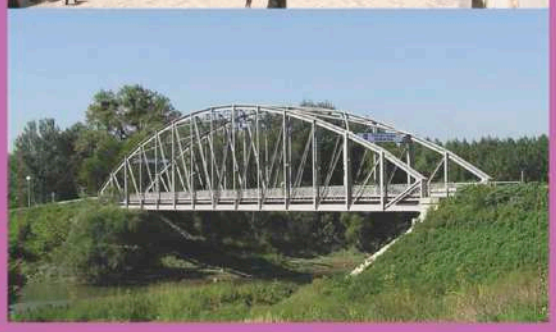
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проф. д-р инж. Дончо ПАРТОВ

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Юлиан ТУЛЕШКОВ

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DESIGNERS OF 50 YEARS OLD SNP BRIDGE IN BRATISLAVA

Baláž Ivan[1]

Faculty of Civil Engineering, Slovak University of Technology in Bratislava, the Slovak Republic;

Abstract: *In 29th August 2022 the SNP Bridge over Danube River in Bratislava, capital of the Slovak Republic, will celebrate 50 years. The paper is a tribute to the people from the Department of Metal and Timber Structures, FCE, STU in Bratislava who designed the SNP Bridge.*

Key words*: cultural heritage, 50 years old bridge, cable-stayed bridge, designers*

1. Introduction

When it was constructed in 1969, the SNP Bridge over Danube River in Bratislava, with main span 303 m, was the world record holder in the category of cable-stayed bridges. The bridge had the fourth-longest cable-stayed bridge main span when it was opened to the traffic in 29thAugust, 1972 (1. Duisburg-Neuenkamp, 350m, 1970; 2. Kniebrücke, Düsseldorf, 320 m, 1969; Erskine, Scotland, 305 m, 1971). The SNP Bridge is the winner of the competition *Structure of the Twentieth Century in Slovakia*, organized in 2001. The original name of the bridge was Slovak National Uprising Bridge (In Slovak: Most Slovenského Národného Povstania = SNP). It was renamed, like other Bratislava Danube bridges, after the collapse of the communist regime in the beginning of the 1990s. The name "New Bridge" was valid only in the period 1993–2012. Before and after this period the name is SNP Bridge.

In the category of single pylon cable-stayed bridges the SNP Bridge was in 2014 on the 16th place in the world [1, 2]. Till today it is in the top 10 bridges in the category of the single pylon cable-stayed bridges with single cable plane. In the category of all cable-stayed bridges is currently the world record holder Ruskij Bridge in Vladivostok opened in 2012 with the main span 1104 m [3, 4, 5].

The Government of Czechoslovak Socialist Republic and Central Board of Trade Unions awarded in 9th February 1968 to the members of the Faculty of Civil Engineering (FCE) Slovak University of Technology (STU) in Bratislava the Honorary Diploma for the elaboration of the project of steel structures and foundation of the new road bridge over Danube River in Bratislava (Fig. 1). The Council of the National Committee of the Bratislava, capital of the Slovak Socialist Republic, awarded to the members of the Department of Metal and Timber Structures, FCE, STU in 26th August 1972 at the occasion of the SNP Bridge opening the Silver Badge for developing of Bratislava (Fig. 4).

[1] Baláž Ivan, emeritus Prof., Ing., PhD., Slovak University of Technology, Radlinského 11, 810 05 Bratislava, Slovak Republic, ivan.balaz@stuba.sk

A lot of people and organizations took part in design, fabrication, erection and testing of the SNP Bridge (Fig.2). Ing. Igor Scholtz (Fig.3), a friend of Prof. Chladný, photographed the bridge during period of its erection. Four albums are full of many of his photographs. With the treat of his own life he helped with erection of the lift in the bridge pylon. Instead of an award he was punished by then director of Investing.
In 29th August 2022 the SNP Bridge will celebrate 50 years from its opening.

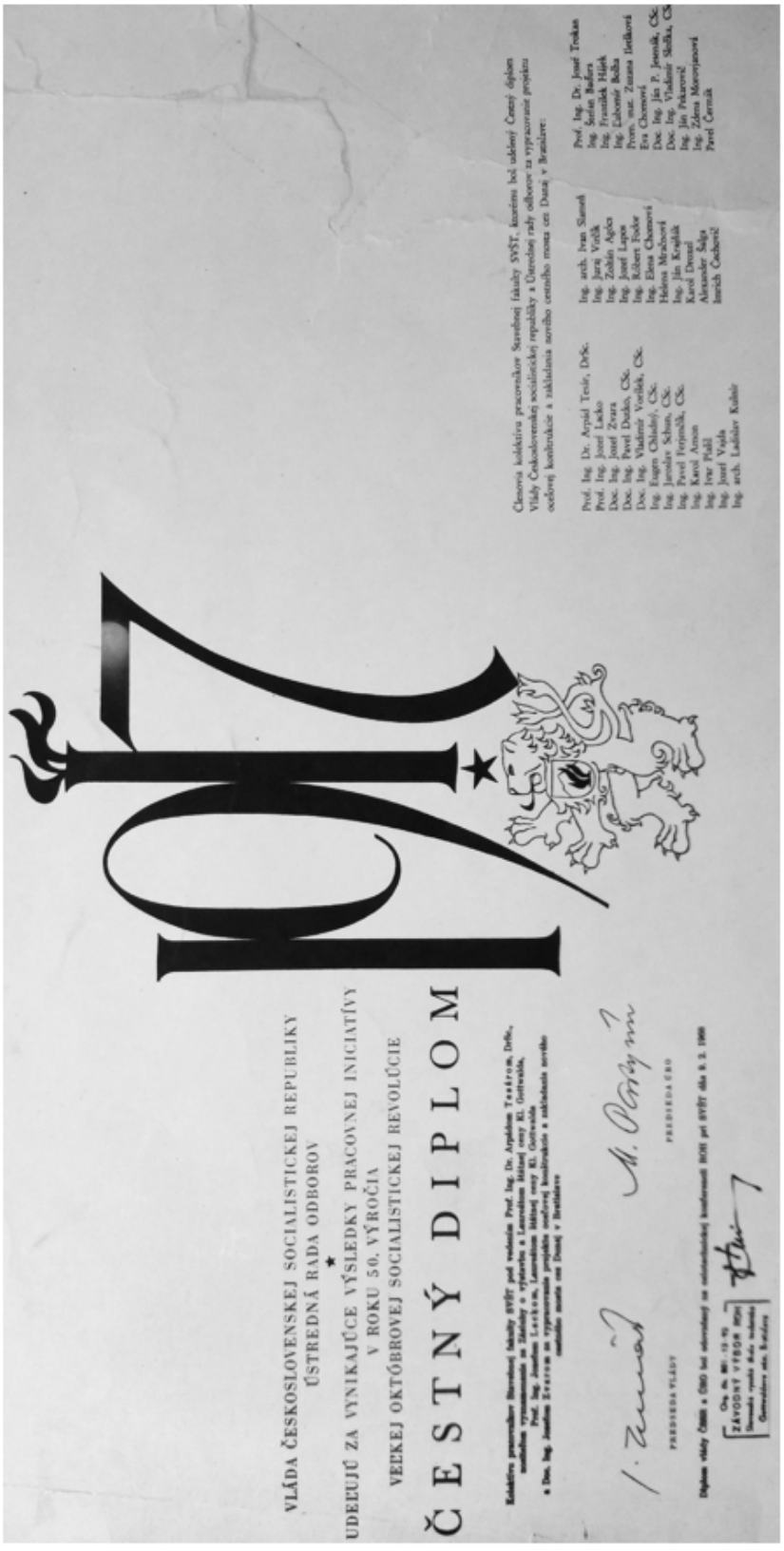


Fig.1. Honorary Diploma awarded by the Government of Czechoslovak Socialist Republic and Central Board of Trade Unions in 9th February 1968 to the members of the Faculty of Civil Engineers Slovak University of Technology in Bratislava for the elaborating of the project of the SNP Bridge over Danube River *in Bratislava (courtesy of archive of Alexander Šalga).*

A lot of people and organizations took part in design, fabrication, erection and testing of the SNP Bridge (Fig.2). Ing. Igor Scholtz (Fig.3), a friend of Prof. Chladný, photographed the bridge during period of its erection. Four albums are full of many of his photographs. With the treat of his own life he helped with erection of the lift in the bridge pylon. Instead of an award he was punished by then director of Investing.

In 29th August 2022 the SNP Bridge will celebrate 50 years from its opening.



Fig. 2. Participating organizations. Table on Rybné square, 6. 4. 1969 (courtesy of Juraj Bončo, J.) [6].

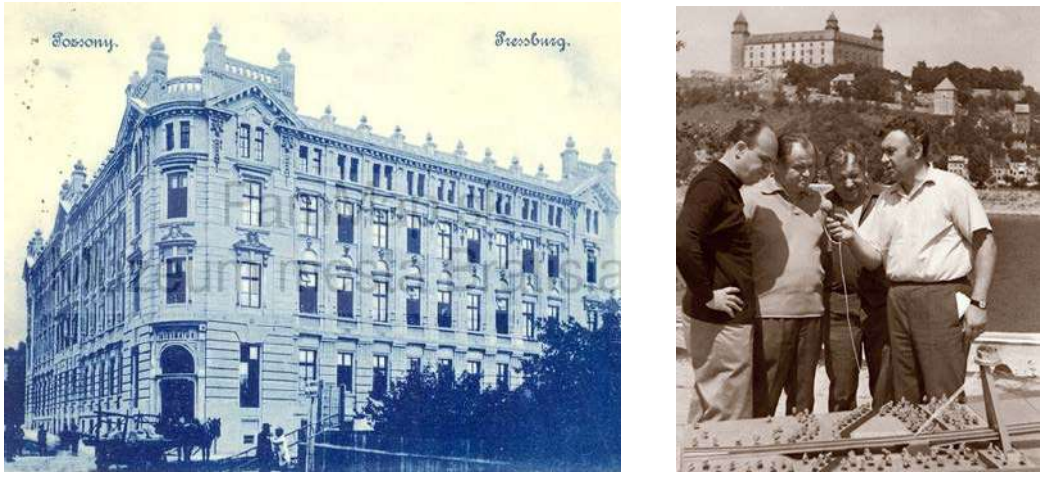
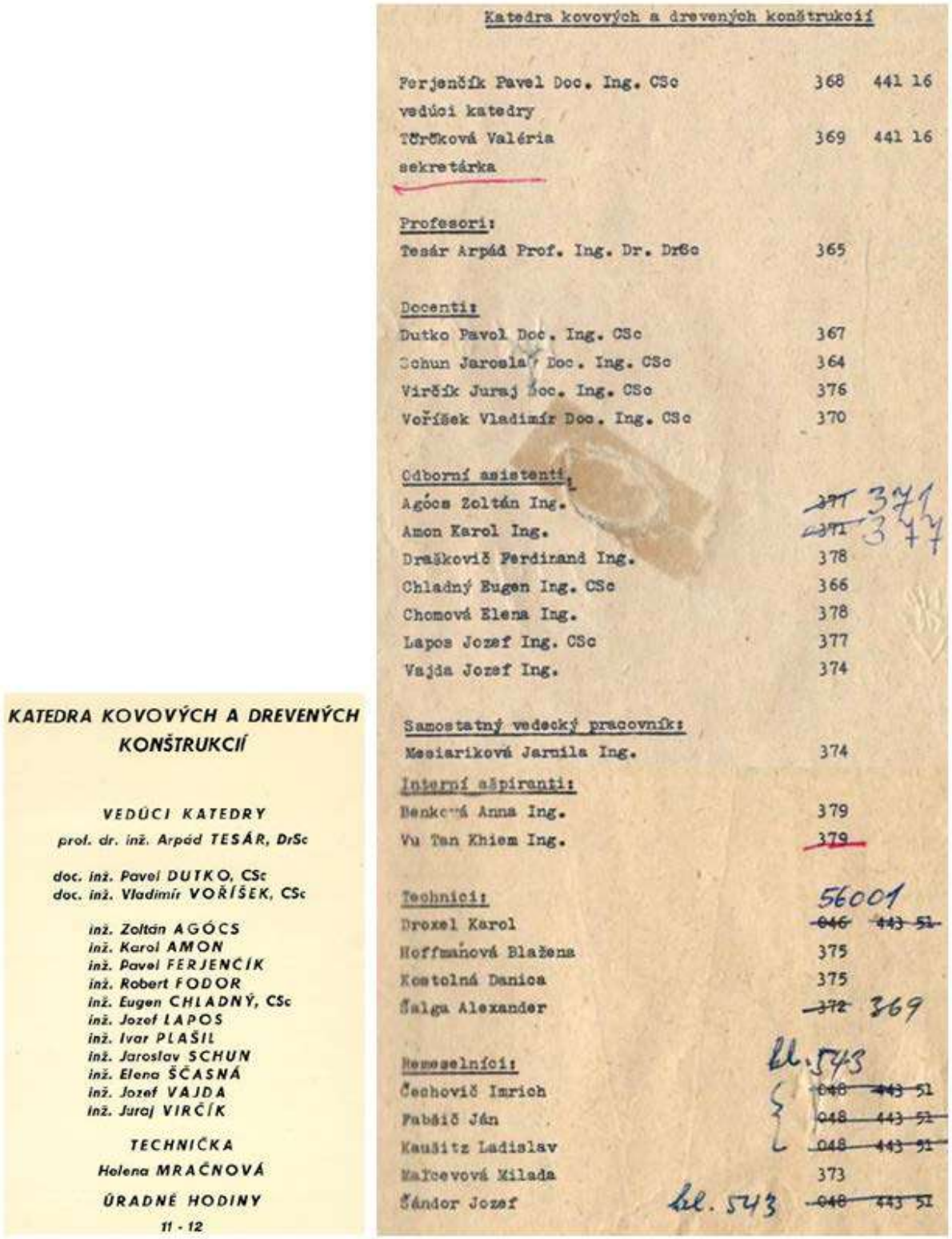


Fig. 3. (a) Former building of the Faculty of Civil Engineering on Tolstoy street No.1 (Evangelic dormitory & German school, photo from 1901, courtesy of the Museum of Bratislava city, PamMap), where department was located from 1945. From 1966 members of the department elaborated a tender project of the SNP Bridge during days, nights and weekends; (b) From left: Ing. Igor Scholtz, Head of investor unit MSK (*16.VIII.1928), Prof. Ing. arch. Jozef Lacko, CSc., (*1917 - † 1978); Dipl. technik Imrich Sládkovič, the chief construction manager, Doprastav; PhDr. J. Koščo (*1929 - † 2010), TV reporter (courtesy of Juraj Bončo, J.) [6].



KATEDRA KOVOVÝCH A DREVENÝCH KONŠTRUKCIÍ

VEDÚCI KATEDRY
prof. dr. inž. Arpád TESÁR, DrSc

doc. inž. Pavol DUTKO, CSc
doc. inž. Vladimír VOŘÍŠEK, CSc

inž. Zoltán AGÓCS
inž. Karol AMON
inž. Pavol FERJENČÍK
inž. Robert FODOR
inž. Eugen CHLADNÝ, CSc
inž. Jozef LAPOS
inž. Ivar PLAŠIL
inž. Jaroslav SCHUN
inž. Elena ŠČASNÁ
inž. Jozef VAJDA
inž. Juraj VIRČÍK

TECHNIČKA
Helena MRAČNOVÁ

ÚRADNÉ HODINY
11 - 12

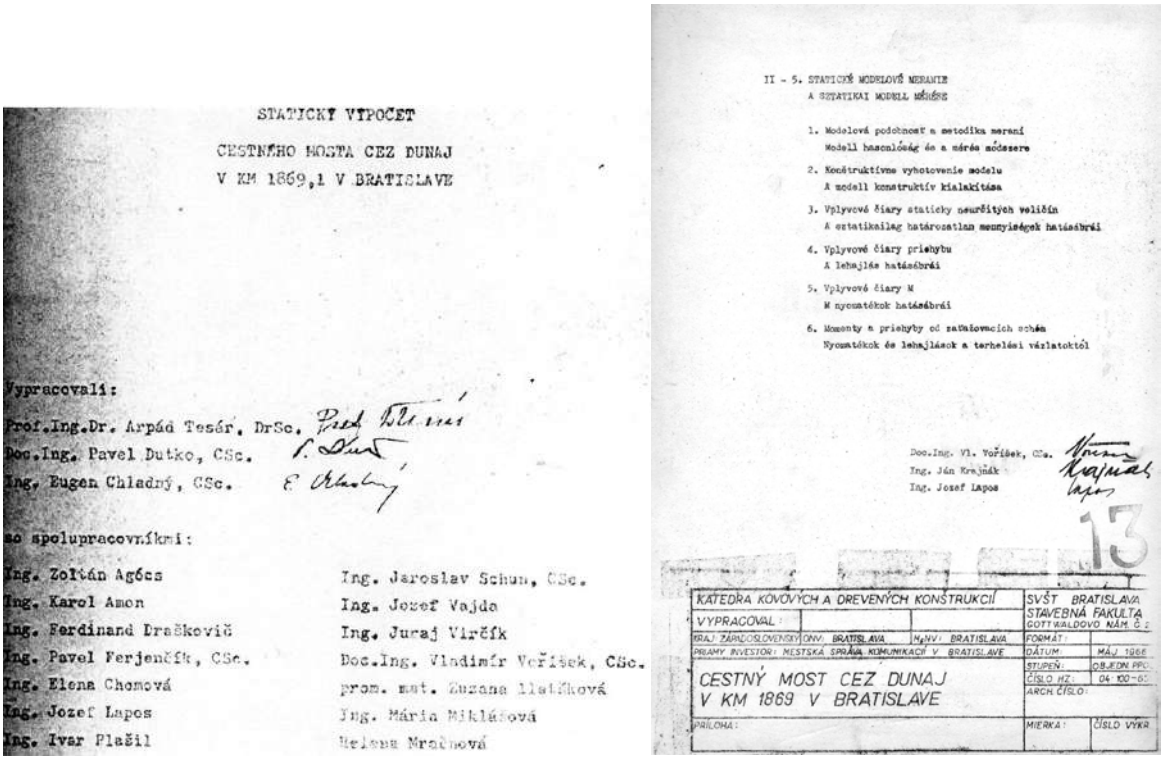
Katedra kovových a drevených konštrukcií

Ferjenčík Pavel Doc. Ing. CSc	368	441 16
vedúci katedry		
Tŭrčková Valéria	369	441 16
sekretárka		
Profesori:		
Tesár Arpád Prof. Ing. Dr. DrSc	365	
Docenti:		
Dutko Pavol Doc. Ing. CSc	367	
Schun Jaroslav Doc. Ing. CSc	364	
Virčík Juraj Doc. Ing. CSc	376	
Voříšek Vladimír Doc. Ing. CSc	370	
Odborní asistenti:		
Agócs Zoltán Ing.	~~371~~ 371	
Amon Karol Ing.	~~371~~ 377	
Draškovič Ferdinand Ing.	378	
Chladný Eugen Ing. CSc	366	
Chomová Elena Ing.	378	
Lapos Jozef Ing. CSc	377	
Vajda Jozef Ing.	374	
Samostatný vedecký pracovník:		
Messiariková Jarmila Ing.	374	
Interní aspiranti:		
Benková Anna Ing.	379	
Vu Tan Khiem Ing.	~~379~~	
Technici:	56001	
Drexel Karol	~~046~~	~~443 51~~
Hoffmanová Blažena	375	
Kostolná Danica	375	
Šalga Alexander	~~372~~ 369	
Remeselníci:	kl. 543	
Čechovič Imrich	~~048~~	~~443 51~~
Fabšič Ján	~~048~~	~~443 51~~
Kaušitz Ladislav	~~048~~	~~443 51~~
Maťcevová Xilada	373	
Šándor Jozef kl. 543	~~048~~	~~443 51~~

Fig.4. (a) The list of the members of the Department of Metal and Timber Structures from 1965 which was placed on the department entranced door in the building of the Faculty of Civil Engineering on Tolstoy street No.1 in Bratislava;
(b) The telephone directory of the members of the Department of Metal and Timber Structures from the year 1977. (Both courtesy of archive of Jozef Lapos).

2. Designers of the SNP Bridge

Tesár`s team who performed the structural analysis of the SNP Bridge is on the Fig. 5a. The measurements of the statical behaviour of the bridge model from 1966 [7] were performed by Assoc. Prof. Ing. V. Voříšek, CSc., Ing. J. Krajňák, Ing. J. Lapos, A. Šalga, K. Droxel, I. Čechovič and were made immortal by the photographer Ladka Zemanová-Maľcevová-Brucknerová (Fig. 5b).



STATICKÝ VÝPOČET

CESTNÉHO MOSTA CEZ DUNAJ

V KM 1869,1 V BRATISLAVE

Vypracovali:

Prof.Ing.Dr. Arpád Tesár, DrSc.

Doc.Ing. Pavel Dutko, CSc.

Ing. Eugen Chladný, CSc.

so spolupracovníkmi:

Ing. Zoltán Agócs — Ing. Jaroslav Schun, CSc.

Ing. Karol Amon — Ing. Jozef Vajda

Ing. Ferdinand Draškovič — Ing. Juraj Virčík

Ing. Pavel Ferjenčík, CSc. — Doc.Ing. Vladimír Voříšek, CSc.

Ing. Elena Chomová — prom. mat. Zuzana Hlaváčková

Ing. Jozef Lapos — Ing. Mária Miklášová

Ing. Ivar Plašil — Helena Mrahová

II – 5. STATICKÉ MODELOVÉ MERANIE
A SZTATIKAI MODELL MÉRÉSE

1. Modelová podobnosť a metodika meraní
Modell hasonlóság és a mérés módszere
2. Konštruktívne vyhotovenie modelu
A modell konstruktív kialakítása
3. Vplyvové čiary staticky neurčitých veličín
A sztatikailag határozatlan mennyiségek hatásábrái
4. Vplyvové čiary priehybu
A lehajlás hatásábrái
5. Vplyvové čiary M
M nyomatékok hatásábrái
6. Momenty a priehyby od zaťažovacích schém
Nyomatékok és lehajlások a terhelési vázlatoktól

Doc.Ing. Vl. Voříšek, CSc.
Ing. Ján Krajňák
Ing. Jozef Lapos

13

KATEDRA KOVOVÝCH A DREVENÝCH KONŠTRUKCIÍ — SVŠT BRATISLAVA STAVEBNÁ FAKULTA GOTTWALDOVO NÁM. Č. 5

VYPRACOVAL:

KRAJ ZÁPADOSLOVENSKÝ ONV BRATISLAVA — MsNV BRATISLAVA

PRIAMY INVESTOR: MESTSKÁ SPRÁVA KOMUNIKÁCIÍ V BRATISLAVE

CESTNÝ MOST CEZ DUNAJ V KM 1869 V BRATISLAVE

FORMÁT:
DÁTUM: MÁJ 1966
STUPEŇ: OBJEDN. PD
ČÍSLO HZ: 04-100-67
ARCH. ČÍSLO:

PRÍLOHA: MIERKA: ČÍSLO VÝKR.

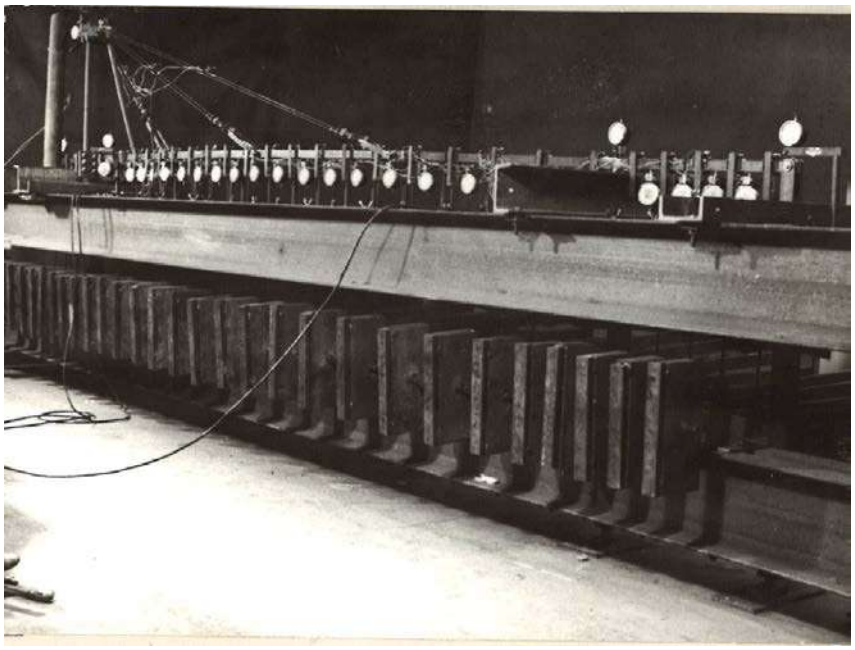
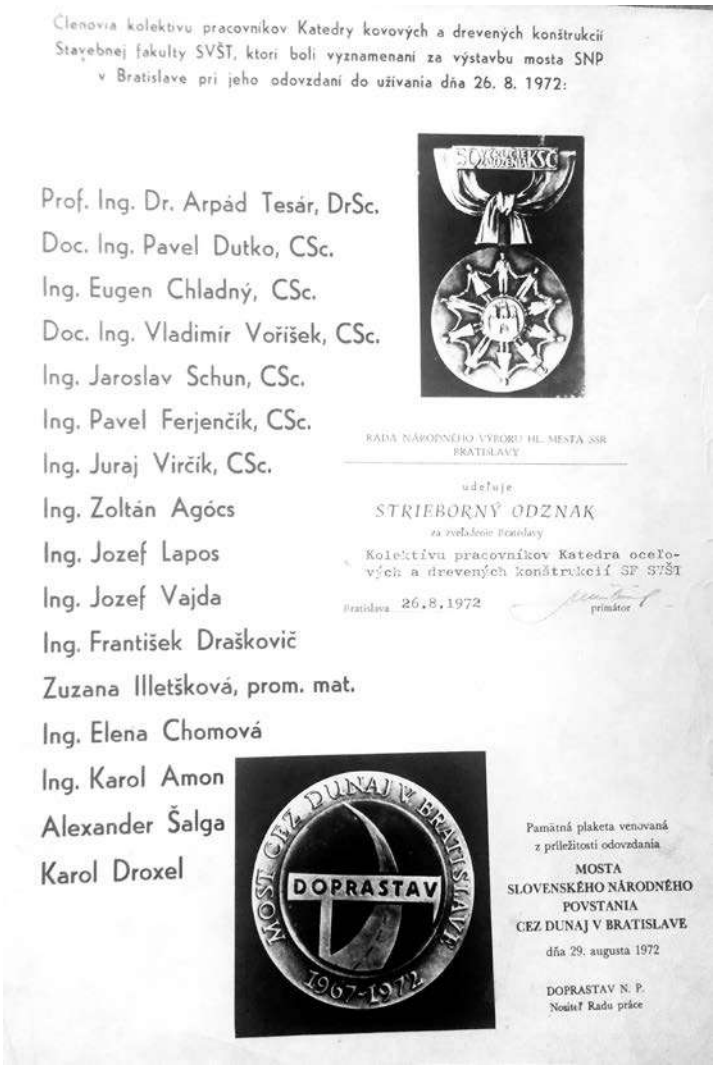


Fig. 5. (a) In the left: the title page of the Structural analysis of the road bridge over Danube River in km 1869,1 in Bratislava; (b) the title page of the Technical report about bridge model measurements. SNP Bridge in scale 1:50, May 1966. (Both courtesy of archive of Jozef Lapos).


Členovia kolektívu pracovníkov Katedry kovových a drevených konštrukcií Stavebnej fakulty SVŠT, ktorí boli vyznamenaní za výstavbu mosta SNP v Bratislave pri jeho odovzdaní do užívania dňa 26. 8. 1972:

Prof. Ing. Dr. Arpád Tesár, DrSc.
Doc. Ing. Pavel Dutko, CSc.
Ing. Eugen Chladný, CSc.
Doc. Ing. Vladimír Vořišek, CSc.
Ing. Jaroslav Schun, CSc.
Ing. Pavel Ferjenčík, CSc.
Ing. Juraj Virčík, CSc.
Ing. Zoltán Agócs
Ing. Jozef Lapos
Ing. Jozef Vajda
Ing. František Draškovič
Zuzana Illetšková, prom. mat.
Ing. Elena Chomová
Ing. Karol Amon
Alexander Šalga
Karol Droxel

Fig. 6. Silver Badge awarded by the Council of the National Committee of the Bratislava, capital of Slovak Socialist Republic in 26th August 1972 to the members of the Department of Metal and Timber Structures, Faculty of Civil Engineering, Slovak University of Technology in Bratislava (courtesy of archive of Alexander Šalga).

The SNP Bridge was designed by teams from the Faculty of Civil Engineering Slovak University of Technology (STU, former SVŠT) in Bratislava led by Prof. Ing. Dr. Arpád Tesár, DrSc., (structural engineer, design of steel structures), Associate Professor Ing. Jozef Zvara, (structural engineer, design of concrete foundation) and prof. Ing. arch. Jozef Lacko, CSc., (architect). Prof. Arpád Tesár graduated at TH Berlin – Charlottenburg in 1944. Prof. Jozef Lacko graduated at the German Technical High School (Deutsche Technische Hochschule) in Prague in 1941. Assoc. Prof. Jozef Zvara graduated at the STU in Bratislava in 1952. All three professors were teachers at STU. More about Prof. A. Tesár see in [8, 9].

Ing. Karol Amon, a contemporary of Prof. Tesár, studied at TU Brno. There was there also the famous German TU where e.g. Ernst Chwalla (*1901 - †1960) and Alfred Hawranek were among the teachers. Ing. Amon moved to Vienna when Hitler closed the Czech universities, where he graduated with Prof. Kurt Pfeiller. They were the first engineers graduated in Vienna after the World War II. and at that occasion Bruno Kreisky, who later became Foreign Minister and Chancellor shook their hands. His son Karol II. is MUDr. and his grandson Karol III. was graduated 15 years ago at the Faculty of Civil Engineering, STU in Bratislava.

Tesár`s team from the Department of Metal and Timber Structures is below on Figs. 8-10.



Fig. 7. Left to right: Prof. Dr. Ing. Arpád Tesár, DrSc. (*1.II.1919 - †15.VI.1989); Prof. Ing. arch. Jozef Lacko, CSc. (*19.I.1917 - †9.IX.1978); Assoc. Prof. Ing. Jozef Zvara (*17.VII.1925 - †29.II.2004)



Fig. 8. Left to right: Prof. Ing. Eugen Chladný, CSc. (*1.VIII.1928 - †7.VII.2020); Prof. Ing. Pavol Dutko, CSc. (*23.X.1928 - †29.III.2000); Assoc. Prof. Ing. Vladimír Vořišek, CSc. (*9.VI.1924); Prof. Ing. Jaroslav Schun, CSc. (*4.X.1930 - †12.VIII.2021); Prof. Ing. Pavel Ferjenčík, CSc. (*1.VII.1929 - †26.III.1992); Ing. Karol Amon (*4.XII.1918 - †8.III.2005).



Fig. 9. Left to right: Assoc. Prof. Ing. Jozef Vajda, CSc. (*1935 - †2013); Prof. Ing. Juraj Virčík, CSc. (*8.III.1937 - †21.III.1986); Prof. h. c. Prof. Ing. Zoltán Agócs, PhD. (*24.IV.1938 - †14.II.2018); Prof. Ing. Jozef Lapos, PhD. (*22.I.1939); Assoc. Prof. Ing. Ferdinand Draškovič, PhD. (6.XI.1943); Ing. Elena Ščasná-Chomová, CSc. (*21.XI.1939). Not available photos: Ing. Ivar Plašil; Ing. Róbert Fodor; Ing. Ján Krajňák was the Head of laboratory; Mrs. Zuzana Iletšková, graduated mathematician; Ing. Mária Domčeková-Miklášová; Mrs. Helena Mračnová, secretary.

Ing. Ivar Plašil emigrated to Germany (TU Dortmund; Head for Design of Engineering Structures, Krupp Stahl AG). Ing. Róbert Fodor married Bratislava woman of German origin and moved to Germany. Mrs. Helenka Mračnová became later the technician and Mrs. Holičová became the new secretary. Mr. František Kučera, the technician in the laboratory [1962, till 1968] emigrated to USA in 1968. Mr. Štefan Hrubík, carpenter [cca 1968], retired in 1976, when he was replaced by Mr. Jozef Šándor. The numbers in the brackets [..] indicate from which year they worked at the department:

Voříšek [1950, the year of the department foundation], he will celebrate in 2022 his 98 years, Dutko [1951], Chladný [1951], Amon [1952], Ferjenčík [1953], Schun [1953], Plašil [1958, till 1969], Virčík [1960], Šalga [1962], Kučera [1962], Krajňák [1963], Zemanová-Maľcevová-Brucknerová [1963], Agócs [1963], Vajda [1963], Ščasná-Chomová [1964], Lapos [1964], Droxel [1964], Čechovič [1964], Kaušitz [1964], Fodor [1965, till 1967], Draškovič [1967], Nič [1970], Farkašová-Mesiariková-Čierna [1970]. More about beginning of the history of the department read in [10].



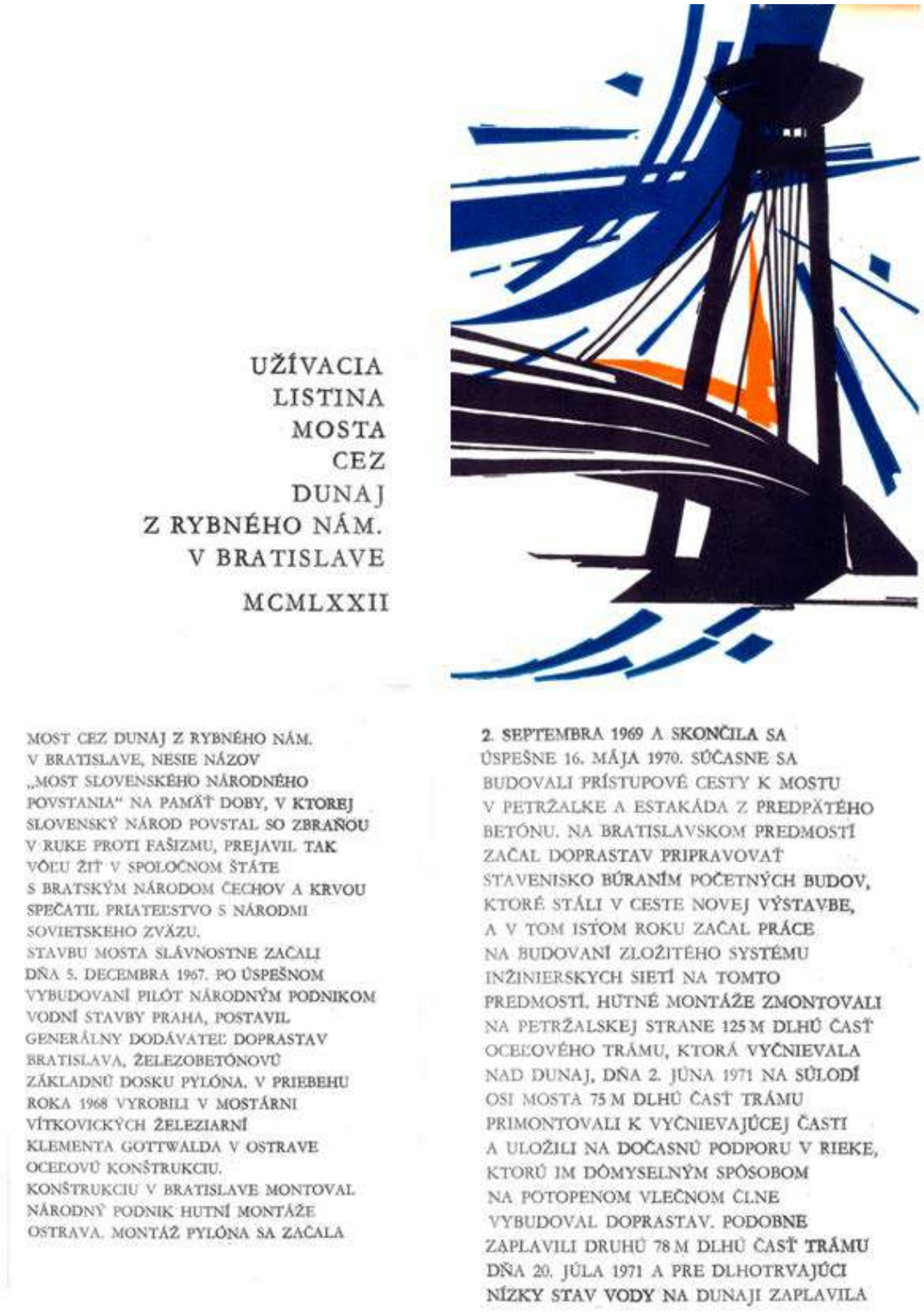
Fig. 10. Left to right: Mr. Alexander Šalga (10.IX.1938) electrical technician; Mr. Karol Droxel (*12.X.1939), craftsman; Mr. Imrich Čechovič, craftsman; Mr. Ladislav Kaušitz, craftsman; Mrs. Milada Zemanová-Maľcevová-Brucknerová (31.V.1940), photographer; Mrs. Valéria Töröková, secretary.

Mr. Alexander Šalga designed the technology of gluing, cabling, insulation of strain gauges and carried out strain gauge measurements during construction and load-bearing testing of the SNP Bridge.

Zvara`s team from the Department of Concrete Structures and Bridges consisted of: Š. Baďura, Ľ. Bolha, F. Brtáň, F. Hájek, E. Holub, Š. Choma, D. Majdúch, E. Madunický, J. Krajňák. Team from the Department of Surveying: O. Michalčák, J. Staněk, D. Píš, F. Kohút, P. Bartoš and V. Složka from the Department of Structural Mechanics were another people who took part in design of the SNP Bridge. Lacko`s team created Ing. arch. Ladislav Kušnír**,** PhD., (*1929 – †2010) and Ing. arch. Ivan Slameň (*1932 – †2006).
Branch of VŽKG in Bratislava elaborated complete project of steel structures and working drawings. For example 15 thick volumes containing working drawings of the bridge girder were elaborated from December 1968 till June 1970 by members of the projecting and construction branch of VŽKG in Bratislava and the drawings were undersigned by Ing. Jozef Šubr, Head of the designers and Ing. Ján Bustín, CS. (*1926 – †11.2.2017), a legend of the Slovak designers of steel structures. More about Bustín see in [11].



Fig. 11. 1-Prof. Chladný; 2-Ing.Bustín, 3-Ing. Frťúsová, 4-Ing. Šubr, all three from VŽKG.



UŽÍVACIA
LISTINA
MOSTA
CEZ
DUNAJ
Z RYBNÉHO NÁM.
V BRATISLAVE

MCMLXXII

MOST CEZ DUNAJ Z RYBNÉHO NÁM.
V BRATISLAVE, NESIE NÁZOV
„MOST SLOVENSKÉHO NÁRODNÉHO
POVSTANIA" NA PAMÄŤ DOBY, V KTOREJ
SLOVENSKÝ NÁROD POVSTAL SO ZBRAŇOU
V RUKE PROTI FAŠIZMU, PREJAVIL TAK
VÔĽU ŽIŤ V SPOLOČNOM ŠTÁTE
S BRATSKÝM NÁRODOM ČECHOV A KRVOU
SPEČATIL PRIATEĽSTVO S NÁRODMI
SOVIETSKEHO ZVÄZU.
STAVBU MOSTA SLÁVNOSTNE ZAČALI
DŇA 5. DECEMBRA 1967. PO ÚSPEŠNOM
VYBUDOVANÍ PILÓT NÁRODNÝM PODNIKOM
VODNÍ STAVBY PRAHA, POSTAVIL
GENERÁLNY DODÁVATEĽ DOPRASTAV
BRATISLAVA, ŽELEZOBETÓNOVÚ
ZÁKLADNÚ DOSKU PYLÓNA. V PRIEBEHU
ROKA 1968 VYROBILI V MOSTÁRNI
VÍTKOVICKÝCH ŽELEZIARNÍ
KLEMENTA GOTTWALDA V OSTRAVE
OCEĽOVÚ KONŠTRUKCIU.
KONŠTRUKCIU V BRATISLAVE MONTOVAL
NÁRODNÝ PODNIK HUTNÍ MONTÁŽE
OSTRAVA. MONTÁŽ PYLÓNA SA ZAČALA
2. SEPTEMBRA 1969 A SKONČILA SA
ÚSPEŠNE 16. MÁJA 1970. SÚČASNE SA
BUDOVALI PRÍSTUPOVÉ CESTY K MOSTU
V PETRŽALKE A ESTAKÁDA Z PREDPÄTÉHO
BETÓNU. NA BRATISLAVSKOM PREDMOSTÍ
ZAČAL DOPRASTAV PRIPRAVOVAŤ
STAVENISKO BÚRANÍM POČETNÝCH BUDOV,
KTORÉ STÁLI V CESTE NOVEJ VÝSTAVBE,
A V TOM ISTOM ROKU ZAČAL PRÁCE
NA BUDOVANÍ ZLOŽITÉHO SYSTÉMU
INŽINIERSKYCH SIETÍ NA TOMTO
PREDMOSTÍ. HUTNÉ MONTÁŽE ZMONTOVALI
NA PETRŽALSKEJ STRANE 125 M DLHÚ ČASŤ
OCEĽOVÉHO TRÁMU, KTORÁ VYČNIEVALA
NAD DUNAJ, DŇA 2. JÚNA 1971 NA SÚLODÍ
OSI MOSTA 75 M DLHÚ ČASŤ TRÁMU
PRIMONTOVALI K VYČNIEVAJÚCEJ ČASTI
A ULOŽILI NA DOČASNÚ PODPORU V RIEKE,
KTORÚ IM DOMYSELNÝM SPÔSOBOM
NA POTOPENOM VLEČNOM ČLNE
VYBUDOVAL DOPRASTAV. PODOBNE
ZAPLAVILI DRUHÚ 78 M DLHÚ ČASŤ TRÁMU
DŇA 20. JÚLA 1971 A PRE DLHOTRVAJÚCI
NÍZKY STAV VODY NA DUNAJI ZAPLAVILA

Fig. 12. Deed of Use of the the SNP Bridge over Danube River in Bratislava issued by Ing. Ladislav Martiňák the mayor of Bratislava City. From original 10 pages document two pages were lost forever (courtesy of archive of Rudolf Ároch).

KTORÉ SA PODIEĽAJÚ NA STAVBE MOSTA:

MESTSKÁ SPRÁVA KOMUNIKÁCIÍ, BRATISLAVA

DOPRASTAV, N. P. BRATISLAVA

HUTNÉ MONTÁŽE, N. P. OSTRAVA

VÍTKOVICKÉ ŽELEZÁRNY KLEMENTA GOTTWALDA, N. P. OSTRAVA

ŽELEZNIČNÉ STAVITEĽSTVO, N. P. BRATISLAVA

ELEKTROMONTÁŽNE ZÁVODY BRATISLAVA, N. P. BRATISLAVA

SLOVENSKÝ PRIEMYSEL KAMEŇA, N. P. LEVICE

SLOVŠPORT, PODNIK SLOVENSKEJ TELOVÝCHOVNEJ ORGANIZÁCIE, BRATISLAVA

KOVOSPRACUJÚCI PODNIK MESTA BRATISLAVY

TERMOSTAV, N. P. BRATISLAVA

ZA ZVLÁDNUTIE TAKÉHO NÁROČNÉHO DIELA, KTORÉ JE V BRATISLAVE STAVBOU STOROČIA A JE DOKONALÉ PO TECHNICKEJ AKO AJ UMELECKEJ STRÁNKE, ĎAKUJEM VŠETKÝM PRACOVNÍKOM NA TOMTO DIELE.

AUTOROM:

prof. Ing. arch. LACKOVI,
prof. Ing. Dr. techn. TESÁROVI, DrSc.,
Ing. MEGOVI, Ing. MIKLÁNKOVI, CSc.,
SMÉKALOVI, Ing. PŘIBÁŇOVI,
Ing. SCHOLTZOVI, Ing. DONOVALOVI,
KURKOVI, Ing. DUBOVI, Ing. SIVOŠOVI,
Ing. KNAUSOVI, Ing. MELCEROVI,
dipl. techn. SLÁDKOVIČOVI,
Ing. TOMAŠOVIČOVI st., Ing. KARELOVI,
Ing. PRIKRYLOVI, Ing. ŠESTÁKOVI
Ing. HRNČIAROVI, Ing. MOJŽIŠOVEJ,
ZAJACOVEJ, Ing. VYLEGALOVI, KADĚROVI,
ZPĚVÁKOVI, TURKOVI, stav. KOVÁČOVI,
MENDELOVI, WALTEROVI, KIANIČKOVI,
KATONOVI st., KATONOVI ml., MESZÁROSOVI,
GAŽIMU st., PCHÁLKOVI, MRUZKOVI,
VAŠICOVI st., A ICH KOLEKTÍVOM.

ĎALEJ SI POZORNOSŤ A VĎAKU ZASLÚŽIA:

Ing. VOREL, Ing. MARŠÁLEK, Ing. SUROVÝ, prof. Ing. MICHALČÁK, Ing. PÍŠ, Ing. STANĚK, doc. Ing. DVORÁK, doc. Ing. DUTKO, CSc., Ing. CHLADNÝ, CSc., doc. Ing. VOŘÍŠEK, CSc., Ing. arch. KUŠNÍR, Ing. arch. SLAMEŇ, Ing. BARTKOVÁ, Ing. ROTH, Ing. TEVEC, KULÍK.

ĎAKUJEME AJ ĎALŠÍM SPOLUPRACOVNÍKOM MESTSKEJ SPRÁVY KOMUNIKÁCIÍ, KTORÍ SA ZASLÚŽILI O ZDARNÉ VYBUDOVANIE PREMOSTENIA:

Ing. DUDÁŠOVI, Ing. HASENÖHRLOVI, Ing. HORVÁTHOVI PAVLOVI, LAMOŠOVEJ, LEDNÁROVI, Ing. MIGROVI, PRAŠTÍKOVI, STANEKOVEJ, RAJNOHOVI, Ing. TOMAŠOVIČOVI ml.

SRDEČNÚ VĎAKU EŠTE RAZ

Ing. KAROL ŠTRBA
riaditeľ Mestskej správy komunikácií

UŽÍVACIA LISTINA

ĎAKUJEM VŠETKÝM PRACOVNÍKOM, KTORÍ PRISPELI K ÚSPEŠNEJ VÝSTAVBE MOSTA SVETOVEJ ÚROVNE.
MOST JE PRVÝM DEFINITÍVNYM MOSTOM VYBUDOVANÝM PO OSLOBODENÍ NAŠEJ VLASTI, NECH DLHO SLÚŽI OBČANOM NÁŠHO MESTA I NAŠIM HOSŤOM A NECH ÚSPEŠNE PODPORÍ ROZVOJ NÁŠHO MESTA NA OBOCH BREHOCH DUNAJA.
NA ZÁKLADE PRIAZNIVÝCH VÝSLEDKOV ZO ZAŤAŽOVACÍCH SKÚŠOK

POVOĽUJEM

ODOVZDAŤ MOST S PRIĽAHLÝMI ÚSEKMI DO PREDČASNÉHO POUŽÍVANIA V DEŇ OSLÁV 28. VÝROČIA SLOVENSKÉHO NÁRODNÉHO POVSTANIA.

DANÉ V DEŇ SLÁVNOSTNÉHO ODOVZDANIA MOSTA DO POUŽÍVANIA DŇA
26. AUGUSTA 1972.

Ing. LADISLAV MARTINÁK,
primátor
hlavného mesta SSR Bratislavy

Fig. 13. Continuation of the Deed of Use of the the SNP Bridge over Danube River in Bratislava issued by Ing. Ladislav Martiňák the mayor of Bratislava City. From original 10 pages document two pages were lost forever (courtesy of archive of Rudolf Ároch).

2. Service period of the SNP Bridge



Fig. 14. SNP Bridge over Danube River in Bratislava opened 26.VIII.1972. (Photo I. Baláž).

Prof. Ferjenčík replaced the former Head of department Prof. Tesár in 1973. The most of the following members of department were admission to department by its new head after 1973:
(i) the teaching staff: Ing. Jarmila Farkašová-Mesiariková-Čierna, CSc [1970]; Assoc. Prof. Ing. Anna Benková, CSc. [1973], Ing. Juraj Rónaj came from BAUMS and was approximately 3 years the Head of laboratory. He was known as a magician;
(ii) the staff in laboratory: Mr. Jozef Šándor [1976]; Mr. Jozef Géci;
(iii) the administrative staff: Mrs. Danka Friedlová-Kostolná [1974], Miss Blažena Hoffmanová, Mrs Terézia Selecká, secretary.



Fig.15. Ing. Jarmila Farkašová-Mesiariková-Čierna, CSc. (*26.VI.1946); Assoc. Prof. Ing. Anna Benková, CSc. (*XI.1948); Ing. Juraj Rónaj; Mr. Jozef Šándor (*17.IV.1944), carpenter; Mr. Jozef Géci, craftsman.



Fig. 16. Adminstrative staff: Mrs. Danka Friedlová-Kostolná; Miss Blažka Hoffmanová; Mrs. Terka Selecká, secretary.



Fig. 17. Some more ladies from the past: Miss Anna Benešová, drawer; Mrs. Štefka Čomajová, photographer; Mrs. Dagmar Forgáčová, administrative staff; Miss Libuška X., secretary; Mr. Ján Fabšič, craftsman, he is the first from the right on Fig. 19.

Prof. Ing. Dr. Karol Havelka
Ing. Dr. Tomáš Májovský
Ing. Anton Šedivý
Ing. Anton Jablonský
Prof. Ing. Dr. Jozef Trokan
Prof. Ing. Dr. Jozef Harvančík
Ing. Ľudovít Šrámko
Ing. Leopold Hanák
Ing. Pavol Marko
Ing. Rudolf Skrúcaný, CSc.
Prof. Ing. Dr. Jozef Wünsch
Prof. Ing. Ján Hájek, CSc.
Prof. Ing. Ľudovít Grenčík, CSc
Doc. Ing. Jozef Zvara
Ing. Emil Holub, CSc.
Ing. Miloš Ballo, CSc
Ing. Ladislav Pirháč, CSc.
Ing. Róbert Lamprecht
Ing. Ladislav Fecko, CSc.
Ing. Vlasto Kuna

Ing. Ivan Havránek, CSc.
Ing. Bohumil Búci, CSc.
Ing. Štefan Hajdu
Ing. Ľudovít Jaraba
Ing. Dušan Majdúch, CSc.
Ing. Kvetoslava Váňová
Ing. Jozef Vrabec, CSc.
Ing. Štefan Bačura
Ing. Bohumila Knižková
Ing. Ivan Belanský
Ing. Ivan Hamerský
Ing. František Hájek
Ing. Ivan Callo
Ing. Ján Cesnak
Ing. Milan Čabrák
Ing. Ľubomír Bolha
Ing. Ivan Harvan
Ing. Štefan Choma
Ing. František Brtáň
Ing. Milan Pastucha
Ing. Adriana Páliková

Fig. 18. Members of the Department of Concrete Structures and Bridges, Faculty of Civil Engineers, Slovak University of Technology in Bratislava from 1940 till 1970 [12].

In 1967 Tesár`s department moved to the new buildings on Radlinského street No.11. Prof. Chladný was responsible for the design of the bridge girder and its erecting stages. He became the Head of the department in 1989 after political changes following wishes of the members of the department. In the service period of the SNP Bridge Chladný was main co-author of the several publications: (i) the scientific papers devoted to measurements of imperfections and their influence on load-bearing capacity of the bridge [13, 17, 18]; (ii) the scientific paper devoted to the influence of the shear lag [19]; (iii) the technical reports about the load-bearing capacity of the bridge [16, 20, 27, 28]; (iv) the technical reports about the principal inspections of the bridge [14, 23, 24]; (v) the technical reports and the papers about strengthening and possible reconstruction of the bridge [20, 21, 22, 25, 26].

Assoc. Prof. R. Ároch, PhD., the current Head of the Department of Steel and Timber Structures since 2016, was responsible for: (i) the technical report on the influence of deck surfacing replacement [29]; (ii) the special inspection of the bridge [30]; the diagnostic of the steel orthotropic deck and proposal for repair [31, 32].



Fig. 19. Visit of Prof. Belenja from Russia at Depatment of Metal and Timber Structures (courtesy of archive of Ferdinand Draškovič).



Fig. 20. Smolenice 1974. Meeting of the departments from STU (SVŠT) Bratislava, ČVUT Prague and VŠDS (ŽU) Žilina. In the middle Assoc. Prof. Dvořák from Prague, in the right Prof. Vladimír Dvořák from Žilina (courtesy of archive of Ferdinand Draškovič).

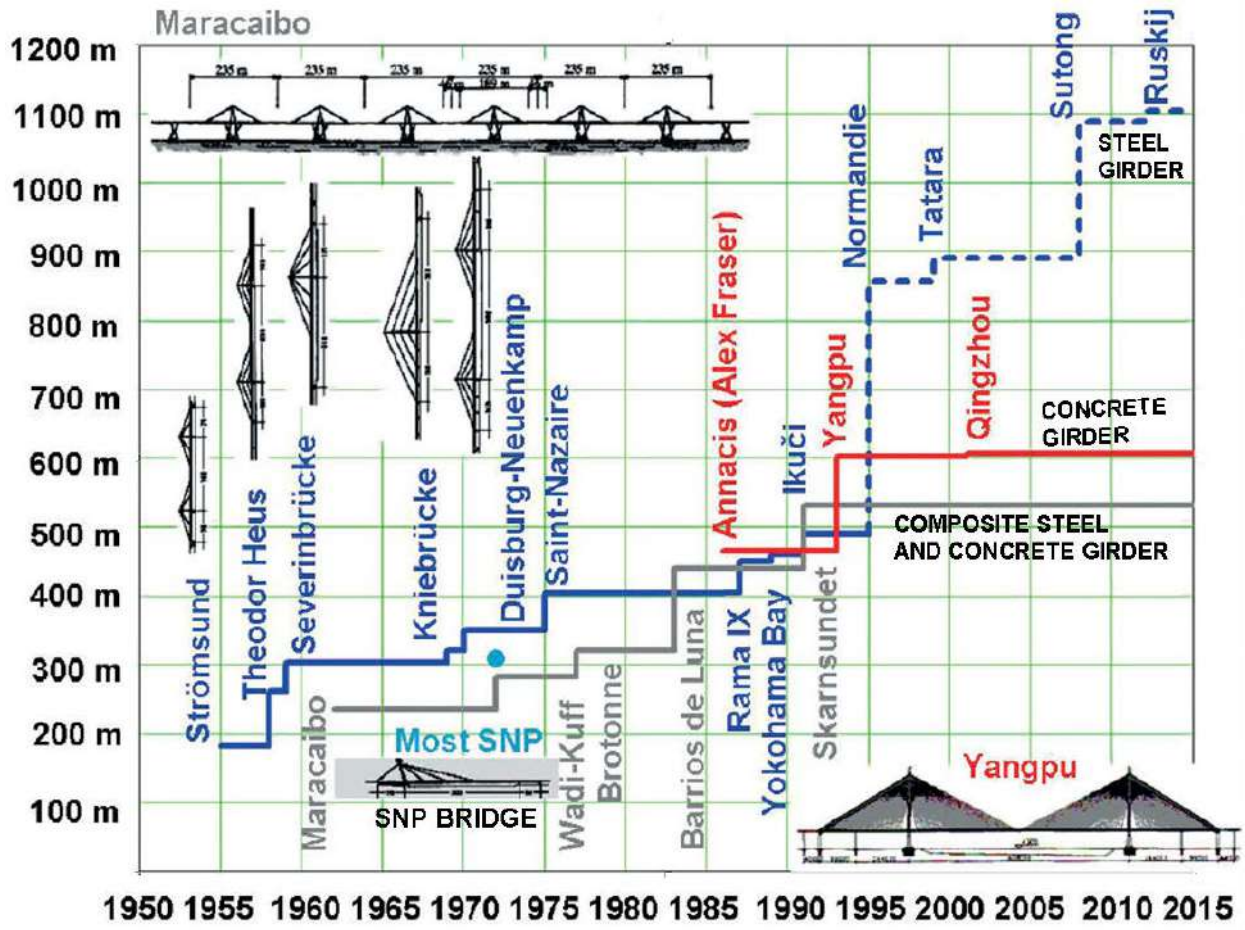


Fig. 21. The SNP Bridge of the Tesár`s team stands at the beginning of the development of the cable-stayed bridges with the world record main span. The steel won the fight of structural materials from which main span of the bridge girder is made. The dashed line indicates that in the middle of the main span the steel is used and the concrete at the pylons [3].

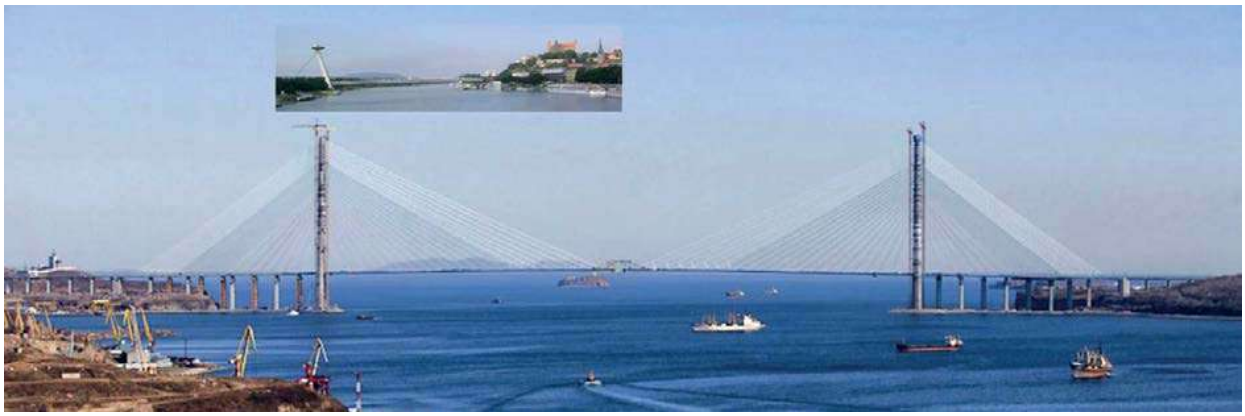


Fig. 22. The comparison of the SNP Bridge (main span 303 m, pylon 85 m) with the Ruskij Bridge (main span 1104 m, pylon 320,9 m), the current world record holder in the category of the cable-stayed bridges. The same scale is used [3].



