sciendo

Civil and Environmental Engineering
Vol. 20, Issue 1, 98-108, DOI: 10.2478/cee-2024-0009

THE WORLD'S OLDEST PAVEMENTS AND IN THE TOWN ŽILINA INTO THE CONTEXT WITHIN MUNICIPAL ENGINEERING

Milos DUDAS[1], Martin DECKY[2,*], Katarina HODASOVA[2], Matej BRNA[2]

[1] Department of Mediamatics and Cultural Heritage, Faculty of Humanities, University of Zilina, Univerzitna 8215/1, 010 26 Zilina, Slovakia.
[2] Department of Highway and Environmental Engineering, Faculty of Civil Engineering, University of Zilina, Univerzitna 8215/1, 010 26 Zilina, Slovakia.
[*] corresponding author: martin.decky@uniza.sk

Abstract

In this article, the authors explore examples of preserved cultural heritage related to traffic structures, focusing on the world's oldest bridges in Europe and Slovakia, as well as the oldest preserved roadways. They delve into the detailed history of Marians Square in Žilina, particularly its surface treatment, drawing from credible historical sources. The article also presents comparisons of elasticity modules and deformations of the roadway, based on measurements taken in 1966 and the last reconstruction from 1995 to 1997, which cost SK 64.5 million (equivalent to EUR 6.9 million in 2024). Through an evaluation of mechanical characteristics and environmental criteria, the authors conclude that the reconstructed road, even in 2024, effectively protects against frost damage, minimizes particulate matter and noise pollution (excluded motor traffic), and adheres to principles of contextual design for pavements.

Keywords:

Municipal engineering;
The oldest bridges;
The oldest pavements;
Marian square in Žilina;
Static plate load test.

1 Introduction

The article presents the latest knowledge used in the education of the urban engineering subject in the 2nd stage of university studies at the Faculty of Civil Engineering of the University of Žilina in Žilina. They familiarize the professional public with the author's definition of Municipal Engineering (ME) and deal in more detail with an integral part of ME, which is the building protection of monuments, including traffic structures [1, 2]. In [3] they presented their definition of Municipal engineering as a multidisciplinary set of competencies, knowledge, skills, tools, and procedures used in the application practice of municipal management, directed towards the development and subsequent implementation of the intentions of the development strategies of settlement units. They apply the principles of integration, inclusion, innovation, and strategy in decision-making and project design, with the activities implemented having a demonstrable positive impact on the long-term improvement of the quality of life in the city and region and sustainable development. In the article, the authors present examples of preserved cultural heritage from the point of view of transport structures, in which they address:

- the oldest preserved bridges and their remains,
- the oldest preserved pavements,
- the pavements of Marians square (MS) in Žilina and the evaluation of the mechanical efficiency of the layers built as part of its last reconstruction in 1995 to 1997.

© Author(s) 2024. This work is distributed under the Creative Commons BY 4.0 license (https://creativecommons.org/licenses/by/4.0/).



Fig. 1: Covers of textbooks Decky, M., Muska, M., Remisova, E. et al. Municipal engineering. Part 1 (2021), Part 2 (2023) and Part 3 (2024).

As part of the protection of monuments in the context of building law, it is mainly about the protection of real estate directly or indirectly forming a monument fund [2]:

• they are then directly part of the monument fund, if it is a property entered in the list of cultural monuments maintained by the Slovak Monuments Office under the Ministry of Culture of the Slovak Republic, which is a specialized state administration body for the protection of the monument fund, performing state administration with a pan-Slovak scope,

• indirectly, it refers to situations where the property has a direct impact on the cultural monument, for example a road, bridge construction, etc., which ensures connection to the transport infrastructure,

• a special status of protection is given to an immovable object that has been investigated and for which the procedure for declaration as a national cultural monument has been initiated.

It should be noted that this protection does not represent an absolute regime of inviolability of national cultural monuments. It is only a mode of taking into account their important public interest, which they represent for society and ultimately the whole civilization.

