FIRST EUROPEAN TRUSS CANTILEVER BRIDGE IN THE LIGHT OF NUMISMATICS, ICONOGRAPHY AND WRITTEN SOURCES

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Introduction

The bridge in Torun was the first bridge on permanent wooden piers built over the middle and lower Vistula. The city of Torun (Thorn) was founded in 1233. After the Second Peace of Torun – a treaty concluded in 1466 between the Polish Kingdom and the Teutonic Order, the city was incorporated into the Royal Prussia and became subordinate to the King of Poland. Owing to its location on the Vistula riverside, which became the main water route to the Baltic Sea in the 16th century, Torun gained significant profits from trading in commodities exported from the territories of Poland, Lithuania and Ukraine to countries of western and northern Europe. Torun's membership of the Hanseatic League from 1280 brought prosperity to the city. Big towns of the North Sea and the Baltic regions such as Lübeck, Hamburg, Cologne, Dortmund, Bremen, Rostock, Stettin (now Szczecin), Danzig (now Gdańsk), Elbing (now Elbląg), Königsberg (now Kaliningrad), Kaunas, Dorpat (now Tartu), Riga, Reval (now Tallinn) and Stockholm belonged to this confederation of merchant guilds and their market cities.

The Torun Bridge was built in 1500 by the Municipality of Torun with the permission of Jan I Olbracht, King of Poland and with financial participation of the Polish Crown equal to ¾ of the expenditure. The bridge was built within three years by Peter Postil, who was brought to Torun from Bautzen (Budziszyn) in Lusatia. The bridge structure with a total length estimated at between 620 and 670 meters consisted of a large number of wooden spans, each approximately 19 m long, supported by piers and abutments resting on wooden piles connected with caps.[1] The bridge was divided into two parts located on both sides of the island on the Vistula River which were commonly called the German Bridge on the north-eastern side and the Polish Bridge on the south-western side. Every spring the Torun Bridge was endangered by floods and drifting ice. 16th-century chronicles report it was seriously damaged in 1533, 1544, 1570, 1584, 1595 and 1598.[2] At the beginning of the 17th century the bridge was protected against drifting ice by very long ice noses connected to the piers. In the 17th century the bridge superstructure was modernized, with two large spans provided, located on both sides of the German Bridge.

Two large spans of the Torun Bridge are mentioned in two publications of historical nature;[3] however the authors do not analyze its significance for the development of the bridge technology. The first articles containing an analysis of engineering solutions applied to the Torun Bridge were published in 2010 and 2011[4]. In 2012, some technical problems were mentioned by the author in monograph on 17th century bridges.[5]

Research methodology

In the study on the bridge over the Vistula in Torun content of plans and historical maps, drawings and the city views from the 17th century has been examined. These iconographic sources have been confronted with the 17th century news about the city delivered by the Torun mayor Henry Stro-

[1] M. Mistewicz, *17th century bridges over the middle and lower Vistula river in the light of iconography, cartography and written sources* [in Polish]. Warsaw 2012, ed. by the Road and Bridge Research Institute, (based on a doctoral dissertation at the Faculty of Architecture at Warsaw University of Technology – Supervisor prof. Danuta Kłosek-Kozłowska), p. 126.

[2] B. Dybaś, *Historical notes on the history of Pomerania and the Baltic countries. Stroband's concept of modernization of the bridge over the Vistula River in Torun at the end of the 16th century* [in Polish]. Torun 1989, Poland, "Zapiski Historyczne", 54 (Nº 2-3), pp. 35-53.

[3] B. Dybaś, K. Walczak, *Torun river crossings and bridges on the Vistula*. Torun 1989, Poland, Towarzystwo Miłośników Torunia, pp. 35-53; B. Dybaś, ibid.