Fig. 23. The SNP Bridge over Danube river in Bratislava (courtesy of Ivan Baláž).

3. Conclusion

The paper is dedicated to the memory of the members of the Department of Metal and Timber Structures, Faculty of Civil Engineers, Slovak University of Technology in Bratislava, who elaborated project of the SNP Bridge over Danube River in Bratislava. They performed it in sixties of the 20th century without computers using mechanical calculators.

Almost all of them were my perfect or good teachers, later colleagues and friends. They were: (i) active in the design of many real structures; (ii) the authors of several books or text-books; (iii) the authors of the scientific papers; (iv) the authors of the Czechoslovak

engineers to make easier design of steel and composite steel and concrete structures and bridges according to the standards: Czechoslovak ČSN, Slovak STN, German DIN, European ENV and EN Eurocodes supported by relevant text-books and proceedings. They should not be forgotten.

Many of the teachers from various departments of the Faculty of Civil Engineers, STU in Bratislava helped the Faculty of Civil Engineering, Technical University in Košice founded in 1976 at its beginning. The reason was the shortage of the teachers in Košice. Among others also several members of the Department of Metal and Timber Structures and the Department of Concrete Structures and Bridges helped FCE, TU in Košice. For example J. Virčík moved to Košice, P. Dutko taught there 5 years and author of this paper 6 years every Friday as external teachers. The help of many Bratislava teachers was fully forgotten by the dean Vincent Kvočák (PhD student of the author of this paper) in the jubilee book published at the occasion of 40 years of the Faculty of Civil Engineering, Technical University in Košice (1977-2017). See also http://svf-old.tuke.sk/?page_id=298.
Similarly the document of the mayor of Bratislava city in Figs. 11 and 12 forgot to mention the big contributions of several people important for the design and realization of the SNP Bridge. There is small hope that their names are on the two lost pages of this document.
When the SNP Bridge, which may be found in all books about bridges in the world, became the winner of the competition *Structure of the Twentieth Century in Slovakia*, organized in 2001, many Slovak "influencers" were very dissatisfied. How it is possible, they asked themselves. The bridge destroyed the old part of Bratislava near the Bratislava Castle! What "influencers" knew about the technical parameters of the bridge and people who designed it? Moreover, the designers of the SNP Bridge are not responsible for the location of the bridge in the desolating part of the old Bratislava.

Much more important are the following facts. During the period 1969-1973 five big bridges with box-girders collapsed: 4th Vienna Danube Bridge, Austria in 1969; the Cleddau Bridge in Milford Haven, Wales in 1970; the West Gate Bridge over Yarra river in Melbourne, Australia in 1970; the Koblenz-Horchheim over Rhine river in the West Germany in 1971; the Zeulenroda road bridge over Weida valley in Thuringia in the East Germany in 1973. At that time the real behaviour of the compressed orthotropic flanges of large bridges with the box-girders was not fully known. In the UK the construction of this type of bridges was immediately stopped. The Merrison committee started to check all bridges of this type which were in UK in service. And in such atmosphere the SNP Bridge which has also the box-girder was projected, designed, erected and opened.
It cannot be forgotten: the Tesár`s team, who was able to create a project of the bridge with the world record parameters, except Honorary Diploma, Silver Badge and putting names some of them in Deed of Use document, was awarded also the goulash, beer and oilcakes in the restaurant of the 4th category near the SNP Bridge, just after its ceremonial opening.

The author is the owner of the many memorabilities relating to the SNP Bridge including: a) the set of hundreds photographs, b) the six volumes of the original calculations of the SNP Bridge performed by members of Department of Metal and Timber Structures, Faculty of Civil Engineering, Slovak University of Technology in Bratislava under Prof. Tesár, c) 15 thick volumes of the working drawings of the girder of SNP Bridge elaborated by VŽKG projecting bureau, the branch in Bratislava, d) several other documents similar like [12] – [28]. The original calculations was saved by the author just before their destroying. That is the reason why author plans to devote his collection to the Archive of Bratislava City to save it for the next generations.

This paper will hopefully decrease the gap in the memory and the knowledge of the public and technical community.

Acknowledgements

Author would like to thank to all who helped with their information, also to Prof. Ing. Josef Macháček, DrSc. and Prof. Ing. Jiří Studnička, DrSc from the FSv, ČVUT in Prague for identification of their colleagues in Fig. 20. Special thanks go to Prof. Jozef Lapos, Assoc. Prof. Ferdinand Draškovič, and Mr. Alexander Šalga for their help, information, support and providing historical documents. Assoc. Prof. Rudolf Ároch provided the document on the Figs. 12 and 13 and included the paper in the proceedings [33]. Special thanks go also to Ing. Igor Scholtz (see Fig. 3), a good friend of Prof. Chladný, for his information and set of photographs. We wish him return of good health and happy birthday celebration his 94 years in August 2022.

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RECONSTRUCTION OF WHITE TOWER IN HRADEC KRÁLOVÉ

Rusek Bohumil[1]

Structural engineer at Stavoprojekt HK (1962 - 1992). Founding member and long-term vice-president of the Czech Chamber of Authorized Engineers and Technicians in Construction (16 years). Designer of a new Malšovice housing estate in the 1960s.

Abstract: *Description of reconstruction of White Tower, dominant and landmark of Hradec Králové.*

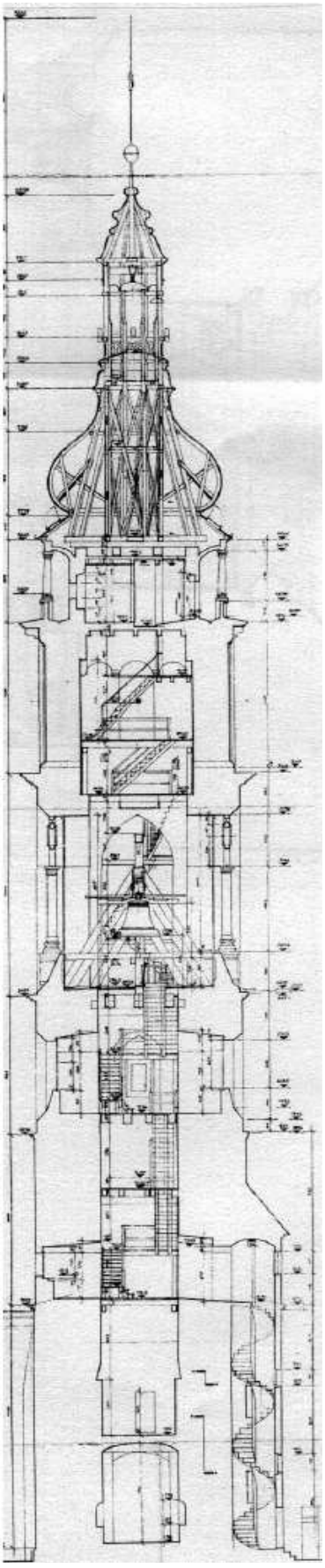
Key words*: reconstruction, cultural heritage, tower, cathedral*

1. History of the construction of the White Tower in Hradec Králové

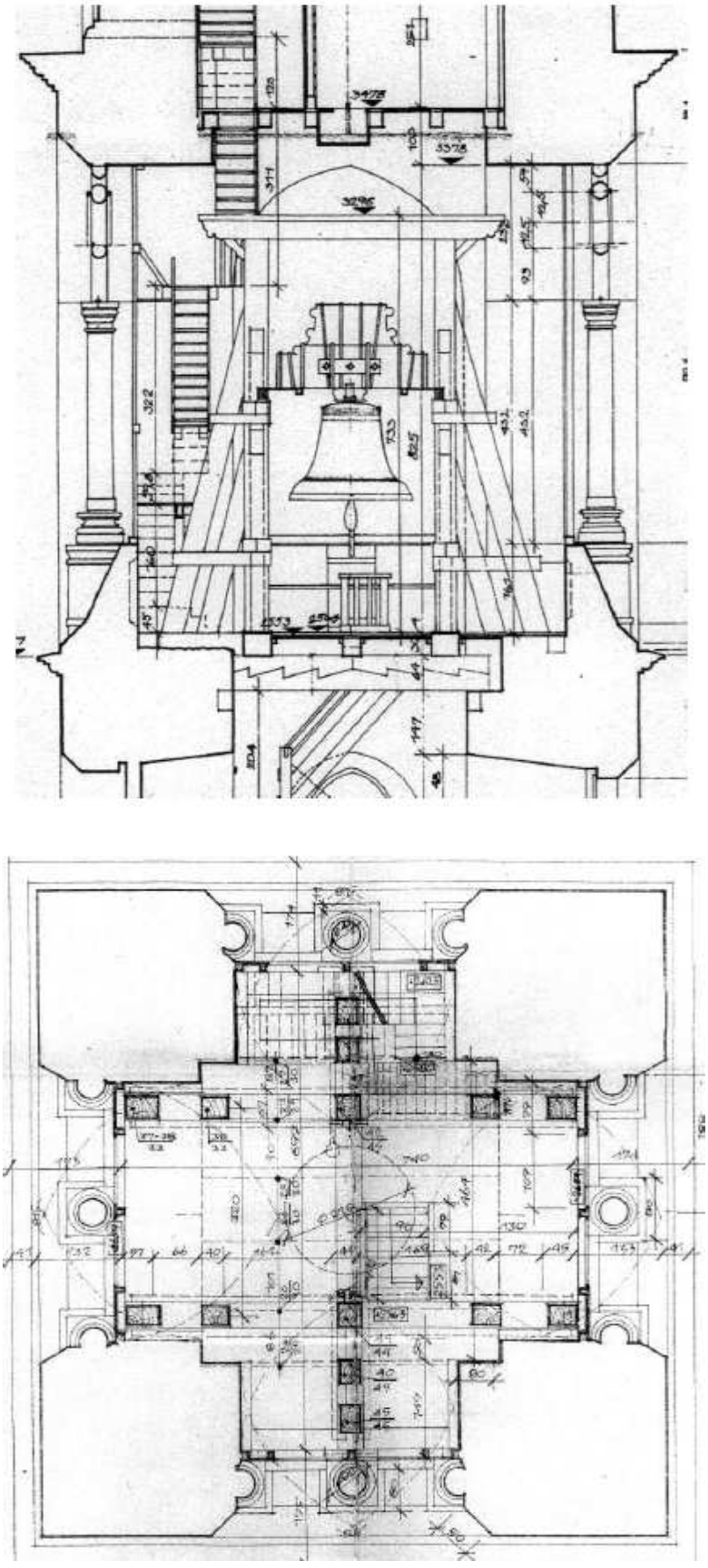
The White Tower is located in the historic part of Hradec Králové. In 1509, a large bell called AUGUSTÝN was made and paid by the city council and the townspeople of Hradec Králové. The bell is 169 cm high, its bottom diameter is 206 cm and weighs 9,800 kg. At that time, the city council was considering construction of the bell tower. However, the city did not have enough money for expensive construction in the coming years. The construction of the tower was not started until June 7, 1574. The tower was added to the Gothic chapel of St. Clement (Sv. Kliment), which was built in the 14th century (after the town fire of 1339). The construction of the tower started in 1574. The tower is about 68 m high, with the lightning rod with a star at the top almost 72.5 m. The floor plan dimensions at the foot of the tower are 10/10 m. The main material is solid fired bricks, the outer shell is made of sandstone blocks. The thickness of the walls varies in height, at the foot of the tower 3.6 m, in the highest floor 0.7 m. The tower is based on a 4 m high foundation made of quarry stones poured with lime mortar. During the construction, the forged rods were inserted into the masonry on the individual floors, terminated on the face of the stone masonry by split pins. The bell was supported by temporary structure located near the construction of the tower at the cathedral of St. Spirit (Sv. Duch) from 159 till 1581, that means 72 years. In 1581, the bell was pulled onto the tower under construction. The completion of the tower above the floor, in which the bell was placed on a massive structure of oak beams, lasted until 1596. The construction of the Renaissance tower with Gothic elements took 22 years.

In the years 1714-1717, Bishop Adam Count Vratislav of Mitrovice destroyed the old Gothic chapel of St. Kliment from the 14th century, to which the White Tower was added in the 16th century and built a new Baroque chapel. The chapel which is adjacent to the northern facade of the tower, has a rectangular floor plan, length 17.3 m and width 12.7 m. The stone building (bricks mixed with sandstone) is covered by an octagonal dome with sheet metal, which carries a brick, also octagonal lantern topped by a smaller dome. At the top is a large papal tiara supported by two keys.

[1] Rusek Bohumil, Ing. , retired, Na konečné 1816, 500 09 Hradec Králové, Czech Republic, kkrusek@gybon.cz



a)



b)

Fig. 1. a) Cross section of White Tower; b) storey with the bell

In the following centuries, the tower was repaired many times. For example, in 1731 and 1839 a complete dome of the tower was replaced. In 1829 a new clockwork was installed on the tower, the author of which was the Prague mechanic František Božek. It was paid from public collections thanks to Václav Kliment Klicpera, who worked in Hradec as a professor at grammar school in the years 1819 to 1846.

At the beginning of the reconstruction, it was found that the original horizontal grate supported the bell, dating from the 16th century, formed by massive oak beams, is seriously damaged by moisture and wood-destroying pests. Therefore, it was decided to replace most parts of the grate and repair the damaged sloping posts with prostheses. The oak beams were hand-worked into the necessary profiles. The grate was replaced so that the bell was lifted from the bearings and hung on a temporary steel structure. After the grate was replaced, the inclined struts were strengthen by prosthesis in the damaged parts and then lowered and seated in the grooves in the grate beams.

After the test ringing, it was stated that the reconstructed structure did not show any defects. The reconstruction of the White Tower was completed in March 2015. A 3.6 m high glass model of the tower and glass touch panels with the option to select information about the history of the tower and Hradec Králové were installed in the completed air-conditioned interior of the tower.

The author`s parents had a wedding in the neighboring chapel of St. Clement under the White Tower and the author was baptized in cathedral St. Spirit. In the 1980s, author took part in the then reconstruction of the framework and roof of the cathedral. He devoted himself to the White Tower in an extensive study in the 1970s and also in the final project for its reconstruction.

The structural engineers managed to reconstruct the chapel just before the visit of Pope John Paul II. in 26. April 1997. The remains of pope (a drop of his blood and strand of his hair) are saved in cathedral of St. Spirit from 2. April 2021.

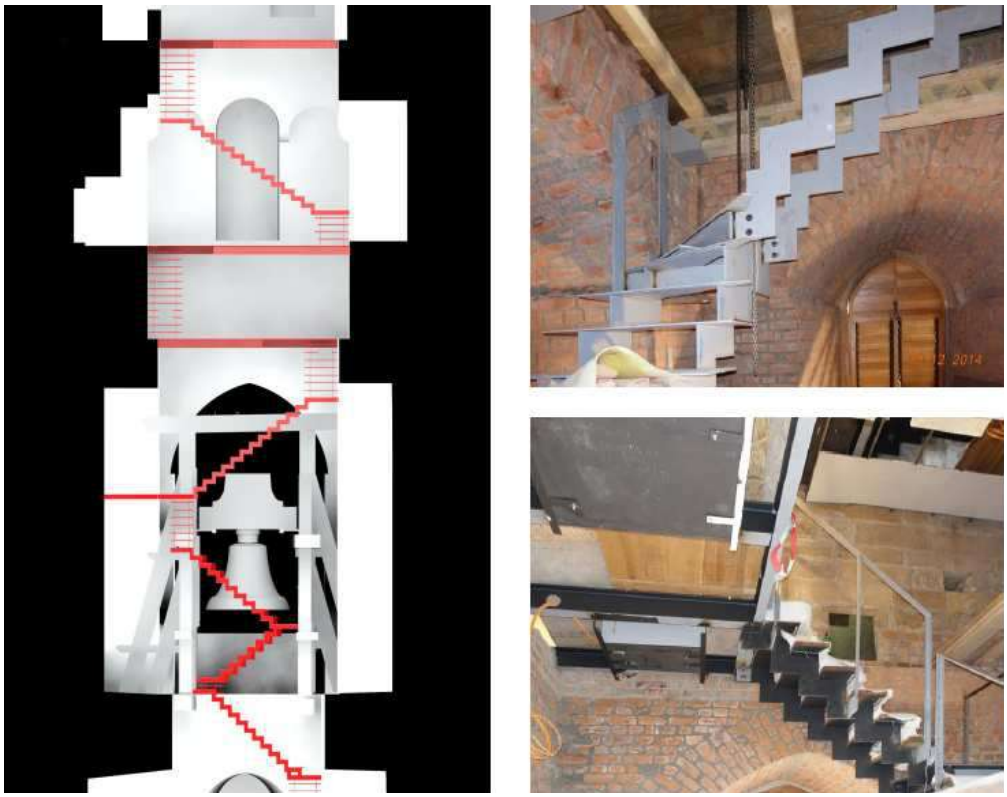


Fig. 3. Replacement of staircase







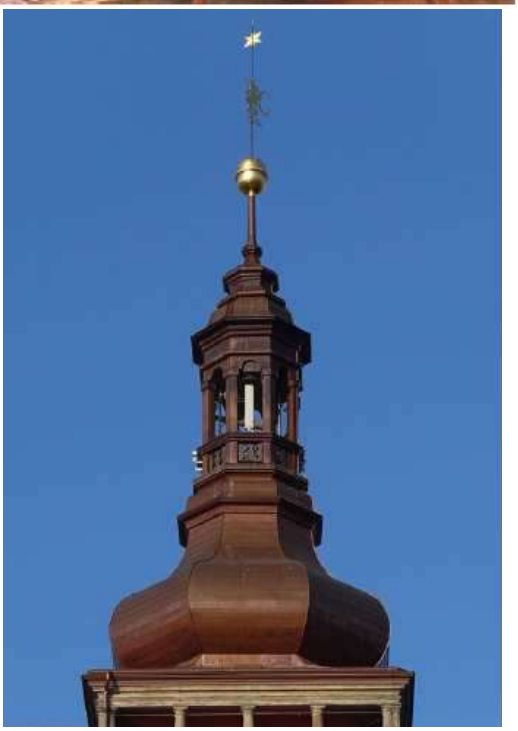


Fig. 2. Repair of framework and new cooper roofing





Fig. 4. Damaged parts of grate and sloping post

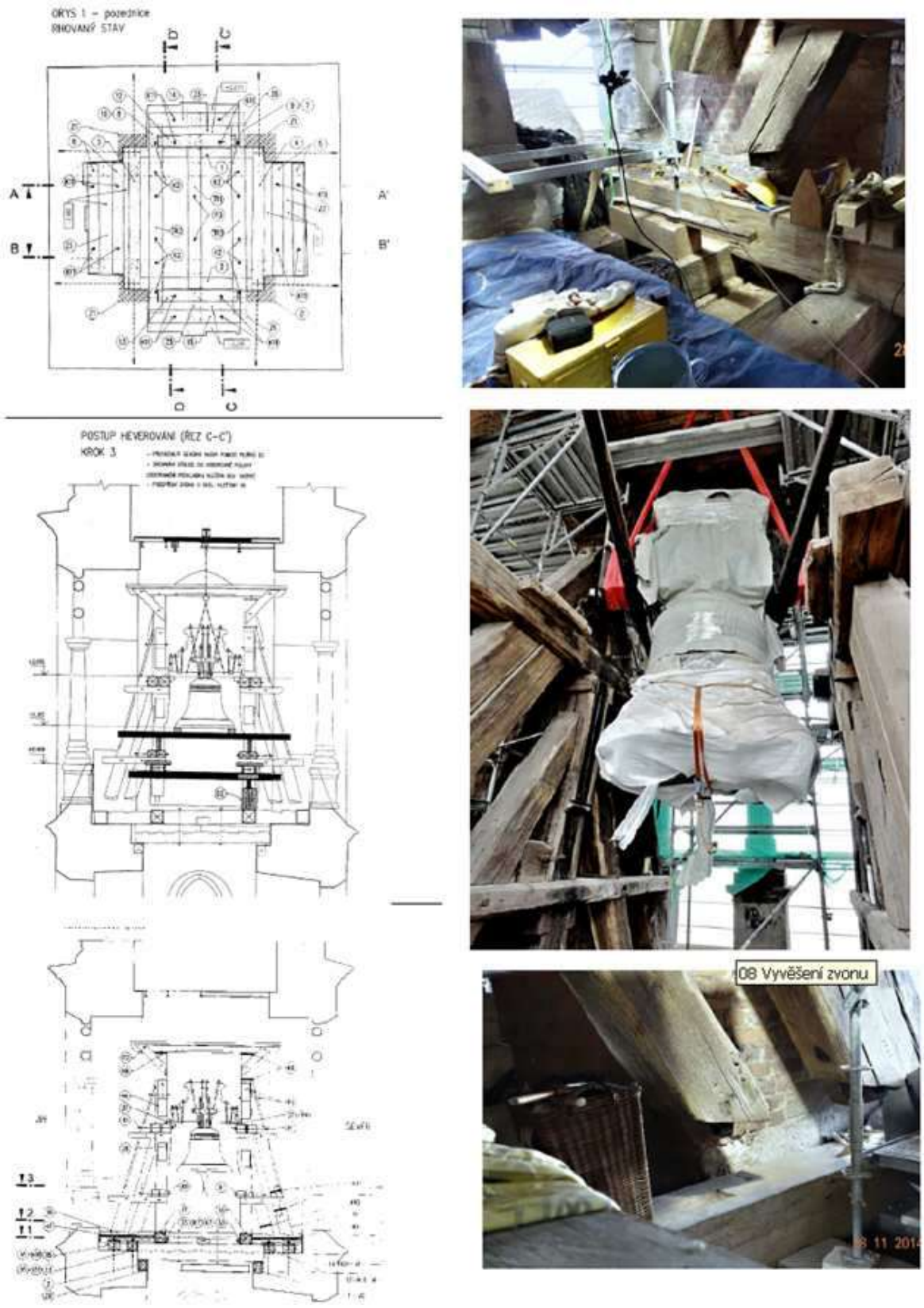


Fig. 5. Project and realization of timber structure loaded by bell



Fig. 6. Cathedral of St. Spirit and White Tower in Hradec Králové, Czech Republic.



Fig. 7. Pope John Paul II. in 26. April 1997 in Hradec Králové.
(Courtesy of HRADECKÝ denník.cz)..

URBANIZATION OF BOSNIA AND HERZEGOVINA IN THE OTTOMAN PERIOD

Borislav Puljić [1],

[1] *University of Mostar, Academy of Fine Arts*

Abstract: *The focus of this article is the discussion how the Ottomans fundamentally changed the network and system of settlement after conquest of Bosnia and Herzegovina. Due to their military strength, they did not continue the medieval tradition of building on hills as important strategic positions, but settled in river valleys, which were now becoming a significant military advantage due to better traffic connections.*

Key words: *Bosnia and Herzegovina, urbanization, Mostar, muafiyet*

1.Introduction

With the conquest of Bosnia and Herzegovina, the Ottomans fundamentally changed the network and system of settlements. Due to their military strength, they did not continue the medieval tradition of building on hills as important strategic positions, but settled in river valleys, which were now becoming a significant military advantage due to better traffic connections. At the very beginning, they settled in occupied towns (suburbs) and burgs (towns)[1], and slowly moved towards valleys and rivers. For them, towns were not just places of living, trading and crafts, but administrative centers and military garrisons to accommodate the army. Considering that their military objective was not defense but attack, the army was now stationed in towns (cities) on important roads to ensure its mobility for further conquests and expansion of the Empire[2]. What was important was no longer the elements of sight distance in space and suitability for defense, but the traffic route and movement of troops to new areas. That is why the towns became centers for the accommodation of the army and its logistical equipment, which significantly affected the location and formation of towns. With the Ottomans, towns were not the product of economic laws and expanded reproduction, but were formed by the will of the state. They functioned as administrative centers, providing accommodation and logistics to the army, expanding Islam, craft production and trade, as well as lodging and traffic needs of merchants. At the same time, these towns had to be at the center of the rural environment because it and its production were the basis that under the specific sipahi-timar system ensured the life of towns, and the sultan's wealth and control. Descriptions of these settlements from the early Ottoman period are rare, but based on them it can be concluded that the basic appearance of most towns in Bosnia and Herzegovina did not significantly change until the second half of the 16th century[3].

[1] Borislav Puljić, PhD**,** University of Mostar, Academy of Fine Arts, boro.piljic@ecoplan.ba

2. Urbanization as a controlled process

Immediately after the Ottoman conquests, an empty space was left, not only as a consequence of the war[4], but primarily due to the well-designed demographic policy of the occupiers to displace the existing population[5]. One third was taken into slavery to other areas, one third to the Sultan in Istanbul, and one third was left as producers - serfs (raya) for production and "to further reproduce"[6]. A well-thought-out demographic and urban planning policy was used in the thus obtained half-empty spaces[7] The proof of the well-thought-out urban policy of the state is not only the deliberate and planned demographic policy, but also the well-known state initiatives of giving state land into private ownership for the purpose of building and developing towns[8]. This land was given to certain feudal lords with the aim of building imarets, that is, public town buildings, mosques, *inns*, *hammams*, *madrasahs*, within the institution of waqf (endowment). They were built and maintained by the income of the waqf[9].
New or existing settlements that were selected for further development were now built according to new principles of their network and hierarchy.Hierarchically, the settlements were formed by the decision of the state, depending on the importance of the town for the administration and army needs, and were divided into kasabas (towns) and shehers[10]. The network developed as a result of military and trade needs, that is, the need for accommodation and overnight stays of merchant travelers, and accommodation of military units. Inns and caravanserais were built on important traffic routes at a distance of a day of horse gait. In the beginning, these buildings (barracks, inns and caravanserais) were the core around which the first workshops and shops were built. Shops and crafts were used for local and wider exchange of agricultural goods and craft products, but also logistics for the army. Inns and barracks were often located next to the existing squares, or shops and craft workshops from the medieval period. With craft workshops and shops, a bazaar (čaršija) developed, and residential settlements - mahalas - were formed in its vicinity, and so the town developed.

It is known that wars and constant expansion were the foundations of the existence, strength and functioning of the Ottoman Empire. They were initiated by the Islamic demand for the expansion of the religion, but also by the need for constant war booty (new wealth) that was turning into a base that gives life. Everything worked as long as there were sources, and these were the spoils from the conquests and well-organized oriental exploitation of raya. Towns had a clear role in this regard. They were logically set and networked with the purpose of constantly expanding the Empire (the religion of Islam) and waging wars. The formation and development of Ottoman towns in the Balkans "did not happen as a consequence of a basic factor - the development of productive forces, but as a consequence of Turkish-Oriental culture or more precisely the culture of Islam[11].
Towns were providing accommodation for the army and overnight accommodation for travelers, but also crafts and trade for military needs, as well as the exchange of goods with the population in the neighborhood. At the same time, towns were a means of further conquests and Islamization. Accommodation was provided both in occupied "towns" - fortresses if they were close to the urban center, and also in existing or new urban centers in new forms of military accommodation facilities: *ocaks*, *chardaks*, *towers*, *palankas*, etc. The new military-feudal class settled in the towns because it did not own land in the rural surroundings. The owner of the land outside the towns was Allah, that is, his representative on the Earth, the sultan, the user (holder) was the cultivator, and the sipahi was only the collector of part of the income as a salary for his service in the war. In principle, private land (mulk land) was in towns, mostly owned by all ruling ranks of the feudal class. Peasant-serfs as a source of material goods were easily available to them for exploitation.

For the efficient functioning of the sipahi-timar feudal system, the towns that accommodated regular soldiers (local janissaries), reserve soldiers - sipahis, fortress garrisons and the captain's army, and all the ruling state-administrative and religious class, had to be close to the agrarian surroundings, because they received salaries from endowments to agricultural land and its products. Such a position facilitated all forms of exploitation of the rural surroundings, that is, ensured the functioning of logistics for the army and taxes for the state. So, the possibility and level of transport communication and the agrarian environment, along with all other reasons, are a prerequisite for locating towns.

3. Urbanization and Islamization

In addition to the military and governmental, towns initially also had another role. In addition to conquests, the goal was the Islamization[12]. It was implemented first by settling a new Islamic immigrant military class in the settlements, and then by immigrating the already Islamized craft and trade population from other conquered areas.
The town also attracted the Christian population in the immediate vicinity. Coming to the town, converts from Christianity to Islam were exempted from most taxes, and Muslims also from land tax (*resm-içift*)[13] and some other taxes.

With its attractive forces, the town emptied its gravitational area, but it controlled the immigration of the Christian population into the town and thereby its urban demographic structure by two important elements in the tax system.

First, there was a ten-year obligation to pay a new tax, the so-called hearth tax (tütünresmi), and the second was retention of the ten-year obligation to the sipahi of the village from which one comes. Coming to the town, a non-Muslim rural resident fell under the status of a *muafiyet* [14], which in turn fundamentally changed his social and economic status.

The settlements that had the sultan's document, the muafnama, were given the status of a muafiyet settlement, or kasaba. In this way, they were transformed from a rural to an urban settlement. This document also established the boundary of the urban settlement which separated it from the rural surroundings.

As a rule, the boundaries were set for a part of the settlement, or for settlements with a majority Muslim population, while Christian parts of the settlements were most often excluded from the privileges[15]. And in that way, urban development was put in the function of Islamization.

In addition to economic reasons (living in the town), which became an encouragement for the change of religion (expansion) and strong urbanization, towns also allowed easy relocation of the Islamic population and filling of demographic gaps from already conquered and Islamized areas.

The entire history of the Ottoman Empire is rich in examples of smaller and larger, and even collective, relocations of entire settlements by political decision in order to control demographic processes.

What is also evident there is a direct connection of the tax system and the well-thought-out state and religious policy of Islamization with the process of rapid urbanization of empty conquered areas.

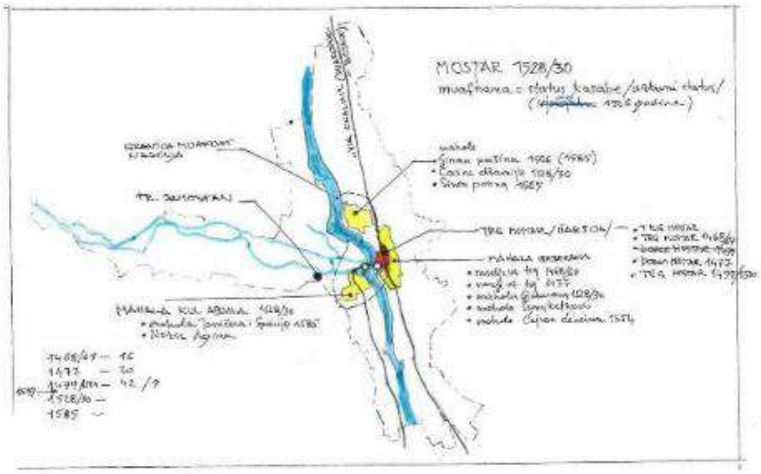


Fig. 1: Establishment of the muafiyet area, or the kasaba of Mostar at the beginning of the 16th century in relation to the mahala of the Geberans - Christians, which remained outside of this privileged status

We can vividly follow this process on the example of Mostar, where one of the well-known principles of Ottoman-type urbanization was applied. The process of urbanization took place with the construction of new Muslim mahalas from the immigrant Muslim population from other areas next to the already existing Christian settlement. In its further development, when this Christian mahala is Islamized, it will also be included in the boundaries of the town, fall under the muafiyet status and merge into the urban area.
Until the beginning of the 16th century, Mostar was an exclusively Christian settlement, which is evident from previous censuses in 1468/69 and 1477. The following 1499/500 census indicates the appearance of Muslim inhabitants as well, with 42 Christian and 9 Muslim families[16].

In 1519 the town had 85 Christian and 8 Muslim families. In the 1528/30 census, the majority of the population was Christian, but in addition to the Christian settlement, the mahala of the Geberans (Fig. 1), which had 86 families and 10 unmarried, there were also two Muslim mahalas, ČasnaDžamija (Venerable Mosque) and Kul Abdala, which together had 62 families and 35 unmarried residents. From this document we know that from 1506these two mahalas had the status of muafiyetmahalas and that Mostar had muafnama[17] that is, the status of kasaba, an Islamic urban settlement with precisely defined boundaries. It also indicates that Mahala of the Geberans was out of that status[18]. This means that the Christian part remained within the tax system for rural areas, and the inhabitants were subjected to drastically greater exploitation, although they lived within the same settlement (Fig. 1).

This inevitably led to the encouragement of Islamization of this part of settlement too, which would come under the town in the coming period with the expansion of the muafiyet area. This can be seen already in the next census defter from 1585, where the presence of the Muslim population was predominant, and Mostar was Islamized with 11 non-Muslim families and 514 Muslim ones. Of these 514 families, 106 were converts who converted to Islam in the first generation[19]. From this fact we can conclude that thirty years before (in the middle of the century) the balance was tilted in favor of Islamized inhabitants of the town.

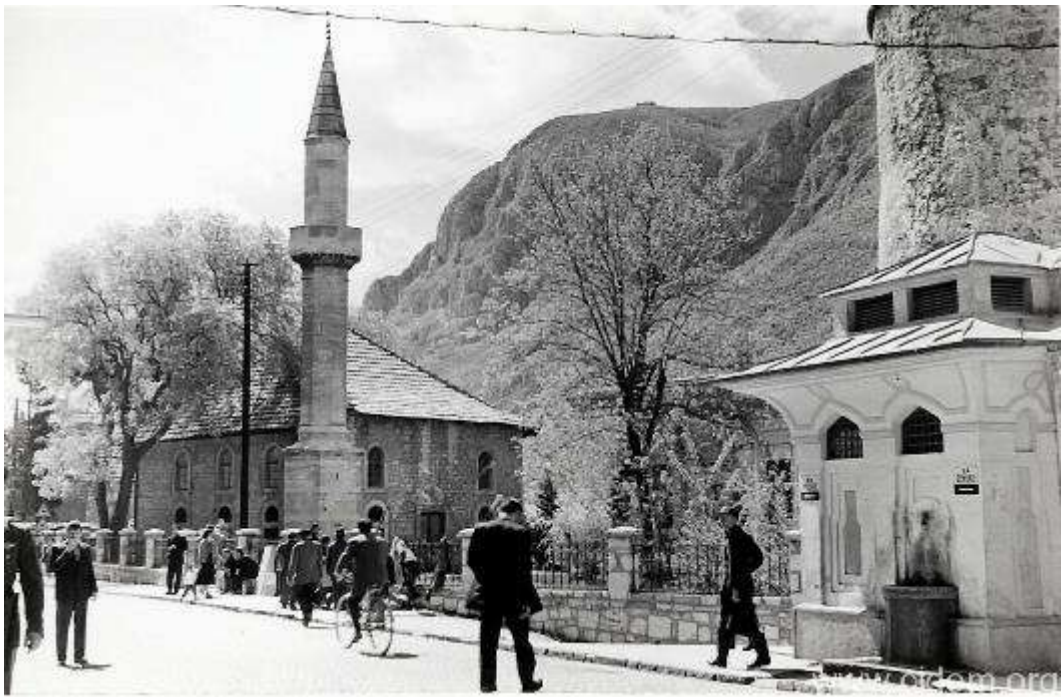


Fig. 2: Mosque in the Ceyvan-Cehajinamahala which developed from the mahala of the Geberans (Christians) right next to the medieval tower Tara

The process of Islamization and the expansion of towns emptied their immediate surroundings. Another reason for the emptying is the constant terror over directly accessible serfs and unlimited exploitation by extraordinary taxes[20]. It can be concluded that in the phase of formation or development of towns, the process of strong urbanization, immigration was strongly present, but so was the relocation of inhabitants from the immediate surroundings to towns. The processes of urbanization and Islamization took place simultaneously, intertwined and conditioned. Although most researchers claim that this process of urbanization began with the Ottoman occupation, N. Filipović believes that in the first period there were almost no changes in the urban structure of the existing towns and that the process of urbanization and Islamization did not begin until the second period after consolidation of authorities[21]. The specific study on the example of Mostar in this paper confirms this thesis.

4.The main characteristics of Ottoman urbanization

All the insights of historians about the Bosnian and Herzegovinian towns and the Balkans in a broader sense that are important for the urban planning profession can be reduced to six basic ones, specifically:

1. towns (cities) were legally and formally hierarchized by the status granted to them by the state, or the sultan (hierarchy of towns),
2. in the process of forming towns, encouragement for their emergence and development of waqf institutions was important,
3. towns had the exact territory determined by the regulation (institution of the muafiyet)[22] and as part of it the legal status of the muafiyet (exemption from a large part of tax duties),

4. towns were clearly divided into residential and business parts - mahala and bazaar.
5. The organization network by which the towns are located is a product of military needs and the religious obligation to accommodate (provide overnight stay to) merchants, all in the river valleys and at a distance of a day of horse gait.
6. In the Ottoman Empire there was a clear administrative division of settlements into urban and rural.

Various researchers classified Balkan towns differently in hierarchical terms. All of them were divided into open and closed (fortified) ones. The opened ones were without a military garrison, and closed ones with a military garrison. Open towns were divided into: *kasabas* and *shehers*[23]. From the military-fortress aspect, there were the following categories: a) *palankas* (smaller wooden fortifications on important roads) and b) towns that were divided into *hisar* (fortress, tower without ramparts) and *kale* (town fortified with towers and strong ramparts)[24]. Ottoman towns are most often called with two attributes. One is a state attribute such as a kasaba or sheher, and the other attribute is the military status of the town fortress such as a hisar or kale. Usually only one is written in documents, the dominant one[25]. The general and roughest division would be into kasabas and shehers, that is, small and large towns, and some add to this categorization also palankas or varoshes as a transitional form to kasaba[26]. In any case, the Ottoman Empire had an official classification of settlements. We do not know from the literature so far whether this was established by a regulation, whether it was the subject of standardization or an experiential-traditional product[27]. The following types of civilian settlements in the Ottoman period can be found in the literature:

- village (*česta, češta*). In Ottoman documents in our area, villages are marked with the Slavic word *čista* (it should be read as čestaorčišta)[28],
- settlements that are not rural, and have not yet developed into urban ones, are called sama, samo, sami-a-o. These are the suburbs of fortresses that have a market day or a pandjur (fair). They consist of mahalas, but do not yet have Islamic sacral institutions or economic facilities. The term "square" was used for these settlements in the pre-Ottoman period, and the Ottomans also call it "pazar" (the market, bazaar) in their documents. They differ from villages in that they have a market, a marketplace and a market day. As a rule, these settlements developed into towns. Sometimes they are called nefs, which literally means "the very place", and most often have the same meaning as kasaba,
- kasaba is "an urban-type settlement that exceeds village in size and importance, but has not yet reached the dimensions and appearance of a town."Kasaba was an unfortified settlement the population of which was engaged in trade and crafts. Like any town, it had limited territory with a minimum number of public buildings. A settlement became a kasaba by decree of the sultan, and this included changes in the status and tax obligations of the urban population (which had to be predominantly Muslim),
- sheher is a fully developed town (city) with a mandatory military garrison and state administration,

- varoshes are suburbs of medieval Balkan towns, and in Ottoman times it was the Christian part of the town.

Other names for settlements are often found in the literature, but their real status has not yet been determined. It seems that these are more linguistic problems considering the use of Arabic, Turkish and Persian languages, so the Arabic word medine corresponds to the Persian word sheher. Thus the names belde, mahmiyya, medine appear.

In theory, three approaches to the classification of towns are known so far, namely Anadolian, Balkan and Bosnian. Anadolian divides towns by function and size, so there are small (from 400 to 1000 tax units - households-hane), medium (from 1000 to 3000 tax households) and large ones (more than 3000 tax households). In the Balkans, administrative function and administrative status are dominant, so there are small towns with up to 400 houses, medium-sized ones from 400 to 800, larger ones with 800 to 1600 and the largest ones with more than 1600 tax units. The Bosnian classification of towns is based primarily on functional criteria. In order for a settlement to have urban status, it must have the following elements:

1- at least one mosque for common prayer on Fridays,
2- bazaar and fair day,
3- the majority of the population must be Muslim and engage in non-agrarian activities.

Studying Bosnian and Herzegovinian settlements, it was determined that sheher is usually the center of kaza, and kasabas are the centers of nahiyes. One of the essential conditions for declaring a kasaba a sheher is the existence of a military garrison in the settlement. In the 16th century, towns also appeared on important roads, namely at places of dangerous crossings. These were towns in which the residents were responsible for the safety of travelers. These were derbend settlements with a Christian population that enjoyed privileges for their service and which were called dervendjis.

There is no doubt that the waqf is one of the fundamental Islamic institutions. Among others, one of its goals is to build facilities of Islamic culture and religious requirements. It played an immeasurable role in the formation and functioning of towns. Many of the researchers touched on this aspect only incidentally, but in this area HamdijaKreševljaković and AdemHandžić dealt with it in particular detail.

By an administrative-legal act, the imperial firman (berat), the settlements changed their status and became kasabas or shehers. This act changed the legal position of the population in them. Muslims and Christians in the towns were freed from the status of raya, and thus fully or partially from state or feudal obligations, regular and extraordinary ones. Urban territory was clearly and precisely demarcated from the village and rural territory. This act was called muafnama, and the legal institute muafiyet. Imperial firmans on the establishment of a settlement usually provide information on a service of the inhabitants of that settlement for the state and indicate the reason for its formation, which is usually a military-strategic or communication need.

It is not known what the conditions were for a settlement to become a kasaba, but it is obvious that one of the important ones was the majority Muslim population. This condition was achieved by building a new settlement, next to the existing pre-Ottoman one, for the immigrated Muslim population, or by building a new Muslim mahala within the existing settlement. Thus, in the further development of the varosh (Christian mahala), the peripheral settlements of towns (new bazaars and their Muslim mahalas) remained. Strong medieval urban centers, such as Fojnica, Kreševo, Sutjeska, Visoko, Olovo, Srebrenica, for centuries tenaciously resisted Islamization and urbanization, and thus slowly gained the

status of a kasaba. In them, the process usually took place slowly, and so by growing through the medieval tissue.

With a majority Muslim population, Handžić believes that it is clear that the conditions for a settlement (village, market, varosh) to become a kasaba are cultural, economic and urban-geographical. Cultural implies the existence of a bazaar mosque, town mosque. Economic conditions include a square, which means the existence of a weekly fair day, and several shops (bazaar), then an inn or caravanserai and possibly, but not necessarily, other institutions that gave the settlement a Muslim urban character. Urban-geographical conditions implied clear boundaries of the kasaba and a clear demarcation from the rural area, which was determined by issuing a muafnama, a document on the status of the town and its boundaries. This request resulted from tax obligations to the feudal lord and the urban space exempted from these obligations.

The division of Ottoman towns into a mahala and a bazaar is a commonly known, repeatedly mentioned fact, so it is not necessary to prove it or deeply elaborate on it here.

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[2] Bejtić, A., 1953: 234; Handžić, A., 1974: 64.

[3] Redžić, H., 1983: 85; Redžić, H. 1982: 37; thinks that the layout of towns changed by the second half of the 16th century, but this is denied by graphics from Kuripešić's travelogue; Kuripešić, B., 1530: Our research will prove on the example of Mostar that this happened only in the second half of the 16th century.

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[10] Moačanin, N., 1999: 137–157.

[11] Bakaršić, S., 1973: 218.

[12] Handžić, A., 1974: 62 and 67.

[13] Moačanin, N., 1999: 102–105.

[14] Muafiyet - complete or partial release of the raya (rural) population from state and feudal obligations, regular or extraordinary ones; Handžić, A., 1974: 60.

[15] Handžić, A., 1974: 65.

[16] Todorov thinks differently, that Mostar has no Muslim families, as previously quoted.

[17] The existence of the muafnama was also recorded in a document from 1506 (Čar-Drnda, H. 2014: 64)

[18] Čar-Drnda, H., 2014, 158, We know that Mostar is a kasaba with muafiyet status since 1506 (Čar-Drnda, H. 2014: 64), and we know from this document that it is only two mahalas with that status.
[19] Registered in the census defter as sons of Abdullah (slave of God, favorite of God), which is a designation for a convert from Christianity to Islam Čar-Drnda, H., 2014: 182-183.
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[23] Zlatar, B., 1988: 65–66.
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RECONSTRUCTION OF EXISTING OLD BRIDGES WITH ORTHOTROPIC STEEL DECK PANELS AROUND THE WORLD

Doncho Partov [1], Hartmut Pasternak [2], Alfred Mangus [3] , Yvona Koleková [4] and Lazar Georgiev [5]

[1] University of Structural Engineering and Architecture, VSU "L. Karavelov", Sofia
[2] BTU Brandenburg, Germany
[3] Caltrans, California,USA
[4] STU Bratislava,Slovakia
[5] UACG, Sofia

Abstract: *The focus of this article is the discussion about conceptual solutions for reconstruction of existing old steel bridges with orthotropic steel deck panels. This paper describes successful experience of reconstruction of old steel bridges using this contemporary technology around the world. The advantages of large piece erection of orthotropic steel decks panels by reconstruction and widening of old bridges will be demonstrated. Case histories show that the low weight of orthotropic option for redecking is desirable. The technique of orthotropic steel deck panel replacement is the innovative technique for reconstruction and widening of existing steel bridge. Reconstruction of old existing steel bridges with orthotropic steel deck panels are very efficiency.*

Key words: *reconstruction, widening, existing steel bridge, orthotropic steel deck panels*

1. Introduction

According [1] rehabilitation of existing bridges is an extremely complex and challenging aspect of bridge engineering. Widening and reconstruction of old steel existing bridges without interruption of traffic is even more complex. The focus of this discussion is conceptual solutions, an overview of the fundamental issues or choices in practicable widening and reconstruction of old steel existing bridges. The technique of orthotropic steel deck panel replacement is the innovative ABC (Accelerated Bridge Construction) technique for widening and reconstruction of existing bridges. The USA Federal Highway Administration (FHWA) is promoting the term "ABC" for economical efficient construction methods with more prefabrication and less site work. The goal of any ABC method is achieve the FHWA's desired 100-year service life for a new bridge. FHWA's goal is (a) to minimize traffic delays while erecting a bridge, (b) to minimize river commerce and harbor shipping delays while erecting a bridge over navigable bodies of water, and (c) to minimize environmental impacts while erecting a bridge. Some of the featured existing bridges were not physically widened, but their traffic flow was increased via renovation of the existing deck system with orthotropic steel deck panels. Bridges built and in operation with steel orthotropic steel decks in North America are very rare; about

[1] Doncho Partov, Prof./PhD, Univ. Struct. Eng. and Arch.,VSU "L.Karavelov", partov@vsu.bg
[2] Hartmut Pasternak, Prof./DSc, BTU Brandenburg, Germany, H.Pasternak@web.de
[3] Alfred Mangus, Caltrans, California,USA, Al Mangus@dot.ca.gov
[4] Yvona Koleková, Assoc.Prof./PhD, STU Bratislava, yvona.kolekova@stuba.sk
[5] Lazar Georgiev, Assoc. Prof./Phd, UACEG, Sofia, Lazar_fte@uacg.bg

100–120 are orthotropic while there are 650 000 bridges in the USA alone. The FHWA is currently in the process of creating a new orthotropic bridge manual to replace the 1963 Orthotropic Bridge Manual authored by Roman Wolchuk and published by the American Institute of Steel Construction (AISC). There is lack of enthusiasm in the USA for orthotropic bridges that existed in the 1960s among the US steel industry and affiliated trade associates. Another design challenge is the lack of orthotropic bridge design software. Although US software has many excellent specialized bridge design programs, none is specific for orthotropic bridges based on the American Association of State Highway and Transportation Officials (AASHTO) Bridge codes. Ironically USA orthotropic experts are involved in the actual design or review of designs of bridges located in other countries. Featured widened bridges from around the world include the Cologne-Rodenkirchen Bridge of Germany (1994); Wakato Ohashi Suspension of Japan (1999); Angus L. Macdonald Bridge (1999); Tamar Suspension Bridge, UK (2001)), and the Songsu Bridge, Korea (2002). A comprehensive reference list (Table 1) in [1] is provided to assist in obtaining more detailed design and fabrication information about renovated bridges with orthotropic steel decks. A comprehensive table of projects located around the world is also included [1].

2. Worldwide Summary of Orthotropic Redecking Projects

Panelized decking was first promoted in the literature in the 1960s or possibly earlier [1]. The Russian Government uses a standardized open-rib deck system for all its bridges [3-5]. Lions Gate Approach Viaduct popularized the use of renovating existing superstructures with redecking of orthotropic panels in 1975 [6-8]. Featured bridges from around the world deemed to be the most valuable to the reader are included in Table 1 [1]. Although an honest effort was made to locate projects, it is highly probable some bridges were not included in this table. Roman Wolchuk has documented bridges redecked in North America [9-12]. His articles and those of the various project engineers and researchers are recommended for reading about the redecking issues [13-17]. There is a 20–40 % reduction in dead weight of the deck per square meter of deck area [11].

3. The Great Deck Durability Debate

There is a great deck durability debate among designers, owners, contractors, product manufacturers and trade association representatives. This discussion is beyond the scope of this review. However, these examples demonstrate that pre-engineered orthotropic deck panels are internationally used as the most practicable solution for bridge widening, when the lowest total weight of the superstructure is the controlling issue. Any deck incorrectly designed, fabricated or constructed will provide misinformation on that deck system solution (Table 2 [1]). The heated debate is always whether the deck system was an abnormality or a deviation from industry standards. The orthotropic deck system was initially utilized based on the logic of post- World War II steel shortages, plus an abundance of unemployed engineers and welders. Today, the wealthy countries want durable structures with around 100–150 years of life. In the wealthy "G-8" countries engineers and welders are highly paid with material costs of much lesser importance. In the USA "globalization" or "out-sourcing" of complex welded orthotropic bridges has been debated amongst the taxpayers, involved parties and steel industries. A very practicable problem of durable structures of 100–150 years of life is that the original designer will be deceased. Thus, documentation passed down through generations of designers and bridge

maintenance engineers is paramount to increased knowledge. Minimal orthotropic top-deck plate thickness has increased with newer versions of codes. The authors have proposed a "fat deck" solution of 25 mm deck plate for structures of 100–150 years of life. This allows for multiple wearing surface replacements, accidental milling and "pit" rusting. Comparing designs between different countries is more complicated than just translating the languages. (It is also more difficult because engineering slang or jargon varies with each country, so basic language translations are incorrect). Every country has different "design vehicle" live loading, which complicates the issue further. The manufacturers of special large vehicles have to reverse engineer vehicles' axle locations and spacing so as not to overload the existing bridge infrastructure. An interesting graphic comparison between code minimum design vehicle loads of Germany, Belgium, Sweden, Norway, Finland, Netherlands, Italy, Spain, USA (HS 20), Switzerland, United Kingdom, France and Japan is shown in Fig. 1. These complexities make it even more difficult to internationally compare design and maintenance issues. Thus, case histories should be looked at mainly from a conceptual philosophical viewpoint. Copies of details from another country's codes may or may not work without investigating it in conjunction with complex codifications that most designers utilize.

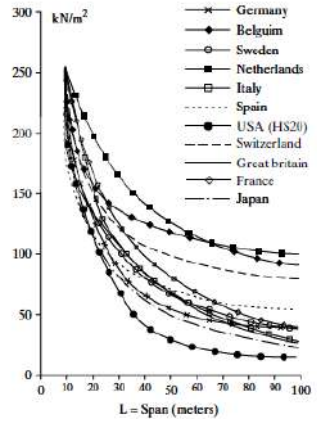


Fig. 1. Various four-lane design loadings[39]



Fig. 2. Burlington-Bristol Bridge NJ, PA (installed in 1931).

3.1. Background

An orthotropic deck system consists of a flat, thin steel plate, stiffened by a series of closely spaced longitudinal ribs and supported by orthogonal transverse floor beams. This is shortened from the original term orthogonal-anisotropic. Orthogonal means that it is pertaining to or involving right angles or perpendiculars. Anisotropic means that it has the property of being dependent directionally. These terms apply because the orthotropic deck has a series of longitudinal ribs that are at right angles with the supporting diaphragms and floor beams, and deck also has a completely different set of properties longitudinally and transversely. There are many advantages to implementing an orthotropic deck system, and sometimes the system is necessary because of construction time restraints and span length requirements. Compared to traditional reinforced concrete decks, orthotropic decks are lighter, have a shallower deck depth, and can be installed much more rapidly. The lighter weight allows longer spans to be more efficiently designed. Also, orthotropic decks are often used in moveable bridges due to the lower weight. The disadvantages of orthotropic decks include a high cost of fabrication due to the amount of welding required and less flexibility in the field due to the fact that the panels must be completely pre-fabricated. In

the 1920s, American engineers began using steel plates riveted to steel beams for large movable bridges. The purpose was to minimize the dead load of the lift span. The lift span for the Burlington-Bristol Bridge Company, a private toll company, used bare steel "checkered plate" for minimal initial completed superstructure weight. The designer wrote, "Since the plates are heavy enough to distribute some load to the adjoining beams, the individual stringers are designed to carry only 80 % of the maximum wheel loading." Thus began the publishing of the idea of using the steel deck plate in harmony with rolled steel sections. At the time of erection it was the longest lift span in existence. So this bare steel plate riveted to steel beams lasted 64 years without the kind of wearing surface used on modern orthotropic bridges **(**Fig. 2 *Burlington-Bristol Bridge, NJ, PA installed in 1931, Riveted "checkered steel plate" deck after 64 years of use prior to removal in 1995).* Actually, ADT (Average Daily Traffic) is also critical in comparing the life of a bridge. The average life for either concrete decks or open steel grating is in the range of about 30 years, due to heavy road de-icing salting used in colder USA states. The Caltrans owned San Mateo Hayward Orthotropic Bridge opened in October 1967, and it has the original wearing surface supported by three-fourth of an inch (about 19-mm) thick deck plate.The self-weight or dead load typically exceeds the loadings from vehicular traffic for any long-span bridge over 100 m. Orthotropic steel deck bridges offer significant benefits to their owners because the lowest final total weight of bridge results in "total bridge initial cost savings". Extensive comparisons on redecking weight savings are available from Wolchuk [10-13]. The complex issues of maintaining large suspension bridges are discussed by Buckland [7]. Hybrid superstructures are being built mixing orthotropic with prestressed concrete [15]. A contractor, in references [15,16] discusses Steel Bridge Economics. In the USA, 99,9 % of all deck repairs/replacements are replacements in kind or concrete for concrete. The US legal system requires that every document needed for a lawsuit, and/or independent study, to be placed on the website [41]. Apparently, the decision was to repair the deck system first; then strengthen or renovate the numerous steel bridge components at a later date. Apparently, no deck weight savings study was performed taking into consideration other deck material choices similar to those listed in Table 3 [1] for this long-span steel truss vertical lift bridge. The centre span of the I-35W bridge consisted of a single 458-ft (140 m) steel arched truss over the 390-ft (119 m) channel. The deck was 113 ft 4 in (34,5 m) in breadth and was split longitudinally. It had transverse expansion joints at the centres and ends of each of the three spans (main and back spans). So it is about twice the deck area as the bridge in Table 3[1], but with almost identical main spans. These engineering deck studies are expensive in terms of designer costs, but may be a bargain in terms of overall bridge management costs. Resurfacing consisted of removing the top 2 inches (about 50,8 mm) of the existing 8-inch (about 203 mm) concrete deck slab. New concrete material was cast on top to bring the deck back to its original thickness. Orthotropic steel deck dead weight savings, the maximum possible, would be in the range of 2 232 504 kg (2 456 t) of dead weight just for the main span area. Dead weight savings would be double if back spans were included i.e. 4 465 500 kg (4 912 t). This possible would probably have saved the cost of structural retrofit and other numerous steel components, especially if orthotropic steel deck had been installed. "Theoretically", replacing 25 % of the deck in kind with resurfacing requires no "construction engineering calculations". At the time of the I-35W bridge collapse, four of the eight lanes were closed for resurfacing, and there were 261 000 kg (287,5 t) of construction supplies and equipment on the bridge. Normally, placing materials and equipment would require the contractor to provide engineering calculations submitted to most owners in the USA. The media is speculating on the role the stored materials played in the bridge collapse. Most bridge owners in the USA require falsework engineering calculations prepared by a licensed engineer to be submitted to the owner. In 1967, US federal laws established a

national bridge maintenance inspection and repair program to prevent existing bridges from collapsing while the general public was driving on a bridge. Thus, US national and worldwide interest has been the result, since these laws were intended to prevent an I-35W-type collapse. There have been other bridge collapses in the USA since 1967 due to scour, earthquake, fires, hurricanes, barge and ship impacts, and vehicular impacts. Some deaths have occurred from these other failures. In the US legal system, some "out-of court" settlement agreements prohibit the sharing of "lessons learned" for many problematic structures and collapses. However, the opposite is true for the I-35W west-bound bridge collapse tragedy. At least two collapse reports will be made public. This collapse does clearly demonstrate the risks of bridge retrofit and redecking work while the general public is also driving on the bridge. No orthotropic steel deck bridges exist in the State of Minnesota and the vast majority of other states in the USA. There is a wide-spread lack of interest in the orthotropic system in the USA and many recent projects are being fabricated in other countries for US owners. Thus it is a difficult solution for US bridge fabricators. *About ten US consulting firms have actual orthotropic bridge design experience. These engineers make up for a lack of public domain software and design aids with in-house computer programs. To stay competitive these software solutions are kept as proprietary "trade secrets". These firms work on bridges in other countries to stay competitive. Thus, an owner will need to make that extra level of effort and incur additional engineering costs in the USA to get an orthotropic deck system built.* The cost of engineering and the cost of construction would have greatly exceeded the planned resurfacing option chosen and in progress for the I-35W. The point is not to second-guess what others should have done on the collapsed I-35 W Bridge since it is too late. But a possible useful rehabilitation tool, "orthotropic steel deck redecking panels" should be included in the designers' solution toolbox for a much larger volume of future deck replacements, including widening for long-span steel bridges. Steel bridges similar to the I-35W apparently exist in other locations in the USA and other countries. Table 1 includes examples of redecking of steel truss bridges. One of them, the 100-year-old arch truss bridge "Ponte Dom Luiz I" in Porto Portugal by Gustuv Eiffel, was renovated and saved for light rail or trolley trains [21]. Until the two collapse reports are made public, no dramatic changes in the numerous US bridge-owner policies are expected to be made. Concrete deck corrosion and deterioration are a major bridge maintenance cost in the USA. Some bridge owners wait until portions of the concrete deck fall out (known as "punch outs") before ordering a total concrete deck replacement because of limited maintenance funding. A 90-year-old concrete arch bridge in Snohomish County, Washington, has won a national US award from the American Public Works Association after engineers discovered a way to add about 62 % more surface area to the deck without adding significant weight. Crews widened the narrow span with heavy slabs of precast concrete, but counter-balanced the load with lightweight cellular concrete to replace the heavier soil fill on top of the arches. By avoiding a complete replacement, the county saved more than 4 years and $5 million on the project. Also for 100 % concrete bridges, lower total dead weight is seen as innovative. Currently, US highway funding has actually decreased after the I-35W collapse. Thus, it becomes necessary for cost effective practicable deck replacement options. Concrete deck replacement of 100 % for steel bridges is probably not a wise policy, since reinforcement of numerous bridge steel components may also be needed (Table 2) [1]. Saving the maximum amount of dead weight by switching to orthotropic steel deck panels can reduce loadings on many other bridge components. This is a practicable choice for older long-span steel bridges with concrete decks. For short span steel bridges, the orthotropic steel decks may not be cost effective. Another US State Department of Transportation released an orthotropic redecking design plan set in 2008 for construction bidding using the "Buy America Clause". This would have been their first bridge to use orthotropic decks. A series

of parallel simple span trusses with a maximum span of 338 ft (103.02 m) × 2 –lanes, or 20 ft (6.09 m) (1451 ft × 20 ft = 29 020 ft^2 or about 2 696 m^2) for redecking. The south trusses would be redecked with concrete and north trusses with 723 t of orthotropic steel deck panels using trapezoidal ribs. The new concrete deck was much cheaper and bid prices for orthotropic steel deck panels exceeded the owner's planned budget. In retrospect, the concept allowed for a 25- to 35-year life replacement concrete deck to compete as an equivalent with a 100-year life fatigue orthotropic steel deck. The age of the existing trusses was not stated in publicly available bid plans. So the designer and owner need to match up fatigue life and detailing with what is really needed. The AASHTO Bridge code shows 100-year life fatigue detailing. If the existing truss bridge had a 40- to 50-year life so far, then adding a new 100-year orthotropic deck is probably logical, since the life of the deck is much longer. Most western designers tend to favour the trapezoidal rib over flat plate ribs. Caltrans' largest orthotropic bridge, the San Mateo Hayward Bridge, uses flat plate orthotropic ribs. *The Bulgarian and Russian mass-produced orthotropic deck panel system uses flat ribs, which are easier to weld, inspect and fabricate.* They are quite acceptable for many bridges. It is not known if weight savings were needed, but plans do not indicate rehabilitation to other truss members. So selecting the appropriate bridge is important because orthotropic decks are more expensive (Fig. 3).

