Stručni rad/Professional paper
Primljen/Received: 24. 10. 2019.
Prihvaćen/Accepted: 03. 12. 2019.

CONCEPTUAL DESIGN OF ARENA NIKOLA GAZDIĆ STADIUM SPLIT

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Abstract: Conceptual design of the stadium named "ANG"- Arena Nikola Gazdić, for recreational-sports and business purposes, is presented in this paper. The stadium is located between streets Put Brodarice and Hrvatske mornarice in Split on the current location of the "Park Mladeži" stadium. The main structural elements of the structure are: upper and lower concrete ring with grandstand, internal and external columns and access staircase. The roof structure is spatial steel truss made of primary and secondary trusses. The stadium is designed as a prefabricated reinforced concrete structure with some monolithic parts. The design contains technical description, calculation of bearing members and construction plans.

Key words: stadium, conceptual design, monolithic and prefabricated construction

IDEJNI PROJEKT STADIONA ARENA NIKOLA GAZDIĆ SPLIT

Sažetak: U radu je prikazan najznačajniji dio idejnog projekta stadiona „ANG“- Arena Nikola Gazdić, za rekreativno-sportsku i poslovnu namjenu. Stadion je smješten između ulica Put Brodarice i Hrvatske mornarice u Splitu na lokaciji postojećeg stadiona „Park Mladeži“. Osnovni konstruktivni sustav građevine su dva betonska prstena s tribinama, vanjskim i unutarnjim betonskim stupovima, te pristupnim stubištem. Krovna konstrukcija je prostorna čelična rešetka izrađena od primarne i sekundarne rešetke. Stadion je predviđen kao polumontažna armiranobetonska konstrukcija s pojedinim elementima koji se izvode monolitno.

Ključne riječi: stadion, idejni projekt, monolitna i polumontažna izvedba

1. Technical description

In Hrvatske mornarice Street in Split, there is a building plot where the investor intends to construct a stadium on the location of the existing city stadium "Park Mladeži" (Figure 1).
The plot is located between Hrvatske mornarice Street on the south, Put Brodarice Street on the north, and two streets accessing the Turkish Tower Park and other buildings.

The approximate area of the building plot is 40,705.00 m^2. Analyzing the location, shape and size of the building plot, height differences of the terrain, and taking into account the applicable spatial and planning documentation, the conceptual design of the new stadium is developed.

This conceptual design is aligned with the spatial planning documentation (Split City Urban Development Master Plan from 2006).

1.1 Shape and size of the structure

The newly formed plot has an irregular shape and an area of about 40,705 m^2. The stadium consists of two interconnected rings of grandstands supported by columns and strip foundations. The above-ground plan area of the stadium is 25,080 m^2. The development coefficient of the plot is 61.6%. The position of the structure on the plot results from the location conditions, possibility of vehicular access from the surrounding roads, and pedestrian access from all four sides of the stadium (Figure 2).

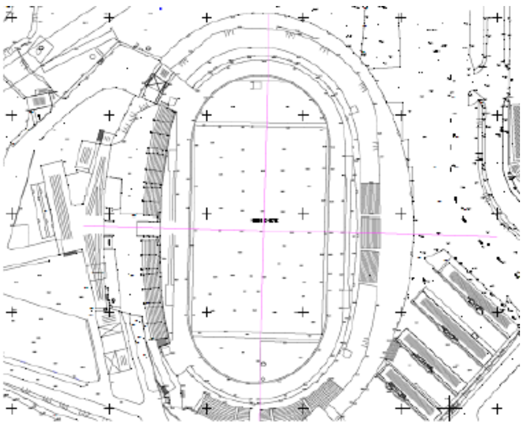


Figure 1. Layout view of the current position of the stadium "Park Mladeži" (Youth Park)

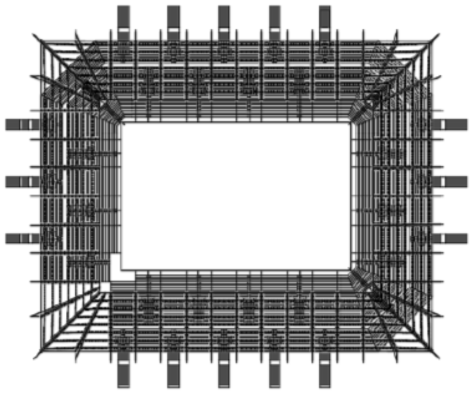


Figure 2. Layout solution of the new stadium

1.2 Shape and size of the structure

The purpose of the structure is a sports stadium with auditorium (grandstand) and a field (court), accompanying facilities necessary for this type of stadium (gyms, training halls, locker rooms, administration rooms ...) and business premises located below the stadium grandstands (shops, fan area, restaurant, retail outlets ...).