[4] M. Mistewicz, *Bridges over Vistula river in Torun on 17th century engravings* [in Polish], "Drogownictwo" 12/2010, pp. 424-429; B. Obiegałka, *It is about an old wooden bridge in Torun in the first half of 17th century, with touches aesthetic*, [in:] Materiały z VII Krajowej Konferencji Estetyka Mostów Warszawa-Jachranka 2011, Warsaw 2011, ed. by the Oficyna Wydawnicza Politechniki Warszawskiej, pp. 125-130.

[5] M. Mistewicz, *17th century bridges...*, op. cit., pp. 120-138.

band in his memorial, by English travelers Peter Mundy and Robert Bargrave in their diaries and with notes in the chronicle of the Torun city. Town images have also been studied that are presented on coins minted in the Torun Minting House between 1629 and 1659 (Fig. 1).

This article tries to prove that the cantilever truss (Gerber carrier) solution was applied for the first time in Europe ever in the Torun bridge to achieve greater span length and that this span length happened to be the longest in European bridges in the middle of the 17th century. The aim of the study is to estimate the year of the erection of two large spans and their period of service.

Written accounts mentioning the Torun Bridge

In 1591 Henry Stroband (1548–1609), who was the mayor of Torun, wrote a memorial concerning preparation for the defence of the city, which contained five pages on the subject of modernization needs of the bridge on Vistula River and costs.[6] While working on the memorial, he collaborated with an architect Anton van Obberghen from the Netherlands, who was temporarily engaged at that time in the reconstruction of the Town Hall of Torun. The memorial is nowadays stored at the National Archives in Torun.

In his memorial, Stroband suggested the construction of "grossen eiskasten", which can be translated as "large ice boxes" and interpreted as huge ice-breakers for the protection of bridge piers. He wrote about "weite schwebewerk", what most probably means large suspended spans. In Stroband's opinion, after the reconstruction the bridge structure would be more capable to withstand the flow of floodwater, drifting of ice and fit for navigation.[7]

Some valuable information on the bridge was given by Jacob Heinrich Zernecke (1672–1741) in his „Thornische Chronica in welcher die Geschichte dieser Stadt von 1231 bis 1726 aus bewehrten Scribenten und glaubwürdigen Documentis zusammen getragen worden". This chronicle was published by Ambrosius Haude in Berlin.

On 18 March 1632, Zernecke quoted MSc. Streuwig who mentioned a floating bridge in Torun "Shiff Brücke".[8] If a floating bridge had to be assembled, this means that the permanent bridge could not be used. This situation may have been due to some damage or reconstruction works carried out on the permanent bridge at that time. Another piece of information concerns a person connected with the bridge in Torun, Philipp Ahmon, who died on 2 August 1634. Philipp Ahmon was a brewer and member of the Council of the New City of Torun for a period of fourteen years. He was given the title of the Lord of the Bridge "Brückenherr". Zernecke cites posthumous commemoration of him: "Corpus ob eximium secisset Te India Regem, Thorna sed elegit Te fibi Pontificem".[9]

A detailed account on the bridge structure was provided by the famous English traveller Peter Mundy (1600–1667) who described the Torun Bridge in his diary twice in 1640 and 1643. The diary was published by Richard C. Temple & The Hakluyt Society in London. During his first short stay in Torun in 1640, Peter Mundy wrote: "Over the River is a wodden bridge of near ¼ off a Mile in lenght, under some part wherof itt Never Freezes, For great watters, especially running Rivers, will in one place or other have an opening, as itt were a respiration. I went over the said bridge unto a small Polish towne named Potsgarre [Podgorz]. Note thatt over the River is properly termed Poland or Polonia".[10]

Three years later Peter Mundy visited Torun again. He wrote in his diary as follows: "Thorunia or Toorne, a hansome Citty of which I have formely said somwhat. Only a word or two of the bridge, or 2 arches therof, which I taken noted not, one on each end, of a wonderfull length, made of purpose to give a Free passage for the Ice when itt breakes aboutt the spring of the year, which then comes downe in such a quantity and with such violence thatt itt carries downe all afore itt, as bridges; (...) The Arches aforementioned are somwhatt after the forme described in the paper hereunder annexed. Soe that from A to B, which is the widnesse of one arche, is 83 of my owne steppes, which is about 60 English yeards or 180 English feet, the Floore, pas-

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[6] B. Dybaś, op. cit., pp. 35-53.

