Architectus

2012
No. 1(31)

DOI: 10.5277/arc120110

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EURO 2012 Enterprise – attempt at assessing the achieved architectural and structural effects

Introduction

In April 2012 we will celebrate the 5th anniversary of choosing Poland and Ukraine as the host of EURO 2012 tournament by the Union of European Football Associations (UEFA). Today, almost on the eve of the championship opening ceremony and taking into account these five years, we can assess the results of preparation and significance of the whole enterprise for both countries. This decision made by UEFA played a role of the flywheel which contributed to the instant development of the sport infrastructure and made it possible to make up for the distance which differed us from other European countries. It was all possible thanks to the activation of specific organizational and financial mechanisms. An overall assessment of their consequences will be possible only in 2024 when – according to the assumptions – the particular cities will have paid off their debts which in fact have burdened their citizens. In Poland new big stadiums which meet contemporary requirements of functionality and safety have been built. However, the stadiums were built with the funds gained by means of short-term loans. They were built from scratch and in the cities in which there were neither such constructions nor traditions connected with football before. Nevertheless, it is a pity that all of them are one-function stadiums. In this situation, it is quite probable that 'Silesian Stadium' ('Stadion Śląski') – after the completion of its current stage of modernization and being equipped with athletic devices – will take over the role of the representative multifunctional stadium.

The purpose of this article is to answer the following question: are these spectacular and unquestionable achievements accompanied by equal successes in the field of architectural and constructional qualities? Did quick and protective decisions concerning the choice of foreign designers influence unification of solutions which – instead of providing unique offers with architectural icon features – became similar to many other famous constructions in the world?

UEFA – the status and legal requirements connected with EURO 2012

The Union of European Football Associations (UEFA) is by definition a non-governmental and non-profit federation exempt from the obligation to pay taxes to the tax office in Switzerland where it is based. The following quote adequately describes its profits [...] *in spite of the economic crisis, the International Federation of Football (FIFA) is doing just fine, and according to the financial report for 2009 it generated 1.05 billion dollars in profit*[1].

On Feb. 28, 2011, the Polish Minister of Finance exempted UEFA from VAT also on all expenses and expected earnings connected with the organization of EURO 2012[2]. This is a very serious provision as the failure to

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[1] Newspaper Dziennik Gazeta Prawna, Daniel Rupiński http://forsal.pl/artykuly/407979,zysk_fifa_za_2009_rok_wyniosl_196_mln_dolarow.html, 22.03.2010.

[2] Directive of the Minister of Finance dated Feb. 28, 2011, Journal of Laws no. 52, item 267 on exemption from income tax on certain kinds of income.

execute it would violate the terms and conditions of the agreement on organization of the final tournament of the championship and it would be the basis for its termination effective immediately[3].

The agreements also provide that UEFA assumes all rights to the organization the championship from the host for the period of about three weeks following the principle that the host provides infrastructure and UEFA runs the whole event and it hires the stadiums from their operators during the event. UEFA makes the primary profits from broadcasting rights, advertising, sale of tickets and contracts with sponsors. For instance it transferred the championship broadcasting rights to Polish Television for about PLN 80 million[4].

[3] http://biznes.wieszjak.pl/wiadomosci/podatkowe/271025,UEFA-nie-zaplaci-podatku-od-dochodu-z-EURO-2012.html, Paweł Huczko, 31.03.2011.

[4] Source: "GW", http://www.eu-20'12.pl/euro-2012-wszystkie-mecze-w-telewizji-polskiej/, April 3, 2009.

Organizational and financial basis of the undertaking

Taking into account the assumption that granting Poland and Ukraine the organization of EURO 2012 could have been a natural extension of the European Union's policy toward a strategic country, one could assume that financing costly events would be extensively subsidized from the Union. It should be kept in mind, however, that already in May 2007, still before the decision to organize EURO 2012 was made, Poland was awarded grants from the Structural Funds and from the National Cohesion Fund (NSRF) for 2007–2013. Consequently, immediately after EURO 2012 was granted to Poland and Ukraine, an assessment was made of the possibility of using the funds (under the earlier agreed proposals) for the purpose of efficient organization of EURO 2012[5]. The following was determined in the analyses of the possibility of using the Union's funds for **stadium investments**:

– due to their high costs (over EUR 50 million), the European Commission's additional consent is required,

– due to the profits generated by the stadiums, the possibility of using the Union's funds is very small,

– the investments should depend on the rational calculation of social and economic cost and due to the difficulties connected with later generating the stadium profitability and its usefulness in achieving the goals set in NSRF[6], the **possibility of using the Union's funds is very small.**

Consequently, it was recommended that public-private partnership (PPP) entities should be established for stadium investments which would use BOT[7] type of financing, a technique presented in the Strategy for the Development of Sport in Poland until 2015[8] as the dominant form of financing sports infrastructure.

Under BOT, a private company is granted a license to build and use a sports facility which normally would be built and used by public sector. It is also responsible for the development of project and financing the undertaking. After the license expires, the company transfers the facility ownership rights to the public entity. The period for which the license is granted primarily depends on the period needed for the profits generated from the infrastructural facility to cover the company's debt and assure a reasonable rate of return for the effort made and risk taken. However, in the case of EURO 2012, no PPP investments have been made in Poland, and the reason for that may be little interest on the part of private companies in making such a risky investment during crisis in an Eastern European country where the middle class is just beginning to grow, the society has little leisure time, and the culture of spending such time is different.

Summing up, it can be said that the funds for the development of infrastructure (apart from stadiums) which would serve efficient organization of the championship were not greater or additional but, as provided in the document, they were taken from the same pool of funds which had been agreed with the Union in May 2007 still before the accession to organize EURO 2012.

As a result of a precise division of grants into five main operational programs (Human Capital, Development of Eastern Poland, Infrastructure and Environment, Innovative Economy and Technical Assistance) which would assure balancing the development of individual regions of Poland, the Union's funds redirected to the investments related to EURO 2012 had to hurt the other regions.

EURO 2012 also contributed to the acceleration of infrastructure development and these are the changes which have been evident to every citizen attributing them to that glorious event for our country. The special laws allowed for more efficient and effective actions and one can only hope that there are no concealed defects caused by the haste which will require costly repairs.

In March 2009, EURO 2012 – POLSKA Sp. z o.o., a company headed by the President of Polish Football Association (PFS) was established to control all investments connected with EURO 2012. Due to the obligations and guarantees provided by the Council of Ministers in the agreement between EURO 2012 PL and UEFA, individual stadiums were granted additional funds in 2008–2012 from the State Budget. In June 2008, the resolution No. 143/2008

[5] Directions of activities toward the use of the Structural Funds and Cohesion Funds to efficiently organize EURO 2012, Ministry of Regional Development, Grażyna Gęsicka, Warsaw, 09.2007.

[6] The National Strategic Reference Framework 2007–2013 – supporting economic growth and employment, Ministry of Regional Development, Warsaw, 05.2007.

[7] Build-Operate-Transfer.

[8] Strategy for the Development of Sport in Poland until 2015, Ministry of Sport, Warsaw, 01.2007.

