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Canterbury: 24-26 June, 2020

TITLE:

THE PAVEMENT HANDBOOK FOR BRATISLAVA CITY HISTORIC AREAS – CONTRIBUTION ON HOW TO MAKE THE HERITAGE CITIES MORE RESILIENT IN THE ERA OF CLIMATE CHANGE

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INTRODUCTION

The impacts of climate change are already affecting our everyday life and threatening the state of cultural heritage of our cities, both tangible and intangible. These cities will face frequent extreme events in future and the risk to cultural heritage and historic urban centers from climate change will also increase. “... *Megalopolises are the best invention in the history of humankind and our future greatest hope...*”ⁱⁱ, these words of the economist Edward Glaeser hence reflect in a broader sense current needs of urban development.

Therefore, some of the relevant questions to ask are: How to create a human friendly city environment? How could we make the historic urban areas more sustainable and resilient? How could we get all the related parties to participate in terms of improvement of life in our historic towns? The submitted contribution is searching for answers to these questions. The aim is not only to introduce the climate change issues that the city of Bratislava is dealing with on daily basis, but also to inform about the H2020 project ARCH: Advancing Resilience of historic areas against Climate-related and other Hazards, about its principles and co-creation activities. Contribution will further specify the project work done so far and suggested methodology for the development and elaboration of the “The pavement handbook - guide to design pavements in historic areas”. This poses a challenge also for urban planners and conservationists that are confronted with planning of Bratislava, as rapidly developing post - socialist city.

INTERNATIONAL H2020 PROJECT ARCH

ARCH is a European-funded research project that aims to better preserve areas of cultural heritage from hazards and risks.ⁱⁱⁱ The ARCH team with the cities of Bratislava, Camerino, Hamburg and Valencia will co-create tools that will help cities save cultural heritage from the effects of climate change. ARCH will develop a disaster risk management framework for assessing and improving the resilience of historic areas to climate change and natural hazards. Tools and methodologies will be designed for local authorities and practitioners, the urban population, and national and international expert communities. The project will present various models, methods, tools and datasets to support decision-making. ARCH expert interdisciplinary team includes four European municipalities; research scientists, city network ICLEI and standardisation organisation DIN.

In order to achieve the project objectives and ensure applicability, acceptance and replicability of results, researchers, city practitioners, local policy makers, community members and other

CONNECTIONS: EXPLORING HERITAGE, ARCHITECTURE, CITIES, ART, MEDIA

AMPS, Architecture_MPS, Parade, University of Kent
Canterbury: 24-26 June, 2020

stakeholders will collaborate closely according to a co-creation framework and through the establishment of local partnerships.

The ARCH Team of the Bratislava city case consists of three partners: The City of Bratislava - represented by the Office of Chief Architect, Faculty of Natural Sciences of Comenius University in Bratislava and Municipal Monuments Preservation Institute in Bratislava. This ensures assembly of experts supervising the fields of ecology, environment, monument protection, urban planning processes, disaster risk management and climate change adaptation.

BRATISLAVA CASE STUDY

Bratislava, with 420 000 inhabitants, is the capital city of Slovakia, located in the south-west of the country. The city is administratively divided into 5 districts, and for self-government purposes, it is further divided into 17 city boroughs, each of which is governed by an elected local government and an elected Mayor.^{iv} Bratislava City is governed by the City parliament and the elected Mayor – currently a former architect Matúš Vallo. Bratislava is often historically referred to as the Beauty on the Danube. The river has long been to its utmost importance. The tangible and intangible heritage of Bratislava covers architectural, monumental, and archaeological, as well as natural heritage. It is characterized by complex settlement arrangements with a high density of cultural monuments, which are mainly at risk from heat waves, drought, fluvial and pluvial flooding, erosion, and other extreme weather events.



Fig. 1 Aerial view of historic Bratislava City in autumn time. Source: P. Chromek

The Old Town City Borough, is Bratislava's city core. This becomes increasingly crowded during the day as people commute to work or universities and visitors arrive either by buses or by ship cruises. The Old Town consists of two main protected areas of the Bratislava city. The medieval town center gained the status of monument reservation in 1954. The enactment of a monument zone, protecting the wider city core, followed in 1992.

PROTECTED AREAS OF BRATISLAVA CITY

On the basis of Act No. 49/2002 on the Protection of Monuments^v, Monument Board of Slovak Republic maintains a General list of National Cultural Monuments, which includes movable and immovable monuments and protected areas - conservation reserve or zone. The main strategic document that defines means of protection, preservation and regeneration of conservation areas is Principles of protection.

