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HISTORICAL AND STRUCTURAL SURVEY OF 19TH AND EARLY 20TH CENTURY BUILT HERITAGE IN NORTHERN VOJVODINA

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Abstract. *Studies of the historical development of construction and applied building materials have so far mainly focused on the most important architectural and engineering achievements that had a major impact on further developments. This paper focuses on the development of structures and building materials in a region that has not been the subject of previous researches, as the buildings studied belong to the narrow geographical area of northern Vojvodina during the period when it was part of Austro-Hungarian Empire. The research includes a detailed analysis of the preserved archival material, review of the literature, as well as analysis and research on individual buildings during restoration works. The results shown in the paper reveal the appearance of exceptional design solutions for individual structures and architectural achievements in the seemingly uninteresting and stalled provincial environment.*

Key words: *building materials, building structures, historical development, reinforced concrete, architecture*

1. INTRODUCTION

The 19th and early 20th centuries saw increased building construction as well as a widening range of applied building materials throughout Vojvodina.[1] The rammed-earth walls and timber roofs of the simple rural houses were gradually augmented by more modern structures and materials, such as cast iron and concrete, in the construction of

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[1] During the 19th century the territory of today's Province of Vojvodina belonged to the Habsburg Empire, and from 1867 to the Austro-Hungarian Dual Monarchy. After the First World War it became a part of newly formed Kingdom of Yugoslavia and after the Second World War of the Republic of Serbia.

public, religious, and multi-storied residential buildings [1]. The example of Subotica in the region of northern Vojvodina is significant because a large number of original building designs have been preserved in the city's Historical Archive and most of these buildings still exist. Therefore, the research could be conducted more thoroughly than in other regions.

The research on the development of construction and the application of building materials was carried out by examining all the blueprints that were found dating from before 1875, as well as all the blueprints kept in the Fund 2 of the Historical Archive of Subotica, covering the period between 1875 and 1918. Fund 275, which contains the blueprints for public, industrial and religious buildings was also examined. This paper examines the structure and materials of the most characteristic buildings. The research on certain buildings was carried out during their restoration or adaptation. Some buildings call for further *in situ* examination for this research to be complete, but such an examination has so far proved impossible due to property access restrictions and insufficient financial support. The collection of data was carried out using empirical methods, desk and *in situ* research. In processing the data collected from various types of research (field research of material sources, legislation and planning documentation) methods of artefact analysis and comparative and contextual analysis were used. To obtain the results, methods of synthesis and result interpretation were used.

The historical overview of the development of construction and materials in the region around Subotica covered in this study is divided into three periods. The earliest period was marked by the use of traditional materials, including rammed-earth walls, mud brick and masonry structures, timber roofing and flooring, and thatched, caned, or shingled roofs. The second period saw the beginnings of the application of iron structures combined with masonry structures, whereas the last period introduced the use of concrete and composite materials, although most buildings, especially residential ones, continued to use masonry.

2. Traditional Material in Building Construction

At the beginning of the 19th century, Subotica had the status of a free royal town within the Habsburg Empire and was at a time called Maria-Theresiopolis. The town developed slowly throughout the 18th century after the territory had been deserted and ransacked by the retreat of the Ottoman Empire and the area returned to the Habsburg Empire [2]. The population that moved into the area during the 18th century usually built modest three-room rural houses of rammed earth walls, timber roofing, and thatched or caned roofs.[2] In the 18th century, brick was only used for religious and public buildings, such as churches and town halls. At the beginning of the 19th century, brick started to be used in the construction of two-story town houses of the wealthier townspeople. The first multi-storied residential building with traditional brick walls was constructed around 1815 on the Main Square (Republic Square 10), for the owner Jovan Milinović [4]. This occurred in the period that saw attempts to establish the "inner town" of Subotica, the

[2] The most widespread type of rural house was one with three premises: two rooms and the central area of a kitchen with an open fireplace. The fireplace, in addition to cooking, served as the source of heating for domed mud stoves positioned in the rooms. [3]

borders of which were finally defined in 1820 at the request of and by the instructions of the royal commissioner Ferenc Scultety [5].