[7] Ibid.

[8] J. H. Zernecke, *Thornische Chronica in welcher die Geschichte dieser Stadt von 1231 bis 1726 aus bewehrten Scribenten und glaubwürdigen Documentis zusammen getragen worden.*, bey Ambrosius Haude, Berlin, 1727, p. 286.

[9] Ibid., p. 289.

[10] R. C. Temple, *The travels of Peter Mundy in Europe and Asia, 1608–1677*, Vol. IV, *Travels in Europe (1639–1647)*, London 1925, printed for the Hakluyt Society, Kessinger Publishing, pp. 99-100.

sage or way above hanguing on 4 beams, C. D., soe that thatt part of the bridge hangeth as a paire of scales with waights on a paire of Triangles; used att London".[11]

Peter Mundy attached a detailed drawing of a large span of the Torun Bridge to this part of his diary, the drawing shows a wooden span composed of a king-post truss supported on two cantilevers (Fig. 2). There are two horse carts passing over the bridge and two big oar-propelled river ships underneath. In his diary, not only did Mundy describe the structure of the bridge, but he also gave dimensions of the span measured in feet between points marked on the drawing. According to the data that the famous English traveller furnished, clear length of each of the two spans of the bridge was 60 English yards. As one English yard equals 0.9144 metres according to Fenna,[12] each span was about 54.86 metres long. The Torun bridge builders constructed such a large span by placing the simplest truss of king-post type on the ends of two cantilevers reinforced by two angle braces fixed to the piers. The superstructure created this way can be defined as a cantilever truss structure. The dimensions and proportions of the elements on Peter Mundy's drawing show that the truss length was about 40 English yards, which is 36.58 metres. Similarly, the truss height and spacing of truss posts was about 10 English yards, which is 9.14 metres.

The done in 2010 author's calculations of internal forces and stresses in a king-post truss structure under the live load of the lowest Class D (according to the Polish Standard PN-85/S-10030) demonstrated that a 40-English-yard-long truss with a deck that is 16 Polish Crown feet [4.69 m] wide could have been constructed of wooden logs with a diameter of 1½ Polish Crown feet, which is 0.44 metres.[13] It was certainly possible to find and fell trees for such wooden logs in the nearest forest at the town of Nowa Nieszawa in the Polish Kingdom, as well as at other locations within the territory of the Grand Duchy of Lithuania at that time.

Nearly ten years after Mundy's visit, in December 1652 the Torun Bridge was traversed by another English traveller named Robert Bargrave (1628–1661) who was a Levant merchant and author of *The Travel Diary*. Under the date of December 2nd he noted: *"*we passd through severall Villages and Woods to Torne; over the great wooden bridge on the Wesil; which costs annually about :30: thousand Dallers (above:[li] 1000:) to repaire: and & yet was it now so decayd, that passing over it, my horse brake a hole throught a Planke; & I esteeme my deliverance not among the least God has vouchsafd me"...[14] This means that these days the bridge was not maintained in technical condition allowing for safe use.

Numismatic sources

Numismatic sources prove very helpful in estimating the service life of the large spans of the Torun Bridge. Probably as early as 1233 coins for the Chełmno land (Kulmerland) started to be minted in Torun, under a privilege conferred by the Teutonic Order. The minting house was situated on Bridge Street leading to the floating bridge over the Vistula. It continued its services for the Teutonic state and later for Casimir IV Jagiellon, the King of Poland. The right to mint coins was officially confirmed by King Sigismund I of Poland. Coins with his image were minted from 1529 to 1535 and destined for circulation in Royal Prussia. Later, the Torun Minting House remained closed for many years.