The structure has two above-ground floors. The first stadium ring (on the first floor) from the outside is primarily for business purposes, while the second ring is exclusively a grandstand. Taking into account the problem of parking spaces, it is planned to build an open parking area with 500 places for stadium users on the north side of the stadium. The rest of the plot can be developed as a green area with facilities for rest, recreation and children's play.

The height of the stadium is 24.00 m, measuring from the level of the developed ground around the structure. The first stadium ring is 7.00 m in height while the second ring is 12.00 m in height from the ground level. The main load-bearing column is 24.00 m high. This column is used to support the roof structure and provide the necessary elevation for installation of the cables holding the main girders of the roof structure, which is made of steel. All infrastructure connections will be made according to the specific requirements of utility and public companies or professional city and county services.

2. Structural details of the stadium

In structural terms, the structure is designed as a standard reinforced concrete structure (both stadium rings together with columns and ancillary rooms) supporting the steel structure of the stadium roof (Figure 3). The structure consists of two main reinforced concrete rings of stadium grandstands supported by columns which are also made of reinforced concrete. A flat roof with steel truss structure will be constructed on the structure, with four-sided trusses for the main girders and three-sided trusses for the secondary structure. The foundations of the structure will be made as strip foundations and as isolated footings at some places of the structure. The depth of the foundation is defined by the design.

The stadium structure is designed as a ring supported by columns and cross girders. The lower stadium ring consists of cross girders resting on internal columns, which then support longitudinal girders. Cross girders are also designed for the upper stadium ring. They rest on external columns, and support longitudinal girders of the upper stadium ring.

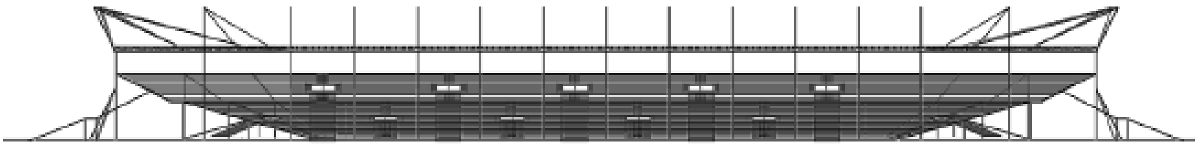


Figure 3. Section through the structure of the new stadium.

3. Architecture and concepts of the "ANG" stadium

3.1. Present condition of the stadium

The existing city stadium "Park Mladeži" (Figure 4) is located in the north part of the Split city between Hrvatske mornarice Street on the south, Put Brodarice Street on the east and Put Supavla Street on the north side of the stadium. On the east side there is an access road leading to the city park of the same name. The stadium is oriented in the north-south direction and is intended for sports and recreational purposes. Auxiliary fields, sports clubs' management offices and business premises, for example car wash and the like, are located on the east side of the stadium.

Figure 4. Stadium “Park Mladeži” illuminated at night

The stadium is primarily used by sports clubs such as the Workers' Football Club "Split" (RNK Split) and the Athletic Sports Club "Split" (ASK Split). In addition, due to its attractive location, the stadium often hosts numerous festivals, concerts and similar entertainment programs.

The seating capacity of the existing stadium is approximately 4075. The field is a grass surface with a running track around the perimeter. On the north side there is an area mostly used by ASK Split for javelin throw, shot put and pole vault. Floodlights for night illumination are installed over the perimeter of the stadium, and they were supplied from the Stari Plac field when the football club HNK Hajduk was relocated from Stari Plac to the new stadium in Poljud in 1979.

3.2. Historical development of the stadium

Construction of the Split City Stadium began in 1949 according to the design of Vuko Bombardelli. It is designed as a sports and recreational facility with a seating capacity of 35,000. The stadium was supposed to be constructed in stages.

In 1955, the first works on the lower concrete ring were completed and in the same year RNK Split started using the stadium premises. The Split City Stadium was not completed according to Bombardelli's design and in the late 1970s an aesthetic renovation was carried out for the purposes of the Mediterranean Games held in Split in 1979 (MIS 79) - Figure 5 [1].