Unlike other free royal towns within the Habsburg Empire, at the beginning of the 19th century, the Magistracy[3] of Maria-Theresiopolis did not have a building regulations book [6]. New houses were built without prior official notification or request for a permit from the Magistracy, so in early 1820 Commissioner Scultety asked for a decree to be issued by the Magistracy forbidding unlicensed building and rebuilding of houses until the city's urban plan was completed [7].[4]

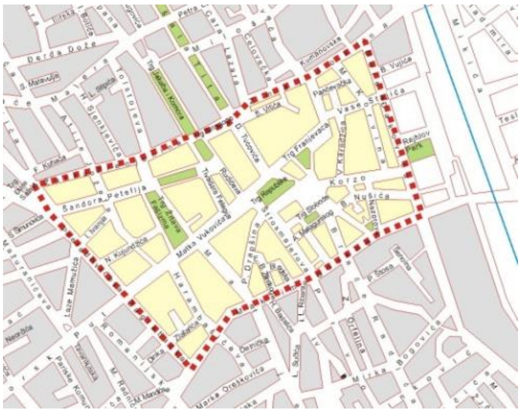

Fig. 1 Borders of the "inner town" of Mária-Theresiopolis
(author's drawing on the contemporary chart of Subotica)

In July 1820, the Commissioner issued instructions containing a number of clauses, all of which insisted on the separation of the "inner town" of Maria-Theresiopolis from the outskirts, prescribing that the houses in the "inner town" be built on a street alignment, with their longer side turned towards the street, constructed from solid material (brick) with tile or shingle roofing, unlike the houses on the outskirts, which might be constructed from rammed earth or adobe, with thatched or caned roofs, their triangular gables turned towards the street [7]. At the initiative of Commissioner Scultety, a Commission for town arrangement, appointed by the Magistracy, developed the Plan for Urban Development, which defined the zone of the "inner town" by means of six border streets. (see Fig. 1) [5]. The building regulations defined by the Plan for Urban Development also provided incentives for the application of brick and the construction of multi-storied houses in the "inner town".

After the Milinović house, similar houses were increasingly being erected on the Main Square and surrounding streets, in accordance with the established building regulations. These houses were constructed with masonry walls, their flooring made of timber, with parallel half-cylindrical or square timber beams. The blueprints dating in 1907 for the facade redesign of the previously mentioned Milinović house, shows a ceiling cross-section constructed with timber beams.[5]

[3] The town was ruled by the town council, which replaced the external Magistrate of the eighteenth century, the town Magistracy, judge, mayor, town captain, town attorney and town lawyer. [6]

[4] Historical Archive of Subotica (hereinafter HAS), F:13, 9.A.46./1820. Scult.

[5] HAS, F:2, ép. eng. VII kör 19/1907.

In 1827, a two-storied Inn was built at today's No. 8 Štrosmajer's Street, by Andreas Winkler. In 1841 Magistracy intended to purchase the Inn. An agreement was made on the price and submitted to higher administration levels for approval [8]. Engineer Sándor Tóth was engaged to design the extension of Inn, the design shows what the original Inn looked like [9] (see Fig. 2).[6]

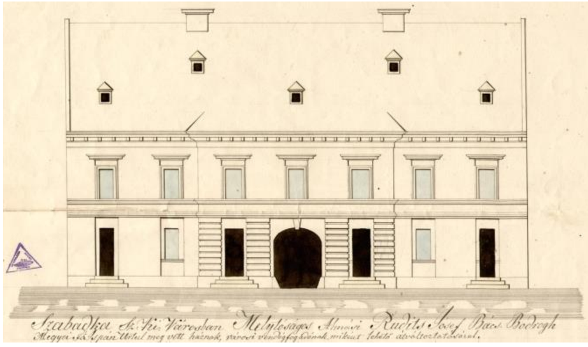

Fig. 2 Adaptation design for Inn, made by engineer Sándor Tóth (HAS, F:272, 13.A.20./aec.1843.)

The Inn was a two-storied building in the late-Baroque style with a large arched gate and gateway in the middle of the ground floor. The second adaptation design for Inn was made by János Scultety, commissioned by the town. Cross-section drawings show that the existing ceiling joists were made of parallel timber beams. The narrower rooms and the hallways had brick vaulted ceilings.[7]

The town owned only one Inn - "Nagy Vendégfogadó". This building was, in fact, a modest single-story house with rammed earth walls, built in the late 1770s [9]. As there was a need for a new town Inn, it was debated, for several years, whether new facilities should be built on the town-owned lot where "Nagy Vendégfogadó" was located or on the site of Inn originally owned by Andreas Winkler. It was finally decided that a new Inn, together with a theatre, should be built on the lot of the existed "Nagy Vendégfogadó".

Engineer János Scultety was commissioned in 1844 by the Magistracy to design the new Inn and the theatre. Scultety made the design for the Inn and theatre in 1845, and the foundation stone was laid in 1848 (see Fig. 3).[8] The revolutionary events of that year in Hungary [10] delayed the building's construction and work was not resumed until 1853, when the hotel wing of the building was completed, while the part containing the theatre hall was finished the following year.

