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Editorial

Robert Špaček

At the start of new year and new issue of our journal, a bit of moralizing seems to be in order. Our age is subject to constant analysis. We evaluate our world either globally or with some degree of segmentation, and can view the situation through a variety of filters. The approaches and analytical aids are inexhaustible. We assess people through Dunning-Kruger Effect, or apply the Overton window to politicians... Even without resorting to dogma, we can take the liberty of claiming all current problems are anchored mostly if not entirely in ethics. To define it in negative terms, all around us we now find the intolerable terms post-truth, post-facts, and alternative facts... and those who use them actively are plainly suffering from a deficit of morals. Ethics as a philosophical discipline sooner or later will come to terms with the value relationship between what is true, what is good, and what is beautiful.

These three dimensions are familiar to architects, partly because of the classical Vitruvian Triad. Beauty has shown itself to be the substance of sustainability per se. Beauty is subject to the natural traps of history, showing it has some Darwinian resilience and easily taking on Bregman's thesis of survival of the friendliest. Truth and goodness have had a harder time of it through history. We call architecture truthful when it reflects the spirit of the age in which it originated. What is good is often relativized to that which properly functions. There is peril in the still-surviving opinion that our value triad is to be legitimized by majority opinion. We will not here repeat the indispensability of ongoing discussion. Yet we will allow ourselves the statement that life values ought to be cultivated in all spheres, from culture to politics. Our journal is a medium in which we caress architecture with texts: analytically, descriptively, and where possible poetically as well.

Today, the most-used adjective in architecture is sustainability. This term has come to be narrowed to its environmental aspect. We now speak of the beauty of sustainable architecture practically as added value. There is also a problem with truth. For instance, the term 'nearly zero standard' is extremely misleading. Architecture that has this attribute is far from zero energy consumption; in this sense the term 'nearly' is applied very generously. Sustainability is good, and should be true, and architecture beautiful. Cheap greenwashing is a scam, lying to oneself. The imaginary scissors-blade spread between described fact and verbal description is too often very wide indeed.

It is easy to find truth in the past, and truth dissolves completely in the future. Probing the past, and writing about it, is to a significant degree a game of certainty, with rather flat amplitude of uncertainty. To write how things ought to be locks in our idea of architecture at least for its calculated lifetime, in the hope that it will survive longer thanks to its beauty. Writing brings an increasing risk of losing the connection between words and their content. Easy writing may yield difficulty in reading. Writing is an individual endeavour, authorship can be shared, and publishing is a collective act. Money and material things have no morals, only the people that work with them do. If an effective ethical concept, or at least a mechanism of correctives, is lacking, the result is a cubature of capital with superficial and shallow marks of architecture. We sometimes entangle ourselves in this process through writing. Influential criticism can be very cheap.

Ethics are implicit in architecture's transcendental overlays; we have to bring materiality to it. A positive amazement at architecture directly addresses our inner world of moral values. We get the feeling 'that's unbelievable' as we stand under the Pantheon's dome, in Gothic cathedrals, and even in Calatrava's World Trade Center Transportation Hub. On the other hand we can be amazed by uncommon humility and unpretentiousness, by an architect's ability to endow things and spaces with a second life. 'Internet of things' is now a known phrase; now let us bring into the world a 'moral of things'. We tend to relativize what is true and good down to success and usefulness; can it be useful to demolish the old and build the new, even if it is not moral? Ethics of circular urban design may be the way forward to the future look of architecture and the city. We can perceive architecture and the architect as a mediator between nature and culture. This was elegantly expressed by Oscar Wilde in 1889 in the book The Decay of Lying:

'If Nature had been comfortable, mankind would never have invented architecture, and I prefer houses to the open air. In a house we all feel of the proper proportions. Everything is subordinated to us, fashioned for our use and our pleasure.'

The architect translates into the language of culture the story of climate, forests, stone, and rivers… In the best case, very little is 'lost in translation'. Nature creates stories in its own language, and the architect's language translates them into stories of architecture and agglomerations. The development of humankind is accompanied by an exchange of resources between nature and culture. For ages, culture was a 'pure recipient', later a majority recipient, and only now does human production of materials exceed nature's biological production. The issue of reverse motion is ever greater, as nature has come to be the receiver in the cycle of culture's by-products. The cause may lie in inadequate knowledge of the language of nature, people; for our part, architects are behaving towards nature like Google Translator back in its earliest days. In linguistic communication between nature and culture, we find ourselves in the science/poetry range. Nature's poetic language must be not just translated, but more importantly transformed into the language of culture, and at this many architects have been succeeding. Even the slightest probing reveals dialects and subtle linguistic nuances.

The mediation comes with a shaping of lifestyle. If we as people are generally able to program our future, we architects also need to decrease the amplitude between nature's capacity potential and the needs and desires of those anchored in the area of culture. Of course in the broad sense, in culture we subsume technology too. Described and describer grow more distant, and words more cheap. In architecture, beauty is sought as majority opinion, or as influential opinion that can also be subdued by an enchantment with success. The pop culture mechanism can kill architecture. Meanings dissolve in instant architectural concoctions. What is beautiful, good, and true have been relativized by what is successful, leaving aside the discussion of whether ours is a neoliberal architecture. Let us leave general thinking of this sort for consideration in other texts, and look now at the articles in this journal issue. Our authors will take you on a journey along the quest for truth, discovery of beauty, and empowering of the good. All the pieces to some extent and in a certain sense touch on these general theses, and to a certain degree offer a way to new ethical concepts and correctives in our work. Writing is a search for truth, where we formulate results of research and devote consideration to how the text should look.

In the article *Alpine huts: Architectural innovations and development in the High Tatras until the first half of the 20th century*, Mária Novotná comes into direct confrontation with how nature grows into architecture, or how they grow into one another; she writes at the margins of local protoarchitecture, shaped ad hoc from in situ material. The limits of the cultural inputs here were set particularly by the energy potential of transporting material. The article opens the question of whether mountain architecture in Slovakia created an autochthonous typology.

The text by Natália Filová, Lea Rollová and Zuzana Čerešňová, *Route options in inclusive museums: Case studies from Central Europe*, outlines the language a museum speaks to its guests. Visitors need some orientation, and to grasp the 'museum's story'. For the child visitor, the museum journey is an educational activity, supplementing and perhaps to some degree substituting the role of the school. The museum translates the language of history into the future, because the present as presented in words here and now is in fact indefinable.

In their research, Tomáš Hubinský and Ján Legény work from the thesis that cities are the crowning phase of culture's spinning off from nature. It is in cities and on their example that we can read how humans have transformed natural conditions into their own cultural expressions or creations. We take the opinion that a city is not just a problem, but quite particularly a solution. In the article *Microclimatic factors in urban development: The setup of an environmental observatory at the FAD STU*, the authors fashion the fine thread between the two worlds of Professor Snow, utilizing the quote of Ernest Rutherford's, considered the father of nuclear physics and the scientist who established the nuclear structure of the atom: *'All science is either physics or stamp collecting'.* In essence, they put forward the question of whether the city ought to accommodate to the changing climate situation or should itself limit its negative impacts. Optimally, cities will contribute to stabilizing the state of things globally if their positive influences stretch beyond their boundaries. The physical measurement methods and partial results are meant to be extrapolated to creating public spaces and urban segments: physics coming together with urban architecture.

The present climate situation is advancing the nature-culture dialogue to a new level. Humans alter the earth's surface through agriculture, forestry, transport, and construction. Current data shows that humanity has modified almost 15% of all dry land, with urban aggregations alone representing 3% of land surface. This seems a small number, but once we visualize it we find human settlements have carved off a considerable piece of land surface. Some of these surfaces we have filched from nature, while others we have politely requested, with commensurate outcomes to each approach. In a variety of synergies, local impulses manifest globally. The terms mitigation and adaptation to climate change have worked their way into the vocabulary of urbanism. Moderation and reduction of human activity's impact will, in the best case, be a lengthy process. In the near term, we need to react quickly and adapt to the changes, both those that have happened and those anticipated. In their article *The impacts of climate change on urban structures in Slovak cities: Identifying vulnerable urban structures*, the authors Miroslava Kamenská and Katarína Smatanová present preliminary findings from their research on resilience of selected small towns in Slovakia to heat waves and floods. The aforementioned nature-culture dialogue is growing ever more dramatic, and we as people must, so to speak, use diplomatic arguments, sometimes even asking nature's pardon.

Theatre is a phenomenon founded on linguistic and visual communication. Since its origins, theatre has become a typological category of architecture. Firmly established forms have constantly been accompanied by detours into what is alternative and experimental. Experimentation is at present an independent line, albeit hard to grasp, as experimenting initiates a journey with an unknown conclusion. In the article *Pop-up architecture as a tool for popularizing theatre: Prototype No. 1* the authors Kristína Boháčová and Alexander Schleicher attempt to frame an experiment by appraising the current state of theatres, and are motivated by seeking support for establishing a setting through its alternatives. Their pop-up experimental building creates, for dramaturges yet unknown, space for a Talebian black swan.

Overlays between nature and architecture, with ethics as mediator, will in our conviction be one of the decisive ways we shape the future.

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Alpine huts: Architectural innovations and development in the High Tatras until the first half of the 20th century

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Abstract: For man, the mountain environment was a source of raw materials and a place of economic activity until the end of the 18th century. This paper examines how the exploration of mountain valleys lead from the first ascents to the peaks to today's exploitation of the mountain environment. We are currently following efforts to protect the unique environment of the mountains and to preserve the architectural heritage of the 20th century. In the paper, we look at the architecture of the High Tatras of the first half of the 20th century, which is lost under the coatings of today. The article traces the line of innovation in the 20th century and examines the causes and consequences of the origin and development of architecture in the alpine environment, with a focus on changes in the paradigm of social thinking in the relationship between architecture and the original landscape. The subject of the paper is mapping of the architectural heritage embedded in the unique environment of the world natural heritage of alpine terrains in the High Tatras and the study of the settlement process with innovative technologies and materials that have enabled architecture to enter difficult terrains. As industrialization, mechanization and electrification have greatly simplified and streamlined the construction process, the work identifies not only the development of new design, technological and material solutions, but also the resilience of the environment to innovation. It focuses on the analysis of innovative progress and monitors its development in contact with the mountain architecture from the moment of planning, work implementation and possible construction changes. The work focuses on the typology of mountain huts and the process of their architectural design.

Keywords: alpine architecture, innovations, High Tatras, alpine hut, modernism, chalet

REFLECTIONS ON THE HIGH TATRAS

Mountain exploration and later gradual exploitation has been commented and reflected by architects, journalists, environmentalists, and hikers since the beginning of the 20th century, with some mentions in periodicals from the 19th century. However, the absence of discussion was related to the absence of original settlement structures in the alpine landscape (Moravčíková, 2013, p. 136). The few periodicals in the times of Austro-Hungarian Monarchy were: Karpathen Post and Turisták Lapja. The mountains of the Hungarian Kingdom became the mountains of the Czechoslovak Republic after the socio-political changes brought after the First World War. The popularity of tourism in the High Tatras was still rising along with winter sports activities and spa recreation possibilities. Dušan Jurkovič who deliberated on its previous development and planned to create protected areas in the regions of the High Tatras and other mountains, summarized his ideas in the periodical entitled Prúdy in 1923 from a position of Commissioner for the Preservation of Artistic Monuments in Slovakia (Jurkovič, 1923). A periodical which provides data for studies of the building process in the interwar period is Slovenský Staviteľ. This review offers information on the building process in the High Tatras and examines the knowledge and availability of new materials and innovative building methods in architecture – gas concrete, reinforced concrete and its new options, eternit, hollow bricks, glass bricks, linoleum, bauxite cement, special bricks for chimneys, and fire proof treatment of wooden structures. Another topic covered by the periodical is innovations which had found its place and application in architecture of the interwar period, with the typology of recreation in mountain regions. In addition to the periodical, there are publications which cover the development of architecture in Slovakia during the 20th century and they are touching the topic of construction in the mountains. The topic is handled either as a chapter dedicated to the High Tatras or within the framework of analysis of the architect's masterpiece. Architektúra na Slovensku 1848-1918 from Martin Kusý offers a view on the beginnings of Tatra's architecture. Kusý characterizes architecture of this period rather as *"copying purpose-built tourism buildings from the Alpine areas"* (Kusý, 1995) and places the Tatra architecture in the stylistic framework of romantic eclecticism. The work of Ladislav Foltyn – Slovenská architektúra a česká avantgarda 1918-1939– studies the interwar period, focusing on the rise of functionalist architecture and showing how the modern architecture formed architectural appearance of the High Tatras.

The historians and theorists of architecture Henrieta Moravčíková and Matúš Dulla reveal the approach to building process in the mountains. Their extensive publication entitled Architektúra 20. storočia na Slovensku offers a complex view on the century which formed architecture in the alpine regions. The authors distinguish between Czech and Slovak contribution to Tatra's modern architecture as "Large scale functionalism" and "Small scale functionalism" (Dulla, Moravčíková, 2002). The work of Henrieta Moravčíková Stavět v Tatrách, as a part of the anthology Tvary formy ideje, comments on the beginnings of tourism in the High Tatras since the 19th century. It zooms on the changes in social classes, such as mountain visitors, from Hungarian bourgeoisie to Czechoslovakian upper class, and finally working class of the postwar period (Moravčíková, 2013, pp. 131-143). Matúš Dulla writes about the High Tatras as a symbol of the Slovaks in his work Zapomenutá generace, stating that architecture should be respectful and subordinated rather than ruthless (Dulla, 2019). Dulla criticizes the architecture as a work of an architect, professional architecture, for its egoistic claims. And due to the architectural inspirations form different nations, the Tatra architecture is described as a transnational work. The publication supports consideration of the absence of original settlements due to no mention of the Tatras in the Slovak folklore tradition.

The extensive polythematic monograph Vysoké Tatry včera a dnes touches the topic of building in the High Tatras generally in the chapters related to the development. Surveying exclusively the architectural process of the Tatras construction and avoiding building without architects, the chapter entitled Architektúra stems from the historian Maroš Semančík. His writing is dedicated mainly to the era until 1918, followed by modernism and briefly mentioning developments after the velvet revolutions (Semančík, 2017). The chapter Tatranské osady do roku 1918 provides a chronological overview of how the urbanization of the Tatra terrain formed first settlements. The authors of the chapter are Ivan Bohuš sr. and Ivan Bohuš jr. Michal Sýkora, Peter Chudý and Vladimír Labuda compiled a publication Štrbské Pleso v premenách času, which offers a historical overview of the settlement around the mountain lake Štrbské pleso, its important events and historical photographs (Chudý, Sýkora, Labuda, 2019).

Besides the architectural scientific publications, there are some other professional publications touching the topic of the High Tatras and its architecture examining the rise, life and eventual fall of the neglected typology – alpine huts. The publication Tatranské chaty, majáky v mori skál a snehu written by Ivan Bohuš jr. gives us an overview of probably all of the alpine huts ever built and planned in the High Tatras. It shows them on the historical maps, documented with historical photographs (Bohuš, 2007). Another summarizing publication, Ako vznikali turistické chaty a útulne na Slovensku, written by Ernest Rusnák, Ladislav Khandl and Eva Potočná is a collection of selected huts throughout Slovakia, again with historical photographs. The book gathers information from the archives of hiking clubs. The value of those works is more of a guidance than architectural critics for us. Both publications draw information from historical periodicals, mainly Krásy Slovenska, and publish clippings of historical maps with hut locations.

Markéta Svobodová processes the archive of the Czechoslovak hiking club (KČST) and its building activities in the publication Hore Zdar! From a historiographic point of view. The work presents huts of the club in a medallion way along with historical photographs or architectural drawings. The catalog of buildings contains only two huts in Slovakia, of which one is located in the High Tatras (Chata pod Rysmi) (Svobodová, 2020, pp. 107-109, 164-167).

APPROACH AND METHODS

In this research, we study the buildings in context of the alpine architecture of the High Tatras region until the first half of the 20th century. The overall picture is made by development in the 19th century. The mapped objects are mainly non-residential buildings intended for temporary housing. The paper primarily focuses on the construction of alpine huts typology. The High Tatras area is defined by the territory limited by the Slovak-Polish border, by Dolina Kežmarskej Bielej vody valley, and by Liptovské Kopy from the north, east and west, respectively. The alpine territory is usually defined by the altitude limit of 1,000m (Lupták, 2017) (Fig. 1). From the south, the research is limited by a contour line at 1,000m above the sea level (Fig. 2). The examined objects are located at an elevation up to 1,500/1,650m above the sea level in the forest vegetation zone, up to 1,800 m above the sea level in the dwarf pine vegetation zone, and in the zone of alpine meadows and the sub-snow zone.

As used in this paper, the High Tatras architecture means the architecture which was actually erected or planned in the High Tatras. The traditional rural style architecture of log houses is not claimed as being exclusively the Tatra's architecture, just the same as the half-timbered buildings from the second half of the 19th century are not called "the true Tatra" architecture, but could be rather called the first Tatra architecture, as they were the first buildings built by architects in the Tatra territory, strongly inspired by the Alpine architecture. The innovative materials and constructions, their durability and resistance to weather conditions are examined on the mapped objects. The focus is at objects in terms of the arrival of new architectural styles to the Tatra region and how innovations in architectural thinking have been applied to the architecture of alpine huts.

HISTORICAL DEVELOPMENT

Showing how the construction of the huts was influenced by the development of settlements and technological innovation, the timeline creates a picture of the period context in the High Tatras. The origin and extinction of individual buildings, their eventual restoration and the investors who were behind their implementation are shown in a chronological order. (Fig. 3)

Till the end of the 19th century

The 18th century was a romantic escape from city life that removed the balance from nature (Pijoan, 2000). References from various researchers show a growing interest in the alpine environment (Towson, 1797). During these early alpine expeditions, the researchers stayed in mountains dependent on existing shelters, shacks and huts of miners, lumberjacks and shepherds, or in fireplaces (emergency shelters under a rock overhang). The researchers and their guides moved along the hunting trails. At that time, residential structures were built exclusively from local materials, not primarily intended for the construction of shelters. The primitive shack of lumberjacks protected its interior from rain and wind by a layer of scuffed bark. As compared to the shacks, the huts of the shepherds were sophisticated one-room log houses. The first Tatra settlement, Starý Smokovec, was founded around the healing waters in 1793 (Fig. 4). In 1806, on the west side of the High Tatras, Kriváň huts were formed around the Tri Studničky site. They were meant to serve as a basecamp for reaching the Kriváň's summit.

Mountain spa, hiking, and recreation in the mountain environment was gaining popularity. From the middle of the 19th century, the Rainer family contributed to the development of proto-tourism, which in 1850 built the first two-storey brick hotel in Starý Smokovec and the first alpine hut in 1865. The hut served not only as a utilitarian alpine shelter, but also provided basic refreshments and accommodation. The next one was built in 1871. Eduar Blássy colonized Velická dolina valley with alpine hut and created a basecamp for the Gerlachovský štít peak. These beginnings of architecture in the Tatras are documented by artworks, paintings, engravings, and later by photographs. The first buildings were traditional log cabins, like many in the foothills in the territory of northern Slovakia. At that time, the Tatra region was not yet considered a profitable centre of tourism. The planned line of Košice-Bohumín Railway (KBŽ, 1871) was to fulfil the business plans between the east and the west of the monarchy, and to protect the northern borders of the Kingdom of Hungary (Chudý, Sýkora, Labuda, p. 20). While the Halíč area was part of the Hungarian Kingdom, a water canal was planned, which would connect the river Váh with the river Poprad. The reservoir and the buffer pool were to be filled with water from the mountain lake Štrbské pleso (Chudý, Sýkora, Labuda, p. 27).

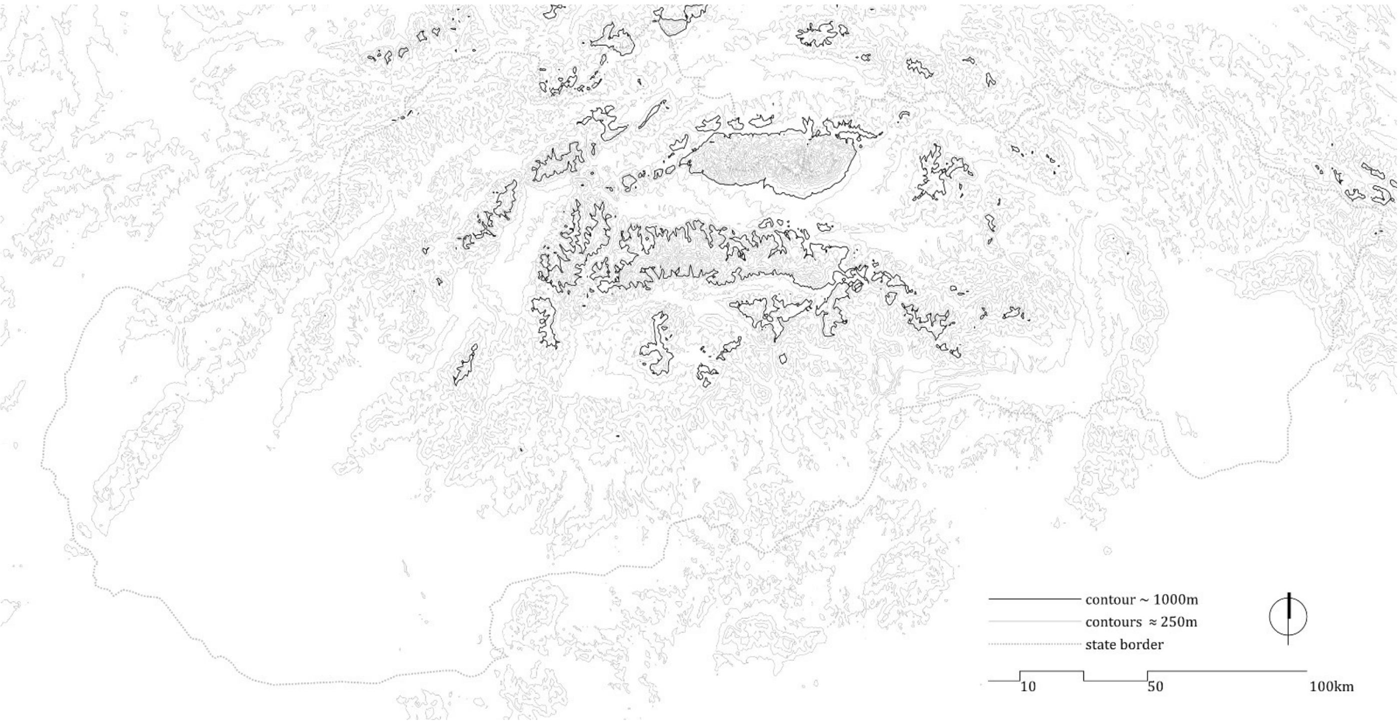

Fig. 1. Alpine areas in Slovakia. (Author: Mária Novotná)

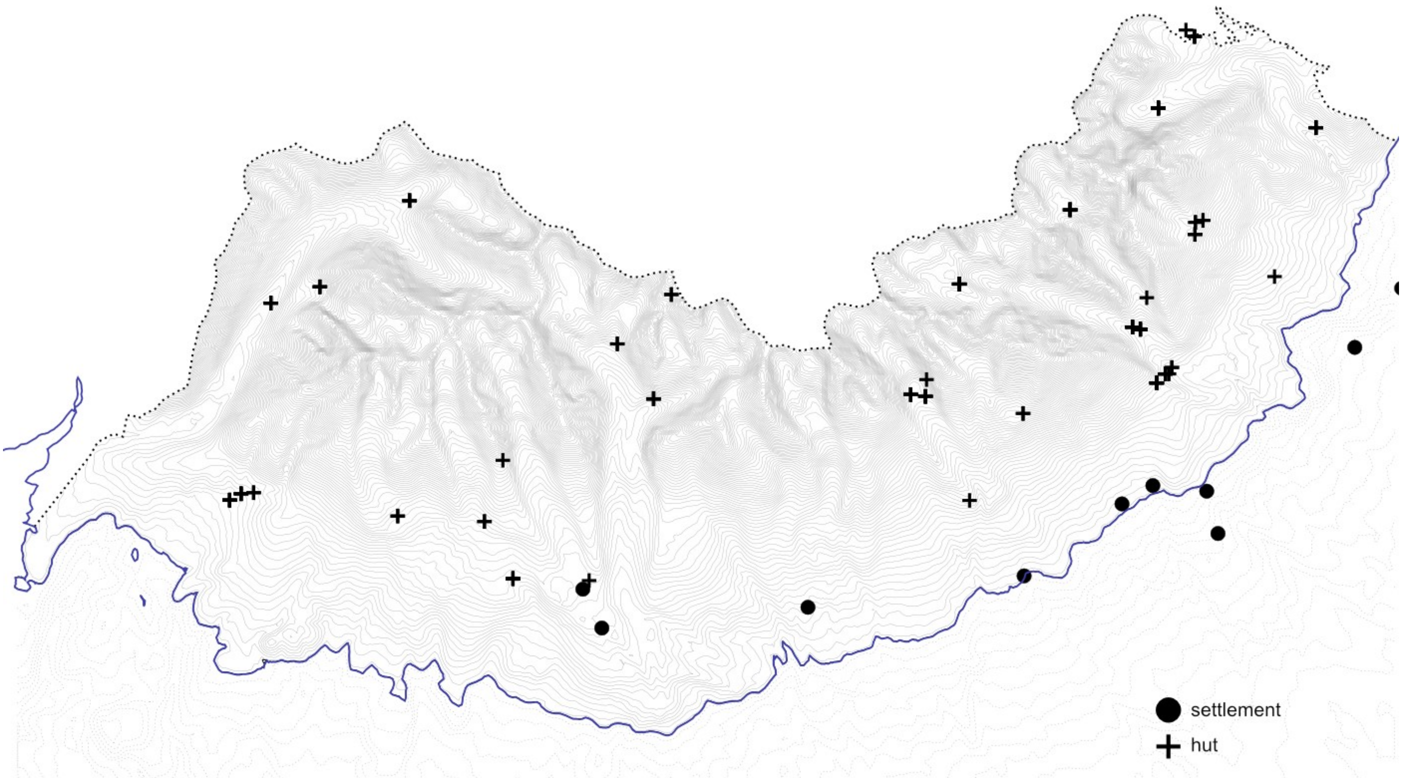

Fig. 2. High Tatras area with huts and settlements. (Author: Mária Novotná)

