"AGRAM ARENA ZAGREB"

New Zagreb Municipal Stadium Project

GENERAL INFORMATIONS

Location: Ljubljanska avenija - Jankomir, Zagreb, Croatia
Purpose: Multi-purpose stadia
Floors: Ground floor + 3 (varies)
Gross area (without field): 24938m²
- Ground floor: 8025m²
- First floor: 10358m²
- Second floor: 5363m²
- Third floor: 1192m²
Stadia type: all seater
UEFA stadium rank goal: Category 4 football stadium
Gross capacity: 9912 (Lower tier) + 15874 (Upper tier) = 25786
- Standard seats: 24084
- Business seats: 910
- VIP seats: 390
- PRESS seats: 282
- Disabled places: 120
Main tenant: GNK Dinamo Zagreb
Other tenants: HNS (Croatian Football Federation), KHL Medveščak, PPD Zagreb, local football clubs, concert events, motorsport events etc.
Field dimensions: 105×77 meters
Floodlights: LED 1600lux
Parking spaces: 3400
Retractable roof system: Yes
- Roof type: three-section single side extraction
Estimated construction cost: cca. 150 mil. €
Estimated construction time: cca. 20 months
LOCATION AND ORIENTATION

Stadium is located in the Zagreb’s southwestward industrial and commercial district of Jankomir, next to one of the city major traffic connection points. Main reason for this location is the fact that the stadium site is accessed via Ljubljanska avenija street (connecting it with Jankomir junction) and Zagrebačka avenija street (connecting it with city center). This allows for a fast approach to site from all directions, especially thanks to Jankomir junction which connects some of the country’s major highway routes to both inner Croatia and Europe, such as: A2 (Zagreb-Macelj) connecting the site with Slovenia and Hungary; A3 connecting to both southern and eastern Croatia as well as to Slovenia, Austria and central Europe. This assures fast and safe access to the stadia without creating any major unnecessary traffic jams and security issues throughout the city center. In this way, all focus is shifted to the outer city perimeter, which is than easily controlled by the security personnel.

Second reason for this site is plenty of connection abilities. A lot of shopping center parking lots are present just nearby, allowing visitors to park their vehicles using these lots, if stadium ones, 3400 places, are already full. There is also a great public transportation connectivity. Bus line 116 (Ljubljanica - Podsused most) connects the site from both city center and the northwest. Bus schedule would have to be slightly increased in this scenario, but it would only have to be done so during the events held within the stadium. Bus stop would also had to be added on the Ljubljanska avenija on both sides. To easily connect these sides, an underground pedestrian passages would have to be implemented as well. There is also a possibility of extending tram lines 5 and 17 tracks for additional 2,3km to connect stadium directly with tram traffic. All those traffic benefits, also including train stations located in Gajnice and Podsused, prove that this location is the best spot for this project to be implemented at.

Third reason is a vicinity of Jankomir Nexe Grupa-Tehnika d.d. concrete plant, located only 1,2km away, allowing fast transport of fresh concrete to temporary concrete moulding plants in the construction site.

Fourth reason is low land value in Jankomir industrial zone. The investors would have to pay significantly less for construction land, compared to other city districts. Proximity of Sava river can cause a great threat towards stadium site. Therefore embankments in the area would have to be increased and improved. Land category in the area is rated 1st-2nd due to mud and sludge in the soil, but this can be solved by implementing wider foundations and creating a solid drainage system.

Altough it is very unusual in football stadia design, main pitch is orientated west - east. Due to very high roof deviation (30m), small amount of sun rays would reach surface of the field during any year period. Therefore field surface is chosen to be partly artificial. That directly excludes the sun from roles of both illuminating the field and deriving grass growth. Another problem would be sunrays falling directly on the stands in the evening and disturbing both fans and the main camera, which is again unusually located on southern stand due to low height of steel compression ring carrier on the north, and creating flare on the camera lens. Again, roof helps, and if necessary upper section of the retractable roof system can be extracted to increase deviation and solve this problem.

One of the reasons for this orientation is a view from northern facade offices towards Medvednica mountain and Zagreb itself. The views from Jankomir, Ljubljanska avenija and Zagreb towards stadiums representative main facade is taken in consideration as well. This facade is made out of ISO-Glass and windows, which are also equipped with sun-stoppers for both functional and aesthetically reasons. There are also a lot of shopping centers nearby, a luxury hotel etc. Around the site itself, a lot of opportunities and space for additional content appears as well. More fields can be built, center can be expanded with more sport facilities etc.