The building of the hotel and theatre "Pest Városhoz" (as it was called then – today it bears the name of "Narodno pozorište – Népszínház" (National Theater)) had a V-shaped floor plan, with one wing featuring hotel facilities as the building's primary purpose at the time, and the other containing the theatre hall. The exterior facade was designed in a strict

[6] HAS, F:272, 13.A.20./aec.1843.
[7] HAS, F:272, 13.A.20./aec.1843.
[8] HAS, F.275, box 1.

and modest classicist style, whereas the front oriented towards the square was adorned with six monumental Corinthian columns with a tympanum above. The columns were made of brick and decorated with plaster flutes. Behind the columns, the main entrance and grand staircase led to the first-floor ballroom. In addition, the building also contained a restaurant and a confectionery. It was the first monumental public building, offering facilities yet unseen in the town, all located within a single building.

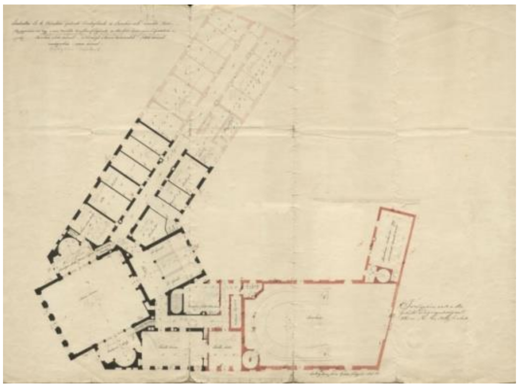

Fig. 3 Design for the ground floor of the Inn and theatre "Pest Városhoz", made by engineer János Scultety in 1845 (HAS, F.275, box 1.)

The theatre hall was built with horseshoe-shaped interior walls made of brick instead of timber, as was the custom for theatre halls at the time. Loggias and galleries constructed from timber abutted against the brick wall. The central part of the building and the hotel wing were masonry structures. The ground floor fascia had a vaulted structure (see Fig. 4), while the loft structure on the first floor was flat and made of timber. The roof structure was also made of timber. The central part of the building, oriented towards today's Republic Square, was roofed with tin, and the lateral parts with flat clay tiles [9].

Fig. 4 Photograph of the vaults on the ground floor of hotel facilities in the "Pest Városhoz" building (photograph author: Photonino, www.subotica.info)

An example of the ceiling structure made of timber half-cylinders split from round logs, characteristic of this period of construction in Subotica, was discovered in 2011 during the adaptation of the ground-floor premises of the house located at No. 5 Trg Žrtava Fašizma (see Fig. 5).

The space between the half-cylinders was filled with construction rubble, brick debris and mortar. This two-story building was constructed in 1880 as the hotel "Hungaria", for the owner Bela Jakopčić, designed by the Szeged architect Mihály Tóth.[9] The ground-floor gateway is vaulted, and so are the hallways and basements. Two years later, as an extension to the hotel, a ballroom was built in the courtyard, designed by Géza Koczka, a Subotica architect.[10] The ballroom building was constructed with brick walls, and its long span was bridged with a coffered timber ceiling supported by massive beams (see Fig. 6).

Fig. 5 Photograph of the ceiling made of timber half-cylinders on the ground floor of the former hotel "Hungaria" (photograph author: Viktorija Aladžić)

Fig. 6 The cross-sectional design of the hotel "Hungaria" ballroom, built in 1882 (HAS, F:2, ép. eng. IV kör 10/1882.)

Few original blueprints completely survived with floor plans, elevations and cross-sections, from the earliest period of construction of multi-storied houses in Subotica, a period that lasted from 1815 to the 1880s. Three of the most complete designs of the kind are: the 1859 design for the two-story house of Adolf Geiger (Štrosmajer's Street No. 6);[11] the 1873 design for the two-story house of Marko Batić (Dimitrija Tucovića Street No. 5);[12] and the 1880 design for the two-story house of Béla Váli (Matka Vukovića Street No. 5).[13] All three buildings are characterized by solid brick walls, floors made of timber beams, and semi-circular barrel vaults in the basements and kitchens with open fireplaces. Ceramic ovens in the rooms were grouped around common stacks fuelled from hallways, utility rooms, or the kitchens' open fireplaces. Although the construction and materials were identical for all three buildings, they differed in the stylistic features of

[9] HAS, F:2. ép. eng. jelz. nelk. 6/1880.
[10] HAS, F:2, ép. eng. IV kör 10/1882.
[11] HAS, F:2, 899/polg. 1859.
[12] HAS, F:2, 1770/polg. 1873.
[13] HAS, F:2, 128/polg. 1880.

their facades. Adolf Geiger's house was built in Baroque style, with arched openings on the ground floor. Marko Batić's house was built in the Romantic style, whereas Béla Váli's house was Neoclassical. Consequently, we can conclude that architectural styles did not influence the application of building materials in this case.