2 The oldest preserved bridges and pavements

According to Korcula road University of Zadar Facebook [4], at the submerged Neolithic site of Soline, an astonishingly modern-looking road of stacked stone was found under deposits of sea mud. It connected an artificial island associated with a people known as the Hvar Culture, with the coast of the island of Korcula (Fig. 2). The road was four meters wide, or about 12 feet. The date 7,000 BCE was determined via radiocarbon dating of preserved wood from buildings of the Hvar culture's settlement. Bridges are an integral part of roads and therefore their historical dating is similar to that of the oldest preserved remains of roads. In [5] regarding the oldest preserved bridge, the block bridge at the foot of the Great Pyramids in Giza is mentioned, which was documented by the measurements and plans of Kemal El-Mallak from the year 1948 (Fig. 3 – left). It is the oldest known two-level intersection in the world. The viaduct bridges the lower road leading from the territory of Chefren's valley temple in a roughly north-south direction. The dimensions of the block bridge confirm that the upper road was at least 7 m wide. The width of the underpass was about 3 m, the clear height, 5 m, and the main lintel is 7 m long, 2.5 m high, and 3 m wide. Koreckého's photograph from 1968 (Fig. 3 on the right) shows this bridge structure already heavily covered with deposits of fresh sand.



Fig. 2: Underwater view of a 7,000-year-old road in Croatia [4].

The Lake Moeris Quarry Road is indeed considered one of the oldest paved roads in the world, dating back to around 2575 BC. It was used for transporting heavy blocks of basalt from a quarry to the

Giza plateau, where the pyramids are located. The oldest preserved pavements often include the surface layers of stone bridges. An overview of still functional or preserved remains of bridges are provided in Table 1.

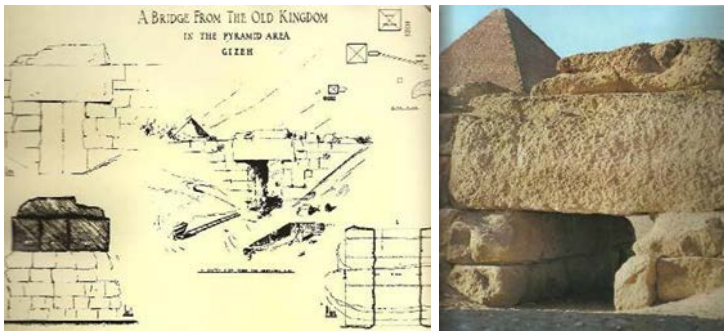


Fig. 3: Kemal El-Mallak's drawings of "the oldest 2-level intersection in the world" at the foot of the Great Pyramids in Giza (approx. 2,550 BC) from 1948 and her photo from 1968 [5].

The road was approximately 7 miles long and was made of limestone, sandstone slabs, and petrified wood. It played a significant role in facilitating the construction of the pyramids by providing a means to transport the massive stone blocks used in their construction.



Fig. 4: Views of a 4,800-year-old road, according to ASCE, the oldest preserved road with a paved surface [6]. In the centre are basalt slabs of the ascending road, and on the right are sandstone slabs on the road leading from the Valley to the Mortuary Temple of the Pyramid of Giza [5].

Table 1: The oldest bridges identified as part of the solution of the KEGA project no. 027ŽU-4/2022, taken from [7].

The oldest bridges in the world and Slovakia		
Identifying the age of the oldest bridges	**Views of bridges**	**Name or brief description**
The oldest bridge in the world *approx 2,550 BC*		Egyptian archaeologist Kemal El-Mallakh's drawings of the world's oldest 2-level stone bridge at the foot of the Great Pyramids of Giza from 1948 and his photograph from 1968 [5].
The oldest remains of a bridge in Europe *approx 2,000 BC*		"Drawings and remains of the Minoan bridge have been discovered at the archaeological site of Knossos in Crete [8]."
The oldest functional bridge in the world *850 BC*		According to the Guinness Book of Records, the oldest still-used stone bridge in the world is the bridge over the Meles River, Izmir Turkey [9].

The oldest bridges in the world and Slovakia		
Identifying the age of the oldest bridges	**Views of bridges**	**Name or brief description**
The oldest functional bridge in Europe *14 to 21 AD*		The Emperor Tiberius Bridge in Rimini, which, according to the latest research, has surpassed the Pont Du Gard [10].
The oldest bridge in Slovakia *14. century AD*		The stone bridge from the 14th century near the village of Leles, which once bridged one of the branches of the Tisa river, today, as a result of water management improvements, only spans a dried-up riverbed [11].

3 History of surface treatment of Marians Square in Žilina

The settlement of the area of the historical core of the city, the current Marians square (MS), is documented at the beginning of the 13th century. At that time, there were several, probably wooden buildings that formed a small Slavic settlement. It was just one of several separate settlements located within a radius of a few kilometres from the Church of St. Štefana Kráľa (King Stephen, today's location of Dolná Rudina). From the square, it is only a 15-minute leisurely walk to the church. Regular urbanism and a characteristic building structure were brought to Žilina only by German settlers at the turn of the 13th and 14th centuries. In addition to well-thought-out urban development, they also applied a special legal system derived from the older Tešín and later Krupin (Magdeburg) law. Dozens of villages in the wider vicinity of Žilina were governed by this legal framework, and its townspeople were hereditary magistrates in many settlements [12].