This applies also to the protected areas of the city of Bratislava. Conservation reserve^{vi} and conservation zone^{vii}, both located in the Old Town city borough, represent the preserved historic urban

CONNECTIONS: EXPLORING HERITAGE, ARCHITECTURE, CITIES, ART, MEDIA

AMPS, Architecture_MPS, Parade, University of Kent
Canterbury: 24-26 June, 2020

pattern of Bratislava City with most significant examples of tangible heritage such as immovable national cultural monuments. Conservation reserve consists of three different urban patterns. First, a medieval town core surrounded by remains of fortification walls, that is known for St. Martin's Cathedral, its many churches and three significant squares and narrow streets. Second, the Bratislava Castle, which is situated on the southernmost tip of the Small Carpathian Mountains and above the western side of the medieval fortification walls. Third, the riverfront below the castle, that is characterized mostly by new development.

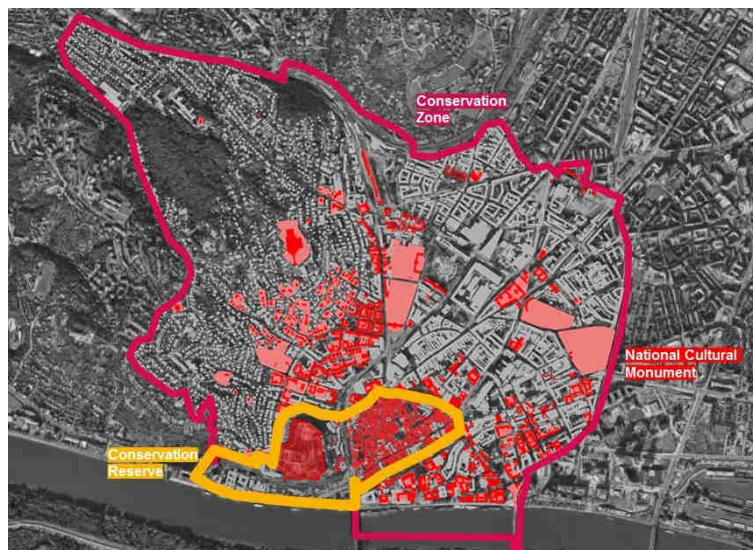


Fig. 2 Protected areas of Bratislava City. Source of the drawing: authors; source of the background map: <https://www.google.sk/maps>

The conservation zone is further divided into three sectors, based on the character of built-up area, architecture, terrain and landscape. The eastern part is characterized by compact city blocks of historic residential houses, modernistic single houses, parks and former industrial areas transformed into residential and office buildings. The western part of Conservation zone differs from the other parts of Old Town Borough with its situation on the Small Carpathian Mountain foothills, and mainly provides residential housing (villa houses). Last sector represents the industrial area and the surroundings of the main railway station.

CLIMATE CHANGES AND CULTURAL HERITAGE

The heritage areas of Bratislava are exposed to certain climate - related and other hazards, that are affecting the quality of life and both – built up and natural environment. The first vulnerability assessments were undertaken as part of the Horizon 2020 Resilient Cities and Infrastructures RESIN project and meanwhile, the city has started implementing adaptation options. Due to the high concentration of impermeable surfaces, high population density as well as the concentration of cultural heritage sites, the Old Town is especially vulnerable to climate change impacts such as pluvial flooding and heat waves. These surfaces become quickly warmed up, and it gets very uncomfortable for pedestrians during the summer heatwaves. In the second half of the 20th century, the park-like Main square was paved according to its medieval origin. In 2017 the City decided to plant mature trees on this square, and the adjacent Franciscan square, to help ease the impact of summer heat on the pedestrian zone.

CONNECTIONS: EXPLORING HERITAGE, ARCHITECTURE, CITIES, ART, MEDIA

AMPS, Architecture_MPS, Parade, University of Kent
Canterbury: 24-26 June, 2020



Fig. 3 The Main square during the summer time. Source: www.visitbratislava.com

The Old Town is located at the foothills of Male Karpaty mountains, which are densely built-up with villa houses. Paved roads and sidewalks, high building density, as well as topographical relief, increase the risks of pluvial flooding in the historical city centre.

During heavy rainfall, the rainwater comes rushing down into the lower parts of the historical centre. Underground historic buildings and monuments are at risk from pluvial flooding as a result of intensive rainfall periods, especially during summer months and augmented by aspects such as building density, surface permeability and terrain.