Preserved examples of industrial and agricultural buildings from the first half of the 19th century are rare in Subotica; however, the latest research has shown that the courtyard building located at today's No. 13-13a Jakaba i Komora Street actually was once a three-story barn, built in 1869 and owned by Salamon Halbrohr.[14] The barn was constructed with solid perimeter brick walls and four wooden columns longitudinally aligned along the middle of the barn, supporting a floor of load-bearing timber beams. The single-pitch roof was constructed from timber beams and covered with shingles. The interior wood structure is now damaged by the fire, but the exterior walls have been preserved, as well as the vent shafts on the facade and the metal screens that cover them (see Fig. 7).

Fig. 7 Photograph of the interior of Salamon Halbrohr's barn, built in 1869.
(photograph author: Viktorija Aladžić)

3. Use of Iron Elements in Building Structures

The development of Subotica was rather slow until the arrival of the railway in 1869. Since the town is not situated on a river that would facilitate the transport of goods, it was the railway that enabled the development of the trade, export of the multitude of agricultural products which Subotica had at its disposal due to the vast areas of fertile farmlands, as well as the development of the industry. The sudden progress of the town's economy began in the 1880s, coinciding with the beginning of the application of the new iron construction. The progress was reflected in the population growth, but also in the sudden rise in the number of multi-storied apartment buildings and residences being built: during the 1880s, Subotica witnessed the construction of 26 two-storied residential buildings, as many as in the preceding 65 years altogether.

Iron construction elements in floor structures, as well as cast iron support columns, were being introduced gradually with the simultaneous ample use of the aforementioned

[14] HAS, F:2, 1019/polg. 1869.

traditional methods of constructing floors of timber. Out of approximately thirty multi-storied houses built throughout the 1880s and at the beginning of the 1890s, only four made use of iron I-beams in floor structures.

The turning point in utilizing new materials and construction methods was the return of the architect Titus Mačković from his studies to Subotica [11]. His initial designs included what was a local novelty: a floor structure supported by iron I-beams with shallow brick arches between them (referred to as the "Prussian vault") [12]. This design was first used in a two-story apartment building owned by Luka Aradski, located at No. 4, Štrosmajer's Street.[15] Mačković's next design comprising an iron beam floor structure and shallow brick arches was a two-story apartment building owned by Petar Radišić, designed in 1882 and located at No. 9 Matka Vukovića Street;[16] followed by the two-story apartment building of Ferenc Sümegi, designed in 1885 and located at No. 25 Maksima Gorkog Street.[17]

In the house owned by Petar Radišić, iron I-beams were utilized only in the ground floor ceiling, while the ceiling below the attic remained of timber, and the basement ceiling had brick vaults. In the house owned by Ferenc Sümegi, the "Prussian vault" was also used in the basement ceiling. Simultaneously, Mačković was also designing houses with timber ceilings, just like all other architects in Subotica. Timber floors were predominantly used for another decade and a half, probably because of the high price and limited availability of iron beams throughout the 1880s.

According to our research, the first structure which utilized vertical iron elements, i.e., cast iron columns, was the railway station passenger platform roof erected during the expansion of the station building. Towards the end of the 19th century, the existing railway station building was becoming too small for the increased traffic. A significant expansion of the building was ordered, including the extension of the roof over the passenger platform, made of an iron lattice structure supported by 18 cast iron decorative columns. The design of the extension of the Railway Station was developed in 1891 in Szeged by the engineer signed as Kurt.[18]

The wide use of iron I beam supports in ceiling structures started in Subotica in the second half of the 1890s and, as evidenced by the preserved blueprints, all multi-storied buildings constructed in that period had their ceilings made of the "Prussian vaults". However, the ever faster economic development of the town towards the end of the 19th century brought in its wake new materials and construction methods for erecting multi-storied houses and public buildings, namely, the use of concrete.

4. Use of Concrete and Other Composite Materials

Developments in the use of new materials and building methods, propelled by the industrial revolution all over Europe, thoroughly transformed the general appearance of the world and influenced the less advanced European regions, such as northern Vojvodina, that found themselves on the fringes of industrial progress.

The oldest record of the fact that Portland cement was available in Subotica originates from 1864, when the Portland cement factory in Perlmoos (Austria), owned by a certain

[15] HAS, F:2, ép. eng. I kör 5/1880., ép. eng. I kör 6/1881.
[16] HAS, F:2, ép. eng. I kör 8/1882.
[17] HAS, F:2, I – 232/1885.
[18] HAS, F:2, ép. eng. VIII kör 17/1891.