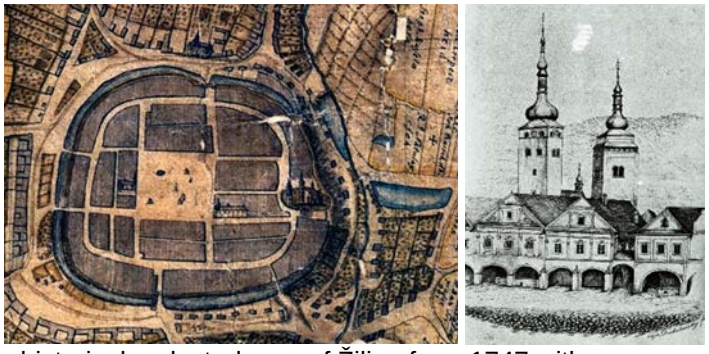


Fig. 5: Cut-out of the historical cadastral map of Žilina from 1747 with a square market square, both wells and a statue of the Immaculate Conception (Archive of KPU Žilina), on the right – a drawing of a part of the Žilina market square from the 1830s or 1840s, also with probably older stone paving [13].

The new settlers established a square market square, the so-called rínok (ancient name for market place in Slovak), with a rectangular network of streets that fit into the oval plan of the older settlement. They connected the marketplace with the church grounds by a narrow alley, the so-called Burian's gap. During the first half of the 14th century, the small church was expanded and enlarged to a more or less current form of a three-nave building, and since 1586 it bears the current patronage of the Holy Trinity.

At the beginning of the 14th century, Žilina received city privileges and is referred to as "civitas". In 1321, King Karol Róbert (1288 – 1342) recognized her older privileges and granted new ones, including the so-called mile right and fishing right. At the turn of the Middle Ages and early modern times, other Hungarian rulers confirmed and extended the city's market law, with the fact that craft products can be sold on the market and regular and annual markets can be held, especially on the feasts of Corpus Christi and St. Michael [13].

The almost regular square plan of the market (square) has an area of one hectare, where each side measures approximately one hundred meters. The individual sides of the square were originally divided into ten narrow and long plots. In their front part, burgher residential houses were built, first one-story and mostly wooden, later, after the fire in 1521, already multi-story and brick. Farm buildings were

usually located in the rear parts of the plots, which gradually replaced other residential tracts only from the second half of the 19th century. On the ground floor of the houses, from the side of the square, there are open arcades (so-called “laubne” in Slovak), which in the past formed an important background for crafts and trade and which today create a typical and unrepeatable architectural colour of the city centre.

Construction of the Jesuit monastery and the Church of the Conversion of St. Paul on the site of five town houses in the middle of the 18th century partially disturbed the original medieval urbanism of the square. On the other hand, however, the new sacral objects sensitively complemented its architecture and enriched it with a new landmark. However, this cannot be said about some of the new buildings of the interwar functionalist architecture that were built on the square in the 1920s and 1930s. Despite this, the former market has largely preserved the medieval city plan and the clearly legible urban structure of the period. Even today, some streets bear names directly derived from its original medieval form (for example Na bráne, Dolný and Horný val, Na priekope streets – At the gate, Lower and Upper rampart, At the moat, which originated in the Middle Ages when the town had walls).

The extent of the historical core of the city with Marians Square, which has changed its name several times in the past (Rínok, Hlavné námestie, Námestie sírá František Jozef, Námestie Slobody, Námestie Dukla) is essentially copied by the Žilina Municipal Monument Reserve announced in 1987.



Fig. 6: Tiles pavements of MS, upper one from the middle of the 19th century, lower one from the beginning of the 18th century. [14], right – pavement from the 19th century on Wuruma Street in Žilina [11].

Because markets have been held on the Žilina square since the Middle Ages, it is likely that its area was paved already at that time. If not the whole, then at least its main central part, where craftsmen sold their goods and where stood a smaller stone object measuring 8.5 x 7.5 m identified during archaeological research in the 1990s. This object is also captured on the historical maps of the city from 1747 and 1775 or on the drawing of the square by geometry student Karl Hauer from 1779. Its form and purpose are unknown, we believe that it was used to store the goods of craftsmen and merchants, or to paying a fee to the city for the possibility of selling products during markets, or fairs.



