainfall collection network. During heavy rainfall this system becomes saturated (especially when the sediment is accumulated), and water penetrates the spaces below.

RECORDED PAST EVENTS & ADOPTED MEASURES

The water damage (protection) plan for the city of Pécs has been completed in 2016, but it mainly contains flooding emergency protection procedures concerning public citizens.

Due to the heavy rainfall that occurred in Pécs between May 30 2010 and May 16, on July 22, 2012, and July 10, 2013, at Cella Septichora Visitor Center (Fig. 6.3), water abrasions of different strengths occurred in the following places:

- The water and the mud flowed in through several points of the concrete protecting wall and of the glass roof, which directly affected the interior of the Cell Septichora, the south-western corner of Tomb III, and flooded the other places of the visitor center (corridor, elevator shaft, ...).
- The surface of the paved area located outside the building, tot he north of the glass ceiling collapsed in several places.
- At the locations described above, the contracted service provider performs warranty repairs, but unfortunately, in case of extraordinary rainfall the water penetration reoccurs/is repeated.

Figure 6. 3. Heavy rainfall effects at Cella Septichora Visitor Center.

7. Troja (CZ)

ACTION	EVENT	ICON
Pilot action 1: **Preparedness strategies** for monumental complexes in historic city centres	Flood events in large basin	

SITE LOCATION	
Lat: 50.119	**Long: 14.413**

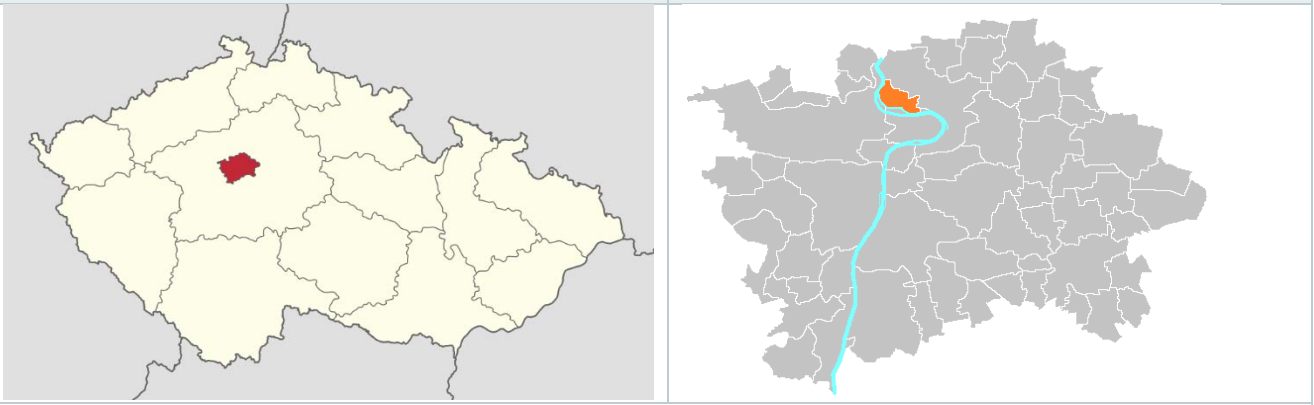

Figure 7. 1. On the left: Prague location within Czech Republic; on the right: Troja location within the city of Prague.

The Historic District in Prague Troja rises on the iconic and important river Vltava, in Czech Republic (Fig.7.1), characterized by shallow banks smoothly continuing in the adjacent urban areas dating back to medieval times. The settlement is featured by natural heritage, hosting the Prague Zoological and Botanical gardens, and protected cultural monuments, namely the Baroque Chateau Troja, Historic Brewery and Troja Mill.

SITE DESCRIPTION

In Prague Troja the iconic and important river Vltava conserves its natural white water character with shallow banks smoothly continuing in the adjacent urban areas which have historic roots long back in the medieval times. The settlement is organically pervaded with rather dramatic natural heritage creating a geo-park situation exploited for expositions of the Prague Zoological and Botanical gardens. The contact of the district banks with the river reaches several kilometres and the territorial protection of Troja has been built only along a part of it. Large part of the Troja territory is not protected, which creates specific socio-economic problems in the community. The case study is therefore focused not only on physical protection of cultural and natural heritage but also on creation of a management policy acceptable for all stakeholders – in this case inhabitants but also managers of important cultural and entertainment facilities (ZOO, Sport clubs). Currently the City of Prague is preparing the study of possible scenarios of additional flood protection of the Zoological garden together with valuable and protected cultural monuments, namely the Baroque Chateau Troja (Fig.7.2), Historic Brewery and Troja Mill. The aim is to prepare relevant material for decision making process for the most suitable technical and architectural solution, respecting the cultural, historic, urban and landscape values of the locality.

SITE DESCRIPTION

Figure 7. 2. Early Baroque Chateau Troja, built in 1679-1691. On the left, aerial view; on the right internal ceiling richly decorated.

MAIN RISKS IMPACTING THE SITE

River flood represents the most important risk in the area. Due to climate change, the area starts to experience a higher frequency of major floods, similar to the medieval period with intervals of about ten years repetitions.

Minor risk is associated with wind storms, which are dangerous namely for large trees in the historic gardens and natural areas of the district.

RECORDED PAST EVENTS

Due to a very different depth of water and different places and velocity of water stream during recent floods the district experienced a rather wide diversity of damage. The effects on buildings can be sorted according to forces generated during flood situation: damage due to horizontal static pressure of raised water typically destroys light shutters of building openings, e.g. doors and windows, especially glazing, and it can destroy free standing walls and fences, in many cases together with dynamic action of streams and flows.

In Troja, the Chateau garden wall was destroyed (Fig. 7.3). Upward hydrostatic pressure can uplift floors or whole objects, decreases their stability against overturning and facilitates their damage by horizontal forces, it further causes water penetration through sewage systems into areas protected by vertical structures and having floors below the high rise water level. Such damage impacted the historic mill in the area. Dynamic low velocity stream action is typically observed inside closed buildings where floated objects move and are displaced, e.g. furniture from one into another room, long lasted action can even wash out subsoil or clay mortar from masonry. It caused collapse of historic retaining walls. Dynamic high velocity stream action represents one of the most dangerous actions on structures and it is responsible for the majority of severe damage on bridges, on earth structures, (e.g. dams), destruction of masonry by washing out joint mortars. In our case study this effect in combination with other actions, including water pollution, severely damaged a foot bridge which did not collapsed but its degradation accelerated and the bridge collapsed 15 years later (December 2, 2017). Further a relocation of some detached wooden parts from historic buildings occurred.

Specific damage is caused by compacting of soils or infill where water penetrating through particulate media can wash out fine particles and cause remarkable compacting and subsidence, which may cause further damage on infrastructure, e.g. sewage piping or pavement damage. Saturation of materials with water causes a wide variety of actions and damage related to volumetric changes, chemical action, loss of strength and some more – such types of damage were fund on the buildings in Troja. Soiling of cultural heritage

RECORDED PAST EVENTS

objects by mud and debris which are transported and deposited in cultural heritage objects was another type of damage. Post-flood effects were apparent and they included, for example, differential settlement, drying effects, biological attack, inappropriate remedial interventions, change of interior climate (high humidity).

Figure 7. 3. Photos illustrate the extent of the river flood in 2013.

ADOPTED MEASURES

The devastating flood in 2002 accelerated construction of combined permanent -temporary protection barriers, which proved a successful protection of an important part of the territory during the recent flood in 2013. However, a substantial part of the urbanized area is still unprotected by the river barriers and under a river flood risk, which creates specific socio-economic problems in the community.

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