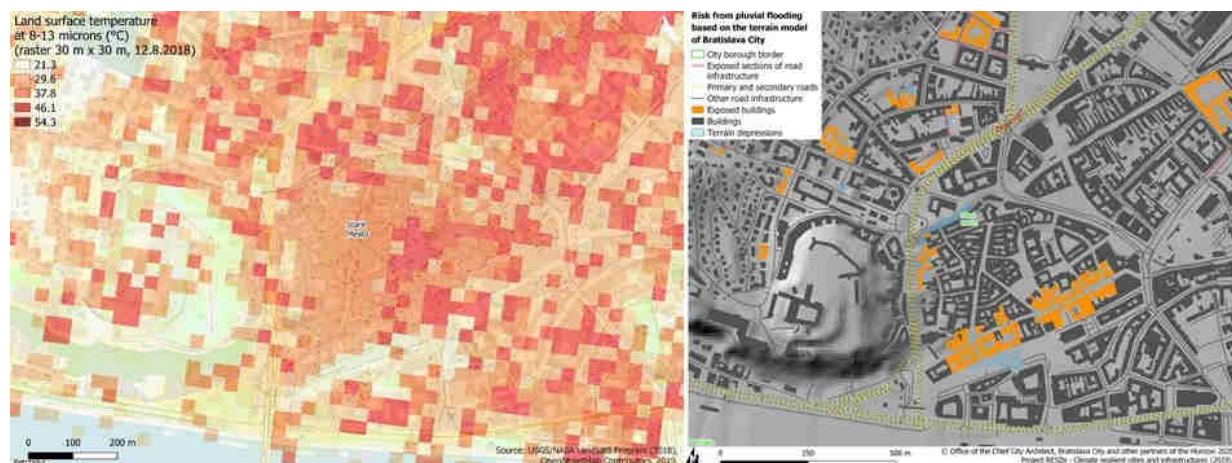


Fig. 4 Left - Land surface temperature model based on the evaluation of a multispectral satellite image of Landsat 8. Source: USGS/NASA Landsat8 Program, adapted by Office of the Chief Architect, 2019.

Right - Model of the risk of pluvial flooding in the conservation reserve. Source: Office of the Chief Architect, 2019

The renovation and repair work of paving in the past were in fact realised by layering impermeable materials such as concrete. This approach echoes especially during the heavy rains and worsen the impacts of pluvial flooding. Therefore, the sectional patterns of paving shall be rethought. Archaeological monuments in situ, considered within the Bratislava case study, located mostly underground, are particularly vulnerable to changes related to surface permeability, intense precipitation and rising groundwater levels.

CONNECTIONS: EXPLORING HERITAGE, ARCHITECTURE, CITIES, ART, MEDIA

AMPS, Architecture_MPS, Parade, University of Kent
Canterbury: 24-26 June, 2020

The city of Bratislava recently developed, under the auspices of Mayor Matúš Vallo, “Technical sheets of the city of Bratislava” or so-called “asphalting manual”^{viii}. This document specifies the requirements of the City of Bratislava for design and realisation of construction work related to road management. Although the subject of developed sheets are technological procedures connected to repair works of roads in various conditions, they neither consider historic areas nor deeper sectional patterns of paving. Considering that “Technical sheets” is an “...open document that can be regularly amended with new details, the need for which will become apparent during planned repairs or new constructions. It will also be possible to modify the original designs according to the experience gained or when offering new materials and technological processes...”^{ix}, view of conservationists shall be brought into perspective. One of the ambitions of The Pavement handbook is to deepen the current knowledge and become valuable contribution to the Technical sheet of the City of Bratislava as such, considering the involvement of all the relevant stakeholders.



*Fig. 5 Archeological excavation - The fore-gate of the Fishermen's Gate, Hviezdoslavovo Square.
Source: M. Musilová, P. Horanský*

METHODOLOGY ON CREATING “THE PAVEMENT HANDBOOK”

Because the main concern of “The Pavement Handbook” development are historic areas that are under legislative protection (conservation reserve/zone), it is essential that its methodology is based on the monument protection goal. These areas represent a certain set of architectural-urban values and the paving (textures, materials, surfaces). Both are considered a vital part of these urban patterns and need to be considered as a part of a whole.

According to methodological documents such as Principles of protection of conservation zone Bratislava^x, the paving is a feature of the street interior and as such it is a representation of a certain heritage values, therefore rules for replacement paving should be defined. The surface of roads and public spaces is required to be based on typical components, historical patterns and materials while preferring traditional paving materials, shapes, sizes and ways of tile laying. New accessories are to be designed such as metal artifacts shaped on the basis of historical analogies, however without the use of unsuitable prefabricated or standardized elements and foreign materials.