Until 1990, the stadium was called "Park Skojevaca" or "Park SKOJ-a". After that year its name was changed to “Park Mladeži” (Youth Park) which is still in use. The stadium is also known to the general public for the nearby park on the Turkish Tower hill, with which it forms a single spatial and landscape whole.

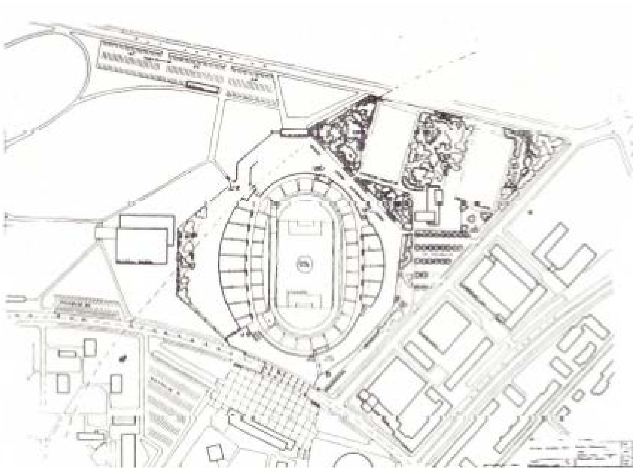


Figure 5. Layout view of the Split City Stadium according to the concept of V.Bombardelli

3.3. Concepts of the new stadium

The conceptual design of the new stadium with the working name ANG "Arena Nikola Gazdić" requires complete removal of the structure of the existing stadium "Park Mladeži". In case the stadium is realized according to this idea, the urban development and architectural aspects of the design should be considered in more detail. Therefore, the conceptual design primarily addresses the structure of the future stadium and its statics, functionality, durability, cost-efficiency and sustainability.

The design of the new stadium was aimed to connect the local community with the stadium, integrate the stadium with the existing urban development and architectural structures of the city and establish a connection with the surrounding nature. The cranes of the nearby shipyard, popularly known as Škver (Figure 6), are an inspiration for the design of the stadium structure columns. The playfulness of the structure is the main motif of this design, which sought to connect the construction aspect of stability and functionality of the structure with the aesthetic fitting into the space.

The exterior of the stadium is dominated by columns and the roof structure, which with their geometry emphasize the interaction of the environment with the stadium and attract spectators and visitors. With its impressive structure and size, the stadium would certainly find a place on the rich tourist map of Split. The aim of this design is clear. In addition to the fact that the city of Split, its residents and sports enthusiasts certainly deserve a better stadium than the existing one (which certainly carries the quality of the idea and the historical trace), efforts were made to offer a structure that would bring additional economic and financial value to sports clubs, the local community and the city of Split.

Columns of the structure analyzed by this construction design represent a geometrically broken shape whose height and domination in space are aimed to imitate the cranes of the nearby shipyard. The thus shaped columns are a spatial and symbolic link of the stadium with the nearby surrounding area.

The columns reach up to 24 m in height from the developed flat ground surface and break into two segments. The first is the tilted column arm in the lower part, which, in addition to its significant contribution to the load-bearing capacity and spatial stability of the column, provides an interesting appearance and breaks the monotony to which concrete as a material is quite prone.

Figure 6. View of a shipyard crane as the basic design motif

Figure 7. Portrait of Nikola Gazdić

3.4. About the name of the stadium

The new stadium is named Arena Nikola Gazdić, abbreviated "ANG".

Nikola Gazdić (Figure 7) is a famous and celebrated footballer and sportsman who has marked and obligated the city of Split, its citizens and all sports enthusiasts. He was born and died in Split and made his career as a football player at the Hajduk football club.

In the rich history of Hajduk, Nikola Gazdić's name is inscribed in gold letters as the first player to score 100 goals. Until his tragic death, he scored a total of 106 goals in 91 matches played. This sportsman has obligated the coming generations of sportsmen, supporters and followers not only of football but of sports as a whole as an example of self-sacrifice for his city and club.