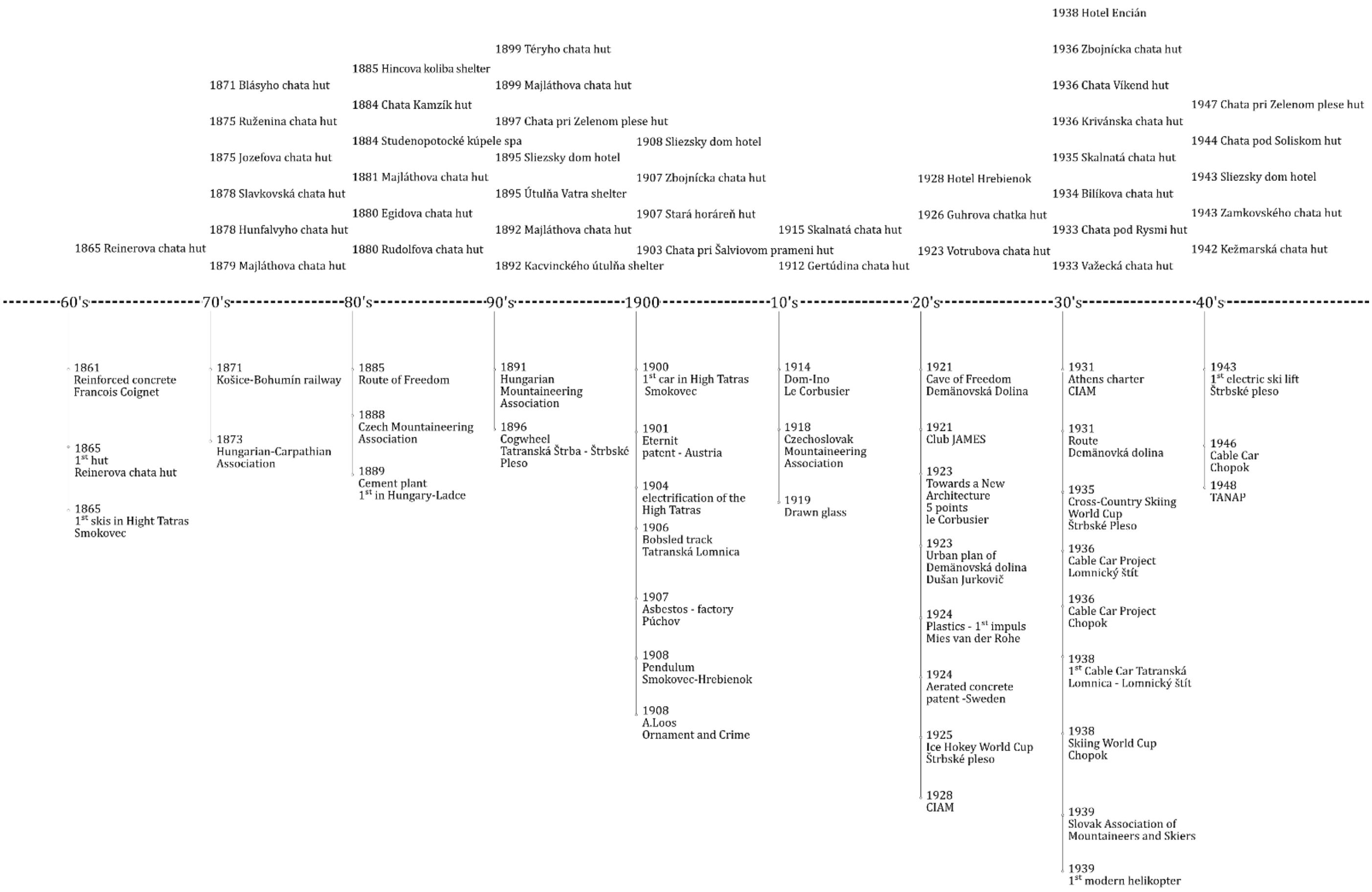

Fig. 3. The construction timeline of the huts in the High Tatras. (Author: Mária Novotná)

Fig. 4. Starý Smokovec at the beginning of the 19th century. (Source: Ivan Bohuš, Tatranský kaleidoskop, Osveta, Bratislava, Slovakia, 1977)

The free will of eclecticism

The KBŽ railway was a historical landmark in the Tatra development. After the railway was finished, the settlement of Štrbské Pleso was founded, and architects found their way into the attractive environment, replacing rural buildings with architectural opinion and bringing the "Swiss-style" from other mountain areas of Europe, especially from the Alps (Semančík, 2017, p. 464). For the first time, we witnessed the recognition of a half-timbered structure as an architectural intention, was a hotel in Starý Smokovec in 1872 (Semančík, 2017, p. 465). Later, the architecture of the settlements begun to form a mixture of imported styles from Bavaria, Tyrol, Switzerland, Romania, Scotland, England, Norway and to a limited extent from Poland (Semančík, 2017, p. 457). We could call it alpine or Tatra eclecticism. (Fig. 5) The beginnings of Tatra spa saw a limitation of tourism to summer seasons. Building construction mostly took place in winter, as an off-season activity, and the structures did not have a long service life (Semančík, 2017, p. 464).

Fig. 5. Starý Smokovec at the end of the 19th century. (Source: Ján Gašpar, Tatry, Region of Poprad, Slovakia, 2002)

The Hungarian-Carpathian Association (UKS) took over the patronage of mountain hiking in 1873 and started a network of huts in the High Tatras. Tourists came to Velická dolina and Studená dolina valleys from Smokovec. The starting point for the mountain lake Zelené pleso was Tatranské Matliare which later in 1885 moved to Kežmarské žľaby. Kriváňske koliby huts at Tri Studničky became a decaying base for entering the long Kôprová dolina valley, where a hut for Rudolf Habsburg was built in 1880. All these huts were built without any connection to the architectural events “down in the settlements”. At that time, they did not reflect fashionable half-timbered constructions with carved railings. Huts were traditional buildings built from materials available on site, stone and wood. Either they were log huts with a gable shingle roof or stone huts, some of which had a simpler shed roof.

The most accessible and attractive valleys for tourism were Studené doliny. In 1884 the UKS built better-equipped and larger Chata Kamzík hut close to Rainerova útulňa hut, and in 1883 the Spišská Sobota forest company had the Studenopotocké kúpele spa complex built. Štrbské pleso became a base for hiking in Mengusovská dolina valley, where the second Majláthova chata hut stood next to the mountain lake Popradské pleso. Deeper in the valley, in the early years of mountaineering, the UKS built Hincova koliba hut, which was better situated for the summit goals. The UKS saw the potential in the locality of the mountain lake Zelené pleso, and the hut standing there was permanently under repair and refurbishing over the decades. UKS created a construction committee, which oversaw the refurbishing of the damaged buildings and the construction of new ones, ensured higher quality within economical limits and oversaw the construction of roads and sidewalks (Zvarinyi, 1884).

Chata Kamzík hut, initially a simple log house with a gabled roof, was the first two-storey hut in the High Tatras. Studenopotocké kúpele spa was built according to the model of magnificent spa houses in the Tatra settlements with half-timbered technology with dormer roofs and turrets. The other huts remained utilitarian single-storey buildings. In 1891, the Budapest-based fraction, the Hungarian Tourist Board (MTS) separated from the UKS. MTS did not like the exclusivity of the upper classes with a German predominance in the UKS. In 1895, the Silesian section of the UKS built another, larger tourist hut at the Velické pleso mountain lake due to its growing popularity. The Sliezsky dom house was probably the first building in the Tatra alpine environment, which showed an architectural opinion in the context of the place. Its author was Gustáv Husz, a builder from Poprad (Bohuš, 2007, p. 58), who built the cottage as a ground-floor building to better withstand the gusts of wind from the valley. It was masonry work, we assume a stone building with a flat roof, plastered with lime plaster. It was the first plastered hut in the High Tatras. Until then, plaster was only used on the buildings of the Studenopotocké kúpele spa. Until 1928, these were the only buildings plastered from the outside. Opinions on the justification of plastering buildings in the alpine environment differ, especially due to the complexity of transport (Majunke, 1900).

In the meantime, material and technological innovations arrived in Slovakia. A professional production base for reinforced concrete construction was established in Bratislava in 1884 with the Pittel and Brausewetter company. In 1889, the first cement plant in Slovakia was opened in Ladce. In 1896, the mantra of modern architecture was formulated: form follows function. In the western part of the High Tatras, two huts were built, Kacvinského útulňa shelter in 1892 to the west from the mountain lake Štrbské pleso and the hut named Vatra at the end of Kôprova dolina valley. Hincova koliba and Kriváňske koliby huts thus lost their meaning and soon became completely decayed. The facilities in the settlements of Smokovec and Tatranská Polianka allowed a comfortable entrance to Velická dolina valley and so another cottage, by the mountain lake Slavkovské pleso, ceased to be visited and fell into disrepair. Kacvinského útulňa hut responded to the architectural proximity of Štrbské Pleso and was built with half-timbered technology. However, gray masonry was not used as a filling between the castles, wooden boards were used instead.

Gedeon Majunke, a member of the UKS building committee, was commissioned in 1891 to oversee the restoration of the hut at the mountain lake Zelené pleso (Fleischhakker, 1891), but the design and construction was carried out by an architect from Kežmarok, Juraj Cornel Schwatz, in 1895 (Semančík, 2021). The first version of the cottage had a flat roof, but soon received a hip roof, which gave the cottage with a square floor plan the expression of a typical vernacular square family house with a centrally located chimney. In 1899, a new hut was opened thanks to the initiative of MTS Vice President Dr. Téry in Malá Studená dolina valley. It was the highest-elevated hut in the High Tatras until the interwar period. The basic project was designed by Jozef Pfinn and the architectural project was developed by the architect Majunke (Bohuš, 2007, p. 93). Téryho chata hut was a pioneering representative of the typology of mountain huts, which underwent a complex process of architectural design.

Although the architecture of the Tatra settlements at the end of the 19th century was subject to a gradual eclecticism, the omens of modern architecture were visible in the additions by Majunke. During the restoration of the buildings, he designed and built flat vegetation roofs and glass verandas (Semančík, 2017, p. 466). The “typicality” of dormer roofs met with the innovation of simplicity. In contrast to the free will of eclecticism that shaped the Tatra settlements and covered them with ornaments, the huts were excluded from this historicist tradition. The architecture of alpine huts was mostly loyal to the vernacular tradition. Their form was shaped by the architecture of necessity, not of a need for a presentation that brought economic returns. They were adequate for the vegetation zone. In the lower elevations, in the forest zone, there were log cabins. In the alpine meadows sub-snow zone, they were built from stone.

UNTIL THE END OF THE MONARCHY

The first years of the 20th century brought innovations to the settlements in the form of motorization, electrification, canalization and flushable toilets (Kollárová, 2017). The construction technology returned to traditional masonry, which offered a higher quality of construction in comparison with half-timbered buildings. This type of improved construction allowed all year-round usage, including winter. The development resulted in increased aesthetic requirements for the interiors where ornamentally innovative style was implemented (Semančík, 2017, p. 486). The stronger relationship with winter sports was supported in 1906 by the construction of a bobsled track in Tatranská Lomnica. In 1912, Getrúdina chata hut was added to the bobsled track above Tatranská Lomnica as a base for sportsmen. Thanks to Michal Ghur, Velická dolina valley has also become a winter sports centre. He organized international winter sports competitions, maintained ski slopes and built ski jumping ramps (Bohuš, 2007, p. 65). At the end of Veľká studená dolina valley, a hunter’s shelter was built in 1907, which later became known as Zbojnícka chata hut. In the same year, the Tri Studničky site was restored as a tourist base. Finally, in 1908 a pendulum cable car to Hrebienok was built. In the last years of the monarchy, Rudolfova chata hut was symbolically replaced by a hut built by the state forest administration in 1912. Later, in 1924, the Czechoslovak Tourist Club (KČST) renamed it to Mühlmannova chata cottage (then chairman of the Slovak commission of the club). The buildings of the first years of the new century were still equally utilitarian, built by traditional techniques, without architects. According to historical photographs, the only buildings in Hrebienok show elements of half-timbered buildings from the settlements, and the Kiosk building shows elements of Art Nouveau. (Fig. 6)

Fig. 6. Kiosk, the restaurant at Hrebienok. (Source: Ján Gašpar, Tatry, Region of Poprad, 2002, Slovakia)

TATRAS IN CZECHOSLOVAKIA

Fig. 7. Dr. Holzman Sanatorium, architect: Fridrich Weinwurm. (Source: Archive of the Architecture Department of the Historical Institute of the Slovak Academy of Sciences in Bratislava, Slovakia)

Functionalism surpassed the Czech official style of rondocubism and firmly anchored in the territory of young Czechoslovakia. The ideas of CIAM came here, Le Corbusier's 5 points of modern architecture, and Mies van der Rohe considered light, cheap and insulating materials, thus creating a background for the arrival of plastics. Loos' manifesto Ornament and Crime (1908) began to take effect. The changing borders after the First World War made it more complicated for the members of the Czech Tourists' Club (KČT, 1888) to access mountain terrains in the Alps, thus turning their attention to the High Tatras. The initiator of the first hut in Czechoslovakia was Václav Dusil, a major in the Czechoslovak army of Czech origin. Votrubova chata hut was built at Biele plesá mountain lakes for strategic reasons, so that they could secure the northern borders against Poland's claims (Bohuš, 2007, p. 121). In 1928, the Šport Hotel was built in Hrebienok with a significantly reduced ornament on the facade, as an addition to the Art Nouveau Kiosk. With the easy pendulum transport, the atmosphere of Hrebienok was closer to the atmosphere down in the settlements than the silence around the alpine huts.

The 1930s began with the declaration of the Athens Charter and ended with the invention of the 1st modern helicopter and the beginning of World War II. The transnational architecture of the High Tatras continued with the Czech contribution in the first half of the 20th century. Their large-scale architecture manifested functionalism in Slovakia most significantly in the Tatras (Dulla, 2019, p. 329). The Czech influence allowed the Tatra architecture to dispose of the ornament. The works of Czech architects are a recognition of the theme of early modernity in an alpine environment and solve the problems that the modern age has attempted to eliminate. Functionalism, which unequivocally condemned eclectic symmetry, but settled for a floor plan as a functional scheme, was already reflected in the design solution of the TBC Sanatorium in Vyšné Hágy. There it manifested the priority of function and the modern age over the manner of functionalism. Instead of a functionalistic asymmetrical solution, a solution that provided the equal area for recovery in the women's and men's blocks of the sanatorium. The functionalistic dialog between the exterior and the interior was implemented in the concept of sanatorium Morava by Bohuslav Fuchs. Open floorplans and dematerialized facade should respond to the unique and dramatic nature with a contrasting addition of straight and horizontal lines with a regular grid of facades (Foltyn, 1993, p. 133).

Architects of Slovak origin implemented "small-scale functionalism" on the buildings of family villas, guest houses and small sanatoriums. (Fig. 7). Fridrich Weinwurm also contributed to the removal of the ornament with the construction of a sanatorium for Dr. Holzman. The building was an example of a work that created a contrast between the modern open floor plan and the possibility of intimate space on sunny balconies (Moravčíková, 2014). The upcoming focus of Tatra functionalism with a high concentration of modern manifestations was set to be the settlement of Nové Štrbské Pleso (1905). Ján Móry, nephew of the founder Karol Móry, had ordered a design for a functionalist extension to the Móry Hotel. During the construction, significant changes were made for unknown reasons, causing the idea of a functionalist steamer boat over an artificial lake to be transformed into a more conservative building which, as an extension, was consistent with the historic building of the original hotel. The ideals of early modernism were implemented in the design of a private villa, a "folk" hostel lodge for backpackers and an octagonal cafe. In contrast to the fashion of tubular railings, flat roofs, white plaster and large area glass windows, there were alpine huts, which were still built using traditional technologies. In the 1930s, the network of cottages at the level of the long-distance hiking trail Tatranská magistrála was expanded to include Važecká chata, Kriváanska chata, Furkotská chata and Bilíkova chata hut. In this decade of changes, the shelter by the mountain lake Skalnaté pleso has become Skalnatá chata hut. By type, the emergency shelter was upgraded to a hut with service.

Markéta Svobodová describes the 1930s as a period, when the KČST started to build smaller, but higher and technically innovated mountain huts (Svobodová, 2020, p. 163). Téryho chata hut (2,015 m.a.s.l.) was surpassed in altitude by Chata pod Rysmi hut (2,250 m.a.s.l.) in 1933. Zbojnícka chata hut was adapted for year-round operation by the innovative technology of asbestos (1907 factory in Púchov) plaster as a thermal insulation layer (Bohuš, 2007, p. 88). Other huts went through innovation by extension. The cottage near the mountain lake Zelené pleso has undergone construction changes. Two wings were added to the original stone building with a hip roof. One wing was constructed as a log house and the other was half-timbered with gray masonry infill. In the 1940s, the roof was rebuilt in order to increase capacity. Votrubova chata hut was extended with another building, Kežmarská chata hut, designed by Alexander Hanuš in 1938 (Svobodová, 2020, p. 163). Sliezky dom house also waited to receive an expansion in 1942. Originally a simple ground floor building with a flat roof was given a log extension with a gabled roof and an accommodable attic. The innovation of involving an architect in the planning and design process appeared also in 1943, when Ladislav Foltyn designed a hut for Štefan Zamkovský which was built by Jozef Šašinka.

However, technological innovations have also made their way into the alpine environment. The project of the first cable car in Slovakia, which set several period records, was implemented. These were objects at the altitudes of the alpine environment in all vegetation zones. We could consider this an exemplary adaptation of functionalism to the conditions of the alpine environment. It can be considered an extraordinary form of regionalist functionalism. The basic form of cable car construction was dictated by the technical requirements of Weisner Chrudim company. While architecture was the work of Dušan Jurkovič, his choice of materials and dealing with the means of expression "represents "the cultural intervention of man in nature." (Bořutová, 2010) In 1943, the first electric ski lift in Slovakia was installed on the slopes of Solisko. The dome called Becvařova kupola was installed as the first shelter for ski lift operators at the exit station. It got there from the reinforced concrete terrace of the café at the Grandhotel in Štrbské Pleso (Chudý, Sýkora, Labuda, 2019, p. 249). A year later, Chata pod Soliskom hut was built near the exit station. The first hut keeper was František Bujak, who was also an owner of a functionalist villa in Nové Štrbské Pleso. Although Chata pod Soliskom was built in the traditional way using log technology on a stone foundation, unlike the ski lift "shed" at the lift boarding station, it had a flat roof and for the period of building relatively large windows without partition. However, we do not yet have additional documents to assess its overall architecture from the time of the original state. It seems that the steps of early modernism were stopped in the ascent to the mountains by the rugged terrain and the possibilities of material transport. However, the construction of mountain huts represents more of a modernist idea of innovations in leisure and free time activities. They act as the background for these activities in a 100% sunny and illuminated area of the original landscape. Functionalist objects that have become a cover for modern activities have remained with all their typical means of expression in the Tatra settlements.

FROM IMPROVISATION TO INNOVATION

The architecture of solitary buildings in the original landscape of the alpine areas in the High Tatras reflected contemporary architectural events only exceptionally. Usually, architecture followed the tradition of log and stone masonry buildings, one, two and three-room houses. The scale of the buildings depended on the popularity of the site and the level of terrain difficulty, while the construction and material were based on the vegetation zone of the site and the available building material. There were typical wooden buildings in the vegetation zone of the forest and stone ones in the alpine zone. Cooperation with an architect would also be a significant innovation in the construction of the alpine huts. The huts rarely went through the process of architectural design, a significant exception being Téryho chata hut, the essence of which by the author Gedeon Majunke is preserved to this day. The absence of historical architectural elements in eclectic Tatra settlements maintained the purist expression of the huts. Innovative materials have entered mountain architecture sporadically and with a delay compared to applications in the lowlands of the Tatra settlements. Likewise, the fashion of innovative architectural elements has found its way to the mountainous environment to a limited extent. Interior equipment innovations took place as modernizations, or rather as redevelopments of the layout, after they found their place in the typology of spas and hotels in settlements.

Mountain huts arose more from the enthusiasm of tourists than the architectural incentives to create in the original natural landscape. Therefore, architecture, or rather buildings, were often erected as a result of improvisation. If the meaning of the huts was proven, they went through a process of innovation. However, the architecture in the hard-to-reach terrains remained resistant to architectural innovations, true to tradition and reflected the essence of the necessity of a shelter. (Tab. 1) In the period of early modernity, innovations in mountain architecture manifested themselves as a reaction to innovative social phenomena of recreation. However, the invention of the helicopter and the innovation of access roads have forever changed the thinking about building materials in the alpine environment. Reduction of materials to the necessary minimum, use of the construction potential of the site and the adaptation of the layout of the terrain have become past. In the following period, the alpine landscape is approached by a brick, aerated concrete, heavy building machinery and other standard building methods from the urban areas. Another part of the research will examine how mass recreation has changed the view of the architecture of alpine areas and how tourist huts have been innovated after privatization.

Tab. 1. The huts through the 19th and first half of the 20th century. (Author: Mária Novotná)

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Route options in inclusive museums: Case studies from Central Europe

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Abstract: Museums are complex architectural works with many distinctive elements. One of the most significant museum features are routes or paths on which visitors circulate museums and perceive exhibitions. Children and people with special needs often have specific demands on physical accessibility of the surrounding environment, chronological arrangement of spaces and amount of information presented at a time. The arrangement of functional units in museum layouts affects wayfinding in space, understanding of the exhibition, as well as visitor guidance. The order in which people visit particular segments in a museum can also be described as one of the most important architectural and operational characteristics of this type of cultural buildings and areas. The article examines ways of arranging spaces in a museum building and the suitability of their application. These forms are evaluated based on various aspects; some of the created effects are studied, e.g. creation of a desired atmosphere. Existing concepts are compared and supplemented with other theoretical knowledge. The article aims to present variant suitable ways of composing routes that would meet the needs of different people, and bring them a quality leisure and educational experience from a museum tour. Various types of museum layout organisation and arrangement of exhibition spaces are illustrated with abstract schemes, as well as with specific case studies of five selected museums. The selection consists of architecturally exceptional and high-quality museums in Central Europe, which are able to attract a whole range of various groups of people including a younger audience. They are examples of both modern museums in this area and route planning options. The case studies highlight interesting local ideas, space concepts, routing methods, and also solutions for increasing inclusion of all visitors and children in particular.

Keywords: museum, children, tour route, inclusion, architecture, exhibition, sequence

INTRODUCTION

Interactive or hands-on museums provide an opportunity for extracurricular education in a playful way, encourage creativity and imagination, and broaden the intellectual horizons. Museums can inspire children and the young in particular, because young people have a greater potential to expand their less-defined interests (in comparison to adults), increase enthusiasm for education, shape them, and perhaps even influence their choice of future profession. The importance of experiences and education in museums is addressed by several authors, such as Graham Black (Black, 2012, 2015), John H. Falk, Lynn D. Dierking (Falk, Dierking, Lynn, 2018), Tim Caulton (Caulton, 1998) and George E. Hein (Hein, 1998). By developing their positive attitude towards cultural facilities at an early age, it is possible to encourage children's curiosity and self-confidence in education, discovery and communication, and to maintain their interest in museums and galleries in the future. Particular emphasis should be placed on museum's accessibility and the inclusion of people with disabilities in all the activities a museum has to offer. It is crucial for museums and other public buildings to welcome all visitors with various needs equally. In the context of inclusive education, Vladimír Jůva (Jůva, 2004, p. 156) emphasizes the importance of inclusion of children and young people with special needs in all spheres of contemporary life. As Meredith Banasiak (Banasiak, 2020, p. 231) states, museums' exhibitions and exhibits are an integral part of museums, they are therefore currently presented in various multisensory and interactive forms. Black (Black, 2005, p. 131) also highlights the opportunity to participate directly in individuals' experiences and support the diversification of their audience. People need appropriate conditions for learning and creativity; they can better concentrate on gaining knowledge or discovery in a well-designed, structured environment – for example, in the interest of inclusion, it is necessary to take into account principles of universal design. Therefore, the accessibility and order and amount of information or exhibits are very important in this regard. Hence, in this article, special attention is paid to different kinds of routing systems and space segmentation in museums. Moreover, the importance of museums extends also to playful experiences contributing to healthy development and contentment of children. Meaningful and creative (structured) play can be therefore supplemented with "immediate activity" of "free play" mentioned by Lívia Kožušková (Kožúšková, 2017), where children are given freedom to choose their playful activities.