Fig. 7: Remains of the younger level of the historic stone pavement between J. M. Geromett and Horný Val streets, right – detail of the younger historic stone pavement (Archive of the KPÚ Žilina).

Archaeological research carried out on Marians square in the second half of the 20th century (1966, 1993, 1995) revealed two levels of historical stone paving, which was made up of river stones imported from nearby Váh or Kysuca. The older historical pavement is located at a depth of about 1 meter and the younger one about 50 cm from the level of the current level of the square.

According to several finds of coins, the older historical pavement can be dated to the end of the 17th or the beginning of the 18th century. This is evidenced, for example, by the silver coin of the Polish and Swedish king John Casimir II. (1609 – 1672) from 1660 or a copper coin of Francis II. Rákociho (1676 – 1735) from 1706. This pavement could have been laid at the time when two brick wells with a depth of 10 to 13 m were created on the southern and northern corners of the market square (both are presented in the form of a hypothetical reconstruction today in the square). Until then, in the first half of the 17th century, the people of Žilina brought water to the market via a simple wooden pipe from the relatively distant location "Hradisko" (Castle) [15].

The square's pavement was modified to accommodate the installation of the statue of the Immaculate Virgin Mary in 1738. The statue was intended to commemorate the completion of the city's reconversion to Catholicism and the protection offered by St. Florián on its sandstone pillar against fires. This likely entailed minor alterations to the square's center to accommodate a sandstone plateau for the statue. However, the stone pavement made of river pebbles and its height level remained unchanged. This is corroborated by the presence of the copper grajciar (grain or mite, red cent) of Jozef II. (1741 – 1790) from 1790, which rested on this older paving level.



Fig. 8: A shot of a section of the market square (Marians square) featuring historic stone paving from 1903 (State Archives in Žilina with headquarters in Bytča, Žilina Archive), right – a modification of the market square in the vicinity of the Immaculate Conception statue during the interwar period, likely around the turn of the 1920s and 1930s (coloured postcard, Archives of KPÚ Žilina).

The construction of the younger historical paving, again made of river stones, probably took place in the middle of the 19th century. This could have happened after the renovation of the square, which was related to the removal of damage after the great flood in 1813, or after devastating fires in 1845 and 1848, or even damage caused by the earthquake in January 1858. The time classification of the creation of this pavement is confirmed by two coins found archaeological research on its surface, these were copper coins of Francis Joseph II. from 1860 and 1868 [15]. This construction modification did not only concern the paving of the square itself, but also the streets in its immediate vicinity. Even today, during excavations, which are carried out during the repair of utility networks, or with the modern resurfacing of several streets, this historical paving is easily legible. Until the beginning of the 20th century, the appearance of the Žilina square and its paving made of river stones remained more or less unchanged. However, it is not entirely clear when the area under the pavilions was paved with large-format sandstone paving. Only the surroundings of the Immaculate statue required minor modifications during this period. Probably already at the end of the 1880s (after the devastating fire of the city in 1886), a small grassy island with greenery and a wooden fence was created around Immaculata, which was replaced by a metal fence after a few years. Both brick wells were closed with a shallow brick vault and covered with paving stones at the level of the square. For some time, water from them was pumped using cast iron pumps. In the time just before the First World War, in the period when markets and fairs stopped being held on the square, a major modification of the surface of the square was carried out. In addition to the modernization of the public space, the reason was also the need to adapt its surface to the increasing number of motor vehicles. Thus, in the square and on the surface of some related streets, basalt cubes of dimensions 7 – 10 x 7 – 10 cm, placed in the shape of fans, replaced the river stones [16]. However, a smooth cast surface was used in the central part of the square and on the area in front of the facades of the town houses, which was primarily intended for pedestrians. After the creation of Czechoslovakia, more attention was paid to the park arrangement of the central part of the square. Around Immaculata, small grassy areas were created and decorative bushes were planted, to which ornamental trees were subsequently added. Cast iron pumps have been cancelled. In the 1940s, during the so-called of the Slovak State, there was a relatively extensive construction boom in Žilina. A new

representative Municipal House (today's Municipal Theatre) with travertine cladding is being built near the square, and the balustrade and the nearby Parish Church are being fundamentally rebuilt. Travertine was also used on the area of the square. The areas for pedestrians in front of the houses were paved with large-format travertine paving, which smoothly passed into the space under the gazebos. The park arrangement around the Immaculate was consolidated and enlarged, and a space was created in front of it for the siting of a fountain with a baroque floor plan pool. Linden and spruce trees were planted behind the statue. After several decades, the local government removed the conifers, but the growing lindens already overshadow the square's dominant feature with their mass and silhouette and problematize its overall urban and architectural perception. On the other hand, however, they create a pleasant microclimate and atmosphere in the square, especially in summer and hot weather. After half a century, the visual and surface of the square were once again fundamentally revitalized (Fig. 9 and 10). In the mid-90s of the 20th century, the older basalt and travertine paving was replaced by small andesite cubes, and in 1998 the old fountain with a pool was replaced by a new pyramid-shaped one with a marble lining.