4. In general about the calculation model

Numerical models of the structure, consisting of bar 1D elements of columns and beams, were made in order to test the feasibility of construction of the planned structure in question. Several models were made: plane models of characteristic trusses, for checking the load-bearing capacity of columns and steel trusses, and a spatial 3D model for checking the elements for earthquake loads

The following loads were considered in the structural analysis:

- Constant load on the structure (dead weight)
- Additional constant load
- Imposed load
- Temperature
- Snow
- Wind (both down- and up-moving wind variants are analyzed)
- Seismic accidental load

All loads are classified into several load combinations divided into two basic groups: load combinations for ultimate limit state (ULS) and combinations for serviceability limit state (SLS), and those most critical for the element were selected when calculating the structural element. All calculations and dimensioning were performed according to European standards [2, 3, 4]. Some characteristic parts of the calculation are given below.

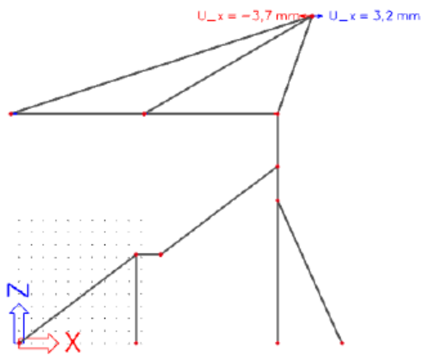
5. Plane analysis of the model

5.1. Structural analysis - spatial stability of structural elements

Analysis of the plane model of the structure considered four key parameters that must be satisfied in order for the variant solution of the structure to be accepted, namely:
Displacement of the structure (external column) in the x direction, stresses in concrete, allowable longitudinal force in steel tension elements and deflection of the roof structure in the z direction.

The figures below and the satisfied criteria are shown only for the selected variant solution of the plane model of the structure.

The value of each considered parameter must be less than the allowable value, and they are: deflection of the column in the x direction L/250 = 33.96 mm; allowable stresses in concrete for C 35/45 are □=15.75 MPa; allowable value of longitudinal force in steel tension element is N= 385 kN; deflection value of the roof structure in the z direction is L/200 = 109.45 mm.



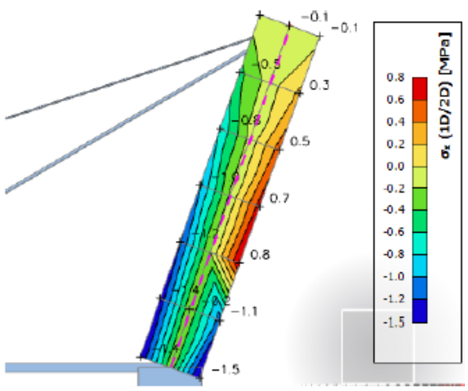


Figure 8. Deflection of the top of concrete external column x direction

Figure 9. Illustration of stresses in

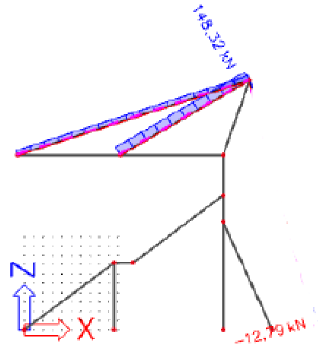


Figure 10. View of longitudinal force

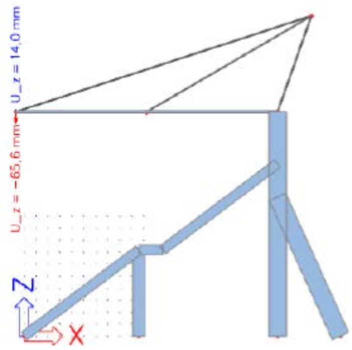


Figure 11. Deflection of the roof girder z direction

6. Calculation of vertical elements of the structure

The calculation of columns was conducted using the Aspalathos Section Design software suite. The reinforcement in column was assumed and for several different sections of reinforcement bars ultimate bearing capacity of the column was calculated for the given cross section and selected reinforcement. Then, a load capacity diagram of the column was created in Microsoft Excel with the data obtained from SectionDesign. By applying maximum cutting forces (combination of M and N) to the bearing capacity graph, it was determined which reinforcement profile is satisfactory.

The calculation also takes into account the effect of column slenderness by the approximate EC-2 procedure in such a way that the moments obtained from the model are increased by a certain value □.

6.1. View of forces for the usual combination of loads for external columns

Figures 8 - 13 show some calculation results from the spatial 3D model.