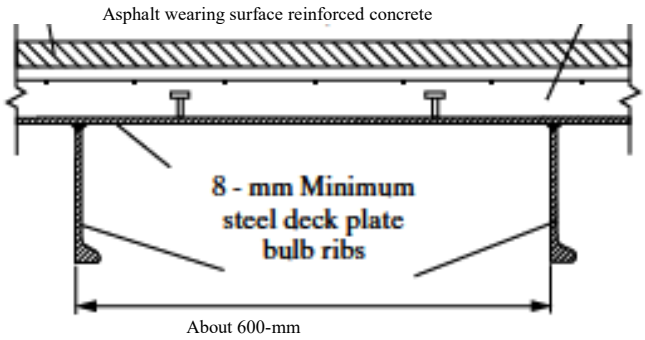


Fig. 3*:* Rio Verde Bridge, Italy–courtesy of IABSE [22]

Engineers love to experiment with solutions. It is common to have hybrid deck solutions in bridges. There are examples of orthotropic wearing surface multi-materials plus multi layers of protection [22-24]. The most popular topics at the 2004 and 2008 OBC symposiums [42] were wearing surface and metal fatigue issues.

4. Reconstruction of old Existing Bridges with orthotropic Deck Panels-Case history

4.1 Cologne-Rodenkirchen Suspension Bridge Widening, Germany (1994)

The Cologne-Rodenkirchen Bridge is part of the Cologne ring road in Germany. The 378 m span, traditional two main cable suspension bridge was opened in 1940, destroyed by a bombing in 1945 and rebuilt in 1954 with a concrete deck. This bridge is a three-cabled suspension bridge. They engineered the construction of the widened towers, a new third cable "A", and erection of the new steel decks at "A-B" and redecking at "B-C" [25,26] About half the 12,000 t of fabricated steel for the stiffening girder and orthotropic decks were made in the UK and the remainder in Germany. Cleveland Bridge replaced the existing concrete deck with an orthotropic steel deck, and erected the 2 200 m long deck on site, including lifting of the 1 000 t units with gantries on the main cables (Fig. 4).



Fig. 4. Completed Widening Cologne – Rodenkirchen – cables "A"; "B" and "C" [25,26]

4.2. Wakato Ohashi Suspension Bridge, Wakato, Japan (1999)

Wakato Ohashi is a toll way totalling 2,1 km in length and is Japan's first full scale suspension bridge, which was completed in September 1962. The toll way road surface was widened. Doubling the traffic lanes from two to four increased the bridge's traffic capacity. The very wide original sidewalks on the suspension bridge section were sacrificed for traffic lanes. *The heavier reinforced concrete deck was replaced with open-rib bulb flat orthotropic steel deck panels (OSDP), using a large gantry crane* (Figs. 5, 6). This allowed two lanes of traffic to use the bridge during renovation [27].



Fig. 5. Existing sidewalks, replaced with OSDP

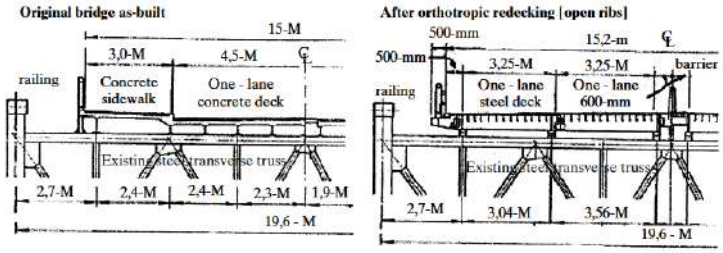


Fig.6. Original Cross section (left side); New cross section (right side)

4.3. Angus L. Macdonald Bridge, Halifax, Canada (1999)

A similar approach was used on the Canadian Angus L. Macdonald Bridge. The width between the trusses is 11,28 m. The concrete deck in the approach spans deteriorated over the years since the 1950s and had to be replaced to restore the original safety factors of the bridge [28] (Fig.7). *The concrete deck was replaced with an orthotropic steel plate deck. Each orthotropic steel plate panel was covered with a special wearing surface at the steel fabrication facility.* When the deck replacement was complete, the entire deck surface received one more layer of wearing surface. **The site construction began in May 1997 and the entire bridge officially reopened on October 31, 1999.**



Fig.7. Completed widened Angus L. Macdonald Bridge

4.4. Songsu Steel Truss Bridge, Korea (2002)

The original concrete deck on the steel truss Songsu Bridge opened in the 1970s, and collapsed in Oct 1994 [29]. A collapse investigation was completed. Due to high traffic demands, a replacement superstructure the 672 m long seven span Gerber truss bridge across the Han River, in Seoul Korea was expedited. The five spans are each 120 m in length. *Between 1999 and 2002 it was widened (from four to eight lanes) using a new exterior truss on each side with orthotropic decks due to even higher traffic demands,* (Figs. 8 and 9).

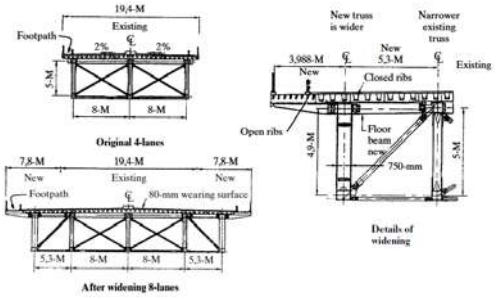


Fig. 8. Before and after widening. Songsu Bridge

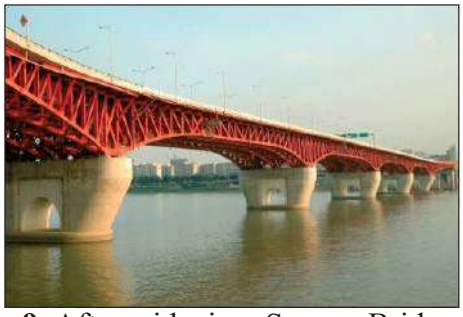


Fig.9. After widening: Songsu Bridge

4.5. Tamar Suspension Bridge, UK (2001)

The Tamar Bridge opened in 1961, and it was the longest suspension bridge in the UK. In 2001 it was widened (from three to five lanes) by using two cantilever decks (Fig. 10) [30]. Since 1961, all traffic merged and shared the three lanes. The five lanes are divided as follows: three lanes carry the A38 trunk road; the fourth is reserved for eastbound local traffic and the fifth for pedestrians and cyclists (Fig. 10). *The original concrete deck had badly degraded and it was entirely replaced with orthotropic steel deck panels.* New cantilever lanes were added to each side of the existing bridge before the existing concrete deck was replaced for diverted traffic. The existing members were strengthened by additional steel components, and 18 new diagonal cable stays were also added. By utilizing staged construction, the three lanes of traffic over the bridge were never interrupted. Engineers must be constantly aware of the distribution of weight while renovations are being carried out. *The orthotropic steel deck was the best choice of construction material for the replacement deck.* Today, the bridge supports five lanes of steel deck instead of the original three of concrete (Fig. 10). The superstructure weighs only 25 t more than the original, even with the replacement steel deck, plus the addition of two cantilever lanes. *The new steel deck is formed from 82 orthotropic panels.* Each panel weighs 20 t, and measures 15 m × 6 m. They were constructed in Darlington and driven nearly 600 km to the Tamar Bridge and welded together onsite [30].

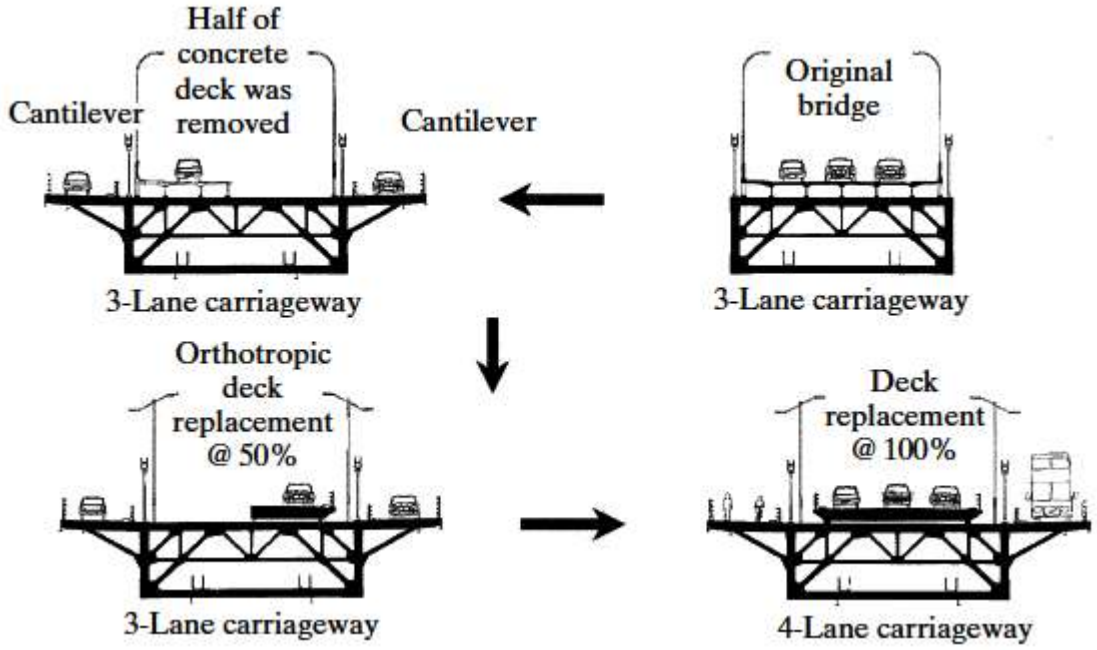


Fig. 10. Tamar Bridge. Four key phases of staged redecking,

4.6. Brooklyn Bridge orthotropic Deck installation

The Franklin Square Arch Structure roadway of the iconic Brooklyn Bridge was recently retrofitted with orthotropic deck panels. The advantages of orthotropic deck panels include rapid installation, reduction of dead weight loading, longer service life and minimal maintenance. During installation, the orthotropic deck panels were aligned before being welded in the flat and overhead positions. Multiple alignment tolerances needed to be met, including: vertical alignment, root openings, diaphragm offsets and panel elevations. The Franklin Square Structure is a truss bridge that utilizes pin connections with eyebar members. It is a trapezoidal shape; with the shortest span about 169' and the longest span at about 212' in length (Fig.11) [12]. There are theoretically no bending stresses throughout the structure due to the freely rotating pinned connections. The trusses were constructed from wrought iron, which has low carbon content in contrast to steel. Wrought iron is tough, ductile, and has good resistance to corrosion, which is a contributing factor as to why the structure is still in good condition. In 1999, after it was found that the existing pins were failing, six steel arches were added below each of the existing trusses. Arches were chosen so that the roadway could remain open, and also to keep the appearance consistent with the original historic structure. Increased dead load throughout the years was the cause of the pins failing (Fig.11). The first step in the Brooklyn Bridge Project at the Franklin Square Structure was to replace the floor-beams that the orthotropic deck would eventually be supported by. After the floor-beams were replaced, the next step was to remove the existing reinforced concrete deck, including the underlying supporting steel. *After removal of the existing deck and supporting steel, a temporary steel deck panel system was installed*. A total of 32 temporary deck panels were installed on the Brooklyn Bound roadway. When the orthotropic deck panels were ready to be installed, the temporary steel deck panels were removed with a crane (Fig.12). Upon delivery to the project site, the orthotropic deck panels were inspected for damage by American Welding Society Certified Welding Inspectors. A total of 24 orthotropic deck panels were installed on the Manhattan and Brooklyn bound lanes at the Franklin Square Structure (Fig.12).



Fig. 11. Franklin square structure



Fig.12. Panel installation.

4.7. Lions' Gate Suspension Bridge Suspended Structure Replacement

The Lions' Gate Suspension Bridge, which was opened in 1938, has a 472 m centre span and is located in Vancouver, British Columbia, Canada. Figure 13 [6] shows the elevation view of the bridge. In 1997 the designer was retained to design the replacement of the suspended structure (deck, sidewalks, stiffening trusses, and hangers including seismic upgrade).

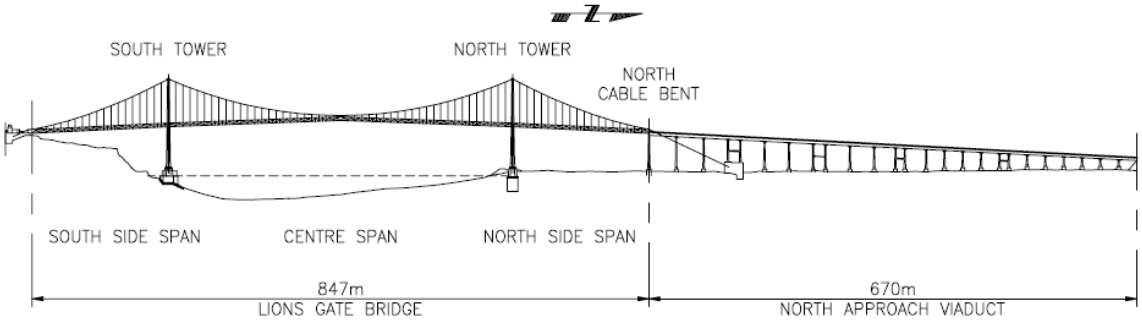


Fig. 13. Lions' Gate Bridge elevation

The Lions' Gate Suspension Bridge is a landmark structure marking the entrance to Vancouver, one of the busiest harbours on the West Coast of North America. Constructed in 1938 to a brilliantly light design, the bridge was privately financed. Since 1972, the Owner's Bridge Engineer has designed all major structural works that have been executed on the bridge, including the deck replacement of the north viaduct during short night time closures. This design is for the "first" replacement of a concrete deck with a lighter, stronger (and wider) orthotropic steel deck. There were several design challenges involved in the project. These include: • replace the suspended structure while minimizing the impact on regular daily traffic; • widen the traffic lanes and sidewalks while not increasing the weight; • increase the aerodynamic stability of the bridge; and • increase seismic performance of the bridge. The new suspended structure had to be designed to be replaced with minimal impact to the 70 000 vehicles per day using the bridge. The concept was to have 47 deck sections, typically 20 m in length weighing 106 tonnes, progressively erected from north to south. The field splices were located to allowed the new deck section to be raised with little interference from the previously erected section. The splicing of the stiffening trusses and deck troughs were all made with bolted connections, to allow for alignment and quicker completion of the splice. The original stiffening trusses, floor beams, stringers, concrete filled tee-grid deck, and steel sidewalks produced a relatively light design for the suspended structure. Though the new deck is approximately 35% wider, with almost 45 % more usable width than the original deck, the weight was kept to that of the original bridge. See Figures 14, 15, 16 and 17.

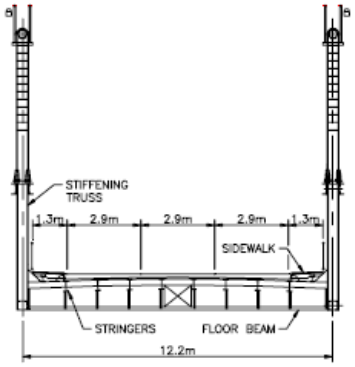


Fig. 14. Old Cross Section



Fig. 15. Old Sidewolk Photo

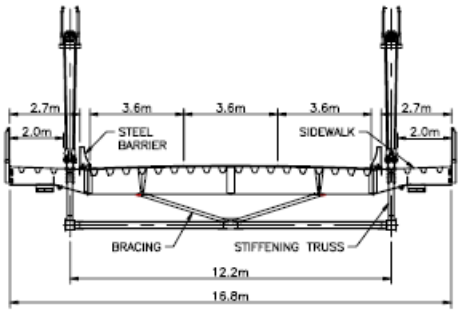


Fig. 16. New Cross Section



Fig. 17. New sidewalk rendering

Substantial increase to the weight of the suspended structure would have required the existing main cables, towers, and anchorages to be upgraded, therefore increasing the cost of the project. Maintaining the same light weight was also critical to allow sequential replacement of the deck in sections without inducing unacceptably large deformations and stresses in the original or new structural components during reconstruction. The new longitudinal stiffening trusses are composite with the orthotropic deck, and unlike the original trusses, the new ones are placed under the deck. As for any long span bridge, the aerodynamics of the new section was evaluated. The evaluation consisted of full bridge aeroelastic models and section models, with various cross sections. Once the geometry of the cross section and elements was finalized the aerodynamic characteristics of the bridge were evaluated. The model testing produced wind coefficients for loading on the bridge. A buffeting analysis was conducted to determine the dynamic interaction of the structure with the wind causing an amplification to the loads in the structural elements. The configuration of the new cross section, with lateral bottom bracing creating a torsion box, greatly improved the aerodynamic stability of the bridge. The testing program determined that the critical flutter velocity was approximately 70 m/s, well in excess of the 45 m/s target speed. As a comparison, the original bridge had a critical flutter velocity of about 35 m/s. Due to the significance of the structure and the location on the West Coast of North America, the response of the structure to an earthquake was crucial in the design. Two types of seismic events were considered, a moderate magnitude quake close to the site and a major, subduction earthquake located some 200 km away. Ground motion records were developed for the Lions' Gate Project location; rock motion records for the south foundations and soil motion records for the north foundations. Time history analysis was conducted for the completed bridge, including the north approach viaduct. The new structure has a few characteristics that improve its anticipated performance in the design earthquake; the dead load of the suspended structure had been kept to a minimum and the primary dynamic

periods of the structure are long. *These characteristics reduce the impact of a seismic event on the structure, the result being that wind loading was the controlling factor for many of the transverse structural elements.* For new elements of the bridge, attention was paid to the movements of the bearings at the towers, north cable bent, and the south foundation. The foundations of the existing structure required some modifications to ensure the integrity of the concrete. This consisted primarily of confinement of the concrete to satisfy current codes. The orthotropic deck was built in four full length subassemblies by pressing the U-shaped troughs to the deck plates and welding a continuous 85 % (minimum) one sided partial penetration weld (see Fig.18).



Fig. 18. Trough to deck plate welding

Once fully welded, the floor beams were cut at the interface between the unconnected deck plates, and the four subassemblies were removed from the jig and turned right side up. The stiffening trusses were then welded onto the two outside subassemblies.

4.8. Rehabilitation of Tornionjoki Steel Truss Bridge, Finland

Truss bridges have been a solution for railway bridges and bigger road bridges over the stronger rivers in the country. One example is the Tornio River Bridge (Fig.19), which was completed in 1939. The bridge was the biggest road bridge at the time. The main span has a length of 108 m. The bridge has been renovated. The concrete deck has been changed to an orthotropic deck and the pedestrian lanes have been widened outside the truss girders.

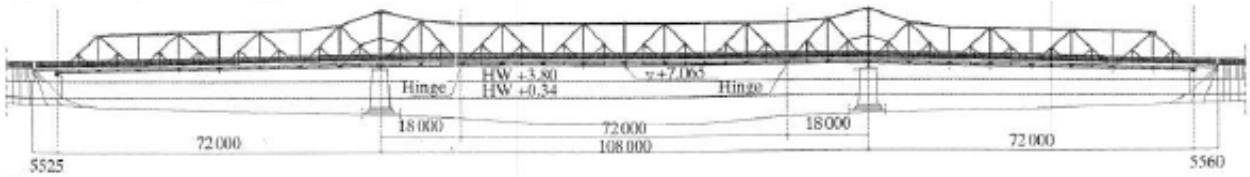


Fig. 19. Elevation

The construction of steel bridges in Finland began in the 1850's. At this time bridges were prefabricated mainly in Great Britain, Belgium and Germany. The assembly of Bridges was carried out on site. At the beginning of the 20th Century the development of domestic workshop techniques enabled construction of steel truss bridges were destroyed in the 2nd World War, but most of them were rebuild after war. The steel truss bridge was a superior bridge type for long river crossings with span length more than 100 m. In Finish rivers the middle piers of bridges must be equipped with ice-breakers but at this time the construction of large, massive ice-breaker piers in water was expensive and challenging work. The disadvantage of old steel truss bridges is their width. It is almost impossible to utilize an

old bridge which requires widening of several meters. The easiest way to widening of several meters. The easiest way to widen a deck to accommodate pedestrians is to construct steel cantilever outside the original steel frame. The Tornionjoki River is border river between Finland and Sweden (Fig.20) [44]. The city of Tornio is located on an island where the river discharges into the Gulf of Bothnia. An intersecting detail is that the bridge between the City of Tornio and Sweden was completed 52 year earlier than the bridge between the City and the mainland. The connection to the mainland was operated by ferry until Tornionjoki Bridge was completed in 1939. The spans of the bridge are 72 m – 108 m – 72 m in length (Fig.20). The width of the deck was originally 5 m for vehicles and 1,5 m for pedestrian. Between 1962 and 1963 the deck for vehicles was widening to 6,2m. At the same time 1,6m wide cantilever were built for pedestrian on both sites of the truss and the deck structure was reconstruction foe vehicles. Unfortunately during the reconstruction work the wooden deck caught fire. The fire caused the collapse of the steel truss in one of the side spans. The part fell on the ice and one man was killed and another 24 men were injured.



Fig.20. Tornionjoki Steel Truss Bridge, Finland

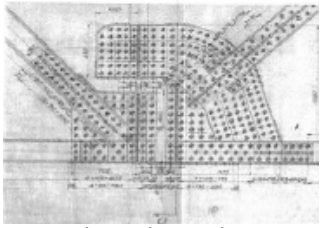
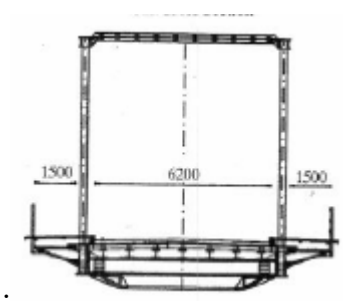


Fig.21. Hinge in main span

The superstructure consists of three steel truss girders, which are connected to each other by two hinges in the main span. The hinges are located 18 m from the intermediate supports (Fig.21). In side span the girders have cantilevers. The hanger girder in the main span is 72 m long. Te hinges can transfer downward vertical forces and horizontal forces in both directions. The structure of the hinge consists of the cantilever and hanging beam and between beams are steel bearings. The bearings of the structure are roll bearings except for the fixed bearing which is located on one of internal supports. The truss girder has been constructed in open rolled steel sections, which have been fixed by rivets. All joints and splices have also been made by riveting. The height of the truss is 9 m and at intermediate supports the height 3 m higher. Vertical frames are placed at supports and the steel parts were painted against corrosion. The wooden deck plate was made of planks fixed on longitudinal I-steel beams. The surface layer made was made of asphalt. Old electric were placed under the deck (Fig.22). The aim of the design of new steel details was avoided structures where permanent moisture in joints and corners could exist. The second goal was to develop an easy and simple construction method for the new orthotropic deck. The new deck is an orthotropic steel deck which is supported on the existing crossbeams (Fig.23).



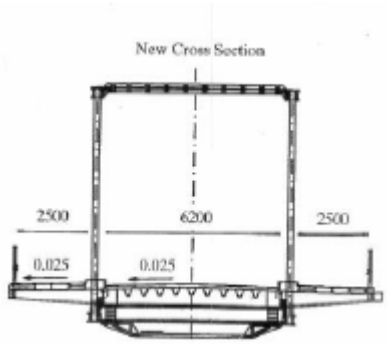


Fig.22. The old cross section

Fig.23. The new cross section

The surface plate is stiffened with orthotropic steel section. A plate thickness of 12 mm was allowed, because of the reduced traffic loads on the bridge. The distance between the cross beams is 4,5 m. These crossbeams continue as cantilever beams outside the truss. The pedestrian pavement is supported on the cantilever beams by longitudinal I-beam and steel plate. The edge beam is made of steel plate (Fig.24). Zinc-epoxy polyurethane paint 240μm, which consisted of 4 layers was used. Three layers were painted in the workshop and the last layer was painted on site. Edge drain pipes and drain pipes for rainwater were installed on the deck. The waterproofing was made of rubberized bitumen mastic asphalt. Surface layers were made of poured concrete asphalt. On the pedestrian deck a thin surface pavement was used.



Fig.24. New deck

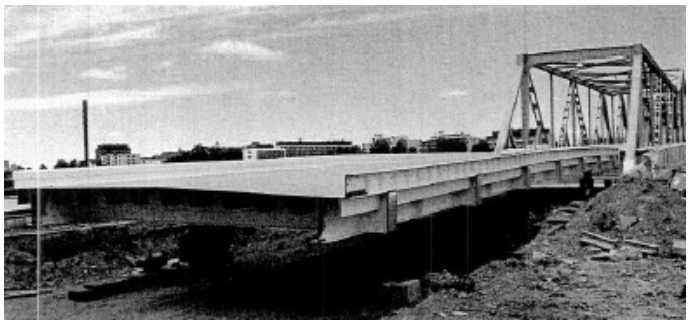


Fig.25. Launching of orthotropic bridge

The launching method was used for the steel deck (Fig.25). The length of the prefabricated steel deck section was 18 m. The continuous deck was welded on the embankment behind the abutment. The inner width of the existing truss frame was 7 m. The crossbeams had to be cut and spliced after launching. The section were launched on Teflon bearings which were placed on the crossbeams. After launching the deck was laid down and the structure was fixed to the existing crossbeams. The Tornionjoky is famous salmon river. During the time of salmon spawning all construction work was forbidden. Sand blasting and painting works were done in a temporary tent to avoid pollution of the river. It was noted that by carrying out repair works early enough, the deterioration of difficult inaccessible details can be avoided. Thus, in the long term, correctly timed rehabilitation works are cost effective. In this case the main steel sections under the deck were corroded but could be repaired and repainted at reasonable cost. The wooden deck structure was replaced with an orthotropic steel deck to avoid an increase in the dead load. In the detailed design, making simple steel joints and details accessible in order to keep structures dry could be utilized. The launching method used to put the new deck in place on site enabled almost full prefabrication of the steel elements in workshop. The quality of painting work was optimized. In this rehabilitation project, the original appearance of the steel truss bridge was conserved. The bridge was illuminated in such a way that the light colour of the structure emphasizes the shape of the old historic bridge. The rehabilitation work, carried out in 1995, was awarded the Finnish environment prize in 1996.

Conclusion

Most of the record-span portions of suspension, cable-stayed, arch, movable, floating and pedestrian bridges have orthotropic steel decks. Thus, an "ABC" solution, using prefabricated orthotropic steel deck panels to rehabilitate existing large span superstructures, is a very practicable solution. *Only a few bridge engineers (far less than 1 %) are interested in orthotropic decks, because 99 % of all bridge decks are reinforced*

concrete. This may change as, the Federal Highway Administration (FHWA) discussed the progress of their new *FHWA Orthotropic Bridge Manual* at the 2008 international OBC.

These orthotropic bridge conferences (OBC) allow the networking of engineers interested in a specialized topic. Designers, owners, contractors want current relevant information and active contacts. Wearing surface, metal fatigue issues, design issues unique to orthotropic bridges were discussed and the OBC proceedings were published in 2004 and 2008 on CD-Rom [42]. The largest number of orthotropic bridges located in North America in terms of replacement costs and variety/quantity are located within California. Caltrans (State of California Department of Transportation) and other owners, Golden Gate Toll Bridge District, BART (Bay Area Rapid Transit), Alameda County, etc. Maintain these bridges. Caltrans owns/maintains largest number of orthotropic bridges in terms of replacement costs and variety/quantity of any single owner located within North America. The two largest concentrations of completed orthotropic bridges in North America are in greater New York City area and greater San Francisco Bay area. All the orthotropic-decked bridges in New York City area and Philadelphia are redecking projects listed in Table 1[1]. The largest orthotropic bridge owned by Caltrans is the San Mateo Hayward Orthotropic Bridge, which opened to traffic in October 1967. The original wearing surface on this bridge has a three-fourth inch (about 19 mm) thick deck plate [16]. Another recent orthotropic bridge about 10 years old has also been performing well [31]. When building record-span bridges, minimizing dead weight is economically critical in high seismic areas. When widening existing long-span and movable bridges, minimizing dead weight is economically critical in order to avoid strengthening existing components, foundation, columns, piers and towers. Most bridge engineers and researchers work with reinforced concrete decks. Many assume that the vast majority of orthotropic deck systems are not durable because of some articles and reports written about metal fatigue and wearing surface repairs or renovations for some orthotropic bridges. Owners from around the world would not continue to build record-span bridges if there was a problem with the orthotropic steel system. These steel decks exceed span lengths achievable with reinforced concrete deck bridges. There is no "perfect material". All bridges and components require maintenance. Metal structures eventually have metal fatigue. FHWA's desired 100-year service life requires a different approach to bridge durability details. The issues of wearing surface and fatigue-resistant detailing are critical for 100-year goals. There is one small book on the subject [31] but many US practicing engineers commission project-specific orthotropic steel deck research [33]. Project-specific fatigue studies are the common procedure for world class spans built in Asia and Europe. Most of these state-of-the art fatigue studies are available to recognized bridge engineers from various bridge owners and applicable universities. There are about 50–200 project-specific reports available. Metal structures are subject to corrosion, but so are reinforced concrete bridge decks. If corrosion of reinforcing steel begins, serious concrete deck deterioration can occur within a few years time. Repair of all types of concrete structures is a major business and there is a specialized group with its own specialty magazine. All ICRI (International Concrete Repair Institute) members receive a complimentary subscription to the *Concrete Repair Bulletin*. For more information on how to receive the *Concrete Repair Bulletin* magazine, contact ICRI, Caren Giles, Member Services, at 248-848-3809 (http://www.icri.org/publications/bulletin.asp). The only material with proven 500- to 1000-year bridge life has been stone. Timber structures are subject to rotting, fire and insect attack. A timber railroad trestle was set on fire and destroyed in 2007 in Sacramento, California, by an arsonist. Fire fighters saved the steel truss section over the Sacramento River. A portion of the Caltrans- owned MacArthur Maze steel multilevel interchange was damaged by a fuel tanker truck fire [34]. Both the steel members and concrete deck were damaged by the

intense heat. Whether orthotropic steel decks or modern reinforced concrete decks can be made to last 500–1000 years is an unresolved debatable issue, because both systems were invented less than 150 years ago. Copying successful decking solutions is more practicable than over- analyzing bridge failures or problematic solutions. A problematic orthotropic bridge would have short metal fatigue life or incorrect detailing. Studying these repair reports would have very limited, if any, useful value for a new project. Today, owners in wealthy countries demolish existing bridges that present too many maintenance problems. However, these owners do not have enough money to replace all bridges needing retrofit. Thus, it is a complex challenge to properly utilize available funding. There is no "perfect material" and our infrastructure is not indestructible. The cost per square meter of deck is much higher for orthotropic steel deck panels than reinforced concrete. Thus, significant dead weight reduction is necessary for practicable use of orthotropic steel panels for deck replacement. Many bridges have orthotropic decks but they are very hard to find for an interested engineer or researcher because the issue of the orthotropic deck is not the main focus of the discussion, conference or engineering handbook [35-38]. Readers are encouraged to contact the authors for projects omitted. These and other presented orthotropic steel deck panel case histories listed in Table 1 [1] are complex, and their success should be appreciated for their innovations!

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THE KOKALYANSKI URVICH MONASTERY, FIELD CONSERVATION.

Filip Petrunov

PhD Candidate, Bulgarian Academy of Science, National Archaeological Institute with Museum, Department of Medieval Archaeology

Correspondence address:
Filip Petrunov, MA
Bulgarian Academy of Science
National Archaeological Institute with Museum
Department of Medieval Archaeology
1000 Sofia
2, Saborna Str.
Tel.: (+359) 888229676
E-mail: fili4@abv.bg

Abstract: *The investigations of The Late Medieval Monastery with the Church of St. Elijah placed at the Kokalyanski Urvich hill started during the 1960s by Prof. Dimitar Ovcharov. Later on (2011 to 2015) the study has been continued by a team led by Assoc. Prof. Dr. Boni Petrunova and Assoc. Prof. Nikolay Ovcharov from the Department of Medieval Archeology of NAIM -BAS. Since 2017 the site has been investigated under the directorship of Violina Kiryakova (NMH) and Filip Petrunov (NAIM-BAS). At the very beginning of the study has been established that all structures, with the exception of the church of St. Elijah, are built of stones soldered with mud in the substructure and in preserved areas of superstructure as well. During the field conservation of the preserved structures ordinary construction nylons, geo-membrane and reinforced plastic have been used. For various reasons, it turn out that they have been ineffective against the climatic conditions. In order to preserve the buildings, it was decided to use polyethylene film with UV stabilization to prevent the penetration of air and heat. This way the treated areas are completely devoid of air circulation, which allowed to preserve the clays and mud solders in the structures.*

Keywords: *Kokalyanski Urvich, Saint Paisius of Hilendar, architectural monuments, Middle Ages, Field conservation, polyethylene film with UV stabilization*

2022 marks the 300th anniversary of the birth of SSaint Paisius of Hilendar (Samokov Diocese, 1722). The present day historians and the Church place the Saint as a starting point of the Bulgarian Revival. On June 26, 1962, he was canonized as a Saint by the Bulgarian Orthodox Church, and his book "Istoriya Slavyanobolgarskaya" laid the foundations of the modern understanding of the historical memory and heritage. Nevertheless, this article is not focused on the work of his life, but on a specific location that can be find in his book. As is well known "Istoriya Slavyanobolgarskaya" follows in to some extent the historical treatises of the Western historians at that time. In any case, in the text is mention, none other but the Kokalyan fortress and Monastery (Fig. 1) toponym connected with events happened in the late fourteenth century: "... and here they stopped in some narrow places along the river Iskar and on Vitosha Mountain. Here they received help from the Serbs, from King Vukashin and from the Ohrid Bulgarians. And for seven years King Shishman stayed in Sredets and near Iskar. He had a monastery "Urvich" with a strong Fortress, surrounded by water. He spent this time with a small army and hid from the Turks with the nobles of Tarnovo. When the Turks took the land of Ohrid from King Vukashin and enslaved and conquered it, here they finally captured and destroyed Tsar Shishman and the army, and the Tarnovo and Bulgarian nobles. That is why there are still treasures in many places in these places, people in those times hid and buried for fear of the Turks, then died and their property remained in the ground. (Paisii Hilendarski, Istoriya Slavyanobolgarskaya, Sofia, 1960, p. 80.). This treatise from the epic about Tsar Shishman is not accidentally mentioned in the text of St. Paisius. Urvich is an exceptional monument, a Monastery, heir to a Medieval Fortress, which lasted nearly 200 years under the Ottoman Empire. Although it was destroyed three decades before the birth of the Holy Father, the Monastery is an important historical bearer of the Bulgarian culture under the conditions of foreign religious and political power.

The archaeological research around the church of St. Elijah, started in 1969 led by Prof. Dimitar Ovcharov (Ovcharov, 1981, 4, 50-60). In 2011 the project continued under the leadership of Assoc. Prof. Dr. Boni Petrunova and Assoc. Prof. Nikolay Ovcharov from the Department of Medieval Archeology of NAIM-BAS. (Ovcharov, Petrunov, 2020, 46-56). As a result of their study, through the methods of archeology, for the first time a Late Medieval Monastery dating from the 15th - 17th century on the territory of Bulgaria was completely discovered (Fig. 2). The Monastery was built around the church of St. Elijah. To the south of the Church is located a residential wing and the main entrance, paved with tiles. To the west is situated the food block with a large kitchen and basement, followed by an elongated dining room and bell tower. (Ovcharov, Petrunov, 2020, 57-75).

The process of surveying the architecture lasted until 2021, and it should be pointed out that after 2013 no new buildings from the Late Middle Ages complex were discovered. However, a number of valuable finds were acquired. Additionally, human remains were found as well. Moreover an in-depth analysis concerning the stratigraphy and the processes of cultural deposition within the monastery was carried out. An important part of the preservation of the monument was the field monitoring connected with the field conservation methods, which are the main goal of this paper. From the very beginning it was established that all the structures, with the exception of the Church of St. Elijah, are built of stones soldered with mud in the substructure and in preserved areas of superstructure as well. In the initial studies different materials have been used during the field conservation. The preserved structures were covered with ordinary construction nylons, geo-membrane and reinforced plastic. For various reasons, it turn out that they have been ineffective against the climatic conditions. The southern slope of the hill, on which the Monastery is located, most of the day is exposed to direct sunlight, which adds to the rapid burning of some of the materials used to wrap the structures. The high humidity, due to the closeness to the Iskar River, on the other hand, contributed to the accelerated vegetation and germination of various plants in and around the covered architectural structures. In addition, plain nylons as well as geotextiles create a favorable environment for vegetation. Поради тези причини бе взето решение за използването на полиетиленово фолио с UV стабилизация, непозволяващо проникването на въздух, влага и топлина.

In order to preserve the buildings, it was decided to use polyethylene film with UV stabilization to prevent the penetration of air, moisture and heat. The product is also known as silage foil and is broadly used in agriculture. This way the treated areas are completely devoid of air circulation, which allowed to preserve the clays and mud solders in the structures. At the same time, the available bulky roots that penetrated the walls began to reduce. Subsequently, they were easily removed, at a stage where the contact between the roots and the stones no longer put pressure on the structure (Fig. 3). The materials used are multilayered and with a density of over 100 microns. This way the packaged architectural structures are additionally protected from human activity and the possibility for interventions of any kind are limited as much as possible.

In conclusion, it can be stated that the development of the agricultural industry has provided a suitable materials for the needs of the archeology and fragile historical remains (Fig.4). However, its application should not be taken unequivocally. There are also some weak points in using this method. One of the main problem is the complete lack of access of the visitors to the preserved material cultural heritage. This problem would find its solution after the complete and permanent conservation of the site. Steps in this direction have already been taken. Already in 2018, under the coordination of the Institute for Cultural Monuments at the Ministry of Culture of the Republic of Bulgaria a project for the conservation of the Western Monastery wing has been provided. Since 2014 a conceptual designs about the vision of the Monastery have been developed and after the archaeological research of the south wing in 2021 are possible to be performed. Ultimately, until the complete accomplish of the conservation, the silage film will

provide maximum protection of the architectural structures. It will prevent the re-emergence of the vegetation root systems in buildings. The observations show that in some degree it favors their preservation. On the other hand, its durability and density is a guarantee to be minimized the potential damage due to the ecological condition of the site. The current market conditions in Bulgaria allow its systematic replacement, with very affordable, budget funds and its reuse after recycling.

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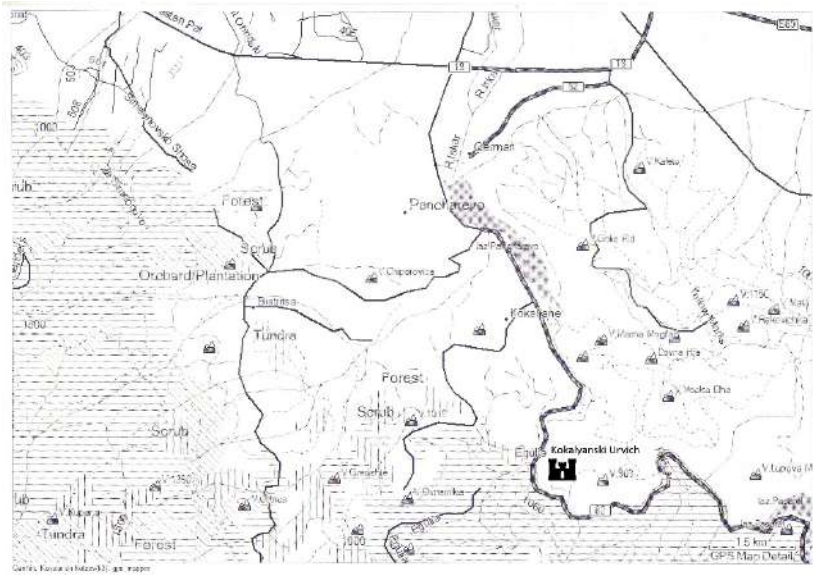

Forest
Orchard/Plantation
Scrub
Tundra
Forest
Scrub
Scrub
Tundra
Forest
Kokalyanski Urvich
1.5 km
GPS Map Detail

Fig.1



Fig. 2



Fig. 3



Fig.4

RECONSTRUCTION OF THE IMPERIAL-ROYAL RIDING HALL IN NOVÉ ZÁMKY

František Lužica[1]

Abstract:

With this contribution I want to pay tribute to the art of master carpenters from the end of the 19th century.

1. Introduction

The riding hall in the barracks in Nové Zámky was built at the end of the 19th century for the Imperial-Royal Regiment. It was used for military purposes until the withdrawal of Soviet troops from our territory. She also survived the bombing of Nové Zámky at the end of World War II, when most of the historic buildings in the city were destroyed. It is a national cultural monument registered in the central list of the monument fund. The building was fallen into disrepair since the 1990s.



Fig.1 - Condition of the building before reconstruction

In 2014, the city received a non-repayable financial contribution of 2.388 million euros for the reconstruction under the Regional Operational Program, which represented 95 percent of the eligible costs.

[1] Ing. František Lužica, aut.ing., Gúgska 75, 940 54 Nové Zámky, tel.: +421905350558, e-mail: luzica@slovanet.sk

2. Description of the construction

The building is a single-nave hall building with floor plan dimensions of 22.78 x 60.85 m with an extension, which had to be demolished. The roof structure consisted of thirteen wooden trusses of carpentry construction with a span of 22.10 m at an axial distance of 5.0 m, of which two trusses were dismantled due to the emergency situation. The lower belt of the trusses consists of a steel rod with tensioners. The trusses are placed on wooden poles. The columns are attached by steel hoops to the supporting brick pillars in the perimeter masonry. The rafters at a distance of 1.0 m are placed on purlins with strips and also on inclined purlins without strips. The original tile covering for battens and wooden formwork was replaced in the second half of the 20th century into asbestos-cement corrugated roofing.



Fig. 2 - Emergency condition of the dismantled trusse

3. Built-in-parts

A vestibule was created as a two-storey reinforced concrete structure in place of the dismantled trusses. The load of the construction was concentrated on four short large-diameter piles placed in the middle of the floor plan in order to have as little impact on the existing foundation strips of the perimeter walls as possible. The base range of piles is located on a layer of gravel at the elevation of 5,300.

At the opposite end of the hall, a two-storey masonry structure was built with continuous reinforced concrete slabs placed on transverse load-bearing walls, perpendicular to the existing perimeter walls, so as to affect the existing foundation strips of the perimeter walls as little as possible.

The subsoil of the existing foundation strips formed by cohesive soils was strengthened by grouting synthetic resin using TOPINJECT technology.

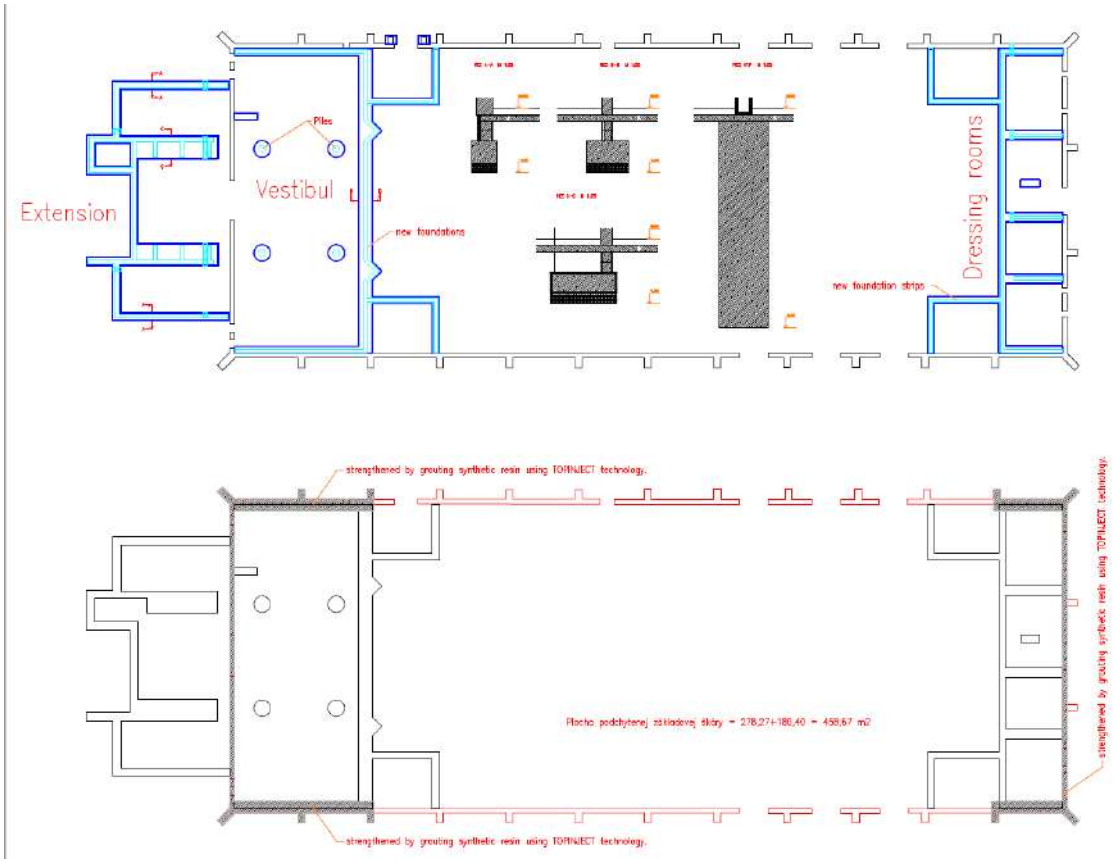


Fig. 3 - Foundations of built-in parts of the building

4. Wooden structure renewal

The project envisaged the dismantling of the two most damaged trusses and their associated fields and the removal of the formwork. Compared to the original load of the roof cladding, only the load of thermal insulation placed on the new formwork in the amount of approx. 0.1 kN / m2 was added. The snow load was considered according to the new national annex STN EN 1991-1-3 / NA1. The repair of wooden structures was estimated at 15 percent of the volume of lumber. But after the formwork was removed, some of the exposed rafters were rotten to the point that they needed to be replaced. This caused additional costs. The surface of the wooden structure of the trusses and purlins was cleaned with a high-pressure water cleaner. The rot-damaged parts of the trusses were replaced. In order to increase the interaction of the cross-section of the upper strip consisting of two prisms, the prisms were fastened with X-shaped full-thread screws, drilled from the upper surface to make them invisible. The existing hinges in the thirds of the steel drawbar were supplemented by three more hinges in order to reduce the momentary stresses in the drawbar from its own weight.



Fig. 4 - Damaged rafters had to be replaced

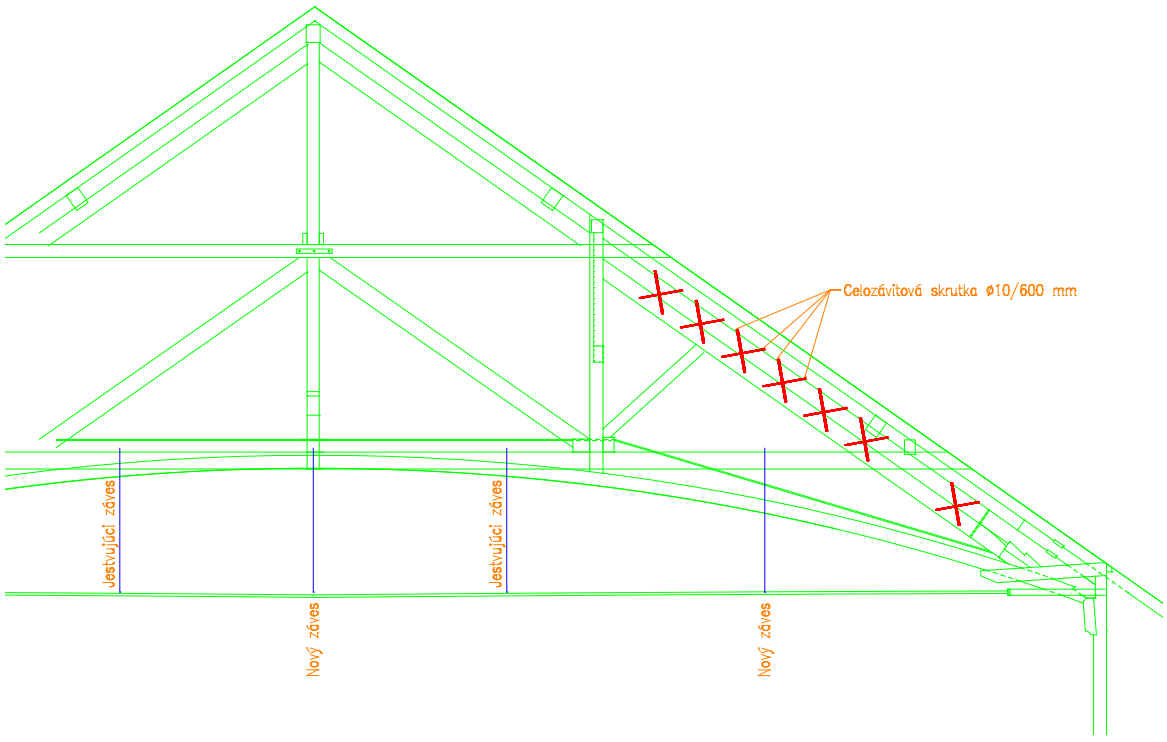


Fig. 5 - Coupling of the upper belt cross-sections and added hinges of the steel drawbar



Fig. 6 - Repair of the supporting part of the trusse



Fig. 7 - The final appearance of the structure

5. Conclusion

With the reconstruction of the historic riding hall, the town of Nové Zámky gained a cultural and social hall with a capacity of about 800 seats.

KALMÁRKA

Baláž Ivan[1], Balážová Pavla[2], Koleková Yvona[3], Kotleba Štefan[4], Arany Karol[5]

Faculty of Civil Engineering, Slovak University of Technology in Bratislava, the Slovak Republic;
Department of Languages, Faculty of Civil Engineering, Slovak University of Technology in Bratislava and Department of Romance Languages, Faculty of Arts, Comenius University in Bratislava, the Slovak Republic;
Department of Structural Mechanics, Faculty of Civil Engineering, Slovak University of Technology in Bratislava, the Slovak Republic;
Retired, TRW Electronics Datacom International in Los Angeles, CA, USA;
Retired artist, Prievozská 11a, Bratislava, the Slovak Republic.

Abstract: *History of apartment house called Kalmárka built in capital Bratislava in the year 1932. In the thirties in the period of shortage of housing Bratislava city built apartment houses especially for the unprivileged people. Information about famous German photograph Josef Hofer who produced in Slovakia thousands photos from the period 1914-1944. Notice about German printer and politician Heinrich Kalmár who participated in the social democratic movement in Bratislava. Information about famous Slovak architect Desider Quastler who designed also apartment houses for socially weaker classes. Thanks to above people and those who lived in Kalmárka for 70 years, the picture about projecting, building, maintaining and renovation of similar apartment houses will be more comprehensible. Such types of apartment houses, today 90 years old, belong to the cultural heritage of Slovakia. Rare photographs are added.*

Key words*: cultural heritage, architecture in Bratislava, houses for underprivileged, renovation of apartment houses*

1. Introduction

Czechoslovakia was formed after the collapse of the Habsburg monarchy at the end of World War I. The independence of Czechoslovakia was officially proclaimed in Prague on 28 October 1918. The paper shows an example how the new young state solved in the

[1] Baláž Ivan, emeritus Prof., Ing., PhD., Slovak University of Technology, Radlinského 11, 810 05 Bratislava, Slovak Republic, ivan.balaz@stuba.sk
[2] Balážová Pavla, Mgr., Bc., Slovak University of Technology, Radlinského 11, 810 05 Bratislava and Comenius University, Gondova 2, 811 02 Bratislava, Slovak Republic, balazpa@gmail.com
[3] Koleková Yvona, Assoc., Prof., Ing., PhD., Slovak University of Technology, Radlinského 11, 810 05 Bratislava, Slovak Republic, ivan.balaz@stuba.sk
[4] Kotleba Štefan, retired, TRW/JKC Inc., 10880 Wilshire, Los Angeles, CA, USA, kotlebas@gmail.com
[5] Arany Karol, retired, Mgr. art., Prievozská 11a, 821 09 Bratislava, Slovak Republic, aranykarel@gmail.com

thirty`s shortage of the flats especially for the underprivileged. In these activities several famous Slovak architects took part.

The famous photographer Josef Hofer produced thousands today very rare and valuable photos in the period 1914-1944. Some of them are used in this paper.

Josef Hofer was born 10.02.1883 in farmer`s German family in Schildern village (in Hungarian: Dénesd; today Jánošíková, part of Dunajská Lužná, 16 km from Bratislava). He worked from 1914 for Bratislava municipality. The life of Germans was after WORLD WAR II in Czechoslovakia very difficult. Already in 1940 he sent 8 boxes with photos to Austria. Many of them were devastated by bombing. Hofer with his family emigrated to Austria in February 1945. The life in Austria was difficult for emigrants. Hofer`s family therefore moved to Germany. Josef Hofer died 22.10.1967 in Nürtingen.



a) b)

Fig. 1. a) Schildern (today Jánošíková, Dunajská Lužná), 1943. (Courtesy of Senior Club, from H. Muráňová); b) Josef Hofer. (Collection of Juraj Šedivý on PamMap [1, 2]).



a) b)

Fig.2. a) Roman Catholic church Exaltation of the Holy Cross in Schildern (today Jánošíková, Dunajská Lužná), which was in the World War I. destroyed by bombing and never reconstructed to this original form (Photo: Josef, Hofer in 1915-1918, courtesy of Juraj Šedivý); b) the same church today (Photo: Yvona Koleková, 22.11.2021).

2. Kalmárka

Kalmárka is colloquial name of the apartment house known under name Kalmár`s courtyard (Kalmárov dvor in Slovak). There are three courtyards in the building (that is why in Slovak the plural Kalmárove dvory is often used). In the middle courtyard there are three entrances, in the edge courtyards there are 2 entrances. In the altogether 7 entrances there are 7 x 16 = 112 flats. On both sides of and behind Kalmárka there is a small garden. The plot on which Kalmárka stands has 3409 m^2. The building was built in

the beginning of thirties of 20th century (probably in 1932). The rare photo of Kalmárka in Fig.3 was done on glass negative 13 x 18 cm by photographer Josef Hofer in 1932.