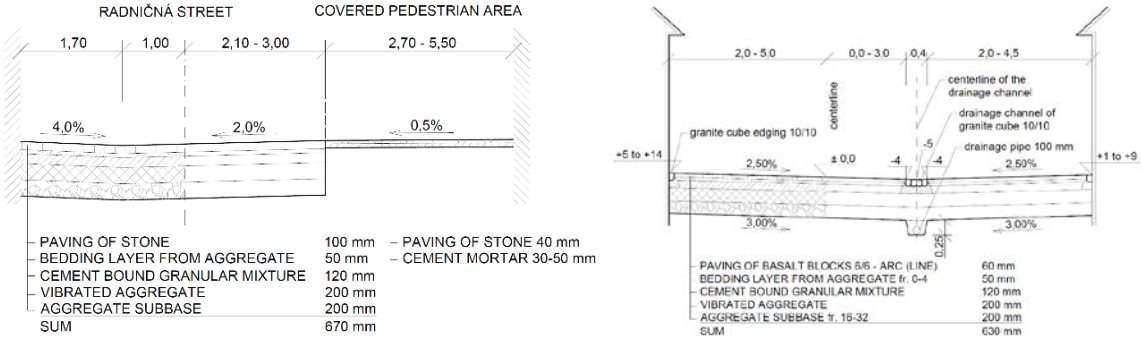


Fig. 9: Views of the cross-sections of the renovations of MS and the communications of the city monument reserve – I. stage (year 1995) and II. Stage from year from 2002, KPÚ archive Žilina, redrawing by Matej Brna.

Along the perimeter, the area of the square was complemented by ornamental trees of globose form and mobile vegetation greenery in concrete containers. In 2006, the pyramidal marble fountain was replaced by a contemporary one, with debatable material and "baroque" shape solutions. Currently, the city of Žilina is preparing an urban-architectural competition for the overall revitalization of the square, which will affect both its surface treatment and greenery, as well as the fountain and small architecture.



Fig. 10: A view of the current form and arrangement of MS (Photo: M. Gjer).

4 Assessment of the load-bearing capacity of the structural layers of Marians square

Measurements of static load tests were in 1996 implemented for the purpose of quality control of the construction works of the last large-scale reconstruction of MS, which took place between 1995 and 1997. The measurement of the load-bearing capacity of the structural layers of the MS pavement was carried out through the Static plate load test (SPLT) of building constructions, in October 1996 by a team led by prof. Ing. Ján Čorej, CSc. Details of the SPLT valid in 2023 can be found e.g. in [17, 18]. The subject of the measurement was the determination of the bearing capacity of base layers of MS pavement (Figs. 8 to 10), the location of the measuring points and the structure of the assessed structure is shown in Fig. 11.

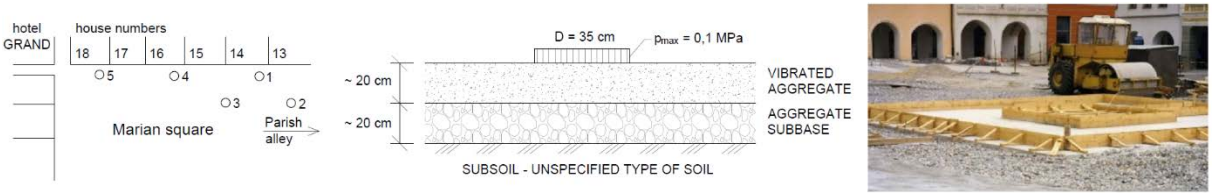


Fig. 11: Situational sketch of measuring points, scheme of the assessed structure and a view of the cylinder [19] forming the SPLT counterweight 10/7/1996.

According to STN 73 6190 from 2019 [20] and STN 73 6133 [21] the largest contact stress is usually 0.3 MPa at SPLT. The test takes place in 2 cycles with loading stages: 0.0 MPa, 0.05 MPa, 0.1 MPa, 0.2 MPa and 0.3 MPa and unloading stages 0.1 MPa, 0.05 MPa and 0.0 MPa, during which the deformations (pushing) of the plate of SPLT are recorded (an example is shown in Fig. 12). At each degree of loading and unloading stage, it is necessary to wait until their deformation stabilizes. From the 1st load cycle for the increase in deformation (Δy) when the load changes by 0.1 MPa (in the range 0.1 MPa – 0.2 MPa = Δp), the modulus of elasticity $E_{def,1}$ is determined and from the 2nd load cycle $E_{def,2}$.