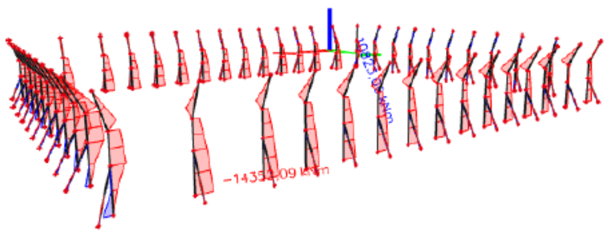


Figure 12. Maximum bending moment on columns MEd (kNm)

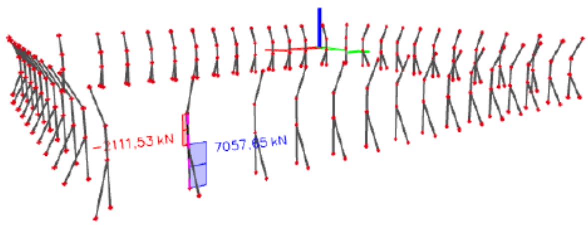


Figure 13. Corresponding longitudinal force in columns N_{Ed} (kN)

6.2. Column bearing capacity control

As previously noted, for the calculated values of moment and longitudinal force, the cross-section bearing capacity was controlled using the Aspalathos Section Design software.

Figure 14 presents a cross section of a column showing positions of reinforcing bars in the column. The bearing capacity diagram (Figure 15) is made for bars with diameter Ø32 (blue line) and bars with diameter Ø36 (orange line). It is evident that for the purposes of sufficient bearing capacity it is necessary to use bars Ø36 and the 40Ø36 (407.20 cm^2) reinforcement is selected.

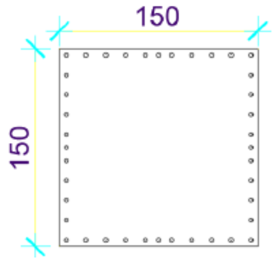


Figure 14. Cross-sectional view of the column

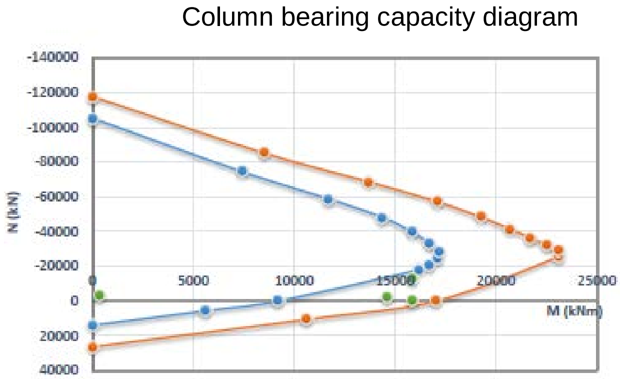


Figure 15. Column bearing capacity diagram

7. Steel roof structure

The stadium roof is designed in steel - steel trusses resting on columns (position S2) and stayed to column tops with cables (Figure 16). These steel trusses are 38.50 m in length in the largest span. The main girder is a spatial four-sided truss. The main girders are supported by columns position S2 and are stayed by cables from the top of the column to the main girder. Each main girder has two cables (a longer one and a shorter one) due to deflection conditions but also force, and due to cost-efficiency.