CONNECTIONS: EXPLORING HERITAGE, ARCHITECTURE, CITIES, ART, MEDIA

AMPS, Architecture_MPS, Parade, University of Kent
Canterbury: 24-26 June, 2020



Fig. 6 Examples of repair works of paving realized by layering impermeable materials such as concrete. Source: B. Resutík

The map of Bratislava from 1905 shows the former state of paved areas. At the beginning of the 20th century, the historic core and the main axis were covered by three types of paving: keramit^{xi}, asphalt and granite cubes.

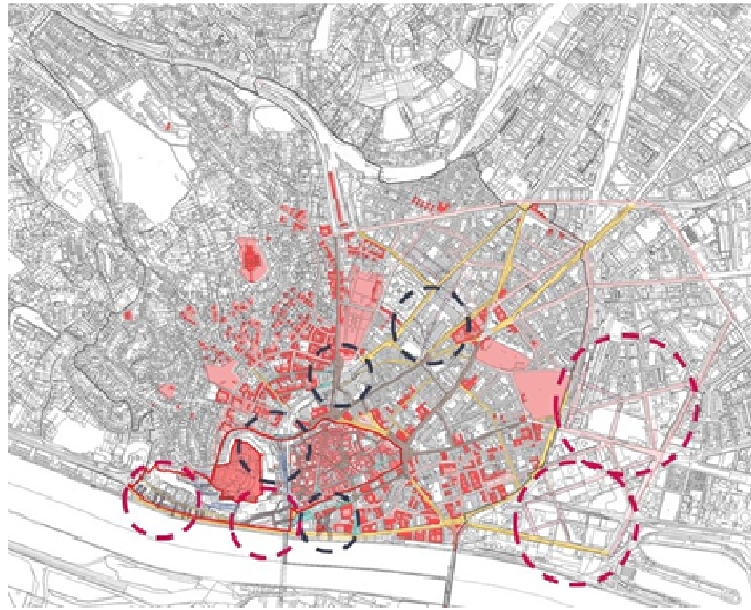
It is noticeable that the map also shows the old paving and the paving supposed to be used later. Municipal Monument Preservation Institute is currently conducting archival and historical research with the aim to complete finds of such type of “paving maps” and to search for other relevant archive - based data from the following eras.

In terms of principles of co-creation, within the Bratislava case study tasks, we closely cooperate with our research partners from Faculty of Natural Sciences Comenius University and Bratislava City Municipality - department of the Chief Architect, while creating an interdisciplinary and intersectoral team. Last, but not least, research and further implementation of its results is conducted by building local partnerships with other important stakeholders (like experts, decision makers, building owners, public service providers, etc.).

Municipal Monument Preservation Institute in cooperation with the Faculty of Natural Sciences Comenius University are preparing data sheets of the current state of paving in protected areas. Data sheets are among most important features necessary for the pavement handbook elaboration. Each sheet contains basic information of location, characteristics and individual elements - roadway, pathway, curbs etc. Their important part is the technical information such as drainage system and other variables like color, vegetation or permeability.

CONNECTIONS: EXPLORING HERITAGE, ARCHITECTURE, CITIES, ART, MEDIA

AMPS, Architecture_MPS, Parade, University of Kent
Canterbury: 24-26 June, 2020



*Fig. 7 Projection of Historical Map to Current Cadastral Map, circle - the defunct urban pattern.
Source: authors; source of the background cadastral map: <https://zbgis.skgeodesy.sk>*

Data sheets, results from archival and historical research are valuable sources of information to the process in the next steps of creating the handbook. The data sheets as such capture the current state of paving in the protected areas and serve as a basis for implementation of this knowledge into the existing GIS system^{xiii} of Bratislava city. Analyzed areas will be from the view of monument protection subsequently sorted into various categories:

- original urban pattern
- defunct urban pattern
- refurbished public spaces
- public spaces before refurbishment

The recommended design of paving takes into consideration the specific preserved heritage values in each type of structure (blocks). These values are represented mainly by the state of urban and architectural values, e. g. original plotting, location of objects on the plot and mass - spatial composition

After considering all the criteria of monument protection (type of tiles, material, type of tiles laying, tile gaps, curbs) we will further implement criteria for mitigation of most relevant impacts of climate change. This is going to contribute to a multidisciplinary and multisectoral process for development a sectional typology of the proposed paving.