Angelo Saulich (Portland-cement Landesfabrik von Angelo Saullich im Perlmoos)[19] sent a notice to the Town's Construction Department to advertise the production of this building material. At the time, however, a factory of Roman cement had already been opened in Beočin (Belcsény), near Novi Sad, in 1855, owned by József Csík [13]. The production of Portland-cement commenced in Beočin around 1870 [14] after Csík returned from the World Exposition in Paris in 1867. The cement used to produce concrete in Subotica most probably originated from the Beočin cement factory which was much nearer to Subotica than the factory in Perlmoos.

The earliest known application of concrete in Subotica occurred in 1898, when this material was used in building the pool of the first steam bath owned by Dezső Joó and Emánuell Fürst, in what today is No. 12 Dimitrija Tucovića Street [4]. The first building of the steam bath, with two smaller cold-water pools, two dressing rooms and a line of rooms with individual baths, was built in 1879, by expanding an older building of unknown purpose.[20] This bath house building was rather unimposing and built of traditional materials. In 1893 and 1894, two small-scale upgrades were made to the building by the design of Nándor Wagner.[21] In 1898, Dezső Joó engaged a young architect named Lajos Fazekas to design another, bigger pool, to be built on the plot of land behind the existing bath house.[22] Realization of this design involved the use of contemporary materials and construction methods. Lajos Fazekas, just like Titus Mačković, was a forerunner in utilizing state-of-the-art building techniques and materials in Subotica. The pool was made of some type of concrete, this being the oldest documented use of concrete in Subotica. The ceiling was constructed with "Prussian vaults" supported, via iron I-beams, by the two rows of iron columns stretching longitudinally on both sides of the pool (see Fig. 8). Exterior walls were of brick, while the single-pitch roof was of timber. (see Fig. 9).

Fig. 8 Photograph of the bath house owned by Dezső Joó, shot in 2013. (photograph author: Viktorija Aladžić)

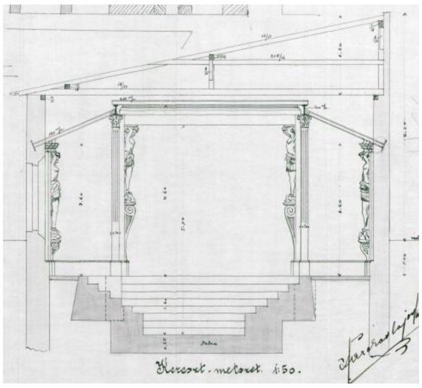

Fig. 9 Design of the cross-section of the pool in Dezső Joó's bath house dating from 1898 (HAS, F:2, ép. eng. VII kör 20/1898.)

[19] HAS, F:2, 1743/polg. 1864.
[20] HAS, F:2, 4823/polg. 1879.
[21] HAS, F:2, ép. eng. VII kör 24/1893, ép. eng. VII kör 17/1894.
[22] HAS, F:2, ép. eng. VII kör 20/1898.

The next year, Titus Mačković designed a three-story apartment building for the architect Lajos Fazekas, currently at No. 13 Age Mamužića Street [8]. This was not only one of the earliest buildings in a town built in the style of Secession, but it was also planned to utilize reinforced concrete for the floor structure, instead of the commonly used “Prussian vaults”. It is yet to be examined whether concrete was actually used. This was the first design of a residential building which envisaged the use of reinforced concrete.[23]

4.1. Synagogue structure

The most famous building in Subotica that was built with the use of concrete is the Synagogue. Its structure was a pioneering work of two Budapest architects: Marcell Komor and Jakab Dezső [15]. The Synagogue was built in 1902 in the style of the Hungarian Secession, with rich floral ornaments inspired by Hungarian folk art. However, its greatest value is the unique structure made of iron columns and beams, supporting the vaults and the dome made of concrete and wire mesh. [16]

The central eight-sided space in the Synagogue is created by eight iron columns arranged along the edges of a square with truncated corners, the longer sides being 10.6 m long and the shorter ones 3m long. These columns are the base for the building’s exquisite structure. At their tops, the columns are connected with horizontal iron beams 80 cm high, which in turn support a regular octagon-shaped brick wall called a tambour. The octagonal base for the brick tambour was created by staggering the iron beams at the angles of the truncated square inwards. Above the tambour stretches a concrete dome 8-10 centimetres thick, reinforced with wire mesh [17]. Its rigidity and bearing capacity are provided by 50-centimetre-high ribs arranged in the shape of a star. There are eight of these ribs near the apex of the dome, while they multiply to a total of 32 separate ribs near the base [18] (see Fig. 10). The interior height of the dome is between 15 and 23 meters. Above the interior concrete dome rises the timber structure of the outer roof dome, which shields the interior dome from the weather while simultaneously emphasizing the dome’s position viewed from the outside.