Fig.4 shows details of Kalmárka. It is written on the façade *Heinrich Kalmár Dvor* in Slovak, *Heinrich Kalmár Hof* in German and *Heinrich Kalmár Udvar* in Hungarian language. In the middle part there is written in three languages *Mliekáreň*, *Milchhalle* and *Tejcsarnok*, which means Dairy, where milk is sold.



Fig. 3. Kalmár`s courtyard, Prievozská street No.11-17, Bratislava. Photo: Josef Hofer in 1932. At that time it was periphery of Bratislava. There were only few family houses with gardens behind Kalmárka. (Courtesy of Bratislava city Archives).



a) b)

Fig. 4. Details of Kalmárka a) left side; b) right side. Photo: Josef Hofer in 1932. (Courtesy of Bratislava city Archives).

The second oldest photograph of Kalmárka is in the Fig.5. On the façade there is a word HOLIČ (Barber). The first shop from the left is BUDÚCNOSŤ (Future). It was grocery of consumer`s cooperative. The similar shop may be seen in [3] in Fig.16. The shop in the middle of the block of flats is Dairy which is described above and may be seen in above Fig.4.



Fig. 5. Kalmár`s courtyard, Prievozská street No.11-17, Bratislava. Photo: unknown author. It was taken in 1933.



Fig. 6. Kalmár`s courtyard, Prievozská street No.11-17, Bratislava. Photo: unknown author. It was taken in sixties. On the left and on the right side of Kalmárka there are new buildings. Just in the front of Kalmárka it was local road. The trees were full of may-bugs.

In the Figs. 7 from 1939 there are only parts of Kalmárka. In the Fig. 7b may be seen that on the façade under the word HOLIČ (Barber, see Fig. 5) it was added the word KONZUM, which was kind of consumer cooperative. In Fig. 7b it is seen that in front of Kalmárka there were no buildings in the year 1939. Photos are from the archive of Arany family. In Fig.7a there are from left Štefan (1938-2021 in Canada), cousin, Alžbeta (1936-2015), Jozef (1932-1999). In Fig-7b there are Štefan, Alžbeta and mother Rozália (1909-1983). Ján (1946) lives in Canada, Karol (1951) in Kalmárka. Father was József (1907).



a) b)

Fig. 7. a) Back of Kalmárka and adjacent garden of Mrs. Doležalová; b) in the photo background there are some small structures. There were no buildings in the front of Kalmárka in 1939. (Courtesy of Karol Arany).

One should know that Czechoslovakia was founded in October 1918, when it declared its independence from Austria-Hungary (Austro-Hungarian Dual Monarchy). It was not clear at that time if Bratislava will belong to Austria, Hungary or Czechoslovakia. At that time mostly German and Hungarian speaking people lived in Bratislava (Tab.1).

Table 1 Nationalities on Bratislava territory. Courtesy of [4].

Year	Slovaks	Czechs	Hungarians	Germans	Jews
1850 / 1851	17,95 %		7,44 %	74,58 %	
1880	15,69 %		18,69 %	65,60 %	
1900	16,26 %		30,51 %	50,40 %	9,66 %
1921	37,72 %		21,11 %	26,31 %	3,82 %
1930	48,45 %	20,32 %	15,25 %	26,48 %	3,83 %
1940	48,99 %	3,58 %	13,13 %	20,09 %	8,77 %
1950	90,15 %	4,81 %	3,53 %	0,54 %	0,024 %

During years there were various shops located in Kalmárka, e.g. dairy, grocery, butcher, wedding clothes rental, tailoring, Thai massage, pet shop, decorators, electronics shop, sex shop, etc.

A flat in Kalmárka consists of kitchen including bathtub (8,83 m^2), 1 bedroom (29,50 m^2), anteroom (5,32 m^2), chamber (1,25 m^2), and toilet (1,38 m^2) having altogether 46,28 m^2. A cellar (3,58 m^2) belongs to the flat. In basements of all 7 entrances there are common wash-rooms and drying rooms. In the basement it was located also common ironing room, a wood workshop and a clubroom. The document from 7.7.1938 written in Czech language

and with stamp in German language shows that Malozáhradnícke a osídlovacie družstvo Ružinov – Rosenheim (Small gardening and settlement cooperative Ružinov) was the administrator of Kalmárka. Another document from the years 1946-1950 shows that rent for an apartment was 235 Ks (Slovak crowns) per month. For water and garbage disposal it was necessary to pay 50 Ks – 80 Ks per month.

Load-carrying structure of Kalmárka is constructed from massive brick walls. The flats are separated by thin brick partition walls.

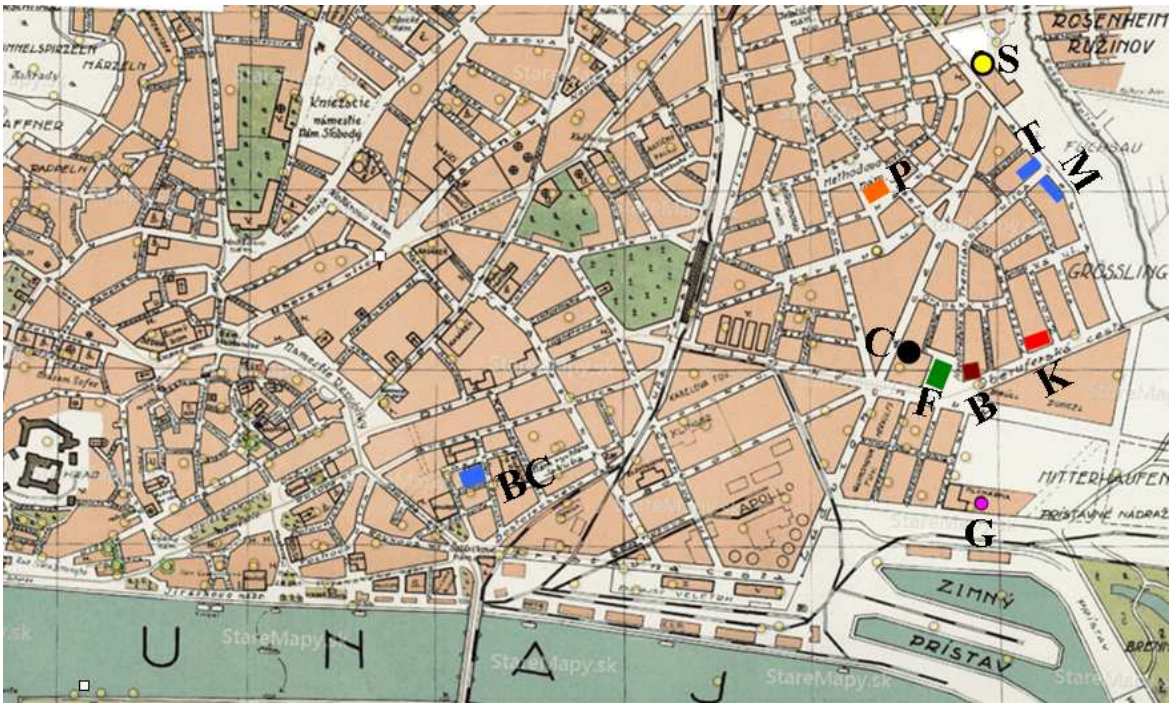


Fig. 8. Bratislava. Map is from 1931. Locations of K = Kalmárka on Oberuferská street (today Prievozská street), B = Warehouse Blažek (Fig.11), C = Cvernovka, F = playfields of Cvernovka, BC = Blue Church (Fig.17), G = Gasholder (Fig. 12), eleven apartment houses on T = Trenčianska and M = Miletičová street, P = Primary school on Kvačalova street (Fig.9) and S = Slaughter-house. All houses are at periphery of Bratislava. (Courtesy of Staré mapy [5]).

In the past all inhabitants of 112 flats lived as one big family celebrating together important holidays as Christmas, etc. Later 5 garages were built behind Kalmárka. No more than 3 families from the very past live today in Kalmárka. Today small flats in Kalmárka are bought as an investment and they are rented to other people. People living in these flats do not know each other.

Kalmárka suffered all the time from flooding of basements after heavy storms. Legend says that builder of Kalmárka wanted to commit suicide because of this problem. He went on Kalmárka`s roof and wanted jump down. His colleagues caught him in the very last moment. During his second attempt the workers were able to attach umbrella to the back of his coat and after flight he safely landed. Only his third attempt was successful and he died. From that time the building has its name Kalmár`s courtyard. Apparently the legend is not truthful.

The people from Kalmárka and its surroundings practiced various kinds of sport (football, handball, volleyball, basketball, tennis) in sports facility which belonged to near Cvernovka factory (Thread factory, Zwirnfabrik, Czerna gyár, Figs.8). The children attended primary school on Kvačalova street not far from Kalmárka (Figs.8, 9).

There are no original projects and documents relating to Kalmárka. All were lost during repeating move of various administrators of Kalmárka from one place to another place. At the time of building Kalmárka was located at periphery of Bratislava, today is in the centre of capital of Slovakia. That is why today a small flat in Kalmárka costs approximately 140 000 euro.

Housing association CENTRUM is in this period administrator of Kalmárka. Flat owner pays monthly contribution to the house fund 82,06 euro for CENTRUM services. Real estate tax is 51 euro yearly. Flats owners are represented by Board of owners which decides what CENTRUM role is, and monitor its activities. It was decided that for maintenance of Kalmárka, which included also renovating of desolated façade, bank loan 529 643 euro was at credit 3,95 %. Approximately 630 000 euro should be paid-back to the bank within 10 years.

During 90 years the renovation of Kalmárka`s façade was done three times. Heating of flats was first realised by stoves, coal and timber. Later by gas heating elements called Gamatky. After two big gas explosions in two flats the people were asked to remove old type of Gamatky. Nowadays the gas boilers together with radiators are used in Kalmarka`s flats.



Fig. 9. Location of Kalmárka (symbol 1932) on Oberuferská street at periphery of Bratislava. In the right part of aeronautical photograph of Bratislava from 1949 there are only meadowland and fields [6].

Figs.11 and 12 show two structures located not far from Kalmárka. It may be seen that Kalmárka at that time was situated in the periphery of Bratislava (Figs. 8, 9). The Hofer`s photographs may be obtained under strictly defined conditions after paying from the Bratislava city Archives.



Fig. 10. Primary school on Kvačalova street. See its location in Fig.8. View from Velehradská street. It stands also today. Photo: Josef Hofer about 1934-1937. (Courtesy of Bratislava city Archives).

In the store-windows of warehouse of Blažek brothers (Fig.11) it is written in Slovak language MINERÁLNA VODA and in German language: GEBR. BLÄŽEK. KAFFEE, THEE, RUM und sämtliche KOLONIALWAREN. On the façade it is written family name BLAŽEK surrounded by the word brothers in three languages (in Slovak: BRATIA, in German: GEBR. = GEBRÜDER, in Hungarian: TESTV. = TESTVÉREK). In the building there were later many various shops, e.g. TIC, Jurki, VESNA, carpet shop, etc. It stands also today.



Fig. 11. Warehouse of Blažek brothers at the crossroad of Prievozská and Novohradská street. See its location in Fig.8. Photo: Josef Hofer in 1929. See also Fig.15. (Courtesy of Bratislava city Archives).

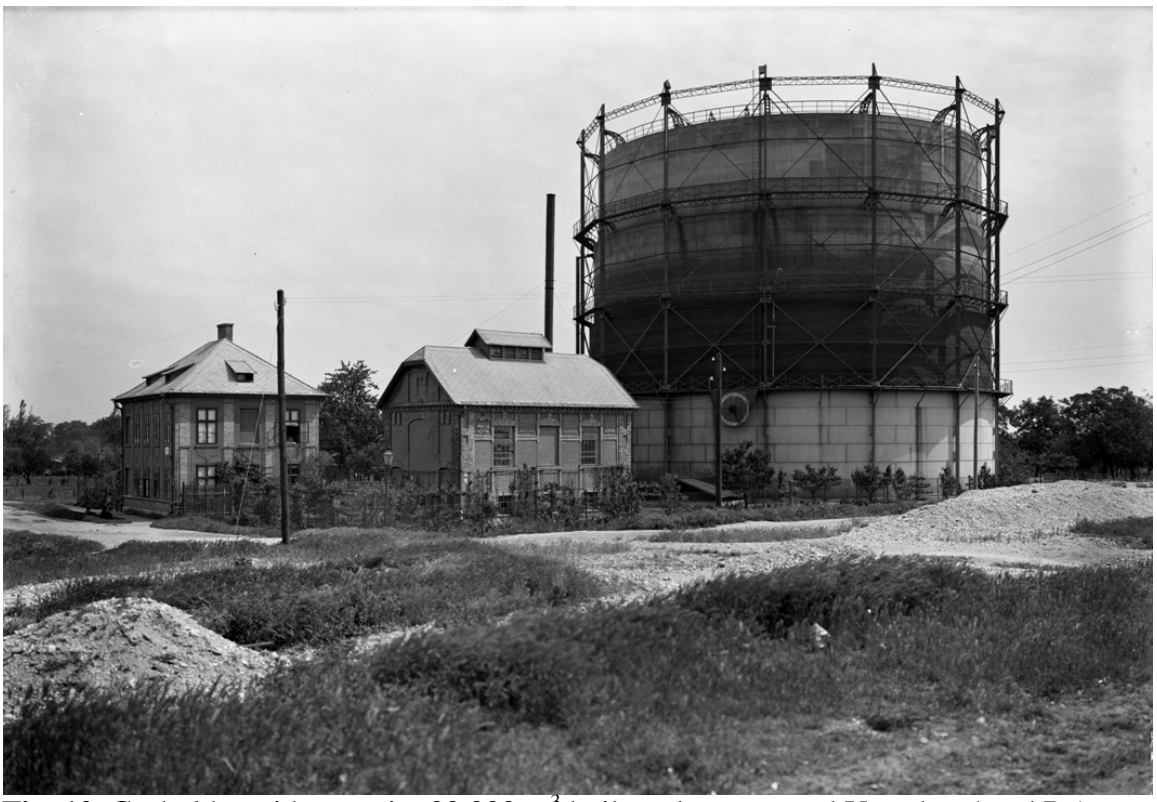


Fig. 12. Gasholder with capacity 20 000 m^3 built at the crossroad Votrubová and Prístavná street in 1921. It was connected to old Gas works in Fig.13. See its location in Fig.8. Photo: Josef Hofer about 1925. (Courtesy of Bratislava city Archives).



Fig. 13. Courtyard of old Gas works at Sloboda square. Jawa motorcycle, Praga cars and Praga and Škoda lorries. Photo: Josef Hofer about 1925.
(Courtesy of Bratislava city Archives).

3. Heinrich E. Kalmár (Fig. 14a)

Henrik Kalmár (born Elkán Kohn) was a printer, and social democrat. He was born into a Jewish family in Pozsony (now Bratislava) on 25 March 1870, his father was József Kohn his mother was Júlia Grünhut. He acted as a radical social democratic agitator, therefore got deported from Budapest in eighties. Then he participated in the labour movement in Bratislava, the Social Democratic Party, and served as secretary. He became editor of the Westungarische Volksstimme weekly. During the Soviet Republic of Hungary, he acted as People's Commissioner for German Affairs. On August 15, 1919 he was arrested and sentenced for life term in prison. During the prisoner exchange went to Czechoslovakia, where he again participated in the social democratic movement of Bratislava. He died on 23 June 1931.

Authors were not able to discover why the name of Heinrich Kalmár was written on the façade of Kalmárka shortly after his death. Probably he as social democrat supported building of such kind of apartment houses for the social weak classes.

4. Desider Quastler (Fig. 14c)

Almost nobody knows that Kalmárka was designed by established Slovak Jewish architect and builder Desider Quastler (* 3. January 1889, Bratislava – † 1944, concentration camp, Oświęcim, Auschwitz-Birkenau, Poland).

He was graduated at secondary technical school in Budapest in 1908. He worked at Grunwald & Schiffer company in Budapest and designed military school in Tigru Mures in Romania and Palace of River and Sea Shipping in Budapest. After return from Russian capture he came in 1920 in Bratislava where he as an established architect designed a lot of important buildings till 1939. Some of them are: 1926: Family house in Božena Němcová street; Villa in Šuleková street; 1926-1930: Apartment houses in Ružinov; 1930: Administrative house and Warehouse Orion on Hurban square (Fig.14b); Apartment house of Guttenberg typographers in Dunajská street; Family house of doctor B. in Stará vinárska street; Kalmár`s courtyard (Kalmárka) in Prievozská street; 1931: Family house in Fraňa Krála street; Gallery and apartment house in Röntgenová street in Petržalka; 1932-1935: Polyfunctional apartment house in Obchodná street; 1934: Polyfunctional apartment house, former Halmos, in Suché Mýto; Apartment house Práca in Radlinského street; 1937: Jewish restaurant in Zámocká street; Apartment house in Drevená street; Apartment house in Obchodná street; Warehouse and apartment house Fehér in Obchodná street; 1938; Apartment house in Dunajská street; Family house of Mrs. O. Meyer in Podtatranská street.







a) b) c)

Fig. 14. a) Heinrich Kalmár. (Photo: Vajda M. Pál in 1919); b) Orion building, 1930 [7]; c) Desider Quastler [7].

The situation of Kalmárka`s surroundings in the year 2021 may be seen in Figs.15 and 16.



Fig. 15. K = Kalmárka today. In the past there were only meadowlands on both sides and in the front of Kalmárka. Behind Kalmárka there are family houses like in the thirties. (Courtesy of Google Earth, 2021).

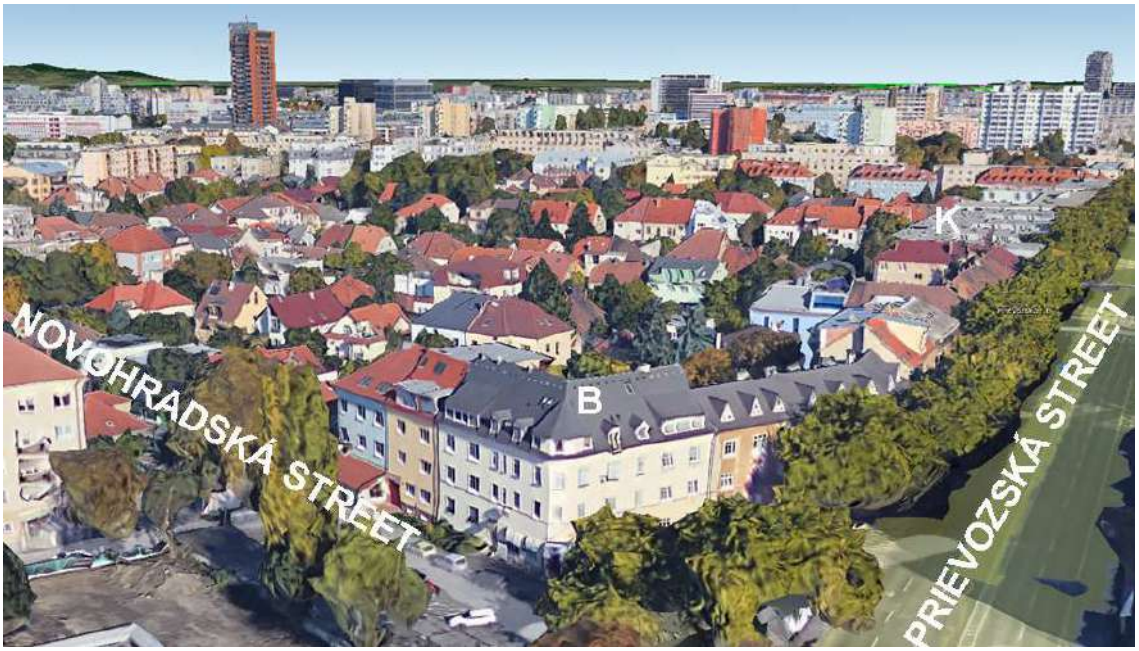


Fig. 16. B = Blažek house today. K = Kalmárka. (Courtesy of Google Earth, 2021).

5. The Little Blue Church

In the fifties almost all dwellers from Kalmárka and its neighbourhood took part in Masses in the nearby Blue church (Figs.8 and 17). The Church of St. Elizabeth (Slovak: Kostol svätej Alžbety, Hungarian: Szent Erzsébet templom), commonly known as Blue Church (Modrý kostolík, Kék templom), is a Hungarian Secessionist (Jugendstil, Art Nouveau) Catholic church located in the eastern part of the Old Town in Bratislava. It is consecrated to Elisabeth of Hungary, daughter of Andrew II, who grew up in the Bratislava castle (Pressburg Schloss; Pozsonyi vár). It is referred to as "The Little Blue Church"

because of the colour of its façade, mosaics, majolica and blue-glazed roof. It was initially part of the neighbouring high school and served as the school chapel.

The one-nave church was built in 1908-1913, four years after the plans of the architect Ödön Lechner from Budapest to build a church in the Hungarian Art Nouveau style. The so-called Hungarian secessionist style forms dominate in the church. Lechner also drew plans of the neighbouring high school and of the vicarage (also in the Hungarian Secessionist style).

The ground floor of the church is oval. In the foreground there is a 36.8 metre high cylindrical church tower. At first, a cupola was planned, but was never constructed; instead, a barrel vault was built, topped by a hip roof. The roof is covered with glazed bricks with decoration, for the purpose of parting.

The main and side entrances are enclosed with Romanesque double-pillars, which have an Oriental feeling. Pillars are also located near the windows.

The façade was at first painted with light pastel colours. Later the church got its characteristic blue colour. A line of blue tiles and wave-strip encircles the church.

The interior is richly decorated with altarpieces. On the altar there is an illustration of St Elizabeth, depicted giving alms to the poor (Wikipedia).

The Little Blue Church looks like a church from fairly tale. A lot of its pictures may be seen in two parts source [8, 9]. It is an example of perfect reconstruction.



Fig. 17. The Little Blue Church on Bezručová street.
(Courtesy of visitbratislava.com and slovakia.travel.sk).

6. Authors and sources

The first, fourth and fifth authors lived in Kalmárka from 1948, 1949 and 1951 respectively. They have the opportunity to follow the changes of Kalmárka and its neighbourhood during several decades. The second and third authors lived in Kalmárka short time and they are interested in the history of this part of Bratislava including way of life of people living in Kalmárka from the thirties till nineties. As the teachers of Slovak and foreign students at Faculty of Civil Engineering STU in Bratislava they are informing

their students within the Engineering education in Slovak and English language about all collected information. Students are usually keen to know about important historical structures and their designers. They are proud on achievements done in the past. Students are interested also in other actual topics like those treated in [10 – 13].

Students are asked to prepare their own presentations relating to historical buildings, bridges, towers etc. They may use very useful sources such as PamMap [2], Beliana [14] and Archives are and any other authentic source as well. PamMap [1] is a project that aims to allow access the historical documents to both the amateurs and professionals in the modern digital form. Thanks to the attribution of historians, archivists, etc., it is suitable also for scientific use. People who are interested in professional outputs (usually 600 dpi) can contact the owners of old documents, postcards, photographs, audio and video memorials. Documents in the low resolution (usually 100 dip) are available free of charge.

Acknowledgement

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APARTMENT HOUSES AND FUNCTIONALISM IN THIRTIES IN BRATISLAVA, CAPITAL OF THE SLOVAK REPUBLIC

Baláž Ivan[1], Balážová Pavla[2], Koleková Yvona[3]

Faculty of Civil Engineering, Slovak University of Technology in Bratislava, the Slovak Republic;
Department of Languages, Faculty of Civil Engineering, Slovak University of Technology in Bratislava and Department of Romance Languages, Faculty of Arts, Comenius University in Bratislava, the Slovak Republic;
Department of Structural Mechanics, Faculty of Civil Engineering, Slovak University of Technology in Bratislava, the Slovak Republic.

Abstract: *Severe worldwide economic depression took place mostly during the 1930s, beginning in the United States. The timing of the Great Depression varied across the world; in most countries, it started in 1929 and lasted until the late 1930s. It brought in thirties in Czechoslovakia the theme of so called the smallest flat. On the Slovak territory the most important contributions to this topic were done by architects Friedrich Weinwurm, Ingnác Vécsei, Emil Belluš and Desider Quastler. From several of their projects realised in the thirties are presented: Unitas (Unity), Nová doba (New times) I, II, III, eleven apartment houses on Trenčianska and Miletičová street, which helped to solve the problem with shortage of houses for socially weaker classes. Such types of apartment houses, today 90 years old, belong to the important cultural heritage of Slovakia. The iconic buildings which were also built in thirties in Bratislava, capital of the Slovak Republic, are shortly described here too*: *Manderla apartment and commercial building, residential and retail block Avion, building of the Salesians of Don Bosco, slaughter-house of Bratislava city. Quastler and Vécsei were killed in 1944 in concentration camp. Weinwurm, also Jew, was killed on a border in 1942 during attempt to escape from under German pressure created separate puppet Slovak state. Slovak photograph Josef Hofer, born in farmer`s German family in Schildren, the village 16 km from Bratislava, produced in the period 1914-1944 several thousands photographs on glass with high resolution. His rare photographs are used in the paper. The life of Germans was after World War II in Czechoslovakia very difficult, therefore Hofer emigrated in 1945 to Austria and died in Germany in 1967.*

Key words*: cultural heritage, housing in thirties, architecture in Bratislava, houses for underprivileged, renovation of apartment houses*

[1] Baláž Ivan, emeritus Prof., Ing., PhD., Slovak University of Technology, Radlinského 11, 810 05 Bratislava, Slovak Republic, ivan.balaz@stuba.sk
[2] Balážová Pavla, Mgr., Bc., Slovak University of Technology, Radlinského 11, 810 05 Bratislava and Comenius University, Gondova 2, 811 02 Bratislava, Slovak Republic, balazpa@gmail.com
[3] Koleková Yvona, Assoc., Prof., Ing., PhD., Slovak University of Technology, Radlinského 11, 810 05 Bratislava, Slovak Republic, ivan.balaz@stuba.sk

1. Introduction

In architecture, functionalism is the principle that buildings should be designed based solely on their purpose and function. The debate about functionalism and aesthetics is often framed as a mutually exclusive choice, when in fact there are architects, who attempt to satisfy utility, firmness and beauty.

The ideas were inspired by the need to build a new and better world for the people expressed by the social and political movements of Europe after the extremely devastating world war. In this respect, functionalist architecture is often linked with the ideas of socialism and modern humanism. A new slight addition to this new wave of functionalism was that not only should buildings and houses be designed around the purpose of functionality, architecture should also be used as a means to physically create a better world and a better life for people in the broadest sense. This new functionalist architecture had the strongest impact also in Czechoslovakia.

The paper contains information about apartment houses for social weaker classes and other buildings in Bratislava in thirties (Fig.1).

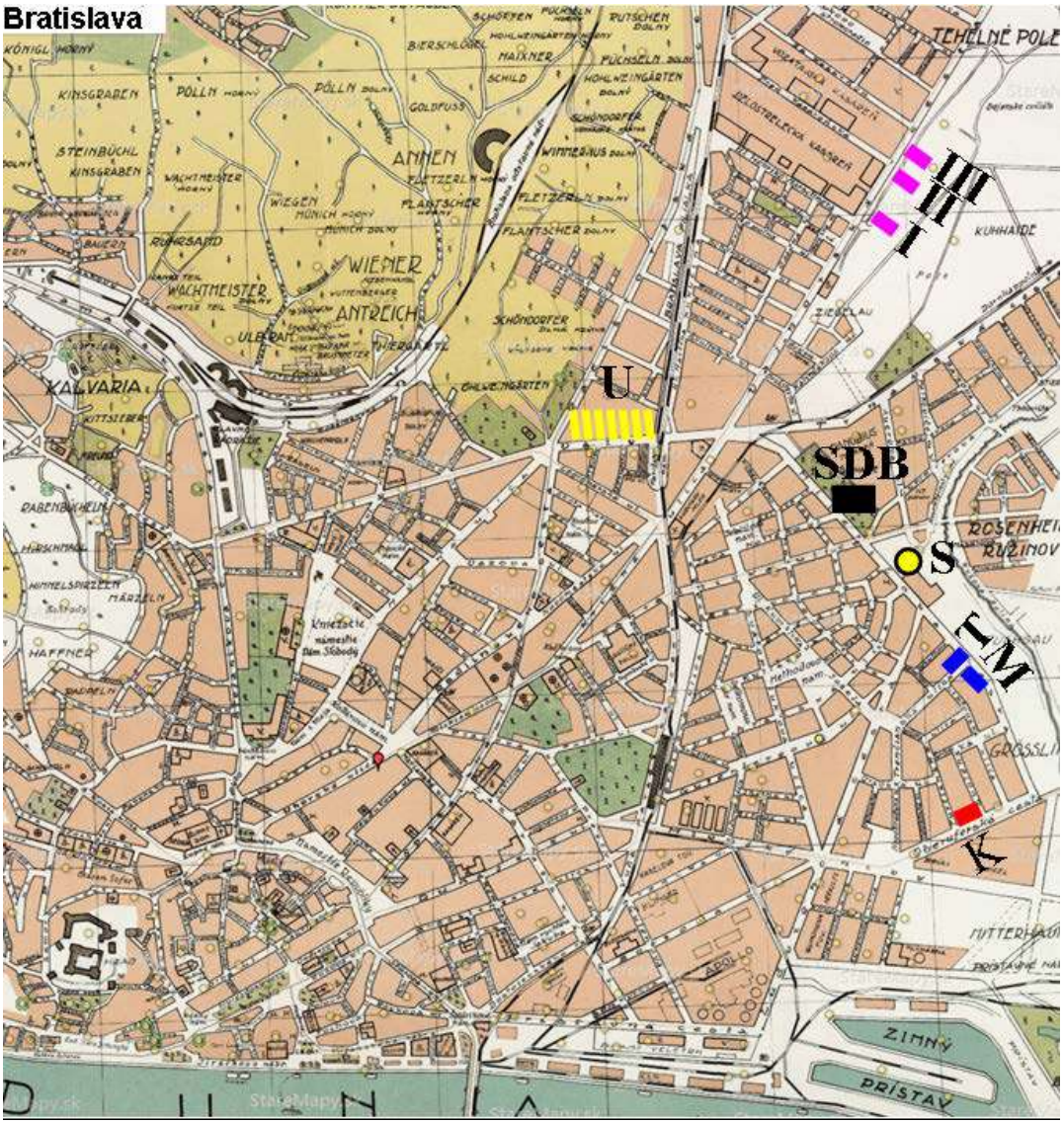


Fig. 1. Locations of K = Kalmárka on Oberuferská street (today Prievozská street) [1], eleven apartment houses on T = Trenčianska and M = Miletičová street, S = Slaughter-house, SDB = Salesians of Don Bosco, U = UNITAS and Nova doba (New times) I, II, III. The buildings were built in thirties at periphery of Bratislava. Map is from 1931. (Courtesy of Staré mapy [2]).

2. Apartment houses on Trenčianska and Miletičová street and other buildings on Miletičová street

The colony of 11 four storeys apartment houses was built in 1930-1931 (Figs.1, 2, 3, 4). Author of the project was famous Slovak architect Emil Belluš (Fig.13a). These buildings were built from city resources in the frame project solving housing shortage (Fig.2). There are 400 small flats of similar size as flats in Kalmárka [1] in 9 buildings with the ground plan having shape H and in 2 buildings with ground plan having shape L (Fig.4). On the typical storey in the side wings there are 8 one-bed rooms flats (Fig.4). These buildings are located on Miletičová street No. 66, 68, 70, 72, 74 (Figs.1, 3, 4, 6) and on Trenčianska street No. 34, 36, 38 and 37, 39, 41, 43 (Figs.1, 2, 4, 5).



Fig.2. Four H-shaped apartment houses on Trenčianska street (see Fig.4). There is written on the façade: DOMY S MALÝMI BYTMI POSTAVENÉ MESTOM BRATISLAVA V ROKU 1931 (Houses with small flats built by Bratislava city in the year 1931). Photo: Josef Hofer about 1936. (Courtesy of Bratislava city Archives).



Fig.3. From the left: one L-shaped and four H-shaped apartment houses with small flats built on Miletičová street by Bratislava city (see Fig.4). Photo: Josef Hofer about 1936. (Courtesy of Bratislava city Archives).

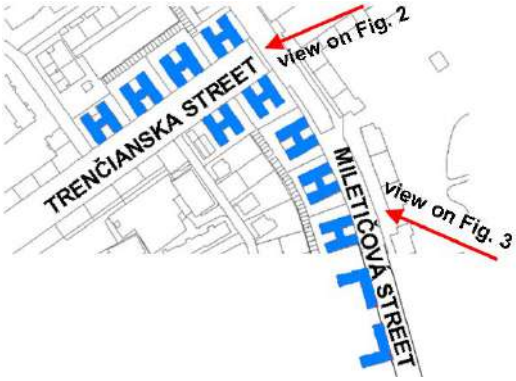


Fig.4. The Colony of 11 apartment houses with small flats. (Courtesy of Jana Hamšíková).



Fig.5. Four apartment houses in the background and two apartment houses with small flats on Trenčianska street today. Three houses have penthouse. The house in the left in the background has penthouse in construction. (Courtesy of Google Earth).



Fig.6. Apartment houses with small flats on Miletičová street today. Some houses have penthouse. In the background S = the former slaughter-house of Bratislava city, M = Market. (Courtesy of Google Earth)

Eleven apartment houses are situated on Trenčianska and Miletičová street also today (Figs.5, 6). The same is true concerning Lipeczky house (Figs. 7, 8, 11) from 1934. Also main parts of old slaughter-house are standing today in the middle of the large marketplace on Miletičová street (Figs. 9, 10, 11).



Fig.7. The pub in the house of Lipeczky on the corner of Kvetná and Miletičová street No.44. On the shop sign it is written Pub, Beer and Wine in three languages (HOSTINEC, GASTHAUS, VENDÉGLŐ and PIVO, BIER, SÖR; VÍNO, WEIN, BOR. Photo Josef Hofer in 1934. (Courtesy of Bratislava city Archives).



Fig.8. The back of the house of Lipeczky on the corner of Kvetná and Miletičová street No.44. There is the tower of slaughter-house in the backround (see Figs.9, 10). Photo: Josef Hofer in 1934. (Courtesy of Bratislava city Archives).



Fig.9. Slaughter-house of Bratislava city on Miletičová street. The tower stands today in the centre of the marketplace. Photo: Josef Hofer about 1930. (Courtesy of Bratislava city Archives).



Fig.10. Slaughter-house of Bratislava city on Miletičová street. Photo: Josef Hofer about 1929. (Courtesy of Bratislava city Archives).

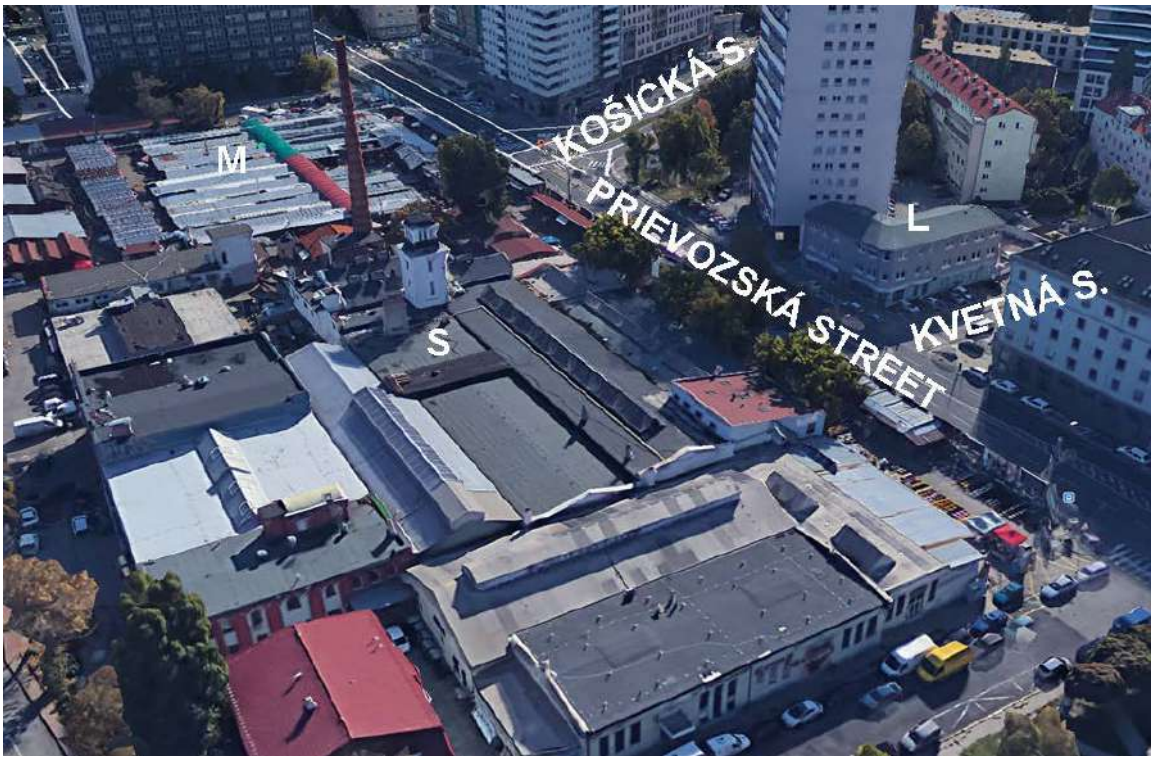


Fig.11. The former slaughter-house of Bratislava city (S) and the former Lipeczky house (L) on Miletičová street today. M = Market. (Courtesy of Google Earth).

3. Buildings of the Salesians of Don Bosco on Miletičová street

The Salesians of Don Bosco (SDB), formally known as the Society of Saint Francis de Sales (Latin: Societas Sancti Francisci Salesii), is a religious congregation of men in the Catholic Church, founded in the late 19th century by Italian priest Saint John Bosco to help poor children during the Industrial Revolution. The congregation was named after Saint Francis de Sales, a 17th-century bishop of Geneva.

The boys from surroundings of Salesians practiced various kinds of sport (football, handball, volleyball, basketball, table tennis) in sports facility which belonged to Salesians.



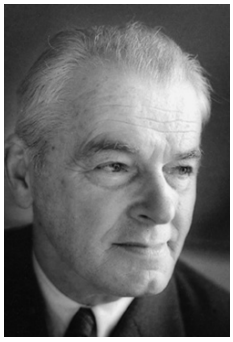
Fig.12. Building of the Salesians of Don Bosco, the church of Virgin Mary helper and statue of Don Bosco made by Alojz Rigele on Miletičová street (Fig.1). It was opened 15. 09.1933. Photo: Josef Hofer in 1938. (Courtesy of Bratislava city Archives).

4. Emil Belluš (Fig. 13a)

Emil Belluš (*19. September 1899, Slovenská Lupča – † 14. December 1979, Bratislava) was a Slovak functionalist architect [3]. Emil Belluš began his studies at the Technical University in Budapest in 1918, but completed them at the Czech Technical University in Prague in 1923. He then returned to Slovakia where he became a founding member of the Association of Slovak Artists (later the Slovak Architects Society, of which he was president 1945–1953) and of the Slovak Rowing Club. From 1925 he had his own atelier in Bratislava. From 1939 he worked at SVŠT (today Slovak University of Technology) in Bratislava, in 1945-1946 as a dean. He was professor from 1940, the first chairman of Association of Slovak Architects from 1945, academician of Slovak Academy of Sciences from 1955, doctor of sciences DrSc from 1956. His contribution to the European functionalist architecture is enormous.

He designed in: 1930 the building of Slovak Rowing Club in Bratislava; 1930-1933 Colonnade Bridge in Piešťany; 1932 propeller ship station in Bratislava; 1935 post and telegraph office in Piešťany; 1936 building of branch of insurance company in Banská Bystrica; 1938 automatic mill NUDOP in Trnava; 1933-1939 cooperative houses on SNP square in Bratislava; 1937-1938 the building of former Czechoslovak bank, today attorney general ship in Bratislava; 1942 the building of real estate and communal bank on Gorký street in Bratislava; 1943 the building of chamber of engineers on Kapucínska street in Bratislava; 1941-1946 Water tank tower in Trnava-Bučany (with K. Havelka); 1947-1948 the building of New town hall in Bratislava; 1948-1953 the pavilion of the theoretical

institutes of SVŠT, today building of Faculty of Architecture, STU on the square of Liberty in Bratislava; 1949-1954 hotel Devín in Bratislava (with E. Krampol and V. Uhliarik); 1951-1955 college Mladá Garda in Bratislava. Emil Belluš was from 1965 national artist.


a)


b)


c)

Fig. 13. a) Emil Belluš [4]; b) Ignác Vécsei [6]; c) Friedrich Weinwurm [5].

5. Residential complex Unitas

Unitas means in Latin unity. It was name of housing association which built houses. Housing complex Unitas are open gallery–type apartment complex designed by architects Friedrich Weinwurm [5] and Ignác Vécsei [6]. UNITAS was built in the beginning of the thirties by the city of Bratislava for the underprivileged. It comprises seven objects in a row estate (Figs.1, 14), with austere architectural forms, so characteristic of Weinwurm's puristic work. Initially, it was planned as collective housing project, but the idea of collective kitchen and other shared space was abandoned.

Each dwelling is accessible from a balcony oriented to the north – at end of each are the two-room dwellings (50 of them altogether), the one-room being in the middle (240). Each of the houses has two staircases. The architects have formerly devised built-in furniture and light interior accessories made of steel pipes. Yet, this plan hasn't been carried out. At the time of its creation, this complex was a rare example of functionalist principles applied to a housing project in Slovakia.



Fig.14. Housing complex Unitas are open gallery–type apartment complex on Šancová street designed by architects Friedrich Weinwurm [5] and Ignác Vécsei [6]. Photo: Josef Hofer in 1936. (Courtesy of Bratislava city Archives).

In the Fig.14 on the shop sign it is written in Slovak ODBOČKA MESTSKEJ VEREJNEJ ĽUDOVEJ KNIŽNICE and in German language FILIALE DER STÄDTISCHEN OFFENTLICHEN VOLKSBÜCHEREI.

6. Residential complex Nová doba

Nová doba (New Times) estate is a residential complex at Vajnorská Street in Bratislava, Slovakia. It was built in 1932 according to the plans of architects Friedrich Weinwurm [5] and Ignác Vécsei [6]. The complex is an excellent example of the new urban, technical and economic approach being taken to solve the social housing problems. The work is connected with the socialist concept of the minimum dwelling and is also close to the ideas of functionalism. Nová doba consists of three blocks: I, II, III. The Nová doba I was built in 1932 and it was first time in Czechoslovakia that its steel structure was used in such big amount. The shortage of steel after World War II led to use of reinforced concrete structure used at Nova doba II and III. The designers created five types of different flats: one room flat, one-room flat, one-room flat with cabinet, two types of two-rooms flats and bachelor apartment. The flats had warm water, central heating, central wash-room and drying-room. More information may be found in [7, 8]. The quality of living in Nová doba complex is highly evaluated also today. The living in Nová doba is described in very interesting and attractive way in the book [9]. Nová doba is an important cultural heritage of Slovak avant-garde architecture.



Fig.15. Housing complex Nová doba I and II on Vajnorská street. Photo: Josef Hofer in 1937. (Courtesy of Bratislava city Archives).

7. Friedrich Weinwurm (Fig.13c) and Ignác Vécsei (Fig.13b)

Friedrich Weinwurm (*30. August 1885, Borský Svätý Mikuláš – † 1942, killed at boarder during escape from Slovak state). He studied in Germany in Dresden and in Berlin where till the World War I worked. From 1924 he works in common architectural atelier with Ignác Vécsei.

Friedrich Weinwurm, a contemporary of Le Corbusier, Mies van der Rohe or Walter Gropius and one of the most noteworthy architects of Slovakia, can be ranked among the leading representatives of the interwar Central European architectural avant-garde. His legacy of several dozen designed and completed office buildings, single-family houses, villas and housing complexes forms an oeuvre attracting admiration today. His progressive

social program and clear principles for architectural design influenced the Slovak architectural scene of the 1920s and 1930s more than the work of any other architect [5].

Ignác Vécsei (*6. April 1883, Prievaly, (Senica) – † 1944, concentration camp, Oświęcim, Auschwitz-Birkenau, Poland) studied in Budapest, where shortly worked.

Weinwurm and Vécsei designed together in period 1929-1939 in Bratislava [6]: Danube bank, Villa of dr. Riesner, Villa Stein, ceremonial room of Jewish graveyard and terrace wall, residential and retail house Schön, Unitas, Nová doba, palace Coburg (together with Belluš), family house of. dr. Weil, Považská farmer`s and industrial bank (in Žilina), family house of dr. Holzmann (in Horný Smokovec).



Fig.16. Housing complex Nová doba I on Vajnorská street. On the shop sign it is written in Slovak BUDÚCNOSŤ (Future). Photo: Josef Hofer about 1943.
(Courtesy of Bratislava city Archives).



Fig.17. Housing complex Nová doba I on Vajnorská street. Photo: Josef Hofer in 1936.
(Courtesy of Bratislava city Archives).

8. Residential and retail block Avion

The preparation of the resulting project of this cooperative apartment block, in which compact and more dispersed construction are combined, was entrusted to architect Josef Marek. In the lower floors, the block is solid, while the upper floors form three separate wings; the outer wings have six floors and the central wing seven. On the ground floor are 25 shops and six entrances into the residential section. In the block are a total of 118 flats from one to four rooms. The architecture of 'Avion' has a simple Functionalist appearance, composed from right-angled rectangular forms articulated by striking comb-shaped inserted loggias. Avion is a successful combination of a unified urban parterre with a Functionalist dispersion of masses in the upper floors.



Fig.18. Residential and retail block Avion on Americké, Floriánske square and Májková street. 1931-1932. View from Odborárske square. In the bottom left an Ambulance car Praga. Photo: Josef Hofer 1934. (Courtesy of Bratislava city Archives).

9. Manderla apartment and commercial building, popularly called Manderlák

The butcher and entrepreneur Rudolf Manderla ordered the construction of the first modern high-rise 45 m tall in Bratislava, the business and residential building named after him, in 1933-1935. Rudolf Manderla, who had frequently visited the USA and wished to build something at home similar in its ambitions to the trans-Atlantic structures he admired. He was inspired by slaughterhouses in Chicago.

The 11-storey skyscraper was completed in the record time of nine months. One storey was built in a single week. The 70-metre tall crane got a lot of attention from curious onlookers. The building was opened to the public in May 1935, with the "Manderla" sign affixed to the top of it. On the ground floor was the most state-of-the-art butcher shop of its time. Manderla let poor people sit in its windows and eat there, as a promotional move. On the first floor, the Grand Café became a meeting place for the city's social elite, while the floors above consisted of residential flats.

The Manderla family was deported from Czechoslovakia, along with other citizens of German ethnicity, after World War II, and their property was "nationalised", i.e. confiscated by the state. Rudolf Manderla settled in neighbouring Austria and died in Vienna in 1968, at 84.

The essential concept of the buildings is based on the assumption of the maximum utilisation of the land, for construction of a multi-storey apartment block. The spatial, volume and structural solutions were reached by the architects relatively quickly; more complex was the search for an exterior appearance. In the end, the builder decided on a relatively austere architecture with marked vertical strips along the facade growing into the roof structure with its inscriptions. The structure of Slovakia's first skyscraper is a reinforced-concrete skeleton, of eight axes after the fifth floor and (after the 10th floor) four-axial. In the ground floor there is a modern variant of the vaulted passageway and an organically bent arcade with entrance into smaller shops. The architects planned the parterre as entirely glass, which further increased its sense of air and lightness. On the second floor were offices, and a large cafe with a view of the city. The building was designed and constructed by the architects Christian Ludwig, Emerich Spitzer and Augustine Danielis. The highly demanding construction work was entrusted to the Bratislava branch office of the important Viennese company Pittel & Brausewetter. The eleven-storey Manderla tower, however, managed to be provocative even in this environment, both with its height and its positioning outside of the street line [10].



Fig.19. Manderla apartment and commercial building on the corner of SNP Square and Kamenné square. View from Klobučnícka street. Photo: Josef Hofer in 1935 just before building completion. (Courtesy of Bratislava city Archives).

10. Authors

As teachers of Slovak and foreign students at Faculty of Civil Engineering STU in Bratislava inform students about important historical structures and their designers. Students are interested also in other actual topics like those treated in [11 - 14].

Acknowledgement

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RESTORATION OF FENCING FOR A NATIONAL CULTURAL MONUMENT

Ľubomír Baláž[1], Eduard Vyskoč[2]

LuBAL project s.r.o., Lipník 157, 97232, Slovak Republic

***Abstract**: Any construction work near national cultural monuments requires a great deal of care and thorough cooperation on the part of numerous specialists. This particular case involved the comprehensive restoration of fencing for the Great Church of the Evangelical Church of the Augsburg Confession. During the restoration itself, it was necessary to meet the requirements for structural engineering and foundation requirements for the structure, along with the requirements of the academic sculptor for the construction of the masonry parts of the building, as well as the requirements of artistic blacksmiths when restoring the metal parts of the fencing. All proposals were subject to strict control by the supervising staff of the Regional Monuments Office.*

***Key words**: restoration of fencing, national culture monument, stone and brickwork*

1. Introduction

In our practice, we have in several cases encountered an issue that was quite different from standard industry practice within structural engineering but it was necessary to provide the best possible and most economical solution, while working with professions that we do not usually encounter in our work: an artisan blacksmith, and a stonemason. This is part and parcel of restoring a national cultural monument.

In this case, based on a successful earlier collaboration on the repair of another building, the Evangelical Church of the Augsburg Confession in Bratislava's Old Town approached us to take part in the restoration of the severely damaged fencing of the Great Church complex from the Panenská Street side.

It is clear that very close cooperation with the Regional Monuments Office was also necessary in the restoration of the national cultural monument.

2. Basic characteristics of the structure

The subject of the restoration is the fencing of the immovable national cultural monument (NKP) "Veľký kostol evanjelickej cirkvi augsburského vyznania a záhrada" ("Great Church of the Evangelical Church of the Augsburg Confession and Garden") on Panenská Street in Bratislava, registered in the Central List of Monuments under registration number 174 / 1-2, located in the central urban core of Bratislava. The national

[1] Ľubomír Baláž, Ing. PhD., Lipník 157, 97232, Chrenovec – Brusno, Slovak Republic, lubalproject@gmail.com
[2]Eduard Vyskoč, Ing., Ožvoldíkova 2, 84102, Bratislava, Slovak Republic, eduard.vyskoc@gmail.com

cultural monument itself is enclosed by fencing form Panenská Street with a total length of approximately 35 m.

The fencing is composed of the following structural elements:

Underground part of the structure:

- The foundation part of the structure was at an average depth of 60 cm below ground (as determined based on excavated surveying work).

Aboveground parts of the structure:

- The stone and brickwork ("masonry") structure had an average height of 70 cm above the ground and was approximately 60 cm thick. It was comprised of 14 stone blocks made of shell limestone, among which there is masonry of solid fired bricks with lime mortar, covered with sandstone stone slabs (10 pieces). The height of the stone blocks is the same as the height of the covering stone slabs, which creates a uniform "masonry ridge" in the middle of its thickness.
- The metal part had an average height of 270 cm above the ground. This consists of cast iron gate pillars and fence parts set in the middle of the stone blocks. Metal fence parts are also placed on the central "masonry ridge". The metal part of the fencing also includes 2 side-entry forged gates and 1 central double-leaf forged gate.



Fig. 1. View of the fencing



Fig. 2. Damaged foundation block



Fig. 3. Damaged cover slab and plaster on the fence

3. Solution and work procedure

Construction and remediation work was preceded by several months of preparatory and design work, where it was necessary to align the requirements of architects and the Monuments Office, along with the technical capacities of the stonemason and artisan blacksmith. Emphasis was placed on an appropriate foundation of the structure and the overall cost of the project.

The most important and most checked requirement on the part of the architect (Ing. Arch. Pavol Vadkerti) and the Monuments Office was to preserve as much of the original structures as possible or to replace them with the same materials as the original ones.

From the perspective of the artisan blacksmith (ŠULEK s.r.o.) the entire steel fencing structure and cast iron posts had to be completely disassembled and taken to the blacksmith's shop for complete refurbishment. Given the fact that none of the fencing components are the same, this requirement was preceded by extensive measurement and marking of the elements to facilitate their reassembly in the proper location. The total weight of forged and cast iron parts of the fence is 4,600 kg. This loading is carried by the load-bearing cast iron posts in the stone parts, which are installed on an unstable foundation. The cast iron posts show signs of damage where they are installed on the stone blocks. The main load-bearing components of the fence part are joined by riveting. As a

result of corrosion, most rivets are damaged and do not fulfil their function, also the riveted joints of the connection to the stone pillar are broken and corroded. In this case, there was a risk of many fence parts falling on the pavement, the weight of one piece was about 240 kg. Forged swing entrance gates are attached to load-bearing cast iron columns with a height of 3500 mm using three hinges. The hinges are currently inoperable and corroded and the gate cannot be opened, as there is the risk of the entire structure collapsing directly on the street.

The stone blocks that support the metal fence are made of shell limestone (Fig.4). However, the roof covering connection between the blocks is made of sandstone. The stone load-bearing blocks are all sheared vertically, probably due to the weight of the cast iron fence and the displacement in the foundations themselves. As almost all the supporting stone elements as well as the sandstone lintels are so damaged and weathered that their repair is not possible, the responsible stonemason (academic sculptor Juraj Síleš, and later stonemason Branislav Moskáľ) designed a shaped stone copy of the supporting elements as well as lintels. The material originally proposed was solid silica sandstone (Božanov, Czech Republic), which is very durable and resistant to weathering due to its high quartz content. Sandstone lintels are not exposed to mechanical pressure, so he proposed to make these parts from artificial stone, the main component of which is dolomite limestone. The surface treatment of the stone parts was consulted and approved by the Monuments Office in Bratislava. The surface of the stone was to be chemically treated and waterproofed after shaping and setting. Due to the problems with obtaining silica sandstone, it was finally agreed and approved by the Monuments Office to use artificial sandstone on the pillars of the posts. It was basically a white cement concrete with fine aggregate fractions up to 8 mm, reinforced so that the blocks (each weighing 600 kg) could be handled using lifting equipment on the trucks used to bring them to the construction site. In order to be able to precisely fit the fence posts into the inserted sleeves in the pillars, there was a steel plate on the underside of each pillar with adjustment screws used to move the pillars to the final position so that the individual parts of the fence could be definitively mounted on the posts. After the final assembly of the entire structure, the lower parts of the pillars are concreted into the foundation concrete structure below the level of the pavement, so as not to disturb the original character of the structure.



Fig. 4. Stone blocks in the fencing

During these works, great emphasis was placed on accuracy because each part of the fence had a precisely defined length and place where it had to be placed. The masonry

parts formed a fill structure between the stone pillars into which the metal parts of the fence are attached. In particular, solid fired brick was used to create such a filling, which was subsequently plastered on both sides. In some sections, the original plaster reached a thickness of 10 mm to 50 mm. At present, a considerable part of the plaster has already fallen off and on the remaining part of the fence it is "abraded" and separated from the substrate or shows considerable cracking. The individual bricks show a high degree of damage, are disintegrated, disintegrate on contact and have largely lost their strength.

The masonry parts have ceased to fulfil their function, they are constantly exposed to atmospheric precipitation and ground moisture and, to a large extent, sanding salt in the winter. In some parts, the structure is overgrown with moss, which also contributes to the degradation of bricks as well as bonding mortar.

The last part of the whole process was the removal of the entire damaged and cracked foundation structure, which no longer fulfilled its intended function, and in selected sections the foundations made of stone, mortar and bricks were completely disintegrated. The most important condition set by the Monuments Office was that no modern reinforced concrete could protrude above the ground, so we had to deal with an underground foundation for the entire fence structure. The biggest problem was with the design of the foundation for the large steel entrance gate with cast iron columns, which weighed 960 kg.

A set of footings was designed under the terrain, which was connected by a strip foundation for the installation of new fencing. A massive, monolithic reinforced concrete block was created at the small and large entrance gates, which served to smoothly transfer the load to the foundation soil. A layer of compacted gravel was formed under this base strip 250 mm thick and was sloped away from the fence. In places where it was necessary to remove a thicker layer of the original foundations, the thickness of the gravel backfill was greater. The gravel bed was compacted in 150 mm thick layers. A drainage pipe was placed in the gravel layer and seepage water was drained into a seepage well for infiltration. The modulus of deformation was set at Edef > 30 MPa for this gravel bed. This parameter was checked at the investor's request. A dynamic load test to determine the deformation parameters of the embankment under the foundation of the fencing was completed on 3 August 2019. The measurement results can be found in Tab. 1. Based on the results, we can assess that the required value of the modulus of deformation was met and it was possible to continue.