Tab. 1. Stadium designers and contractors/costs and capacity. Prepared by: M. Pelczarski
Tab. 1. Projektanci i wykonawcy stadionów/koszty i pojemność. Oprac. M. Pelczarski

Name of facility	**Designer (after 2007)**	**Contractor (after 2007)**	**Total cost with grant[1]**	**Grant from state budget[2]**	**Capacity[3] ('000 seats)**
Warsaw Stadium	Consortium *JSK Architekci sp. z o.o.*, *GMP International GmbH* and *Schlaich Bergermann Und Partner*	Consortium ALPINE – PBG SA – Hydrobudowa Polska SA	PLN 1.915 billion	PLN 1.915 billion	58.145
Wrocław Stadium	Consortium *JSK Architekci*	Mostostal Warszawa S.A., J& P Avax, and since Jan. 18, 2010 Max Boegl	PLN 855 million	PLN 110 million	44.308
Poznań Stadium	*Modern Construction Systems*	Consortium of Hydrobudowa Polska SA, PBG SA, AK-BUD Kurant, Alpine Construction Polska from Krakow, Alpine Bau Deutschland from Berlin and Alpine Bau GmbH from Austria**.**	PLN 638 million or PLN 746 million[4]	extension in 2007 PLN 75 million and PLN 88.5 million in 2008	41.609
Gdańsk Stadium	*RKW Rhode Kellermann Wawrowsky*	Hydrobudowa polska s.a, Hydrobudowa 9, Alpine bau deutschland ag Berlin, Alpine bau gmbh Austria, Alpine Construction Polska sp. z o.o.	PLN 863.5 million	PLN 144 million	40.818
Kraków Stadium	Not analyzed	Not analyzed	–	PLN 80,4 million	
Chorzów Stadium	1994–2007 *Zakład Projektowania i Wdrożeń TB, Katowice* – general designer Construction of the roof: since 2008 GMP Architekten – from Aachen (this company was commissioned to design west stands and remodel east stands)	since July 2009 *Hochtief Polska, Hochtief Construction A.G., Mostostal Zabrze Holding S.A.* and *Thermoserr*	PLN 338 million	PLN 110 million	47.202 design: 60.00 55.211[5]

1 Article by Tadeusz Arkit, MP "Koszty budowy stadionów w Polsce" from October 14, 2011 http://www.tadeuszarkit.pl/index.php?option=com_content&task=view&id=494&Itemid=54.
2 Reply no. 4919 of Minister of Sport and Tourism Adam Giersz from October 21, 2009 to the question ref. no. SPS-024-4919/09, http://orka2.sejm.gov.pl/IZ6.nsf/main/1CB394D6.
3 http://pl.wikipedia.org/wiki/Mistrzostwa_Europy_w_Pi%C5%82ce_No%C5%BCnej_2012.
4 http://sport.interia.pl/euro-2012/news/euro-2012-konsorcjum-lecha-i-marcelin- management,1700052,4324%2026%20wrze%C5%9Bni.
5 "Stadion Śląski", http://pl.wikipedia.org/wiki/Stadion_%C5%9Al%C4%85ski.

signed by the Prime Minister approved additional grants for the construction of the stadiums for EURO 2012 in the amounts depending on, inter alia, the required capacity of the stadiums, with the cost of EUR 1,000 per one seat, or (acc. to another source) in the net amount of 30% of all expenditure (in relation to the number of seats included in the offer application)[9] (see Tab. 1).

In compliance with the *Act on Preparation of the Final Tournament of the European Football Championship*, the host cities established companies operating as project management companies for the investments connected with the construction of the stadiums. As a result of such solutions, the city budgets are not charged directly by the investments and the debt is not included in their total debt which cannot exceed 60% of their profits. Instead, the companies are indebted and the installments for their credits are paid back by the cities in annual tranches guaranteed by the provisions in the city budgets until about 2024, i.e. over 14–15 years from the end of EURO 2012.

9 Response of Minister of Sport and Tourism, Mirosław Drzewiecki for the query no 401, Warsaw, 18.02.2008, http://orka2.sejm.gov.pl/IZ6.nsf/main/1FF7479E.

It seems that the visible improvements in the infrastructure of the cities and regions have been greatly appreciated by the society, which when combined with the general nationwide trend of organizational "elation" **made it possible to conduct extremely costly stadium investments with the taxpayers' money** because, in spite of the efforts made by the government administration and politicians, the stadium investments were financed totally from city budgets. Naturally, it is the objective of the stadium operators to generate as high profits from them as possible. However, as experience of highly developed countries demonstrates, it is not an easy task and already more and more often concerns are expressed as to the degree of usage of the new stadiums after EURO 2012.

Tab. 2. Financing of Stadiums and Operators. Prepared by: M. Pelczarski
Tab. 2. Warunki finansowania stadionów oraz operatorów. Oprac. M. Pelczarski

Name of facility	Operator	Terms and conditions of operator agreement	Terms and conditions of owner agreement	Financing of the stadium
Warsaw Stadium	Not analyzed	–	–	100% financing from with the funds from state budget
Wrocław Stadium	SMG	Provision of services over 12 years for PLN 7–9 million annually paid by the city[1]	The city will get 85% of profits generated by SMG[2]	Wrocław 2012 takes credit from consortium of BRE bank, ING and Nordea in the amount of about PLN 663 million annually for 14 years[3]
Poznań Stadium	Leased for 20 years to consortium of KKS Lech Poznań and Marcelin Management		Operator will pay rent to the city about PLN 3 million annually plus variable rent, depending on income from game-day about 7.5%. Additionally, operator will pay 30% from sale of rights to the name of the stadium but not less than PLN one million annually[4]	Euro 2012 Poznań financed with the funds from Poznań City Council
Gdańsk Stadium	Leased for 10 years to consortium of Lechia Operator, SportFive, and HSG Zander24.	Modernization and extensive stadium repair work charge investor	Lessee covers the costs of facility maintenance, pays to the city net rent of about PLN 2 million and transfers net 5% of all profits[5] PGE bought the name PGE Arena Gdańsk for 5 years for PLN 7 million annually[6]	Stadium is in 75% owned by BIEG (Biuro Inwestycji Euro Gdańsk) and in 25% by the city Bank Pekao SA bought the claim in the amount of about PLN 384 million from the city on the basis of forfeiting agreement for 15 years

1 http://www.stadion-slaska.pl/index.php?p=1_13_Operator.
2 http://www.portalsamorzadowy.pl/rozmowa-tygodnia/deficyt-inwestycje-i-dochody-to-mechanizm-naczyn-polaczonych,13581.html, Agnieszka Widera, Feb. 21, 2011.
3 Resolution No. LI /1486/10 of Wrocław City Council from June 10, 2010, http://wrosystem.um.wroc.pl/beta_4/webdisk/136430%5C1486ru05.pdf and http://www.2012.wroc.pl/news/115/archiwum/Umowa-na-kredyt-podpisana.html.
4 http://www.portalsamorzadowy.pl/inwestycje/stadiony-maja-na-siebie-zarabiac,16594_0.html, PAP 03.05.2011.
5 http://www.arenamarketing.pl/pl/newsy/euro-2012/191-amerykanie-bior-hal-gdasko-sopock-.html ,02.03.2010.
6 http://stadiony.net/stadiony/pol/arena_gdansk.

Stadium designers and contractors – investment assumptions

In order to fulfill the covenants and meet the deadlines for completion of the facilities for EURO 2012, the reputed designers and contractors from the West were commissioned without any hesitation. Although it was connected with high pricelist rates, a successful completion was guaranteed by high insurance in case of unexpected developments. Table 1 shows that basically the same German companies designed and built Polish stadiums, and the contracts for EURO 2012 were for them a source of income in the middle of crisis. Tables 1, 2, and Figure 1 show that the projects and their completion commissioned from those companies as well as the protective investment assumptions mentioned above resulted in designs which are neither original nor innovative. They are mere examples of already existing off-the-shelf designs which rarely can meet the local architectural or cultural identity requirements – *genius loci* and *genius saeculi,* especially taking into account the fact that these facilities will consti-