Fig. 10 Dome of the Synagogue
(photograph author: Viktorija Aladžić)

[23] HAS, F:2, ép. eng. I kör 6/1899.

The main nave of the Synagogue, as well as the transept, are vaulted by concrete and wire mesh vaults, also stiffened by ribs below the timber roof structure. As the central dome is supported by the iron columns, the exterior walls are unburdened, turning into curtain walls, while the interior dome itself mimics the structure of a tent. Four smaller towers above the corner areas of the Synagogue, which house the stairways to the galleries, serve to achieve the balance of the masses, as well as to emphasize the verticals of the four stairways. The central top outer roof dome of the Synagogue, as well as the four smaller towers, were covered by zinc sheet, while the quarter-domes above side entrances at the corners of the Synagogue were roofed by lead sheeting. However, during the building's restoration, the roofing on all domes and quarter-domes was replaced with copper sheets [19].

The main binding component of the concrete used in casting the vaults and the dome of Subotica Synagogue was gypsum [17]. No cement was used in making this concrete mixture. Since gypsum is water-soluble and has a corrosive effect on iron, i.e., the wire mesh, it appears that the concrete used in building the Subotica synagogue was not an entirely reliable material, even though it has persevered for more than 110 years now. The structure made of it certainly represents a pioneering engineering achievement in concrete structures. It remains unclear why cement was not used in producing this concrete. At the time of the Synagogue's construction cement had been produced for a long time in the Beočin factory. In any case, the beginning of the 20th century was a period of exploring the possibilities of new materials and types of structures, especially concrete. Since no material testing or static calculations were undertaken at the time, the design of concrete structures and concrete mixes was performed experimentally and empirically.

Compared with other early reinforced concrete structures, which are considered as the world's first reinforced domes in history, namely domes of Armeemuseum (1902–1904) and Anatomie (1905–1907) in Munich, the dome of the synagogue in Subotica can also be considered as a very important early pioneering work, although the application of material was not the same. Reinforced concrete as elective subject appeared at the Budapest University in 1903/04 in the lectures given by Szilárd Zielinski. Other reinforced concrete domes in Hungary dated from a later period, reaching intensive development between the two World Wars [20].

4.2. Szilárd Zielinszky's intervention on the theatre building in Subotica

The introduction of concrete into building practice was quite slow, conditioned by two main reasons: the unavailability of high-quality aggregates and cement, i.e., their high price, and the lack of confidence in modern structures made of concrete.

The next important building in which concrete and reinforced concrete were used is the National Theatre ("Narodno pozorište – Népszínház"), reconstructed in the period between 1904 and 1907. During the reconstruction, a new reinforced concrete roof structure was built (see Fig. 11) above the auditorium of the main theatre hall. The structure was designed by the well-known engineer Professor Szilárd Zielinszky (1860–1924), who is considered to have been one the best constructors of concrete structures in Europe at the time, especially for the structures of water towers [14]. In 1900, he had the opportunity to meet François Hennebique at the Paris World Exhibition, get acquainted with his methods of construction using reinforced concrete and obtain the rights to use this French patent in Hungary. Dr. Zielinszky manifested his exquisite engineering abilities and knowledge in several dozen large buildings throughout Austria-Hungary, and the structure above the "Great Hall" of Subotica's National Theatre is a typical example of magnificent concrete construction at the time, carried out according to the Joseph Monier and François Hennebique construction system [21].

The reinforced-concrete roof structure above the theatre hall was built during the reconstruction of the building between 1904 and 1907, replacing the old timber structure. The new RC roof structure was three-dimensional and made up of six transverse frames spanning 17.3 m connected with concrete blocks resting on solid brick walls. The roof end RC frames were enclosed with 8-cm-thick RC walls. Each RC frame had horizontal ties, partly hanging from the frames by means of 20x25 cm trussed beams reinforced with 30 mm ø iron reinforcing bars. Trussed beams with 35x40 cm cross section were reinforced with 30 mm ø vertical reinforcing bars and 30x1 mm ties (following Hennebique's armoured concrete system) spaced at 30 to 50 cm. Across the roof frames, at a 35^{o} of inclination, a Monier RC slab was formed, 10 cm thick and reinforced in both directions with 8 mm ø bars spaced at 25 cm. This slab was longitudinally supported by RC beams and transversely by the frames. The longitudinal beams were supported by the frames and had cross-section of 12x15 cm, reinforced with 20 mm ø bars. The lower horizontal Monier RC slab hung from 16x20 cm RC longitudinal beams supported by the ties. The slab was 5 cm thick and reinforced in both directions with 8 mm ø bars spaced at 25cm. The frame closest to the Great Hall stage had a vertical RC wall constructed within the frame, which together with the RC gable wall constituted the firewall [22].