Table 1 Measurement results from 03. 08. 2019

number	modul of elasticity M_{vd} (MPa)	coefficient "k"	Modul of deformation E_{def} (MPa)
LLD 01	42,6	1,5	63,9
LLD 02	43,8	1,5	65,7
LLD 03	47,6	1,5	71,4
LLD 04	32,3	1,5	48,4
LLD 05	27,3	1,5	41,0

Original design of the new foundation for the structure

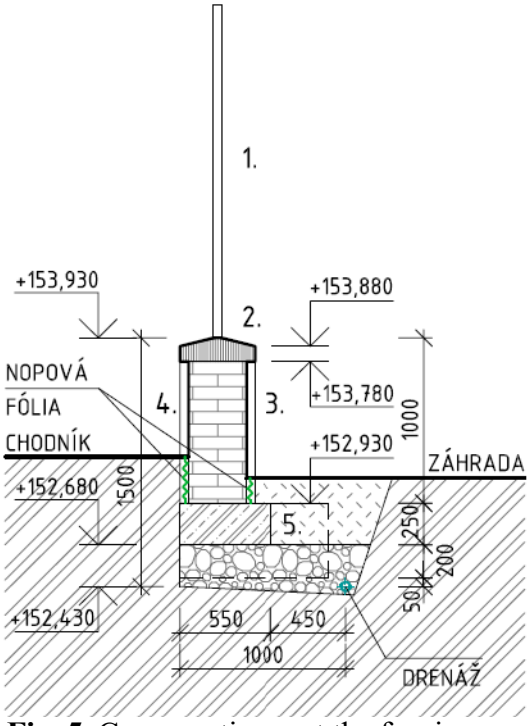


Fig. 5. Cross section – at the fencing

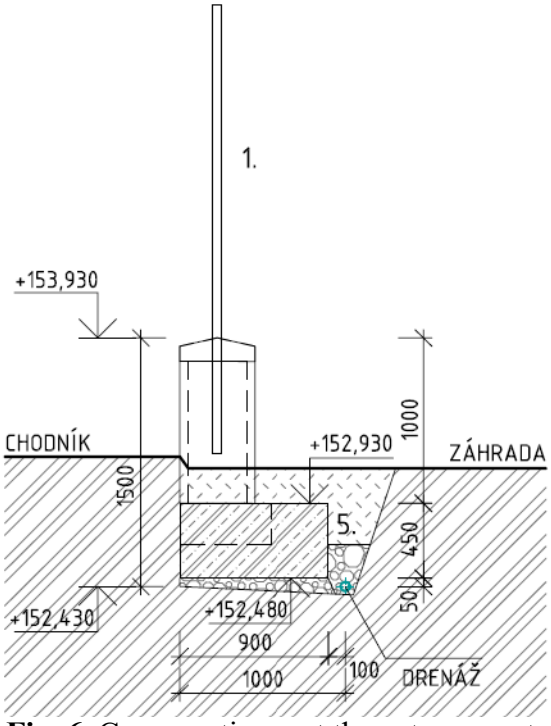


Fig. 6. Cross section – at the entrance gate

4. Conclusion

After several months of preparations, construction and renovation work on the comprehensive restoration of the fencing began in the summer of 2019. After a precise survey was complete, the steel and cast iron parts were dismantled and then transported to the blacksmith's workshop where renovation took place. Subsequently, all the stone and masonry parts were removed because they were too damaged and their repairs were not possible. After removing the above-ground part of the fence, the entire damaged foundation under the fence was removed except for the terrain. Subsequently, the compacted gravel substrate and control measurements to determine the modulus of deformation of the compacted gravel layer were made. A monolithic reinforced concrete strip foundation into which anchoring elements for the fence posts were installed was then poured on this substrate. The new strip foundation has a thickness of min. 250 mm and a width of 550 mm with local extensions at the side gates for people and also the central double-leaf primary gate. After a few days, stone blocks and fence posts were installed directly in place.

The original brickwork was carefully dismantled and bricks that were not significantly damaged (did not disintegrate, and were not broken or otherwise degraded) will be used in the construction of the new brick structure. Only solid fired bricks of a similar format to the original can be used for construction; the use of any other bricks is not allowed.



Fig. 7. Newly created stone blocks for fencing

To date, the foundation structures and stone blocks with cast iron columns, which have undergone a complete refurbishment in the blacksmith's shop (Fig. 7-9) and all masonry parts of the fencing are complete. All construction work was regularly reviewed and approved by authorised Regional Monuments Office personnel. The entire project was turned over in the summer of 2021.



Fig. 8. Newly created stone block



Fig. 9. Newly created stone block



Fig. 10. Newly created stone block – entrance gate

Acknowledgement

This paper was created thanks to the extraordinary cooperation of professionals involved in the project: Ing. arch. Pavol Vadkerti, ŠULEK s.r.o., stonemason Branislav Moskáľ and Regional Monuments Office staff.

ANALYSIS OF CIRCULAR CABLE SUSPENDED ROOF

J. Sandanus[1], M. Slivanský[2], K. Freudenberger[3]

Slovak University of Technology in Bratislava, Faculty of Civil Engineering, Department of Steel and Timber Structures

Abstract: *The paper presents a rope roof structure from 1980 beneath a circular floor plan with a diameter of 60.5 m. Defects and conclusions stated in the report from the earlier ended internal inspection related to the technical condition of the supporting ropes on the main roof structure of the swimming pool were the reason to develop the control static assessment of the roof structure.*

Key words: *Steel structure, cable suspended roof, load-bearing rope, corrosion, static analysis*

1. Introduction

The aim of the control static assessment referring to the roof structure over the swimming pool in Duslo a.s. Šaľa company was to identify defects based on conclusions stated in the report regarding an earlier performed internal inspection of the technical condition of the supporting ropes included in the main roof structure over the swimming pool. By the inspection, load-bearing ropes damaged by corrosion were found at the point of anchoring to the outer reinforced concrete wreath. Due to the detail of anchorage, it was not possible to carry out any measurements other than by a visual inspection. Based on that, depth of corrosion could not be measured. As a result, the level of corrosion and the corrosion losses were not determined by the inspection.

The aim of control static assessment of the load-bearing roof structure [1] was to verify reliability of supporting ropes that create the rope roof structure with span of approx. 60,5m (Fig. 1). The assessment of other elements, construction details of connections or the extension of the heating, ventilation, and air conditioning (HVAC) engine room located on the roof of the main building was not the subject of an assessment.

The control static assessment was based on a relatively extensive original project documentation and other relevant available documents and was verified by construction without the influence of possible failures (such as existing unspecified corrosion related to parts of the supporting ropes). The control static analysis of the roof structure was processed according to the set of Slovak Technical Standards (STN) valid at the time of construction.

[1] Jaroslav Sandanus, doc. Ing, PhD., Faculty of Civil Engineering, Slovak University of Technology in Bratislava, jaroslav.sandanus@stuba.sk
[2] Miloš Slivanský, Ing., PhD., Faculty of Civil Engineering, Slovak University of Technology in Bratislava, milos.slivansky@stuba.sk
[3] Klara Freudenberger, Ing., Faculty of Civil Engineering, Slovak University of Technology in Bratislava, klara.freudenberger@stuba.sk

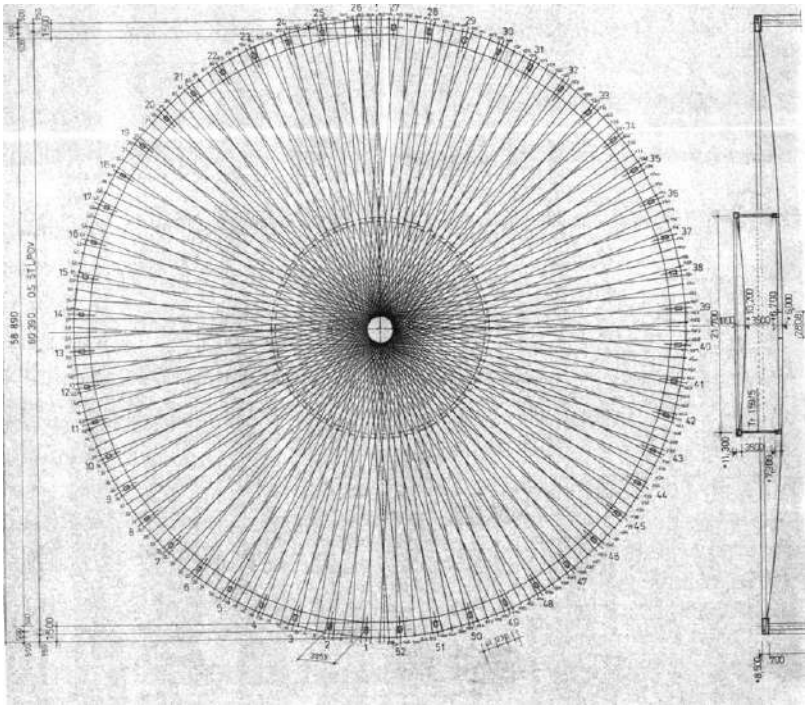


Fig. 1. Roof of swimming pool

The results of the control static assessment consist of a conclusion on the reliability requirements according to the relevant standards, while the possible reserve in the rope resistance was quantified. Based on the achieved results, a set of temporary measures was proposed to ensure the reliability of the analysed roof structure.

2. Construction description

The roof structure of the swimming pool is the main subject of assessment. The load-bearing structure of the sheltered swimming pool consists of a reinforced concrete prefabricated skeleton with a circular floor plan and a theoretical diameter measured in the axis of the load-bearing columns of 60,5 m. The so-called "Poštulka" rope system was used as a suspended rope roof, which contains a total of 104 pieces of freely suspended steel ropes. Steel ropes are anchored in a reinforced concrete circumferential wreath around the perimeter of the building, which is supported by a system of circumferential load-bearing columns transferring the effects of vertical loads. There are a total of 52 pillars of rectangular cross-section measuring 300x500mm. The circumferential wreath is also of rectangular cross-section (with a trapezoidal recess for fitting and anchoring of the supporting ropes) with a dimension of 1500x700mm. Based on available documents, single strand wire ropes of an open construction with a diameter of 30 mm are used for the roof structure.

The HVAC engine room is located on the top of the main roof load-bearing structure. The engine room is placed directly on the roof structure of the swimming pool's shelter. It is designed as a combined skeletal system with a circular floor plan and a theoretical diameter in the axis of the columns of 21,7 m. The roof structure above the circular floor plan consists of a total of 40 free-hanging steel ropes. Steel ropes are anchored around the perimeter of the building to a reinforced concrete circumferential wreath, which is supported by a system of steel load-bearing columns due to the effects of vertical loading.

There are a total of 20 steel columns of circular tubular cross-section measuring 159/5,0 mm on the perimeter. The steel columns at the lower edge are anchored in a reinforced concrete wreath with dimensions of 350x800mm. The circumferential wreath is of a rectangular cross-section with a dimension of 600x500mm. Based on available data, single strand wire ropes of open construction with a diameter of 18mm are used on the roof structure of the HVAC engine room.

The layers of the roof structure are laid on a cable net (Fig. 2). As a spreading layer, steel mesh with hole 100x100mm and 5mm wire diameter is used. The supporting ropes in the part of the swimming pool are provided with a plastic protective coating.



Fig. 2. Overall view of the crossing of ropes in the middle of span

The preliminary geometry of the suspended roof structure of the swimming pool (further used in the static analysis) was determined based on the measurement of the structure - by subtracting the height of the rope structure above the floor at the anchorage point and in the middle of the span. The total thickness of the rope structure at the point of intersection of several supporting ropes (in the middle of the span) was also tentatively measured.

Beneath the main roof structure are suspended service bridge and piping for HVAC (Fig. 3a). A steel footbridge designed for access to HVAC engine room is in exterior with a span of approx. 20m (Fig. 3b). Details of these constructions were not available in the provided documentation.



a) b)

Fig. 3. a) Suspended service bridge; b) Steel footbridge with HVAC engine room

3. Control static calculation

3.1. Numerical model

The finite element method (FEM) was used for a static analysis. Based on the idealized geometry of the load-bearing structure, 3D models were prepared. Nonlinear analyses (pressure elimination in rope elements and geometric nonlinearities) were done. The rope elements are connected by hinge joints and the ropes are designed as flexible fibres without significant bending stiffness for the purposes of the numerical model.

Based on available information, the geometry data of the structure and the dimensions of the load-bearing elements were modelled. According to the available project documentation, the theoretical values of the overhangs of the load-bearing ropes were determined to be 2,15m for the main rope roof with a span of 605m and 0,85m for the roof of the HVAC engine room with a span of 21,7m (Fig. 4).

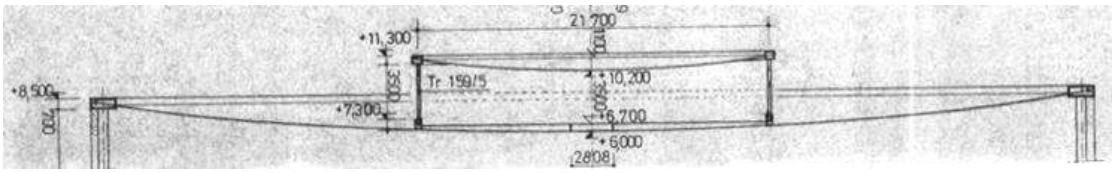


Fig. 4. Geometry and theoretical deflection of the rope roof

The theoretical overhang determined by measurement (in the median plane of the intersecting layers of load-bearing ropes) had a value of 2,12m. This value was measured in the conditions of the roof structure without snow load, so for the purposes of calibration of the numerical model, all components of permanent loads and the payload of the engine room floor were considered as relevant loads. For such a characteristic load combination, a vertical deflection of the main roof structure in the middle of the span of 1775mm was calculated and the initial overhang of the unloaded structure was entered to be 250mm. The resulting deformed shape thus reached the value of the overhang in the middle of the span 1775mm + 250mm = 2025mm and the measured value was 2120mm. The resulting deviation of 95mm is due to the reliability of the suspended rope construction on the safe side.

The strength class of the used materials (steel, concrete) was not verified during the inspection. Structural steel of the lowest strength class steel series 37 was considered for the needs of control static calculation. For rope elements, the strength limit of wires 1370MPa was considered and for reinforced concrete elements the strength class of concrete B25 (currently classified as C20/25) was considered.

3.2. Construction load

The load of the structure and combinations of individual load effects were compiled based on STN 73 0035 (Load actions of building structures).

For the comparison with the provided data, the weight of the roof layers was also determined by sounding the actual roof structure. The measurement was performed by the client. A sample of approx. $1m^2$ was weighed with a final value of 45kg. The theoretical weight according to the available data with a value of $52kg/m^2$ was considered in the calculation because it represented a slightly higher value, the effect of snow loading on the roof structure were determined for II. snow area with basic snow weight $s_0 = 0.70kN/m^2$ and shape factor $\mu = 1,0$. The resulting standard value of snow load was $s_n = 0.84kN/m^2$. The effect of wind loads on the roof structure were determined for III. wind area with the

value of the basic wind pressure w_0= 0.55kN/m^2 for terrain type A height above the terrain 15m (Table 19, coefficient of altitude and terrain type κ_w = 1,10). Due to the assumed form factors and the resulting load effects on the roof structure, the wind load represented suction - thus lightening of the roof structure. Therefore, this load was not included in the static calculation. The effects of wind were considered in the static calculation only as a load acting horizontally on the perimeter walls of the HVAC engine room, because this effect can cause asymmetrical loading of the roof structure under consideration. As payload of floor of HVAC engine room was considered as uniform load with a value of 2,0kN/m^2 and a dynamic factor of 1,3 (according to Table 3 in the standard STN 73 0035 ceiling category "technical floor").

3.3. Results of static analysis

The steel load-bearing ropes used within the roof structure of the swimming pool were assessed in accordance with STN 73 1407 (Design of structures with tension components). The highest design value of axial force in the load-bearing rope was N_d=293,8kN, (stress of the load-bearing rope σ_L=559,6MPa). Design axial force without snow load on the roof structure (neither the swimming pool nor the HVAC engine room) was N_d=245,4kN, (tension in the load-bearing rope σ_L=457,4MPa). Single-stranded wired open ropes with a diameter of d = 30mm with an assumed nominal wire strength of 1370MPa and a basic design strength for the new wired rope RL = 850MPa are used as load-bearing ropes in the main roof structure. Dimensions of the load-bearing ropes comply with the ultimate limit state (ULS) based on a comparison of the above values.

The assessment of the rope structure at limit state of serviceability (SLS) was performed regarding the additional deformation caused by the variable load components (the most significant are climatic loads of snow and wind, the payload of the HVAC engine room floor is more similar to a long-term technological part of the structure). The value of the deformation reaches 300,1mm, which is approx. L/200 and from the characteristic combination of variable loads, such as snow and wind (where the payload of the HVAC engine room floor is included as a permanent load), the value is 99,7 mm, which is approx. L/600. Due to the operational requirements of the structure, the static system, and the located technological equipment, it can be assumed that neither the structure nor the equipment are sensitive to deformation and the structure is suitable for SLS.

4. Conclusion

4.1. Summary of analysis results

Based on the results of control static assessment, it can be stated that rope roof over the swimming pool with circular floor plan with diameter 60,5m was designed in accordance with technical standards at the time of designing, respectively the at the time of realization of the building and the supporting ropes with a diameter of 30mm, theoretically fulfil the criteria of the ultimate limit state and the limit state of serviceability.

Regarding the results, the theoretical reserve in resistance of supporting ropes was analysed as follows:

- $\mu_1 = \frac{559,6MPa}{850MPa} \cdot 100\% = 65,8\%$ utilization of supporting ropes according to ULS (total)
- $\mu_2 = \frac{467,4MPa}{850MPa} \cdot 100\% = 54,9\%$ utilization of supporting ropes according to ULS (without snow load)

- $\alpha_1 = \frac{100\%}{\mu_1} = 1,52$ theoretical reserve in resistance (total)
- $\alpha_2 = \frac{100\%}{\mu_2} = 1,82$ theoretical reserve in resistance (without snow load)

In relation to the conclusions stated in the inspection assessment, in which it is stated that existing unspecified corrosion of parts of load-bearing ropes with a diameter of 30mm in the anchoring area was found, the theoretical results were obtained and interpreted as follows:

- The resistance of load-bearing ropes of the roof structure is satisfactory if the corrosion of the load bearing ropes has a weakening of the load bearing cross section of a maximum of 34,2%,
- if the corrosion of the load-bearing ropes is more of a random (local) failure and it is not a surface system failure of the structure, local failure of one load-bearing rope, due to the determined reserve of adjacent (non-corrosion) ropes, does not represent total damage to the entire roof structure. Loaded adjacent load-bearing ropes will theoretically be stressed at 98.7% of its design load-bearing capacity, while multiple crossing of load-bearing ropes in the structure will ensure more favourable redistribution than the stated value approaching 100% utilization,
- the values of the theoretical reserve in resistance are even more favourable for the mode of operation of the structure in conditions without snow load. When the area theoretical weakening of the load-bearing cross-section of the rope would be maximum 45.1% and the stress on adjacent ropes in case of local damage 82,4% of their design load capacity.

4.2. Draft measures

To increase the detail of the technical documentation for the purpose of a more accurate theoretical assessment of the reliability of the structure, the client was recommended to add the following characteristic data of the structure:

- detailed geodetic and geometric data of the supporting structure,
- verification of the actual composition of the floor structure of the HVAC engine room, determination of the payload of the engine room floor based on the passportization of the actual position, type, and weight of located technological equipment, determination of additional loads of the roof structure due to the installation of other technological and service structures,
- detailed diagnostics aimed at determining the degree of corrosive damage to the load-bearing ropes of the main roof structure around anchoring.

Even though, the rupture of one supporting rope does not theoretically present a risk of the entire roof structure collapse, this may be associated with a risk to the health of visitors or swimming pool staff due to the release of the rope and it is subsequent free suspension. Therefore, the client was recommended to use the swimming pool temporarily and under stricter operating measures, which mainly concerned monitoring the thickness and weight of snow layer on the roof structure over the swimming pool and engine room. And regular inspection of all rain gutters, in order not to increase the load on the roof structure.

4.3. Current state of construction

The control static assessment of the roof structure and a set of proposed measures was prepared in the period November 2017 to January 2018. The construction continued to

be used in compliance with stricter operational measures, but a detailed diagnostics of the technical condition about the ropes in the anchorage area was not performed, as the client could not find a potential supplier for complex disassembly, inspection, and subsequent assembly of suspended ropes. In the event of more serious corrosive damage, it would be necessary to replace the rope ending and/or the damaged part of the rope, because due to the multiple crossing of the ropes, replacing the entire rope/rope system would be technically unfeasible.

In April 2019, one supporting rope broke. The rope was damaged at the place of its anchoring on the supporting reinforced concrete wreath. It was a rupture of all the wires of the rope at the point of transition to the rope end. The rope in the line of the inspection footbridge broke, while it was suspended by a system of secondary suspensions on a pair of parallel ropes of the roof structure. By tearing the rope, one side of the inspection footbridge dropped, and the footbridge tilted transversely. The damaged load-bearing rope remained suspended on the released end and, due to the multiple crossing of the load-bearing ropes, it did not fall into the pool area. The inspection bridge was secured by the client, as means of temporary support made of steel tubular scaffolding installed in the pool area, and the building of the swimming pool has been out of service since then.

Regarding the previously prepared technical documents and provided documents [2], the following probable causes of the failure are mentioned:

- corrosive damage to the supporting rope around anchoring to the circumferential wreath,
- overload of load-bearing rope,
- other unspecified causes.

During the inspection of the damaged rope and its end piece, only surface corrosion was observed at the point where the wires entered the anchoring in the area where the rope was not protected by a plastic cover. Wire damage can be classified as concentrated in one section (as from the point of view of the wires themselves as well as from the point of view of the rope itself). All the concerned wires were probably damaged by rupture, but no significant weakening of the cross-section of the wires by corrosive loss was observed. Based on the surface corrosion of the cross-sectional area where the wires were broken, it can be stated that the outer layers of wires (18 + 12pcs) broke probably in the past, because parts of the broken wires were corroded on surfaces, but the resulting collapse internal wires (1 + 6 pcs.), where the rupture and / or tearing of the wires from the rope ending-connection occurred and corrosion on the cross-sectional area did not appear on these wires.

The performed static control analysis introduced certain general assumptions regarding the determination of load effects and did not consider the real load effects resulting from the location and installation of technological and service structures. The suspension of the inspection bridge on a pair of ropes could therefore represent a local additional load when the actual utilization of the affected ropes at the ultimate limit state will be higher than the value of 65.8% determined by the theoretical calculation, e.g., additional load of the supporting rope along the entire length by a line load with a value of 50kg/m (0.50kN/m) will increase the axial force in the rope by approx. 110kN, which is approximately 25% of its design resistance.

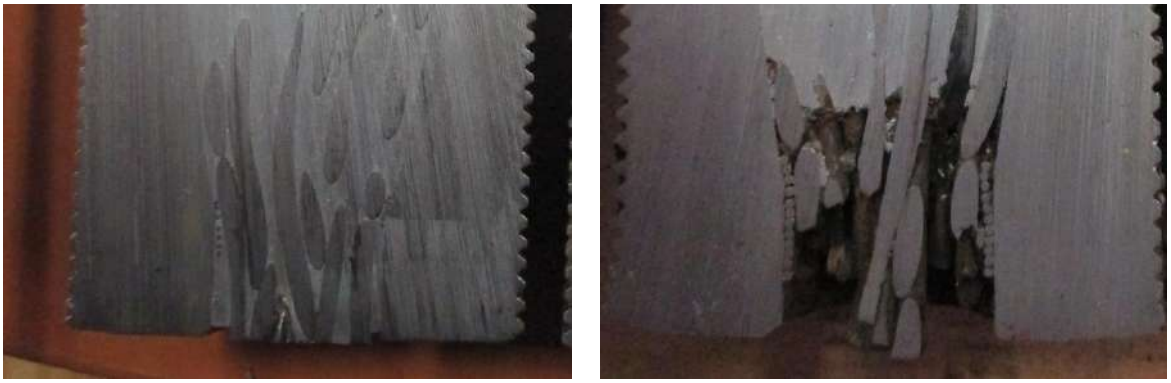
Considering the above facts and the fact that the load-bearing rope loaded by the inspection bridge was damaged, it is possible to assume that the rope is overloaded as a significant cause of the rope failure.

These possible causes of damage to the supporting rope have been mentioned:

- inappropriate, respectively insufficient filling of the rope end with a metal grout at the point of the rope into the end (Fig. 5) in the transition cross-section, the support of the rope wires on a rigid wire bandage, which could/may cause additional stress

on the wires, which are sensitive to oscillation tension and thus lead to fatigue damage to individual wires,

- additional bending stress of the rope at the point of opening into the rope end piece, because the support of the end piece on the supporting structure does not allow its free rotation
- damage and/or additional load of the part forming the supporting rope wires during assembly, e.g., when rectifying (tightening) the cable end by its torsional stress (twisting).



a) b)

Fig. 5. Cross section of rope ending: a) undamaged; b) damaged

Acknowledgement

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RECONSTRUCION OF THE ROAD BRIDGE ACROSS THE LITTLE DANUBE RIVER IN KOLÁROVO TOWN

Jozef Lapos [1], Peter Tatarko[2]

Abstract:
The paper deals with the renovation of an old steel bridge over the river Little Danube ahead of Kolárovo. The riveted truss steel structure of the bridge with 70,7 m span was built even in 1915. The roadway and the floor were strongly damaged by holes, the bridge deck by corrosion and a couple elements of superstructure by impacts caused by vehicles. The reconstruction began with installation of a boat bridge beyond the bridge in Oct. 2005 and after the winter the renovation of bridge was finished in May 2006.

***Key words**: Renovation, old steel bridge, riveted truss structure, corrosion*

1. Introduction

The bridge on the state road II / 573 leading from Šala to Komárno crosses the Little Danube river near Kolárovo, not far from its mouth to Váh river. It is a lattice riveted structure with a span of 70.70 m, that was built in 1915, at a time when a road with the width of 4.8 m was still enough - Fig.1. Axial distance between main girders is 6.40 m. The need for repairs resulted from the critical condition of the load bearing structure under the road, from strong corrosion of cross girders and longitudinal girders due to leaks, but also from the hitherto unsuitable solution of road drainage. It was already necessary to restore the complete corrosion protection of the entire bridge structure and repair the damage of the main girders and stiffeners from vehicle impacts. The bridge is placed on two gravity supports without an expansion device. At the end of World War II, the end of the bridge was hit by a bomb, released from the bearings and fell to the ground, but after being lifted and placed back on the support, it has served its purpose until now. Fixed bearings are on the support from the side of Kolárovo town, movable four-roller bearings are on support from the side of Šala town.

[1] Jozef Lapos, Prof. Ing. PhD., (retired), 821 02 Bratislava, Súmračná 16, lapos2011@gmail.com
[2] Peter Tatarko, Ing. PhD, 841 02 Bratislava, Cabanova 2, tatarkop@gmail.com



Fig. 1 View on the bridge before the reconstruction



Fig. 2 Traffic on a pontoon bridge

In accordance with the regulations, it was necessary to adjust the road centre line with transition arcs at both ends of the bridge and to put expansion device above the movable and fixed bearings. It was also necessary to repair the damage of the supports and their wings and to build transition plates, which were not designed in the original solution. Due to the fact that the nearest bridges for a possible bypass are only in Šala and Komárno, during the repair of the bridge deck it was necessary to build a pontoon bridge next to the bridge - Fig. 2, which also allowed traffic for public bus transport. For the design of a pontoon bridge, it was necessary to take into account the possibility of the Little Danube water level fluctuation that also depends on the flow in Váh river.

The documentation for the repair of the steel structure was prepared up to the construction stage of the repair project, which was provided and coordinated by the company Banské projekty s.r.o. Bratislava, for the investor Regional Administration and Maintenance of Roads Komárno. During the processing of the project, it was possible to obtain the necessary documents only gradually during the inspection and diagnostics of the structural elements, because the investor did not have available project documentation. Material data were obtained by tests at VUZ - Industrial Institute Bratislava, which showed that the bridge was made of Bessemer steel strength group S 235 with sufficient strength, ductility and notched toughness, but due to the possibility of brittle failure at low temperatures and the age of the structure, VUZ forbade the welding during the bridge repair.

2. Reconstruction of the bridge deck and load bearing road surface

The construction of the lower open grid bridge deck consists of riveted cross girders connected to the verticals at distances of 5.05 m. The deptht of the riveted cross girders is 770 mm. The side and middle longitudinal girders with a span of 5.05 m are connected to the cross girders. The side longitudinal beams with depth of 600 mm are located at a distance of 800 mm from the axis of the main girders. The three internal longitudinal beams with a depth of 525 mm are 1200 mm apart from each other and from the edge longitudinal beams. The upper flange of the inner longitudinal beams was embedded by 220 mm compared to the outer longitudinal beams - Fig.3. The load bearing structure of the road from ZORÉS profiles No. 26a was in a critical corrosion state caused by leaks,



Fig.3 Corrosion of the bridge deck and critical condition of the load-bearing structure from ZORÉS profiles

which was manifested on the road surface by potholes and in several places holes in the road.

Bridge deck repair - see Fig. 4 and 5, was carried out by replacing the upper neck angles on the longitudinal girders with new ones, after the previous removal of the neck rivets and their replacement by friction joints.



Fig.4 View on the open bridge deck during reconstruction



Fig.5 Reconstruction of the cross girders

After cleaning the surfaces for friction connections, the connection of the new neck angles to the longitudinal girders was carried out with preloaded bolts M16–10K at distances of 100 mm.

Corroded U 200 sections were removed from the cross girders. After drilling holes in the new U 200 sections and adjusting the friction surfaces, these sections were connected by two rows of preloaded bolts M16–10K, also at distances of 100 mm - Fig. 5.



Fig.6 Corroded ZORÉS sections

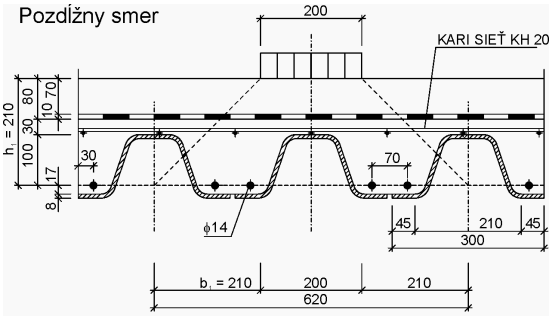


Fig.7 New floor sections made of 8 mm thick steel plate

Existing load bearing structure from the ZORÉS sections that is under the road was in critical condition - see Fig. 6 and it has been replaced by cold-bent floor sections made of 8 mm thick steel plate - see Fig. 7 and 8. On these new floor sections a reinforced concrete slab with a thickness of 130 to 180 mm was created - Fig. 9. A new 80 mm thick road made of modified asphalt concrete was built above the waterproof layer of the slab. New gutters of road drainage are placed under the sidewalks. They are made of galvanized steel plates with a thickness of 5 mm.



Fig.8 Load bearing structure under the road



Fig.9 Work on a new steel concrete slab of bridge deck

3. Reconstruction of main girders

Main girders were inspected to determine the actual dimensions of the bars, diameters and arrangement of rivets in the upper chord, diagonals, verticals and in the lower chord. It was absolutely necessary to completely restore the coating system of the bridge, Fig. 10. It was also necessary to repair the damaged verticals of the main girder from vehicle impacts. The girders of the vertical portals at both ends of the bridge have also been damaged by high vehicle impacts.

Due to the previous sharp turns of the road centre line, transition arcs with a radius of 500 m or. 300 m at both ends of the bridge were used. As a part of the repair, the functional capability of the fixed and movable four-roller bearings was also verified. Transition plates have been added to both supports. A bridge expansion joint of the 80 J type was installed on the side of the support with a movable bearing. New sidewalks were built and the existing handrail was repaired and painted.





Fig.10 Repair of main girders and bridge deck

The drainage of the bridge is designed using gutters made of 5 mm thick steel plate. The gutters are placed under the reconstructed sidewalks on both sides of the road. Water from the gutters is released by 2 x 4 spouts.

4. Load capacity of the bridge

The load capacity of the bridge - normal, exclusive (one vehicle) and exceptional (special set), was determined according to the standard ON 73 6220 valid at that time. The results are in Tab. 1.

Tab.1 Load capacity of the bridge

Types of load capacity	Normal	Exclusive	Exceptional
	[t]	[t]	[t]
Bridge load capacity	17,3	35,7	86,4

5. Static and dynamic load test

After the bridge reconstruction, a static and dynamic load test of the bridge was performed. The static load test was performed by two TATRA 815 trucks with a weight of 21.0 t and 21.75 t respectively, see Fig. 11.



Fig.11 Static load test



Fig.12 Dynamic load test

During the static test of the bridge deck elements, the deflections and stresses were checked by strain gauge measurement on selected places of the longitudinal and cross girders. The static tests of the main girders were carried out to check the deflections on both main girders. The load test of the bridge deck and the main girders confirmed not only their elastic behaviour, but also the favorable effect of the composite concrete and steel structure, which was not taken into account in the load calculation.

Dynamic test - Fig. 12 was performed by a TATRA 815 vehicle with the weight of 21.75 t. During the dynamic test, the vehicle speed on the bridge gradually increased from 5 km / h to 50 km / h. The same value of the first natural oscillation frequency of 2.8 Hz was repeatedly measured, compared to the theoretically calculated value of 2.5 Hz, which proofs the fact that the effect of connection between steel bridge deck elements and newly built reinforced concrete bridge deck has a positive effect on the flexural stiffness of main truss girders.



Fig.13 View on the 106-year-old bridge over the Little Danube in Kolárovo - L = 70.7 m

6. Conclusions

The reconstruction of the bridge took place in 2006, i.e. after 91 years after the bridge commissioning. Another 15 years have passed since the renovation, the reconstructed bridge, see Fig. 13 has served its purpose for 106 years to this day. The deck and the main girders are optically in good condition, so it can be assumed that its service life will reach at least 130-140 years. An indicator of the efficiency of such structure, that is based on the costs of its construction, maintenance and reconstruction with consideration of a lifetime, would certainly show how often today the benefits not only of steel bridges, but also, unfortunately, of composite steel and concrete bridges are overlooked.

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VENETIAN CASTLE IN SPLIT - CROATIA

Katja Marasović

University of Split, Faculty of Civil Engineering, Architecture and Geodesy
katja.marasovic@gradst.hr

***Abstract**: After the Venetians had subdued Dalmatia in the early 15th century, they built castles in most of the cities. The Split castle was built in 1441, and today is only partilay preserved. Drawing on a scholarly study of papers published previously, historical sources and the results of aechaeological excavations, the author puts forward new understandings of the construction and transformation of this building, and provides spatial reconstructions of the castle in five characteristic historical phases.*

***Key words**: Castle, fortification, Venetians, Split, Dalmatia*



Figure 1. The Venetian Castle in Split (photo by K. Marasović)

1. Introduction

In 1409 the Venetian Republic bought the rights to Dalmatia from the King of Hungary-Croatia Ladislav of Naples, and gradually, thanks, among other things, to military undertakings, imposed its rule on most of the territory, with the exception of the Dubrovnik Republic. The Venetian possessions in Dalmatia were, however, much diminished during the expansionary conquests of the Ottoman Turks during the 15th and 16th centuries.On June 28,

1430, a decision of the Major Council surrendered the city of Split to the rule of Venice. One of the conditions of the surrender was: "Similarly, let the doge never permit anyone in the city of Split or close to the city to build any tower or fort" [1]. And yet, just a few months later, on December 30, 1420, the envoys of Split (probably pressed by the Venetians) [2] sent a plea to the doge asking to have a castle (*castrum*) or fort (*forticilium*) built in Split for the sake of the security and well-being of the city [3]. The castle was built in 1441 in the south-east part of the city, on the seashore, only a part of it, the northern, surviving to this day [4].

We can find important information about the building and modifications of the Castle in papers by D. Kečkemet, J. Marasović and A. Duplančić, as well as in original Venetian documents and drawings that Alessandra Sartori assembled for her dissertation *Spalato rinascimentale, la fortezza e la città, Gli interventi veneziani dal sec. XV al sec. XVII* at the Venice architecture faculty back in 1988. Of crucial importance for the precise definition of the plan of the Castle were archaeological excavations carried out on the Waterfront (Riva) in 2006 and 2007 [5]. Reconstructions are founded on architectural survey of the preserved parts of the Castle of 1963 [6] and an architectural survey of the historic core of Split [7].

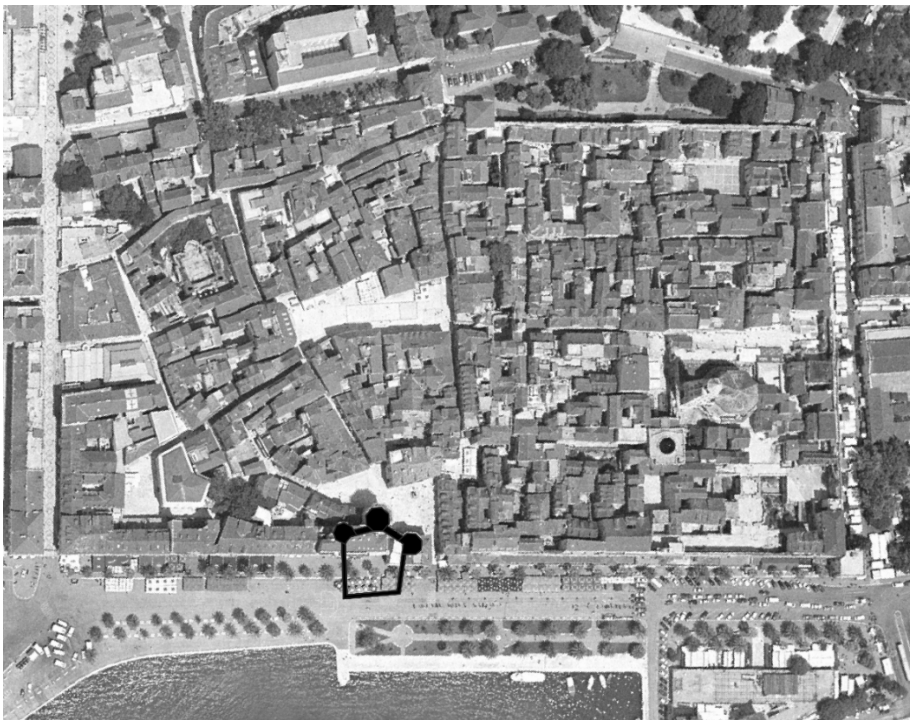


Figure 2. Position of the Venetian Castle in the historical core of Split

2. The hypothesised state before the construction of the Venetian castle

The site on which the Venetian castle was built was already occupied by buildings in the Middle Ages. Here on the seafront there was the court of the Sabaka family, and to the north of it the Convent of St Clare. The 1312 statute of the city of Split enjoins the building of a wall on the western part of the port "*starting from the wall of the court of the Sabakas then southwards to the sea, like the wall beneath the archbishop's tower, in such a way that neither man nor beast can pass that way…. The headman is also bound to raise some wall from the corner of Sabaka Court and all the way to the corner of the tower of Petar Petraka and must in all suitable ways compel those who have houses and walls in this court to build the wall of the said court,* ***which is on the sea****, just as high as the commune shall build its own*" [8].

The western part of the southern wall of the New City [9], which joined the tower of Petar Petraka (the south-west tower of the Palace) [10] and the corner of Sabaka Court, was found while the Eastern Tower of the Castle was being renovated in 1985 and 1986 [11]. This medieval wall was incorporated into the thickness of the southern wall of the tower. At that time two vaults of its cantilevered defensive walkway or chemin de ronde were found and it was determined that the width of the medieval wall together with the cantilevered walkway came to 1.64 m, and 1.18 in the lower part. The eastern part of this same city wall is still in existence in its full height as the wall of a five-storey house to the east of the southern entrance into Voćni trg (Fruit square). On the highest floor of this house, right by the actual defensive wall which is intersected at its full height in this spot, it is possible to see bricked-in door that led to the cantilevered defensive walkway.

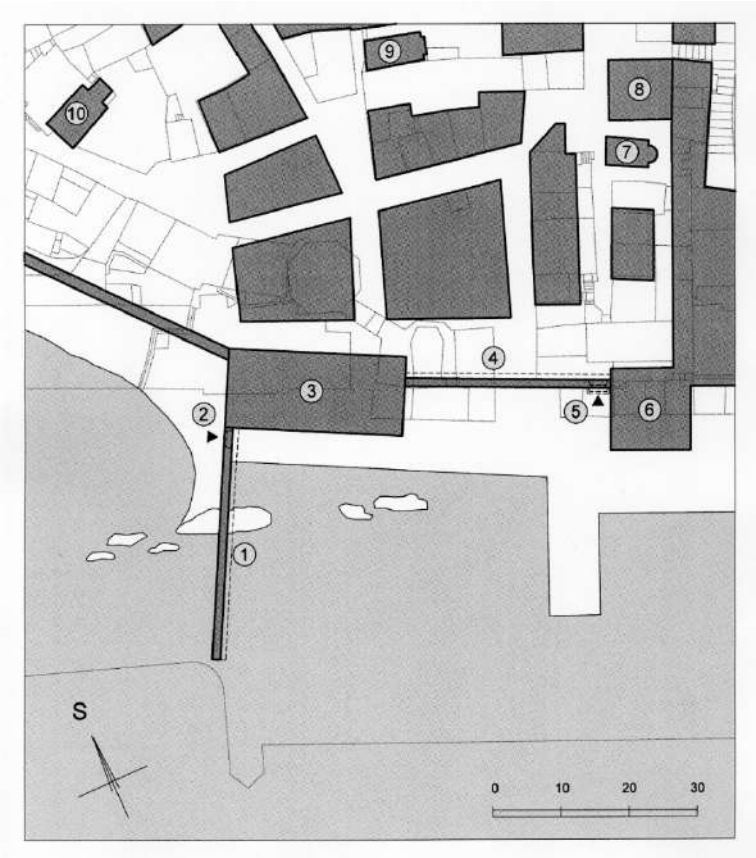


Figure 3. Hypothesised state before the construction of the Castle in 1400, plan:
1 – Western wall of the port, 2 – Butchers' Gate, 3 – Sabaka Court, 4 – Southern wall of New City, 5 – Maritime Gate, 6 Petraka Tower, 7-St Michael's, 8 - Diocletian's Tower, 9 – St James', 10 – Our Lady of Dobrić (by K. Marasović)

The remains of the wall that extended from Sabaka Court to the sea were found in archaeological excavations of the Waterfront in 2006 and 2007 beneath the former building of the Port Quarantine Station (the Sanità), located on the Mali Mul (small pier). Since it was also about 1.18 m thick, it can be assumed that it was also possessed of a cantilevered walkway, like the wall mentioned earlier, for, according to the drawings of Santacroce (Fig. 4) and Angelo degli Oddi (Fig. 5) both walls had defensive crenellation.Paying careful attention to the wording of the Statute of 1312, it can be seen that these two medieval city walls determined the position of Sabaka Court just below the Venetian castle. And right in the central part of the Castle, during archaeological excavations of 2006-2007, a wall that was 3

m thick and 19.5 m long was found, in en east-west direction, going in the east as far as the eastern wall of the Castle. On the southern side, this wall was built in the scarp. Since it is not related in any way to buildings later built in the Venetian castle, it can be concluded that it is older than the latter and that it is the southern wall of Sabaka Court that lay in the sea [12]. Significantly, this above described western medieval wall of the port of Split was placed exactly at right angles to the southern wall of Sabaka Court.

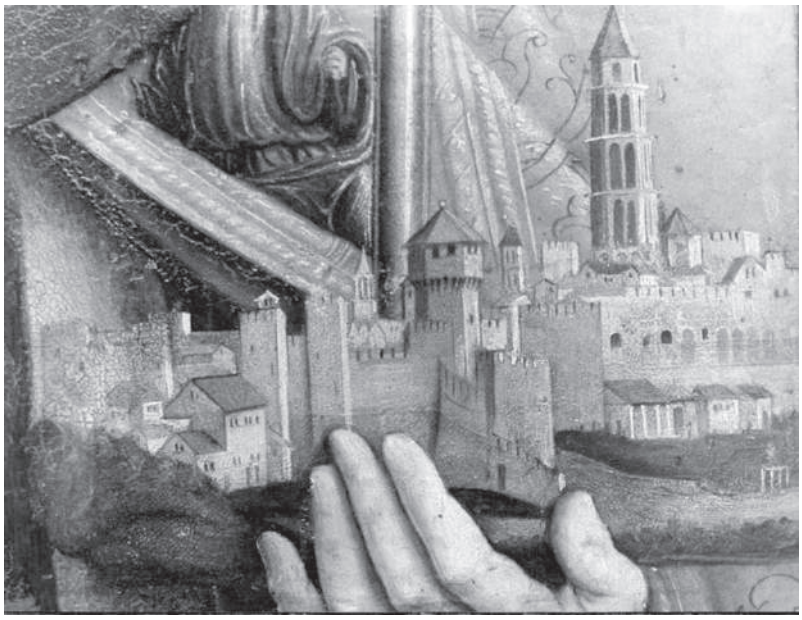


Figure 4. Girolamo da Santacroce, Split in 1549

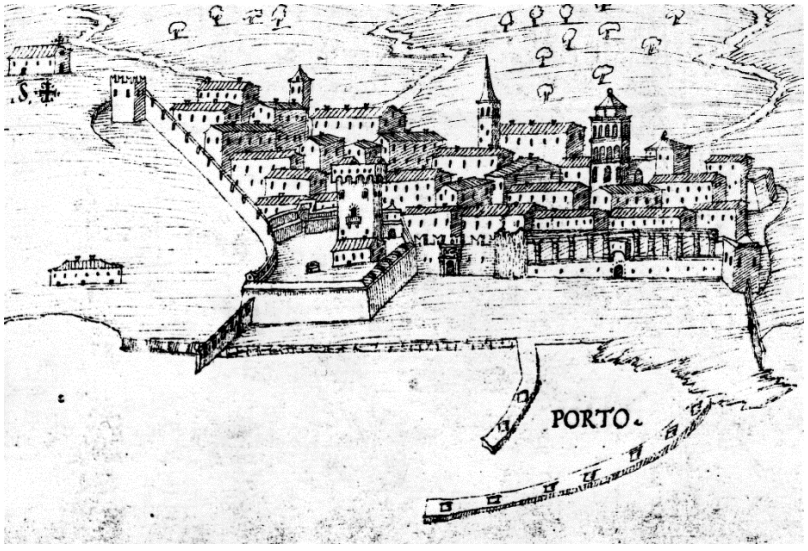


Figure 5. Angelo degli Oddi, Split in 1584 (detail)

It is ordered in the decision of Doge Francesco Foscari of 1424 that a castle be built on the site of St Clare's Convent [13]. For this reason, the convent was demolished and the Poor Clares set up a new convent in the south-west part of Diocletian's Palace. The position of the first convent and church of St Clare of the early 14th century can be assumed to have been north of Sabaka Court, i.e., under the northern part of the Castle and on the site of the Fruit

Square and Radić Brothers Square. While municipal works were going on in Fruit Square in 1999 probe archaeological excavations were conducted [14] showing that this space was, before the construction of the Castle, fully built up. Interestingly, in front of the northern gate of the Castle, when in 1936 they dug the foundations of the Mosettig House on today's Fruit Square, the gravestone of Archbishop Petar Ugrin was found; in 1311, he had consecrated the Convent of St Clare [15].

The medieval town on its southern side had two doors: the southern gate of the Palace, the Gate of the Grotto, so called, and the Maritime Gate or Porta Marina, in the extension of what is today Marulić street, in the medieval wall, just by the south west tower of the Palace [16]. Existing in the south west of the city was the Butchers' Door (Porta delle Beccarie), first mentioned in 1353 [17]. It got its name from the butchers' i.e., slaughterhouse, that lay in the vicinity, on the seashore [18], and its position of that time can be assumed to have been on the western wall of the port, south of Sabaka Court. After the construction of the Castle, a new door was cut through, named the same, on the same wall, south of the Castle.

While the Venetian Castle was being built, in Trogir a square tower on the southern wall of New City was knocked down, for it was too close to the new fortification [19] and so it is reasonable to suppose that the tower of Petar Petraka (the south western tower of Diocletian's Palace) was demolished for the same reason [20]. This tower was a potential threat to the Castle, for it could have been a redoubt of the citizens in some possible conflict with the Venetians. And it was probably for the same reasons that the rectangular tower on the western wall of Diocletian's Palace alongside the church of St Michael was then pulled down.

3. The hypothesised state of the Castle in 1441

Almost 20 years had passed between the taking of the decision to build the Castle and the conclusion of the works. A document of 1431 mentions stone and lime for the building of the Castle [21]. In 1441, castellans in the Venetian castles of Šibenik, Split, Trogir, Kotor and Feltre were appointed, and the rules of their service were determined. In the same year there was an order for the import of armaments, munitions and other equipment needed for the castle [22] and so it can be concluded that the building works had finished by that year.

The Venetian Castle in Split was built in the form of an irregular pentagon with three towers to the north. The main tower of the Castle, the donjon, or impregnable tower, from which the castellan directed the defence, was in the middle. Two walls that linked the towers, joining walls, so called, were three metres thick city-wards, and the walls of the Castle to the sea on the west, south and east were about 1.80 m thick. It is interesting that in Trogir Castle, the thickness of the walls to the city and to the sea were the same as in Split. The Split and the Trogir castles had similar dimensions. Trogir had a plan of 1350 m2, and Split of 1100 m2. The towers turned townwards and the thick walls between them show that the castle was built not to defend but to control the city. Its position at the end of the city, on the seacoast, was supposed to ensure the evacuation of the Venetian garrison by boat in the event of danger. The Venetian castles in Trogir and Zadar had a similar position in relation to the city.

A description of 17th century Split says that the building of the Castle had involved the destruction "*of parts of those gorgeous octagonal towers*" [23], meaning Diocletian's towers alongside the western gates of the Palace, for the other octagonal towers were knocked down no earlier than the 17th century [24]. The formats and the surface dressing of the stone blocks on the preserved parts of Split Castle, as well as the ancient masons' marks on some of them, confirm that during the building of the Castle, stone material from Diocletian's towers really was used. Since the amount of ancient blocks used in the construction of the castle way surpasses the amount of material that could have been contained in Diocletian's two towers, it can be assumed that the materials of the corner and rectangular tower on the western wall of the Palace were put to the same use, discussed in the previous chapter. The outer walls of the

castle and its towers were built with ancient blocks, but the interior sides, save for the inside of the eastern and western joining wall, were built with roughly carved stone blocks.

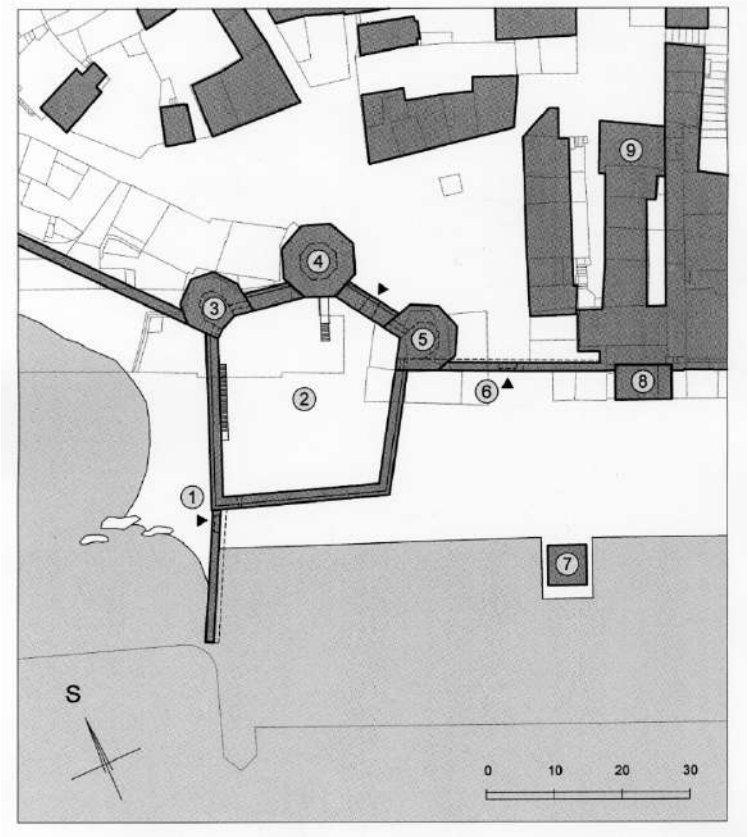


Figure 6. Hypothesised state of the Castle in 1441, plan: 1 – Butchers' Gate, 2 – Venetian Castle, 3 –Western Wall, 4 – Great Tower, 5 – Eastern Tower, 6 –Maritime Gate, 7 – Butchery, 8 – Loggia, 9 – St Michael's (by K. Marasović)



Figure 7. Archaeological excavation of the western side of the Waterfront in 2006 and 2007 (Conservation Department in Split)

Constantly resident in the Castle was the Split castellan, whom the Venetian administration had appointed to guard the city. He was also a chamberlain (camerlengo) i.e., financial supervisor of payments and all revenues in the city. It can be concluded that the city exchequer was guarded in the Castle. As Venetian patrician and a distinguished personage, he would often have also been the vice-conte, the deputy of the city Count [25].
The garrison of the Castle in 1525 consisted of a sergeant (*capo*) and fourteen soldiers, and in 1534 of only ten soldiers. In 1559 it was increased by two bombardiers [26]. As for weapons and armaments, 1550 mentions just two cannon, without carriages, and in 1559 six or seven cannon, the carriages of which were rotten and could not be used [27]. Other weapons were pistols [28], spears, swords, with powder also getting a mention [29].

3.1. Great Tower

The central northern tower, the Great Tower (Torre Grande) [30] or Turiun as the inhabitants of the town called it is in excellent condition even today. It has a regular octagonal plan, the dimensions of which are 10.5 x 10.5 m, 24 metres high with four floors. The level of the ground of the lowest floor is about 2.5 m higher than the level of the original ground in the Castle [31]. In free standing towers, where the entrance was regularly raised above the level of the surrounding ground, the ground floor space would often be used as a cistern, which made sure the building had an independent source of water. However, during archaeological research carried out in 2012 [32] instead of a cistern, a well supplying fresh water was found. It was probably the same well that in 1353 was mentioned in the courtyard of St Clare's Convent [33], which, as already noted, was demolished to make way for the construction of the castle. At the top of the tower there was originally one more floor, cantilevered, the machicolation [34], of which today only the triple brackets remain. With a tent-shaped roof, the machicolation is recorded on a picture of Split drawn in 1549 by Girolamo da Santacroce.

The first, second and fourth floors of the tower have vaulted ceilings made of tufa, while over the third floor there is a wooden construction borne on a step in the thickness of the wall. The stone brackets at the root of the vaults, some of which are preserved, while some are broken off, served as supports for the wooden formwork during the construction of the vaults. The lowest floor has walls 3.5 m thick, and the highest 2.80. The staircases linking the floors are embedded in the thickness of the walls of the tower (Fig. 8).

The entry door into the tower was to the south. They are 83 cm wide, and 259 cm high. A detailed analysis of the stone blocks that formed the aperture reveals that the original threshold is not preserved, and that its upper surface was 71 cm higher than that of today, i.e., the original door was 188 cm high. In the side walls of the entry corridor traces of the original flooring can be seen. To the east of the door is a broken off bracket that can be assumed to have supported a drawbridge over which there was access to the tower. The remains of a second bracket, to the west of the door, are concealed by the wall of the adjacent building. In a parapet of a window of the third floor, in the axis of the entry door, a triangular shaped opening, through which the drawbridge must have been raised, is preserved (Fig. 9). In the thickness of the wall, on the lateral sides of the window, finely worked circular grooves for the bearing of the axle of the winch that raised the bridge are situated.

On the east wall, on the fourth floor of the tower is a door, which was hidden on the outside by the adjacent building, and bricked-in in the inside. On a photograph of the time before the building of the adjacent building, two brackets can be seen in front of this door, those that supported the balcony depicted on a drawing of Angelo degli Oddi of 1584. The eastern one can be seen alongside the side wall of adjacent building. It was from this balcony that the castellan would have commanded the defence of the Castle.

On the third floor of the Great Tower there is a 140-cm high aperture giving access onto the eastern connection wall of the Castle. For the sake of security, it is as much as 1.80 m higher than the level of the walkway of the wall. On the third floor there was one more such aperture onto the western joining wall, but it was subsequently enlarged on the lower side so as to connect with the third floor of the Seleban House that in the 19th century was built to the south of the Great Tower.

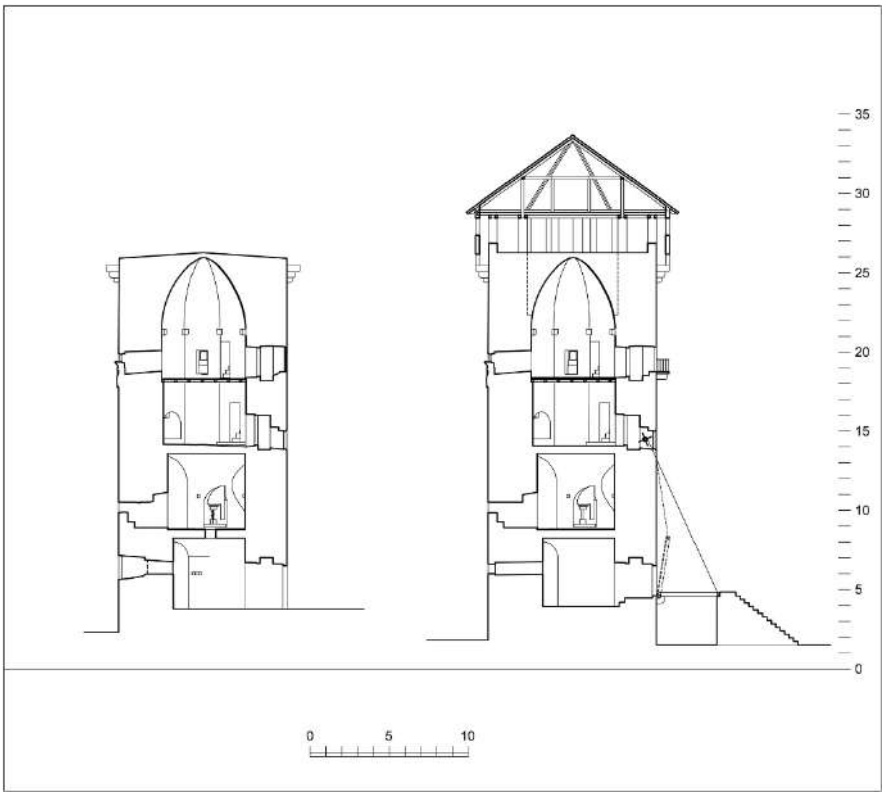


Figure 8. Great Tower of Split Castle, north-south cross section
a) in 1963 (Town Planing Institute of Dalmatia, b) in 1441 (by K. Marasović)



Figure 9. Interior of the castle in 1441 (by K. Marasović)

The apertures in the tower, apart from those described earlier, to a great extent have preserved their original appearance. According to the older photographs, on the northern façade of the tower there was a Venetian lion in relief, accompanied by coats-of-arms of distinguished people, probably those who took part in the building of the castle. All of them were carved off in the mid-20th century. In the interior of the tower there are elements indicating that it was used for residence, like a chimney in the ceiling of the fourth floor, traces of wooden doors and windows on the third and fourth floor [35].