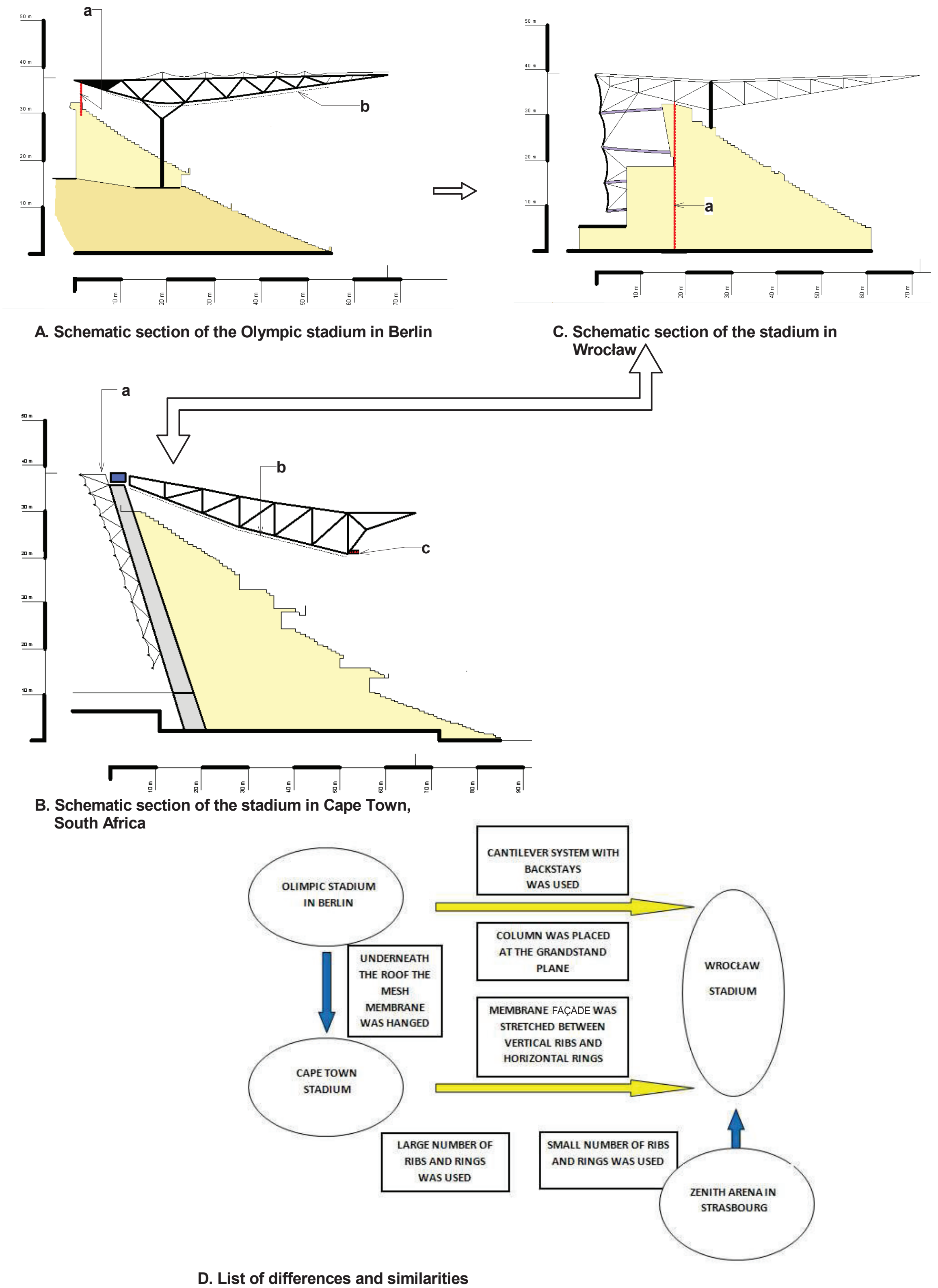


Fig. 1. The stadiums in Berlin, Cape Town and Wrocław – differences and similarities. A) Schematic section of the Olympic stadium in Berlin: a – truss girder backstay, b – membrane underneath the roof. B) Schematic section of the stadium in Cape Town, South Africa [1]: a – compression ring, b – membrane underneath the roof, c – tension ring. C) Schematic section of the Wrocław stadium: a – truss girder backstay, D) List of differences and similarities. Developed by: M. Pelczarski

Il. 1. Stadiony w Berlinie, Cape Town i Wrocławiu – zestawienie różnic i podobieństw. A) Schemat przekroju stadionu w Berlinie: a – odciąg dźwigara, b – membrana na podniebieniu. B) Schemat przekroju stadionu w Cape Town, RPA [1]: a – pierścień ściskany, b – membrana na podniebieniu, c – pierścień rozciągany. C) Schemat przekroju stadionu we Wrocławiu: a – odciąg dźwigara; D) Zestawienie różnic i podobieństw. Oprac. M. Pelczarski

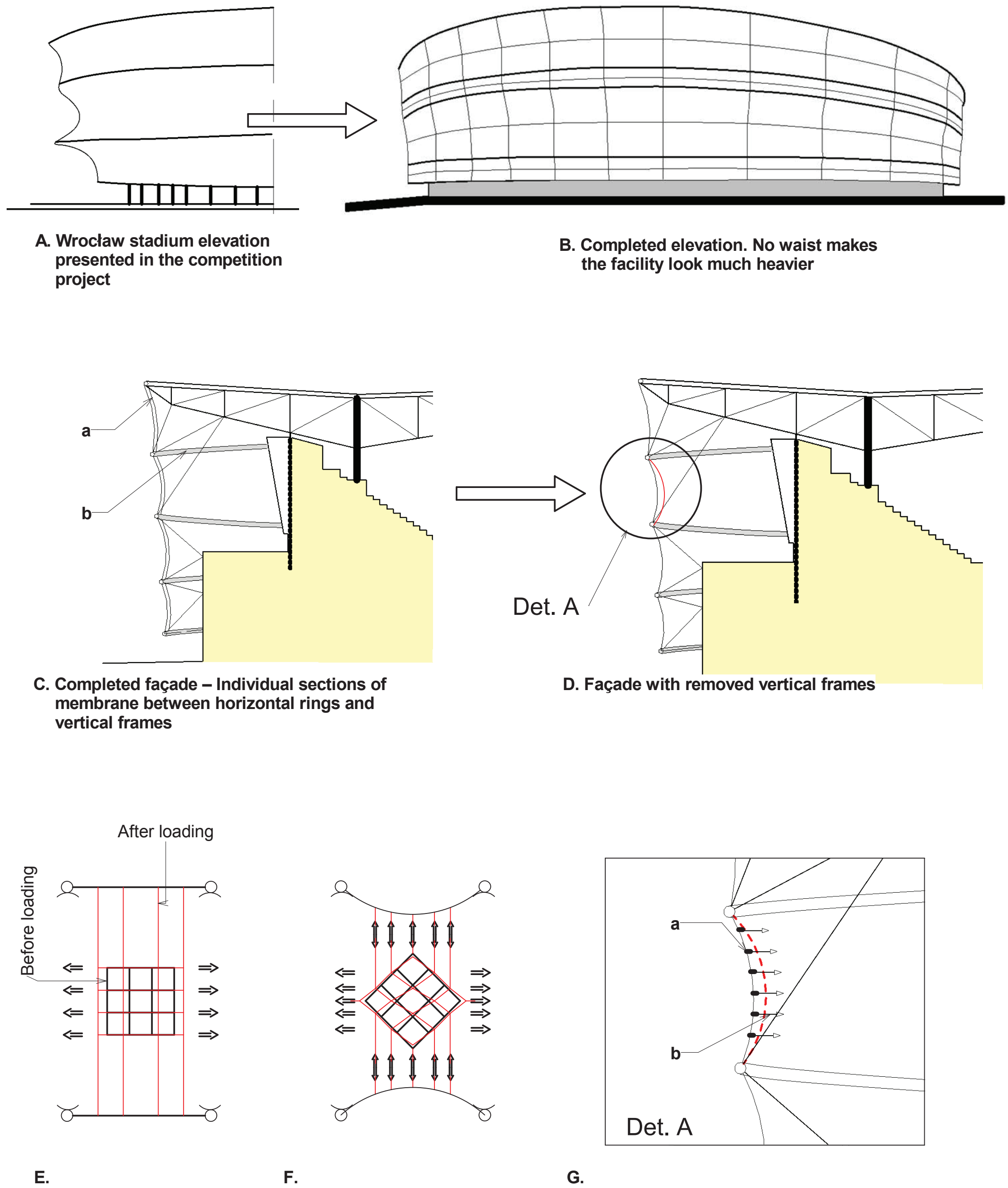


Fig. 2. The method of achieving deeper vertical and horizontal curvatures in the membrane of the façade of the Wrocław stadium. A) Elevation presented in the competition project. B) Completed elevation. No waist makes the facility look much heavier; new tension member inserted horizontally into the membrane. C) Completed façade – Individual sections of membrane between horizontal rings and vertical frames: a – vertical frame, b – horizontal ring. D) Façade with removed vertical frames. E, F) Schematic views show the supporting strips in the membrane and the load direction. Only in F), the horizontal tension caused by new horizontal tension members causes the concurrent stretch of both perpendicular strips of the membrane and its biaxial tension. G) Stretch of the membrane caused by new horizontal tension members (Det. A.) increases horizontal forces in the membrane and its deeper curvatures. In order to achieve an architecturally attractive surface with two curvilinear planes, it is necessary to generate at the same time a vertical stretch of the membrane. In order to achieve that the pattern of the supporting strips in the membrane should be diagonal as shown in the schematic below F) a – new tension member inserted into the membrane horizontally, b – tensile forces from new horizontal tension members. Developed by: M. Pelczarski