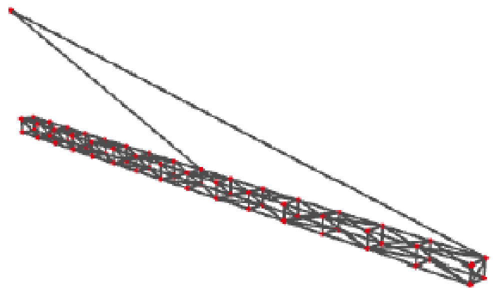


Figure 16. View of the main roof girder - four-sided spatial truss

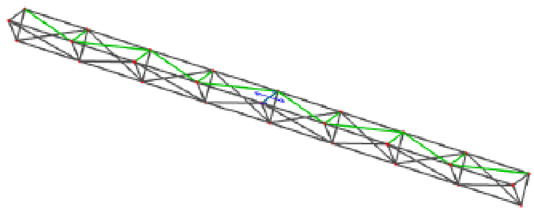


Figure 17. Illustration of secondary roof structure - three-sided spatial truss

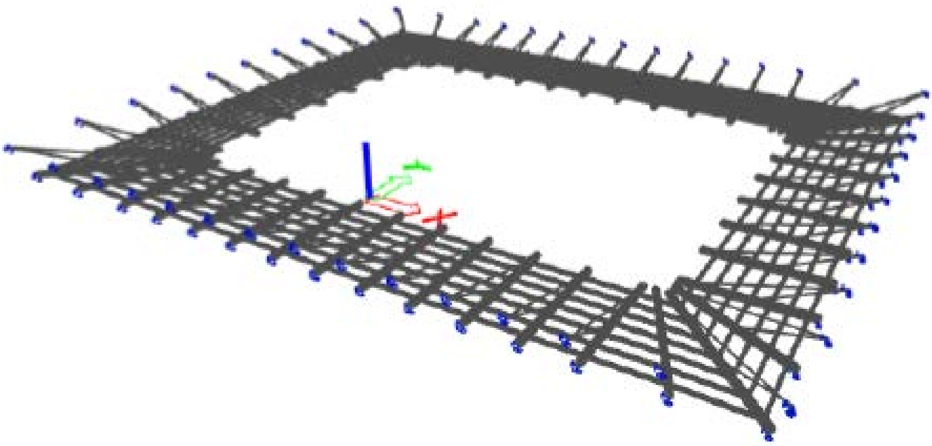


Figure 18. View of the entire model of steel roof (canopy)

The secondary roof structure is designed as a three-sided truss (Figure 17), with its upper side resting on the upper side of the main girder. It reaches up to 15 m in the largest span. The secondary structure is a three-sided girder with the basic elements: upper girder side, lower girder side, and infill of the three-sided truss. The entire model of steel roof (canopy) is shown in Figure 18.

7.1. Presentation of the steel structure elements dimensioning results

All elements of the steel structure are subjected to relevant load and the cross sections were dimensioned for each roof element. The dimensioning was carried out with the SCIA Engineer 19.0 software suite and using the autodesign option.

Some calculation results of the upper side of the main roof girder - four-sided spatial truss (Figures 19-22) are shown below.

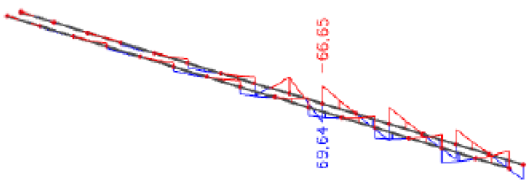


Figure 19. Bending moment M (kNm)

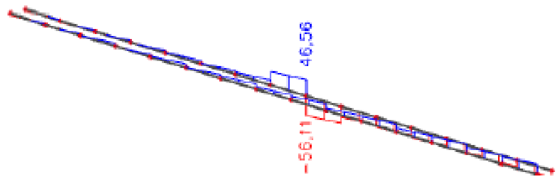


Figure 20. Transverse force V (kN)

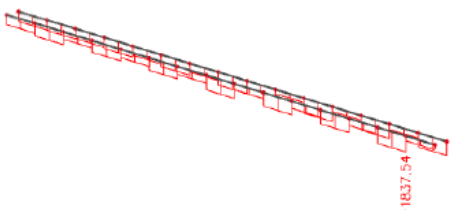


Figure 21. Longitudinal force N (kNm)

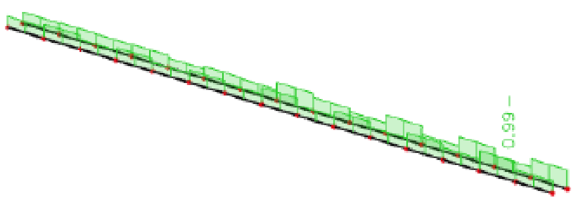


Figure 22. Usability of cross sections

7.2. Characteristic details

Plans of how prefabricated screw- and welded joints of the structure would look like are presented below. Only some characteristic details on the structure are taken into account.