During the battle at the mouth of the Vistula between the Polish Kingdom and the Kingdom of Sweden, in February 1629 the Torun citizens, supported by the Polish King's military forces defended the city against the Swedish army commanded by Field Marshal Herman Wrangel. Anniversary celebrations commemorating the defence were organized in the city in the following years. Coinage production was resumed after this successful defence.[15]

Coin dies of a silver thaler with the panorama of Torun besieged in 1629 by the Swedish army, called "Brandtalers" were made in the Torun Minting House by Henry Hema. Hema came to Torun from Silesia, where his father had been employed as an imperial mint-master. Thalers with his image of the city were produced each year from 1630 prob-

[11] Ibid., pp. 196-197.

[12] D. Fenna, *Dictionary of Weights, Measures and Units. Translation to Polish by Barbara Pierzchalska* [in Polish], Warsaw 2004, ed. by Świat Książki, p. 92.

[13] M. Mistewicz, *Torun bridges...*, op. cit., p. 429.

[14] M. G. Brennan, *The Travel Diary of Robert Bargrave Levant Merchant (1647–1656)*, The Hakluyt Society, London 1999, p. 149.

[15] M. Gumowski, *History of Torun Minting House* [in Polish], Torun 1961, "Roczniki Towarzystwa Naukowego w Toruniu", 65/1960 (Nº 1), p. 111.

ably up to 1632 for the guests of anniversary celebrations.[16] Earlier-minted thalers show a view of the bridge superstructure composed of a large number of short spans of the same length as shown in Figure 3. On the later-minted thalers, there are two king-post truss spans of double length instead of short spans as shown in Figure 4. Truss spans over the right Vistula branch in the north-eastern part of the bridge were for the first time depicted on the described memorial coins.

Gold coins known from Polish collections and showing the same view of the Torun bridge with two large spans are dated to no later than 1655. In Figure 5, there is a fragment of a coin minted in gold in 1655 where king-post trusses are clearly visible. Although a gold coin in Figure 6 dated to 1659 shows the same view of the bridge, the image was corrected by blurring the king-post truss structures on the coin dies used for coining.

According to numismatic sources, two large spans of the Torun Bridge existed approximately between 1630 and 1659.

Iconographic sources

To determine the exact years of the construction and dismantling of two large spans of the Torun Bridge an iconographic sources were analysed. The first known drawing of the German Bridge over the right arm of the Vistula River shown in Figure 7 appeared in the Torun city plan dated to 1631, made by an unknown author. The city plan is stored at the Military Archives in Stockholm. The plan is an ink drawing with a scale in rods (perches). The bridge in the drawing consists of thirteen small spans. Pier spacing measured on the drawing is equal to 7.5 rods, which equals 28.2 metres assuming after Fenna,[17] that one rod equals 0.3139 meter. The clear length of each span is about 5 rods or 60 feet, which is equal to 18.8 m. A similar appearance of seven spans from the same part of the bridge was shown by an engraver, surveyor and architect Jacob Hoffmann in the same year 1631 in the city view titled "Civitas Thorunium una cum sva fortificatione accurate delneata Per Jacobum Hoffmannum Geom. et Archit".

The next view of the bridge shown in Figure 8 comes from a small part of the famous Torun panorama engraved for Samuel von Pufendorf's (1632–1694) book "De Rebus A Carolo Gustavo Sveciae Rege Commentatorium" based on a drawing by Erik Jönsson Dahlbergh (1625–1703).[18] Dahlbergh was a quartermaster of King of Sweden Charles X Gustav during the war between the Polish Kingdom and the Kingdom of Sweden between 1655 and 1659. In 1655, Torun was surrendered without a fight to Charles X Gustav and started to be occupied by the Swedes. A 1696 engraving shows the bridge in 1655 with two large spans and unidentifiable structures above the deck what may mean that the bridge was partially covered with a roof. Dahlbergh once mentioned in his diary that he had passed the Torun Bridge on 1 March 1657, about forty years before he prepared the engraving.