Furthermore, opportunities for play and discovery in museums "for all visitors" also extend to supporting inclusion in communication and cooperation among them, and strengthening family, friendship and multigenerational relationships. In this context, according to Muna Silav (Silav, 2014, p. 358), children's museums especially help *"develop social relationships among children by creating opportunities for solidarity and cooperation."* A playful and encouraging vibe of the space can be achieved by various architectural and design solutions, interventions in the form of sensitively inserted interiors, cosy semi-open nooks, or even through appropriate furniture, materials, colours etc. Clear wayfinding options and landmarks also positively influence well-being and atmosphere of the space. Together with other factors, they encourage inclusion: equal use, accessibility, flexibility, adaptability of spaces and elements (CABE, 2006).

RESEARCH SUBJECT, METHODS AND AIM

The main focus of this research is on the study of routing options by means of theoretical desk research, their application in practice through case studies, and analysis of their suitability for children visitors. Furthermore, additional characteristics of museum spaces are considered, mainly their atmosphere and inclusiveness for all. This research forms part of a broader doctoral research; a brief summary of the findings has been presented and published at Point for science, a platform for doctoral presentations (Filová, 2021).

Firstly, desk research was conducted. For purposes of this survey, Ernst Neufert's (Neufert, 2019) typology was used that summarizes the types of layouts, and also indicates relevant routing options. In addition, findings of Paul von Naredi-Rainer and Angelika Schnell (Naredi-Rainer, Schnell, 2004) focused primarily on routing in the exhibition spaces were considered. The topic is also enriched with information from other authors, such as Uriel Cohen with Ruth McMurtry (Cohen, McMurtry, 1985) and John Pearce (Pearce, 1998). A comparison of the approaches of the aforementioned authors is also supplemented with theoretical assumptions of the authors of the paper.

Secondly, the research continued with practical analysis of selected museums as case studies, using theoretical knowledge and applying it to museums in Central Europe, as this paper is linked to other research conducted in the region. Therefore, Slovakia and four neighbouring countries were selected. The selected buildings meet the following conditions: 1. They are located within 150 km from Slovakia at maximum; 2. They have supraregional significance, thus they are relevant; 3. They were created in the period of 2000 – 2020, so they are contemporary structures and meet accessibility requirements; 4. Their layouts include different types of route arrangements, so they are suitable for comparison.

The following methods were used: on-site observations, interviews with staff and experts on museums when possible, and information search on museum websites and in printed materials. We personally examined the individual museums and described them. Inclusion in museums was evaluated similarly to Access Audits realised by members of Centre of Design for All (CEDA) in various buildings' evaluations. The audits are conducted according to CEDA's Access Audit Checklist based on the principles of Universal design. Comparable methods are frequently applied also in other authors' works in CEDA. For example, Access Audits of various objects including museums, galleries and other cultural institutions in Slovakia are often performed also by students of the Faculty of Architecture and Design STU within the compulsory course Universal Design. Some of these findings have been published in Culture for All (Čerešňová, 2009).

Graphic materials of the selected buildings underline the explained phenomena. They consist of diagrams, authors' own photo documentation and researched original project documentation, on which markings with tracing of possible routes are presented. The expected outcome of the paper is taking several mentioned authors' and also our own theoretical reflections into account, summarizing and comparing them, but also discovering new remarkable elements or combinations of accessible routing systems through case studies. Overall, this study aims at researching theoretical background concerning routes in inclusive museums and reflection of these ideas in practice. The research analyses various known possibilities of creating exhibition paths in museum buildings; it does not intend to unify design principles, only to provide a positive inspiration based on existing layout-type options and their combinations. The awareness of past variants and current creations may lead to diversity of approaches in the future, or even the emergence of innovative design ideas.

DESK RESEARCH: ACCESSIBLE EXHIBITION ROUTES

Routes can result either from architectural design of the building or from the exhibition arrangement. According to Cohen and McMurtry (Cohen, McMurtry, 1985, p. 30), the exhibition routes have greater potential than just guiding the flow of museum visitors. The accessible route determines the sequence of information, activities and objects, it can also tell a certain story, which is one of the most sought-after elements for people in general, as Ann Sussman and Justin B. Hollander (Sussman, Hollander, 2015, p. 7) claim. The layout operation concept and architectural formation of a museum building are closely related to the creation of routes and potentially also to telling stories that can be perceived by at least two senses (e.g. sight and hearing).

The following analytical part of the research contains a comparison of spatial concepts described by Neufert and Naredi-Rainer with Schnell, taking into account works of other writers and findings of authors of this paper, as well. Neufert (Neufert, 2019, p. 386) mentions six basic types of exhibition space layout and the layout concept: 1. Open Plan, 2. Linear Chaining, 3. Round Tour (Loop), 4. Core and Satellite Rooms, 5. Labyrinth, 6. Complex Layout. Naredi-Rainer and Schnell (Naredi-Rainer, Schnell, p. 66) also list six types of spatial layout and routing in museums (Fig. 1). This categorization mainly applies to layout shaping methods and is reflected in museum floor plans. The primary classification of the layout schemes of the museum space is that by Neufert, because it contains also original diagrams and Neufert's works are recognised in a broader sense in other areas of architectural planning, as well. On the other hand, Naredi-Rainer's layout schemes were studied mainly on the basis of texts and groups of selected museums by this author; it is a more subjective point of view. Naredi-Rainer's suggested layout designs are more loosely conceived and sometimes overlap with several of the aforementioned types classified by Neufert. The Naredi-Rainer classification can be therefore viewed as information additional to the main classification by Neufert, with several possible points of contact with listed layout types; they are not parallel classifications.

These layout arrangements provide visitors with different experiences from a museum tour. This paper focuses on the characteristics affecting inclusiveness, wayfinding and well-being, especially for children, but also for people with diverse needs. The characteristics of each of these layout types are as follows: "Open plan" is an important and widespread type of layout. It can generally be considered the least distinctive space of the aforementioned categories, providing the most indifferent "background" for an exhibition. Minimalist architecture makes exhibits stand out, and the viewer's attention can be fully focused them due to the absence of a significant architectural arrangement. However, some examples of implementation of open floor museum plans are no longer perceived as neutral covers only, as they also "carry" the atmosphere and have recognizable characteristics. In terms of good orientation and clarity, this type of layout offers the greatest potential benefits if a navigation system is created. An elaborate design of the exhibition itself is essential, because in the case of the open plan, the curatorial design is the determining factor. Too much open space without thoughtful navigation can reduce concentration of visitors due to disturbing factors (circulation of people, acoustics, etc.). Children in particular are disturbed by overly open spaces; therefore flexible panels and dividing furniture are often utilized.

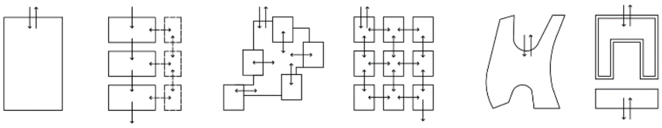


Fig. 1. Scheme of six basic types of exhibition space Layout according to Naredi-Rainer and Schnell (Naredi-Rainer, Schnell, p. 66): 1. Open Plans, 2. Directed Sequences of Rooms, 3. Spatial Interpenetration and Spatial Isolation, 4. Matrix-like Arrangement of Rooms, 5. Free-form Spaces, 6. Conversions and Extensions of Architectural Monuments. (Author: Natália Filová, inspired by descriptive texts by Naredi-Rainer and Schnell (Naredi-Rainer, Schnell, p. 66))

Another layout type is "Linear chaining", which is similar to "Directed sequences of rooms". They are interconnected in such a way that room doors are placed on one axis and allow multiple transparent views. This layout is characterized by a relatively strict order of exhibition parts. It is necessary to work with this aspect while planning an exhibition, because the sequence of exhibits has a great impact on continuity and visitors' understanding. A possible disadvantage of this layout is that it can become too repetitive, when there are many connected rooms. However, there may also emerge alternative routes, such as side routes parallel to the main one, but the core direction of the tour remains recognizable. Alternative routes can enrich the exhibition routing; they stimulate mystery, discovery, imagination, creativity and also provide privacy. "Round tour (loop)" is a variation of these types, because it also contains a programmed order of rooms, and thus a clear route of the tour, but it is no longer linear but cyclical. This layout composition provides an opportunity for appropriate information delivery and structuring, so also for good orientation and clarity.

"Spatial interpenetration and spatial isolation" are another type of museum arrangement; they combine ideas of flowing space and pavilions (Naredi-Rainer, Schnell, p. 143). A related scheme according to Neufert's classification is more difficult to assign, but it is possible to draw a certain parallel with the concept called "Core and Satellite Rooms" in which the premises are divided into the main room and side rooms, or even into scattered passages or hall spaces, a kind of "base", with exhibition rooms, alternatively pavilions, accessible from the scattered space. This concept can create an interesting solution. The ability of orient oneself in these spaces varies depending on the number of adjacent spaces, as well as their marking or differentiation (e.g. by colour, material, shape, acoustic beacon, etc.). Furthermore, the types of floor plan "Labyrinth" and "Matrix-like arrangement of rooms" can be compared as well. The exhibition spaces are connected in a way that there is no single main route with side routes, but there are several equivalent alternatives for continuing the route instead. This type of layout is characterized by ambiguity, often even difficult wayfinding. However, children in particular enjoy discovery and riddles; therefore, it has the potential to become an experiential path that is suitable for some exhibition themes. This type is challenging as regards creating a comprehensible space but signs on floors, doors, and the like can help simplify navigation.

The remaining spatial concepts of Neufert and Naredi-Rainer with Schnell are categories that specific and derived to a greater extent. "Complex" layout is a combination of characteristics from several spatial structures of the aforementioned concepts. A recognizable feature of the "Free-form spaces" in museum buildings represents rejection of application of right angle and geometric regularity. This category exemplifies mainly architecture of a museum, which seeks to be a work of art in itself. The layout of spaces and the method of routing can vary between the above-mentioned types of concepts. "Conversions and extensions of architectural monuments" show attempts to coexist with the existing structure. Museums are often placed in historic buildings with various former functions which are modified, rebuilt including the removal of barriers, or a new object is attached to them, located next to or near them. Especially in children's museums, there is a strong trend towards adapting a building which originally served a different purpose to this new function, as stated by Cohen and McMurtry in the context of American museums for children (Cohen, McMurtry, 1985, p. 36).

To conclude, with regard to designing for children and various visitors, there are both advantages and risks in each of the aforementioned layouts. The open plan is the most flexible space of all, if properly designed, it is usually easy to understand, but potential disadvantages include disturbance from excessively open space, agoraphobia or chaotic delivery of information. In contrast to the open plan, sequence of spaces is already divided and proposes didactic sequential ordering of information on exhibition topics, which requires a stricter sequence and amount of information. On the other hand, core and satellite rooms are suitable when presenting multiple equal topics with no need for a specific order. Labyrinth-like layouts are difficult for visitors to understand and orientate, their potential lies in experiential exhibition topics. The rest of the concepts are specific cases with individual positive elements and drawbacks.

CASE STUDIES: MUSEUMS FROM CENTRAL EUROPE

Fig. 2. Locations of museums chosen for case studies. (Author: Filová, 2021)

Selected contemporary museums located in the Czech Republic, Poland, Austria, Hungary and Slovakia are examples of objects harmoniously integrated into urban and natural surroundings, which reflect the genius loci of the place where they are situated. Efforts to emphasize the local identity and uniqueness resonate with the interest in inclusion and welcoming children and diverse visitors. Each of these museums is an architecturally remarkable and professionally recognized building, they are bearers of various ideas, and have individual characteristics in terms of architectural and artistic solutions. Fig. 2 shows the locations of examined museums. The research focuses on application of some of the above-mentioned theoretical knowledge in the analysis of museums in various contexts, most importantly with respect to the accessible routes proposed by the layouts and spatial planning. The original project documentation found in desk research and during visits to these museums is supplemented with markings of possible routes in exhibition spaces made by the authors of this paper. The markings are illustrative; they do not attempt to reflect precise reality but rather the principles in the routing concepts.

VIDA! Science Centre in Brno

The interactive museum in the Czech Republic is situated in a hall of the former pavilion of an exhibition centre from 1973 designed by architect Zdeněk Denk. The restoration of the object was designed by the studio K4 a.s. (architects Zdena Němcová, Jan Lacina and Vladimír Pacek). During the renovation and adaptation of the building to the new function, the original design was respected and complemented using a ramp with an organic shape, which leads to the new main entrance (Fig. 3). However, the ramp should be less steep for people using a wheelchair. The design was implemented in the years of 2011 - 2014.

Fig. 3. VIDA! Science Centre in Brno, Czech Republic: Exterior view. (Photo: Filová, 2019)

The exhibition route is indicated in the open space by means of drawing and projection on the floor (Fig. 4). Four exhibition areas are also colour-differentiated, which significantly helps in navigation. Visitors may or may not respect the recommended route, depending on their interests, time and general preferences. Several possibilities of vertical movement are provided, including one accessible to visitors with reduced mobility. Visitors can visit the interior gallery on the 1st floor using stairs, a lift or an escalator. It is possible to go down using a slide, which is attractive, especially for children.

Exhibition space is an open plan, as can be seen in floor plans (Fig. 5, 6), and also experienced during a personal visit. The space is divided by larger exhibits and a few partitions forming small pavilions. The museum strives to be inclusive and incorporates many accessible elements; this effort could be further supported with an accessible main entrance. Wayfinding in this museum is rather intuitive for visitors of all ages thanks to the indicated route traces. Possible views of the exterior would improve orientation even more. In conclusion, the VIDA! Science Centre in Brno is an interesting example of the transformation of a building that lost its original purpose into an interactive, entertaining and educational place. It is a museum with an open plan layout and free routing, so it provides great flexibility as regards the viewing of the exhibition.

Fig. 4. VIDA! Science Centre in Brno, Czech Republic: Tour route indicated by drawing and projection on the floor. (Photo: Filová, 2019)

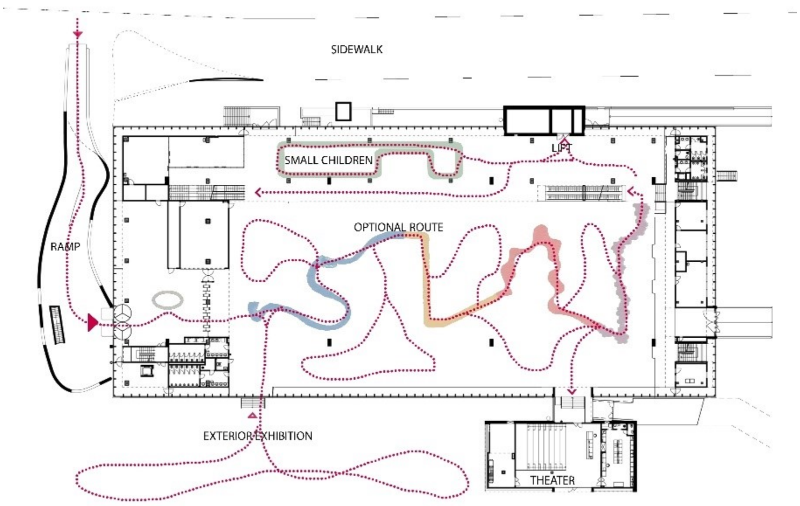


Fig. 5. VIDA! Science Centre in Brno, Czech Republic: Ground Floor. (Source: Floor plan by K4 with markings by Filová, 2021)

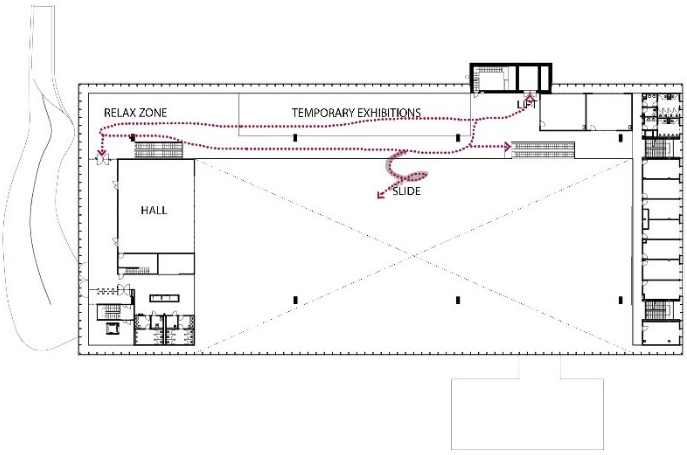


Fig. 6. VIDA! Science Centre in Brno, Czech Republic: 1st Floor. (Source: Floor plan by K4 with markings by Filová, 2021)

Silesian Museum in Katowice

The Silesian Museum, built in 2011 - 2013 in the Polish city of Katowice, is located in the area of former mines (Fig. 7). It has a large floor area in several original and new buildings interconnected with various exterior paths (Fig. 8). Architects Florian Riegler and Roger Riewead chose to locate a large exhibition area mainly underground. Above the terrain, there are abstract glass blocks of various scales, allowing daylight to enter the underground exhibition space. The minimalist glass blocks make the historic architecture of the complex stand out, and emit diffused light at night. Exhibition areas consist of large open spaces, which are in individual zones divided to varying degrees by exhibits, partial partitions or panels, among which it is possible to walk in various ways (Fig. 9, 10). There is also a completely closed organized labyrinth area, where visitors find a very strictly programmed exhibition route with chronological continuity (Fig. 11, 12). Thus, there are several means of routing applied in this museum. Floor levels are interconnected with monumental ramps, stairs and a lift (Fig. 13). The interior design is mostly understandable, wayfinding can be slightly challenging in the labyrinth segment, but it is expected from this type of path. Finally, it can be stated that this is an exceptional example of restoration and completion of a monument area with an architectural novelty. A sensitive, minimalist incorporation of new formations harmonizes with the historical architecture and complements it. There are several layout designs and paths possible in this extensive museum. Visitors can find open spaces, partially divided (semi-open) areas and labyrinthine layout.

Fig. 7. Silesian Museum in Katowice, Poland: Exterior context. (Photo: Filová, 2019)

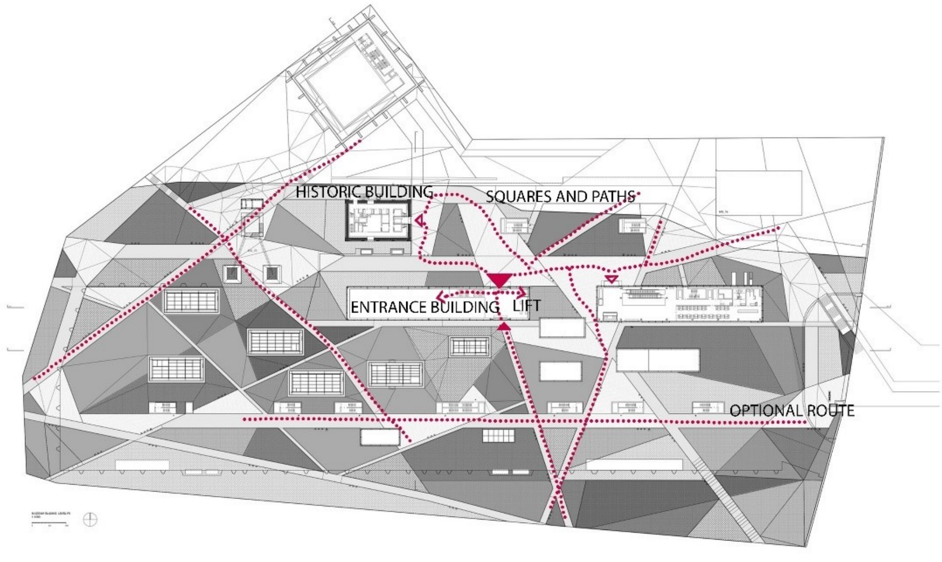


Fig. 8. Silesian Museum in Katowice, Poland: Ground floor. (Source: Floor plan by Riegler Riewe Architekten with markings by Filová, 2021)

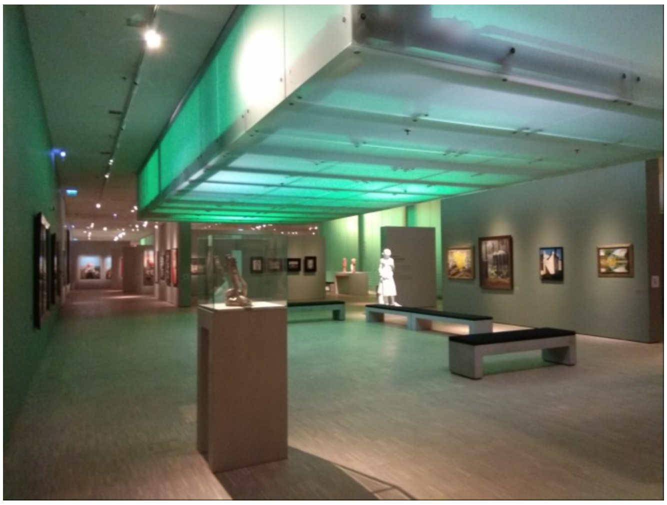


Fig. 9. Silesian Museum in Katowice, Poland: Free tour toute slightly divided by panels. (Photo: Filová, 2019)

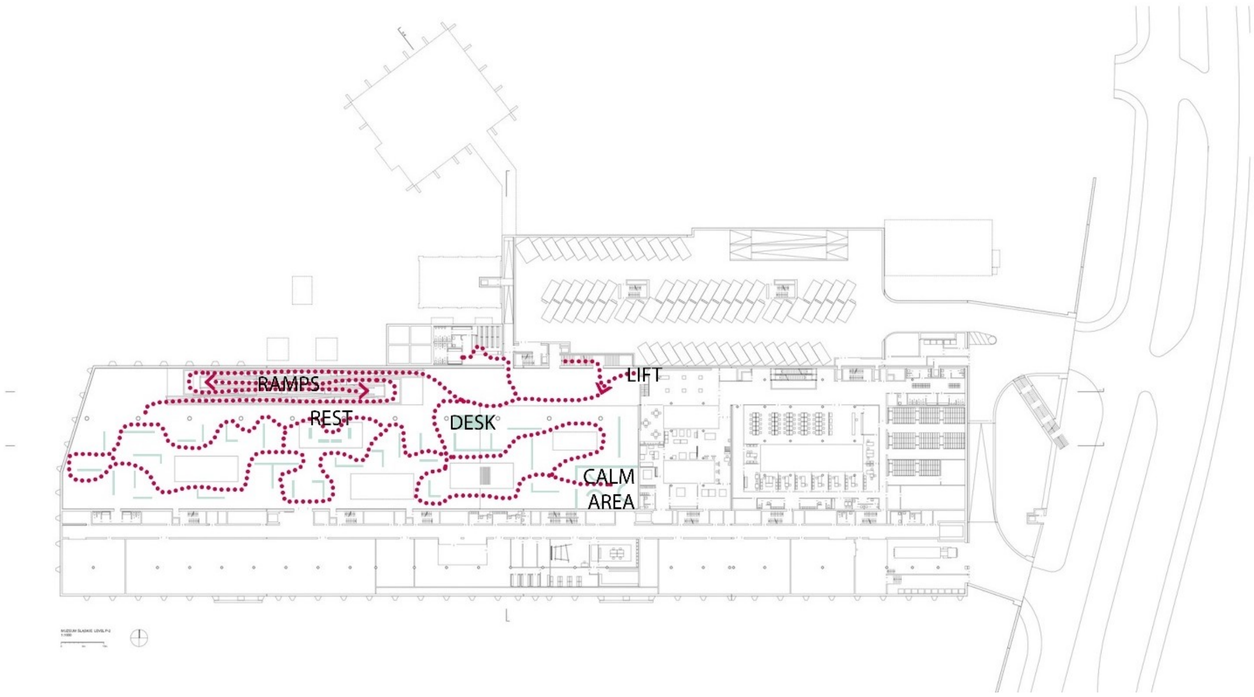


Fig. 10. Silesian Museum in Katowice, Poland: Level -2. (Source: Floor plan by Riegler Riewe Architekten with markings by Filová, 2021)