DISCUSSION

As well as other post-socialist cities, Bratislava underwent significant urban and architectural changes, especially in the second half of the 20th century. These parts are currently not only integrated in protected areas (CR, CZ), but are often declared to be national cultural monuments (Slovak National Uprising Bridge, Slovak Radio building). The second symptomatic feature of post-socialist cities is current massive construction of multifunctional urban complexes and high-rise buildings. The projection of the historical map of paving into the current cadastral map illustrates these changes. It

CONNECTIONS: EXPLORING HERITAGE, ARCHITECTURE, CITIES, ART, MEDIA

AMPS, Architecture_MPS, Parade, University of Kent
Canterbury: 24-26 June, 2020

brings knowledge about the historical character of public spaces, while presenting the preserved urban pattern and demonstrating valuable evidence of defunct historical urban footprint at the same time. The dilemma here is what kind of methodological approach should be chosen when it comes to designing new paving, since these are new urban developments, but at the same time, they are part of historic urban fabric and shall not be considered in isolation.



Fig. 8 View at SNP Bridge, riverfront with Castle hill. Source: <https://finweb.hnonline.sk>

Example of riverfront “Podhradie”

The area below the castle - "Podhradie" and the Danube embankment, is undergoing a significant urbanistic and architectural transformation, which began in the late 1960s. As a result of the construction of the Slovak National uprising bridge connecting the historic center with the newly emerging Petržalka mass housing on the other bank of Danube river, the part of "Podhradie" with Jewish quarter and synagogue was demolished. Nowadays, the bridge is an integral part of the city skyline. Another significant entry into the historical image of the city is the newly emerging construction of multifunctional ensembles - Zuckerman and Vydrice on the demolished areas of the original urban pattern.



Fig. 9 Projection of Historical Map to Current Cadastral Map. Defunct urban pattern of Riverfront, part of conservation reserve. Source: authors; source of the background cadastral map: <https://zbgis.skgeodesy.sk>

CONNECTIONS: EXPLORING HERITAGE, ARCHITECTURE, CITIES, ART, MEDIA

AMPS, Architecture_MPS, Parade, University of Kent
Canterbury: 24-26 June, 2020

Example of “new downtown”

The second significant transformation is undergoing the area bordering the eastern part of the Conservation zone. The former industrial district of low factory buildings (brownfield), which was established in connection to the nearby Danube cargo port, is gradually being transformed into a new high-rise city center, the so-called "Downtown". The new development also includes the project of a new bus station, which became famous as the "largest pit" in Central Europe. Extensive underground garages, the proximity of the Danube River and its underground streams have a negative impact on the quality of the underground levels of historic buildings in the conservation zone. Heavy torrential rains that happen more and more often are intensifying this issue.



Fig. 10 New development of Downtown and new bus station under construction. Sources: <https://www.autobusovastanica.sk>, www.bratislavskenoviny.sk

CONCLUSION

At the beginning of the “Pavement Handbook” development process, we proceeded to conduct analysis of the current state of paved streets in the historical center of Bratislava, using local and state legislative and archival research. This represents a basis from which we have been able to develop, in close co-operation with our local and scientific partners, a methodological approach as part of the desired output - the pavement handbook of the city of Bratislava. This shall serve as a source for designing pavements in historic areas of the city. Finally, we should be able to use the knowledge and transfer the methodology into other Bratislava’s city boroughs, with protected historic sites, either with rural or industrial character. The resulting document should be suitable for supporting policy-makers in decision-making processes and serve as a guidance document for investment projects of all sizes.

This task is not only an issue of climate change, but also of urban planning, monument protection and last but not least – local decision making processes. Surfaces of inhomogeneous or otherwise disrupted urban historic patterns shall not be considered in isolation. The bigger picture should be considered first, while taking into account urban planning processes in order to preserve and strengthen the historic urban footprint.

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CONNECTIONS: EXPLORING HERITAGE, ARCHITECTURE, CITIES, ART, MEDIA

AMPS, Architecture_MPS, Parade, University of Kent
Canterbury: 24-26 June, 2020

viii "Technické listy mesta Bratislava," mesto Bratislava, accessed July 15, 2020, <https://bratislava.sk/sk/technicke-listy-mesta-bratislava>

ix "Technické listy mesta Bratislava."

x "Zásady ochrany PZ Bratislava - Centrálna mestská oblasť."

xi Keramit are type of yellow ceramic tiles, patented in 1904 in former Austria - Hungary. During the 20th century they were used in public areas e.g. for road and sidewalk paving. Tiles were characterized by its yellow color, durability, but also for its surface to become very slippery when exposed to moisture. With the progress of more modern paving materials, these tiles have gradually lost their popularity on the market.

xii Bratislava has an online accessible geo-information system for the general public as a part of the open-data policy. One of the project objectives is to create a new geographical - informative layer, that would be synchronized with current layers of the Bratislava GIS system. As such it would provide support not only for conservationists, investors, owners but the general public as well. Official website: opendata.bratislava.sk

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