Large bridge spans were not marked on the Torun fortification plan dated to 12 December 1657 made in the city of Elbing and signed by "J", nowadays stored at the Military Archives in Stockholm. The plan probably includes a bridge reconstruction design after damage incurred by the city of Torun in September 1657 as a result of Polish military operations against the Swedes. A drawing prepared the following year shown in Figure 9 presents the city of Torun surrounded by the Polish and allied Austrian Armed Forces. The German Bridge consists of eleven short spans most probably constructed by the Swedish army for military purposes. The drawing comes from the collection of Erik Jönsson Dahlbergh and is stored at the National Archives in Stockholm.

On the next engraving from the said book of Samuel von Pufendorf, Willem Swidde showed siege of Torun by the Polish and Austrian Armed Forces, which led to the recovery of the city on 30 December 1658. He drew a destroyed German Bridge, after which the only pier piles left standing out of water (Fig. 10).[19]

Drawings and engravings of Torun city plans dated to 1631, 1655, 1657, 1658 and 1696 together with the Torun bridge iconography taken from memorial "Brandtalers" and gold coins produced in the Torun Minting House between 1630 and 1655

[16] Ibid.
[17] D. Fenna, op. cit., p. 172.
[18] S. Pufendorf, *Samuelis Liberi Baronis de Pufendorf De Rebus A Carolo Gustavo Sveciae Rege Gestis Commentariorum Libri Septem Elegantissimus Tabulis Aeneis Cum Triplici Indice*, Nuremberg, Norimbergae Sumptibus Christophori Riegelii, Literis Knorzianis 1696, No. 24.
[19] Ibid., No. 92.

have enabled the period of service of two large bridge spans to be dated to 1632–1657 period.

The invention of the cantilever truss (Gerber carrier) bridge

A comparison of the bridge pier spacing measured by the author in 2011 on the 1631 plan of Torun with the distance between supports measured by Peter Mundy in 1643 in Torun, leads to a conclusion that the reconstruction of the bridge was based on the elimination of two piers. The doubled distance between centres of the former piers [2×28.2 m] differs slightly by 5% from the sum of clear distances between the new piers and the pier thickness [54.9 m+4.5 m]. A probable view of the bridge spans before their reconstruction compiled of fragments of Peter Mundy's drawing is shown in Figure 11.[20]

As noted above, around 1632, two spans of the Torun Bridge were lengthened from 18.8 to 54.86 metres. This might have happened for the following reasons:

– damage caused to some piers by the big flood that occurred on 20 June 1628,[21]
– destruction of some spans and piers by the Polish or Swedish military troops during the siege of Torun on 16 February 1629,[22]
– implementation of the solutions proposed by the city mayor Henry Stroband in 1591 for the construction of two large suspended spans to cater for sailing needs and allow for safe drifting of ice,[23] or a combination of these.

With one pier missing the builders were forced to cover the free space with a 30-metre-long superstructure. It was possible to use wooden king-post trusses that were a common solution used in bridge building at that time. The truss design had been explained in architectural treatises in the beginning of the Modern Period by Andrea Palladio in "I Quatro Libri dell'Architettura", published in Venice in 1570 and Fausto Veranzio in "Machinae Novae Fausti Verantii Siceni", published in Venice in 1616. The king-post trusses were used for a wooden bridge over the middle Vistula River in Warsaw and were in service from 1573 to 1603. 18 king-post truss spans of that bridge were supported directly on one abutment and a number of piers.[24] In case of the Torun Bridge the truss was simply supported on two cantilevers strengthened with brackets fitted to the remaining piers. Those spans consisted of a suspended beam and two cantilevers. Whether accidentally or intentionally the builders of the Torun Bridge implemented the modern solution of a cantilever truss bridge structure?