![Image 1: Jankomir stadium site (Open Street Map)](image-url)
PITCH AND PERIMETER DESIGN

Due to various usages of this stadium, which can range all over from football, hockey and tennis, to concerts, motorsport and many other cultural and sport events, point of focus in sightline analysis wasn't set on the outer football pitch line as usually, but rather on the beginning of asphalt surface on the outer perimeter. In this way, a positive sightline was assured throughout all events which could take place within the stadium. For easier design and construction, outer perimeter measures 105×77m. This is decreasing football pitch dimensions to 100×68m, but constant distance between stands and field was achieved, measuring 6,80m. This was done to create constant axial spacings of structural concrete elements to 7,00m in all directions. Next to that, sightline analysis was just determined once, because it applies on all parts of the stadium due to constant distance between the field and the stands. Outer perimeter is made out of asphalt surface, with a drainage system for the field.

Pitch is made out of artificial grass due to lack of sun and potential problems with underground waters from the nearby Sava river. The surface has a separated carpet form, so that it can easily be removed and replaced with another surface, if other events are planned within the stadium. Therefore, grass can stay untouched and can't be damaged by visitors during concerts and other types of events.

CONCRETE BOWL DESIGN

Concrete bowl is designed as a separated two tier grandstand. The lower grandstand, or tier, consists of 13 rows. Although there are two bigger tunnels for faster evacuation and vehicles approach, and one smaller for players, staff and referee, lower tier is keeping its constant form. On the corners, prefabricated rows are constructed on concrete carriers which are directly based on artificially implemented promenade embankments at all four corners of the stadium. They are placed at an angle of 22,5° one from another, and at 11,25° at the upper tier. In other longitudinal sections, under the stands, commercial rohebau spaces for lease are present. Under the main stand though, much bigger players and referee changing rooms, together with staff, security and press spaces, are located.

Upper tier consists of 19 rows, not constant in all ways, due to the fact that the main stand's last 9 rows are cut at an angle spanning between structural elements. This is designed to create a direct access from 3rd floor to the VIP and business sections of the stadium. There is even a lounge and a coffee bar placed there as well. In the middle of the main stand, a CCTV and general command center is located for all of the delegates, technicians, engineers and main security personnel of the stadium. It is designed in an arc form to assure great visibility towards every section of the stadium. Problematic visitors can then easily be spotted and dealt with, without too many casualties or further problems. Another major reason for this cut section of the upper tier is the retractable roof, which is implemented very low, to eventually be "hidden" from the outside view. Therefore the stand design follows the secondary steel carrier within the compression - tension ring, which would block the view towards the field if it would have been left constant with the other parts of the upper tier and the steel ring.

SIGHTLINE ASSESSMENT

While assessing the spectator sightlines, point of focus wasn't set on the touchline of football field as usually. Due to many purposes of this facility it was rather placed on the drainage system around the field. In this way, positive sightline was achieved for all events held within the stadium (more informations about sightline calculations on the next page under title "Sightline Analysis"). UEFA and FIFA prescribed that minimal C value should not be less than 9,00cm. In the calculations within the tables on the next page, you will see that minimal value is actually 7,08cm. But keep in mind that this is a calculation for outer perimeter measuring 105×77m. When it comes to football, point of focus moves towards the center, increasing the distance (D) and making C value approximately 20% higher. Only then we get the desired C value of 9,00cm for both tiers, which means this stadium meets all UEFA criteria concerning sightlines, and full gross capacity can be used during all major football events. For any other event, point of focus increases even further.
# SIGHTLINE ANALYSIS

## Lower Tier

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<th>Height (r)</th>
<th>Value (C)</th>
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*All riser values (N) are constant: 30
*All row depth values (B) are constant: 80
*Height (r) is cumulated by 80 due to spectators eye position while seating

## Upper Tier

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*All riser values (N) are constant: 51
*All row depth values (B) are constant: 80
*Height (r) is cumulated by 80 due to spectators eye position while seating

![Diagram](image)

(D): distance between point of focus and spectators eyes
(R): height between point of focus and spectators eyes - (r+80)
(B): row depth
(N): riser height

Sightline was calculated using the first formula, while during the stadium design and sightline analysis, second formula for D value was used. It was also assured that no major obstacles stand in between the spectators and the field, which would result in stadiums gross capacity being decreased. We can guarantee that sightline was correctly assessed for all events held within the stadium.
Stadiums concrete structure consists of a couple of elements. A lot of care was taken during design process, to make this happen. Therefore, we only have one or couple of types of beams, main stand carriers, pillars, row elements, plates, stairways etc. This was done with an axial spacings of 7,00m which is omnipresent throughout the stadium. This construction using prefabricated concrete elements. Stadium is dilated in 12 parts, assuring safety against earthquake and uneven attendance of visitors on certain parts of the stadium. Dilatation is made in a way that all longitudinal parts are dilated in the middle and are also divided from the corner sections also.