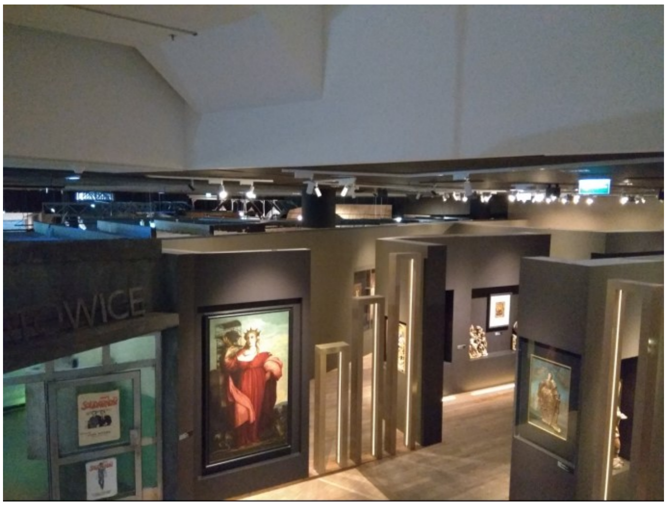


Fig. 11. Silesian Museum in Katowice, Poland: Strict labyrinthine tour route. (Photo: Filová, 2019)

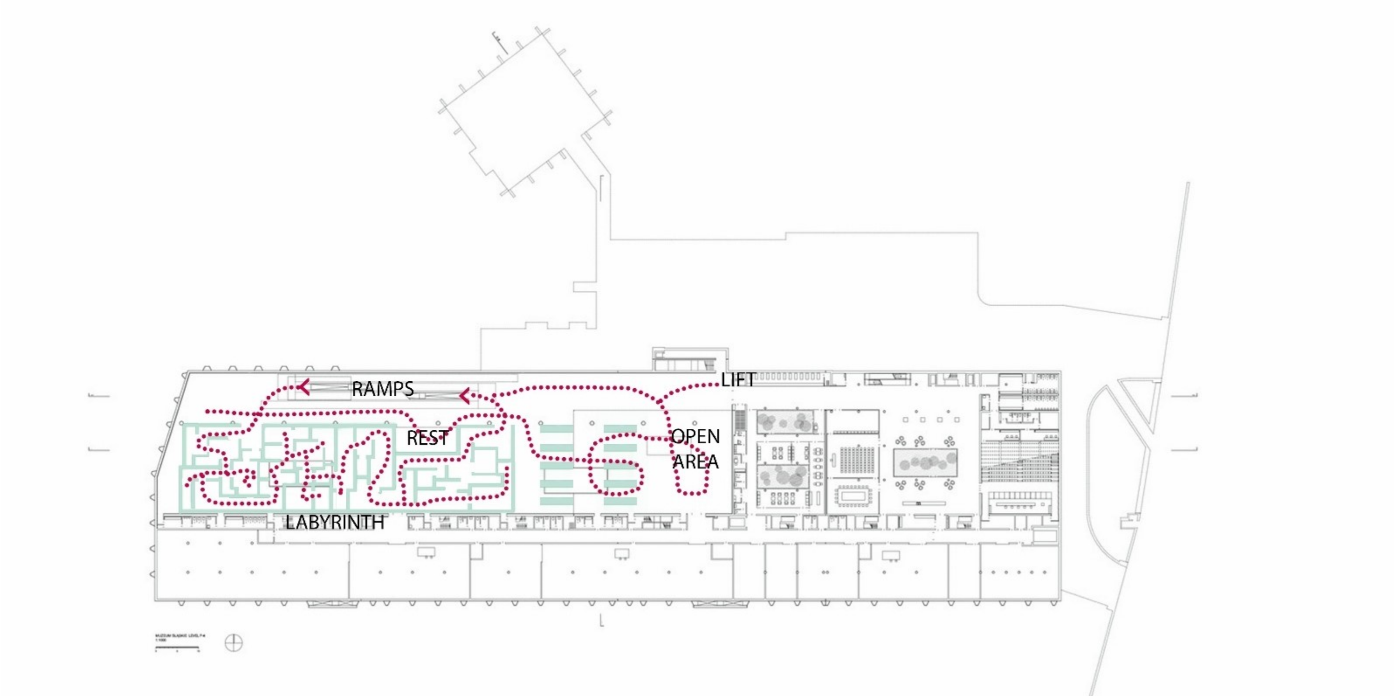


Fig. 12. Silesian Museum in Katowice, Poland: Level -4. (Source: Floor plan by Riegler Riewe Architekten with markings by Filová, 2021)

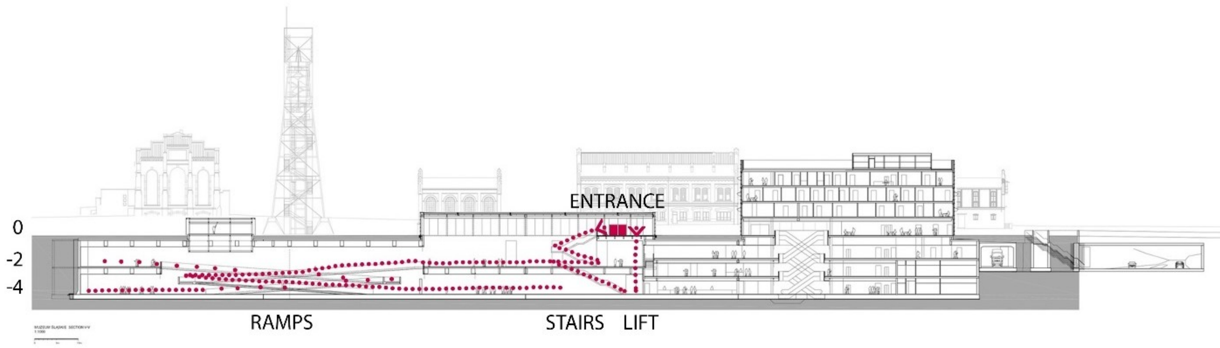


Fig. 13. Silesian Museum in Katowice, Poland: Longitudinal section. (Source: Floor plan by Riegler Riewe Architekten with markings by Filová, 2021)

Lower Austria Museum in St. Pölten

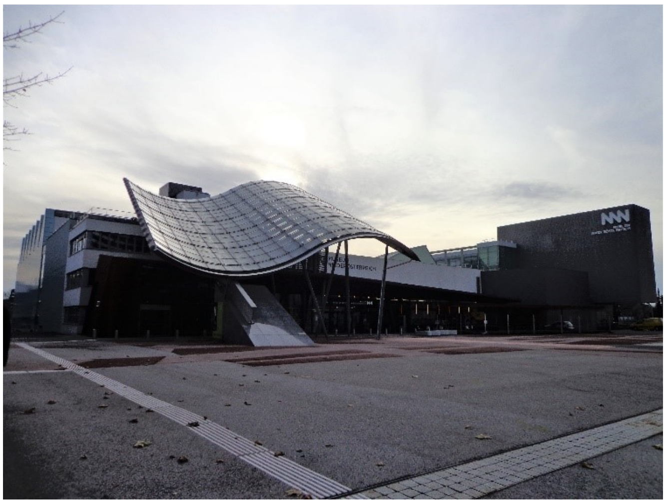


Fig. 14. Lower Austria Museum in St. Pölten, Austria: Exterior architecture. (Photo: Filová, 2019)

The Lower Austria Museum designed by renowned architect Hans Hollein in 2002 and by architectural studio Rata Plan (RATAPLAN, 2010) in 2009 focuses on the art and history of the region in which it is located, as well as on nature. These specialized segments are spatially and organizationally interconnected into a complex postmodern object (Fig. 14). The common entrance hall with facilities allows access to the exhibition hall with art and historical themes, as well as to the museum part specialized in nature. The left wing is of rectangular shape, and is dedicated to art and history, while the right, more complex shaped mass, covers nature. The connecting part serves as a common area and contains facilities. The nature tract is an example of a more programmed routing. Still, the visitor has the option to choose from several alternative circuits and possibilities for accessible vertical movement – a ramp, stairs and a lift. All these elements are an organic part of the tour, because they are located in the exhibition space and provide a view of it. Ramps are part of the inclusive route, and are quite long in some cases. They form one of the possible routes, and there are exhibits along them (Fig. 15). The hall space with the artistic and historical exhibition provides freedom in creating a tour route (Fig. 16, 17, 18). It is a free floor plan into which panels with exhibits are inserted. Visitors experience a rather free, open path there, in some places with certain denser groupings of panels where the route resembles the labyrinth form. The plastic shape represents the type of "Free-form spaces"; in parts of exhibition panels in the History wing it also combines traits of open space and labyrinth. In summary, this museum with its dual focus offers an equally dual experience and atmosphere in its concept. First of all, it is a more minimalistic open form of the art and history sector, which allows variable design of the interior using embedded dividing elements. In contrast, there is a more diverse structure of the part dedicated to nature, in which the strongly architectural solution more strictly determines the exhibition route, while exhibits are complementary elements of the interior. This museum is very variable as far as routing systems are concerned. It contains open or semi-open segments, a labyrinth-like structure and a part is a free form space. Such diversity makes it a complex layout.

Fig. 15. Lower Austria Museum in St. Pölten, Austria: Partially programmed routing and a free form space. (Photo: Filová, 2019)

Fig. 16. Lower Austria Museum in St. Pölten, Austria: Semi-open plan divided by panels, slightly resembling a labyrinth. (Photo: Filová, 2019)

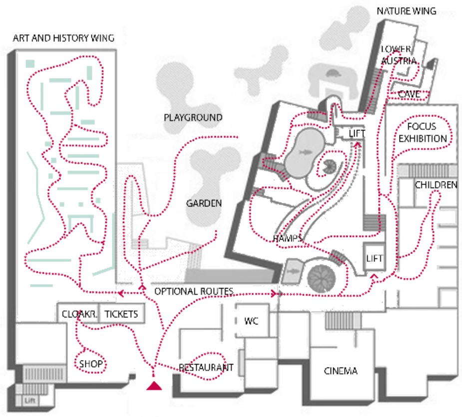


Fig. 17. Lower Austria Museum in St. Pölten: Ground floor. (Source: Floor plan by Niederösterreich Museum Betriebs GmbH with Markings by Filová, 2021)

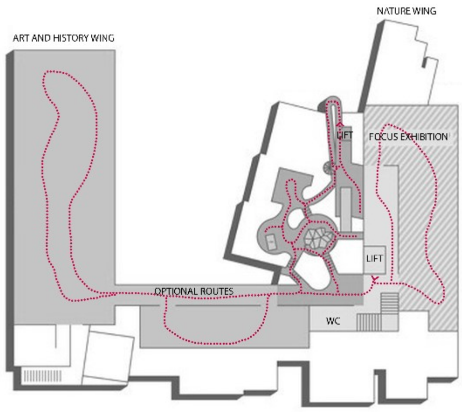


Fig. 18. Lower Austria Museum in St. Pölten, Austria: Level +1. (Source: Floor plan by Niederösterreich Museum Betriebs GmbH with Markings by Filová, 2021)

Kemenes Volcano Park

The Hungarian thematic museum Kemenes Volcano Park in Celldömölk focuses on volcanic activity. In the ancient past, volcanoes existed in this area. The building was completed in 2013, based on the design by the architectural studio Földes Architects. The building visually communicates with its environment using spectacular sceneries visible through the slits and in some places, also through larger glazing. Because of its prismatic shaping, the building evokes a mineral or rock, and with Corten steel or concrete surfaces; in an abstract way, it seems to be carried by flowing and solidified lava (Fig. 19). Numerous steel staircases and ventilation ducts in the open area reach across several floors (Fig. 20), as if there was a volcanic chimney, and footbridges leading through this opening contribute to this effect, and provide visual and physical connection, and also form exhibition routes. However, there is also a lift providing an accessible vertical connection. Visitors often enter the individual exhibition cubes or rooms via the footbridges and the open vertical space, which provide an unusual sequence of the exhibition (Fig. 21, 22). Out of the previously mentioned types of routing, "Core and satellite rooms" and "Spatial interpenetration and spatial isolation" seem to be the closest to this one. Through the common open spaces, even in the form of footbridges, visitors pass to individual mono-functional rooms (Fig. 23). They can choose to use staircases or a lift, so the routes are accessible for all. To conclude, the building is a valuable example of museum architecture, and in its exterior and interior appearance it is in absolute symbiosis with the functional content. Its routing is interesting and connected to the concept of vertical open space of the metaphorical volcano. The types of layout with core and satellite rooms and spatial interpenetration and spatial isolation can be observed in this building.

Fig. 19. Kemenes Volcano Park, Hungary: Architecture's relation to the environment. (Photo: Filová, 2019)

Fig. 20. Kemenes Volcano Park, Hungary: Vertical common space. (Photo: Filová, 2019)

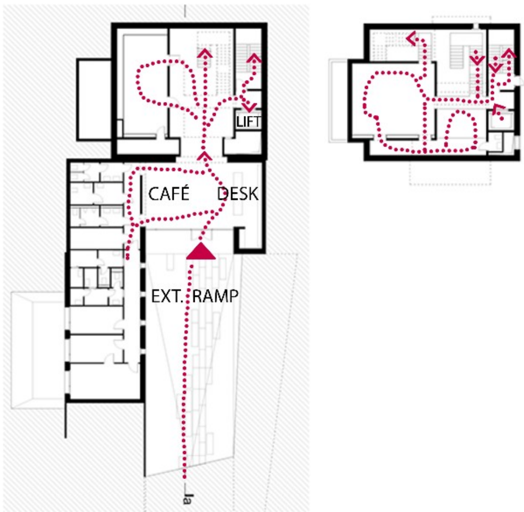


Fig. 21. Kemenes Volcano Park, Hungary: Floor plans. (Source: Floor plans by Foldes Architects with markings by Filová, 2021)

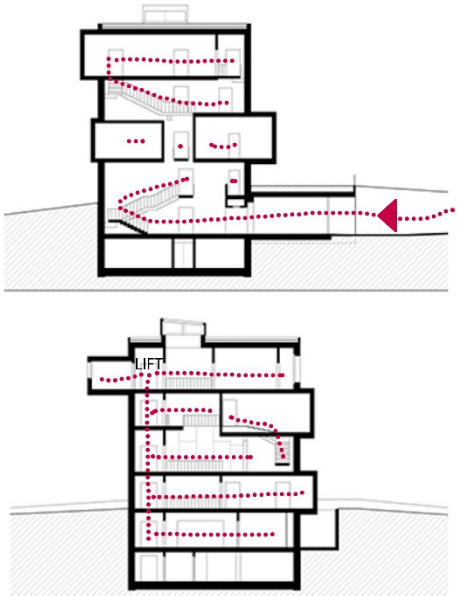


Fig. 22. Kemenes Volcano Park, Hungary: Sections. (Source: Floor plans by Foldes Architects with markings by Filová, 2021)

Fig. 23. Kemenes Volcano Park, Hungary: Example of a Thematic Mono-Functional Room. (Photo: Filová, 2019)

Kulturpark in Košice

The last analysed case is the cultural complex Kulturpark in Slovakia which was created through the conversion of the premises of former barracks from the end of the 19th century, which was completed in 2013 based on the design by Zerozero studio headed by the architect Irakli Eristavi. The solution respects original architecture and greenery, while sensitively placing new minor constructions in the area. Urban design of the area is connected to existing paths and is open to the city (Fig. 24).

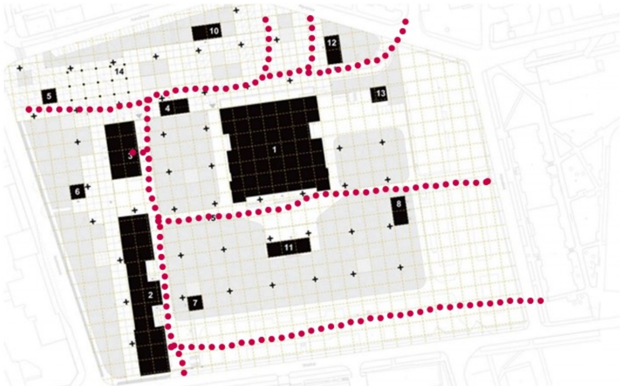


Fig. 24. Kulturpark in Košice, Slovakia: Location. (Source: Location by Zerozero Architects with markings by Filová, 2021)

Fig. 25. Kulturpark in Košice, Slovakia: The Steelpark Museum building. (Photo: Filová, 2020)

It consists of three historic buildings and several new small-scale pavilion solitaires which serve supporting functions, such as an information centre, workshops or a café, and do not compete with historical monuments with the core function. This set of buildings forms a multifunctional cultural centre and one of the buildings is used for museum purposes, which is described the following analysis. It is the Steelpark building (Fig. 25), and it contains a permanent exhibition focused on iron processing which displays a rich variety of exhibits connected with the traditions of the region. Visible brick masonry in the interior creates an aesthetic impression of the original elements of historical architecture. The routing of the exhibition is accessible and easy, as all four floors have an open floor plan without embedded dividing elements (Fig. 26). The layout could therefore be described as a series of halls with an open floor plan and a common vertical opening (Fig. 27, 28), or also as an atypical "Linear chaining" in the vertical direction. All areas for visitors are barrier-free. Overall, the Kulturpark complex has brought a lot of opportunities to its surroundings. People are attracted to this area for countless purposes, such as relaxation, meetings, visits to diverse cultural, as well as temporary or permanent exhibitions. The layout type is a series of open plans; it can be described as vertical linear chaining, as well.

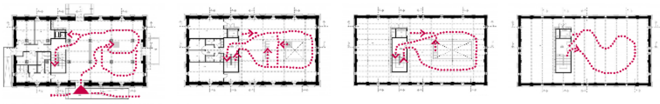


Fig. 26. Kulturpark in Košice, Slovakia: Floor plans. (Source: Location by Zerozero Architects with markings by Filová, 2021)

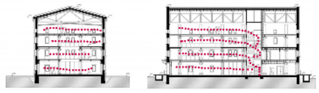


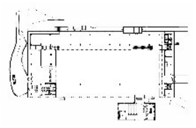
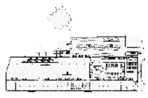
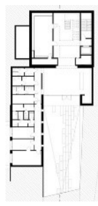
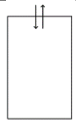
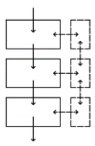
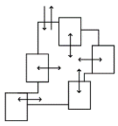
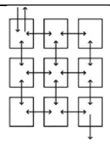
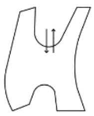
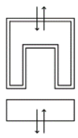
Fig. 27. Kulturpark in Košice, Slovakia: Sections. (Source: Location by Zerozero Architects with markings by Filová, 2021)

Fig. 28. Kulturpark in Košice, Slovakia: Vertical common space. (Photo: Filová, 2020)

DISCUSSION AND CONCLUSION

Based on theoretical knowledge and conducted case studies, several findings can be derived. Routing possibilities with regards to museum architecture and children visitors are still a very topical issue. Several layout types by Neufert and Naredi-Rainer with Schnell have been considered in the study. Tab. 1 shows a brief summary of findings, and presents an overview of routing systems implemented in museums from case studies. Our findings suggest that an open plan solution shows potential in many ways, including routes and orientation, and is most often presented in case studies. Moreover, large spaces can be divided by subtle elements, by inserted temporary or movable walls, panels or by larger exhibits themselves that can divide the interior into various spatial groupings, thus making it possible to create almost any other spatial layout and routing. The open space is usually filled with embedded exhibits or elements, which gives authors of exhibitions both great freedom and responsibility in creating the route. They must often pay more attention to this aspect than they have to when using other spatial arrangements with already predefined routes, e.g. linear chaining or sequence of rooms is usually easy to understand, as the spaces follow up in a simple way. Navigation in the spatial interpenetration and spatial isolation layout depends on the number and complexity of adjacent spaces, but various markings can facilitate orientation there. The labyrinthine type is even more complicated, where signs or views of the dominant elements are needed to facilitate otherwise rather difficult wayfinding. To make the orientation in all aforementioned routing types possible also for people with visual impairment, it is necessary to use methods like natural and artificial guiding lines (guide tiles), tactile orientation plans or models and descriptions in Braille. All in all, multiple suitable solutions were found in the research, in which various aforementioned principles were applied or connected to create interesting hybrids. The accessibility of the museum's routes and premises was also examined, as shown in Tab. 2. Orientation, equal use of routes and multisensory means of presentation were selected and evaluated as very important determinants in inclusive museums.

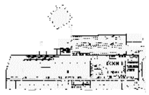
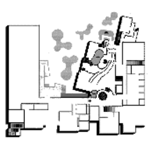
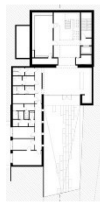
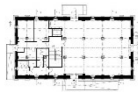
Tab. 1. Brief summary of findings regarding routes. (Author: Filová, Picture source – columns left to right: Naredi-Rainer, Schnell, 2004; K4; Riegler Riewe Architekten; Museum Niederösterreich; Foldes Architects; Zerozero Architects)

Layout Types	**VIDA! Science Center in Brno, Czech Republic** 	**Silesian Museum in Katowice, Poland** 	**Lower Austria Museum in St. Pölten, Austria** 	**Kemenes Volcano Park, Hungary** 	**Kulturpark in Košice, Slovakia** 
	Open Plan	Open/Semi-Open Plan	Open/Semi-Open Plan		Series of Open Plans*
					*also as Vertical Linear Chaining
				Spatial Interpenetration and Spatial Isolation/Core and Satellite Rooms	
		Labyrinth	Labyrinth		
			Free Form Space, Complex Layout		
		Conversion and Extension of Architectural Monument			Conversion of Architectural Monument

There are also limitations of the study, because the question still remains whether the architects followed the above theories and typologies in their design or designed the layouts entirely based on the assignment and requirements of the museum based on its collection, history and situation. It was probably a combination of multiple factors. Nevertheless, even if it is the case that architects of the analysed museums did not specifically follow the mentioned typological principles, these principles appear commonly, and are intuitively applied by architects.

This research focuses on exploring various solutions in Central Europe to gain local inspiration and better understanding of a broader context of possible architectural solutions realised in this area, including Slovakia. The wider research synthesised in this paper was followed by more detailed local surveys conducted later. In both their current and future research, the authors concentrate primarily on Slovak museums and galleries and their suitable routing and on meeting the needs of children and people with special needs. Furthermore, this research also shows that the related issue of the degree of closeness or openness of museum premises is an interesting phenomenon to be explored in the future, and routing itself has a potential for further study with focus on vertical opening of museum levels, as it also helps in wayfinding and intuitive movement.

Tab. 2. Brief Summary of findings regarding inclusion of all. (Author: Filová, Picture source – columns left to right: K4; Riegler Riewe Architekten; Museum Niederösterreich; Foldes Architects; Zerozero Architects)

Partial Inclusion Evaluation	**VIDA! Science Center in Brno, Czech Republic** 	**Silesian Museum in Katowice, Poland** 	**Lower Austria Museum in St. Pölten, Austria** 	**Kemenes Volcano Park, Hungary** 	**Kulturpark in Košice, Slovakia** 
Easy orientation in routes	✓	X/✓	✓	✓	✓
Rationale	Spacious area, many views	Very complex, but efforts to incorporate signal points	Many signal points, many views	Compact solution, many views	Compact solution, simple layouts
Equal use of routes for all	X/✓	✓	X/✓	X/✓	✓
Rationale	Separate barrier-free entry, accessible interior	Common accessible paths	Separate interior routes in parts	Lift in an eccentric position, staircases in the centre	Use of lift or elevator, or a mechanical pulley (for experience)
Multisensory presentation	✓	✓	✓	✓	✓
Rationale	Visual, acoustic, tactile	Visual, acoustic, tactile, even olfactory	Visual, acoustic, tactile, even olfactory	Visual, acoustic, tactile	Visual, acoustic, tactile

Further research will thus concentrate on principles of Universal design implemented in museum architecture with the aim to provide quality experience for all visitors with different needs. Authors' recent audits conducted not only in Bratislava but also with cooperation of students of the course Universal design in Banská Bystrica Region, Slovakia, should be mentioned as well. A total of 12 museums and galleries, including the museum routes, have been examined in recent months with respect to the principles of Universal design. The resulting reports also offer concrete recommendations for the individual museums. In the past, more detailed research was also conducted in Bibiana (Filová, Rollová, 2019), and the authors plan to continue in-depth research there in the future.

In this study, theoretical findings were assessed using five case studies of remarkable museums with various routing options which emphasize their local identity. Unique combinations of space sequence and division show practical application of theoretical layout types found in desk research. The way of guiding visitors around a building and walking them through individual spaces is the key factor for experience, wayfinding, but also understanding, which significantly determines the degree of inclusiveness. Museum routes can thus considerably affect the overall atmosphere and success of the whole building.