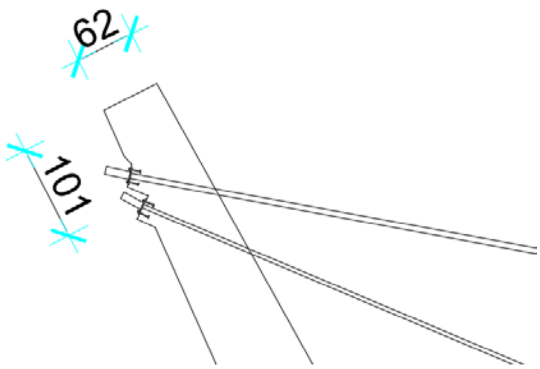


Figure 23. Illustration of the connection holding the cables to the top of the column

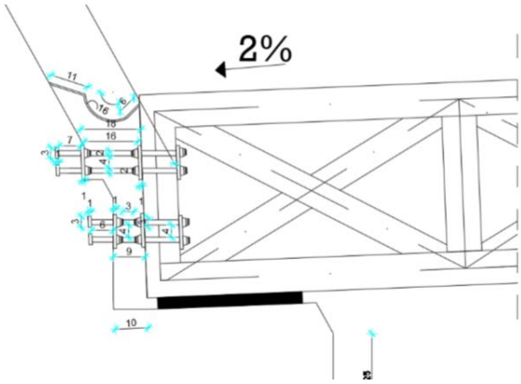


Figure 24. Detail of the truss resting on the column

8. Views of the stadium

Views of the architectural design of the Arena Nikola Gazdić stadium Split are shown below, Figures 25-27.

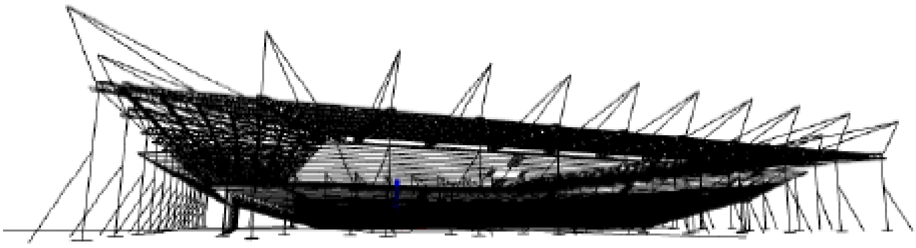


Figure 25. View of the stadium from the south

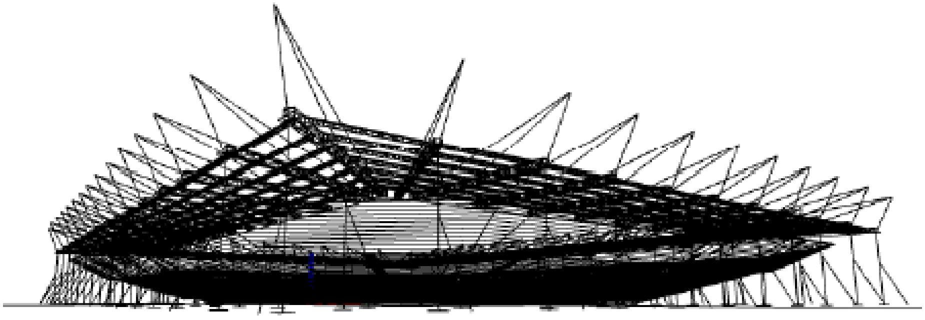


Figure 26. View of the stadium from the southwest

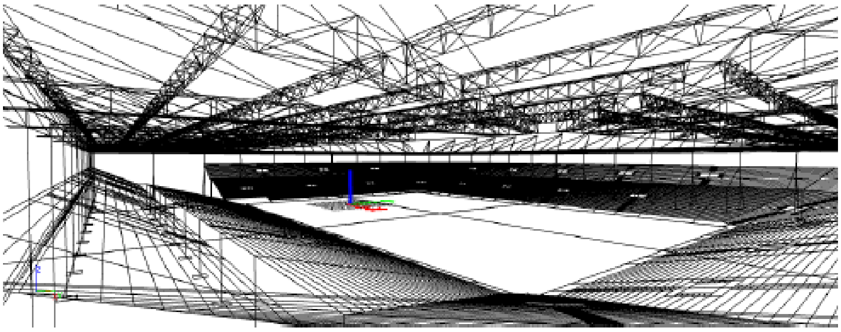


Figure 27. The interior of the stadium

9. Conclusion

The conceptual design of the ANG stadium in Split is presented in the paper. The paper presents architectural and construction plans and the essential calculation proving the feasibility of the designed solution. The material used is Class C 35/45 concrete for RC structural elements and C 25/30 for foundations, while structural steel is of quality S355.

10. References

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