Il. 2. Metoda nadania głębszych krzywizn południkowych i równoleżnikowych w membranie fasady stadionu wrocławskiego: A) Szkic elewacji prezentowany w projekcie konkursowym. B) Szkic wykonanej elewacji. Brak talii czyni bryłę znacznie cięższą optycznie. C) Fasada zrealizowana – poszczególne pola membrany ujęte są pierścieniami równoleżnikowymi oraz wręgami południkowymi: a – wręga południkowa, b – pierścień równoleżnikowy. D) Fasada z usuniętymi wręgami południkowymi. E, F) Schematy przedstawiają układy pasm nośnych w membranie w stosunku do kierunku działającego obciążenia. Tylko w przypadku F) poziome rozciąganie wywołane nowymi cięgnami równoleżnikowymi powoduje równoczesne napinanie obu prostopadłych pasm membrany, wywołując w niej napięcie dwuosiowe. G) Napięcie membrany wywołane nowymi cięgnami równoleżnikowymi (Det. A.) wywoła wzrost sił równoleżnikowych w membranie i pogłębi jej krzywizny równoleżnikowe. Celem uzyskania atrakcyjnej architektonicznie powierzchni dwukrzywiznowej, konieczne jest wywołanie jednoczesnego naciągu membrany w kierunku południkowym. Aby do tego doprowadzić, układ pasm nośnych membrany winien być diagonalny jak na schemacie (F). a – nowe cięgno wpuszczone w membranę równoleżnikowo, b – siły napinające od nowych cięgien równoleżnikowych. Oprac. M. Pelczarski tute permanent landscape elements of our cities for at least the next fifty years. The only exception may include the stadium in Gdańsk because of its original roof structure above the stands and the roof design of "Stadion Śląski" known as SATURN 2005 which, however, was not completed.

Wrocław Stadium

Comparing the geometry of the existing façade of Wrocław stadium with the geometry assumed in the project that won the design competition, a significant difference can be noticed. It refers to much less visible waist concavities in the membrane covering the façade, which results in an evidently worse visual effect (Fig. 2A–D). The architectural appeal of that element was probably the decisive criterion in selecting that particular project. The membrane was made of a network fiberglass fabric Duraskin B 1865 GF (the same was employed on the façade of the stadium in Cape Town).

In the opinion of the authors of this article, in order to make the horizontal and vertical curvatures in the stadium façade deeper, a lot of horizontal tension members with a small diameter should be inserted in the membrane pockets and fused with the existing membrane (Fig. 2G) in those places. The tension members would require short protective tubes fixed to the pockets. This would allow for free movement of the tension members in the membrane. The tension members, going around the whole stadium façade, would be connected every few dozen meters with turn buckles with which it is possible to provide the right stretch and proper geometry of the membrane vertical curvature.

The vertical frames employed in the stadium façade would have to be removed for the horizontal tension members to move freely because they prevent the membrane between horizontal rings from free deformation. In order to achieve the vertical tension of the membrane at the same time, its supporting directions must go diagonally (Fig. 2E, F).

Poznań Stadium

The structure of the roof resembles the designs with retractable roofs similar to the stadium in Amsterdam or Düseldorf, and that was the designers' original idea which probably due to the costs was later abandoned. The facility was built in stages, and its design concepts changed, but it is difficult to precisely track the changes without talking to the designers [2].

The beam structure employed in the project required more material in the middle of the beam or extending its height. Whenever the extension of the construction height of the girders is right above the viewers' heads, an adverse and psychologically disturbing optical effect appears in an extremely exposed place. The viewers experience an impression of a heavy ballast suspended right above the stands (Fig. 3A).

One of the characteristic features of the stadium roof in Poznań is the extraordinary height of its inner edge above the arena. This results in a "water-well effect" (Fig. 3B) and an increased shaded area of the pitch, which in turn reduced its sunlight exposure. This is probably one of the reasons why the grass on the pitch has already been

Fig. 3A. Photo of the interior of the stadium in Poznań and the view of the primary 160m long truss with the secondary 135m long, elliptical truss supported on it. The photo shows the "optical ballast" suspended above the heads of thousands of viewers (photo: M. Pelczarski)

Il. 3A. Zdjęcie wnętrza stadionu w Poznaniu oraz widok na pierwszorzędowy, 160-metrowej długości podciąg i opierający się na nim 135-metrowy, kratownicowy, eliptyczny dźwigar drugorzędowy. Zdjęcie uwidacznia zjawisko „optycznego balastu" zawieszonego nad głowami tysięcy widzów (fot. M. Pelczarski)

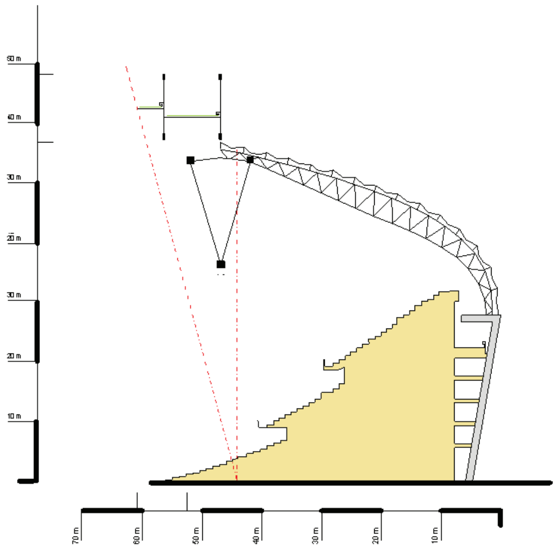


Fig. 3B. Schematic section of right wing of the stands also shows the primary truss triangular in section. Above the truss, there are additional louvers protecting the stands against rain. The area of actual protection against rain is marked with dashedline going at the angle of 15˚ from the vertical line. Developed by: M. Pelczarski

Il. 3B. Schematyczny przekrój prawego skrzydła widowni uwidacznia również przestrzenny kratownicowy podciąg pierwszorzędowy o przekroju trójkątnym ze ściągiem linowym. Nad podciągiem widoczne są również dodatkowe żaluzje chroniące widownię przed zacinającym deszczem. Obszar realnej osłony od deszczu zaznaczono linią przerywaną poprowadzoną pod kątem 15˚od pionu. Oprac.: M. Pelczarski

Fig. 4A & 4B. Photos show how the first, second, and third construction planes overlap and cause "an optical chaos". In such a case the designer must choose whether to expose the aggressive structure to thousands of viewers and present the smooth membrane outside (see Fig. 6A, B) or the other way around. Obviously, extending the construction above the cover exposes it to the elements and their adverse effects and requires a durable anticorrosive protection, but it renders the interior uniform and peaceful. Naturally, the third but costly solution is to apply the membrane under the roof as shown in Fig. 5A, B (photo: M. Pelczarski)