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Microclimatic factors in urban development: The setup of an environmental observatory at the FAD STU

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Abstract: The presented research focuses on energy (im)balance on both global and local scale. The main emphasis is placed on microclimatic factors directly affecting public urban spaces and related physical processes regarding the city that are closely linked to energy flows and result in the formation of Urban Heat Islands (UHIs). As they are one of the main adverse effects of human activities, the paper introduces the classification of UHIs by types, describes the basic differences between the surface energy balance of rural and urban areas, and introduces climate-sensitive urban design as one of the possible ways of mitigating the undesirable anthropogenic impact on the climate change. The authors of the article present their own research, which predominantly focuses on the development of an environmental observatory situated on the rooftop of the building of the Faculty of Architecture and Design STU in Bratislava (hereafter referred to as the FAD STU). They interpret the experimental operation of sensing probe 1 and the first results and measurement data on Global Horizontal Solar Irradiation (GHSI) and their post-processing. In addition, they describe the construction of sensing probe 2, which will provide more data on the total atmospheric precipitation, wind speed and its direction, presence of dust particles and carbon dioxide in the air, or spectral characteristics of incident and reflected solar radiation. Finally, the experimental operation of a thermal and micro- camera with fisheye lenses is described. These cameras are essential for measuring the Normalized Difference Vegetation Index (NDVI) as one of the parameters used for the assessment of vegetation vitality, which also plays a key role in the formation of the UHI effect.

Keywords: city, urban heat island, urban microclimate, physical parameters, environmental observatory, sensing probe, FAD STU

INTRODUCTION

Not only have humans been affecting biotopes, but the negative impact of anthropogenic activities results in the global climate change. As part of the main global goals to mitigate these effects, various international strategic documents on sustainability such as the *EU strategy on adaptation to climate change* (European Commission, 2013), the *European Green Deal* (European Commission, 2019), the *Climate and Environmental Emergency* (European Parliament, 2019), the *2030 climate & energy framework* (European Commission) or the *Paris Agreement* (United Nations, 2015) set out the following measures: keeping the increase in global average temperature well below 2°C compared to preindustrial levels and pursuing such efforts to limit the rise to 1.5°C, since this would significantly reduce the risks and impacts of the climate change; adoption of mitigation strategies, rapid reduction of global greenhouse gases (CO_2, CH_4, N_2O, NO_X) and aerosols among other forcings; smart integration of renewable energy sources; increasing energy efficiency; transition to the low carbon economy; development of energy storage technologies or the application of energy efficient and environmentally friendly construction and renovation of buildings. In general, cities are the man-made products of culture that act as centres of innovation, industry and labour. Currently, the share of the urban population in the world's population has reached 56%, with the expectation of an increase to 9.7 billion by 2050, with 68% of the inhabitants living in urban areas (United Nations, 2019). Although the estimates of global urban land stated in various sources vary widely from less than 1% to 3%, mainly due to different definitions of urban land (Liu, He, Zhou, Wu, 2014), cities are supposed to be responsible for most of the emissions. The *World Resources Institute Global* identified greenhouse gas emissions by sector in 2016 as follows: Energy use in buildings: 17.5% (commercial: 6.6%, residential: 10.9%), transport: 16.2%, energy use in industry: 24.2%, agriculture, forestry and land use: 18.4%, waste disposal: 3.2%; and industry: 5.2% (Ritchie, Roser, 2020). Consequently, the importance of cities will increase, while their rapid growth will bring many opportunities, apart from many challenges, to address their contribution to air pollution, rise in global surface temperature, or to different issues such as population, ageing, inclusion, safety, resilience, and sustainability. The common objective is to achieve the sustainable development introduced by the *Club of Rome* in 1972 that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). The co-existence of living organisms (vegetation, animals and people), their communities, and the abiotic environment within cities is studied by urban ecology (Sukopp, 1998).

In turn, the relationship between the cultural environment (buildings, industry and human activities) and the biophysical habitat of ecological spheres such as the urban atmosphere, biosphere, hydrosphere, pedosphere, and lithosphere determines the characteristic processes known as *urban metabolism*, which means the transformation of materials and energy in a city (Oke, Mills, Christen, Voogt, 2017). Forman et al. calculated that 72% of global primary energy consumption is lost after conversion (Forman, Kolawole Muritala, Pardemann, Meyer, 2016), and 49.3–51.5% of global energy use would end up as waste heat in 2030, as assumed by Firth et al. (Firth, Zhang, Yang, 2019). These heat losses result mainly from (in)efficiency and have an inevitable impact on global or urban climate. Energy balance and energy efficiency are very complex issues that are closely linked with external and internal forces, and involve a variety of scales, physical parameters, distinct processes, or innovations in energy transformation.

This article focuses predominantly on microclimatic factors and their measurement, as they are crucial for city planning. The authors are of the opinion that, among many factors that come into discussion about energy flows on both global and city scale, solar energy is an *a priori* inexhaustible energy source. The general fact is that every hour the Earth is hit by about 430 quintillion Joules (430 x 10^{18} = 430 EJ) of energy from the Sun, which almost equals the total amount of 410 quintillion Joules that all humans use in a year (Nault, 2005). In this context, the advantageous aspects of solar energy such as the utilization of photovoltaics, the generating of urban structures based on the solar access principle or the energy cooperativeness of urban districts, were investigated in previous research by members of the FAD STU, namely Legény and Morgenstein (Legény, Morgenstein, 2015).

Energy (im)balance on global scale

According to Hansen et al. (Hansen, 2005), the Earth's climate system has considerable *thermal inertia* that is of critical importance, as it can influence the effects of undesirable anthropogenic climate change. In 2005, it was calculated that Earth absorbs 0.85 ± 0.15 W/m^2 more energy from the Sun than it emits into space (Fig. 1).

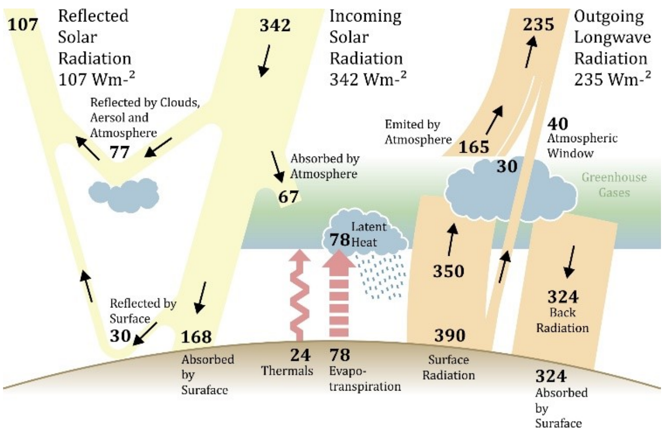

Fig. 1. The earth's annual global mean energy budget [W/m^2]. (Source: Authors based on research by Kiehl and Trenberth (Kiehl, Trenberth, 1997))

This inertia delays Earth's response to climate forcings and alters global temperature. Therefore, evidence of climate change provides the opportunity to act before it becomes difficult or impossible to prevent. Nowadays, the *Earth's energy imbalance* (EEI) is relatively small and reaches the difference of 0.3% between the global mean solar radiation absorbed and the thermal infrared radiation emitted into space. About 90% of this excess energy warms the ocean, and the remainder heats the land, melts snow and ice, and warms the atmosphere. Loeb et al. (Loeb, Johnson, Thorsen, Lyman, Rose, Kato, 2021) also showed that independent satellite and *in situ* observations yield statistically indistinguishable decadal increases in EEI from mid-2005 to mid-2019 of 0.50 ± 0.47 W/m^2.decade. This discrepancy is caused by an increase in absorbed solar radiation associated with decreased reflection by clouds and sea ice and a decrease rate in *outgoing long-wave radiation* (OLR) caused by the increase in trace gases and water vapour (Fig. 2).

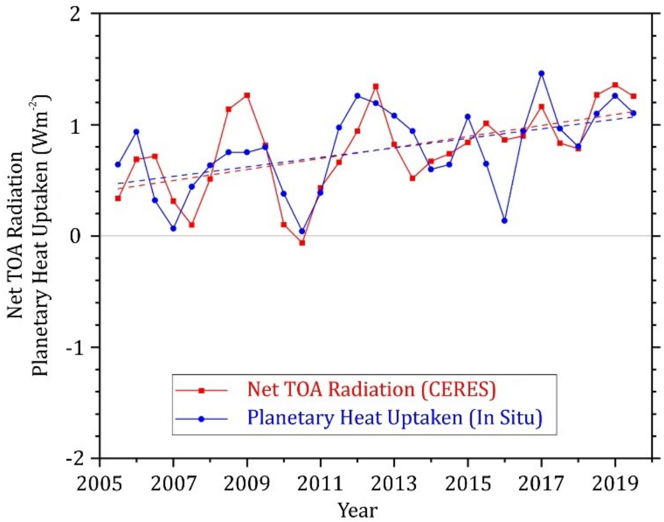

Fig. 2. Comparison of overlapping one-year estimates at 6-month intervals (Loeb, Johnson, Thorsen, Lyman, Rose, Kato, 2021). *Solid red line* - net top-of-the-atmosphere (TOA) annual energy flux from the clouds and the Earth's Radiant Energy System Energy Balanced and Filled Ed4.1 product; *Solid blue line* - an in situ observational estimate of energy uptake by Earth's climate system; *Dashed lines* - correspond to least squares linear regression fits to the data. (Source: Authors)

Energy (im)balance on local scale

Since the second half of the twentieth century, research regarding the cities and their climate has focused on various physical properties and processes, especially in terms of thermodynamics, optics, fluid mechanics, and aerodynamics of materials and their surfaces; vegetation; water bodies and water cycle; conditions in the atmosphere; solar radiation; or spatial configuration (topographic relief, geometrical characteristics of interrelated objects and spaces between them), etc. These physical properties directly affect various physical and chemical processes such as energy absorptivity, reflectivity, emissivity, thermal conductivity, transpiration, evaporation, evapotranspiration, photosynthesis, etc. With respect to meteorology, physical processes that occur on a local scale in the atmosphere near the ground, on the land surface, and in the soil are generally termed microclimatic processes. Due to the long-term consolidation of interactions between *microclimatic processes* and the relatively low rate of emerging climatic disruptions, microclimatic conditions in natural environment are rather stable and predictable in time (short or long periods) with a high degree of accuracy. In the Anthropocene epoch characterized by human activities with dominant influence on disruptions in the natural flow of energy and matter, the climate has become highly unpredictable on all spatial-temporal scales. Thus, urban climate is one of the most evident examples of inadvertent climate modification caused by humans (Oke, Mills, Christen, Voogt, 2017). Human activities are therefore considered the dominant microclimatic processes within the city and are directly linked to microclimate changes.

Urban Heat Island effect

One of the main negative modifications of urban microclimate involves the temperature differences arising from differences in urban and rural cooling and warming rates at the surface, in the substrate, and in the air. Such temperature of an area, volume, or region that is higher than that of non-urban surroundings is referred to as the *urban heat island* effect (UHI), first observed and documented by Luke Howard in 1833 around London, England (Stewart, 2011). An urban heat island simply refers to the characteristic warmth of a town or city. Many papers comprehensively describing main characteristics of the UHI effect in the urban climate have already been written, such as those by Chandler (1976), Landsberg (1981), Oke (1982), Arnfield (1998), Voogt (2002), Weng (2009), Huang and Lu (2018), etc. The UHI effect has an impact on increased energy consumption for cooling the buildings and reduces the residential quality of the urban environment and its public spaces (especially through overheating, increased levels of pollutants, ozone, emissions, and smog), with a direct impact on population health, economy, infrastructure, or urban safety as a consequence of the increased incidence of extreme weather conditions such as storms, floods, droughts, etc. According to Hofierka, mitigating urban heat islands requires understanding the interaction between solar radiation and urban surfaces, as well as the appropriate tools to simulate urban development and management scenarios (Hofierka, Zlocha, 2012).

Within the vertical division of the urban environment and the difference in temperature between urban areas and their non-urban (rural) surroundings, the UHI has been classified into 4 types (Oke, 1995; 2017), (Fig. 3):

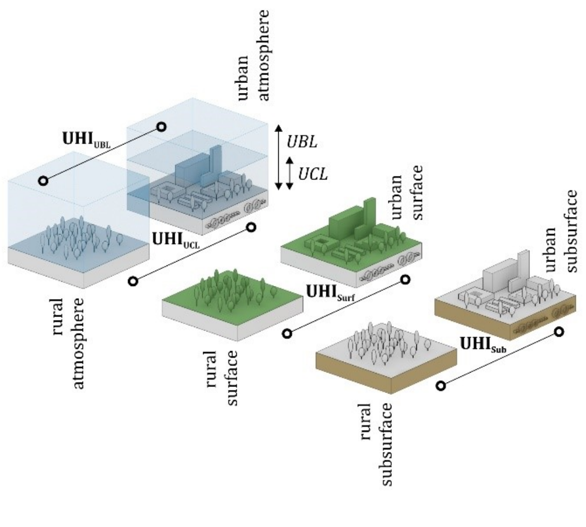

Fig. 3. Representation of temperature differences describing 4 types of UHI: UHI_{Sub}, UHI_{Surf}, UHI_{UCL}, UHI_{UBL}. (Source: Authors, with modifications based on Oke, 2017 (Oke, Mills, Christen, Voogt, 2017))

• ***Subsurface urban heat island ($UHIS_{ub}$)***: differences between temperature patterns in the ground under the city;
• ***Surface urban heat island (UHI_{Surf})***: temperature differences at the interface of the outdoor atmosphere with the solid materials of the city and the equivalent rural air-to-the-ground interface;
• ***Canopy layer urban heat island (UHI_{UCL})***: difference between the temperature of the air contained in the urban canopy layer (UCL), the layer between the urban surface and roof level (the exterior UCL), and the corresponding height in the near-surface layer of the countryside;
• ***Boundary layer urban heat island (UHI_{UBL})***: difference between the temperature of the air in the layer between the top of the UCL and the top of the urban boundary layer (UBL), and that at similar elevations in the atmospheric boundary layer (ABL) of the surrounding rural region.

Regarding the UHI formation, T. R. Oke considers the *surface energy balance* (SEB) to be a statement of the conservation of energy which is applicable to surfaces and volumes at all spatial and temporal scales as the fundamental starting point for understanding and predicting surface microclimates and climates of the *atmospheric boundary layer* (ABL). In urban systems, the energy balance is observed on individual facets (such as roofs, walls, roads, etc.), urban elements immersed in the urban atmosphere (like human bodies, buildings), or within the entire surface-atmosphere interface, or with regard to selected layers of the atmosphere (Oke, 1987). Thus, the SEB determines heat fluxes resulting from the radiative, aerodynamic, thermal, and moisture properties of the constituent surfaces and the state of the ABL.

The surface energy balance of a *rural area* (Fig. 4a) is calculated as follows:

$$Q^* = Q_G + Q_H + Q_E \qquad [W/m^2]$$

In contrast, the surface energy balance of an *urban area* (Fig. 4b) is described by the equation:

$$Q^* + Q_F = Q_H + Q_E + \Delta Q_S + \Delta Q_A \qquad [W/m^2]$$

• ***Q**** *[W/m²] - Net all-wave radiation flux density*
• ***Q_G*** *[W/m²] - Substrate heat flux density* (ground heat flux density that transfers sensible heat downward into the substrate by conduction)
• ***Q_H*** *[W/m²] - Turbulent sensible heat flux density* (sensible heat flux density from the surface upward into the atmosphere)
• ***Q_E*** *[W/m²] – Turbulent latent heat flux density* (latent heat flux density involves exchanges of energy between the surface and the atmosphere)
• ***Q_F*** *[W/m²] - Anthropogenic heat flux density* (heat emitted from human activities such as housing, work and transport)
• ***ΔQ_S*** *[J; W/m², W/m³] - Net heat storage; rate per unit volume or per unit horizontal area* (heat accumulated by city structures, trees, surface and air)
• ***ΔQ_A*** *[J; W/m², W/m³] - Net energy (sensible and latent) advection; rate per unit volume or per unit horizontal area* (energy added or removed from the observed volume by wind: $\Delta Q_A = Q_{in} - Q_{out}$)

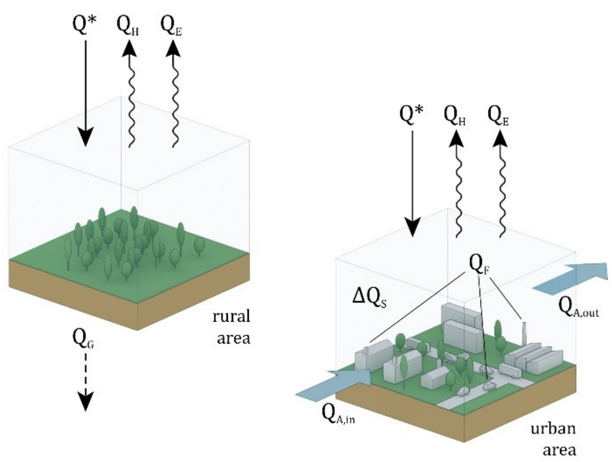

Fig. 4. Comparison of heat flux exchange within rural and urban areas. (Source: Authors, with modifications based on Oke, 1987)

Climate-sensitive urban design

Compared to basic research, the level to which knowledge is implemented in practice in the field of urban microclimate is deficient. Lowry (Lowry, 1988) considers the availability of meteorological data for urban planners crucial and emphasizes the need for their collection and further analysis and interpretation using new advanced tools. Advances in data science have made it possible to process a large number of data (Big Data) from diverse sources (even with different levels of accuracy and spatial detail) using statistical analysis methods, and to thus gain relevant sources of information that complement the existing ground-based and remote sensing infrastructure. For example, civil flight tracks, especially take-offs and landings that involve the crossing of the vertical layers of the atmosphere above the earth's surface (Moninger, Mamrosh, Pauley, 2003), private weather stations (Weather Underground), mobile smart devices simultaneously recording environmental data (ambient temperature, atmospheric pressure and noise level), or personal data devices on user vitality through Health Apps (Niforatos, Vourvopoulos, Langheinrich, 2017) are used in data crowdsourcing. The increasing number of meteosensors should result in higher data quality, their spatial-temporal density, and shorter response time, with the expected accompanying refinement of forecasting models, improved crisis management, and provision of tools for the retrospective assessment of environmental strategies within the city. The main objective of *Climate-sensitive Urban Design* (CSUD) is a city that uses resources efficiently in terms of sustainability in order to protect its residents and traffic from severe weather phenomena. This approach to designing a resilient city system uses networking, technologies, and city process management through compactness, high density, diversity of land use, refurbishment, short-distance accessibility, and community life-supporting measures to prevent the occupation of rural surroundings.

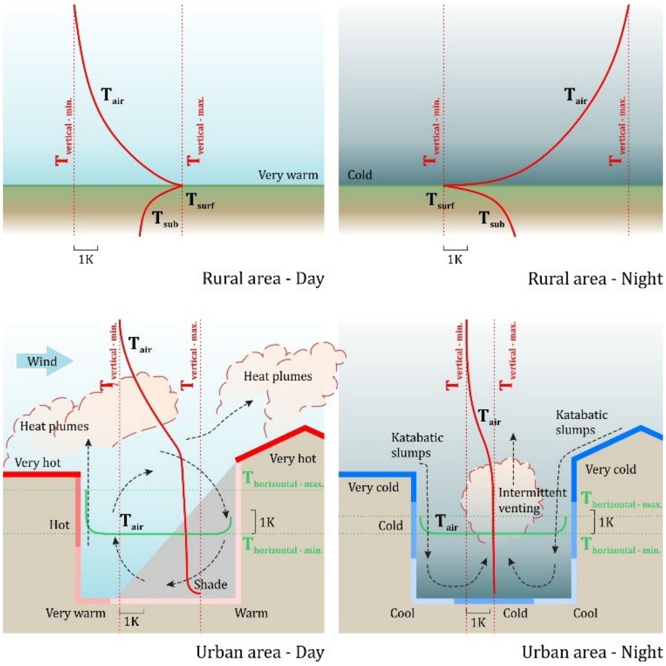

Fig. 5. Schematic representation of a typical diurnal sequence of vertical and horizontal profiles of air temperature in the near-surface layer of an open rural and urban area in the daytime and at night. Compared to the rural environment, the complexity of microclimatic processes in the heterogeneous city environment is significantly higher. It is manifested through the course of temperatures in both the vertical and horizontal plane. The temperature in the horizontal plane in a rural environment is homogeneous with increasing height. Comprehension of these processes is crucial for climate-sensitive urban design. (Source: Authors, with modifications based on Oke, 2017 (Oke, Mills, Christen, Voogt, 2017))

Furthermore, this concept is closely related to another concept termed *Positive Energy Districts* (PEDs) that was created to facilitate the energy transition and contribute to climate neutrality through energy efficiency and net zero energy balance (Derkenbaeva, Vega, Hofstede, van Leeuwen, 2022). The current research conducted at the FAD STU aims to contribute to these sustainable strategies and city management (Fig. 5).

METHODS AND RESULTS

Despite the unparalleled advantage the satellite images provide with regard to the exploration of the UHI_{Surf}, remote sensing in a heterogeneous city environment is about to reach its limits, and its accuracy is affected by many factors such as the observation height, viewing angle, resolution of sensor, atmospheric corrections, surface emissivity, anisotropy, etc. In terms of observations of urban microclimate and the UHI effect, the *Land Surface Temperature* (LST) derived from radiometric thermal images of remote sensing is only partial information quantifying the UHI_{Surf}. A great research challenge is to define the direct, non-empirical interrelationship between UHI_{Surf} and UHI_{UBL} (Voogt, Oke, 2003; Zhou, Xiao, Bonafoni, Berger, Deilami, Zhou, Frolking, Yao, Qiao, Sobrino, 2019) and to apply satellite-derived LSTs directly in air UHI detection, attribution, and modelling (Weng, 2009). In this respect, in addition to remote sensing, it is necessary to perform terrestrial observations, which is fully in accordance with the intention of the authors to build an environmental observatory on the grounds of the FAD STU. The authors have been conducting long-term measurements of the *Global Horizontal Solar Irradiation* (GHSI) at two-minute intervals that began on March 21, 2021 (spring equinox). For this purpose, the first experimental measuring set consisting of a pair of pyranometers (EKO instruments MS-40 that create an albedometer) with a two-channel data logger was installed on the roof of the FAD STU (Fig. 6). Regular measurements were preceded by trial measurements.

Fig. 6. Set of two pyranometers and a data logger on a roof. (Photo: Authors)

The output of *in-site* measurements from this gauger with the data logger is in plain text format that is processed in MS Excel using the *Visual Basic for Applications* (VBA) programming interface. GHSI values are arranged in two-minute, daily, weekly, monthly and annual data sets with average 20-minute daily performances. These data are supplemented with values from the celestial mechanics equations (Global Monitoring Laboratory) based on the geographical longitude of a location, such as the sunrise and sunset times, sunshine duration, the solar altitude and azimuth (Fig. 7, 8). Data sets are then used for analyses and calculations in prediction models, and, in the long term, they provide a basis for observing the year-on-year development of the GHSI as well.

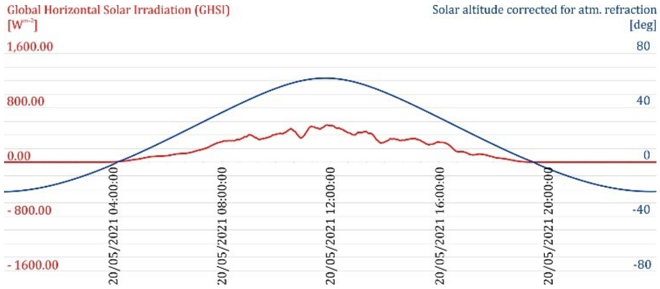

Fig. 7. Average GHSI behaviour in week 20, 2021. (Source: Authors)

Explanatory notes:

— *average 20-minute GHSI per week [W/m²];*

— *solar altitude [deg] corrected for atmospheric refraction on the midday of the week*

GHSI performance per week: 27.550 [kWh/m²]

Sunlight duration per week: 6469.461 [minutes]

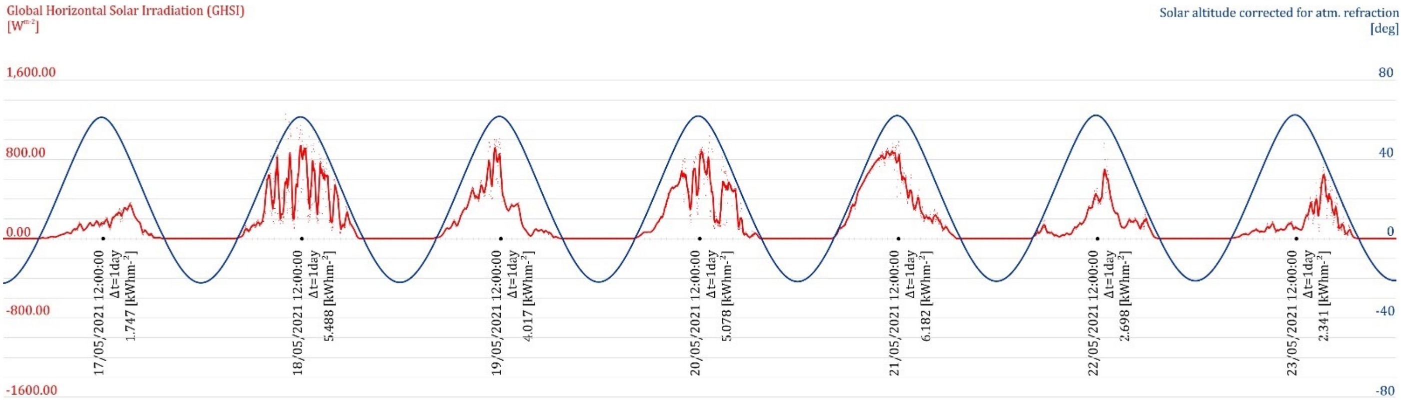

Fig. 8. Daily GHSI behaviour in week 20, 2021. (Source: Authors)

Explanatory notes:

.... *GHSI [W/m²] measured in a 2-minute interval* / — *20-minute mean GHSI [W/m²]* / ● *Daily performance [kWh/m²]*

— *Solar altitude [deg] corrected for atmospheric refraction*

The authors plan to equip the pyranometers with shielding so that diffuse and direct or peculiar components of global and radiation can be measured (Fig. 9a), and with infrared cut-off filters. Furthermore, the filters will reflect or block UV and visible light while passing near-infrared wavelengths (Fig. 9b). Such refined data will provide a basis for better understanding of the microclimate processes in the city associated with solar energy and material properties.