The longest bridge spans used in Europe

The Torun Bridge may be compared to bridges in service in Europe in the same period on the basis of current literature concerning historic bridges. Roman stone arch bridges which still exist generally do not exceed 100 Roman feet between supports, for example the " Puente de Alcántara" bridge over the Tagus River in Spain with an inscription for the Emperor Trajan, built in 104 and rebuilt in the Middle Ages by an architect C. Julius Lacer.[25] Some bridges with longer spans built in the Middle Ages have survived until now. The arch stone bridge *Pont Saint Benezet* over the Rhone in Avignon in France was built by a shepherd named Benezet between 1178 and 1188 and has four spans that are 20 to 35 metres long. The bridge has partially survived until now.[26] In 1336, in the Eastern Pyrenees, a span that was 45.5 metres[27] or 149 feet long was used for the bridge called "Pont du Diable" over the River Tech in Céret, in France.

"The longest of the medieval arches was the fourteenth century Trezzo built [between 1370–1377] over the river Adda in Italy and demolished in a fifteenth century war".[28] It was 251 feet[29] or 72 metres[30] long and has not survived to our times. After destruction of the stone arch over the Adda in Trezzo, the longest span between 1416 and 1454 was a 48.7 metres[31] [160 feet] long masonry arch. This arch can still be seen in a fortified bridge over the Adige in Verona called "Castelvecchio or Ponte

[20] M. Mistewicz, *17th century bridges...,* op. cit., p. 128.
[21] J. H. Zernecke, op. cit., p. 277.
[22] Ibid., p. 280.
[23] B. Dybaś, op. cit., pp. 35-53.
[24] M. Mistewicz, *17th century bridges...,* op. cit., p. 139-151.
[25] VD. J. Brown, *Bridges,* New York 1989, Macmillan Publishing Company, p. 25.
[26] H. G. Tyrrell, *History of Bridge Engineering*, Chicago 1911, The G. B. Williams Co. Printers, pp. 40-41.
[27] L. F. Troyano, *Bridge Engineering. A Global Perspective*, London 2003, Thomas Telford Publishing, p. 116.
[28] Ibid.
[29] H. G. Tyrrell, op. cit., p. 46-47.
[30] L. F. Troyano, op. cit., p. 116.
[31] Ibid.

Scaligieri". It was built between 1354 and 1356 and reconstructed from the ruins in 1951.

Until 1632 arch spans appear to have been the longest spans. On the basis of books on historic bridges, a span of "Pont de Vielle-Brioude" over the river Allier in France might be considered to have been the longest arch span in Europe for more than three hundred years that is from 1454 to 1757. The arch seen in Figure 12 was 54 metres long.[32] According to Serge Montens, the author of the monograph of French bridges, the span was longer and measured 54.57 metres [179 feet].[33] Probably both pieces of information are true when we take it into consideration that the first length was measured in the span clearance and the second one between the arch bearings. Henry Tyrrell[34] estimated span length of "Pont de Vielle-Brioude" on 150 feet [45 m] which may be correct after the bridge collapsed and was reconstructed in 1832.

It has never been mentioned in literature on development of bridge technology that at the middle of 17th century two wooden truss cantilever spans of 180 English feet each [54.86 m] were in service in Torun in the Polish-Lithuanian Commonwealth for about 25 years (1632–1657). The length of the cantilever truss structure applied for that bridge reached and exceeded lengths of arch spans used at that time, which is shown in Table 1. A wooden bridge span longer than the one in Torun appeared a hundred years later in 1758. Three carpenters from Switzerland, the brothers Jakob (1694–1758), Johannes (1707–1771) and Hans Ulrich (1709–1783) Grubenmann built a wooden bridge over the Rhine in Schaffhausen with arches that were 58.8 metres[35] or 193 feet long.[36]