Il. 4A i 4B. Zdjęcia przedstawiają nakładanie się planów konstrukcji pierwszo-, drugo- i trzeciorzędowej, co jest źródłem „chaosu optycznego". W takim przypadku projektant musi dokonać wyboru, czy agresywną konstrukcję uwidacznia tysiącom widzów, a gładką membranową formę prezentuje na zewnątrz (patrz Il. 6A, B), czy też odwrotnie. Naturalnie wystawienie konstrukcji nad pokrycie naraża ją silnie na agresywne środowisko zewnętrzne i wymaga dobrej osłony antykorozyjnej, ale daje jednolite i uspokojone wnętrze. Trzecim, lecz kosztownym, rozwiązaniem jest zastosowanie membrany na podniebieniu dachowym jak na Il. 5A, B (fot. M. Pelczarski)

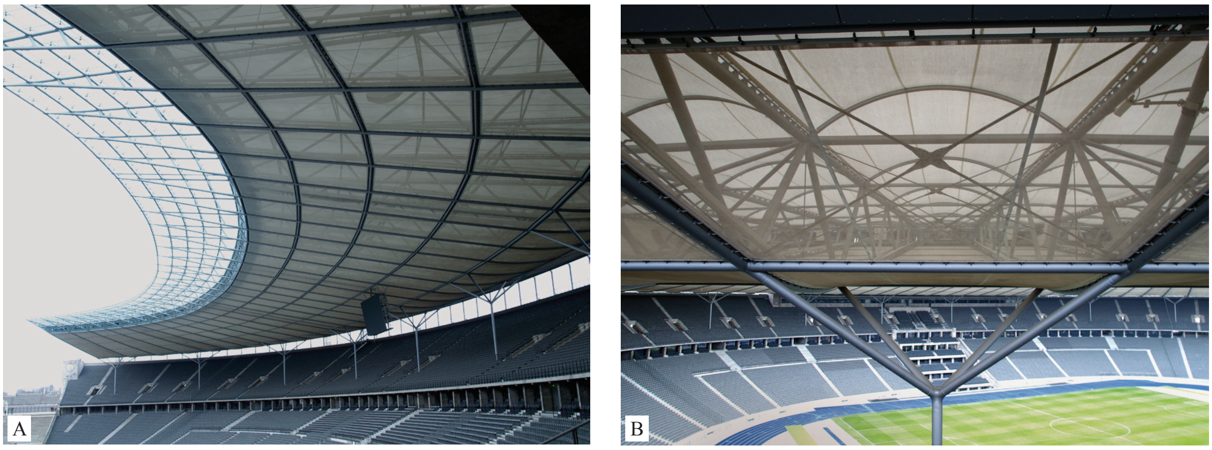


Fig. 5A & 5B. Photo (left) of the interior of the stadium in Berlin. Visible membrane stretched under the roof is an architectural cover increasing the beauty of the interior as well as acoustic barrier (photo: M. Pelczarski).
Photo (right) of the view of the internal roof space through the membrane. There is electrical, lighting, and sound system wiring there. In the case of the stadium in Berlin, Duraskin[10] GF B 18656 membrane was applied, whereas in the case of the stadium in Cape Town, Duraskin B 3704 membrane was used (photo: M. Pelczarski)

Il. 5A. i 5B. Zdjęcie lewe przedstawia wnętrze stadionu w Berlinie. Widoczna membrana rozpięta na podniebieniu pełni funkcję osłony architektonicznej podnoszącej estetykę wnętrza i pełniącej funkcję przegrody akustycznej (fot. M. Pelczarski).
Zdjęcie (prawe) to widok wnętrza przestrzeni dachowej poprzez membranę. W przestrzeni tej umieszczono instalacje elektryczne, oświetleniowe i nagłośnienie. W przypadku stadionu w Berlinie zastosowano membranę Duraskin[11] GF B 18656, a na stadionie w Cape Town na podniebienie zastosowano membranę Duraskin B 3704 (fot. M. Pelczarski)

changed several times (six times within the first year of operation) and the cost of one such replacement is at least PLN 300,000[12]. Furthermore, the high edge of the roof significantly reduces the efficiency of protection against rain.

The stadium in Poznań is also a good example of how greatly its construction with substantially exposed elements can influence the architectural character of the facility interior (Fig. 4A, B). The disturbances of its internal architectural harmony caused by excessively exposed structural elements are additionally intensified as they appear against the background of a light, semitranspar-

[10] http://www.zjff.net:81/showDetails.jsp?favid=164953.
[11] http://www.zjff.net:81/showDetails.jsp?favid=164953.
[12] http://www.tokfm.pl/Tokfm/1,103091,9764074,Zarzadca_stadionu__Jesli_kluby_chca_dobrej_murawy_.html Marcin Krzemiński 10.06.2011.

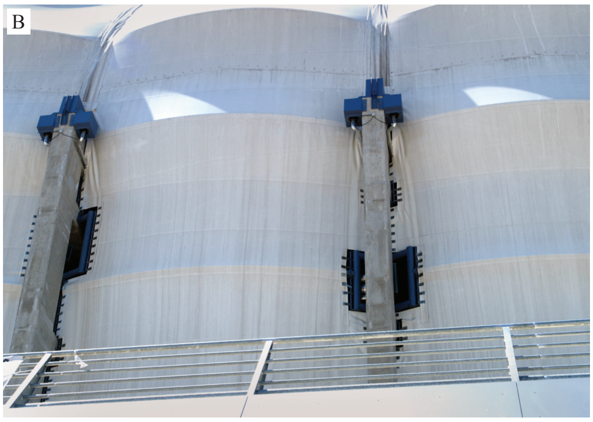


Fig. 6A & 6B. Photos of the façade of the stadium in Poznań. The photo A shows the rhythm of the supporting columns and hopper heads. Below a visible network roofed platform for protection against snow. The photo B shows the rainwater runs. In this case the designer did not design a gutter going along the lower edge, allowing it to drop freely from the edge (photo: M. Pelczarski)

Il. 6A i 6B. Zdjęcia fasady stadionu w Poznaniu. Zdjęcie A uwidacznia rytm słupów podporowych oraz koszy odwodnieniowych. Poniżej widoczna siatkowa platforma pełniąca funkcję bariery śniegowej. Zdjęcie B uwidacznia smugi pozostawione po wodzie opadowej pokazujące trasę jej spływu poza korytami głównymi. W tym przypadku projektant nie przewidział realizacji rynien wzdłuż krawędzi dolnej fasady, pozwalając na swobodny jej zrzut z krawędzi (fot. M. Pelczarski)

ent membrane. Figure 5 shows the positive solution to a similar problem applied in the Olympic Stadium in Berlin. Its high girders supporting the roof were covered on the side visible from the stands with a network membrane. Another design problem which had to be solved by the designers of the stadium was the system of rainwater drainage from the surface of the roof which smoothly joins its façade (Fig. 6A, B).

Chorzów Stadium – back-up stadium

Some interesting and innovative elements are included in the design which was not completed, namely, the construction of the roof of the stadium known as "Stadion Śląski" in Chorzów designed by *Zakład Projektowania i Wdrożeń TB – Katowice* that from 1994 until 2007 was the general designer of that facility modernization (Fig. 7A, B, D).

The designers suggested eight original solutions such as:

– small number (only 20) of supporting columns,

– bicycle wheel system with compression ring located outside the axes of supporting columns, which enables it to serve at the same time as a resisting ring for radial forces as well as ballast for roof girders,

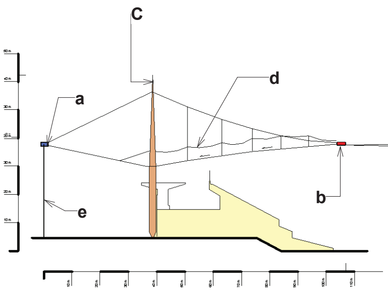
– triangular system of division of the area of the roof and supporting tension members, which was caused by e.g. rainwater roof drainage system inside columns,

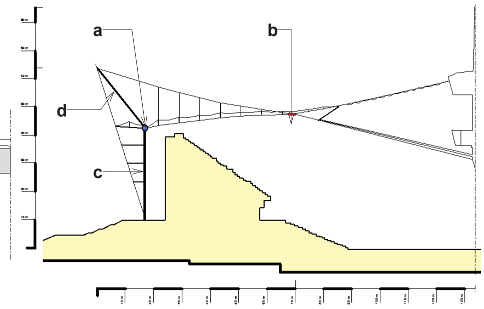
– furthermost arched frames along the columns spanning 40 m,

– system of construction which due to the flexible suspension of the ballast ring was highly resistant to possible seismic loads.