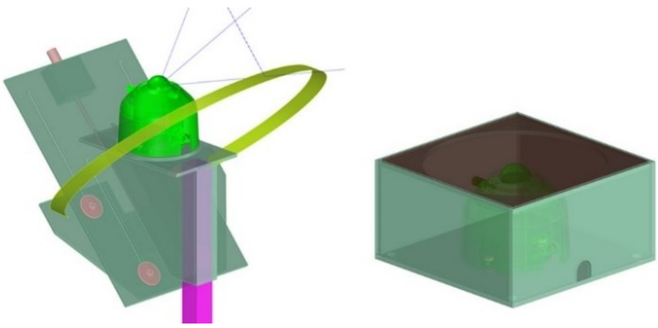

Fig. 9. Proposed shielding and infrared cut-off filter for applied pyranometers. (Source: Authors)

According to the law of conservation of energy and the equation for calorimetry that describes heat exchange, the temperature increase ratio and the GHSI ratio between the seasons should be equal. The disparity resulting from the measured data suggests that under real conditions there is no equilibrium of the energy balance in daily cycles, which is caused by the inertia of heat in the environment (Tab. 1). This property of the environment is inherent, but in the human-influenced habitat of cities, the inertia of heat is manifested through positive temperature differences to a greater extent. Admittedly, this partial research finding is largely simplified compared to the real degree of complexity of environmental climatic inter-actions.

Tab. 1. Measurement data on GHSI, sunshine duration, and increase in average temperature over seasons on the FAD STU rooftop. (Source: Authors)

Season	GHSI [kWh/m²]	Sunshine duration [h]	Temperature increase [°C]
Spring	447 *(100%)*	1351 *(100%)*	6.4 *(100%)*
Summer	528 *(118%)*	1355 *(100,3%)*	11.7 *(183%)*

Experimental sensing probe 1

In parallel with the GHSI measurements, the operation of vertical sensing probe 1 was launched (Fig. 10). The issues of urban microclimate and the mitigation of UHI effects through architectural and urban planning tools are closely related to the interaction between city surfaces and its surroundings. Therefore, the authors started to measure fundamental physical parameters in the vertical direction such as temperature, relative air humidity, direct and reflected solar radiation, the presence of water in the substrate, the presence of water mist, the intensity of direct or reflected sunlight on a surface, and atmospheric pressure. Besides the structural elements forming the support, this experimental vertical sensing probe includes sensors monitoring the above-mentioned parameters and is also equipped with an added controller, clock, and recording medium, which are interconnected and create a measuring set with a data logger constructed with the wiring and processing method using the Arduino platform. As in the previous GHSI case, the gathered data were processed via MS Excel and VBA (Fig. 11). The authors evaluated the possibilities of these programs as limited and consider using the *Matlab* platform for future data processing.

Fig. 10. Experimental vertical sensing probe 1. (Photo: Authors)

Sensing probe 2 – under construction

The measurement method and the output using experimental vertical sensing probe 1 have been verified in trial operation and have been assessed as suitable for future research and development. Therefore, the higher sensing probe 2 (with the total height of 11m) is currently under construction and should provide data from an area of approximately 12 x 22 m. The set of sensors mounted on probe 1 will also be expanded. The authors anticipate the measurement of the total atmospheric precipitation, wind speed and its direction, presence of dust particles and carbon dioxide in the air, or spectral characteristics of incident and reflected solar irradiation. Furthermore, the cloudiness and the Sky View Factor (ψ_{sky}) will be evaluated using cameras facing the sky (Fig. 12).

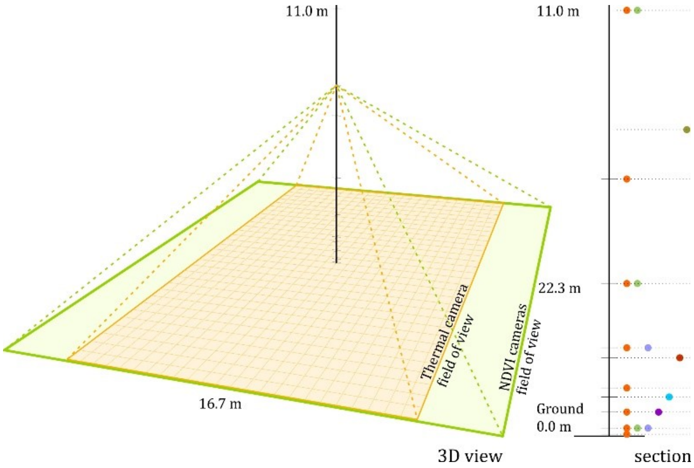

Fig. 12. Scheme of sensing probe 2 with a set of various types of sensors. (Source: Authors)

Explanation notes:

- *Thermal sensor (accuracy ±0.1 °C)*
- *Relative humidity sensor (accuracy ±1.5% RH)*
- *IR thermal sensor (surface brightness temperature, accuracy ±0.2 °C)*
- *Optical sensors of incident and reflected solar radiation (spectrometer – 8 wave bands of visible light and NIR; luxmeter, accuracy ±0.1 lx; UV sensor), environmental sensors (barometer, anemometer, dust laser sensor, CO_2 IR sensor)*
- *Environmental sensors (NDVI – three 5Mpx cameras with 110°FOV lens and IR band cut filter (740 nm), Deep Red band pass filter (650 – 680 nm), Blue band pass filter (425 – 495 nm); stereographic capturing of sky, cloudiness and Sky View Factor (ψ_{sky}) with two 5Mpx cameras with fish eye lenses; thermal camera, 768 px, 110° FOV, (accuracy ±0.5 / ±2.0 °C for capturing surface brightness temperature)*

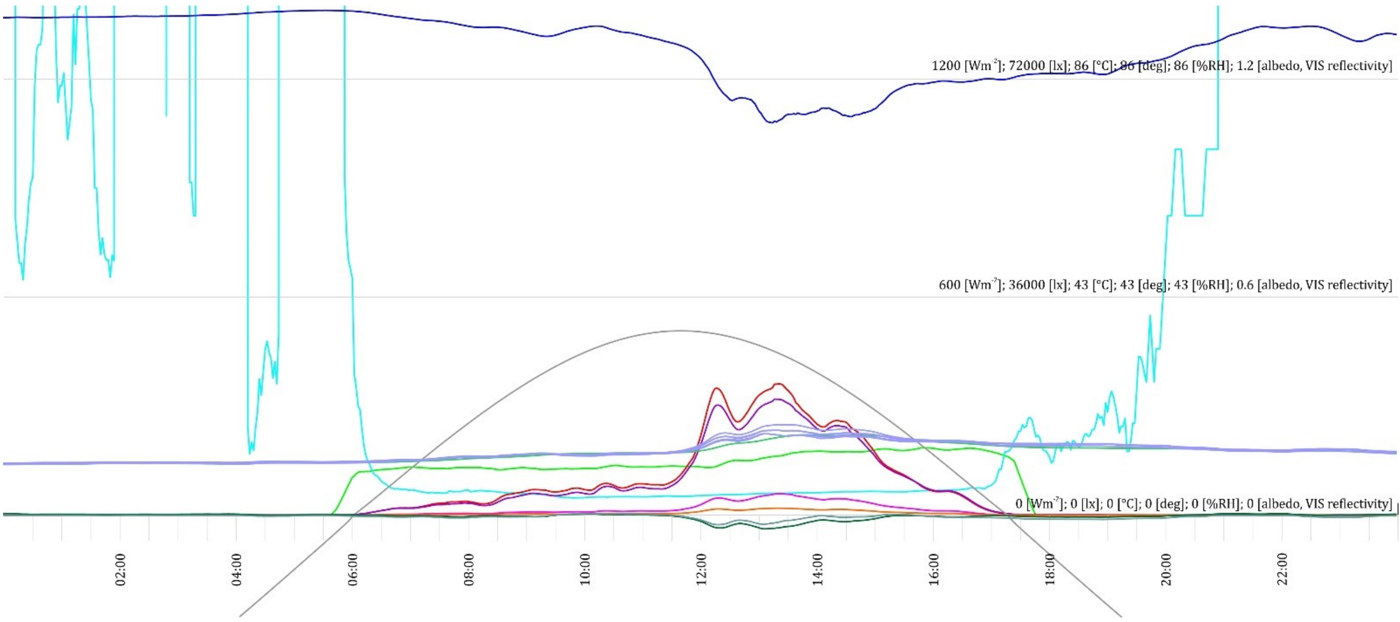

Fig. 11. Daily behaviour of specific physical parameters on November 7, 2021, recorded by sensing probe 1. (Photo: Authors)

Explanatory notes:

● Air temperature above ground at different levels [°C]; ● Surface temperature [°C]; ● Temperature difference between surface and air at 0.15m [°C]; ● Temperature difference between surface and air at 1.2m height [°C]; ● Incident GHSI [W/m²]; ● Reflected solar irradiation on horizontal plane [W/m²]; ● Surface albedo [-]; ● Incident light intensity on horizontal plane [lx]; ● Reflected light intensity on horizontal plane [lx]; ● Light reflectivity [-]; ● Relative humidity [RH%]; ● Solar altitude [deg]

Cameras facing the surface will detect the Normalized Difference Vegetation Index (NDVI) introduced by Rouse et al. (Kuska, Behmann, Mahlein, 2018). It is based on the optical properties of healthy and treated leaves distinguished in the RGB image. Vital plants largely reflect infrared radiation. Chlorophyll, among other photo pig-ments, is responsible for leaf colour and is important in the conversion of energy from light through photosynthesis. It ab-sorbs light of the characteristic wavelength - chlorophyll A (dark red light / 640 – 680 nm), chlorophyll B (blue light / 425 – 495 nm). NDVI is given by the ratio of NearInfraRed–Red and Near-InfraRed+Red light and reaches values in the range of -1 to 1. This index is used not only in remote sensing to assess the vitality of greenery, but also to categorize land use (vegetation, water bodies, soil and built-up areas). Surfaces without vegetation will be scanned by sensing probe 2 using an IR filter cam-era and their response to IR radiation will be evaluated. Currently, the authors are testing the functionality of the NDVI sensors (Fig. 13).

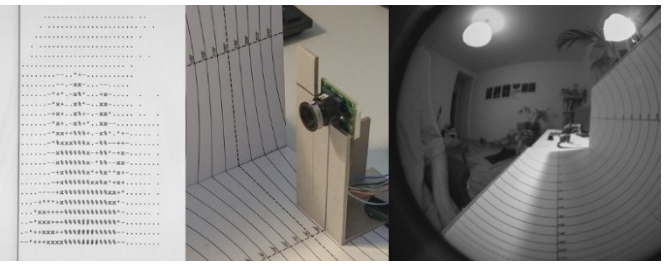

Fig. 13. Testing the functionality of the thermal- and micro-camera with fisheye lenses. (Source: Authors)

DISCUSSION AND CONLUSIONS

The deterioration of the environment and the threat of the climate change are real and some action is needed. The main attribute of contemporary architecture shall be sustainability, and the cities of the future must be resilient, safe, healthy, sustainable, and human-centric while preserving nature, in-deed. The pursuit of climate-sensitive urban design and positive energy districts are possible responses to these human challenges. The unprecedented development of new technologies enables the acquisition and processing of big data to influence the microclimate of cities.

There are still some specific issues that researchers should address. The first is the development and creation of data prediction models, where the current trend is to increase the complexity of the evaluated microclimatic factors in spatial-temporal detail. Such predictive models and simulations (e.g. in Envi-met 4.1 program) help architects and urban planners understand the interaction of microclimatic factors with the surroundings and allow them to verify the expected benefits of solutions during the design phase. The second is the critical retrospective evaluation of implemented solutions exposed to real conditions not only at the level of architectural and urban design, but also regarding engineering and technical solutions, such as the material composition of surfaces (Holečka, Jamnický, Krajčík, Rabenseifer, 2021). This approach supports the continuation of the evolution of engineering design. The third is the increase of the use of quantifiable parameters to rate the impact of individual and interacting microclimatic factors and to facilitate complex decision-making within the design process. For example, the *Solar Reflectance Index* (SRI) generally used by the *Leadership in Energy and Environmental Design* (LEED) certification is a derived parameter that takes into account the solar reflectivity and emissivity of surfaces in accordance with the *Standard Terminology of Solar Energy Conversion* (ASTM E 772) and the *Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces* (ASTM E 1980).

The creation of an environmental observatory on the grounds of the FAD STU whose operation was experimentally verified by sensing probe 1 along with the future location of sensing probes no. 2 in selected public urban spaces creates a prerequisite for conducting further research in the field of microclimatic factors affecting urban development. Based on the review of sources, the authors, together with colleagues and research partners from the Pavol Jozef Šafárik University, the Institute of Geography of the Faculty of Science in Košice, Slovakia, are currently specifying the albedo values of materials usually applied in buildings and urban spaces that affect the reflection and absorption of incident solar energy. These values will refine the modelling of solar radiation in the city areas using the GIS software and the *v.sun* and *r.sun* models developed by Hofierka et al. (Hofierka, Zlocha, 2012). For the presentation of the high-resolution surface temperatures modelling in the city, the *Tangible Landscape* system will be used. This interactive tool will be useful for architects and designers, enabling them to project specific digital layers from 3D GIS not only regarding solar energy.

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The impacts of climate change on urban structures in Slovak cities: Identifying vulnerable urban structures

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Abstract: In the coming decades, our cities will face extreme weather caused by climate change, which they will have to adopt. Adaptation of the urban environment is attracting the growing attention of planners, researchers, and policy makers in Slovakia and around the world. As essential for urban environment, the National Adaptation Strategy identified the adaptation at local level, which represents the participation of municipalities, supports the development of local adaptation strategies and subsequent implementation of actions that provide the cities with stronger sustainability and resilience. Within the last 8 years since the adoption of the national strategy, only 8 out of 141 Slovak cities in total elaborated an adaptation strategy that could be considered for further investigation. Consequently, this paper aims to broaden our knowledge of the two most significant impacts of climate change–heatwaves and floods–on urban structures in Slovak cities and validate the importance of spatial vulnerability analyses as a considerable tool for the expected unified national methodology for developing local adaptation strategies. The study examines analyses of spatial vulnerability to heatwaves in Hlohovec, Košice – Západ, and Trnava, and analyses of spatial vulnerability to floods in Hlohovec and Kežmarok, developed as part of vulnerability assessment within the framework of adaptation strategies of these cities. The analyses selected for comparison allow us to identify vulnerable urban structures and provide a deeper understanding of the causes of vulnerability in Slovakia, which is crucial for the development of adaptation strategies in the future and the building of resilience in Slovak cities. The article provides an exploratory spatial analysis of vulnerability hotspots. Based on the findings, it outlines the principles of spatial planning and urban structures that are resilient to the impacts of heatwaves and floods.

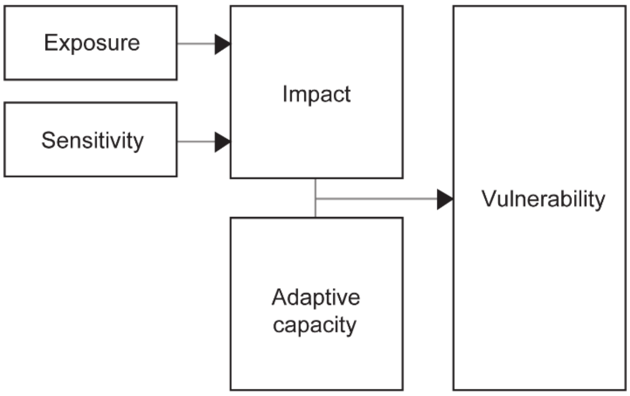
Keywords: climate change, urban adaptation, spatial vulnerability, spatial planning, sustainable development

INTRODUCTION

The climate change in Slovakia is characterized by an increase in average air temperature, number of tropical days, extreme weather events, in particular concurrent heatwaves and droughts, sudden and regional floods, decrease in relative humidity and other extreme weather situations (SHI; CCS, 2017; ME SR, 2018). In the urban environment, the increase in the amount of sudden and intense rainfall results in an increased demand for infrastructure. Raising temperatures and heatwaves create urban heat islands, increasing the risk of negative impacts on the quality of life, health, and safety of residents (Pecho, 2016; Hudeková, Paulíková, 2016). To address these challenges, cities initiate the adaptation process, which includes the preparation of the ground, assessment of risks and vulnerability, adaptation strategy with an action plan for its implementation, the implementation of adaptation measures, and subsequent monitoring and rethinking of the effectiveness of the applied measures (ME SR, 2018). As the adaptation process of the urban environment in Slovakia is in an initial phase and the National Action Plan for Implementing the Adaptation Strategy of the Slovak Republic provides for the preparation of a unified methodology for local adaptation strategies, (ME SR, 2021) this work investigates one of the initial parts of this process: vulnerability and risk assessment from the perspective of spatial planning. Spatial planning has been identified as a critical mechanism through which climate change adaptation can be facilitated (Hurlimann, March, 2012). For this reason, the research is expected to fill the gap in understanding the spatial vulnerability of Slovak cities required for the future spatial development of Slovak cities. The presented article is a partial result of doctoral research focused on the study of adaptation of the urban environment to the impacts of climate change in Slovakia. One of the objectives of this research is to identify strategic areas of intervention. Partial research presented in this paper thus focuses on the identification of such spaces in terms of urban planning and design typology. This classification consequently serves as a basis for finding appropriate solutions within the valid framework of urban planning in Slovakia.

METHODS

This study examines selected parts of strategic documents–climate adaptation strategies–analyses for specific impact of climate change, heatwaves or floods. These documents, elaborated by multi-disciplinary teams mainly consisting of climatologists and other professionals using a specific analytic method, identify spaces in the cities that are the most vulnerable and hence require a particular attention and approach from the side of urban design professionals. In addition to the attempt to match these spaces with the classification provided by urban typology to enable the targeting of urban design responses more systematically, this paper also seeks to validate the importance of spatial vulnerability analyses as a tool that can be applied in the unified methodology for the development of local adaptation strategies in the future, as a potential tool to be used within the valid processes and framework of urban planning. The research aims to identify the most vulnerable spaces in Slovak cities. For identification of such spaces, we will use the information from the vulnerability analyses. The analyses examined were prepared by Carpathian Development Institute (CDI), a leader in adaptation planning in Slovakia, applying a unique method in Slovak adaptation strategies that illustrates the data and results of the vulnerability assessment, based on the international methodology recommended by Intergovernmental Panel on Climate Change (IPCC, 2007). (Diag. 1)



Diag. 1. Methodology of vulnerability assessment according to recommendations of IPCC used by Carpathian Development Institute in examined cities. (Author: Miroslava Kamenská, based on the methodology of CDI and IPCC (IPCC, 2007; CDI, 2020, 2015, 2014))

This method of vulnerability assessment has three core elements: exposure, sensitivity, and adaptive capacity, supplemented by the climate characteristics of the city (IPCC, 2007; CDI, 2020, 2015, 2014). In assessing spatial vulnerability, Carpathian Development Institute divided the analysed area into squares of 200x200 meters or 300x300 meters and provided a quantitative analysis of each square by exposure and sensitivity of the parts. In the final output, the squares were categorized into 3 levels of severity represented by 3 colours on the grid of squares (CDI, 2020, 2015, 2014, 2015, 2018). The adaptive capacity element could not be expressed quantitatively; it was assessed with a descriptive analysis. The organization elaborated 5 of 8 adaptation strategies in total available in Slovakia.

For the purposes of this article, 4 cities have been selected: Hlohovec (CDI, 2020), Kežmarok (CDI, 2015a), Košice – Západ (CDI, 2014) and Trnava (CDI, 2015b), with an existing individual analysis of the specific impact of climate change, heatwaves or floods. The fifth city, Prešov, (CDI, 2018) has integrated the spatial analysis of heatwaves and floods into one spatial analysis, which disabled its objective comparison with other cities. The identification of the most vulnerable areas was carried out in the environment of free map services (OSM). The study uses spatial vulnerability analyses from the adaptation strategies of the selected cities and own qualitative analyses of urban structures (Smatanová, Vitková, Šeligová, 2018) in relation to identified impacts of climate change obtained with field research and observation of affected areas.