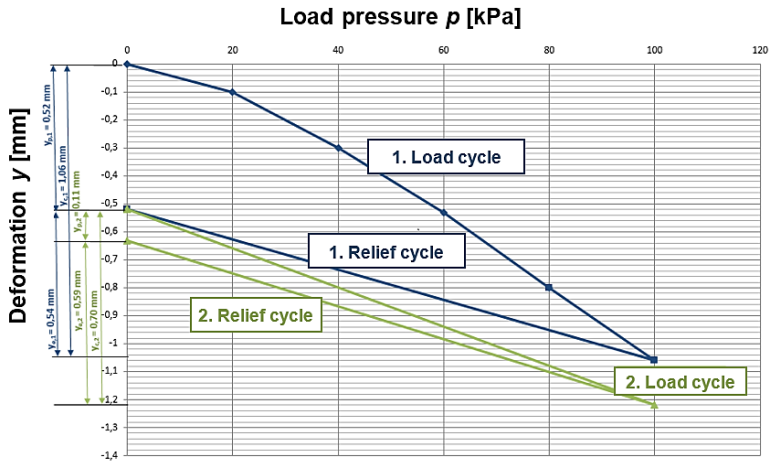


Fig. 12: Measured deformations (squeezes) plate of SPLT, test number 1 – left side, 7.10.1996 [22].

With the selected range of contact stress change (0.1 MPa to 0.2 MPa), the modulus of plasticity (deformation) is evaluated according to the following relationship:

$$E_{def,x} = \frac{\pi}{2} \cdot (1 - \mu^2) \cdot r \cdot \frac{\Delta p}{\Delta y} \tag{1}$$

where:
$E_{def,x}$ – modulus of plasticity (deformation) in [MPa], respectively [kPa],
μ – Poisson number [-],
r – plate radius [m],
Δp – change in contact pressure in [MPa], respectively [kPa],
Δy – change in the drop of the board (deformation of the tested environment) in [m].

In STN 73 6190 from 1980 the following equations were given:

• the static modulus of deformation E_0 [MPa] was determined according to STN 73 6190 by a static load test performed in such a way that at the last load stage the derived pressure of the plate is greater than that used to calculate the modulus according to the equation:

$$E_0 = \frac{\pi}{2} \cdot (1 - \mu^2) \cdot \frac{p \cdot r}{f_{tot}} \tag{2}$$

where:
p – the pressure of the loading plate on the pavement construction layer to be during the test:
- for subbase of pavements 0.10 MPa,
- the lower base layers 0.20 MPa,

o the upper base layers 0.35 MPa,

f_{tot} – the average total deformation of the evaluated layer at contact pressure p [m].

• the static modulus of elasticity E [MPa] is determined in the same way as the deformation modulus E_0 and is calculated according to relation 3, in which f_e is the average elastic deformation below of the plate [m]:

$$E = \frac{\pi}{2} \cdot (1 - \mu^2) \cdot \frac{p \cdot r}{f_e} \tag{3}$$

As part of the solution presented in the diploma thesis, an analysis was conducted using documents obtained from the 1996 evaluation of static load tests on structural layers, in accordance with the methodology valid as of 2023 [20]. Fig. 13 illustrates a comparison between the evaluated modulus of elasticity and modulus of deformation based on the methodologies valid in 1996 and 2023.

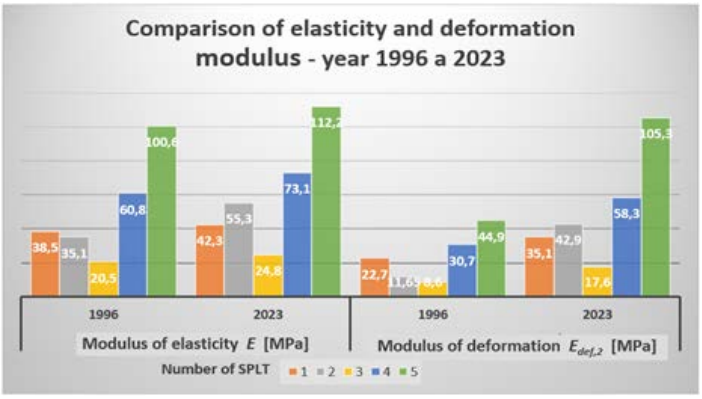


Fig. 13: Comparison of elasticity and deformation modulus evaluated according to STN 73 6190 from years 1980 and 2019 [22].