Unfortunately, in spite of those advantages and the fact that the building permit decision granted already in 2005 was preceded by numerous opinions of reputed authorities in this type of constructions, positive model tests in the aerodynamic tunnel at the Institute of Aviation in Warsaw and approvals of commissions representing the community of architects, the project was not executed. Before it was abandoned, it was a subject of two tender procedures for the development of workshop project as well as construction and assembly works; these tenders failed, which was the result of a dramatically low level of funds that the investor had for the construction. The only positive effect of those efforts was the assurance of the world reputed designers and contractors of their readiness to construct the roof in compliance with the construction design SATURN 2005 but for a little higher price. One of the companies declaring such readiness was a construction company later engaged in construction of stadiums for EURO 2012.

In 2008, probably for the reasons described in the first part of the article, regardless of the costs the investor decided to abandon the project SATURN 2005 which they already had. The decision was made despite the fact that its structure, being exceptional and daring, is similar to the construction of the roof of the stadium in Warsaw (Fig. 7) and in Stuttgart (Fig. 8). The investor commissioned the design works to the German design company GMP-Architekten which suggested a hybrid solution making use of the experience from a few projects it had completed earlier. Money was raised from the state budget grant – 110 million and from the investor's budget – PLN 360 million (see Tab. 1).

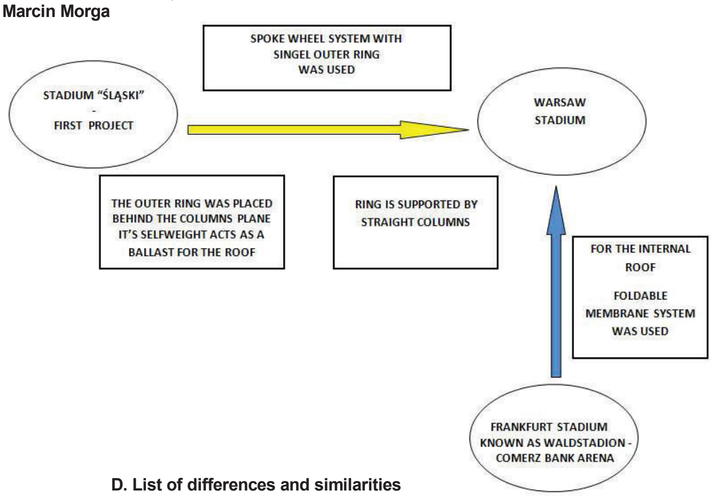




A. Schematic section of Stadion Śląski – Saturn 2005 roof design

C. Schematic section of the stadium in Warsaw

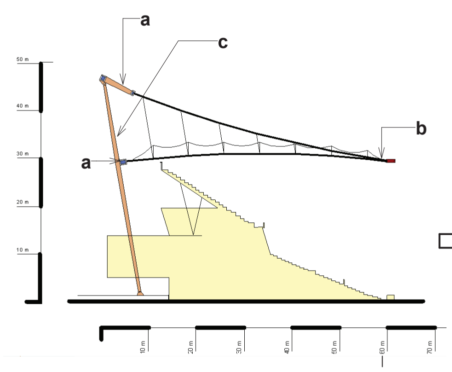
B. Aerial view of Stadion Śląski – Saturn 2005 roof design. Zakład Projektowania i Wdrożeń TB, Katowice. Visualization: Marcin Morga



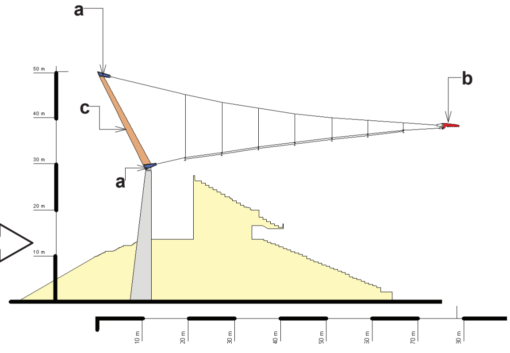
D. List of differences and similarities

Fig. 7. Stadion Śląski and Warsaw stadium – differences and similarities. A) Schematic section of Stadion Śląski – Saturn 2005 roof design: a – compression ring, b – tension ring, c – column, only 20 columns acc. to project, d – membrane placed on arches with span up to 40m long, e – V backstays. B) Arial view of Stadion Śląski – Saturn 2005 roof design. Buckling stability of the compression ring is provided by elements of swingarms, supporting cables and V backstays. Saturn 2005 roof design of Stadion Śląski, Zakład Projektowania i Wdrożeń TB, Katowice. Visualization: Marcin Morga. Large distances between columns, large spans of arches stretching the membrane, and triangular fields of the membrane provided original geometry and architecture adjusted for the scale of the facility as well as a form without a lot of noticeable structural elements. C) Schematic section of the stadium in Warsaw: a – compression ring, b – tension ring, c – columns, in total 72 columns were applied [3], d – two backstays provide lateral stability for the deviator repeated 72 times make the view look "dense" and dominate the form of the stadium. D) List of differences and similarities. Developed by: M. Pelczarski

Il. 7. Stadion Śląski i stadion warszawski – zestawienie różnic i podobieństw. A) Schemat przekroju Stadionu Śląskiego – projekt zadaszenia Saturn 2005: a – pierścień ściskany, b – pierścień rozciągany, c – słup, projekt zakładał zastosowanie tylko 20 słupów, d – membrana ułożona na łukach o rozpiętościach do 40 m, e – odciągi typu V. B) Widok z lotu ptaka Stadionu Śląskiego – projekt zadaszenia Saturn 2005. Stabilność pierścienia ściskanego zapewniana jest przez dochodzące do niego elementy wahaczy, kabli podwieszających oraz odciągów typu V. Duże rozstawy słupów, duże rozpiętości łuków napinających membranę oraz trójkątne pola membrany pozwalały na uzyskanie oryginalnej geometrii i architektury dostosowanej do skali obiektu oraz na uwolnienie formy od dużej liczby elementów konstrukcyjnych nakładających się w polu widzenia. C) Schemat przekroju stadionu warszawskiego: a – pierścień ściskany, b – pierścień rozciągany, c – słup, łącznie zastosowano 72 słupy [3], d – dwa odciągi poprzecznie stabilizujące dewiator powtórzone 72 razy silnie zagęszczają obraz i dominują formę stadionu. D) Zestawienie różnic i podobieństw. Oprac. M. Pelczarski