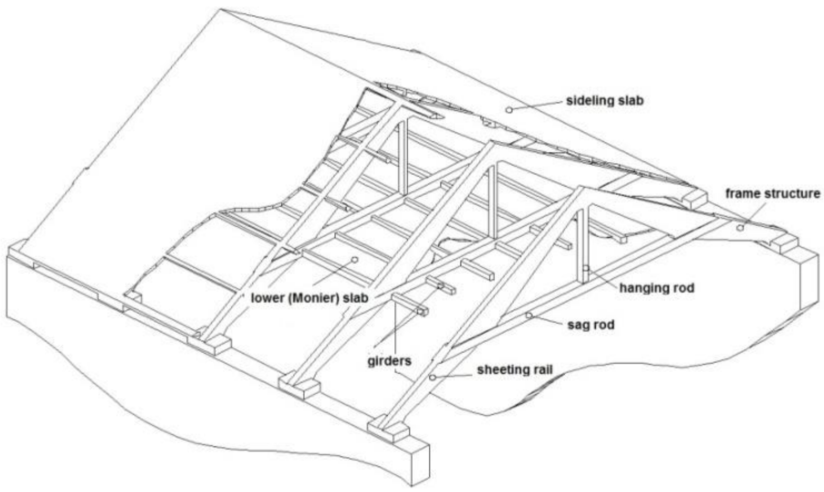

Fig. 11 Spatial reinforced-concrete roof structure on the "Nationa Theatre – Népszínház" building, a masterpiece of Dr. Szilárd Zielinszky (author's drawing)

In 1915, a fire broke out in the auditorium and completely destroyed the stage and the adjoining part of the building, but thanks to the RC structure it did not expand to other parts of the building. As it was the time of World War One and the ensuing post-war period, activities on the reparation of the fire-damaged building only began in 1924, with Prof. Đorđe Mijović from the Faculty of Civil Engineering in Belgrade making a condition evaluation of the theatre structure. In his report from 1924, he concluded that the RC structure, as well as the walls it leaned on, were in satisfactory condition, but that it was necessary to repair the lower slab, for which he also suggested repair solutions [23]. The reconstruction was made in 1926 when the lower RC slab was replaced, while other parts of the structure remained in their original state. This exceptional structure was unfortunately demolished in 2007 when work on the reconstruction, adaptation and extension of the Subotica National Theatre building began.

4.3. Other examples of concrete structures

The next building which had reinforced concrete flooring and ceiling was not constructed until 1907. It was a two-story apartment house owned by Antal Morvay, built by design of engineer Milan Zarić and located at No. 18 Vase Stajića Street.[24] Its walls were made of solid brick. In the same year, Titus Mačković designed the two-story administrative building of the Subotica electrical tramway company, commissioned by the *Compagnie de Services Urbains Bruxelles*, also built with solid brick walls and reinforced concrete flooring and ceiling and is located at today's No. 22 Segedinski put Street.[25]

The beginning of the 20th century was marked by experimentation in house construction methods and materials including the use of different materials as concrete aggregates. Among other things, a new version of concrete came into use, with slag as the aggregate. This material was used in the construction of the foundations and base walls of János Bébecz's house at No. 104 Braće Radića Street, designed in 1908 by Miklós Zakaria, a railroad engineer.[26] This house is today in a bad state. The surfaces of the slag concrete mix exposed to atmospheric conditions are now crumbling, and cracks have appeared in the base walls. Analyses of this concrete mix and structure are certainly called for, in the first place for safety reasons, but also for the purpose of making a comparative analysis of the durability of the concrete, since this house represents one of the early examples of buildings constructed with the application of concrete.

Fig. 12 The Grand Terrace by Palić Lake
(photograph author: Viktorija Aladžić)

[24] HAS, F:2, ép. eng. VIII kör 16/1907.
[25] HAS, F:2, ép. eng. 0 kör 66/1907.
[26] HAS, F:2, ép. eng. II kör 2/1908.