5 Conclusion

Overall, the passage contains a mix of information regarding urban engineering education and the history of Marians Square in Žilina, Slovakia. However, there are some areas where clarity and structure could be improved. Here's a revised version:

The authors present the knowledge utilized in the urban engineering curriculum during the second stage of university studies at the Faculty of Civil Engineering of the University of Žilina in Žilina. They introduce the professional community to the author's definition of Decky-Muska-Remisova Municipal Engineering (ME), published in 2023 and included in the draft STN 73 6100. ME encompasses a multidisciplinary array of competences, knowledge, skills, tools, and procedures utilized in self-governing management practices, aimed at implementing the development strategies of residential units. Within the domain of monument protection, the authors address the preservation of the world's oldest roadways and bridges, with a specific focus on Europe and Slovakia, providing an identification framework as outlined in Table 1. Another aspect covered in the article is the history and present state of Marians Square (MS) in Žilina (Fig. 10, 14). Inhabited before 1290, the square was initially known as the market square. Situated in the heart of Žilina, Marians Square serves as a central hub for various cultural, social, and commercial activities. It stands as a significant cultural and architectural landmark in Žilina, contributing to the city's rich heritage and vibrant urban life:

• Historical postcards also reveal the square's name in German texts, such as Hlavné námestie (Main square) and Kruhové námestie (Circular square). Over time, the square underwent several name changes:

• Emperor František Jozef Square, from 1900 to 1919,
• Freedom Square, following the establishment of the first Czechoslovak Republic,
• Dukla Square, since 1946,
• Marian Square, named after the statue of the Immaculate Conception (see Fig. 8).



Fig. 14: Views from 10.05.2023 of the MS pavement in Žilina [11].

Archaeological research conducted on MS located in Žilina, during the latter half of the 20th century (in 1966, 1993, and 1995) unveiled a significant discovery: two layers of historical cobblestone paving. These cobblestones, comprised of river stones likely imported from nearby Váh or Kysuca, revealed insights into the square's past. The older layer of historical pavement, found approximately 1 meter below the surface, offers a glimpse into Žilina's history dating back to the late 17th or early 18th century, as evidenced by several coin finds. The total cost for the reconstruction of MS amounted to 64.5 million Sk. Converting this amount to the prices valid in 2024 using the INEKO Inflation Calculator [24] (Institute for Economic and Social Reforms), it equals EUR 6.9 million. Based on the evaluated mechanical characteristics of the MS road surface, it can be concluded that even in 2024, the implemented road meets the criterion for protection against the adverse effects of frost, even when considering climate changes [25, 26]. Additionally, it exhibits low levels of particulate matter [27] and noise pollution [28], adhering to the principles of pavement contextual design [29].

Acknowledgement

This article was created thanks to the support of the KEGA project no. 027ŽU-4/2022 Support for bilingual education in the field of sustainable construction and management of transport structures.

References

[1] CESNEK T. - DECKY M. - PIRY M. - HODASOVA K. - VALLETTA A.: 3D Model of Hricov Castle Enhanced by Real Textures. Civil and Environmental Engineering, 18, 2022, doi: https://doi.org/10.2478/cee-2022-0045.
[2] DECKÝ, M. - PÍRY, M.: Law in construction (in Slovak). EDIS – publishing University of Zilina, Zilina, pp. 136, 2022.
[3] PÍRY M. - ŠKORVAGOVÁ E. - DECKÝ M.: Green Infrastructure: Legislative and Behavioral Approaches in the Context of Urban Engineering. Civil and Environmental Engineering, 19, 2023, doi: https://doi.org/10.2478/cee-2023-0068.
[4] https://www.goodnewsnetwork.org/7000-year-old-road-uncovered-in-croatia-paved-in-stone-a-sensational-find, 25.3.2024.
[5] KORECKÝ, M.: Discoveries under the pyramids. The birth of architecture in ancient Egypt III.-V. dynasty. ODEON, Praha, pp. 372, 1983.
[6] Oldest Roads in the World. https://www.oldest.org/structures/oldest-roads-in-the-world, 2.4.2023.
[7] TICHÝ, M.: Historic stone masonry in the context of urban engineering (in Slovak). Bachelor thesis. Faculty of Civil Engineering, University of Zilina, 2023.
[8] Odyssey. Advantures in archeology. https://www.odysseyadventures.ca/articles/knossos/article Knossos05.southernApproach.html, 2.4.2024.
[9] Oldest Bridges in the World. https://www.oldest.org/structures/bridges, 2.4.2024.
[10] MARINO, D.: The true story of the Ponte di Tiberio in Rimini. 2022, https://www.travelemiliaromagna.it/en/ponte-di-tiberio-rimini, 2.4.2024.
[11] Private archive Martin Decký.
[12] MORAVČÍK, J.: Why didn't Zilina become a free royal city? (in Slovak). In My, Žilinské noviny, 21. november 2008, p. 34.
[13] MORAVČÍK, J. - ŠTANSKÝ P. - ŠLOPEK, V.: History of Zilina - Zilina Square (in Slovak). EDIS – publishing University of Zilina, Zilina, pp. 101, 2002.
[14] MORAVČÍK, J.: Zilina – the center of northern Slovakia: from prehistoric times to the Middle Ages (in Slovak). The city of Zilina, 2011, s. 40.