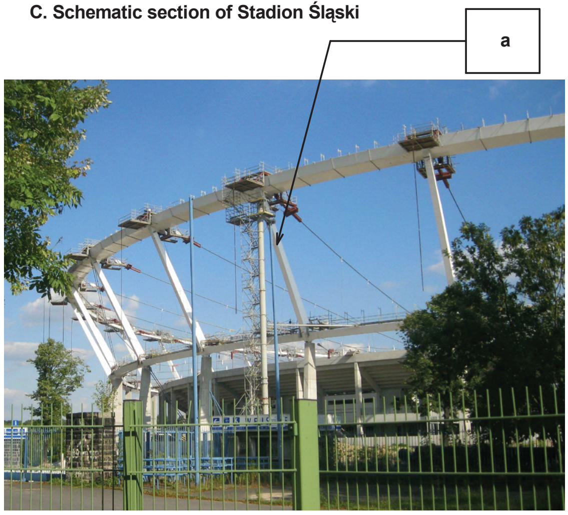


A. Schematic section of the stadium in Stuttgart

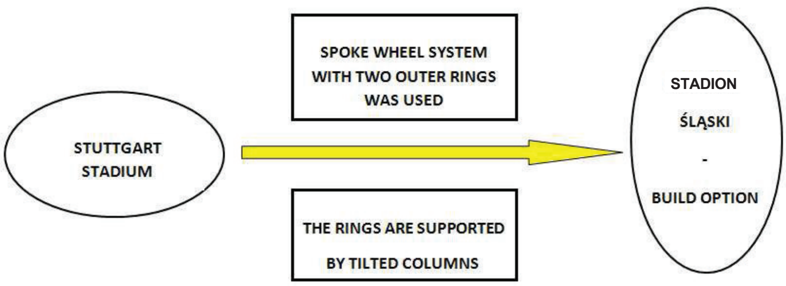


C. Schematic section of Stadion Śląski

B. Stadium in Stuttgart along the major axis of the ellipse



D. Assembly of the roof structure cable-net system in Stadion Śląski



E. List of differences and similarities

Fig. 8. Olympic stadium in Stuttgart and Stadion Śląski – differences and similarities. A) Schematic section of the stadium in Stuttgart: a – compression ring, b – tension ring, c – The radial loads in both compression rings are reduced due to the tilted columns. They are reduced because of the tensile forces generated in the rings due to their deadweight. B) Stadium in Stuttgart along the major axis of the ellipse (photo: M. Pelczarski). C) Schematic section of Stadion Śląski: a – compression ring, b – tension ring, c – The radial loads are reduced due to the tilted columns only in the upper compression ring. D) Assembly of the cabling in Stadion Śląski. Such an extensive tilt of the roof structure 30–40 m above the ground can cause an impression of instability and a subconscious concern of the users (photo: M. Pelczarski). E) List of differences and similarities. Developed by: M. Pelczarski

Il. 8. Stadion olimpijski w Stuttgarcie i Stadion Śląski – zestawienie różnic i podobieństw. A) Schemat przekroju stadionu w Stuttgarcie: a – pierścień ściskany, b – pierścień rozciągany, c – Dzięki takiemu wychyleniu słupów oba pierścienie ściskane uzyskują zredukowane obciążenie radialne. Redukcja powstaje dzięki siłom rozciągającym, jakie generują się w pierścieniach od jego ciężaru własnego. B) Stadion w Stuttgarcie wzdłuż długiej osi elipsy (fot. M. Pelczarski). C) Schemat przekroju Stadionu Śląskiego: a – pierścień ściskany, b – pierścień rozciągany, c – wychylenie słupów prowadzi do obniżenia sił radialnych tylko w górnym pierścieniu ściskanym. D) Faza montażu olinowania Stadionu Śląskiego a) Tak znaczne wychylenie konstrukcji dachu znajdującej się na wysokości 30–40 m nad poziomem terenu może wywoływać wrażenie niestabilności i wzbudzać podświadomy niepokój w użytkownikach. E) Zestawienie różnic i podobieństw. Oprac. M. Pelczarski

Fig. 9A. View of two clamps which broke while raising the cabling. Photo: Dawid WhiskeySix – forum gkw24

Il. 9A. Widok dwóch zerwanych krokodyli w fazie podnoszenia olinowania na poziom projektowany. Fot.: Dawid WhiskeySix – forum gkw24

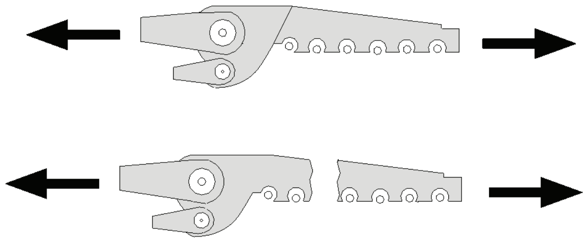


Fig. 9B. View of two clamps which broke while raising the cabling. Developed by M. Pelczarski

Il. 9B. Widok dwóch zerwanych krokodyli w fazie podnoszenia olinowania na poziom projektowany. Oprac. M. Pelczarski

Unfortunately also this time, despite a fairly large amount of public funds credited from Śląskie Province, the stadium was not lucky. A few clamps (Fig. 9A, B) which fasten the supporting cables to the inner tension ring broke and that is the reason for the current, long-term break in the works. These elements were manufactured in Poland and then in Spain but anyway they had defects. They broke when the cabling, which suspends the roof construction, was being raised during assembly.

Currently, after the cabling was lowered, the reasons of the failure are analyzed and further strategies of actions are agreed. For the first time in the history of its operations the Swiss company VSL, which was earlier assembling the costly roof of the stadium in Warsaw, had to lower the supporting cables, which is the opposite of the operation for which the hoisting equipment is designed. It is probable that the reasons for this situation could include the manufacturing and material defects or unequal stretch of the tension members during the hoisting of the inner ring. It should be stressed that it is one of the biggest "bicycle wheel" roofs. Its size is determined by the size of the track and field stadium (Fig. 8).

It is surprising that GMP, a company famous for covering the stadium roofs designed by it above the stands with PTFE membranes, abandoned the application of such a solution in Chorzów and upon the investor's approval suggested covering the roof with multi-chamber polycarbonate sheets. As a result it was necessary to apply a dense steel understructure with a significant deadweight for the polycarbonate roofing. Actually, a physically and optically heavy pseudo-dome with a dense supporting structure for the roof made of 1.25m wide sheets must hang on a system of cable girders. Unfortunately, it is impossible to evaluate those assumptions as the effective visualizations of the stadium interior with the view of the roof from underneath do not show that element. A similar act of falsifying the reality can be seen in the case of renderings of supporting girders of the roof of the stadium in Poznań or tectonics of the façade of the stadium in Wrocław.

By the way, it is worth mentioning that the gaskets of the multi-chamber polycarbonate sheets wear off in time and unseal the chambers. As a result, fauna and flora develop inside them, which in turn is visible in the form of runs that look like dirt.

Gdańsk Stadium

The analysis of the main stadiums built for EURO 2012 in respect of their original constructions demonstrate that the design of the roof of the stadium in Gdańsk is worth our special attention (Fig. 10A, B). It is one of the most interesting self-supporting structures in Poland and in the world. Searching for any possible way to reduce the costs of that design, one could only consider moving the point of support of the roof independent structure to the crown of the reinforced concrete stands, which, in the opinion of this article's authors, would prevent the doubling of the main supporting structure of the roof and the stands.

Conclusions

Due to the limited scope of this article, it was possible to analyze in detail only the main architectural and structural elements of the stadiums which determine their general spatial forms. They include the roofs above the stands and maybe the arenas as well as external cladding. The designs of the stands as well as the issue of comfort and safety of the viewers and other users of the stadiums as well as the issues regarding technical infrastructure were not analyzed due to their extensive and complex character. The issues connected with the organization and financing of EURO 2012 have been presented in greater detail because, in the opinion of the authors, the specific forms assumed in those scopes imposed to a large extent by the Union of European Football Associations (UEFA) have a significant and direct impact on the effects of stadium investments. However, the experience of two previous championships held in Austria and Switzerland (2008) and in Portugal (2004) demonstrates that the host countries, and their host cities, were able to