3.2. Side towers

There were two octagonal towers with irregular ground plans built to the side of the Great Tower. Of these, the eastern has been to a great extent preserved within the later formed urban block. As earlier stated, during the building, they abutted the medieval walls of the city. On old drawings it can be seen that at the top they ended with a flat terrace. Study of the east tower has shown that it was open toward the interior of the Castle [36]. the rule in the case of towers that were built in the context of a certain defensive complex, castle or city so as to be controllable should the enemy capture them. Without further research it is not possible to determine whether the interior space of the tower went originally from the level of the floor in the Castle, or like the towers in Trogir, from the level of the chemin de ronde of the walls.

But from studies of the extant parts and the relations of the volumes of the towers of the Castle shown on old drawings, it can be ventured that the terrace of the side towers was at an absolute elevation of about 19m. If the hypothesised height is accurate, the terrace of the tower had no vault, rather there was a wooden construction at this place; the original window, which was located in the northern facade of the tower, at the highest floor, would interfere with the vaulting and so negate it. Perhaps it is the absence of any vaulting that explains why the side towers are considerably more poorly preserved than the Great Tower.

Up to the beginning of the 20th century the western tower of the Castle was in the same condition of preservation as the eastern, but was almost totally demolished while the "Adriatic bank" was being built in 1912 [37]. Only a few smaller parts were preserved on the first, second and third floor of the 19th century house west of the "Adriatic bank" up to an absolute height of 18 m, which can be seen in an architectural survey of the historical core of Split. Unluckily the walls have been plastered and so are not visible. All that is to be seen are two stone blocks of the wall of the tower that jut out from the northern façade of that house.

3.3. Joining walls

The eastern joining wall of Split Castle, built on both sides with finely worked ashlars from Diocletian's towers is preserved almost in its entirety, together with the entry gate and the remains of the bretèche [38] above it. A defensive walkway, together with parapet wall, is placed on the three-metre thick wall. To the left and right of the bretèche, is one rectangular defensive window. On each side can be seen the perforated stone brackets (rechioni) that supported wooden or leather mantlets. To the side of each of the defensive window there is one vertical loophole. On the floor of the walkway of the joining wall and on the wall of the Great Tower there are still the holes into which the wooden hoardings were fixed onto the interior of the castle.

Both double brackets and the side parts of the wall built mainly of brick and the occasional tufa block remain of the bretèche. The defensive wall and the bretèche were joined with stone blocks fitted into the defensive wall, on the whole still to be seen. Over the eastern bracket, above three courses of brickwork, the beginning of a brick arch that bore the outer

wall of the bretèche can be seen. From a comparison with three bretèches of Trogir Castle it can be assumed that on the outward face there was a defensive aperture with mantlet.

Underneath the brattice is a gate through which the Castle was entered from the city. It is of rectangular shape with a semicircular relieving arch under which can be seen a concavity where there was once a stone slab with inscription or coat of arms. The gate has no stone framework, but the sides consist of blocks of wall. It was usual that the main gate of some fort, apart from its wooden door, also had protection in addition in the shape of a drawbridge or a portcullis, which did exist, among other things, on the land gates of Diocletian's Palace. On both sides of the gate of Split Castle one can see vertical grooves in the wall, and over them, in the same lines, remains of stone blocks that once protruded from the walls. These traces can be explained as the remains of stone guides for a portcullis like that preserved in the northern gate of Trogir Castle (Fig. 10).



Figure 10. Gate of the castle onto the city with brattice and remains of portcullis slide guide a) Split (photo by K. Marasović), b) Trogir (photo by J. Vesanović)

The level of the entry into the castle was about 50 cm above that of today. It was lowered after the southern part of the Castle was demolished at the beginning of 19th century, and this entry became a city thoroughfare. On that occasion the threshold of the gate was destroyed, although the profile of it is very visible today in the side walls of the passage.

The western joining wall is preserved only at ground floor level and can be seen in the store of the café on its northern side. But the Great Tower displays traces of the joins of the wall in their full height.

3.4. Southern part of the Castle

The walls of the southern part of the Castle, 1.80 m wide, were found in the earlier mentioned archaeological excavations of the Waterfront in 2006 and 2007 (Fig. 7). On the

outer side they were made of finely worked ashlars, but the inner sides with roughly carved stone. The fill was of stone rubble in lime mortar.

Judging from the outer face of the eastern wall of the Castle, which was even below the level of the Waterfront built of finely worked ashlars, it can be concluded that the earliest phase of the southern part of the Castle was in the sea. During excavations, a cannon embrasure, funnel-shaped in its plan, placed low at sea level itself, aiming at the hulls of enemy shipping. Subsequently, a stone quay was built in front of it, of 1.30 m width. After that, but before 1582 [39], the Venetian Quay was built, which extended all the way to the eastern wall of the port [40].

According to the old drawings, the walls of the southern part of the castle were a bit lower than the southern medieval city wall and ended with a defensive chemin de ronde with crenellation. The chemin de ronde probably had wooden hoardings fixed onto perforated stone brackets, like those that have been reconstructed in Trogir Castle. The staircase used to climb to the walkway was placed along the western wall, as can be seen in the old drawings.

In the castle in Trogir, apart from the city-facing gate, there was a maritime gate on the southern wall. In all Renaissance fortifications of the Bay of Kaštela there were maritime gates [41]. At that time most transportation in Dalmatia was by sea, and the gates were used for supplies as well as for evacuation should there be an emergency. The existence of the maritime gates can be assumed in Split Castle as well, but their position cannot be ascertained, for only the lowest parts of the wall of the southern part of the Castle have been found in archaeological excavations.

4. The hypothetical state of the Castle in 1666

From the end of the 15th century, the city of Split and its environs were exposed to assaults by the Ottoman Turks. The situation deteriorated seriously after the Turks took Klis in 1537. Klis was re-taken by by the Venetians during the War of Crete in 1648, and this toned the danger down, but did not obviate it.

Marco Antonio da Canal, count and captain of Split, in 1520, found the Castle in poor conditin, and proposed that it be repaird at a cost of fifty ducats or else knocked down [42]. Ivan Batista Giustiniani wrote in 1553 "*nothing is worth anything in this castle apart from one tall tower that overlooks the whole of the city*" [43]. Others too remarked on the poor condition but there is no indication that anyone attempted repairs [44]. It was not until 1625 that governor general Francesco Molino proposed reinforcing the Castle with *terre-plein* and *rivellino* so that artillery could be deployed [45]. The documents confirm that these works were set about at once [46]. According to a depiction of a plan of 1630 [47] the western *terre-plein* was built, and in the report of the engineer, Verneda, about the state of the city fortifications of 1663 [48] there is mention of a western and a southern *terre-plein*, but without parapets. However, later drawings do display them.

In archaeological excavations of the waterfront in 2006 and 2007, on the outside of the western wall of the Castle, the remains of the lower part of the western *terre-plein* were found, and within it two funnel-shaped cannon embrasures. The outside of the *terre-plein* was constructed of finely dressed stone blocks, and the fill was of stone rubble in lime mortar. The outer side of the *terre-plein* was built in a scarp, as can be seen in older drawings. In front of the wall, a stone built quay 1.80 m wide was found. Although no remains of the southern *terre-plein* were found, it must have existed, since it was mentioned in his report of 1663 by Verneda, and it is recorded in all historical drawings. Unlike the western, it was built from the inner side of the southern wall of the Castle, and the fact that it was not found can be explained only by its having been completely demolished.

Alongside the western medieval port wall, at the beginning of the 17th century a pier perpendicular to the Venetian waterfront so-called Small Pier was built. It was mentioned in a

1628 document as "*moletto alle Beccherie*", built by Signor Freddi [49]. The oldest depiction of this pier can be found in the Mondella drawing of the port of 1635 where, alongside it, on the west, the butchery is drawn, the *Beccaria*. On it was later built the house of the Port Quarantine Station, from which it got the name of *Molo della Sanità*. This building was first noted in Santini's drawing of 1666.

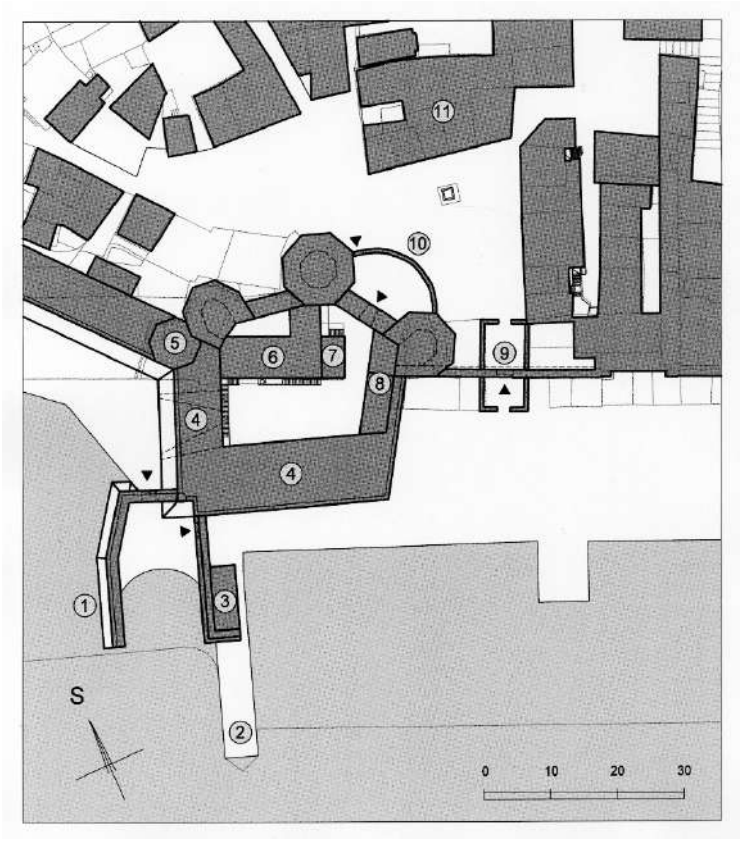


Figure 11. Hypothesised state of the Castle in 1666, plan:
1 – Rivellino, 2 – Molo della Sanità 3 – Quarantine Station, 4 – Terre-plein, 5 – Fourth tower of castle, 6 – House of the Castellan / Chamberlain, 7 – Chapel, 8 – Barracks, 9 – City Watch, 10 - Shelter (Restello), 11 – Milesi Palace (by K. Marasović)

In 1600 it was proposed that a breakwater (*porporella*) [50] be built at the side of the butchery, 10 paces wide, and four founded in the sea [51]. This breakwater was supposed to protect the Butchery Gate from waves from the west. It is not known precisely whether it was built, but in this place a walled shelter (*rivellino)* was later built, with an L-plan, with gate that gave access onto the Butchery Gate. The *rivellino* was built between 1635 (Mondella) and 1657 (Mortier). According to the Santini drawing and the old views, this *rivellino* had a wall on the outer side in the scarp. Waterfront excavations did not reveal any remains of it.

On the northern side of the Castle toward the City, from the Great to the East tower, a brick built semicircular enclosure about 3 m high was built, with musket slits [52], which protected the entrance to the Castle. In the documents it is mentioned as *restello* [53] or external barrier [54]. It is mentioned the earliest in 1638 [55]. The gate of this refuge was placed alongside the Great Tower.

On the outside and the inside of the new Maritime Gate, which at the time of the building of the castle were opened in the southern wall of the city closer to the Castle, there was a shelter for the city watch (*Corpo di guardia*), first time mentioned in a document of 1638 [56]. In it there were steps that climbed to the city defensive wall. In a document of 1789, within this

shelter on the town side, two barracks for the guard are mentioned [57]. On old views, on the south west corner of the Castle, a round sentry box can be found (*garita*).

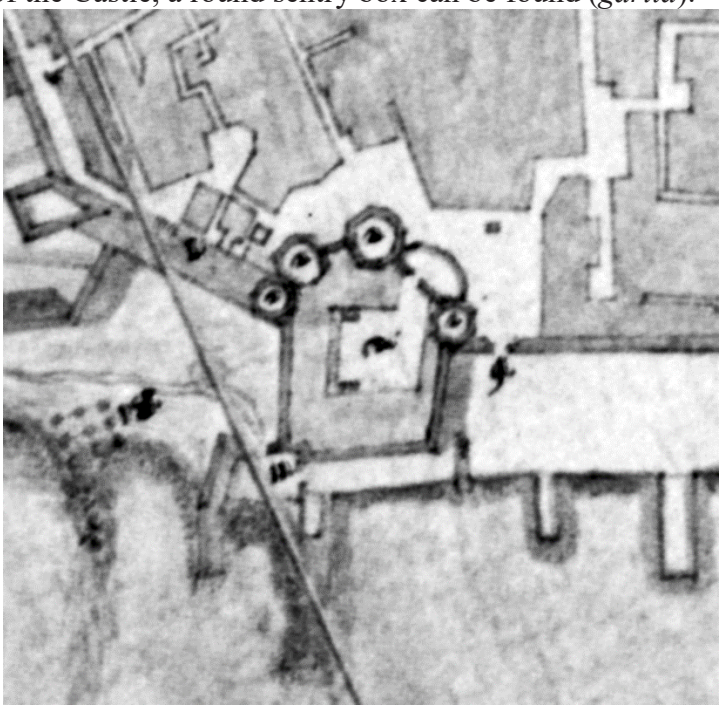


Figure 12. G. Santini, Map of Split of 1666 (detail)

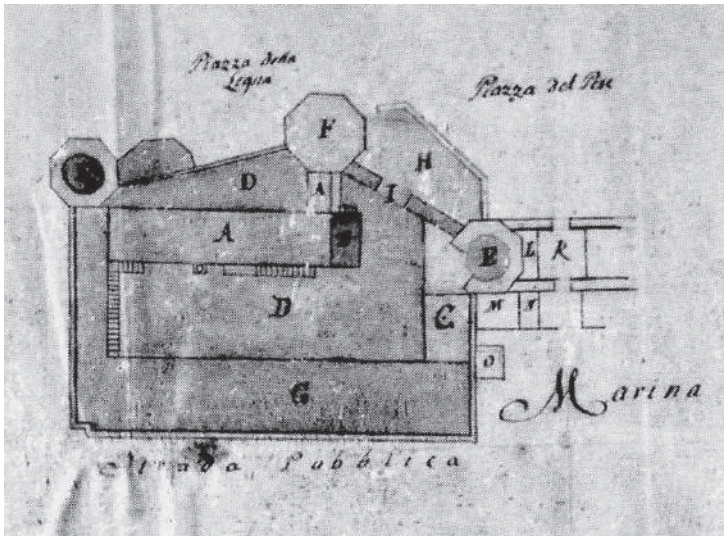


Figure 13. F. A. Kurir, Castle plan from 1798

4.1. The Great Tower

The machicolation of the Great Tower with its tent-like roof was knocked down between 1549 (Santacroce) and 1584 (Angelo degli Oddi). Artillery is mentioned in a document of 1629 [58] placed on a terrace that dominated the whole of the city and the repair of three embrasures there was ordered. It can be concluded that the machicolation was knocked down because it interfered with the placement and deployment of the firearms on the highest level of the tower.

4.2. Fourth tower of the Castle

The fourth tower of the Castle is not recorded on the Francesci plan of 1630, but it is shown in that of Magli of 1648. It is placed in front of the western wall of the Castle, just at the join of the *terre-plein* of the Castle and the medieval wall, so as to be able to control the new line of the defensive wall. The remains of the walls, and the walls of the Western tower of the Castle are preserved on the first, second and third floors of a house that was built on the site in the 19th century. On several old ground plan depictions this tower, and the two side towers of the Castle, are open to its interior.

4.3. Interior of the Castle

It is not known precisely when buildings started being built inside the Castle. In 1534 soldier's billets are mentioned [59] and in a drawing of Angelo degli Oddi of 1584, in front of the Great Tower the house of the castellan-chamberlain can be seen. In the Santini drawing of 1666 the interior of the castle is completely built up. Thanks to a drawing of 1789 [60] its arrangement can be described precisely. In front of the Western and Great Tower was the house of the chamberlain-castellan, and next to it, on the eastern side, the Church of Our Lady of the Rosary [61]. Alongside the eastern tower of the castle was the house of the sergeant, and on its southern side, the barracks.

It is common for forts to have their own sources of water so as o be able to withstand siege a long time. In several depictions, a well is drawn inside the Castle (Angelo degli Oddi 1584; Kurir 1782; a plan of 1798) and it can be concluded that apart from the well in the Great Tower there was another in the yard of the castle in front of the house of the castellan.

5. The Castle in 1831

After the Morean War and the Treaty of Karlowitz in 1699, the Turks had to retreat from this region, but they were completely driven out of Dalmatia only after 1722, when finally a constant frontier was drawn dividing Venetian Dalmatia from Turkish Bosnia. After the fall of the Venetian Republic in 1797, Dalmatia becoming Austrian, the Castle and the buildings in it were used by the Austrian army.

According to a description of 1804 [62] the house of the castellan was used by the Fort Office, and in the barracks, which was in poor condition, the soldiers were quartered. The two lower floors of the Great Tower were a jail, and the upper floors were abandoned [63]. After the Castle lost its defensive role, the upper surfaces of the southern and western *terre-pleins* were used as castle gardens (orto del Castello), as recorded in several drawings. On the eastern side of the Castle, new houses were built, and on the outside of the shelter (*restello*) north of the Castle shops were put up. Here in front of Milesi Palace a square was formed in which fish were sold (Piazza del pesse, later Piazza Milesi, from 1883 Revival Square and today it is called Fruit Square) and to the west was another square where firewood was sold (Piazza della legna, later Piazza del mercato, then Green Square) and today Trg braće Radić.

In 1806 Dalmatia formed part of the Illyrian Provinces, ruled by the French, Because of the safety of the city, and also because of its redevelopment Marshal Marmont ordered the demolition of the old defensive walls, including that of the southern part of the Venetian Castle. The southern part of the Castle was knocked down in 1806 to 1807, for it no longer had a defensive role, and there was a danger of the English capturing it and fortifying themselves in it [64]. The material obtained from the demolition was used to fill in the shore between the Castle and the St Francis Friary, known as the Marmont Waterfront, later the French Waterfront. The Maritime gate, with part of the southern wall of the city, was knocked down a little later, and in 1821 [65] the building of the Quarantine Station with the single-storey house of Nikola Seleban and part of the western wall of the port they abutted were also knocked down. The rivellino by the Buchery Gate gradually fell in.

According to the plan of the surveyor Gale of 1807, trader Nikola Seleban, in exchange for several houses knocked down on the Waterfront, got the house of the chamberlain, the chapel and the two western towers. On the basis of the cadastre of 1831 and some old photographs it can be concluded that Seleban did not knock these buildings down but incorporated them into a large three-storey building. In the line of the southern wall of it, to the west, houses of the same format were built, with Historicist characteristics, creating a new façade for the city, contributing at the same time to the uniformity of the waterfront space. The Great Tower was owned by the state, and the jail was located there. According to the cadastre of 1831, a block of houses was formed around the Eastern Tower.

The Small Pier was expanded to the west, and in 1821 a single-storey Port Quarantine Station was built, knocked down in 1875 [66].

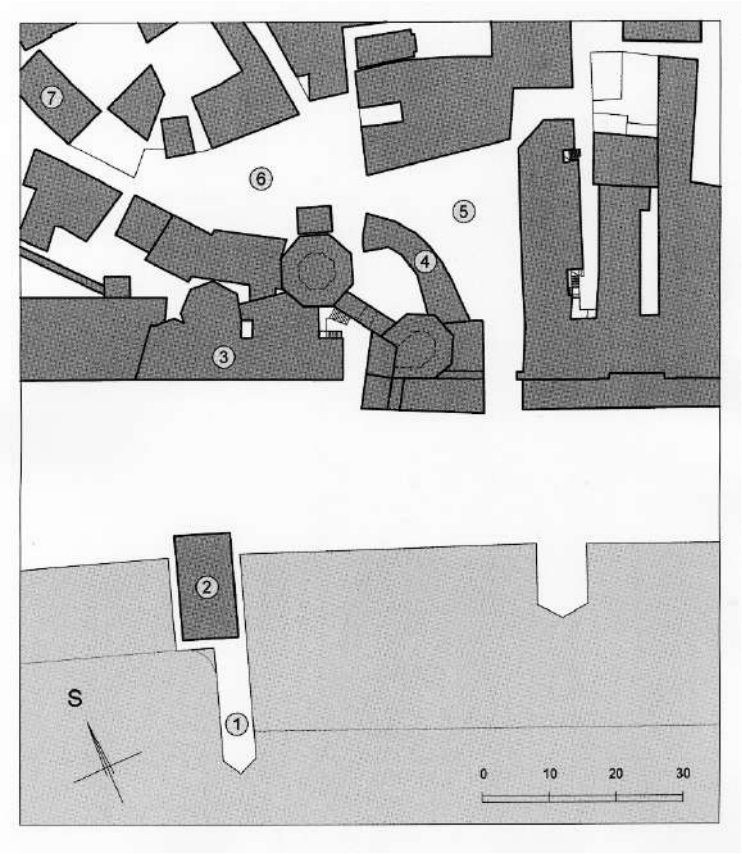


Figure 14. Castle in 1831, plan:
1 – Small Pier , 2 – Port Quarantine Station, 3 – Seleban House, 4 – Shops,
6 – Piazza Milesi, 6-Piazza del mercato, 7 – Our Lady of Dobrić (by K. Marasović)

6. The Castle in 2012

The most striking change in the space of the former Venetian Castle in recent times was the building of the "Adriatic bank" in 1911 to 1912 on the site of the Seleban house. This new four-storey building totally blocked any view onto the Great Tower form the south.

The block formed around the eastern tower was redeveloped in the second half of the 19th century in Historicist style. Among the houses, particularly standing out is that in neo-Moorish in the south west of the block, built in 1896 [67].

On Fruit square – at that time called Revival Square, in 1924 a monument to Marko Marulić was unveiled, the work of Ivan Meštrović. In 1948 the wall of the shelter in front of the entrance into the Castle was knocked down, together with the shops abutting it, and Fruit Square was enlarged and equipped with wooden stands on which fruit was sold. Today this is

one of the more pleasant squares in Split. From 2002 to 2011 works went on concerning the repair of the Great Tower, in which it is planned to place a separate collection of Split Municipal Museum with the theme of the defence of the city.

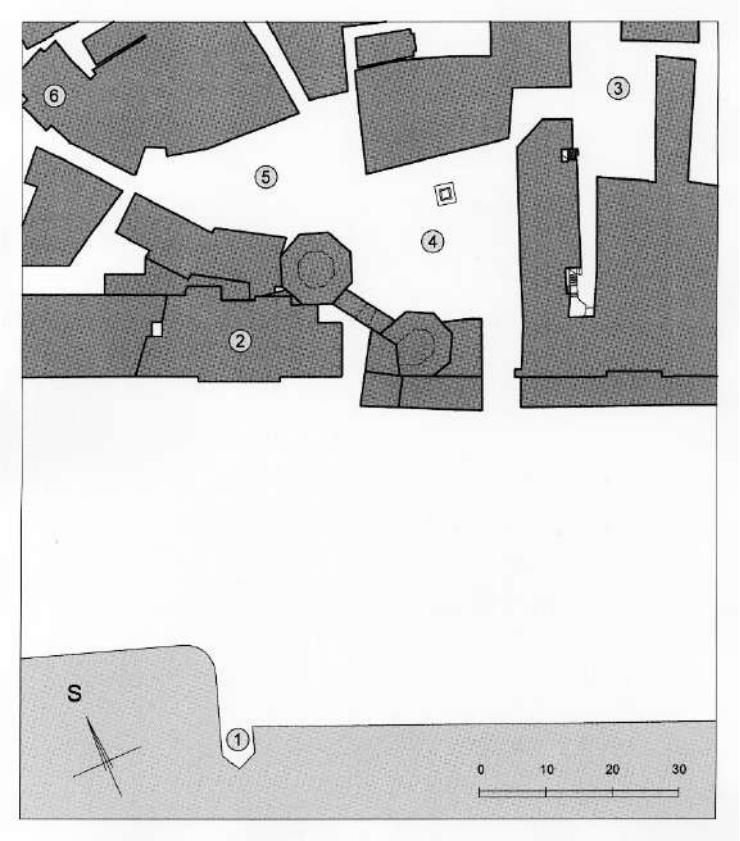


Figure 15. Castel in 2012, plan:
1- Small Pier, 2 –the former "Adriatic bank", 3 – Michael's Square, 4- Fruit Square, 5- Radić Brothers Square, 6 – Our Lady of Dobrići (by K. Marasović)

Conclusion

After taking possession of Split in 1420, in 1441 the Venetians built on the south west side of the city, on the coast, a castle from which they could control the town. They adroitly fitted the fortification in the form of an irregular pentagon, with its three strong towers in the north, into the existing medieval defensive walls. At the end of the 15th century, after they had taken Bosnia, the Turks began to menace Dalmatia, and the city of Split itself. Because of the increasing destructiveness of firearms, the walls of the Castle were reinforced with thicker walls and an extra tower, and the gate of the Castle and the city were additionally protected with new shelters. As the city spread to the west, the Castle found itself in the centre of the waterfront, and at the beginning of the 19th century, when it was longer put to its original use, the southern part was demolished. The Great Tower of the Castle, still dominates in the skyline of the city, was occluded in the early 20th century from the sea by the building of a large four-storey building. During works on the redevelopment of the Split Waterfront in 2006 and 2007, the remains of the walls of the southern part of the Castle were found, but the chance was missed to have them presented in the new paving in order to at least in this partial manner preserve the memory of the building that for four centuries dominated the southern part of the city.

Still, the one-time monumentality of Split Castle can still be sensed today from the northern side, where the Great Tower, the Eastern Tower of the Castle and the mighty wall between

them still dominate the square. The Great Tower is in a perfect octagonal shape, rarely used at the time it was built, clearly indicating the influence of the Diocletian octagonal towers from which building material was taken. The quality of the design of the Castle and the level of the workmanship we can see in the extant parts, recall to us the builders of Diocletian's Palace

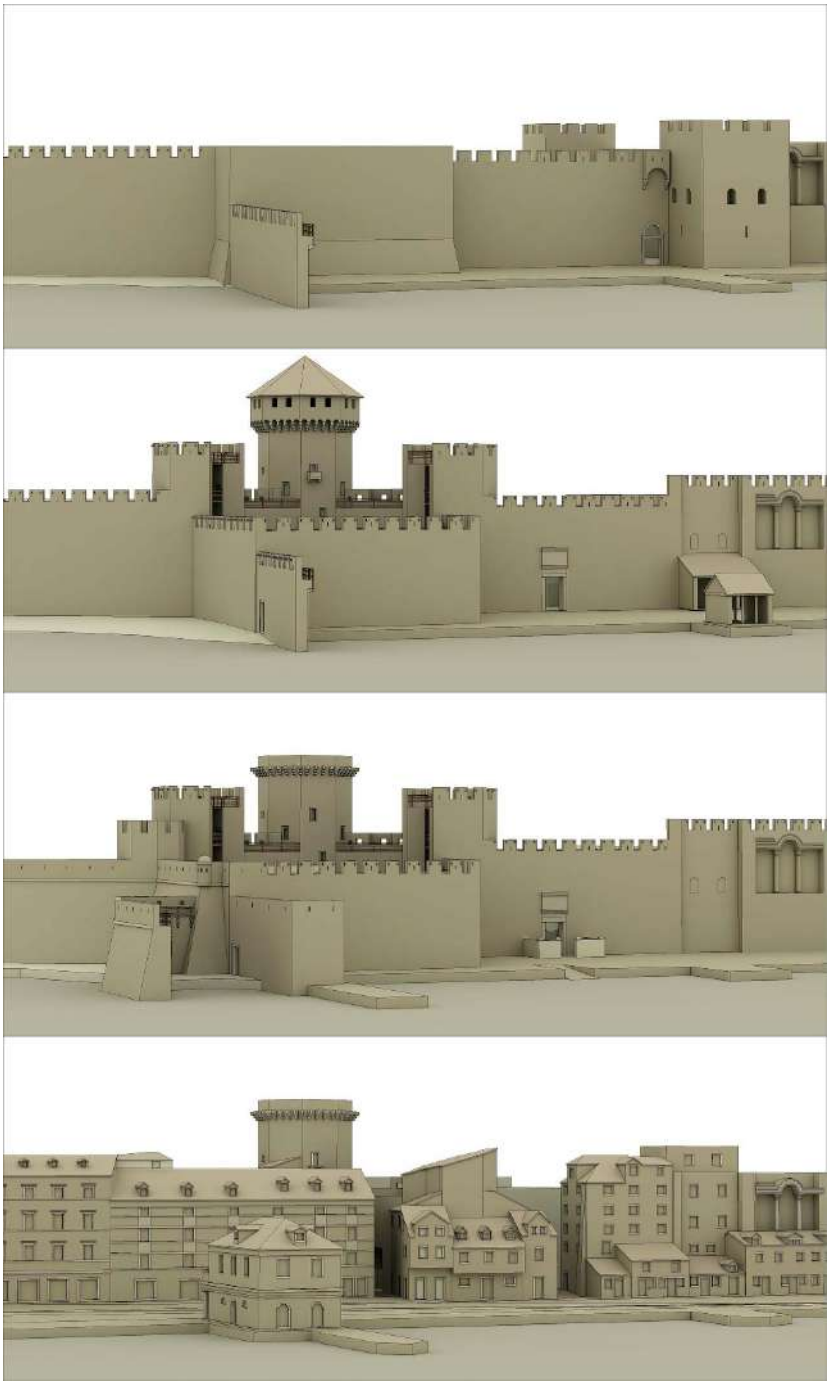




Figure 16. Spatial development of the Venetian Castle in Split, view from the south
a) in 1400, b) in 1441, c) in 1666, d) in 1831, e) in 2012

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DIAGNOSTICS, RECALCULATION AND PROPOSAL FOR REHABILITATION OF OLD MASONRY BRIDGE IN VILLAGE RÚBAŇ

Peter Koteš[1], Miroslav Brodňan[2], Miroslav Strieška[3], František Bahleda[4], Jozef Jošt[5]

University of Žilina, Faculty of Civil Engineering, Department of Structures and Bridges

***Abstract**: Bridge structures are exposed to various environmental loads, which causes gradual degradation of the used construction materials. A detailed diagnosis of the actual condition of the existing bridge structure is therefore very important in order to determine the actual degradation of materials, structural failures and their impact on the reliability, durability and load-carrying capacity of the bridge structure as reliably and accurately as possible. In the presented paper, we will deal with the description and evaluation of the diagnostic, assessment, recalculation and conceptual design of the rehabilitation of a masonry brick arch bridge on the local road in the village Rúbaň, Slovakia. Of interest is the age of the bridge, which is estimated at more than 200 years and is still functional.*

***Key words**: Masonry, bridge, mortar, brick, diagnostics, recalculation, load-carrying capacity, numerical model*

1. Introduction

Diagnosis and subsequent recalculation [1] of a masonry brick arch bridge on the local road over the Paris stream leading to the Château Rúbaň in the village Rúbaň (bridge without registration number in the administration of the village of Rúbaň) were prepared on the basis of the order of the village of Rúbaň from April 2019. The aim was to assess the current state of the bridge and verify the load-carrying capacity and usability of the bridge (Fig. 1).

It was focused on the description of the designed condition and defining the current technical condition, evaluation of test and measurement results, and recalculation with determination of the load-bearing elements of the bridge, taking into account its current condition, conceptual design to eliminate failures and improve its technical condition. There were used available data and codes to prepare the report and recalculation [2-11].

[1] Peter Koteš, Assoc. prof. Eng., PhD., Univerzitna 8215/1, 010 26 Žilina, Slovakia, peter.kotes@uniza.sk
[2] Miroslav Brodňan, Assoc. prof. Eng., PhD., Univerzitna 8215/1, 010 26 Žilina, Slovakia, miroslav.brodnan@uniza.sk
[3] Miroslav Strieška, Eng., PhD., Univerzitna 8215/1, 010 26 Žilina, Slovakia, miroslav.strieska@uniza.sk
[4] František Bahleda, Assoc. prof. Eng., PhD., Univerzitna 8215/1, 010 26 Žilina, Slovakia, frantisek.bahleda@uniza.sk
[5] Jozef Jošt, Eng., PhD., Univerzitna 8215/1, 010 26 Žilina, Slovakia, jozef.jost@uniza.sk



a) b)

Fig. 1. View on assessed bridge object: a) from side; b) on bridge road from top

2. Description of bridge object

Bridge is a single span massive brick arch bridge on the local road over the Paris stream leading to the Château Rúbaň in the village Rúbaň (Nové Zámky district, south part of Slovakia). The bridge is straight in direction, the slope is left, the angle of crossing with the obstacle (Paris stream) is 79°. The road vertical alignment is in a longitudinal descent of 0.77% from village centre towards Château Rúbaň. The span of the bridge field (arch) is 4.92 m, the length of the superstructure is 5.66 m and the total length of the bridge is 12.59 m. The vaulted masonry superstructure is made of solid burnt bricks (Fig. 2).



Fig. 2. View on full burnt bricks removed from bridge structure

The width of the bridge is 5.61 m and the width of the road pavement on the bridge is 4.11 m with double-sided sidewalks 0.75 m wide. These are concrete curb sections 150 mm thick and 10 mm above the road. The road is 120 mm thick asphalt concrete. Its thickness was verified by drilling. The free height under the bridge is 2.52 m from the bottom of the creek bed and the distance from the century-old water flow level is 500 mm. The substructure is part of the superstructure, as it is an arch superstructure made of solid burnt bricks. The flat foundations of the arch are made of sandstone blocks.

The spandrel walls of the arch are also made of solid bricks, but in the upper parts, concrete cornices with bridge rails were additionally completed (it is not known at what time, they are not original structures). The sloping adjacent wing walls are bricked mostly of bricks, in some places also of stone.

3. Current state of bridge and results of diagnostics

Neither the "bridge sheet" nor the original project documentation of the bridge object was available. The load-carrying capacity of the bridge object was not determined by any recalculation before. The bridge facility was not managed by the Slovak Road Administration (SRD) either and there is no relevant information on it. For this reason, the original load-carrying capacity of the bridge structure could not be stated, and the construction condition with an evaluation grade was not evaluated either.

Also, the age of the bridge object was not known in time of evaluation and diagnostics, because the year of construction is not mentioned in any registers. Its age can be only estimated from the stories of local people and municipal representatives (mayor) who claim that the bridge was probably built during the construction of the local Château Rúbaň (it served as an access through stream during the construction of the Château Rúbaň). According to available information, it was estimated that Château Rúbaň was built around the second half of the 18th century (1750 - 1800 AD). The fact that the bridge object could have been built at that time is also confirmed by the brick samples taken. The designation of the bricks "HPA", the production of which dates back to the 18th to 19th centuries, has been identified (Fig. 2). Based on the above information, it can be estimated that the bridge was probably built between 1750 and 1800, resulting in the estimated age of the bridge is more than 200 years.

The superstructure consists of a brick arch made of solid burnt bricks of standard dimensions 300 x 150 x 65 mm. The superstructure (arch) and the sloping wing walls are probably plastered with lime or lime-cement plaster. Chemical analysis of the plaster composition was not performed.

The compressive strength of the brick was determined on two samples taken. The test specimens were taken from the arch and were surface treated so that they could be tested in a hydraulic jack. The destructive quality of bricks is class P17 (17 MPa). The quality of the mortar was estimated to be less than 1.0 MPa. The quality of the concrete in the upper parts of the cornice was not determined, as it does not affect the load-carrying capacity.

The substructure is part of the superstructure, as it is an arch bridge. The vault is based on stone square foundations. Their shape and depth were only estimated, they were not detected and verified by excavation.

The road pavement on the bridge is asphalt 120 mm thick. The backfill between the road and the arch is probably made of stone, gravel, sand and clay. The bridge is terminated on the sides by steel bridge rails and reinforced concrete cornices at the level of the shoulders. The bridge rail is simple made of steel elements (pipes ϕ50 mm - columns and horizontal hand rails), unsatisfactory in terms of current requirements for road bridges. There are no drains (dewaterers) on the bridge structure due to the small dimensions of the object. Drainage is solved by a combination of transverse and longitudinal slope of the road. The bridge closures are also not located on the bridge, as it is the arch structure.

As the bridge structure is more than 200 years old, all its significant defects have been documented in the assessment. The failures on the bridge were probably caused by insufficient maintenance and the age of the bridge itself. The superstructure (brick arch) shows significant damage, especially in the outermost (edges) parts (in the places of the spandrel walls), where there is a leakage from the cornice parts. There are chloride curtains, dropped plaster and dropped bricks on the sides. From the bottom of the arch are moisture areas with chloride curtains and surface cracks and pollutions. The sloping wing walls are similarly damaged, as there are no wider cornices in the upper parts that would prevent the wing walls from leaking. The most damaged is probably the left wing wall of the inlet part, in which there is a considerable amount of fallen bricks and stones, which in its lower part created a hole measuring approximately 600 x 300 mm to a depth of 250 mm

(Fig. 3). In the marginal parts of the arch (surface), where the plaster is dropped, the mortar is also dropped to a depth of 10 to 70 mm. When touched the surface, the mortar was crumbling. The stone foundations of the arch are slightly exposed (fallen plaster, contamination by clay deposits alluvial from the watercourse). The road pavement was partially damaged (the local cracks in the edge parts near the cornices – shoulders - and also a transverse crack throughout the road pavement), which can cause water to flow from the road to the upper surface of the masonry arch. There are no signs of corrosion of the reinforcement of the cornice parts. The concrete of cornices was in a relatively good condition along its entire length and the cornices are only slightly damaged - smashed edges, surface cracks, only the cornice´ parts exceeding the spandrel walls are damaged. The shape of the exceeding parts of the cornices is not suitable because it causes leakage from the sides to the spandrel walls and the outer parts of the arch, which caused the plaster of the arch, spandrel walls and wing walls to fall off. The bridge rails are in poor condition, they are slightly rusted, distorted and does not fulfil current requirements for rails on road bridges.

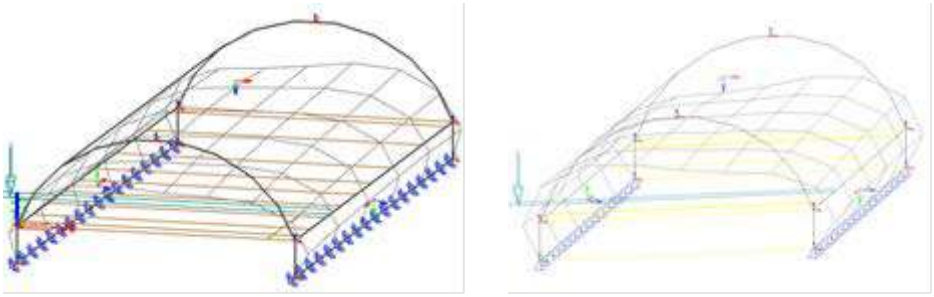


Fig. 3. Fallen bricks and plaster from arch and left wing wall

There is a water pipe (pipe ϕ300 mm in the cover guard pipe) and probably a gas pipe (pipe ϕ105 mm in the cover guard pipe) on the bridge sides. Furthermore, in the immediate vicinity of the bridge, there is a device for measuring the water level.

4. Recalculation of bridge – determining load-carrying capacity

The dimensions of the bridge structure measured during the diagnostics were taken into account in the static calculation. Two methods of arch supporting were compared, namely fixed (Fig. 4 a) and hinged (Fig. 4 b). The structure was modelled as spatial to better take into account the transverse and longitudinal distribution of loads. Two models were done by the finite element method (FEM) using the software system "Scia Engineer 2017" [12]. Due to the time of bridge construction (about 200 years ago), the individual dimensions have a relatively large variability. The supporting on the foundations was assumed to be fixed or hinged in the static calculation, so it was modelled (two models). The recalculation showed that the more unfavourable results were obtained in the case of hinged supporting of the arch and therefore this was considered (more favourable bearing by fixing should have to be verified and proven, for example, by a static load test). Thus, the calculation model using hinges was also chosen when calculating the load-carrying capacity.



a) b)

Fig. 4. Deformation from permanent load: a) fixed arch; b) hinged arch

Based on the recalculation of the bridge structure, it was found that it does not fulfil the full design loads and their combinations according to code [8], but only part of the design load given in percentages:

- LM1 (normal load-carrying capacity 32 tonnes) was reduced to 43% (13.76 tonnes),
- LM2 (load-carrying per axle 40 tonnes) is reduced to 45% (18.00 tonnes),
- LM3 (exclusive load-carrying 90 tonnes) was reduced to 90% (81.00 tonnes),
- LM3 (exceptional load-carrying 280 tonnes) was reduced to 80% (224.00 tonnes),
- height of the tensile area of the cross-section (serviceability limit states) - there is a risk of bricks falling out.

5. Proposal for another solution

The visual inspection showed what faults and failures occurred on the bridge, what is their extent and location on the bridge structure. A significant defect in the masonry arch was the fallen off bricks on the edges of the arch due to leakage from the sides. The surface plaster was also not in good condition, there were cracks in it, in some places it was fallen off. Based on the visual inspection, the condition of the bridge was assessed according to provision TP 060 [13] as follows:

- non-structural parts of the bridge (pavement, rails, cornices): condition: V. bad,
- bridge superstructure (masonry arch): condition: VI. very bad,
-overall bridge: condition: VI. very bad.

It follows that the design of arrangements had to be targeted at the whole bridge structure in order to improve its overall condition and increase its load-carrying capacity. Based on the performed diagnostics and recalculation of the bridge object, it was recommended to increase the reliability and elongate the remaining lifetime of the bridge object on the local road as follows:

- the load-carrying capacity is unsatisfactory, so it was necessary to strengthen the superstructure (it was proposed to rehabilitate the current bridge structure so as to increase its load-carrying capacity with regard to the EN standards),
- increase the quality and regularity of maintenance so that the bridge as a whole and its individual parts do not get into unsatisfactory condition.

The following advance and remediation workings were expected to be carried out during the reconstruction:

- carry out works on the bridge with traffic restrictions as needed, or use a temporary bridge near the existing bridge and redirect all traffic to a temporary bridge,
- remove the non-structural parts of the bridge (pavement, railings, shoulders, cornices), surface plasters on the arch and sloping wing walls, damaged masonry elements, damaged part of the mortar between the bricks to a depth of 50 to 100 mm,

- addition of new bricks in the old places removed, new joints (mortar) between the bricks, installation of accessories and bridge new non-structural parts, completion of the road pavement and landscaping.

6. Conclusions

Diagnostics (visual and touch) and recalculation have shown that the bridge object on the local road can be repaired to the level required by current standards and regulations with the necessary costs. Given the width of the bridge, it will probably not be possible to carry out the reconstruction in two time stages, excluding traffic on one half of the bridge and rehabilitation works on the other half. This would need to be agreed in advance with the construction company - whether to completely exclude traffic on the bridge and redirect it to a temporary bridge, or to do work with the necessary restrictions on traffic on the bridge. It is needed to emphasize that the assumption for the correct function of the bridge (not only this one) in operation is, in addition to all repairs of failures detected by diagnostics, solved in the subsequent project documentation, also regular maintenance of the bridge.

Acknowledgement

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CULTURAL HERITAGE AND ENGINEERING EDUCATION IN SLOVAKIA

Balážová Pavla[1]

Department of Languages, Faculty of Civil Engineering, Slovak University of Technology in Bratislava and Department of Romance Languages, Faculty of Arts, Comenius University in Bratislava, Slovak Republic

Abstract: *Engineering education at Faculty of Civil Engineering Slovak University of Technology in Bratislava, Slovak Republic focused on cultural heritage. Ways of engineering education of Slovak and foreign students. Several examples of castles and mansions in devastated or renovated state with their development in history. Sources of important information with photographs given in recent books and text-books. People who devoted their lives to cultural heritage.*

Key words*: cultural heritage, engineering education, castles, mansion houses*

1. Introduction

Department of Languages, Faculty of Civil Engineering, Slovak University of Technology in Bratislava provides teaching of English and German language in Bachelor study within the first four semesters [1, 2, 3]. The courses are primary focused on various terminologies of 20 different departments: Department of Architecture; Department of Building Construction; Department of Building Services; Department of Building Technology; Department of Concrete Structures and Bridges; Department of Geotechnics; Department of the Humane Sciences; Department of Hydraulic Engineering; Department of Land and Water Resources Management; Department of Languages; Department of Materials Engineering and Physics; Department of Mathematics and Descriptive Geometry; Department of Physical Education; Department of Sanitary and Environmental Engineering; Department of Steel and Timber Structures; Department of Structural Mechanics; Department of Surveying; Department of Theoretical Geodesy and Geoinformatics; Department of Transportation Engineering; Institute for Forensic Engineering. During every of 4 semesters the terminologies of 5 departments are analysed. It is extremely difficult for students to understand meaning of special terms, which are not in the basic dictionaries and applied them in solving their task also in other subjects. A teacher has up 8 groups of students per week. It makes 16 hours per week in the classroom. Each group may have up 25 students. A teacher may have altogether up to 200 students in semester. The participants of the courses consist of Slovak and foreign regular students studying normally 5 years and also for Erasmus foreign students studying in Slovakia only 1-2 semesters. Foreign students are from various countries, e.g. from: Brazil, Greece,

[1] Balážová Pavla, Mgr., Bc., Slovak University of Technology, Radlinského 11, 810 05 Bratislava and Comenius University, Gondova 2, 811 02 Bratislava, Slovak Republic, balazpa@gmail.com

Hungary, Kazakhstan, Kenya, Kuwait, Lithuania, Mali, Palestine, Poland, Russia, Spain, Syria, UK, etc.

Internationalization of teaching is necessary to apply together with teaching innovation and evaluation of their results. One interesting topic of internationalization of teaching is information and analysis of cultural heritage in different countries. Another important topic in engineering education, see in [4, 5]. This part of engineering education contains collection of documentation and information about degradation and restoration of historical structures by Slovak and foreign students. Students are of the opinion that this part of engineering education is interesting for them and consequently it could be useful for the whole society.

2. Information about devastated cultural heritage in Slovakia

There are many important historical structures (churches, castles, mansion houses, important buildings, old bridges, mills, monuments, landmarks and other national heritages) which need monitoring, conservation, preservation, restoration or strengthening. The first step is collecting information about different kinds of cultural heritage and about people who devote big part of their life to saving them. The students like this activity. There are several books with such topic. One of them is brand new book by Mrs. Jana Šturdíková, a photographer. Publication [6] is the second expanded edition of the book [7]. There are more then 443 castles officially registered in the list of cultural heritage. Approximately one third of them is in the terrible or desolate state. Author of books [6, 7] divided castles according to their last use (school, store, fitness centre, discoteque, package of eggs, etc.) and gives interesting information about people who lived in them in the past.



a) b)

Fig. 1. a) Jana Šturdíková; b) Kočovce-Rakoľuby. After fire in 2006. It served as club of socialist youth, later shop of greengrocer. (Courtesy of Jana Šturdíková).



a) b)

Fig. 2. a) Sokolovce at Piešťany; b) Ožďany in Rimavská Sobota county. (Courtesy of Jana Šturdíková).

Mansion in Sokolovce served as mental hospital. During last 10 years without administrator. Equipment was stolen. Mansion in Ožďany was orphanage with nuns after World War II. In eighties communists wanted to have in it restaurant with accommodation and ceramics museum. Fire recently destroyed original timber shingle roof. Some of photographs by Jana Šturdíková may be seen in: https://kultura.pravda.sk/galeria/clanok/591969-aj-kastiele-ktore-chatraju-mozu-vstat-z-popola/, or in https://janasturdikova.com, where it is written that Jana Šturdíková was able to collect quite interesting amount of money, which will be used for new more expanded edition of book and for reconstruction of castles.



a) b)

Fig. 3. a) Mansion in Žíp village in Rimavská Sobota county. b) Mansion in Holíč. (Courtesy of Jana Šturdíková).

Mansion in Žíp was used for accommodation of local people. Attached park is also in desolated state. Mansion in Holíč is after Bratislava castle only second imperial residence on the Slovak territory. Summer residence of Maria Theresa, Holy Roman Empress, Queen of Bohemia, Hungary and Croatia and Archduchess of Austria. It was primary school in the twenties, today part of areal is used as museum.

3. Information about ruins and renovated cultural heritage in Slovakia

3.1. Encyclopaedia Beliana [8]

It is a Slovak encyclopedia. When completed, it will contain ca. 150,000 headwords in more than fifteen illustrated volumes, as well as supplements. Beliana is prepared by the Slovak Academy of Sciences and published from 1999. Its name, Beliana, is derived from Matej Bel, 18th century Slovak writer and historian. As of 2017, eight volumes were published. Encyclopaedia Beliana is a universal encyclopedia with its contents divided into three parts: the first on natural sciences, the second on spiritual culture and the third on technology.



a) b) c)

Fig. 4. a) Encyclopaedia Beliana. Wikipedia; b) Bratislava castle, Beliana [8]; c) Prof. Ing. Arch. Alfréd Piffl, CSc. (1907-1972), Czech architect.

Piffl`s contribution is enormous in preparation of reconstruction of ruins of Bratislava castle in fifties. He inspired his students to cooperate with him. He was obsessed and 2 years imprisoned by communist regime. Beliana`s headword devoted to Piffl is in preparation. Beliana shows a lot of cultural heritage and gives information about people who devoted their lives of their renovations. It is convenient in engineering education to give students the possibility to be familiar with such important information, because some of them may later contribute in creation of Beliana. There is also Internet Beliana version.

3.2. Information in newspapers and Internet

Martin Žigo published in newspaper SME two series of very interesting information and beautiful photographs by Mr. Milan Zachar and Mr. Henrich Vajsábel in papers called: a) Mansions from high 1st and 2nd part, b) Castles from the heaven 1st and 2nd parts. Their photographs show both: ruins and renovated structures. Accompanying texts give all necessary details from history.



a) b)

Fig. 5. a) Castle in Čachtice, b) Devín castle. Photo: Milan Zachar. (Courtesy of Martin Žigo).

Building of Čachtice castle started in the 1st half of 13th century. It is famous thanks bloody Elisabeth Báthory (1560-1614). She took bath in the blood of tortured girls. Devín castle is placed at confluence of Danube river and Moravia river settled already in prehistory. Devín castle was destroyed by Napoleon army in 1809.



a) b)

Fig. 6. a) Ruins of Pajštún castle in Little Carpathians. Photo: Milan Zachar, b) Castle Červený Kameň (Red Stone). Photo: Henrich Vajsábel. (Courtesy of Martin Žigo).

Pajštún castle existed before 1390 when it was given by Sisgismund, Holy Roman Emperor, to Graf Peter from Svätý Jur and Pezinok. History of Červený Kameň castle is connected from 1583 with Hungarian noble family Pálffy. There is museum in it today and a lot of events and festivals are organized there. Castle was seen also in the film Princess Fantaghirò.

4. Engineering Education in current pandemics period

To the end of October 2021, 76 million cases of COVID-19 and 1.4 million deaths have been reported in the WHO European Region. At our Faculty we follow the WHO recommendations: to stay open – with appropriate prevention & response measures in place. This includes schooling environments, where physical distancing, cleaning hands frequently, wearing masks, ensuring adequate ventilation in classrooms and increasing access to testing are important, particularly in high-prevalence settings. Teachers are true heroes in our communities.





a) b)

Fig. 7. a) Mansion in Prievoz, Bratislava. Photo: Milan Zachar, b) Mansion in Bernolákovo. Photo: Henrich Vajsábel. (Courtesy of Martin Žigo).

Mansion in Prievoz was built by Graf Eugen Csáky probably in 1902 as his summer residence. In 1993 it was bought by nuns of congregation of Daughters of Saint Francis of Assisi, nationalized by communists in 1954 and used as geriatric sanatorium, in 1989 it was returned to clergy. Mansion in Bernolákovo was built in 1714-1722 by Hungarian noble family of Count Eszterházy. In 1766 Maria Theresa celebrated here her birthday. It was fully reconstructed in 2017.





a) b)

Fig. 8. a) Mansion in Veľký Biel near Senec, b) Neoclassical Rusovce Mansion, part of Bratislava. (Courtesy of Martin Žigo).

Mansion in Veľký Biel is the biggest baroque mansion in Slovakia built in 1725. Belonged to Graf Csáky, but it was administrated by his brother archbishop. Rusovce Mansion was built on the site of an older manor house from the 16th century. The façade got its current look by application of the Windsor style, which is imitating the English Gothic style. In the twentieth century, mansion and premises have been owned by Hungarian Prince Elemér Lónyay, husband to Princess Stéphanie of Belgium, widow of Crown Prince Rudolph of Austria-Hungary. The couple has lived in the mansion till early in 1945. The communist government seized the premises in 1948. Currently, the building

is managed by the Slovak Republic Government Office and closed to the public. The government has refused to return the estate to the Benedictine Order.

Nevertheless, engineering education relating to cultural heritage may be combined with distance teaching which uses videos. The self study of materials of cultural heritage is also welcomed. In the class students like to exchange gained information especially when information relate to various foreign countries.

In September 2021 The Independent trade organization at Faculty of Civil Engineering, Slovak University of Technology in Bratislava organised successful cultural heritage excursion with visiting Mansion in Oponice, Mansion Saint Anthony near Banská Štiavnica, the largest Central European Spiš castle, Spišská Kapitula (Spiš Chapter house), Church in Žehra and Oravský Podzámok.

Author did not take part in the excursion, but it is proud on the fact that she personaly visited the most castles and mansions in this paper (those in Figs. 1, 4 –8).



a) b)

Fig. 9. a) Spiš castle, b) Orava castle, Wikipedia.

Spiš castle was included in the UNESCO list of World Heritage Sites in 1993 together with the adjacent locations of Spišská Kapitula and Žehra. Spiš Castle was built in the twelfth century on the site of an earlier castle. Before 1464, it was owned by the Kings of Hungary, afterward (until 1528) by the Zápolya family, the Thurzó family (1531–1635), the Csáky family (1638–1945), and (since 1945) by the state of Czechoslovakia then Slovakia. The original design of Orava castle was in Romanesque and Gothic style; it was later reconstructed as a Renaissance and Neo-Gothic structure, hugging the shape of the 520-metre spur on which it perches. The mining magnate Thurzo family, who took charge in the mid-16th century, was responsible for a great deal of rebuilding work, although its present form was not finalised until 1611. It burned down again in 1800, after which it was no longer used as a residence. After a period of dilapidation dating until World War II, the castle became a national monument. Many scenes of the 1922 film Nosferatu were filmed here.

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DRAWING HBIM FOR THE MANAGEMENT OF CULTURAL HERITAGE

Rosaria Parente,[1]

(1) Benecon Consortium University, UNESCO Chair on Landscape, Cultural Heritage and Territorial Governance, Pegaso University, Napoli, Italy
rosaria.parente@benecon.it, rosaria.parente@unipegaso.it

Abstract:
HBIM is a very important instrument for the management of cultural heritage because allows us to consider the life cycle of architecture. In particular, in this paper are shown the results of a survey carried out at Monumental Building of San Lorenzo ad Septimum in Aversa, Italy. The activity was the occasion to think about the process from the sketch to the project of survey by modern technologies like laser scanner 3D that have not take the place of the hand of the architect but are like prosthesis that aid the activity.
In this paper the focus is on importance of sundials that are not only the marker of the time but have also other interestinf functions. Sundials testify to the past, mark the present and orient towards the future: they are "signs of the time". Representing sundials in HBIM was like preserving them in order to pass them to future generations.

Key words: *HBIM, survey, cultural heritage, sundials*

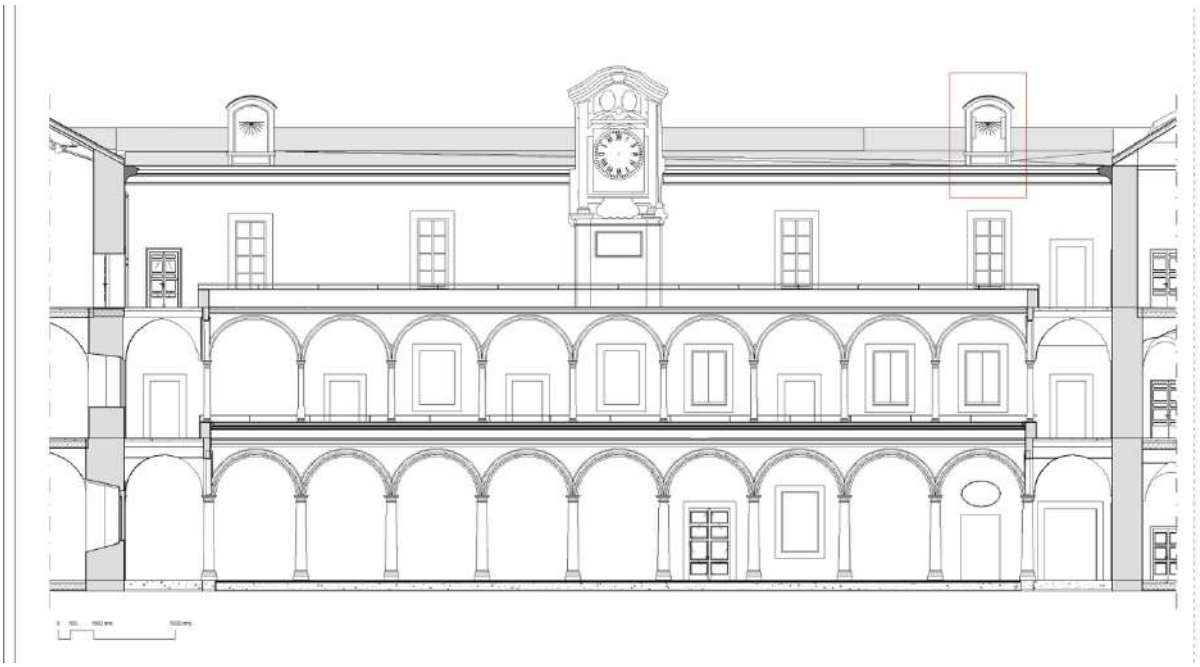


Figure 1. Monumental Building of San Lorenzo ad Septimum in Aversa, Italy. Technical drawing of the Nord Façade in the cloister.