RESEARCH

Hlohovec

The urban structure of Hlohovec is predominantly composed of a block structure with residential houses (from 1 to 3 floors) with pitched roofs and private gardens inside the blocks. The southern part of the city is composed of prefabricated apartment building structures (from 8 to 14 floors) positioned in green areas. The division line between these two parts is formed by the main road communication connecting the two close regional centres Trnava and Nitra. Along this axis, the historic centre, main square, and widespread public amenities are located. In terms of spatial vulnerability to heatwaves, the most critical areas are parts of the city centre providing public amenities, which represent spots with increased concentration of citizens during the day. The central area is in close contact with the residential area of prefabricated apartment buildings and its schools, restaurants, and grocery stores. The public spaces along the main axis and the pedestrian zone are unshaded, with many paved areas and no fluent vegetation. Traffic and parking possibilities are priority functions of the street profile in this area. Among the most vulnerable spaces identified, there were the train and bus station and their surroundings with wide open space without shading, trees, and vegetation. (Fig. 1)

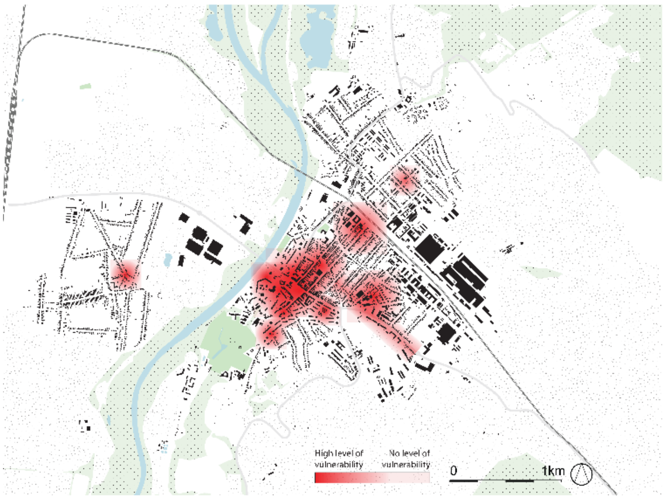


Fig. 1. Spatial vulnerability of Hlohovec to impacts of heatwaves. (Author: Miroslava Kamenská, based on data from CDI (CDI, 2020))

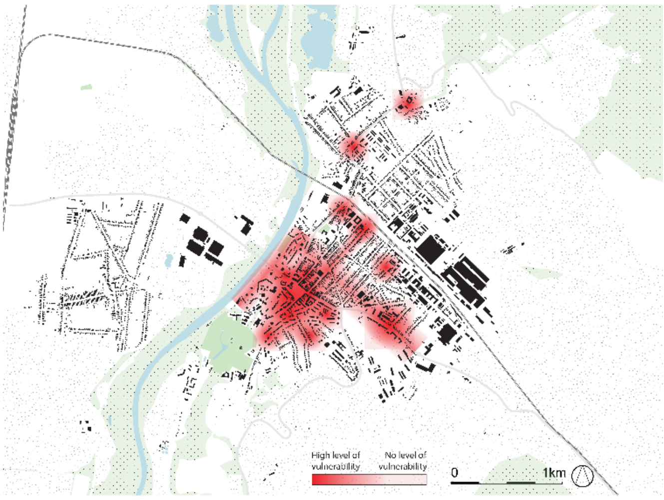


Fig. 2. Spatial vulnerability of Hlohovec to impacts of floods. (Author: Miroslava Kamenská, based on data from (CDI, 2020))

The spatial vulnerability of Hlohovec to floods shows that not only the waterfront area of the river Váh is endangered. The city is exposed to surface floods in the event of heavy rains due to large areas of impermeable surfaces with an out-of-date sewer system. The southern residential zone with apartment buildings is endangered by extensive parking capacities, roads, and sidewalks, as well as the city centre. The vulnerability also includes significant traffic infrastructure of the local transportation scheme, including the main train and bus station and the adjacent streets leading to the city centre. In suburban parts of the city, buildings of production facilities and military premises with more than 80% impermeable area put the structures of nearby houses at risk of access interruption in case of surface flooding. (Fig. 2)

Trnava

The city of Trnava has the character of a compact city with a polyfunctional historic city centre, followed by significant residential areas with the structure of prefabricated apartment buildings (from 8 to 14 floors) and the block structure of individual family houses (from 1 to 3 floors). In the southern part of the city, there is a suburban structure in contrast to large-scale industry and shopping areas. As can be seen in Figure 3, the areas most vulnerable to the impacts of heatwaves are predominantly residential mass housing structures of prefabricated apartment buildings. Extensive parking capacities, traffic infrastructure and other paved areas with lack of tall vegetation and shading are typical of these areas. From socio-economical aspects, the vulnerability of this area is also increased by high population density with the presence of the most vulnerable groups and insufficiency of public amenities. Endangered are the areas with kindergartens due to the presence of vulnerable population groups – kids up to the age of 4. On the other hand, schools and large premises of university campuses are vulnerable because of high concentration of citizens and by their surroundings with parking capacities. The area of the city centre is sensitive in part of the pedestrian zone with a high concentration of public amenities and full paved historic public space with a lack of green infrastructure or other shading possibilities. (Fig. 3)

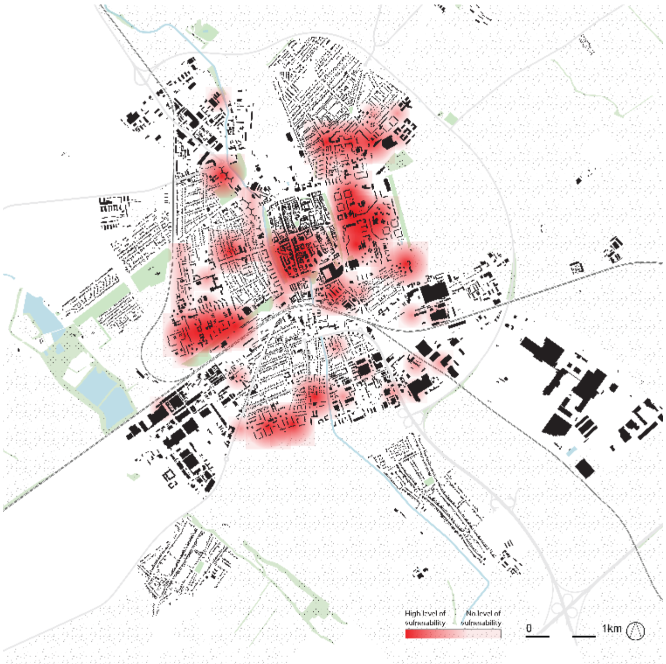


Fig. 3. Spatial vulnerability of Trnava to impacts of heatwaves. (Author: Miroslava Kamenská, based on data from CDI (CDI, 2015b))

Košice – Západ

Západ is the largest city district of Košice, with a dominant residential function, supplemented by public amenities, schools, cultural and healthcare institutions with a developed traffic network located to the west of the central zone. The dominant structure of the district consists of mass housing of prefabricated apartment buildings (from 4 to 14 floors). A tram line and a four to six lane road pass through as a central axis of the territory. The western part of the district is divided with a pine grove and consists of individual and terraced development of family houses and recreational garden houses. The areas most vulnerable to heatwaves in Košice – Západ are the structures of prefabricated apartment buildings, kindergartens, local public amenities, grocery stores, and administrative business premises and their surroundings with extensive roads and parking possibilities without shading. Garage blocks between buildings were identified as a specific element that increases the vulnerability of this residential structure. Also vulnerable is the public space in front of the entrance to the hospital, with poor vegetation and located next to the main crossroad of the central traffic axis. The western part of the district, consisting mainly of family houses, is resistant to the impacts of heat waves at a good level. (Fig. 4)

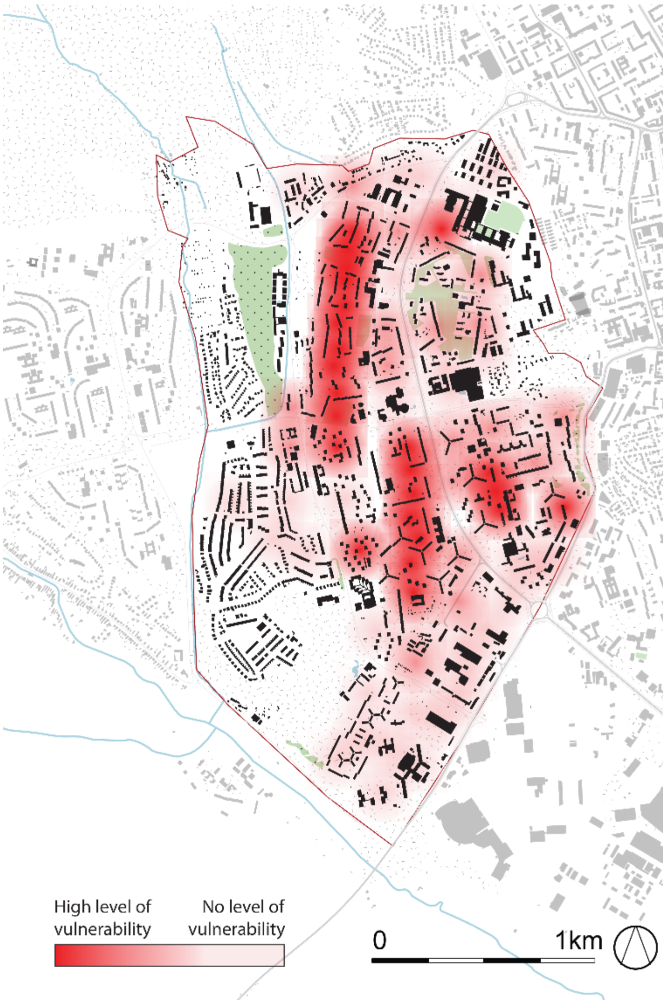


Fig. 4. Spatial vulnerability of Košice – Západ to impacts of heatwaves. (Author: Miroslava Kamenská, based on data from CDI (CDI, 2014))

Kežmarok

Kežmarok is one of the oldest cities in Slovakia. Its urban structure is defined by development along the rivers Poprad and Ľubica. Among these two rivers, there is a polyfunctional historic city centre with a compact structure (from 1 to 4 floors). The western embankment of the river Poprad is predominated by an industrial and production zone complemented with small residential structures of individual family houses and low-rise apartment buildings (up to 3 floors). To the north and south of the historic centre, the area continues with a mix of low-rise apartment buildings and prefabricated apartment buildings (up to 9 floors). To the east and west, there are individual family houses. Figure 5 shows a strong correlation between the rivers Poprad and Ľubica and their threat to the urban structure as a result of the inappropriate form of embankment and the insufficient flow of the riverbed at snowmelt time in the nearby alpine region. On the one hand, the production and industry facilities in this area are affected by river floods; on the other hand, they are characterised by a high share of impermeable areas and extensive roofs that–without a sufficient sewer system–cause surface floods. Vulnerable to surface floods are areas of parking lots adjacent to shopping amenities, schools, and parking areas in residential zones. The historical central zone with fully paved areas and parking capacities without vegetation and trees to infiltrate rainfall is exposed likewise. (Fig. 5)

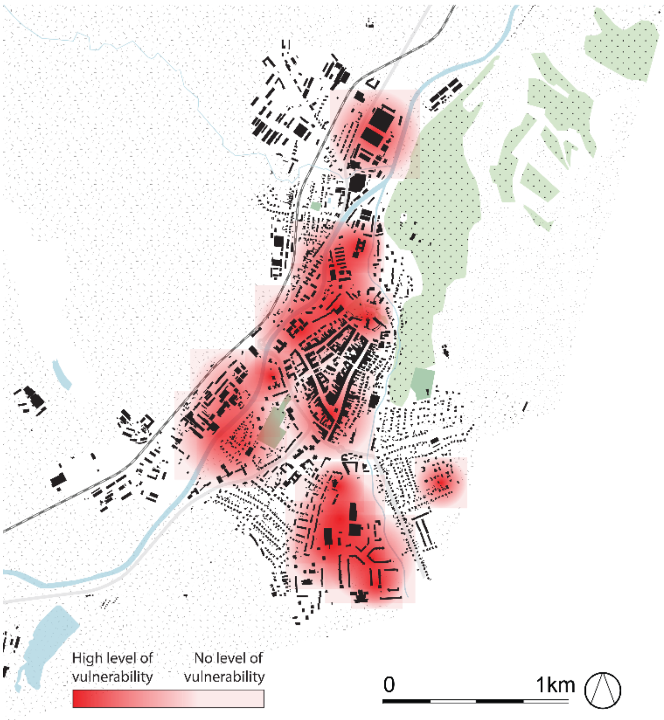


Fig. 5. Spatial vulnerability of Kežmarok to impacts of floods. (Author: Miroslava Kamenská, based on data from CDI (CDI, 2015a))

RESULTS AND FINDINGS

Spatial vulnerability to heatwaves

This study showed the considerable impact of the vulnerability of inhabitants on the vulnerability of urban structures. As was found in the case of all 3 cities covered by the study, the most vulnerable structures are the structures and public spaces with a high concentration of residents. However, the size of evaluated squares of 200x200m does not allow an accurate identification of vulnerable areas, and the generalized orientation of the grid may distort the data. Problems lie in the centres of cities with dense public amenities and a historical footprint with large paved and unshaded areas without vegetation and a lack of trees that could help create the suitable microclimate during heatwaves. Vulnerable territories include transport hubs, train and bus stations, or public transport stops. In the residential zones, there is a vulnerable area in the surroundings of kindergartens, schools, grocery stores or local centres with restaurants and other amenities. As the most vulnerable structure, the mass housing structure of prefabricated apartment buildings was identified. The surroundings of apartment buildings are composed of abundant areas of vegetation and trees. However, in this structure, the extensive traffic network with large unshaded areas of parking capacities, roads, and sidewalks as well as a high concentration of different groups of inhabitants in the area can be observed. Furthermore, the problem lies in the poor technical condition and energy inefficiency of buildings, which cause overheating of indoor spaces. (Tab. 1)

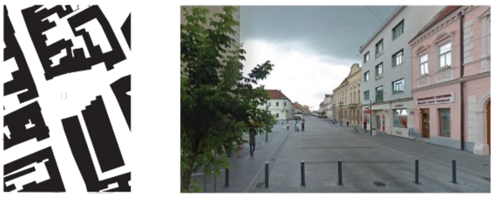
Spatial vulnerability to floods

With the arrival of climate change and its consequences, the vulnerability of cities to floods is no longer a problem merely faced by waterfronts, as was found in both cities covered by the study. The vulnerability of the city to floods is characterised by two different scenarios – river floods and surface floods caused by heavy rains and insufficient runoff capacity or the risk of landslides. Analogous to the vulnerability to heatwaves, vulnerability to floods considers the element of vulnerability of inhabitants, but also vulnerability of their property and the threat to urban infrastructure. In the representation of spatial vulnerability, the most vulnerable spaces are the centres of amenities, transport hubs, and the main transportation network. As the case of Hlohovec illustrated, the areas vulnerable to the impact of surface floods are areas with extensive parking lots adjacent to service facilities, grocery stores, schools, administrative buildings, or residential parking areas. Parking lots are made with impervious surfaces and without vegetation that infiltrates rainfall. Additionally, street profiles without vegetation lines or trees capable of infiltration and with insufficient runoff capacity of sewer systems represent the danger for residential and polyfunctional zones, most significantly in areas of accumulated parking capacities. A particular consequence of surface floods for urban structures is the threat of landslides, and–as the case of Kežmarok showed–intense waterflow from the hillsides. Vulnerable to impacts of river floods are residential and industrial structures built in areas adjacent to rivers. The threat in these areas increases with the inappropriate form of the riverbed and embankment. (Tab. 2)

Resilient urban structure

Based on the results shown in previous sections, a significant difference was found between the vulnerability of residential structures. On the one hand, there is the structure of individual or terraced family houses and low-rise apartment buildings with up to 6 floors, which does not show any significant vulnerability to impacts of heatwaves and when family houses are positioned in an environment with sufficient vegetation and evenly distributed parking spots, no significant vulnerability to impact of surface floods occurs. On the other hand, there are mass housing structures with 8- to 14-floor prefabricated apartment buildings that are highly vulnerable to impacts of heatwaves and their surroundings vulnerable to impacts of heatwaves as well as surface floods. Therefore, from the point of view of vulnerability to the impacts of heatwaves, the most suitable urban structure for the development of Slovak cities is the individual or block development of buildings with up to 6 floors, which supports the idea of accessibility and short distances. Supporting polyfunctional structures and mixed use within buildings and within the city could help reduce the concentration of inhabitants in one place, which this research proved to be a problem of the existing structures. It is suitable to use polyfunctional structures both in existing urban structures, and zones with new development. The structure of apartment buildings with up to 6 floors is capable of accommodating more residents in the area than less dense structures of family houses, but does not create hubs with a high concentration of inhabitants like the current construction of prefabricated apartment buildings. It is also important to pay attention to the spaces between buildings. Based on these findings, the structure of terraced houses or individual family houses in the suburbs seems to be resilient to the impacts of climate change. However, with the intensive development, the city area and the demands on mobility increase significantly, making cities more vulnerable through the network infrastructure.

Tab. 1. Urban structures vulnerable and resistant to impacts of heatwaves. (Author: Miroslava Kamenská, Photos: Google Street View)

Examined impact of climate change: *Heatwaves*	
Vulnerable structure	Resilient structure
Pedestrian zone in central area - Trnava  *Pedestrian zone in historic city centre with high concentration of amenities and fully-paved historic public space with lack of green infrastructure or other shading possibilities.*	Polyfunctional buildings with up to 5 floors - KE-Západ  *Residential zone of apartment buildings with 4 to 7 floors with active groundfloor with local amenities.*
Main railway station - Hlohovec  *City´s main railway station surrounded by wide open space without shading and high concentration of inhabitants.*	Residential street with traffic of local importance - Trnava  *Residential street with historic footprint of terraced family houses situated near the city centre. The street is enriched by vegetation line and evenly distributed parking possibilities.*
Prefabricated apartment buildings with local center - Trnava  *Residential area with mass housing structure of prefabricated apartment buildings with 8 to 14 floors with local centre and traffic of local importance.*	Residential street with terraced houses - Košice západ  *Residential street of terraced family houses with front gardens, private gardens and evenly distributed parking possibilities and vegetation.*
Prefabricated apartment buildings - Hlohovec  *Residential area with prefabricated apartment buildings with 8 to 14 floors and their bad technical condition.*	Residential street with individual houses - Trnava  *Residential street with individual family houses with private gardens and front gardens. The street profile is limited to one way and provide parking possibilities for residents.*

Tab. 2. Urban structures vulnerable and resistant to impacts of floods. (Author: Miroslava Kamenská, Photos: Google Street View)

Examined impact of climate change: *Floods*	
Vulnerable structure	Resilient structure
Central area with amenities - Hlohovec  *Historic central zone with high concentration of amenities and public space with fully-paved parking possibilities and lack of vegetation or infiltration surfaces.*	Residential street with mixed structure - Hlohovec  *Residential street with mixed structure of low-rise apartment buildings and individual family houses with private gardens. Street profile is enriched by vegetation line for infiltration.*
Main railway station - Hlohovec  *City´s main railway station surrounded by wide open space with high concentration of inhabitants. Space is fully-paved without possibility to infiltrate the rain water.*	Residential street with mixed structure - Kežmarok  *Residential street with mixed structure of low-rise apartment buildings and individual family houses with private gardens. In the street profile, the traffic is of regional importance.*
River and its adjacent area with mixed structure - Kežmarok  *River and its adjacent area with mixed structure of residential buldings and amenities.The embankment has natural character that cannot manage the critical water level in snowmelt period.*	Residential street with mixed structure - Kežmarok  *Residential street with mixed structure of individual family houses with private gardens and terraced houses with private gardens. The street profile is limited to one-way communication.*
Prefabricated apartment buildings - Hlohovec  *Residential area with mass housing structure of prefabricated apartment buildings with 8 to 14 floors and its surroundings with fully paved parking possibilities.*	Residential street with terraced houses - Kežmarok  *Residential street with terraced houses with front gardens and private gardens. The street profile is characterised by shared communication and front gardens with parking possibilities.*

In terms of vulnerability to impacts of floods, a resilient structure is, on the one hand, the urban structure of family houses with a better ratio between the built-up and undeveloped area, which allows the infiltration of rainwater. However, intensive development requires an increase in demand for the expansion and construction of transport infrastructure. On the other hand, there is the development of apartment buildings with higher density, which represents better accessibility and decrease in individual transport, the building of new transport infrastructure, as well as extensive parking lots. Similarly, as in the case of vulnerability to heatwaves, the support of polyfunctional structures and the mix of functions within buildings and within the city could help reduce the need to develop parking capacities and intensive transport network, which are the most vulnerable areas to the impacts of surface floods in Slovak cities. The question of the vulnerability of historical structures is the subject of monument care and heritage research and in order to be answered, more cultural and social aspects need to be taken into account.

Spatial vulnerability analyses in practice

Taken together, these findings suggest that the spatial vulnerability analysis could be used to contribute to the development of national methodology for local adaptation strategies, which should be currently in the preparation process (ME SR, 2021), with the particular aim of a deeper understanding of the impacts of climate change and the design of solutions for better resilience of Slovak cities. Spatial vulnerability analyses have the potential to be used as a background document for prioritising the implementation of adaptation measures, as a part of background analyses for land use planners, or as subject for further research. To achieve a greater accuracy of the results, the research recommended establishing the use of the square grid with an area of a maximum of 200x200 meters and drawing the dividing lines according to the main composition axis of the urban structure.

CONCLUSION

The presented research focused on the comparison of spatial vulnerability of Slovak cities. It presents selected impacts of climate change with a focus on evaluating the resilience of urban structures. The current study was limited to a small sample of cities due to the limited number of adaptation strategies developed in Slovakia. Despite the differences in population size of the compared sample of cities, establishment period or their location within Slovakia, results show that there is a possibility to identify the characteristics of their spatial vulnerability. Similar results were observed in the vulnerability of urban structures to heatwaves and in the vulnerability of urban structures to floods. In summary, these results show that the most vulnerable urban structures to both impacts of climate change investigated–heatwaves and floods–are the city centres, the residential structure of prefabricated apartment buildings, and extensive parking lots. These results broaden our understanding of the impacts of climate change on Slovak cities. While not all impacts emerge throughout the country as a result of different climate characteristics of cities, it is crucial to address the impacts separately. The results also show the importance of the vulnerability of citizens to the physical environment of the city and how crucial it is to place importance on the form as well as the environment of the urban structure. Considering the limited number of cities examined, further research is needed in the coming years.

Acknowledgements

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Pop-up architecture as a tool for popularizing theatre: Prototype No. 1

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Abstract: This article builds on previous research dealing with temporary theatres in the context of Europe and Slovakia, discusses the topic of pop-up pavilions in terms of architecture, their use in marketing and as a potential tool for reviving the theatre scene. Just as temporary architecture can activate neglected areas in the city and bring stimuli for a permanent change, we believe that it can be equally stimulating in the area of theatre. The Shed by Haworth Tompkins is one of the examples to demonstrate a possible positive contribution of such designs to a permanent theatre and its surroundings. Based on the analysis of similar examples and statistical data on the attendance of theatre performances, we decided to design and implement a prototype of a minimal theatre scene, which also provides wide variability and can be used beyond the time dedicated to theatre activities. In the design phase, we examine the limits of variability and explore the basics of kinetic architecture. In the second phase after the object is assembled and implemented, the subject of research will be its impact on the environment, the extent of user interaction with the object and the overall functionality of the object. The ambitions of our project do not reach as high as presented in *The Shed.* The aim was to test the possibilities and viability of a much smaller object, to document the cultural, educational, and even economic benefits, in domestic conditions of Slovakia. Thanks to *The Program for the Support of Young Researchers* of the Slovak University of Technology and *The PUN (Universal Design Support) Project No. 321041APA3* financed by the European Social Fund, the object is currently in production, and later will be moved to the faculty premises, surface-threated and then assembled for the very first time. The prototype should be fully available by the end of the year 2022.

Keywords: architecture, theatre, pop-up, temporary, prototype

INTRODUCTION

Previous research has focused mainly on the issue of temporary pavilions intended for theatrical performances. The characteristic features of the completed projects in Europe and Slovakia were examined and compared. The common denominator was the already common word 'pop-up'. The Cambridge Dictionary explains pop-up as something unexpected, suddenly appearing, or happening (Cambridge Dictionary, 2021). This phrase can also be found in the Merriam-Webster glossary, where it is explained on the example of a pop-up shop/store, and therefore a shop/store that is set up in a short time, with temporary operation, without connection to a specific place (Merriam-Webster Dictionary, 2021).

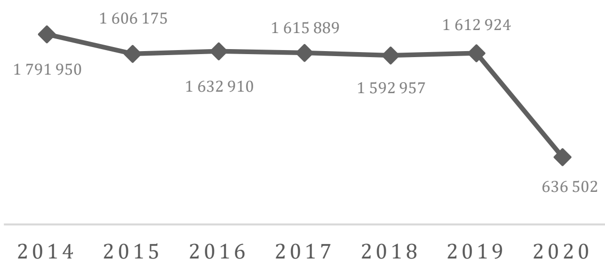
Marketing

This type of architecture has proven itself viable in numerous industries around the world. In the commercial sphere, it is used by many large companies to create a sense of limitedness, based on its temporary nature, to establish a closer contact with customers, to create an event that customers can share, an experience that supports verbal product recommendations. (Glover, 2021) According to Nielsen Global Research and Analysis Company, 92% of people believe recommendations made by their friends and family (Nielsen, 2012). Today, the equivalent of oral recommendations are social networks, for which temporary architecture with its distinct form is often rather attractive. The intention is to use proven methods from abroad, to attract customers, in our case audience, and to use the pop-up principle to popularize theatre in Slovakia.

Theatre

According to the cited Report on the State Statistical Survey in the Field of Culture, which is prepared annually by the Ministry of Culture of the Slovak Republic, the attendance of professional theatres has been stagnating. Ongoing Covid-19 pandemic is not helping this situation either, restrictions have reduced the visit rate by more than half compared to the average for the last five years. (Národné osvetové centrum, 2020) Currently, it is not only theatre but also other fields of culture face the challenge of attracting a wider and more diverse audience. Research shows that the 'core' of theatre-goers are university-educated residents mainly in Bratislava and Nitra regions. Vladimír Blaho speaks of theatre as of an undoubtedly more demanding kind of art, given its eminent artistic regularities on the one hand, and its lesser accessibility on the other hand. In conclusion of mentioned research on the relationship of the Slovak population to theatre, he adds that the result reflects a certain retreat of theatre as a significant social phenomenon in the then last decade and more broadly the direction of artistic culture towards a rather marginal position. (Národné osvetové centrum, 2003) There is a need to mention that although this research was conducted merely some 20 years ago, it still reflects diversity of the theatre audience as it is today. Therefore, we see research into temporary forms of theatre as an opportunity to verify their ability to function as theatre attractors, banners that can potentially attract audiences other than those who normally attend theatrical productions. Due to its volatile nature and mobility, temporary architecture can bring theatre beyond urbanized structures and thus bring culture closer to where it was previously unavailable.

Fig. 1. Visit rate of professional theatre in Slovakia. (Author: Kristína Boháčová, based on statistics from Report on the State Statistical Survey in the Field of Culture 2019)



THE SHED

The Shed by Haworth Tompkins studio can serve as an example of a positive installation that exceeded expectations and also went beyond its planned duration. A temporary theatre, with an original duration of 12 months, offered space for ambitious, experimental productions. Just as the building was an experiment itself, it offered space for experimentation as well as an opportunity to discover new ways of theatre-making and free creation. According to the studio, from the opening show in 2013 to the dismantling of the building in 2017, the Shed attracted a more diverse audience to the National Theatre of London and helped bring energy to the whole area. (HaworthTompkins, 2013) According to Patrick Healy of the New York Times, the London Theatre Complex attracted 1.5 million spectators during the 2012-2013 season, compared to 817,000 during the 2008-2009 season (Healy, 2013).