The Grand Terrace, at the lake Palić, was also constructed with a concrete roof structure, designed by Komor and Jakab [15] (see Fig. 12). In the late 19th century Palić was a spa and favourite resort of Subotica's townspeople. Central to the Palić tourist complex was the "Grand Terrace", built between 1909 and 1912 in a version of the Hungarian Secession style, as a multipurpose building containing halls and two large terraces where balls, parties, theatrical performances, sports competitions and exhibitions were held. A special part of this building is a vaulted concrete structure above the first-story great hall. This vault is supported by the lateral solid brick walls and suspended from the iron roof structure positioned right above it. The structure is built with concrete-mortar of an average thickness of 10 cm and has iron reinforcement with 10 mm and 14 mm ø bars, spaced at 20 cm and 30 cm. The vault is additionally reinforced with wire mesh in its middle plane. Since the vault is suspended from the iron roof structure, this iron structure has the role of bearing a greater part of the load from the vault. The suspension system was achieved by means of wire ropes tied directly to the elements of the roof structure or indirectly to transverse iron "I-220" cross-section beams leaning against the rafters. An integral part of this structure is also a pair of iron "2xI400" beams that bridge the span above the middle side entrance to the great hall in the middle longitudinal wall. A vault was built right above this entrance from the same material as the structure above the great hall [24]. At the beginning of 2006, the Government of Serbia and the City of Subotica initiated the reconstruction and restoration of the building that was completed in 2012.

The Town Hall in Subotica is the most monumental building constructed at the given period, between 1908 and 1912. It was built according to the design of Marcell Komor and Dezső Jakab [15]. In the construction of the Town Hall, a plenitude of modern materials and structures were used in combination with traditional ones, but in situ analysis of this building was not possible due to its idiosyncratic features; furthermore, the designs for the Town Hall preserved in the Historical Archive do not provide precise insights into its construction and it was therefore not examined as a subject of this research. Examination of the Town Hall construction and the applied materials will be possible during the next restoration of the building, since it is protected by law as one of the cultural monuments of exceptional importance, and thus not available for partial research outside the official restoration works.

5. Conclusions

Buildings in Subotica that incorporated new developments in construction and materials had both local and international significance. Although South-East Europe at the beginning of the 19th century largely lagged behind the rest of the world with respect to the development of construction materials, the spreading of the railroads allowed for a fast connection to the world, as well as the exchange of new ideas. Thus Subotica, which in the 18th century was an extremely underdeveloped area, by the end of the 19th century had made great strides in the development of building materials, construction and technology.

The purpose of this research has been to point out that provinces should not be overlooked in favour of large cities, especially capitals, since the provinces can also boast important constructors who leave their legacy, sometimes producing more daring building achievements there than those in the capitals and other centres of growth. Although there are not many buildings in Subotica that represent significant achievements in terms of novel materials and structures at the end of the 19th century, these buildings are still relevant and unique pioneering works of architecture and construction. Their significance is recognized primarily in the case of the Subotica Synagogue, which has been listed by the World Monuments Watch organization as one of the world's one hundred most endangered monuments (in 1996, 2000, 2002 and 2006), and in 2014 it was included in the Seven Most Endangered Monuments program by the Pan-European organization Europa Nostra.

Regarding the fact that the construction of the Synagogue was a forerunner of modern concrete structures, and it is currently facing restoration works, the process of designing the dome and vault structure deserves to be exhaustively explored. It is not known yet how Marcell Komor and Jakab Dezső developed the synagogue structure and why they applied gypsum instead of cement as a building material. These questions might never be answered, but more efforts have to be put into the research of a synagogue structure through cooperation between engineers and researchers from Serbia and Hungary.

In addition to research on this topic, we propose further studies of the oldest concrete from the beginning of the 20th century in this region, because in this way their characteristics of durability and strength can be recognized even today.

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ISTRAŽIVANJE ISTORIJE I KONSTRUKCIJE OBJEKATA GRADITELJSKOG NASLEĐA 19. I POČETKA 20. VEKA U SEVERNOJ VOJVODINI

Dosadašnja istraživanja istorijskog razvoja izgradnje i primene građevinskih materijala uglavnom su bila usmerena na najvažnija arhitektonska i inženjerska dostignuća, koja su imala presudni uticaj na daljnji razvoj. Ovaj rad se fokusira na razvoj građevinskih konstrukcija i materijala u regiji koja nije bila predmetom ranijih istraživanja, a istraživani objekti pripadaju užem geografskom području severne Vojvodine u razdoblju kada je ona bila u sastavu Austrougarske. Istraživanje obuhvata detaljnu analizu sačuvanog arhivskog materijala, pregled literature, kao i analize i istraživanja pojedinih objekata tokom restauratorskih radova. Rezultati prikazani u ovom radu otkrivaju pojavu izuzetnih projektantskih rešenja pojedinih struktura i arhitektonskih dostignuća u na izgled nezanimljivom i zaostalom provincijskom okruženju.

Ključne reči: *građevinski materijali, konstrukcija objekata, istorijski razvoj, armirani beton, arhitektura*