Figure 2. Monumental Building of San Lorenzo ad Septimum in Aversa, Italy. Photo of the cloister

1. Introduction

The aim of this paper is to think about on the importance of HBIM in the management of Cultural Heritage and at the same time to think about the first action of the sketch as an important tool at the basis of the design/drawing and relief of monuments.

This contribution intends also to define the essential role of the monitoring and knowledge activity aimed to preserve the Cultural Heritage and so guarantee the transmission to the future generation; thanks to the use of HBIM methodology, it has been possible create the model of the cloister and in particular of the clock that is in a several state of decay. Only in this way it is possible organize the correct restoration of cultural heritage because if we know the survey we can also think to the restoration for the transmittion to the new generations.

As is known, the action of drawing forces us to observe reality and understand its structure, to see the objects that surround us, overcoming the mental categories that identify them as already known objects; to evaluate the proportions and relationships between the parties.

Using modern digital technologies, however, there is no longer a distinction between the moments of observation, sketch and measurement of the object as with advanced tools we are able to capture information in a single instant with a high degree of accuracy that will need to be processed and somehow simplify to arrive at the desired representations.



Figure 3. Focus on the right sundial, photographic survey

The drawing sketch has a value of testimony of past experiences, of a mnemonic outline of knowledge. In the process of studying a building, the digital survey is followed by the modeling phase, geometric synthesis, which the designer must carry out using 3D authoring and information management tools that also allow the attribution and connection of information parameters of various kinds (e.g. geometric, material, economic, historical, etc.) directly to the solids created, thus constituting a semantic link with the single three-dimensional components that form the model, orienting these forms to their meaning or functionality

which takes the name of BIM (Building Information Modeling) methodology, although conceived to manage the entire design life cycle of a building, is also widely used in the analysis and conservation of architectural assets through reproduction so-called as-build of existing buildings, applying reverse engineering methods that from digital survey lead to the modeling of a real "digital twin", in a process that takes the name of ScanToBIM. In the scientific literature, the term HBIM has been adopted to consider the application of the BIM methodology to historic buildings, characterized by strong stylistic and architectural connotations, with the aim of safeguarding or managing these assets, exploiting the semantic and parametric content offered by the BIM approach. In this method, as has been said, the survey phase conducted by digital instrumentation and methodology produces enormous quantities of spatial information recorded mostly uncritically, through a process that leads to a sort of automatic punctual decomposition. Although this leads the designer to less effort in the campaign phase, it leads him to discern, in the massive survey, the points attributable to the essential forms for the description of the object of study, through decimation, optimization and discretization activities. These operations must be guided by the objective of identifying the indispensable geometric generatrices and directions, in the subsequent phase within the BIM Authoring software, for the coherent creation of three-dimensional solids.

2. The case study of the San Lorenzo ad Septimum in Aversa

The study of the Monumental architectural structure, more specifically of the cloister, provided for a first phase of analysis through a preventive photographic campaign and the definition of eidotypes. During the creation of these eidotypes, greater attention was paid to the volumetric and morphological proportions and syntax, leaving out the metric information for the subsequent survey phase. The eidotypes have allowed a better formal awareness of the

building and a subsequent more effective design of the indirect survey campaign through the identification of criticalities and morphological specificities of the context studied.



Figure 4. Focus on the left sundial, photographic survey

For the laser survey, a FARO FOCUS 3D 330 instrument with relative photographic tripod was used. The instrument belongs to the category of phase control laser scanners and is based on the emission of a laser beam that affects neighboring obstacles reflecting towards the instrument. Thanks to the measurement of the length (calculated by phase difference) and the emission inclination (calculated using an integrated digital inclinometer), the instrument deduces the polar coordinates of the collimated points, which will form the point cloud. The elements, both architectural and natural, that shape and characterize a certain environment create, as the seasons change and the hours of the day pass, shadows and lights, empty and full, transparencies and opacities that combine to form the image, excited and poetics, of a place. The sundials are works of a composite nature, in which different disciplines converge - science, technology, art, and more - and virtually offer the viewer more levels of reading. As man's conscience expands, some aspects of reality seem to inexorably escape it; one of these is the essence of time. While human memory collects traces of the flow of events, the present moment turns out to be elusive and, with it, the consistency of the past and the future. Sundials mark the time. This is their main function, but in reality they represent much more: they mark the time that cuts through space, they indicate the sky to the earth, they sing silently with the shadow of the light, they celebrate a subtle and concrete metaphor. Sundials testify to the past, mark the present and orient towards the future: they are "signs of the time".

3. Survey activity for the creation of HBIM model

The research concerned the study of the quadrants present in the Cloister of the Monastery of San Lorenzo in Septimum, now headquarters of the Department of Architecture of the Luigi Vanvitelli University of Campania.

The monumental architecture of the Benedictine Abbey of San Lorenzo ad Septimum, probably founded in the Norman age (11th century) on pre-Roman, Roman and late ancient pre-existences, has a large Renaissance cloister with loggia in which the clock and two possible sundials are located. The monastery, suppressed in 1807, was the first seat of the college for noble girls "Casa Carolina", then, from 1812, the Military Orphanage of Mars, then from 1818 it housed the Artistic Institute, called in 1874 "Istituto Artistico Meccanico San Lorenzo ", after other changes of name and address, in 1959 it was entitled" O. Conti ".

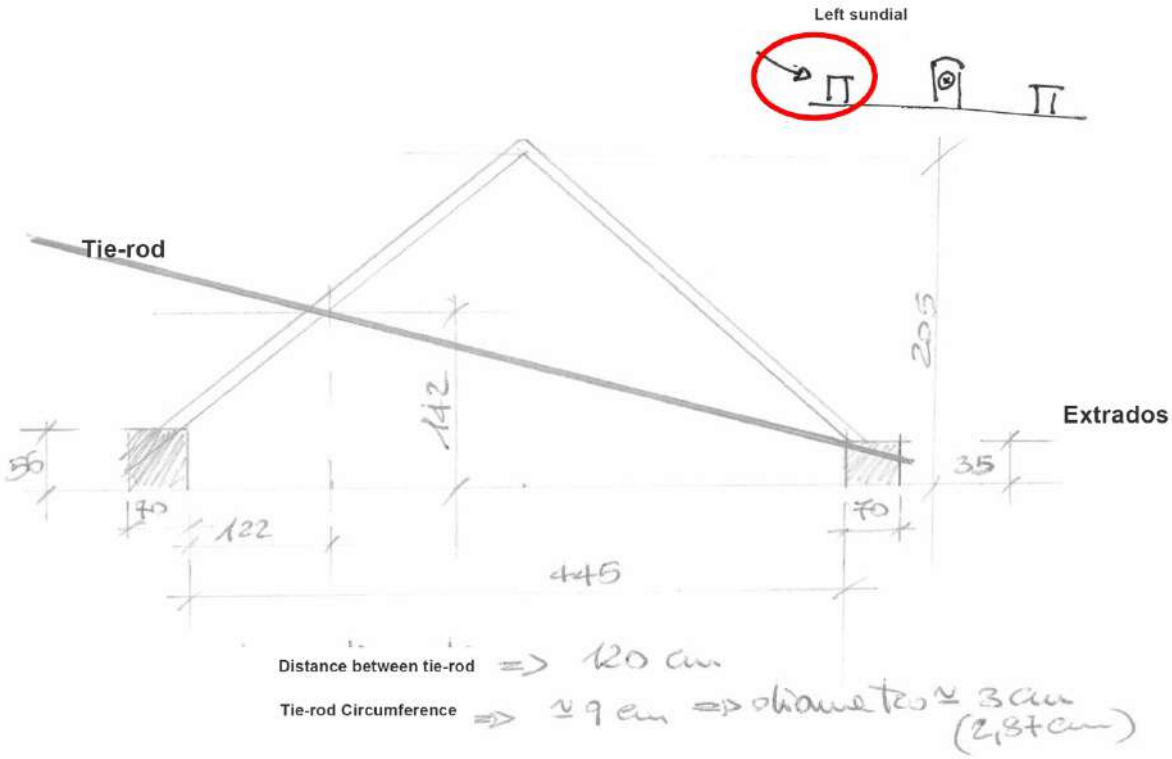


Figure 5. Sketch study for the process of securing and restoration project

The mechanical clock and the sundial dial almost certainly date back to the late nineteenth-century phase of the monumental architecture. The sundial can be recognized in the façade of the sail to the right of the one that houses the mechanical clock: you can see a painted writing with the numbers << 18 ... >>, now completely illegible. The specimen is proposed with a dubious formula: in fact, there is a dense geometry of lines arranged in a radial pattern but no figures can be seen, however in the center of the dial the signs of the interlocking of a stylus, of any type, seem to be absent. The sail on the left also shows a dial, even less legible than the one on the right and even more doubtful to be recognized as a possible sundial, in the confused structure of convergent lines.

The survey carried out allowed us to understand how the solar quadrant represents the sky in a small way. Through the projective system, gnomonics allows to represent the microcosm, the great celestial phenomena, in a field dimensioned within our physical reach - the quadrant - to be able to observe, study and then extrapolate laws. For those looking for the profound meaning of things, beyond their most immediate material function, sundials prove to be a very happy topos, a mental place where opposing elements meet and join together: light and shadow, sky and earth, space time, reason and feeling. The research envisaged a first survey phase in the site through laser scanner technology using, specifically, the instruments available at the facilities of the Consortium of Universities Benecon, thus obtaining a first discrete model for points from which to derive metric and morphological data. The survey was carried out with a number of scans using some checkerboard targets, carefully studying any shadow areas that might arise. The recognition through the survey of practices, morphologies, decorative choices that are able to identify and qualify the culture and that appear linked to the specific construction traditions of the workers allows a deepening of non-secondary aspects of architecture, in comparison with the solutions construction and decoration adopted by contemporary architecture or previous to their realization, in different cultural and territorial contexts.

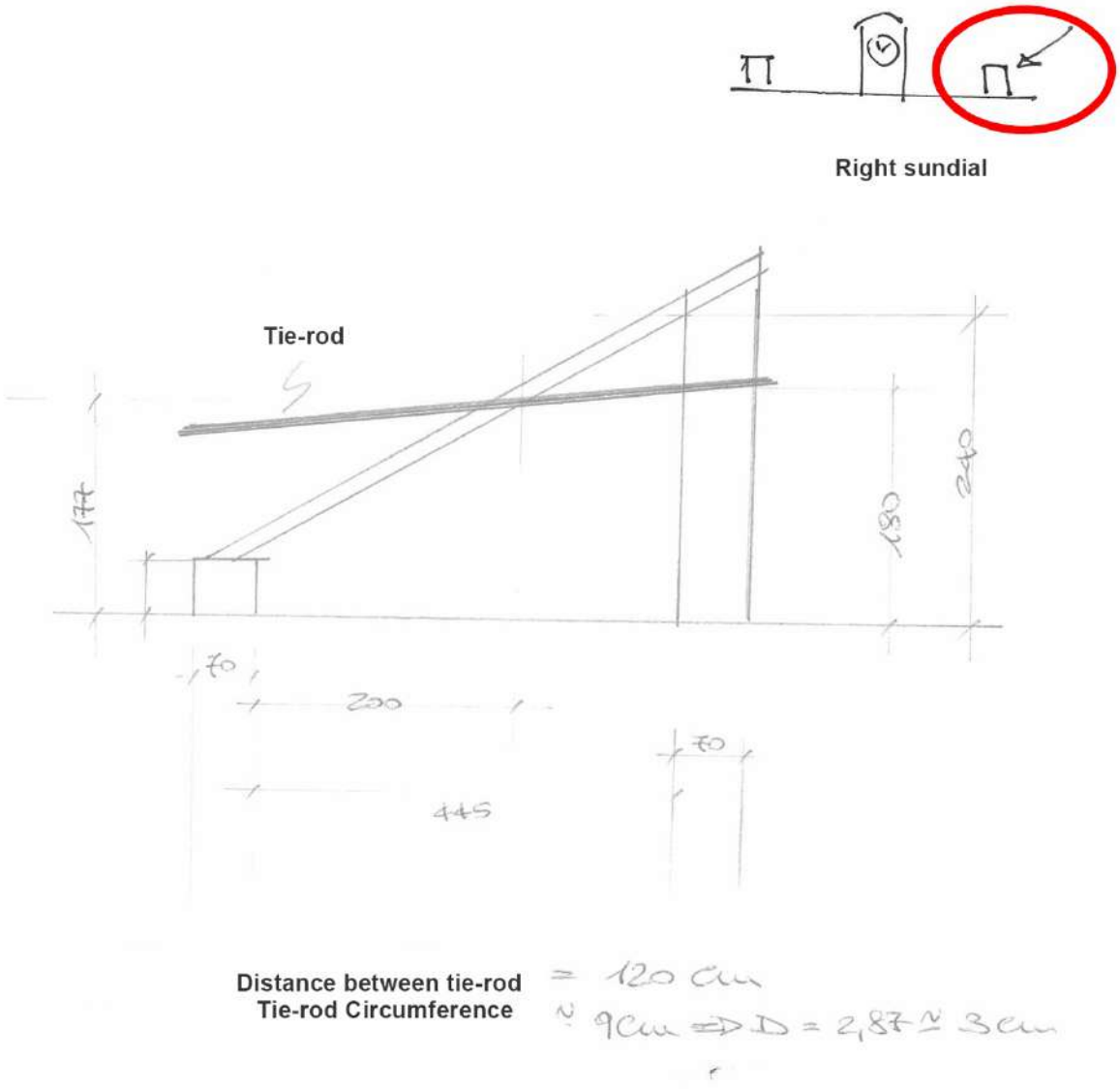


Figure 6. Sketch study for the process of securing and restoration project

A prior theoretical knowledge necessarily precedes the survey phases, to lead to a conscious approach and a critical interpretation of the structure; in this way it will be possible to subsequently focus attention on those parts for which it is believed that there may be greater discrepancies between the state of fact detected and the hypotheses previously formulated, based on a theoretically pre-set geometric model.

As for the implementation of the survey campaigns, which are described in the table, they provide for a continuous and essential integration between the different survey techniques, traditional and new generation.

The direct surveys conducted with traditional instruments for the accessible areas have been planned and partly carried out, but for the most part we have operated, with indirect instrumental survey techniques, more suited to the general conditions of surface inaccessibility: general topographic framework, GPS control campaigns, photogrammetry and laser scanning applications (time-of-flight and triangulation)

The focus of the paper is to secure two sundials present in the monumental architecture by using HBIM's technologies. Starting from scan to bim systems the creation of a parametric

model of the current state of the building is completed, by bringing the point cloud elements back to objects to which historical and construction data can be associated. Moreover starting from acquired data, the 3D model shows the reconstructive hypothesis of the original structure and the virtual reconstruction of the building based on traces found on-site and on the comparison with coeval creations allowing to properly hypothesize the design of point features.

Starting from the point clouds, the built is therefore detected in its virtual cast and, through the parametric modeling, it is given a reconstruction conforming to the real, augmented by information and data that are correlated to it and constitute its underlying historical, compositional and constructive foundation.

Modelling in architecture allows to study an artifact in all its metric and materic specifications as well as in its volumetric organisation. It also allows to investigate reality well over its contingent physical form. This is precisely why there are studies in architecture



and archaeology aimed at giving reconstructive hypotheses based on specific studies and researches and on latest generation modelling and survey technologies.

Figure 7. BIM Model, overlap of the model to the points cloud

The activities of research aimed to create a model in H-BIM environment for enrich an interdisciplinary knowledge on architectural heritage, resulting in a systematic reading of built environment, where a model is created for its meaning rather than for its shape and geometry, since its definition necessarily requires the ontological identification of the individual parts and the connections linking them and referring to them in their lexicon and semantics.

Moreover starting from acquired data the 3D model shows the reconstructive hypothesis of the original structure and the virtual reconstruction of the building based on traces found on site and on the comparison with coeval creations allowing to properly hypothesise the design of point features.

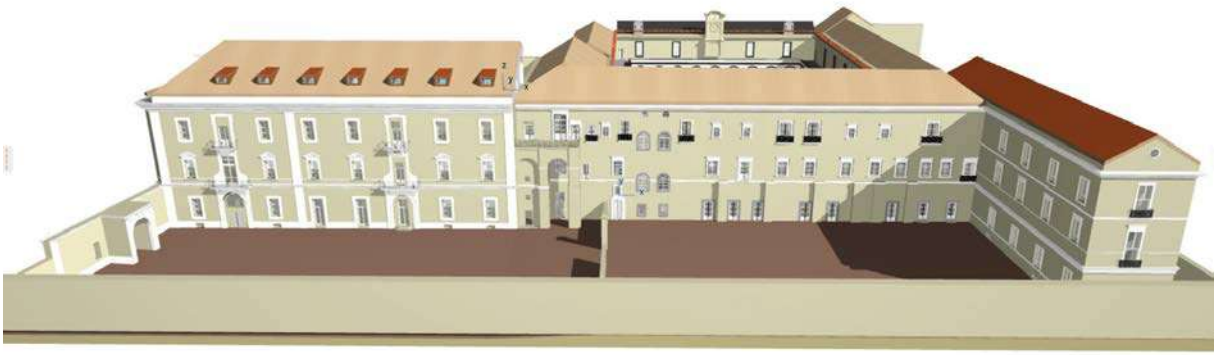
Conclusion

The paper was an opportunity to study and deepen the architectural elements of the sundials that have some different purpose.

They, surely, mark the time but we can consider also other function. The sundials mark the time that cuts through space, but also they indicate the sky to the earth.

Iti is very interesting consider that they sing silently with the shadow of the light, they celebrate a subtle and concrete metaphor.

Sundials testify to the past, mark the present and orient towards the future: they are "signs of the time". Representing sundials in HBIM was like preserving them in order to pass



them on to future generations.

Figure 8. Model results by the processing of points cloud

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INAPPROPRIATE INTERVENTIONS INTO LOAD-BEARING STRUCTURES OF ARCHITECTURAL MONUMENTS

Kohút Vladimír[1]

Authorised engineer SKSI, PRODIS+, s.r.o.

Abstract: *In designing of interventions into historical load-bearing structures in heritage buildings, it is necessary to respect the basic fact that this involve not only the issues of supporting the other historical materials but also that the load-bearing structures themselves have their cultural and heritage values requiring an adequate protection and individual approach. In this contribution, several examples of inappropriate actions neglecting basic requirements for choosing an optimum intervention into the structural stability design are shown, including the requirement for maximal preservation of original historical material substances, authenticity, reversibility, and other requirements specified in the international legislative documents for the sphere of historical monuments and memorial buildings.*

Key words: *Shotcrete process in vaults, vault drawbar system, helical reinforcements, gravel backfills in foundations, and draining systems*

1. Introduction

On 20 March 2001, the National Council of the Slovak Republic has adopted the Declaration on the Cultural Heritage Protection, which refers to: … cultural values created by the previous generations … that are permanently endangered by the degeneration and extinction of traditional trades and technologies and through the application of technologies that are often not incompatible with the essence and character of these values". In another place of this Declaration, the Slovak Republic pledged to the application of the principles incorporated in the international conventions, agreements, and recommendations of the international organisations for heritage protection, particularly in the documents of UNESCO and the Council of Europe, such as the ICOMOS Charter.

Until October 2003, i.e. the date of adoption of the ICOMOS Charter: Principles for the analysis, conservation, and Structural Restoration of Architectural Heritage [1], there was no argumentative material available that could "defend" heritage structures against evaluations and decisions about their rehabilitations only in view of structural characteristics in terms of the contemporary design standards, but failing to make any provisions for their structural values as a cultural fund instrument. The significance of the Charter content was multiplied by its incorporation into substantial parts of Annex I., STN ISO 13822 - Bases for design of structures — Assessment of existing structures [2].

The examples set forth in this paper, brings about the evidence of neglecting the international conventions (charters, resolutions, …) as well as the current standards. Several interventions have been selected that are either surviving from the past "dark"

[1]Kohút Vladimír, Ing., Tvarožkova 17, 811 03 Bratislava, Slovak Republic, kohut@prodis.sk

period of severe "cement" / "concrete" techniques used for structural stability & safety, or being a demonstration of fallacious innovative activities.

2. Vaults

In the case of masonry vaults, their structural securing was normally provided in the sixties to the eighties of the last century by the technique of "suspending" of the existing bricked vaults by the use of the so-called thin shell, i.e. by applying shotcrete technique (shotcreting) to the vault reverse side.

In an all-inclusive concept, this method was applied by specialised companies providing for structural stability safety, often without any prior repairs as regards main causes of obvious damage. Many heritage buildings were therefore treated by shotcrete process, deeply pointed with activated cement mortar, but at the same time no repairs were performed on the roof, so that rainwater freely leaked as low as to the building foundations, into open engineering-geological test pits left there without any backfills (Franciscan Convent in Levice, burgher houses in Šamorín …).



a) b)

Figure 1. The original bricked vault treated by shotcrete process from the top, but destroyed from below in Jelšava Manor House

In spite of the fact that majority of European countries refrained from such "uncivilized" practices of rehabilitation of vaults long ago, in our country (but the same case is with our Czech neighbours) there are published – even these days - specialised papers, where their topics issue from this technique of rehabilitation of heritage vaults. Therefore, it is no wonder that various designers and subcontracting companies propose and promote this technique on their respective websites, as they are encouraged to this by the top technical institutions – see the specialised publication "Rehabilitation and Restoration of Buildings" [3], with its last edition in 2018 issued by the Faculty of Civil Engineering of the Czech Technical University in Prague. By way of illustration, it is possible to quote the recommendation on page 12: "Flimsy vaults in protected historic buildings, where it is necessary to preserve the vault face side, are to be suspended on a reinforced concrete structure, the so-called back shell (vault) 50 to 60 mm thick". Although at another place below this document, the author reminds the reduced permeability of the redeveloped structure and recommends paying an attention to the evaluation of shrinkage effects of drying concrete as well as the effect of its additional shaping process, there is not a single reference saying that by the decision to "suspend" the vault, the heritage structural substance would be impaired, because by this decision the vault is doomed to a formal existence only.

The suspended vault completely forfeits its nature of a vault structure and changes to a void useless vehicle, to say nothing of the failure to follow the principles stipulated in the international conventions adopted so far. For instance, the ICOMOS International Congress in Florence, Italy, held on the occasion of the VI. General Assembly of ICOMOS, has adopted already this in its 1981 conclusions, from which I take the liberty to quote as follows:

"It is necessary to respect the original materials and use traditional ones in repairs. Replacements may be used only in cases, where original materials are not available."

A lot of damage in heritage buildings was caused by incompatible utilisations of ordinary Portland cement without any proper management and supervision. Portland cement is "unchangeable" and it is not possible to remove it without extensive damage. Therefore, it is recommended to use suitable alternatives based on limestones with pozzolanic admixtures in heritage buildings, and to restrict the use of Portland cement only to places, where it is unavoidable for structural reasons [4].

Based on the so-far investigated disturbances in vault structures, their causes can be seen particularly in two areas.

The first and most common cause is a change in the foundation soil consistency affected by rainwater leaking into the building foundations, where their uneven settlement causes overloading of the structure by deformation forces incurred in this way. Even very small deformations in supporting elements may cause strain forces exceeding the material strength, which documents the high sensitivity of vaults to deformation effects. In such case, the technique of suspension the vaults, without any remedy to the prior cause of rainwater leakage, will be effective only to a very small degree.

The second cause of such failures occurring mostly in the Prussian vaults of baroque churches consists in decreased functions of wooden drawbar (draw-beam) mechanisms intercepting the horizontal reaction components of arch rings. In the case of damaged profiles of wooden horizontal carrier beams (often designed as indented beam grids), into which diagonal drawbars are fixed, the vault structure is again overloaded by forced deformation in the places of supports. In this case, the optimum solution would be a repair of the original carrier beam, or - in the last resort – by its replacement, i.e. the insertion of a new structure assembled directly on the site.



a) b)

Figure 2. a) Church of Saint Bartholomew in Prievidza; b) Church of St. Peter and Paul in Záhorská Bystrica, Bratislava

If this draw-beam mechanism is not understood correctly, the design and its implementation will result in demanding technical, technological, and particularly costly interventions. More than forty years ago, I was invited to the Roman Catholic Church of

St. John the Baptist in Sereď. A well-known company specialised in structural security of buildings urged on the parish management that the condition of load-bearing structures was in disrepair and therefore they were to be structurally secured by coupling of vaults with shotcreted shells, together with foundations being reinforced by micro-pilots. The evidence for such recommendation was based on ceiling fissures. The arch rings among individual fields of the Prussian vaults, including the triumphal arch were damaged by cracks at the apex. In the ceiling space, there was the draw-beam mechanism of the vault discussed above. However, its only disturbance was a partial degradation of wood on the surface of the horizontal indented beams, which caused slackening of the tension in oblique drawbars and consequent cracks in arch rings. As a rather significant cost for providing the structural security for the system in alleged disrepair was required by the contractor, and I was approximately five years from my graduation from the university only, I did not want to reject confidently the offered solution, and so - to be on a safe side – I started with a one-year monitoring of movements in the cracks using a contact strain gauge. This monitoring resulted in a sinusoid-shaped diagram. The wooden indented beams were repaired, cracks were filled up during the church decoration, pointed by lime mortar, and the remaining structures remained ever since without any stabilisation intervention, i.e. in the state of supposed "disrepair".

In the case of vaults of the Roman Catholic Church of St Mary Magdalene in Vyšné Medzeve in the nineties of the last century, the method of horizontally pre-stressed masonry has been used. In the next visit, I noted that from the three original baroque vault systems of draw-beams, two were absolutely out of action - the horizontal load-carrying beams with decayed heads fell down to the vault.

3. Fascination with helical reinforcement

A rather new phenomenon, only recently significantly spreading over in the sphere of rehabilitations of load-bearing structures in heritage buildings, consists in their reinforcement by additional "paste-in" of helical reinforcement, i.e. where the stainless-steel spiral-shaped reinforcement is placed into grooves and drills using high-strength binding agents on the polymeric-concrete base. In spite of some drawbacks (substantially higher hardness of the binding agent as compared to the original mortar), this technique does not embody a highly invasive intervention to original historic load-bearing structures. This reinforcement is particularly suitable in cases where it is necessary to replace the reinforcing effect of already wooden drawbars rotten inside masonry wall thickness (see Fig. 3a) and Fig. 3b)).



a) b)

Figure 3. Remnants and traces of wooden drawbars in the Katarínka Convent in Dechtice

However, I have already chanced to seen an extraordinarily unsuitable application intervening grossly into stone elements in arch rings. In the rehabilitation of a small chapel No. 13: Ecce Homo of the unique baroque complex of the Calvary in Banská Štiavnica, where the structural engineer - invited by the conservator - designed the helical reinforcement application consisting of cutting grooves to the bottom of stone elements with consequent insertion of reinforcing rods there. From this time, nobody was able to explain to me the idea of inserting draw reinforcements into the pressure zone of arch rings.



a) b)

Figure 4. Incorrect application of helical reinforcement (The Calvary in Banská Štiavnica)

In the described examples, the historic load-bearing structures have been, or should have been, structurally secured based on a complicated design, without any analysis of causes for the failure originations. Therefore, the interventions were unnecessarily demanding and costly, where the following recommendations of the ICOMOS Charter [1] were not respected:

" 3.3 Safety evaluation and an understanding of the significance of the structure should be the basis for conservation and reinforcement measures.

3.4 No actions should be undertaken without demonstrating that they are indispensable.

3.5 Each intervention should be in proportion to the safety objectives set, thus keeping the intervention to the minimum to guarantee safety and durability with the least harm to heritage values.

3.6 The design of intervention should be based on a clear understanding of the kinds of actions that were the cause of the damage and decay … because the design will be dependent upon them.

3.7 The choice between "traditional" and "innovative" techniques should be weighed up on a case-by-case basis and preference given to those that are least invasive and most compatible with heritage values, bearing in mind safety and durability requirements.

3.8 Sometimes, the difficulty of evaluating the real safety levels and the possible benefits of interventions may suggest "an observational method", i.e. an incremental approach, starting from a minimum level of intervention, with the possible subsequent adoption of a series of supplementary or corrective measures.

3.9 Where possible, any measures adopted should be "reversible" so that they can be removed and replaced with more measures that are suitable when new knowledge is acquired. Where they are not completely reversible, interventions should not limit further interventions.

3.10 The characteristics of materials used in restoration work (in particular new materials) and their compatibility with existing materials should be fully established. This must include long-term impacts, so that undesirable side effects are avoided.

In spite of the fact that that historical monuments have a strong advocate in Annex I of the standard STN ISO 13822 [2], so far I have not come across in structural evaluations for heritage building with the application of other reliability level in new constructions than it is allowed by Art 1.7.3: "... In some cases, the heritage value protection may require the selection among various reliability levels, even lower than resulting from the accepted design standards … ". At the same time, I have not come across with an evaluation of a structure based on satisfactory behaviour of such structures in the past (paragraph 1.8), particularly with the possibility of "… The evaluation based on satisfactory behaviour of the structure in the past may be prepared even in spite of the existence of stabilisation failure. However, it is necessary to verify this by monitoring of the stabilised condition in the place of failure."

4. Fashion of gravel packing

In the conclusion, few comments to my favourite topic: gravel backfills and drainage systems. In the course of recent years, I have addressed to this topic in my several contributions. Today, I would like to quote from those contributed at the STOP Workshop in Prague [5].

"In the first case, the method of creation of air bubble filled with coarse-fraction gravel, which is not protected at the top against penetration of rainwater, is applied across-the board without any consideration given by a structural engineer in cooperation with an engineering geologist as regards the impacts of such solution to the key properties of every building, i.e. its mechanical strength and stability. In the result, there are many renewed churches, where destructions occurred shortly after the reconstruction and this even in places, where they had not been before.

The cause for the failures after applying of such technique of rehabilitation should be seen in changes of physical and mechanical properties of the foundation soil induced by an increased inflow of large volumes of rainwater to the foundation base over the newly constructed vertical drainage system.

On the one hand, this enables drying process in the foundation masonry and separates it from wet soil, but on the other hand, the building foundation conditions are changed in an essential manner. In cases, where the foundation ground consists of fine-grained rock (i.e. sandy loam, sandy and dust clays), the consistency of it is changed by the water brought here, and the original hard/solid or rigid consistency is turned to soft one, or even to a soggy consistence, which is naturally accompanied by a sharp decline in physical and mechanical properties.

Consistence changes result in uneven settling of foundations, which causes overloading to upper building structures by restructuring forces. Particularly in the case of vaults, even small deformations of supporting elements create tension forces exceeding the material strength, which is caused by high sensitivity of vaults to deformation effects.

In the time, when I started to be interested from where the designer could fetch the information about such techniques for wet masonry rehabilitation, I came across of several authors recommending this technique even without any reference to the danger of consequent potential disturbances connected with the circumstances set forth above. In browsing the Internet sphere, I chanced upon to the article of Michael Reisinger [6] from Radelbeul (Germany), who turns the attention to the danger of takeover of the draining detail from DIN 4095 [7] (German Standard). This detail, which fails to observe the basic layout principle for the drainage vertical location was adopted from the DIN standard and applied into the basic design textbook of Ernest Neufert Building Design, but it can be

found in technical papers, expert opinions, or rehabilitation designs of many renowned Slovak and Czech companies specialised in the field of damp-proofing activities or rehabilitation of wet masonry. This is also shown on several pages of the latest specialized publication issued by the Faculty of Civil Engineering of the Czech Technical University in Prague [3].

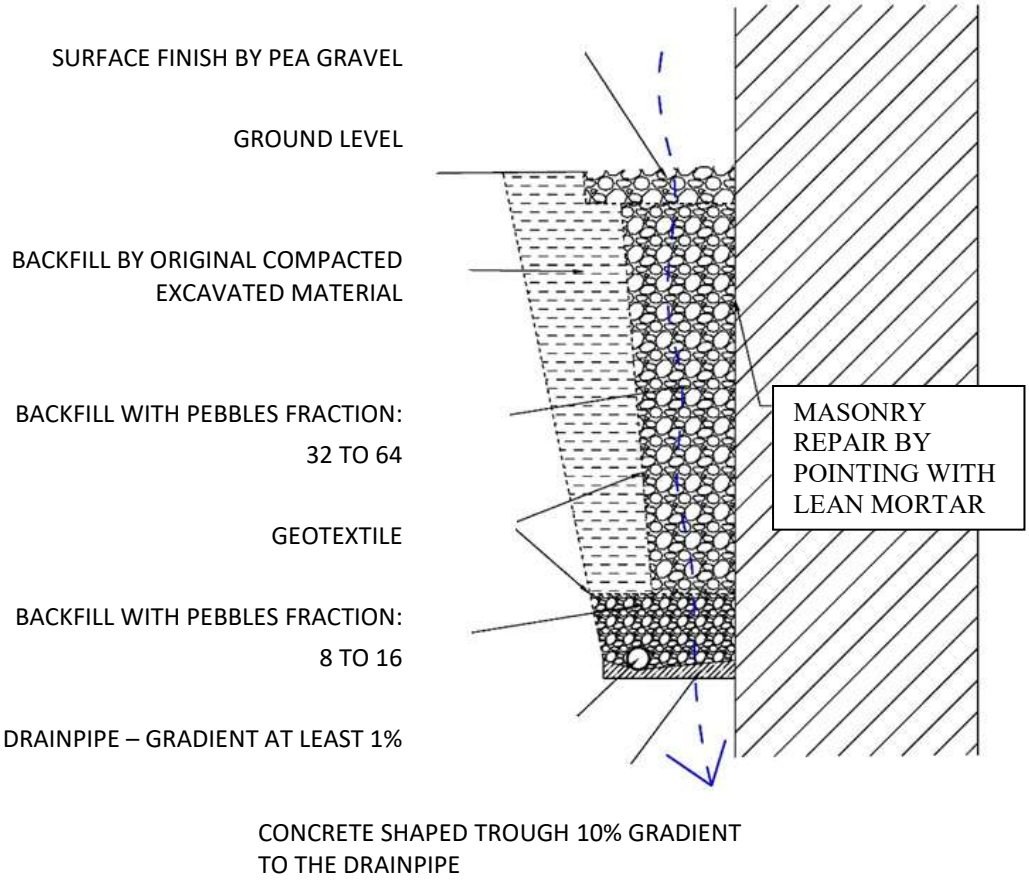


Figure 5. Separation schedule of underground masonry by the use of draining backfill

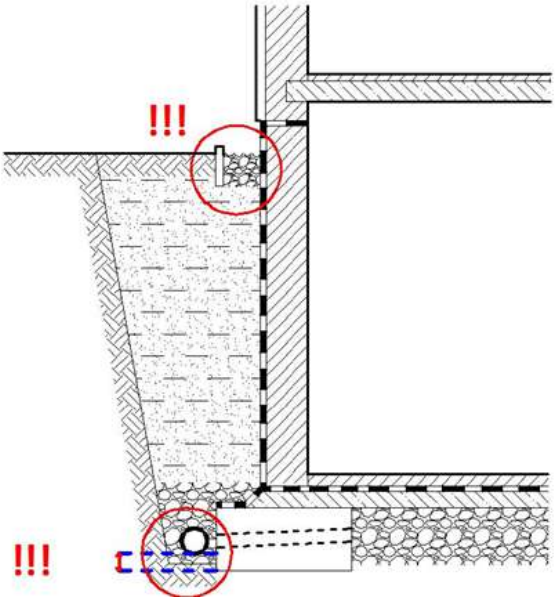


Figure 6. Drainage detail according to DIN 4095 [7]

What danger will arise to the building, if this detail is applied? Let me quote Dipl. Ing. (FH) Reisinger: "Let us ask a fundamental question. When the drainage, in fact, starts to function? Well, at the time when water rises above the drainpipe bottom. Once such situation occurs, there will be sufficient time for water to change, in a profound manner, the foundation soil properties between the drainpipe bottom and the height level of the foundation bottom. Of course, this applies only in the case of fine-grained earth types (Class F1 to F8).

It ensues, from the above stated that any details of rehabilitation of wet masonry applied as an across-the board solution without a prior engineering-geological survey of subsoil layers may bring more problems than benefits.

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CURRENT TRENDS OF HERITAGE PRESERVATION IN SLOVAKIA

Koleková Yvona[1]

Department of Structural Mechanics, Faculty of Civil Engineering, Slovak University of Technology in Bratislava, Slovak Republic

Abstract: *Assessment of heritage structures according to European and international standards. History of Eurocodes. Information about Technical Specification CEN/TS 17440:2020 Assessment of Existing Structures and ISO 13822:2010, Bases for design of structures. Assessment of existing structures . Publications about heritage structures in the Slovak Republic. Books about castles, châteaux, mansions, manor houses and fortresses which are devastated and renovated. Plans to renovate cultural heritage in Slovakia. Examples of devastated castles and buildings.*

Key words*: national heritage, situation in Slovakia, castles, mansion houses, historical buildings, plan of renovation, EN and ISO standards*

1. Introduction

There are many important historical structures:, churches, castles, mansion houses, important buildings, old bridges, mills, monuments, landmarks and other national heritages, which need monitoring, conservation, preservation, restoration or strengthening. These activities depend on laws and technical standards in the given country.

Concerning technical standards the Eurocodes play important role in all CEN member countries (CEN = Comité Européen de Normalisation, European Committee for Standardization). The overview of Eurocodes history and their implementation and application in the Slovak Republic is as follows.

Eurocodes are common European standards for design of civil engineering structures made of the following structural materials: concrete, steel, steel and concrete composite, timber, masonry, aluminium alloys, including foundation, geotechnical design and design in seismic areas.

In 1975 the European Commission decided on the adoption of a program in the field of construction based on the objective of eliminating technical obstacles to trade which included the harmonization of technical specifications.

In 1989 the Commission and the Member States decided, on the basis of an agreement with the European Committee for Standardization (CEN - Comité Européen de Normalisation), to transfer the development and publication of the codes to CEN so that they would, through future development, have the status of European standards (EN).

From 1991 to 1999 altogether 60 parts of ENV Eurocodes (European pre-Standards), two Amendments and seven Corrigenda were published by the CEN in Brussels.

[1] Koleková Yvona, Assoc. Prof.Ing. PhD., Slovak University of Technology, Radlinského 11, 810 05 Bratislava, Slovak Republic, yvona.kolekova@stuba.sk

From 1984 to 2004 the Slovak Standards Institute (SÚTN) implemented ENV Eurocodes into national standardization system. SÚTN supported the translation of ENV Eurocodes and the creation of Slovak National Application Documents (NAD) into Slovak language by 160,000 euro. 52 standrads STN P ENV were published in Slovak language, 4 parts remained in Czech and 4 parts in English language. 59 standards STN P ENV Eurocodes had NAD, one was without NAD. The complete set of STN P ENV Eurocodes (4451 pages) cost consulting engineers 927 euro.

From 2002 to 2007 altogether 58 parts of EN Eurocodes (European Standard) were published by CEN in Brussels. Till today several Corrigenda and Amendments to EN Eurocodes have been published by CEN.

Almost all of these publications were translated into Slovak language and almost all National Annexes (NA) were created in the frame of SÚTN activities.

In the period 1 December 2008 to 31 March 2010 two independent standard systems could be used for design of structures in Slovakia: (i) Slovak national standards STN, (ii) STN EN Eurocodes with Slovak NAs. It was forbidden to mix individual standards or their parts of these different standard systems.

Starting from 1st April 2010 standards STN EN Eurocodes with Slovak NAs are the only valid codes for design of civil engineering structures in Slovakia – taking into account all CEN official Amendments and Corrigenda. All STNs, which were in contradiction with Eurocodes, were withdrawn. Design of structures in Slovakia according to other standards (e.g. foreign standards) must be supported by an agreement in the contract and cannot have lower levels of reliability as design according to Eurocodes.

Technical committee CEN/TC 250 Structural Eurocodes is responsible for creating of new generation of Eurocodes. Several Working Groups (WGs) in the frame of 10 Subcommittees (SCs) are preparing new edition of Eurocodes. New generation of Eurocodes will be available for use in practice in the year 2023.

CEN publishes not only European standards (EN) but also Technical Specifications (TS) and Technical Report (TR). Very important is the brand new CEN/TS 17440:2020 Assessment of Existing Structures [1]. This TS contains also very important informative Annex D Assessment of heritage structures.

2. CEN/TS 17440:2020 Assessment of Existing Structures [1]

This long time expected Technical Specification is in this period in Slovakia translated into Slovak language. Authorised Slovak structural engineers became familiar with the content of TS at their annual conference in October 2021.

Annex D Assessment of heritage structures of this Technical Specification [1] consists from eight chapters written on three pages: D.1 Use of this Informative Annex, D.2 Scope and field of application, D.3 Principles of assessment, D.4 Assessment process, D.5 Assessment based on past performance, D.6 Structural modelling and analysis, D.7 Verification, D.8 Interventions.

D.1 Use of this Informative Annex. This Informative Annex provides complementary rules to that given in Clause 10 for the assessment of heritage structures of cultural significance and social important existing structures. NOTE: National choice on the application of this Informative Annex is given in the National Annex. If the National Annex contains no information on the application of this informative annex, it can be used.

D.2 Scope and field of application. This Informative Annex applies to the assessment of heritage structures. NOTE: Detailed rules for the assessment of heritage structures are provided in ISO 13822, Annex I [2].

D.3 Principles of assessment. D.3.1 Reliability management. The reliability level for the verification of heritage structures should balance safety and serviceability considerations with the protection of heritage value. NOTE The target reliability index for

a heritage structure can be set by the National Annex for use in a country. When a reliability level lower than that implicit in accepted design codes is set to protect the heritage value of the structure, parallel measures such as a restricted use or the provision of an alternate escape route should be adopted to limit the consequences of a failure on people or cultural contents. D.3.2 Preservation of original materials and structural concept. The heritage value of a historic structure resides in the authenticity and integrity of its character defining elements including architectural components and paintings. To retain authenticity and integrity, the structure should be preserved, as far as possible, with its original materials and structural concept.

D.4 Assessment process. D.4.1 General. The assessment process presented in Clause 5 may be used for the assessment of heritage structures taking into account cultural and societal aspects. When character-defining elements are in immediate danger, this shall be reported to the relevant authority or relevant parties so that relevant mitigation measures can be implemented immediately. Any interim interventions necessary to ensure the stability of the structure should not cause damage to its heritage character. D.4.2 Establishing the structural conditions. Monitoring by means of devices should be considered as a measure to detect possible active problems requiring immediate actions. NOTE Monitoring during preliminary assessment can contribute to the planning of later monitoring, during the detailed assessment. Samples taken for material testing should be kept to a minimum and generally restricted to those parts of the structure that have the least heritage value. Non-destructive testing (NDT) or minor destructive testing (MDT) should be preferably used. Destructive tests causing a significant damage to character-defining elements should be adequately justified. D.4.3 Undertaking the assessment. D.4.3.1 Preliminary assessment. The preliminary assessment should be carried out within the frame of a multidisciplinary team of experts, and should consider, as far as possible, available heritage documents. D.4.3.2 Detailed assessment. When undertaking the detailed assessment, it should identify the aspects of either the history or the properties of the structure that cannot be adequately described at the preliminary stage.

D.5 Assessment based on past performance. Assessment based on past performance may be carried out for heritage structures in spite of the existence of a stabilized damage. Monitoring should be used to ascertain the stabilized character of the damage.

D.6 Structural modelling and analysis. D.6.1 Models of heritage structures. Models of heritage structures should ideally satisfy the requirements of regarding the accurate representation of actions, geometry and material properties, while also taking into account any alterations and deterioration, including those caused by both natural phenomena and human interventions. A plausibility check should be carried out as a part of the activities leading to the validation of the models. Explanation of discrepancies should lead to improvement of the models. Where relevant, more than one structural model should be considered. When the models fail to demonstrate sufficient reliability of the structure, additional testing of materials and structural properties or monitoring should be carried out, incorporating the results in a revised structural analysis. D.6.2 Structural analysis for assessment. Structural analysis of heritage structures should take into consideration uncertainties resulting from: incomplete data, damage and deformation, limited knowledge of ancient structural systems, variability of material properties. Structural analysis of heritage structures should explain the effects of past actions on the structure and the effects of previous alterations. Besides commonly used ultimate limit states and serviceability limit states, specific serviceability limit states for preserving the heritage value of the structure, such as artistic paintings and materials, should be considered. When the deterioration of heritage structures is considered, long-term, time-dependent deterioration processes and changes in environmental conditions should be taken into account.

D.7 Verification. The assessment of the reliability of a heritage structure should be made for the remaining working life considering possible protection of the heritage value.

D.8 Interventions. Structural assessment of heritage structures should avoid unnecessary structural interventions resulting in the loss or major alteration of heritage character-defining elements, and, ultimately, in the loss of authenticity and historic significance of the cultural resource. NOTE: An excessive scope of intervention can add unnecessary costs and compromise the viability of a conservation project, and eventually jeopardize the existence of a cultural resource. Intervention should be kept to the minimum level that meets the structural requirements in order to ensure the least harm to the heritage values. Scenarios for interventions should respect the heritage values. The heritage values normally place severe restrictions on possible interventions, and, therefore, more than one scenario should be assessed. Materials used for interventions should be compatible with the original materials in terms of mechanical, chemical and other characteristics, and should maintain these characteristics in the long term. They should not have harmful effects, such as causing corrosion or decay. Intervention should be the result of an integrated plan to meet architectural, structural, and functional requirements. The removal or alteration of any historic material or distinctive architectural features should be avoided wherever possible.

3. ISO 13822:2010, Bases for design of structures. Assessment of existing structures [2]

ISO 13822:2010 provides general requirements and procedures for the assessment of existing structures (buildings, bridges, industrial structures, etc.) based on the principles of structural reliability and consequences of failure. It is based on ISO 2394 [3]. It is applicable to the assessment of any type of existing structure that was originally designed, analysed and specified based on accepted engineering principles and/or design rules, as well as structures constructed on the basis of good workmanship, historic experience and accepted professional practice. The assessment can be initiated under the following circumstances: an anticipated change in use or extension of design working life; a reliability check (e.g. for earthquakes, increased traffic actions) as required by authorities, insurance companies, owners, etc.; structural deterioration due to time-dependent actions (e.g. corrosion, fatigue); structural damage by accidental actions (see ISO 2394). ISO 13822:2010 is also applicable to heritage structures provided additional considerations shown in Annex I are taken into account. It is applicable to existing structures of any material, although specific adaptation can be required depending on the type of material, such as concrete, steel, timber, masonry, etc. ISO 13822:2010 provides principles regarding actions and environmental influences. Further detailed considerations are necessary for accidental actions such as fire and earthquake. It is intended to serve as a basis for preparing national standards or codes of practice in accordance with current engineering practice and the economic conditions.

4. Situation in Slovak Republic

Before renovation of heritage structures according to European standards (Eurocodes and Technical Specifications) and relevant ISO standards, detailed overview of historical buildings, churches, castles, mansions, bridges, etc. must be elaborated. Some of ruins are in unaccessible places. A lot of work was done in this direction in Slovakia also with the help of airplanes and drons (see impressive list of references, which is far not complete).

4.1. Publications about heritage structures in the Slovak Republic

There are a lot of publications in Slovakia focused on castles, châteaux and mansions, see [4-21]. Many of them contain beautiful photographs taken from the air by

planes or drons. Plenty of such books were published especially by Bárta V. and later also by Paprčka, M. (Fig. 1). Just some of them are listed in references [6-11]. Many relevant information may found in Encyclopaedia Beliana [22]. It is a universal encyclopedia with its contents divided into three parts: the first on natural sciences, the second on spiritual culture and the third on technology. Well-illustrated book in two editions was recently published by Šturdíková Jana [4, 5]. More information about her, see in [23]. She took part in several exhibitions and festivals, e.g. in Bratislava, Paris and Warsaw. Except [15, 16] many other books were published in the special edition called Cultural beauties of Slovakia with the topics: Mansions, Gothic churches (countryside), Roman churches, Timber churches, Museums, Open-air museums, City museums, Regional museums, Folk architecture, Fortresses and fortifications, Archaeological monuments, Technical monuments (old mills, furnaces, etc.), Monuments and memorials, The most beautiful cities, etc.



a) b) c)

Fig. 1. a) Encyclopaedia Beliana. Wikipedia; b) Bárta, V.: The most beautiful Slovak castles; c) Paprčka, M.: Castles and châteaux from the sky.



a) b)

Fig. 2. a) Mansion in Kolta, last time used as library; b) Mansion in Horné Lefantovce, last time used as recreation institution for children and youth (Courtesy of Jana Šturdíková [4]).

4.2. Plans to renovate cultural heritage in Slovakia [24]

Slovak jewels after years of deterioration may obtain the second change. In the Slovak cities and villages there area many devastated buildings (Figs. 2, 3,4). Most of them belong to state. According to the Slovak government needed billions will come from Eurofunds, which may be used only for state properties. Government admitted that remains behind. At begin of July passed a document Long-term strategy of buildings renovation. Till the end of the year 2030 4,9 billions euro should be spent and till 2050 16 billions euro. For buildings renovation 741,5 million euro should be used included 213,3 million euro for renovation of public historical buildings. According to Plan of renovation there is in Slovakia 15 thousands public buildings. 75 % from them need to be renovated. Plan supposes that at least 117 000 m^2 will be renovated and till 2026 minimum 100 historical buildings will be reconstructed. There are no opponents to this plan, but there are a lot of obstacles which should be overcame.

19 structures of national heritage are reconstructed from European economic funds.



a) b)

Fig. 3. a) Vila Bellevue in Starý Smokovec, the first storey building in High Tatras [23]; b) Building of former insurance company built in the last quarter of 19th century in Roosevelt street in Košice (Courtesy of Korzár, Ogurčáková, J., photo Čermáková, J.)



a) b)

Fig. 4. a) Historical building of the Slovak National Theatre in Bratislava had to be closed; b) Building of the Slovak Broadcasting built in 1983 needs investments (both Wikipedia).

4.3. Citizen Associations and volunteers

A lot of volunteers Slovak and foreign students help under specialized professional historians and civil engineers especially during summer holidays to renovate ruins and desolated castles and mansions. There are Citizen Associations (in Slovak: Občianske združenia) who try to reconstruct national cultural heritage. They obtain money from 2 % VAT and other sources. For example Citizen Association Vegetabil wants to renovate timber national cultural heritage which served as a drying house for medicinal herbs (Figs. 5, 6).



a) b)

Fig. 5. Timber drying house for medical herbs in Hanušovce upon Topľa in the year: a) 2017, b) 2018. (Courtesy of Korzár, SME).



Fig. 6. Timber drying house for medical herbs in Hanušovce nad Topľou. (Courtesy of Korzár, SME).

4.4. Problems with renovation of historical buildings

In Slovakia the following professions are missing: carpenters, stonemasons, plumbers. On the market there are only few companies with capacity for reconstruction of historical buildings. The danger is not only in missing craftsmen and designer with experience with reconstruction of historical buildings but also relation to green design. Plan is still without detailed analysis of current state of historical buildings.

Another problem is that state prefers to build the new building like to renovate two in desolated condition. One example of historical building in Košice which is in very poor condition is in Fig. 3b. Another one is the building of Regional Office of Public Health also in Košice Fig. 7. The building is in the late historical style from the end of 19th century. Its façade is expressively decorated but in desolated state. Hygienists want after 50 years in this building go to the new one. Historian of art, architecture and design Mrs. Zuzana Labudová from the regional The Monuments Board of the Slovak Republic in Košice considers this building as one of the most interesting heritage building. The regional The Monuments Board of the Slovak Republic in Košice asked building owner to perform basic maintenance because state of street façade evaluated as very desolated.



a) b)

Fig. 7. Building of Regional Office of Public Health from end of 19th century in Senný trh street in Košice (Courtesy of Korzár, Ogurčáková, J., photo Čermáková, J.)

One positive example is the modernization of the longest church in Slovakia (Fig.8). During installation of underfloor heating a historical crypt big as three buses was found.

Political interesting information was recently published in media. The Minister of culture of the Slovak Republic Mrs. Natália Milanová said that she appreciated financial aid by Hungarian government for renovation of churches in the south of Slovakia (near borders with Hungary) in the amount more than 4 million euro. Within this project in 96

villages 69 Roman Catholic churches, 6 Greco-Roman Catholic churches, 25 churches of reformed ecclesia and one Jewish synagogue will be renovated.



a) b)

Fig. 8. Seminary church of St. Anthony of Padua (former Seminar of Franciscans) in Hlavná street in Košice, the third oldest clerical building in Košice. (Courtesy of Korzár, Kolcun, M.). a) Courtesy of FB/ Clerical seminar of Charles Borromeo, b) Courtesy of FB / Church of St. Anthony of Padua.

Another positive example is repair of Švajčiarsky dom (Swiss house) in Starý Smokovec in High Tatras which history reaches the year 1856. It became officially a national cultural heritage in summer 2021. Its roof was in catastrophic state. City of Starý Smokovec decided to use for repair of Švajčiarsky dom 200 000 euro from grant of Government Office of the Slovak Republic intended for national cultural heritage. In Švajčiarsky dom (Fig. 9) there are: museum of mountain bearers, children corner, coffee-bar and two apartments.



Fig. 9. Švajčiarsky dom (Swiss house) from 1856 in Starý Smokovec in High Tatras. (Courtesy of TASR).

At Faculty of Civil Engineering, Slovak University of Technology in Bratislava we have prepared for Slovak and foreign students [25] beside lectures about green design [26] and cultural heritage [23] also very popular pictorial terminological English dictionary [27].

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PROF. ARPÁD TESÁR, HIS WORK AND MEMORIES ON SOME CZECHOSLOVAK PROFESSORS OF HIS GENERATION

Baláž Ivan[1], Partov Doncho[2]

Faculty of Civil Engineering, Slovak University of Technology in Bratislava, the Slovak Republic, European Union,
University of Structural Engineering and Architecture, VSU "Lyuben Karavelov", Suchodolska 175; 1373 Sofia, Bulgaria, European Union

Abstract:
Information about the famous Slovak structural engineer, designer, teacher and scientists Prof. Ing. Arpád Tesár, DrSc. (1.2.1919-15.6.1989) and his projects, from Department of Metal and Timber Structures, Faculty of Civil Engineers, Slovak University of Technology in Bratislava at the occasion of 50 years jubilee of his most important structure: SNP bridge (1972-2022), the large cable-stayed over Danube river in Bratislava. Memories of his colleague Bulgarian Prof. Doncho Partov on some Czechoslovak professors of strong Tesár`s steel generation, he met during period of his study and work in Czechoslovakia in the years 1964-1971.

***Key words**: Arpád Tesár, Tesár`s projects, SNP bridge,Czechoslovak professors*

1. Prof. Ing. Dr. Arpád Tesár, DrSc. and his work



Fig. 1. Prof. Dr. Ing. Arpád Tesár, DrSc. and SNP Bridge.

[1] Baláž Ivan, emeritus Prof., Ing., PhD., Slovak University of Technology, Radlinského 11, 810 05 Bratislava, Slovak Republic, ivan.balaz@stuba.sk
[2] Partov Doncho, Prof., Ing. PhD., University of Structural Engineering and Architecture,VSU "Lyuben Karavelov", Suchodolska 175; 1373 Sofia, Bulgaria, partov@vsu.bg

Prof. Tesár was born 1.2.1919 in Vrútky, Czechoslovakia (today Slovak Republic) in the family of railwayman. After finishing of secondary school in Liptovský Mikuláš, where he spent his childhood, he studied at Bratislava SVŠT (today STU – Slovak University of Technology). He was an excellent student and his university study finished at TU Berlin – Charlottenburg (Technische Hochschule Berlin – Charlottenburg) in 1944. In Berlin Tesár studied at Franz Anton Dischinger, Friedrich Tölke, Ferdinand Alois Schleicher and Arnold Agatz. Till 1945 he worked as an Assistant of Professor Ferdinand Schleicher. In Berlin he gained high level of knowledge, which effectively used in the period of reconstruction and industralization of Czechoslovakia.



Fig. 2. Ing. Arpád Tesár designing Red bridge in CS Railways bureau, October 1945 [1]. Old masonry bridge from red bricks was destroyed by German Army 4.4.1945. The new steel railway Red Bridge was opened 30.4.1948.

After return home he worked till 1948 at the Department of Bridges of Railways Headquarters in Bratislava. From 1949 till 1955 Tesár was the first the Head of Department of Structures at Vítkovice, branch office in Bratislava and later the Director of Hutný projekt in Bratislava. In 1955 he became the Head of department of structures at Research Welding Institute in Bratislava. During more than 13-years activities in practice Tesár designed or under his supervision were designed many important, courageous and original projects of steel bridge and industrial structures: railway Red bridge in Bratislava (1945) (Fig.2), the railway part of the Old bridge over Danube in Bratislava (1950) (Fig.3), the viaduct Pod Dielom on the cog-railway track Brezno – Tisovec near Bánovce (1958), the cable crane for timber industry (1956) (Fig.4), the light footbridge from aluminium alloys with glued joints exposed at International Trade Fairs in Brno (1957) (Fig.5), the roofing of Winter stadium in Bratislava (1958) (Fig.6), the viaduct Pod Dielom on the abt cog-railway track Brezno – Tisovec near Bánovce (1958) (Fig.7), the pipeline bridge over Elbe river at Libochovany (1962) (Fig.8), structures of Šverma`s steelworks in Podbrezová (1967), industrial structures of VŽKG, Kovohuty in Istebné (1967), Kovohuty in Krompachy, NHKG in Kunčice, SNP works in Žiar nad Hronom, etc.