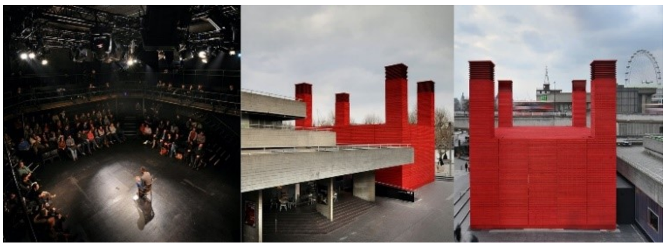


Fig. 2. The Shed by Haworth Tompkins. (Source: Haworth Tompkins, 2013)

PROTOTYPE NO. 1

The nature of the temporary architecture makes it an ideal subject for research by design and subsequent implementation phase. We had an opportunity to verify the gained knowledge in practice and to design and build an object that will continue to be used for research. In the follow-up research, we plan to study the object in different types of environments in which it will be placed, monitor the interaction with users, i.e. time spent interacting with the object to find out people's interest in similar short-term projects. Furthermore, it is planned to focus our research on the clients, who in our case will be the organizers of events, of which our object will be a part. Initially, by designing, placing and later observing the life of an object, we plan to gather as much experience and relevant knowledge as possible for the purposes of writing the dissertation thesis. The input parameters in this case were not given for two reasons. Firstly, due to the nature of the pop-up pavilion, which is characterized by its lack of a stable location and so there is no place to which the object could be tied. Secondly, due to variability, which we have identified as one of the main constituting pillars of the concept, giving us the opportunity to apply a typological experiment. The model we built also derives on current needs for sustainability and universal design. One of the most important aspects was the simple assembly and dismantling of the object, resulting from the basic requirement for its temporary nature and variability during operation.

Variability

Although the idea to design a pavilion arose in response to the need for a deeper examination of a minimum theatre scene, in the process we evaluated that such object that can offer a wide range of functional requirements and, while also without location-bound limits, it can provide wider usability and thus meet the sustainability requirements better than a monofunctional object. At the same time, we wanted to design a universal small-scale architecture, without any specific purpose, as a starting point for architecture with a theatrical content. The selection of varied functions is not random, the functions with the same premise were chosen: and that is to fulfil the function, the viewer and the observer are needed. The 'programme' of the object will include performances such as theatre, cinema, discussions or exhibitions.

Fig. 3. Scheme of variability. (Author: Kristína Boháčová)

Kinetics

The circle as a universal geometric shape became the initial form for the floor plan of the object. It allows you to watch the event from all sides and thus maximize the number of viewers. At the same time, it does not limit itself to the environment and can function as a solitaire in an undefined space. The circle was later modified to a polygon, which was more suitable in terms of the nature of the object, which is not just variable, but also kinetic. It is kinetic in its simplest meaning, which we could have seen in the Middle Ages in the form of drawbridges, which are considered to be the first phenomena of kinetic architecture. (Kronenunberg, 2014) William Zuk and Roger Clark in their book Kinetic Architecture, argued that the goal of kinetic solutions is to adapt space to change (Zuk, Roger, 1970), which in our case would occur frequently, by changing the locations of the object due to various events.

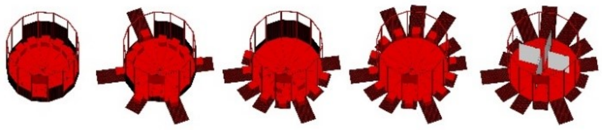


Fig. 4. Scheme of variability. (Author: Kristína Boháčová)

Universal design

The final form of the stage and thus the overall form of the object was largely determined by the need for space accessible to all. This need is reflected in the dimensioning of individual segments to a width sufficient for access of wheelchair users. The places in the 'auditorium' are equal, set-in terrain, with a minimum barrier that is a five-millimetre difference between the terrain and the floor of the object. In the next phase, we are considering adding a blackout fabric top to the construction, so it can also serve as a space for simulating the perception of a space by visually impaired people.

Methodology

For the follow-up research, more than one research method were chosen. Both quantitative and qualitative research will be applied following the nature of research question posed. As an example, we can use a situation where the object is a part of an international construction fair. In this case, the research question could be whether there is a difference in the visit rates of a pavilion, based on the level of architecture attention given to the exhibition system itself. Observation will be the first step. We will be noticing the quantity of visitors of the object and the time spent in or around the object. Simultaneously we will also be observing other pavilions so the comparison can be made. Later we will focus on the clients and by interviewing them we will follow up the same question: i.e. whether they can perceive any difference compared to previous events, based on the pavilion form. The research question is changing along with the content of the object and the type of events, and so are the research methods. We assume that by analysing a full spectrum of situations in which the object can be used and by asking the right questions, we could gain a complex picture of the abilities and potential of the small-scale temporary architecture.

CONCLUSION

This article outlined the potential of pop-up architecture as a populariser of both theatre and architecture among the general public. On the example of the temporary theatre building The Shed from the United Kingdom, which served as an extension to the permanent theatre, we can see the project was a success on several levels. With its four times extended lifespan, it shows acceptance by both the theatre-goers and general public. It enjoyed positive feedback in several articles and recognition of architecture critics. At the time Evelyn Furquim Lima wrote her article Architecture-event installation, or temporary theatre? A study of the Shed in London, there was controversy over whether the temporary theatre would become permanent at the request of the London population and would change its name from The Shed to the Temporary Theatre. (Lima, 2017) Today we know that it did not happen; on the contrary, the building conformed to its temporary nature and then disappeared, remaining true to its mission. However, it does not change our view on the assumption that even temporary objects have a beneficial impact on their surroundings. Experiments have always pushed society forward, and it is temporary objects that, with their transient nature, have become the essence of experimentation. We saw an opportunity to test the limits of such object by experimental design of a minimal variable architectural form, which deviates from the typologically traditional arrangement of a theatre. The ambitions of our project do not reach as high as presented in The Shed. The aim was to test the possibilities of a much smaller object, to document the cultural, educational, but also economic benefits, in domestic conditions of Slovakia. Thanks to The Program for the Support of Young Researchers of the Slovak University of Technology and The PUN (Universal Design Support) Project No. 321041APA3 financed by the European Social Fund, the object is currently in production, and later will be moved to the faculty premises, surface-threated and then assembled for the very first time. For possible future needs, we anticipate the designing of furniture such as seating, an information desk or bar counter. It is our first experience with this type of installation, especially in relation to the material, and therefore we need to include extra time in the project timeline. The prototype should be fully available later this year (2022).

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Summaries

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Tomáš Hubinský, Ján Legény
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Kristína Boháčová, Alexander Schleicher

ALPINE HUTS: ARCHITECTURAL INNOVATIONS AND DEVELOPMENT IN THE HIGH TATRAS UNTIL THE FIRST HALF OF THE 20TH CENTURY

Mária Novotná

Keywords: alpine architecture, modernism, innovations, High Tatras, alpine hut, chalet

The traces of history in the alpine environment reveal how the colonization climbed up the terrains and transformed them into exploited slopes. The paper examines the reflections on architecture discourse in the High Tatras. Analysing the initial discussions while the High Tatras were part of the Hungarian Kingdom and mapping the implementation of innovations during the first half of the 20th century allows to reflect how the copied architecture from other alpine terrains was shaped over time into representations of early modernism. This work focuses on the untamed areas with no urbanization where only solitary objects – the huts – are built. Alpine huts are lighthouses in the mist. They still fulfil the role of emergency shelters despite becoming a goal of mass tourism. In these times when we are losing excellent architecture and unique environments are vanishing, we would like to highlight the buildings which are not the cover for our activities, but represent the activity itself. We study the huts in the context of architectural development in the region of the High Tatras. We do not claim the log and half-timbered houses as traditional or "the only true" Tatra architecture. It could be some first Tatra architecture, as the region does not have any original settlement to refer to. This paper examines the mapped objects from an innovative point of view. It surveys the new materials, construction methods, durability and weather-resistant features. Together with focus on the arrival of new architectural styles, the work creates a chronological picture of the building process in the High Tatras. The view of the unknown alpine terrains changed since the first researchers and travellers escaped there from the city. They followed the hunting trails and stayed in shepherds' cottages. At the end of the 18th century, the first settlement was founded. The trigger to build an infrastructure were the healing waters. Another driver was reaching the summits. Despite the great spa potential, the High Tatras were not about to be a tourist centre. They were meant to be a strategic place to defend the northern border and the supply for the trade water canal. The railway changed everything at the end of the 19th century, with attractivity and increased availability, other settlements were founded, followed by arrival of the architects. The network of alpine huts was soon taken over by the Hungarian-Carpathian Association as an authority responsible for building new huts, maintaining and restoring the existing ones and planning hiking trails and access roads. Until the end of the 19th century, the huts were built traditionally, with local materials, mostly without architects. The only exceptions were the first Sliezsky dom house, hut by the Zelené pleso mountain lake and the Téryho chata hut. The paper surveys the architectural conception and analyses how the dialogue with the terrain, weather conditions, local materials and innovative process was applied in designing and building huts. In contrast to the eclectic free choice of the structures in the settlements, huts were excluded from this romantic tradition. The ornament did not climb up, with the only exception being Hrebienok,

where Studenopotocké kúpele spa was built to the image of the half-timbered spa in Tatra settlements. It was also the only location where art nouveau climbed up to the alpine terrain. The beginning of the 20th century brought innovation into interiors, such as electricity and flushable toilets. Building construction returned to the traditional masonry from the trends of half-timbered houses. This type of construction allowed to use the house all year-round. Tourist winter season developed winter centres for leisure and sports. The arrival of modern architecture introduced functionalism, CIAM's ideals, le Corbusier's points, and started to apply Loos's manifesto. The first hut in the young Czechoslovak Republic was built again to defend the border from Polish claims. Later, along with Czech contribution to a large-scale functionalism and Slovak small-scale functionalism alpine huts were forming the Tatra's landscape. They were still loyal to the traditional techniques, even though as they climbed higher, they were increasingly more technically innovative. The topic of thermal insulation started to be a point of discussion since the huts were to be accessible all year-round. Recreation as social invention of the 20th century resulted in extension of the huts and building accessible ways to the peaks. Technical innovation of the cable car made its way into the High Tatras in the 1930s, built as an example of regionalist functionalism which responded to the condition of alpine environments. The traces of ornament were stopped in the lower altitudes with urbanization and accessibility as well as the traces of modernism. The huts in the first half of the 20th century remained independent from the tradition sustained in lower elevations and true to their harsh conditions. The trends in architecture were determined by the possibility of elementary transport, while alpine huts had to calculate with every option of local material as a building material. However, the construction of alpine huts represents more of an innovative modernist idea of spending time in illuminated areas. Alpine environment was the place where building style was determined by the vegetation zone, not the current trends.

ROUTE OPTIONS IN INCLUSIVE MUSEUMS: CASE STUDIES FROM CENTRAL EUROPE

Natália Filová, Lea Rollová, Zuzana Čerešňová

Keywords: museum, children, tour route, inclusion, architecture, exhibition, sequence

Museums play an important role in the society, as they offer valuable experiences of discovery, education, art, play and interaction. This form of education can have a significant impact especially on the younger generation. Museums nowadays should offer quality leisure time for all, regardless of their age, preferences, status and abilities. Information is therefore provided in different ways and types of sensory perception, and at different levels of knowledge. Playful and educational activities can help visitors to understand exhibits, and bring them a valuable experience. Understandable and clear environment supports positive social interaction and relationships, as it becomes a setting suitable for making new friends and spending quality time. To facilitate understanding and support friendly atmosphere and well-being in museums, it is important to structure information, exhibits and spaces in an appropriate manner. Various means of routing systems and space arrangement can significantly influence the resulting experience. The order in which visitors circulate exhibition spaces in a museum is one of the most important architectural and operational characteristics of this type of cultural institution. Several authors also attach especially great importance to designing routes in museums. Some of their concepts and opinions are presented in the theoretical part of the paper along with the findings of the authors themselves. The typology by Ernst Neufert and ideas of Paul von Naredi-Rainer and Angelika Schnell have been given special consideration. Furthermore, the authors also mention and categorize the basic types of exhibition space layouts and connected routing solutions (open plan, linear chaining / directed sequences of rooms / round tour (loop), core and satellite rooms / spatial interpenetration and spatial isolation, labyrinth / matrix-like arrangement of rooms, complex layout, free-form spaces, conversions and extensions of architectural monuments). These forms have been assessed with respect to various aspects, first theoretically, and then on case studies. The focus of wider related research has been aimed at improving museums in Slovakia, particularly museums for children, and this objective also involved observing best practice examples in proximity. Consequently, five case studies from the region

meeting desired conditions have been analysed and evaluated. The results indicate different methods of routing and spatial division applied in practice. The selected museums are VIDA! Science Centre in Brno, Silesian Museum in Katowice, Lower Austria Museum in St. Pölten, Kemenes Volcano Park and Kulturpark in Košice. Other individual specific aspects of each of these museums have been examined as well, because they offer interesting unique local ideas. The case studies show that the concepts of routes in museums and taking children into consideration are currently very topical issues. Different path structures and combinations of routing types can evoke various types of atmosphere and create possibilities for developing distinctive museum solutions. Open plans appear to be the most commonly utilized type and their properties in comparison to other arrangements of spaces are discussed in the paper. The advantage of a free floor plan is its spatiality, possibly also neutrality, and especially its flexibility, the ability to adjust according to the requirements of exhibitions. Nevertheless, multiple suitable ways of composing routes that would meet all visitors' needs and offer them a quality leisure and educational experience from a museum tour are presented. Unique combinations of space sequence and division show practical application of theoretical layout types found in desk research. Various layouts and arrangements of exhibition spaces are analysed in the paper with abstract schemes, diagrams, layout and photo-documentation of the five selected museums. The paper proposes possibilities for future research, too. Potential subjects to study include museum paths and closeness versus openness of exhibition premises. Another interesting issue is a more precise examination of vertical connections and movement versus the horizontal ones. Last but not least, Principles of Universal Design introduced in museum architecture are another subject to be explored further. Finally, guidance of visitors around a museum when they walk through individual exhibition spaces is one of the key factors for visitor experience, wayfinding, but also easy understanding. Inclusive museum routes can thus positively affect the atmosphere and success of the whole institution and meet the needs of all its visitors. Multiple suitable solutions based on aforementioned principles were found in the research of museum routes, often with interesting hybrid layouts. Countless possibilities of combining route arrangement provide an inspiration for architects for creative and innovative museum designs.

MICROCLIMATIC FACTORS IN URBAN DEVELOPMENT: THE SETUP OF AN ENVIRONMENTAL OBSERVATORY AT THE FAD STU

Tomáš Hubinský, Ján Legény

Keywords: city, urban heat island, urban microclimate, physical parameters, environmental observatory, sensing probe, FAD STU

The presented research focuses on energy (im)balance on both global and local scale. Since the second half of the twentieth century, research regarding cities and their climate has focused on various physical properties that affect various physical and chemical processes such as energy absorptivity, reflectivity, emissivity, thermal conductivity, transpiration, evaporation, evapotranspiration, photosynthesis, etc. With respect to meteorology, physical processes that occur on a local scale in the atmosphere near the ground, on the land surface, and in the soil are generally termed microclimatic processes. Due to the long-term consolidation of interactions between microclimatic processes and the relatively low rate of emerging climatic disruptions, microclimatic conditions in natural environment are rather stable and predictable in time (short / long periods) with a high degree of accuracy. In the era of the Anthropocene epoch characterized by human activities with dominant influence on disruptions in the natural flow of energy and matter, the climate has become highly unpredictable on all spatial-temporal scales. Thus, urban climate is one of the most evident examples of inadvertent climate modification caused by humans. Human activities are therefore considered the dominant microclimatic processes within the city and directly linked to microclimate changes. The main emphasis is placed on microclimatic factors directly affecting public urban spaces and related physical processes regarding the city that are closely linked to energy flows and result in the formation of the Urban Heat Islands (UHIs). As they are one of the main adverse effects of human activities, the paper introduces the classification of UHIs by types, describes the basic differences between the surface energy balance of rural and urban areas, and introduces climate-

sensitive urban design as one of the possible ways to mitigate the undesirable anthropogenic impacts on climate change. The authors of the article present their own research, which predominantly focuses on the development of an environmental observatory situated on the rooftop of the building of the Faculty of Architecture and Design STU in Bratislava (FAD STU). They interpret the experimental operation of sensing probe 1 and the first results and measurement data on Global Horizontal Solar Irradiation (GHSI) and their post-processing. In addition, they describe the construction of sensing probe 2, which will provide more data on total atmospheric precipitation, wind speed and its direction, presence of dust particles and carbon dioxide in the air, or spectral characteristics of incident and reflected solar radiation. Finally, the experimental operation of the thermal and micro-camera with fisheye lenses is described. These cameras are essential for measuring the Normalized Difference Vegetation Index (NDVI) as one of the parameters used for the assessment of vegetation vitality, which also plays a key role in the formation of the UHI effect. The creation of an environmental observatory on the grounds of the FAD STU whose operation was experimentally verified by sensing probe 1, along with the future location of sensing probes 2 in selected public urban spaces creates a prerequisite for conducting further research in the field of microclimatic factors affecting urban development. Compared to basic research, the level to which knowledge is implemented in practice in the field of urban microclimate is deficient. Advances in data science have made it possible to process a large number of data (Big Data) using the statistical analysis methods, and thus to gain relevant sources of information that complement the existing ground-based and remote sensing infrastructure. The increasing quality of data, their spatial-temporal density, and shorter response time, with the expected accompanying refinement of forecasting models, improved crisis management, and provision of tools for the retrospective assessment of environmental strategies within the city. The main objective of Climate-sensitive Urban Design (CSUD) is a city that uses resources efficiently in terms of sustainability in order to protect its residents and traffic from severe weather phenomena. The current research conducted at the FAD STU aims to contribute to these sustainable strategies and city management. There are still some specific issues that researchers should address. The first is the development and creation of data prediction models, where the current trend is to increase the complexity of the evaluated microclimatic factors in spatial-temporal detail. Such predictive models and simulations help architects and urban planners understand the interaction of microclimatic factors with the surroundings and allow them to verify the expected benefits of solutions during the design phase. The second is the critical retrospective evaluation of implemented solutions exposed to real conditions not only at the level of architectural and urban design, but also regarding engineering and technical solutions, such as the material composition of surfaces. This approach supports the continuation of the evolution of engineering design. The third is to increase the use of quantifiable parameters to rate the impact of individual and interacting microclimatic factors and to facilitate complex decision-making within the design process.

THE IMPACTS OF CLIMATE CHANGE ON URBAN STRUCTURES IN SLOVAK CITIES: IDENTIFYING VULNERABLE URBAN STRUCTURES

Miroslava Kamenská, Katarína Smatanová

Keywords: climate change, urban adaptation, spatial vulnerability, spatial planning, sustainable development

In the coming decades, our cities will face extreme weather caused by climate change, which they will have to adopt. The most significant impacts on Slovakia are characterized by an increase in the number of tropical days, average air temperature, concurrent heatwaves and droughts, sudden and regional floods, and a decrease in relative humidity. In the urban environment, the increase in the amount of sudden and intense rainfall results in increased demand for infrastructure, rising temperatures, and heatwaves creating urban heat islands, increasing the risk of negative impacts on the quality of the life, health, and safety of the inhabitants. To address these challenges, cities initiate the adaptation process by preparing the ground for adaptation, assessing risk and vulnerability, developing an adaptation strategy, implementing adaptation measures, and by subsequent monitoring and rethinking of the effectiveness of applied measures. Despite the fact that the National Adaptation Strategy of the Slovak

Republic identified the adaptation at local level as essential for urban environment, within the last 8 years since its adoption, only 8 out of 141 Slovak cities in total have elaborated the adaptation strategy for impacts of climate change. This paper thus explores in more depth one of the initial parts of the adaptation process, part of the vulnerability and risk assessment, as an often-overlooked area in the field of spatial planning. The aim of this work is to broaden our knowledge of the two most significant impacts of climate change –heatwaves and floods– on urban structures in Slovak cities and validate the importance of spatial vulnerability analyses as a considerable tool for the expected unified national methodology for developing local adaptation strategies. This study examines the spatial vulnerability analyses of Hlohovec, Kežmarok, Košice – Západ, and Trnava prepared by Karpatský rozvojový inštitút as a part of vulnerability assessment within the framework of adaptation strategies of these cities. The organisation is a leader in adaptation planning in Slovakia and the creator of a unique method of adaptation strategies in Slovakia. These analyses allowed us to compare cities, identify the most vulnerable urban structures and consequently understand the causes of vulnerability of urban structures in Slovakia, which is crucial for further development of the adaptation strategies and the building of resilience in cities. The research outlines the urban structure of the cities examined, provides an exploratory spatial analysis of vulnerability hotspots, and, based on the findings, defines the principles of spatial planning and urban structures resilient to the impacts of heatwaves and floods. In summary, the results show that the structures most vulnerable to both heatwaves and floods are urban structures with a high concentration of inhabitants. Problems lie in the centres of cities with dense public amenities and a historical footprint with large paved and unshaded areas without vegetation and a lack of trees that could help create the suitable microclimate during heatwaves and infiltrate rainfall. From the point of view of heatwaves, the most vulnerable areas, except for the city centres, are the surroundings of kindergartens, schools, train or bus stations, grocery stores, or local centres with amenities. From the point of view of floods, the most vulnerable areas are extensive parking lots with impervious surfaces and the main transport infrastructure, which suffers from the insufficient runoff capacity of the sewer systems. The results confirmed that the vulnerability of cities to floods with the impacts of climate change is no longer only a problem of the waterfronts. The research shows a significant difference between the vulnerability of residential structures. On the one hand, there is the structure of individual or terraced family houses and low-rise apartment buildings with up to 6 floors, which is resilient to the impact of climate change in Slovakia. On the other hand, mass housing structures of prefabricated apartment buildings with 8 to 14 floors are vulnerable to the impacts of heatwaves due to poor technical condition and energy inefficiency of the buildings, leading to overheating of the indoor spaces. Despite the abundant areas of vegetation, their surroundings are also vulnerable to the impacts of heatwaves and surface floods. The findings of this research outlined that the vulnerability of citizens to the physical environment of the city has a great impact on the spatial vulnerability assessment of urban structures and showed how crucial it is to place importance on the form of urban structure as well as its surroundings. Urban structures that are resilient to the impacts of heatwaves and floods are based on the idea of accessibility and short distances, polyfunctional structures, and mixed use within buildings and within the city, which helps to reduce the concentration of inhabitants in one place, and to reduce the need to develop extensive parking areas and transport network, which has proven to be a problem of the existing structures. Overall, these results suggest that spatial vulnerability analyses have the potential to be utilized in the development of national methodology for local adaptation strategies and as part of background analyses for land use planners. Further development of their application within the processes of urban design and planning should also be examined in the nearest future.

POP-UP ARCHITECTURE AS A TOOL FOR POPULARIZING THEATRE: PROTOTYPE NO. 1

Kristína Boháčová, Alexander Schleicher

Keywords: architecture, theatre, pop-up, temporary, prototype

This article builds on previous research dealing with temporary theatres in the context of Europe and Slovakia, discusses the issue of pop-up pavilions in terms of architecture, their use in marketing and as a potential tool for reviving the theatre scene. Just as temporary architecture can activate neglected areas in the city and bring stimuli for a permanent change, we believe that it can be equally stimulating in the area of theatre. The paper also outlines the potential of pop-up architecture as a popularizer of both theatre and architecture among the general public. The Shed by Haworth Tompkins is one of the examples to demonstrate a possible positive contribution of such designs to a permanent theatre and its surroundings. On the example of the temporary theatre building The Shed from the United Kingdom, which served as an extension to the permanent theatre, we can see the project was a success on several levels. With its four times extended lifespan, it shows acceptance by both the theatre-goers and general public. It enjoyed positive feedback in several articles and recognition of architecture critics. At the time Evelyn Furquim Lima wrote her article Architecture-event installation, or temporary theatre? A study of the Shed in London, there was controversy over whether the temporary theatre would become permanent at the request of the London population and would change its name from The Shed to the Temporary Theatre (Lima, 2017). Today we know that it did not happen; on the contrary, the building conformed to its temporary nature and then disappeared, remaining true to its mission. However, it does not change our view on the assumption that even temporary objects have a beneficial impact on their surroundings. Based on the analysis of similar examples and statistical data on the attendance of theatre performances, we decided to design and implement a prototype of a minimal theatre scene, which also provides wide variability and can be used beyond the time dedicated to theatre activities. In the design phase, we examine the limits of variability and explore basics of kinetic architecture. Experiments have always pushed society forward, and it is temporary objects that, with their transient nature, have become the essence of experimentation. We saw an opportunity to test the limits of such object by experimental design of a minimal variable architectural form, which deviates from the typologically traditional arrangement of a theatre. In the second phase after the object is assembled and implemented, the subject of research will be its impact on the environment, the extent of user interaction with the object and the overall functionality of the object. The ambitions of our project do not reach as high as presented in The Shed. The aim was to test the possibilities and viability of a much smaller object, to document the cultural, educational, but also economic benefits, in domestic conditions of Slovakia. Thanks to The Program for the Support of Young Researchers and The PUN Project, the object is currently in production, and later will be moved to the faculty premises, surface-threated and then assembled for the very first time. For possible future needs, we anticipate the designing of furniture such as seating, an information desk or bar counter. It is our first experience with this type of installation, especially in relation to the material, and therefore we need to include extra time in the project timeline. The prototype should be fully available later this year (2022).

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