[15] MORAVČÍK, J.: The role of archeology in illuminating the earliest beginnings of Zilina (in Slovak). pp. 13 – 23. In MRVA, M. - ŠTANSKÝ P. (eds), 2008. The city of Zilina in the years 1208 – 2008, Proceedings of the professional conference on the cultural history of Zilina, Zilina, 4. 12. 2008.
[16] MAJTAN, V.: The appearance of the public space of MPR Zilina, internal material of the Zilina Regional Monument Office (in Slovak). s. 31, archive of KPÚ Zilina, T 1134, 2023.
[17] DECKÝ M. - DRUSA M. - PAPÁN D. - ŠRÁMEK J.: The Relationship between Dynamic and Static Deformation Modulus of Unbound Pavement Materials Used for Their Quality Control Methodology. Materials (Basel), 15, 2022, doi: https://doi.org/10.3390/ma15082922.
[18] IŽVOLT L. - DOBEŠ P. - MEČÁR M. - PULTZNEROVÁ A.: Verification of the Design Parameters Based on the Control Diagnostic of the Deformation Resistance of the Sub-Ballast Upper Surface. Civil and Environmental Engineering, 19, 2023, doi: https://doi.org/10.2478/cee-2023-0044.
[19] Private archive Mgr. Peter Štánsky.
[20] STN 73 6190 Static plate load test of building constructions, 2019.
[21] STN 73 6133 – Road Building. Roads embankments and subgrades. Standard, Slovak Office of Standards, Metrology and Testing, Slovakia, 2017 (in Slovak).
[22] JAKUBÍKOVÁ, M.: The history and present of roadway constructions in Marians square in Zilina (in Slovak). Diploma thesis. Faculty of Civil Engineering, University of Zilina, s. 84, 2023.
[23] STN 73 6100 Terminology of roads, 1999.
[24] Inflation calculator INEKO (in Slovak). https://www.ineko.sk/kalk.html, 2.4.2024.
[25] REMIŠOVÁ E. - DECKÝ M. - PODOLKA L. - KOVÁČ M. - VONDRÁČKOVÁ T. - BARTUŠKA L.: Frost Index from Aspect of Design of Pavement Construction in Slovakia. Procedia Earth and Planetary Science, 15, 2015, doi: https://doi.org/10.1016/j.proeps.2015.08.002.
[26] DECKY M. - PAPANOVA Z. - JUHAS M. - KUDELCIKOVA M.: Evaluation of the Effect of Average Annual Temperatures in Slovakia between 1971 and 2020 on Stresses in Rigid Pavements. Land, 11, 2022, doi: https://doi.org/10.3390/land11060764.
[27] JANDACKA D. - DURCANSKA D. - CIBULA R.: Concentration and inorganic elemental analysis of particulate matter in a road tunnel environment (Zilina, Slovakia): Contribution of non-exhaust sources. Front. Environ. Sci., 10, 2022, doi: https://doi.org/10.3389/fenvs.2022.952577.
[28] JANDACKA D. - DECKY M. - HODASOVA K. - PISCA P. - BRILIAK D.: Influence of the Urban Intersection Reconstruction on the Reduction of Road Traffic Noise Pollution. Appl. Sci., 12, 2022, doi: https://doi.org/10.3390/app12178878.
[29] TROJANOVÁ M. - HODÁSOVÁ K. - KLEŠTINCOVÁ M.: Contextual Design of Road Traffic Noise Reducing Devices. Civil and Environmental Engineering, 18, 2022, doi: https://doi.org/10.2478/cee-2022-0049.