At Research Welding Institute in Bratislava Tesár was concentrated on research of the strength of welded pressure vessels and tanks. It was necessary within 2 months to show that new technology may be introduced and that pressure in fully welded high-pressure rotational symmetric tank (with diameter d = 11 m, height h = 26 m, plate thicknesses t = 17-32 mm) may be substantially increased. The new technology was necessary to introduce because they wanted to use instead of high quality Swedish ore the less quality ore from Krivoj Rog, Ukraine. The team: Tesár (head), Chmel and Michálek

passed their results to Minister in 24.11.1955. They saved 600 000 Kčs, because the new tank was not necessary to built and they saved several millions Kčs by enabling immediately use of the new technology. Minister awarded to Tesár extraordinary salary. The exact calculations of the tank were based on theory of rotational symmetric shell structures under symmetric and antisymmetric 5 combinations of loading.



Fig. 3. Railway bridge on the joint support with road Bridge of Red Army designed by Ing. Arpád Tesár [2]. The bridge served in the period 1950-1985, removed in 2013, (photo Ivan Baláž).



Fig. 4. The cable crane for timber industry designed by Ing. Arpád Tesár (1956)



Fig. 5. The glued aluminum footbridge designed by Ing. Arpád Tesár exposed at the International Trade Fairs in Brno (1957).

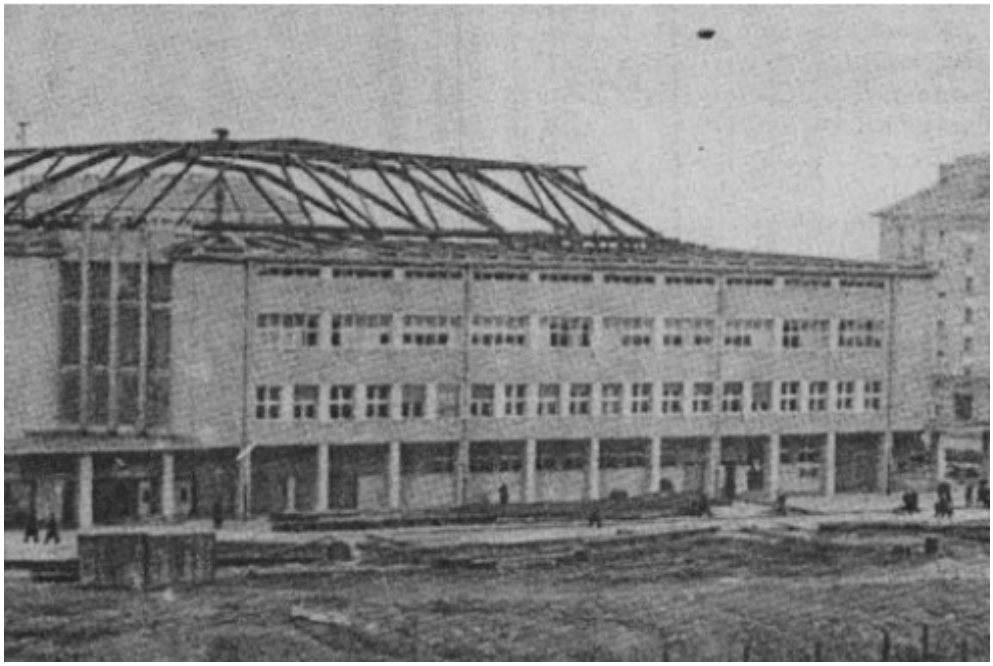


Fig. 6. The roofing of Winter stadium in Bratislava designed by Ing. Arpád Tesár during reconstruction in 1958. Original ice-hockey ground was from 1940.



a) b)

Fig. 7. The abt cog-railway viaduct Pod Dielom on the track Brezno – Tisovec near Bánovce. a) Old viaduct (1893-1896), destroyed by German Army 28.1.1945; b) New viaduct was designed by Ing. Arpád Tesár in 1958 and opened 27.2.1959. The underslung Pratt truss steel bridge. 5-span continuous polygonally arranged in plane trusses with spans 5 x 28 m. The 1st steel railway truss fully on site welded in Czechoslovakia; the replacement of the temporary timber trestle from 1946.

The results from the final research report performed in the period 1955-1958 related to grid structures were published in the proceedings of Slovak Academy of Sciences (Tesár, 1958). Tesár worked at Bratislava SVŠT (today STU – Slovak University of Technology) 40 years. As external teacher he held lectures from subjects Statics of welded structures, Welded civil engineering structures from 1949. In the period 1954-1957 he held lectures Steel structures and Mathematical theory of elasticity at Faculty of Civil Engineering and Faculty of Architecture. He was appointed as Deputy Associate Professor in 1954 and as Associate Professor in 1956.



Fig. 8. Suspension pipeline bridge built in Libochovice over Elbe river according to the patent No. 1141163 [3] of Prof. Arpád Tesár in 1962 (photo Tomáš Malý).

From the 1st October 1959 he started to work at Department of Metal and Timber structures as the Head of department. He was the 3rd Head of the department founded in 1950 after Prof. Ing. Dr. techn. Ferdinand Lederer, DrSc. (1950–1953), (Fig. 9b), and Prof. Ing. Dr. techn. Alexander Georgievský (1953–1959). In 1964 he defended his doctoral thesis Rigidity of composite grid girder in torsion and obtained the highest scientific degree DrSc. In 1965 he was appointed as Professor for steel structures and bridges. Professor Tesár became Correspondent member of Slovak Academy of Sciences in 1968. In the period of 1964-1968 he served as a vicedean for the study branch Structural and transportation engineering. After Warsaw Pact invasion of Czechoslovakia in 1968 he was replaced in his managerial functions by members of Communist party.

Contributions of Professor Tesár for the Department of Metal and Timber structures and the whole Faculty of Civil Engineering were enormous. Due to his enthusiastic lectures characterized by high professional level, clear explanation and application in the



a) b)

Fig. 9. a) Academician Prof. Karol Havelka, Prof. Arpád Tesár, Prof. Jozef Trokan (from left to right); b) Prof. Ferdinand Lederer, Prof. Arpád Tesár, May 1973.

practical problems he acquired big popularity at students. Close link to the praxis Professor Tesár transferred also to young team of department, with whom he elaborated many expert`s reports and projects. For example: steel structures of heat station in Běchovice, steel structures of 120 m tall burner towers in Slovnaft in Bratislava, reconstructions of crane runway girders and steel structures of halls for producing billets, blooms and blocks in VSŽ Košice (1976), etc.

His most important work was the design of SNP bridge (Slovak National Uprising Bridge)) over Danube river in Bratislava. The bridge was designed by the team from Slovak University of Technology in Bratislava led by Professor Arpád Tesár (structural

engineer, steel structures), Associate Profesor Jozef Zvara (structural engineer, concrete structures) and Professor Jozef Lacko (architect) and his team of architects. SNP bridge was built as the second permanent bridge over river Danube in Bratislava, the capital of Slovak republic. It is a steel cable-stayed bridge with a single backward inclined steel tower and a single cable plane. The asymmetrical position of the inclined 84.6 m high A-shaped tower crowned by a circular restaurant with diameter 32 m creates a natural balance to the famous Bratislava Castle and the St. Martin Dome. During construction period of 1969 the bridge with main span 303 m was the world record holder in category of cable-stayed bridges. The bridge was the 4th longest cable-stayed bridge span when it was opened to traffic on August 29, 1972. It was the winner of the competition "Structure of the 20th Century in Slovakia" organized in 2001.

Professor Tesár published in Czechoslovak and foreign journals more than 40 original scientific papers and he was author of 4 text-books. He held lectures in Braunschweig, Bucharest, Budapest, Dresden, Gliwice, Hanover, Helsinki, Karlsruhe, Leningrad, Liège, London, Moscow, Munich, , Sofia, Stuttgart, Vienna, Warsaw, Weimar and in other cities.

For his scientific achievements and activities in design practice Professor Tesár obtained several awards. Among others: State Award for Achievements in Building (1958), Aurel Stodola Golden Medal of Slovak Academy of Sciences in Bratislava for Contribution in Technical Sciences, Stanislav Běchyne Golden Medal of Czechoslovak Academy of Sciences in Prague for Contribution in Technical Sciences, Golden Medal of SVŠT (today STU) in Bratislava, Golden Medal of Slovak Academy of Sciences in Bratislava for achievements in joining science with practice, Laureate of State Prize of Klement Gotwald, Medal of Bratislava City, etc. His main contributions to the structural analysis may be found in [4 – 15]. Further reading about him see in [16, 17].

Prof. Arpád Tesár belonged to strong generation of Czechoslovak steel professors (Fig. 10).



Fig. 10. Prof. Antonín Schindler, ČVUT in Prague (1920-2006), prof. František Faltus, ČVUT in Prague (1901-1989), prof. Arpád Tesár, SVŠT (STU) in Bratislava (1919-1989), prof. Vladimír Dvořák, VŠDS (ŽU) in Žilina (from left to right).

Professor Tesár had three children: Ing. Alexander Tesár, DrSc., († 2021), a civil engineer, Ing. Peter Tesár, PhD., († 1997), a machinery engineer and Assoc. Prof. Ing. arch. Alžbeta Sopirová, PhD, an architect. He died 15.6.1989 in Bratislava just before political changes in Czechoslovakia.

2. SNP Bridge over river Danube in Bratislava. Important moments.

The competition was held in 1965. The winner was a continuous reinforced concrete girder. SNP Bridge gained only the 1st award. The order to realize SNP Bridge is from 1966. It was opened in 29th August 1972.



Fig. 11. SNP Bridge over river Danube in Bratislava opened in 1972 (photo Ivan Baláž).



Fig. 12. a) Loading tests. b) Pylon. c) The ugly lighting lamp-posts were added much later

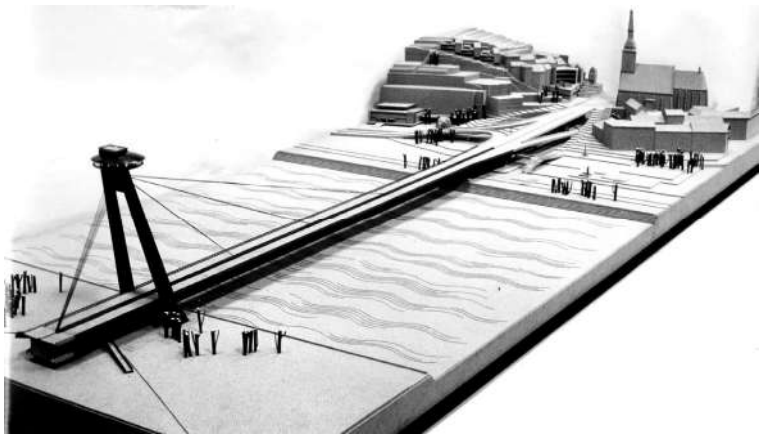


Fig. 13. A vision of architect.

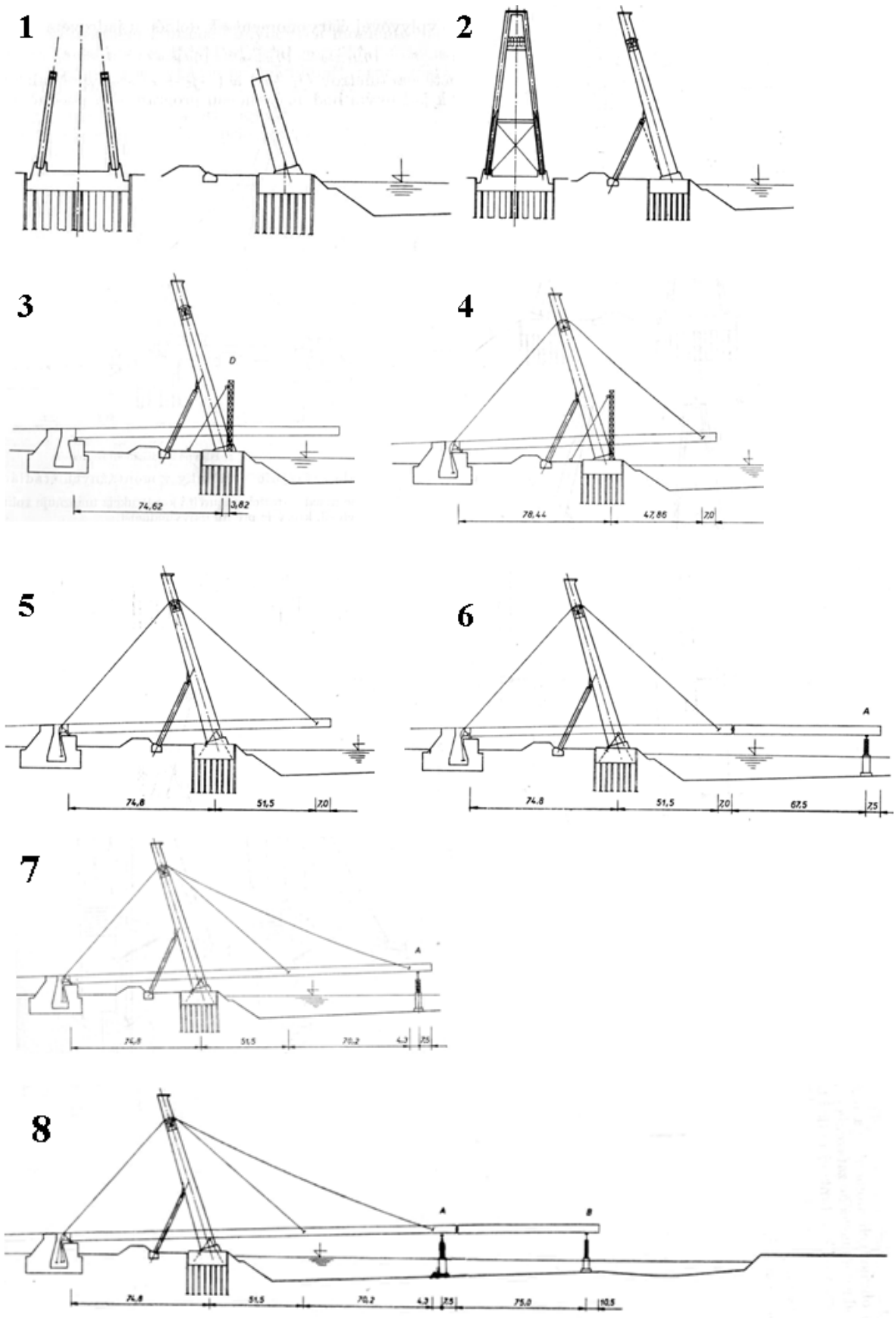


Fig. 14. The erection stages No. 1-8 of SNP Bridge [18].

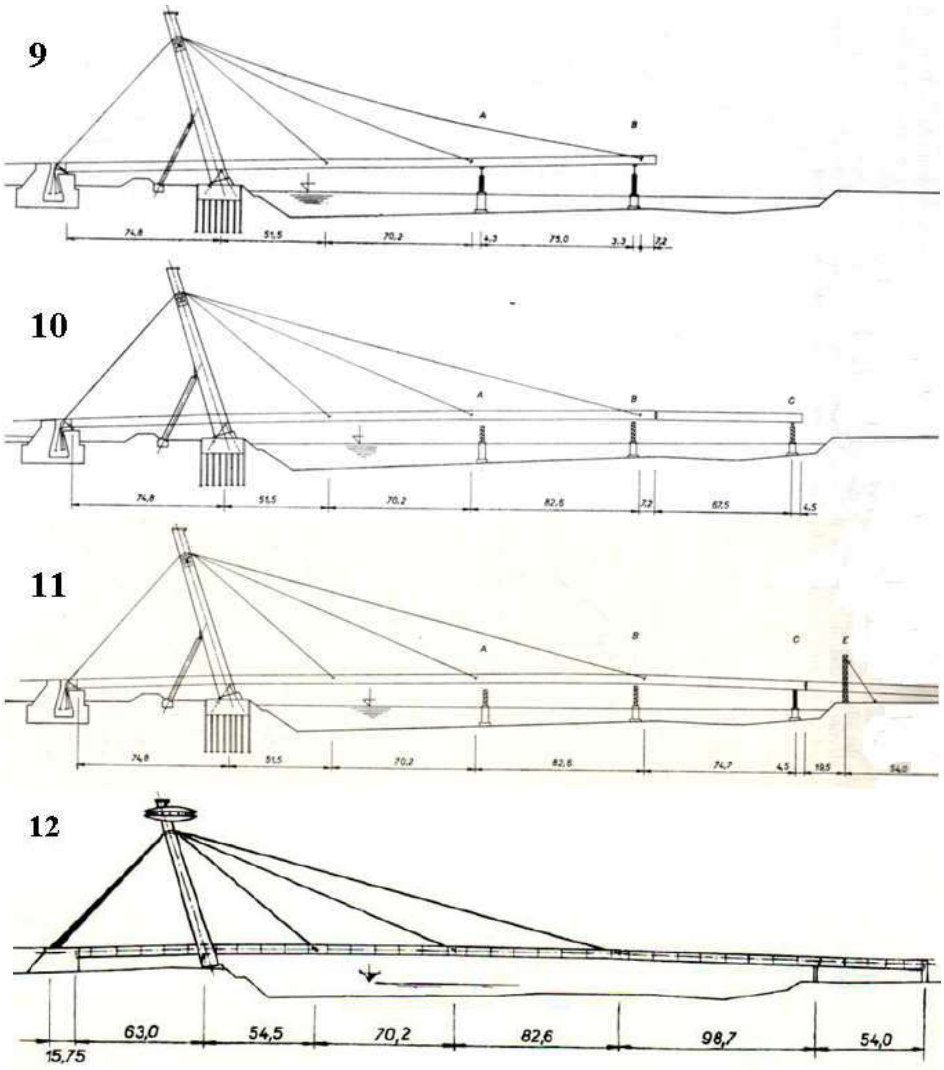
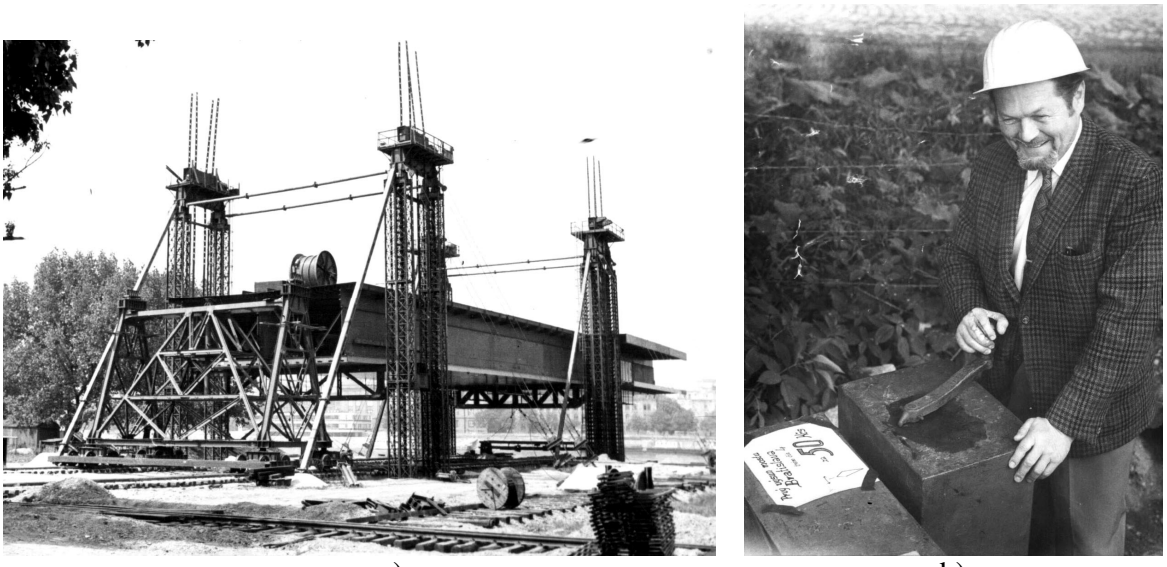
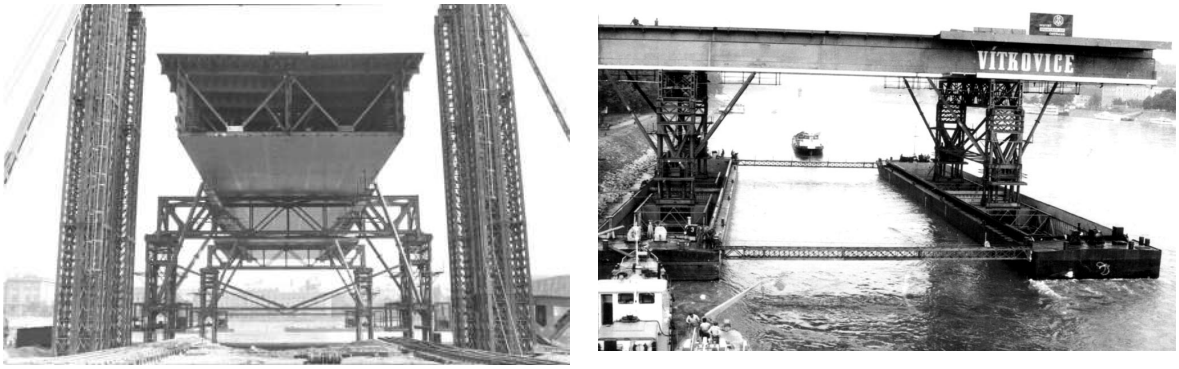


Fig. 15. The erection stages No. 9-12 of SNP Bridge [18].



a) b)

Fig. 16. a) Part of the box-girder prepared for launching; b) Prof. Arpád Tesár just before starting the first launching for fee 50 Kčs (girder No.4).



a) b)

Fig. 17. a) Part of the box-girder just before transfer on the pontoons;
b) The box-girder on two pontoons.



a) b)

Fig. 18. a) Prof. Arpád Tesár watching attachment of the next part of the box-girder;
b) Moment of connecting left and right part of the bridge girder.



Fig. 19. Left and right part of the bridge girder connected. In the left
Prof. Ing. Eugen Chladný, PhD., responsible for girder and its erection stages calculations.

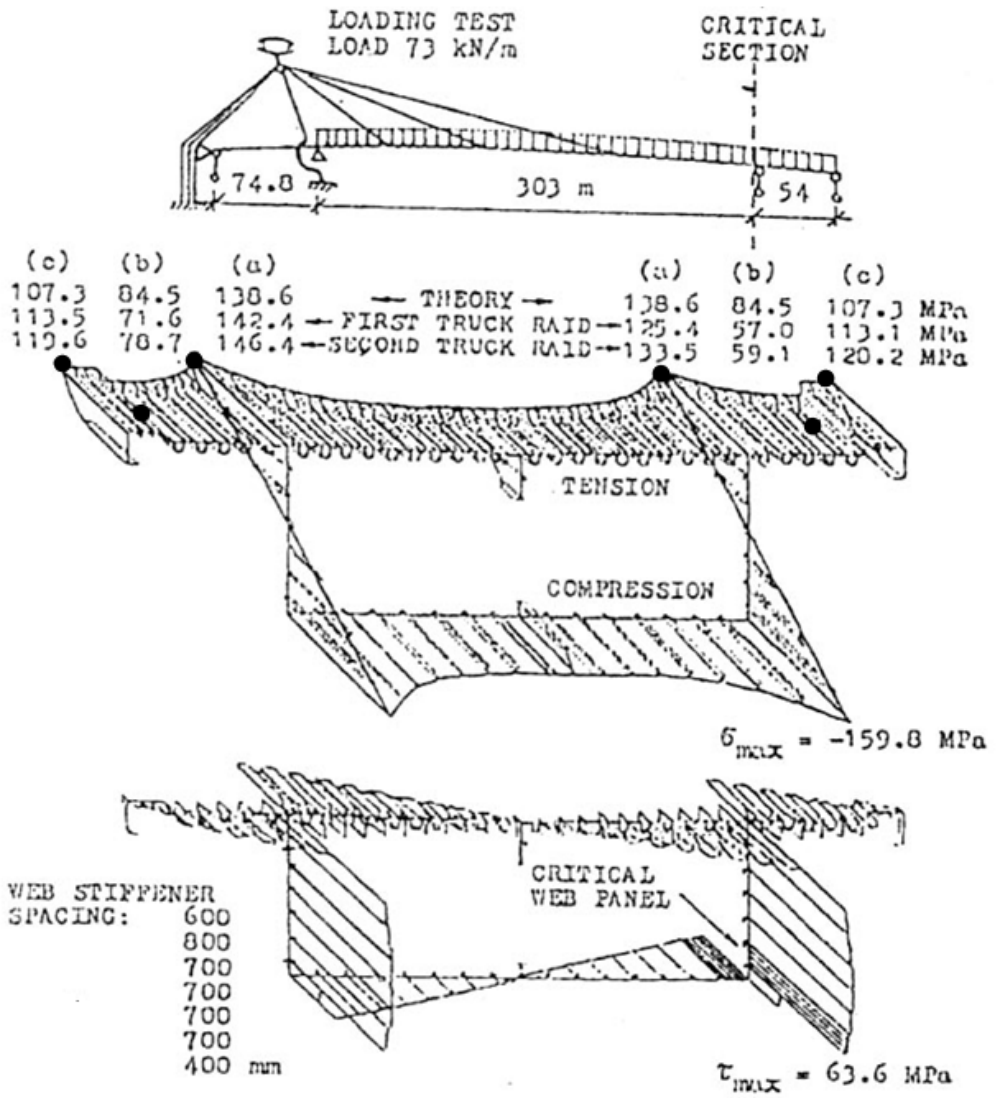


Fig. 20. Normal and shear stress distribution in the critical section by the load at loading test. Comparison of the theoretical values with loading test ones (•) measured at: a) upper girder flange-web connection, b) bottom flange of trapezoidal stiffener, c) cantilever part of upper flange. Computed by computer program SECTOR (author Ivan Baláž).

Loading tests were performed in 1972. The comparisons of the theoretical and the measured values of normal stresses in the critical stress show very good agreement (Fig.20). The first principal inspections were carried out in 1983, 1989, 1999 by Chladný, E. et al., Department of Metal and Timber Structures, FCE, STU in Bratislava.

To meet the requirements of the new codes concerning evaluation rating factors it was decided to strengthen the bridge serving fully satisfactory for 22 years. The proposal for the strengthening was made in 1991 and realised in 1993 [20]. The adding yhe truss middle web from the point of the last most inclined cable anchorage to the Bratislava bridge girder end makes two-cell box-girder along the whole bridge length. Six meter spacing of the Warren type truss "nodes" and the cross-section area of the truss diagonal member A_d = 120 cm^2 provide a fictitious steel wall with thickness t_{shear} = 2,73 mm. The influence of the truss middle web is effective only for variable action. Its influence on the distribution of the normal and the shear stress in the critical section can be seen from the comparison of the results given in Fig.20 before strengthening and in Fig.21 after strengthening.

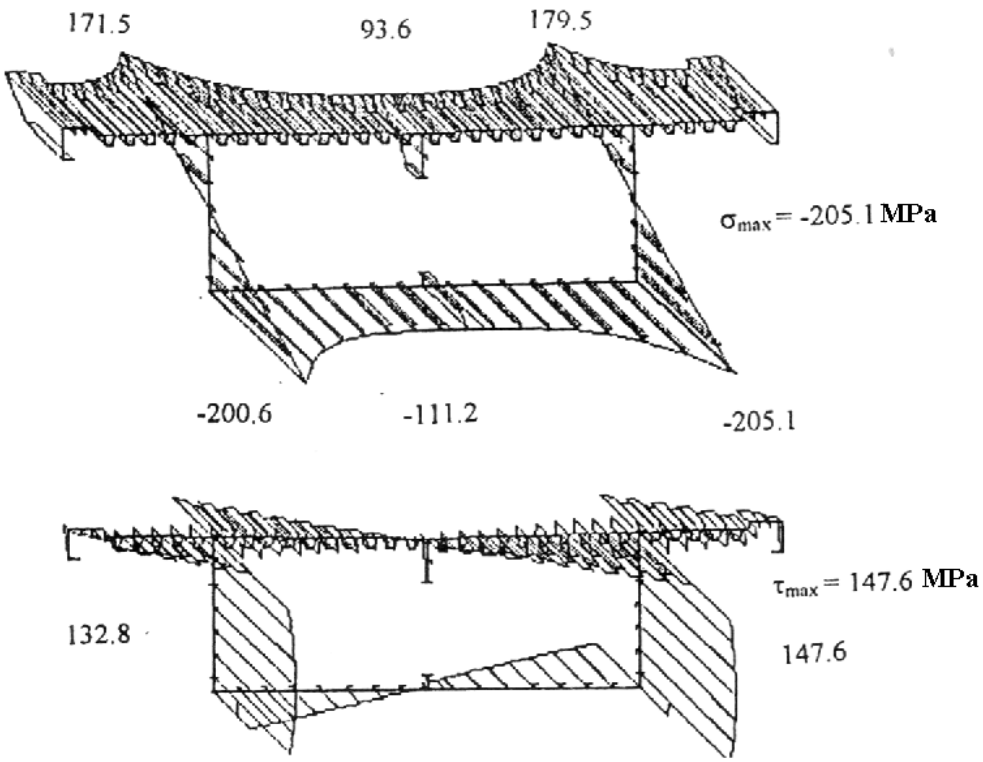


Fig. 21. Normal and shear stress distribution in the critical section **before strengthening** computed by computer program SECTOR (author Ivan Baláž) for the internal forces: N_{Ed} = -370 kN, $M_{y,Ed}$ = -255 956 kNm, $V_{z,Ed}$ = -14 656 kN, B_{Ed} = -6 412 kNm^2, $T_{t,Ed}$ = 10 151 kNm.

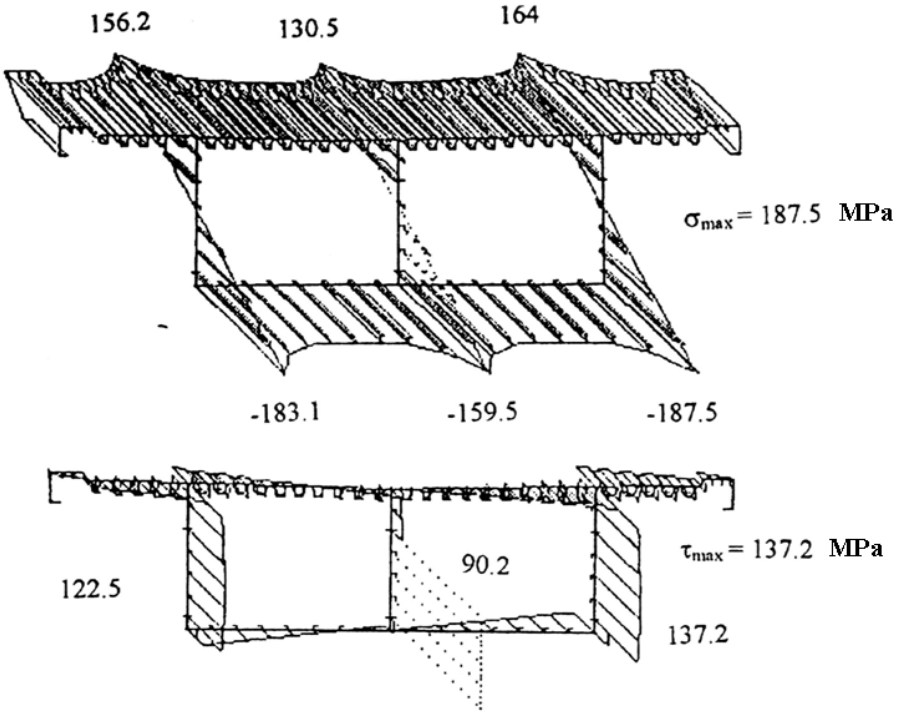


Fig. 22. Normal and shear stress distribution in the critical section **after strengthening** computed by computer program SECTOR (author Ivan Baláž) for the internal forces: N_{Ed} = -370 kN, $M_{y,Ed}$ = -255 956 kNm, $V_{z,Ed}$ = -14 656 kN, B_{Ed} = -6 412 kNm^2, $T_{t,Ed}$ = 10 151 kNm.

The first author asked a friend Mr. Karl-Eugen Kurrer to insert in the 2nd editions of his famous monographies in the chapter Short biogpraphies of the (not living) prominents of the structural mechanics also two Slovak prominents: Prof. Dr. Ing. Arpád Tesár, DrSc., and Ing. Augustín Mrázik, DrSc., from Slovak Academy of Sciences, the first author`s former teachers, later colleagues. After verifying their achievements by Mr. Kurrer, both were included in the list of 243 [21] or 260 [22] famous persons like e.g. Coulomb, Navier, Saint-Venant, Vlasov and many many others. K.-E. Kurrer asked the first author to add two more Slovak prominents. The Czech Republic has in above mentioned chapter five prominents: Zdeněk Bažant, Václav Dašek, František Faltus, Vladimír Koloušek, Josef Šolín thanks to Prof. Ladislav Frýba from Prague.

3. Short memories of Prof. Ing. Doncho Partov, PhD. on his Czechoslovak period and friends

The second author studied and later also worked in Czechoslovakia and he has nice personal memories on many Czech and Slovak professors and designers in practice. He will recall a few dear to me international contacts, which are arranged as follows:

3.1. Memories on Prof. Dr. Ing. F. Lederer, DrSc., (12.12.1906 – 24.04.1990)

Prof. Dr. Ing. F. Lederer, DrSc., (Fig. 23), graduated in civil engineering - specialty "Structures and Transport Engineering" in 1932. He defended his doctoral dissertation on "Determining the degree of stiffness of the clamped riveted connection" in 1934. In 1948 he became a professor by presidential decree in the Department of Steel Structures and Bridges at the Faculty of Civil Engineering in Bratislava. In 1953 he became a professor in the "Department of Steel Structures and Structural Mechanics" at the Faculty of Civil Engineering in Brno, which he headed until 1963. Later until 1971 he was the Head of the department: "Steel structures and bridges". In this department Prof. Partov graduated in 1969 as Civ. Eng. MSc., and defended his degree CSc in 1980 as a four-years student in the academic year 1967/1968 under Prof. F. Lederer (Fig. 23a).



a)



b)

Fig. 23. a) Prof. Ferdinand Lederer (1906-1990); b) Exhibition pavilion in Brno with diameter 93.0 m and height 19,731 m

Prof. Dr. Ing. F. Lederer, DrSc., proved in an indisputable way the great advantage of combining knowledge of the structural mechanics and the theory of steel structures. He dealt with the problems of stability of spatial dome structures and two-layers rod tubular structures. The domes designed by him bear his name: "Lederer cupola" which adorns the Brno Fair City (1959) (Fig. 23b) and the city center of Bucharest (1963).

He designed a series of sport and exhibition halls with spatial bar constructions (Fig. 24a). He is the author of over 50 scientific publications, several textbooks in the field of steel structures and also the author of 12 monographs in the field of steel structures, one of which was published in German language: "Fachwerk und Rostplatten" in 1972. The writing of this monograph was during my studies in Brno. When we took the steel construction exam at the Civil Engineering Institute, the doorman said that Prof. Lederer had been in his office since 4 o'clock in the morning and the exam began at 8,0 o'clock. This dedication of Prof. Lederer to the science was of great educational importance for the students in Brno. Many of his books are in the field of structural mechanics: Statika I. (Bratislava, 1954); Statics II. (Bratislava, 1956); Elasticity and certainty in construction II., SNTL, 1966., Statika stavebních konstrukcí, SNTL, 1967. His books: "Priestorové oceľové konštrukcie", Bratislava, 1981 (Fig. 24b), Ocelové konstrukce pozemních staveb, SNTL, 1971, dedicated to the spatial steel structures are unique in their content with the calculated examples of steel domes by Schwedler, Főppl and two-layers structures (Fig. 24a). Here is the place to admit that his influence on the creation of "Construction system for buildings with spatial-bar structures" - PPK, 84 in Bulgaria, was really huge. The spatial structures in Brno were built according to his patents and the GIRO system from 1959. The conclusion for this occasion is that the progress in the each direction of the human activity depends on taking examples from the world's cultural and technical treasury.



a) b)

Fig. 24. a) Exhibition building with two-layers roof arched steel structures; b) Monograph on spatial steel structures, 1981

The exam at him was a real celebration for his students, because he did not test in the literal sense of the word but used the time to teach something more. The curiosity was that my exam ended with him trying to join the conversation and say what I know about the downloaded questions, with the words: "wait one minute, Mr. Partov to tell you what I think about it, and you will speak when, years later, you also become a professor". This event took place in the 4th year of my study in the academic year 1967/1968. The fact that Prof. Lederer was a unique world-famous specialist in the field of wooden and steel structures is evidenced by the event in April 1980. At that time I defended my dissertation in Brno, before a jury, including Prof. Lederer. After the defending during the break, Prof. Lederer called Assoc. Prof. Ing. Bohumil Straka, CSc., the well-known specialist in the field of wooden structures design, and asked both of us to concentrate on a problem related to the redistribution of stresses between wood in a wooden floor beam and its reinforcing with steel sheets in the lower flange, taking into account the rheological properties of the wood. Based on this conversation, a wonderful article was born and published in the German journal Bautechnik, issue 3, in 2003, in which Volter's integral equations of the second kind and the resolvent method were used to solve the problem.

3.2. Memories on Prof. Dr. Ing. Antonín Schindler, DrSc., (5th April 1920 – 2006)

Prof. Ing. Antonín Schindler, DrSc., (Fig. 25a), graduated from a real high school in 1939 in Prague. He graduated later in 1947 as Civ. Eng. MSc at the Czech Polytechnic, because Czech universities were closed in November 17, 1939, after the annexation of the Czech part of Czechoslovakia by Germany. Until 1958 he worked as a designer in the field of steel bridges. His structural analysis of the world's largest, two-hinged steel arch Žďákov Bridge with the span 330 m in a volume of 3000 pages till today amazes with its details, comprehensiveness and precision (Fig. 25b, Fig. 25c). Žďákov Bridge is the steel arch bridge that near the extinct settlement Žďákov spans the Vltava river between Orlík nad Vltavou and Kostelec nad Vltavou in Písek District, Czech Republic.



a) b) c)

Fig. 25. a) Prof. Antonín Schindler (1920 – 2006); b) The two-hinged steel arch bridge with the largest span in the world 330 m (1967); c) Detail of the support of the steel arch. Project of Žďákov Bridge: Ing. Josef Zeman (19.3.1922 – 31.7.1997), Hutní projekt, Praha

In these calculations he carried out research on the stability of the arch structure, taking into account the second-order theory, which he proposed in May 1959 as the dissertation entitled "Příspěvek k praktickému výpočtu dvoukloubových oblouků podle teorie II. řádu". In June of the same year, he offered a habilitation thesis on the topic: "Static calculation for the technical project of the road bridge near Žďákov with the span 330 m". In 1961 he became an associate professor. In 1969 he defended his major doctoral dissertation: "Contribution to the economics of steel structures and bridges". In 1952 he became a professor in the field of steel structures. He is the author of 16 monographs and more than 120 scientific publications in the field of **O**rthotropic **B**ridge **D**eck (OBD) and composite steel-reinforced concrete road and railway bridges (Fig. 26).



a) b) c)

Fig. 26. Monographs devoted to the theory and construction: a) Metal bridges, 1975; b) Design of steel bridges, 1980; c) Fundamentals in the design of metal structures. Steel bridges

In the period from 1974 to 1978 Prof. A. Schindler was the consultant on Vysočina Bridge (project: Dr. O. Holaň and Ing. Antonín Pechal, CSc. (21.2.1942, Lhotsko u Vizovic), Vítkovice branch Brno) the first large orthotropic bridge in Czechoslovakia, built in the town Velké Meziříčí, with the spans: 80 + 110 + 135 + 100 = 425 m (Fig. 27).



a) b) c)

Fig. 27. The construction of the first large orthotropic bridge in Czechoslovakia, in the period 1974-1978 with spans: 80 m + 110 m + 135 m + 100 m

The collapse of 5 large orthotropic bridges with box-girder occurred in the short period (1969-1971) in Austria, West Germany, Wales, Australia and East Germany. After these accidents, the international bridge community solved this complex issue in many experimental and theoretical works. Important contribution in the solving this problem was published in the Report of Merrison committee [23]. In Czechoslovakia two new methods were very soon developed after these accidents for design of the orthotropic plates in compression creating flange of the large box-girder bridges. The simple method for design of orthotropic plates based on analogy with members in compression [24] was developed by Prof. Ing. Dr. František Faltus, DrSc., (5. 1.1901, Vienna – 6. 10.1989, Prague), from ČVUT in Prague and Prof. Ing. Miroslav Škaloud, DrSc., dr.h.c. Mult., FEng., (25.10.1930), from ČSAV in Prague. The complex method for design of orthotropic plates in compression was developed by Assoc. Prof. Ing. Jozef Djubek, DrSc., from ÚSTRACH SAV and Ing. Ivan Baláž, PhD., from STU in Bratislava [25, 28, 31, 34, 38, 39, 40]. This method was called in the foreign publications as Bratislava method [29, 30, 32, 33, 35, 36, 37]. Both Czech and Slovak methods were immediately incorporated in the standard ČSN 73 6205 [26, 27].

In 1986 I visited Prof. Schindler in Prague, with one of the great Bulgarian bridge engineers: Assoc. Prof. Dr. Eng. Borislav Bankov, in order to obtain the new Czechoslovak standard ČSN 73 6205 "Design of steel bridge structures" [26, 27], on which Prof. Schindler worked as guarrantee being at that time the Head of the Department of Steel Structures and Bridges at ČVUT in Prague. The standard was adopted with great gratitude, because it brought a new moment in the design of these facilities in Czechoslovakia, in which direction in the Republic of Bulgaria intensive work was done on the routes of the Sofia-Varna highway. Here I am obliged to explain how I came into the field of view of Prof. A. Schindler, I am a doctoral student from Bulgaria studying Brno. This happened for the simple reason that my supervisor Prof. Ing. Jiří Bureš, CSc., from the Department of Steel Structures and Bridges, VUT in Brno, sent me to his colleague and friend Prof. A. Schindler to introduce him the topic of my dissertation. What a responsibility it was for me to maintain the high reputation of a hard-working, understanding and smart Bulgarian doctoral student in front of such highly educated **and demanding** professionals.

3.3. Memories on Dipl. Ing. Jozef Poštulka (6.1.1923, Česká Třebová – 5.3. 2009, Bratislava)

In 1950, he was one of the first graduates of the Faculty of Civil Engineering at STU in Bratislava. His classmates were: top designers Behúl Vojtech, Bustin Ján and renowned scientists of the Slovak Academy of Sciences Ing. Gustáv Martinček, DrSc., and Ing. Rudolf Skrúcaný, DrSc., from ÚSTRACH SAV in Bratislava. Ing. Poštulka designed several rope roofs (Fig. 29). His most famous works include e.g. sport hall in Pasienky in Bratislava (Fig, 28). He designed several buildings for the exotic countries such as China, Afghanistan and South Korea, too.



a) b) c)

Fig. 28. a) Ing. Jozef Poštulka (1923 – 2009); b) Sport hall on Pasienky in Bratislava, project from 1958: Ing. Poštulka, architecture Ing. arch Jozef Chovanec, opened in 1962; c) aerial view, the hall has the shape of lime leaf and it is National cultural monument



Fig. 29. Several rope roofs

He also gave his seal to the Olympic Stadium in Munich. He was the author of seven inventions. When a colleague blamed him for illegal business during normalization in 1968, he served four years in prison, but he demanded drawing supplies there and continued to design there.

Ing. Poštulka visited Bulgaria for the first time in 1986, when he visited the town Veliko Tarnovo on the occasion of a conference on steel structures, organized by NTS Sofia. I witnessed his unique meeting with Assoc. Prof. Dr. Eng. Borislav Bankov, one of the great Bulgarian bridge builders. At this meeting I learned that Ing. Poštulka has a degree in civil engineering from the Polytechnic in Darmstadt, where he lectured with Dr. B. Bankov in the field of steel bridges, while he was a doctoral student in the steel structures under Professor Kurt Klöppel. This contact gave rise to Ing. Poštulka to accept me as a very close person. He helped me to become a member of the IABSE by giving recommendations for my membership. Since these years he has been a regular guest in our engineering circles as a participant in conferences at UACEG and VSU "Lyuben Karavelov". As a sign of respect for our educational institutions, he gave us the ideas for his famous patents for suspended roofs. It was said in the former Czechoslovakia that he had justified the funds the state had given for the education of his generation, because his buildings were made with a steel consumption of no more than 15 kg/m^2, while with rod or full-roof roof constructions, the cost was not less than 50 kg/m^2.

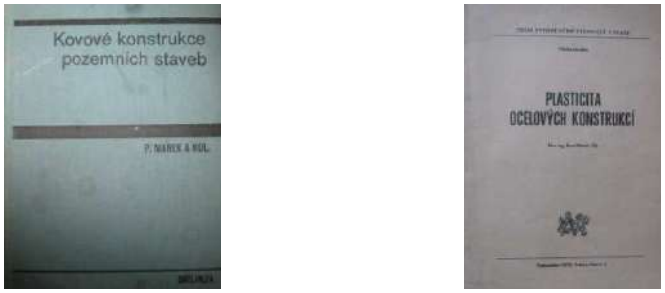
3.4. Memories on Prof. Dr. Ing. Pavel Marek, DrSc., (24.06.1932 – 8.11.2016)



a) b)

Fig. 30. a) Prof. Pavel Marek (1932-2016); b) A walk on Vitosha, in 1983

Prof. Ing. Pavel Marek, DrSc., graduated from a real high school in 1950 in Prague. In 1955 he graduated as a civil engineer at the Prague Polytechnic. As a student he became an assistant to Prof. Otakar Novák in the Department of Structural Mechanics. He worked in the department of the same name until 1960 at the Faculty of Transport. In the period 1960-1963 he worked in India (Ranchi). In 1967 he defended his dissertation on the topic: "Ocelové konstrukce na poddolovaném území". In the period 1968-1979 he worked as a guest lecturer at Lehigh University in Bethlehem (USA). He worked there under the guidance of world-famous American professors: L. S. Beedle and J. W. Fisher in the field of plasticity of steel structures and the mechanics of destruction due to fatigue of the material. He has worked on research assignments commissioned by major American corporations: ASCE; SSRC; AISC. In 1973 he habilitated as an associate professor with a scientific paper on the topic: "Interakce únavových trhlin". In 1991 he defended his doctoral dissertation on the topic: "Mezní stavy ocelových konstrukcí v podmínkách poddolovaných oblastí". In 1997 he was elected professor. He is the author of over 240 scientific publications in renowned journals. He written 16 textbooks in the field of steel structures and 6 monographs: "Kovové konstrukce pozemních staveb", 1985, SNTL, 654 pages, co-authored with: Věra Firbasová, Irena Kárniková, Jindřich Melcher, Jiří Studnička; " Únava i lom ocelových dílců", Prague, ČVUT, 1974; "Steel skeletons of subfloor structures", Prague, ČVUT, 1979; "Steel structures on subdued ground", Prague, ČSSI, SNTL, 1978; "Mezní stavy kovových stavebních konstrukci", Prague, RDJ, 1980, SNTL, 1981.



a) b)

Fig. 31. a) Monograph on steel structures; b) Scriptum for Plasticity of steel structures

The first textbook includes his valuable studies in the field of swimming centers built with steel swimming pools (Fig. 31).

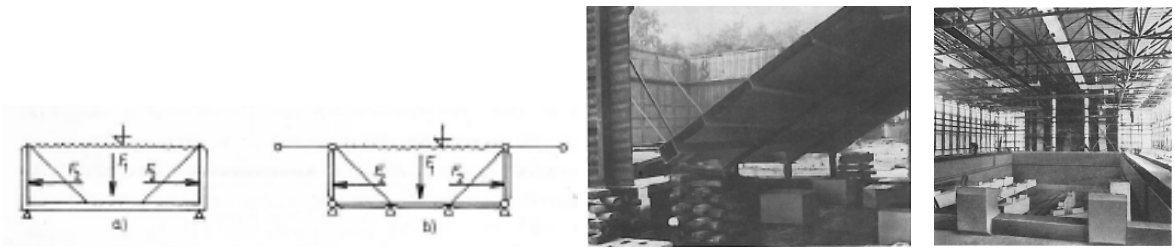


Fig. 32. Constructive schemes and realizations of swimming centers with steel pools

His depth knowledge in the field of fatigue of steel structures he successfully applied to the study of the residual resource of a tram bridge in Prague, which, after his expertise that in the bridge was initiated cracks of fatigue, it was removed from operation, after which its elements were used to build a sport hall with a steel roof built from the beams of this bridge (Fig. 32).

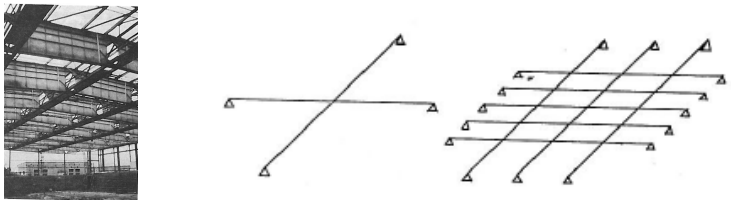
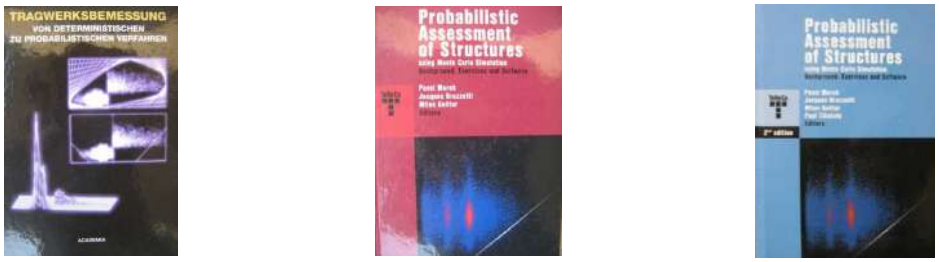


Fig. 33. Steel roof structure in a sports building from old bridge beams

The most significant is his co-authorship of the book: "Probabilistic Assessment of Structures, using Monte Carlo Simulation", dedicated to probabilistic studies of the reliability of building structures using the Monte Carlo method (Fig. 34).



a) b) c)

Fig. 34. Monographs issued in German and English languages dedicated to the probabilistic methods of exploring building structures

The contact between Prof. P. Marek and Prof. D. Partov began in 1977, when Universiade was organized by Bulgaria in Sofia and 7 swimming pools should be built in Sofia. These swimming pools are implemented as steel structures thanks to his contacts with Assoc. Prof. P. Marek. For this reason I made a trip to Prague and visited the department of steel structures, where P. Marek, as always a smiling and well-meaning, asked me – the young unknown colleague, whom I am looking for and what can be useful for me. When I said that I want the consultation for the design of steel swimming pools, P. Marek being in the hallway and not introducing himself, started the lecture about various theories for calculating steel swimming pools and for the various types of stationary and movable bottoms, which ended with warning: do not forget painting the bottom of the pool with the white protective paint Epovin, because if the paint is blue, the water will look muddy in the pool. At this moment I asked him: who I am talking with and I received the answer: "with one you were looking for." It was a lesson from diplomacy, professional training, operational and, above all, in collegiality. In 1983, a conference on the problems of tall buildings took place in Sofia. Prof. P. Marek arrived for this event to meet his mentor and teacher L. S. Beedle, from Bethlem University, USA. In the meantime, he was the guest of the largest design organization in Bulgaria, the "Glavproject", where he gave a wonderful lecture on the application of steel structures in the public construction. One of his examples was the Slovak radio and television building, developed as turned upwards pyramid. He insisted on climbing the top of this mountain because he was a great supporter of winter sports and an exceptional connoisseur of our surroundings. A memory of this visit to Sofia is the photo from his walk on the Vitosha Mountain (Fig. 29b). I was able to take him to one of the successful projects, constructed with steel structures, namely the bridge near to the airport. Its central part was a 100 meter steel structure filled with an orthotropic steel deck. He was interested in all details of the bridge that I explained to him and all the time he took pictures with a small Konica. At the end he asked me: Where is your camera, and added, "such wonderful structures must be sealed with a camera and displayed over time". We saw each other with Prof. P. Marek in the next 35 years regularly at conferences in the

Czech Republic and Slovak Republic. Thanks to people like him, many problems in the field of construction design were well explained and developed, so that the young generation would be more securely on the path of scientific progress. We will remember him, with its significant presence in creating the probabilistic approach to the study of building structures with the SBRA method.

Afterword

Concluding this text, during the night I remembered other new episodes from my respective contacts with the persons mentioned above. In 1979 a large conference on the composite steel and reinforced concrete structures was held in Brno, in which I also participated, at the insistence of my supervisor: Prof. Ing. Jiří Bureš, CSc. After my report, Assoc. Prof. P. Marek came to me and told me directly. You are working in a new field that requires very high mathematical training. We have not yet mastered the mathematics of Newton and Leibniz from the 17th century, and you want to tell us about Voltaire's integral equations from the 20th century. You don't have to fool us with these theories, but try to raise us to your level so that we understand what you're talking about and, if necessary, complete mathematics through evening training. (Note. This recommendation was already behind me). I completed a two-years course in Mathematics in 1976-1978. Due to my special interests in rheology and viscoelastic processes in building materials, in this course besides: numerical methods, operational calculation by Laplace transforms (whose possibilities gave the solution to the problem published in the journal Bautechnik in 2003); variation calculation according to the book of the great Czech mathematician Prof. RNDr. Karel Rektorys, DrSc.; a special course on integral equations was made.

However, when I showed our lecturers the systems I derived from Volter's integral equations of the second kind, I was chosen at BAS, where Academician Bl. Sendov introduced me to the future professor Raycho Lazarov, who is currently in the United States, with whose help we solved the problem. He advised me also something else very important for practice, to include this phenomenon of concrete creep in the philosophy of analysis the building structures by the method of limit states conditions. At defending of my dissertation in Brno, my reviewers were: Prof. Ing. Jiří Pechar, DrSc., Assoc. Prof. R. Kuda and Prof. Ing. Vladimír Křístek, DrSc., dr.h.c., FEng., (15.10.1938 – 9.9.2020), dr.h.c. in VSU, Lyuben Karavelov in Sofia. His analyzes of the new mathematical apparatus applied were significant in the task I was solving, namely: "Contribution to the methods for calculating composite steel-concrete structures, taking into account the rheological properties of concrete". When the defending procedure was over and he had to return to Prague, he said goodbye to me: Prof. E. Winkler, the father of the theory of iteration of a soil massif with a building structure, worked here at this university. He derived a simple differential equation. You have derived a system of integral equations of Volterra and you study mathematics on your own, which gives me the opportunity to say one day, ask on this question: Mr. D. Partov. I have not met so far in a lawyer's approach to solving problems in our area. You talked to yourself the whole time you were getting acquainted with your dissertation. Consider staying to work in Brno and write a doctorate. This advice a few days later became a procedure for me to stay in the Department of Steel Structures and Bridges in Brno to work. However, the fate did not want this to become a reality. I had to return to Sofia and fulfil some commitments to my family regarding our housing problems. In connection with the kind words of Prof. Křístek, I did not owe him anything, because in the publication: Partov, D. et. al.: "Redistributions of stresses due to creep and shrinkage of concrete in supported statically determine composite steel and concrete beams", Der Stahlbau, Vol., 54,1985, p. 205-209, I expressed my gratitude to the reviewers of my dissertation. His reaction was that no one had ever made such a great advertisement of Czech education as I did.

After the fall of the Iron Curtain with a publication in this renowned magazine, you have the right to attack the high peaks, where our Prof. Zdeněk Bažant, what theory are you working on. And I fulfilled this message with a publication in the USA: Partov, D. N., Kantchev, V.,: "Gardner and Lockman Model in creep analysis of composite steel-concrete sections", ACI STRUCTURAL JOURNAL, Vol. 111, No. 1, 2014, pp. 59-70. So I have the feeling that I have fulfilled his covenants. The conclusion from this conclusion allows me to summarize these tips as a great advantage for people engaged in science. These are the people I've talked about so far. They had positions and authority. They stood behind the ideas of others and did not hold back when they had to encourage someone in their path. Thanks to people like them, a turning point in the history of Central Europe was reached, when democracy was recaptured in the fateful year 1989 and returned to our world.

During my study and working stay in Czechoslovakia I met a lot of successful and very kind people. Just few of them is mentioned in this paper. For example Dr. O. Holáň and Ing. A. Pechal, the designers of Vysočina Bridge and Ivančice Viaduct, lent me their studies about composite steel and concrete bridges and we discussed the problem of the old bridges reconstructions. Ing. Pechal sent me later his book [41], with examples of numerous bridges he designed in Vítkovice branch Brno (1964-1992) and from 1992 in his own company. It is very useful book for which the following motto is valid: "for every construction project it is necessary to have initial idea, design it, carry it out, make photographic documentation of the work and then publish the project". Prof. Ing. Jiří Studnička, DrSc., from Faculty of Civil Engineering, ČVUT in Prague, admired the book [41] at its end. He is another kind man I met in Prague, who sent me all his famous text books about design of steel, cold-formed and composite steel and concrete structures, which served for education of generations of engineers. The colleagues from the department he headed Assoc. Prof. Ing. Tomáš Rotter, CSc. and Assoc. Prof. Ing. Milan Vašek, CSc. shared with me their power-point presentations from conferences and scientific papers.

This is just short part of my memories on my study and working stay in former Czechoslovakia and on the noble people I met there with which the friendly relationships last till today. Not all persons are mentioned in this short paper, or not enough mentioned like e.g. my nice friend Assoc. Prof. Ing. Bohumil Straka, CSc., from Faculty of Civil Engineering, VUT in Brno.

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