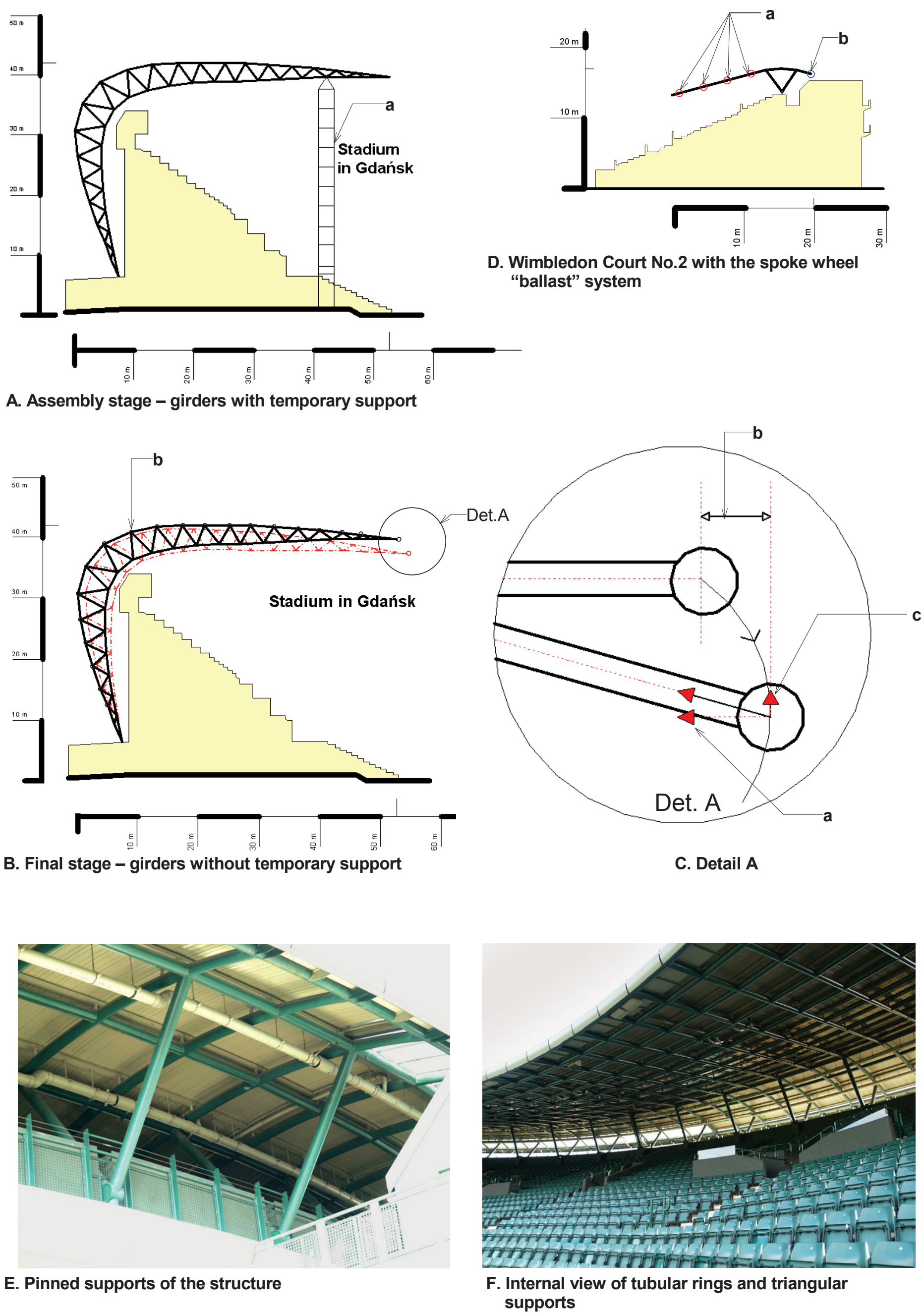


Fig. 10. Structure of the roof of the stadium in Gdańsk. A) Assembly stage – girders with temporary support: a – assembly support. B) Final stage – girders without temporary support. Self-supporting structure "sagged" about 30 cm under its own weight at the end. Such a deformation generated resistance of deformed horizontal rings [4]. The vertical components of that resistance back weighed the structure's own weight. b) perimeter rings were placed in the upper plane of the girders. C) DETAIL A: a) The radial force is the resisting force generated in the ring when its circumference is reduced. b) The vertical component of the radial force is responsible for carrying the roof structure and the loads affecting it. c) Horizontal displacement of the ring point caused by rotation – "settlement" of the girder. D) Wimbledon Court No. 2 with a bicycle wheel "ballast" system with rigid closed rings: a – tension ring, b – compression ring. E) pinned supports of the structure. Photo: M. Pelczarski. F) internal view of tubular rings and triangular supports. Photo: M. Pelczarski. Developed by: M. Pelczarski

Il. 10. Konstrukcja dachu stadionu gdańskiego. A) Faza montażowa – dźwigary podparte są podporami tymczasowymi: a – podpora montażowa. B) Faza końcowa – dźwigary zwolniono z podpór tymczasowych. Konstrukcja samonośna osiadła pod własnym ciężarem w punkcie końcowym o około 30 cm [4]. Odkształcenie takie wywołało opór, generowany przez deformowane pierścienie równoleżnikowe. Składowe pionowe tego oporu zrównoważyły ciężar własny konstrukcji. b) pierścienie obwodowe umieszczono w górnej płaszczyźnie dźwigarów. C) DETAL A: a) Siła radialna jest siłą oporu powstającą w pierścieniu podczas zmniejszania jego obwodu. b) Poziome przemieszczenie punktu pierścienia wywołane obrotem – „zapadaniem" się dźwigara. c) Składowa pionowa siły radialnej, odpowiedzialna za dźwiganie konstrukcji dachu i obciążeń na niego oddziałujących. b) Poziome przemieszczenie punktu pierścienia wywołane obrotem – „zapadaniem" się dźwigara. D) przykład obiektu Wimbledon Court No. 2, gdzie również zastosowano dach w systemie „balastowego" koła rowerowego, wykorzystującego sztywne pierścienie zamknięte: a – pierścień rozciągany, b – pierścień ściskany. E) Wimbledon. Przegub kozła podporowego. Fot. M. Pelczarski. F) Wimbledon. Widok pierścieni rurowych oraz kozłów podporowych od wnętrza kortu. Fot. M. Pelczarski. Oprac. M. Pelczarski meet the tight organizational and completion schedules as well as cope with the pressure of UEFA, achieving a lot of quality success in respect of architecture and construction – also in the case of most stadium investments. Definitely Portugal, where all but one new stadiums were designed by Portuguese architects, is an example to follow. Maybe it was possible because its parliament adopted the relevant laws, expressing the will of the society. The designers were selected in competitions on the basis of their adequately developed rules. Only at the construction stage, when advanced building technologies and experience in building such facilities were needed, were foreign companies hired. Such an investment policy, which was reasonably assumed, resulted in a lot of individual and unique functional and spatial development designs, featuring a high architectural level. Both the country and specific places where they were completed – often earlier unknown, medium-sized cities – have been made famous for them. This is a positive example of resistance to globalization and the unification in creating stadium architecture which is connected with the monopoly of a few huge, specialist designers. Unfortunately, the examples of the investments for EURO 2012 in Poland and Ukraine demonstrate that none of the host countries followed the "Portuguese system".

Translated by
Bogusław Setkowicz

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Przedsięwzięcie EURO 2012 – próba oceny osiągniętych efektów architektoniczno-konstrukcyjnych

Celem artykułu jest odpowiedź na pytanie, czy „spektakularnym" i trudnym do podważenia polskim osiągnięciom budowlanym na EURO 2012 towarzyszą dorównujące im sukcesy na polu jakości architektoniczno-konstrukcyjnej? Czy pospieszne i asekuracyjne rozstrzyganie o wyborze projektantów zagranicznych nie wpłynęło na unifikację rozwiązań, które miast stanowić propozycje unikalne o cechach ikony architektonicznej, stały się podobne do wielu znanych już z innych miejsc na świecie?

Jako rozwiązanie godne naśladowania przedstawiono model portugalski, gdzie dzięki podjęciu przez parlament stosownych ustaw, większość nowych stadionów zaprojektowana została przez rodzimych architektów, a dopiero na etapie wykonawczym, gdy potrzebne były zaawansowane technologie i doświadczenie w realizacji tego typu obiektów, angażowane były firmy zagraniczne. Niestety Polska nie skorzystała z tego pozytywnego przykładu i nie stawiła odporu zjawiskom globalizacji, monopolu kilku wielkich, specjalistycznych firm projektowych, i wiążącej się z tym unifikacji architektury stadionów.

Key words: Polish stadiums for EURO 2012, stadium roof structures, stadium façades

Słowa kluczowe: stadiony w Polsce na EURO 2012, konstrukcje dachów stadionów sportowych, fasady stadionów