Modern cantilever truss bridges

After the Industrial Revolution, in the third decade of the 19th century, the cantilever truss solution was rediscovered to be incorporated in European steel bridge structures. Steel as a new building material of high strength allowed the bridge constructors to achieve spans longer than spans made of wood. Design engineers used to choose the static scheme of a cantilever truss because it was much easier to calculate internal forces and stresses in it. The first designer who patents a structural solution of a suspended span in 1866 was German engineer Heinrich Gottfried Gerber (1832–1912). In 1867, he used this solution to design the "Hassfurt Brűcke" over the Main River (Fig. 13). The truss bridge with a 38-metre-long [124-feet-long] central span is recognized as "the first modern cantilever bridge. It was a continuous girder hinged at the points of equal resistance where the moments of the uniform load were zero".[37] It has never been mentioned before that around 1632 there was a wooden cantilever bridge in Europe, which reached the span length of 54.86 metres [180 English feet], much more than the length of the steel span of the "Hassfurt Brücke".

At the end of the 19th century and in the beginnings of the 20th century, steel structures based on the cantilever solution proved very useful for the construction of very large truss bridge spans. These allowed structural engineers to design structures crossing very deep and wide reservoirs and valleys. The most famous bridge structure based on the cantilever solution was the railway "Forth Bridge" near Edinburg in Scotland. In 1889 design engineers sir John Flower and Benjamin Baker constructed two cantilever spans that were 521 meters or 1710 feet long[38] and are shown in Figure 14. From 1890 to 1917 those spans were the longest ones of this structural type. The railway bridge "Pont de Québec" in the city of Quebec in Canada that was completed by the "St. Lawrence Bridge Co." in 1917 with a 1800-feet-long [549 m] span remains until now the bridge with the longest cantilever truss span.[39]

In 1931, three hundred years after Peter Mundy had mentioned the two spans of the Torun Bridge, the next cantilever truss (Gerber carrier) bridge over the middle Vistula River was constructed at Puławy city. The bridge substructure design was developed by engineer Stefan Zagrodzki. The steel superstructure design was made by engineer Aleksander Pstrokoński and K. Korn. The Puławy Bridge was opened for traffic on 20 October 1934. It consists

[32] Ibid.
[33] S. Montens, *Les plus beaux ponts de France*, Christine Bonneton 2001, pp. 69-70.
[34] H. G. Tyrrell, op. cit., p. 43.
[35] A. Maggi, N. Navone, *John Soane and the wooden bridges of Switzerland: architecture and the culture of technology from Palladio to the Grubenmanns*, 2002, pp. 115-117.
[36] H. G. Tyrrell, op. cit., p. 124.
[37] E. DeLony, *Context for World Heritage Bridges*, ICOMOS conseil international des monuments et des sites, a joint publication with TICCIH 1996.
[38] D. J. Brown, op. cit., pp. 72-73.
[39] J. Durkee, *World's Longest Bridge Spans*. *National Steel Bridge Alliance AISC*, 1999 [cited 4 October, 2013].

of five truss spans that are 85, 88, 110, 88 and 85 metres long and two beam spans at the ends of the bridge that are 12 metres long each. The centre span and two side spans are composed of suspended spans, 60 metres long each, supported on truss cantilevers and abutments. The bridge was named after the President of Poland Ignacy Mościcki and has been in service to this day (Fig. 15).

Conclusions

1st An analysis of iconographic and numismatic sources as well as written accounts has enabled to rediscover a bridge superstructure of great span length of 54.86 metres [180 English feet] located in the territory of the Polish-Lithuanian Commonwealth in the middle of the 17th century.

2nd The sources analyzed have made it possible to estimate that the two large spans were in service in Torun Bridge between 1632 and 1657.

3rd The unique 54.86-metres-long span of the bridge over the Vistula at Torun is undoubtedly a phenomenon among bridge structures known in the 17th century in Europe for two reasons:

– it was probably Europe's first application of the cantilever truss (Gerber carrier) solution for a bridge structure,
– in comparison with other known structures, the Torun bridge span appears to have been the longest span in Europe in the middle of the 17th century.

Translated by the Author

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