Steel elements were implemented with hard and durable stainless steel. A lot of trusses are used. This allowes greater spans, which is visible on primary carriers (156m). The primary carriers (carrying both retractable roof and facade steel carriers) are made out of a 3D triangular truss, while secondary carriers (carrying facade steel carriers) are made out of 2D truss. Due to the fact that retractable roof, while closed, produces such high forces, that want to tip the construction inwards (high moment), secondary carriers are also used to prevent it, forming a compression - tension ring. Primary carriers are placed on four concrete pillars with movable bearings.
COMMUNICATIONS

Stadiums main promenade (1st floor) is accessed via 11 ramps. This allows for a faster and safer evacuation, and easier approach to the stadium for disabled and older people. Time of evacuation is also drastically reduced. There are two emergency exit tunnels, and by evacuation plan, it is specified that 30% of the lower tier occupants would use them in evacuation. It is also important to emphasize, that every stairway on the lower tier has a direct access to the outer perimeter of the field. Main stands lower tier is accessed via stairways and elevators, and not ramps as other parts, but they are all again connected as well.

Upper promenade (2nd floor) and tier are all accessed via stairways, where every stand entrance also has its own stairway. This means, that on every 450 people, there is one 2,00m wide stairway. This allows an extremely fast evacuation of the stadium in cca. 10 minutes time. All together, there are 34 stairways and 2 elevators. For a stadium of this size, this is far above the average, but safety is number one priority, especially when it comes to multi-purpose arenas such as this one, where fair amount of people wants to leave the facility in panic as soon as possible. At least panic factor was eliminated in this way, while all of the exits are marked with illuminated signs and are very clear and easy to notice. Another major factor is the opened entrances from the ramps, which always put in some amount of natural light and clearly show the way of exit. People feel much safer, knowing that they will easily spot the exit. All promenades were designed in such a way to easily allow people to notice the nearest exit and leave the stadium in calm.

Last (3rd floor) is by area the smallest one. It is accessed via 4 main stairways and 2 elevators. There are some offices, caffee bar, lunge and a VIP and business seats access ramps. There is also command center, where general personnel is located. Next to the security and CCTV staff, there are also all kinds of servers and computers operating the stadium. From there, everything can be seen. Therefore we call this command center the eyes and the brain of the stadium.

SECONDARY CONTENTS

Speaking of secondary contents within the stadium, there are a lot of toilets, first aid medical rooms and vendors for food, drinks, snacks etc. They were designed as small container boxes strategically placed around the stadium. Their container design is likewise, mainly because everything within the stadium is made from precasted concrete elements. So are they. In this way, less load and pressure was placed on the plates underneath, while no actual bricks were used to implement them. Another reason is a serious lack of space on the upper promenade, so this solution was voted as the best one possible. They are easy to maintain, and are able to be replaced if necessary. On the main stand section though, they are integrated within the big rooms separated by walls.

On the southern, western and eastern sides, just under the stands, a lot of commercial space is available for lease. They could serve either as small business offices, bars, lounges, fan shops or anything alike. They are accessed from both left and right sides of the ramps, and the entrances are just underneath them. This allows those spaces to stay away from crowds of people during the event and to eventually be damaged by violent people or rioters.

FLOODLIGHTS

Primary floodlights set consist of 144 LED floodlights with output power of 1500W each. This makes all together an output of 216000W to illuminate the stadium field with an area of 8085m². After the analysis, this makes an 1600lux illumination, which is very favorable due to low light pollution and bad effects on the environment. There are also even more of these floodlights on three additional fields outside the stadium where players and teams can train, work etc.

Secondary floodlights (to illuminate stands, floors, stairways etc.) have an output power of 100W. They are also LED, what makes this stadium environmental friendly. Lamp posts on the plaza outside the stadium and lamp poles on the parking lots with output power of 200W each are LED based as well.
The retractable roof system consists of three sections. They are all extracted from one side, above main stand. Process goes in this order when closing: all sections first move 39.00m. Then, middle and upper section move for additional 26.00m. At last, upper section moves for 26.00m again to complete the process. When opening the roof, process is reversed. The goal was to integrate the retractable roof into the stadiums facade, to actually hide it in a way. This was done by lowering the height of the upper tier and lowering northern secondary carrier of the compression - tension ring to the point where it is actually hanging from the primary steel carriers. This was also done to assure resistance towards primary carriers which want to tip inwards during the retractable roof's initial idle position (very high moment of the forces loaded on the primary steel carriers and trusses). This has also caused a new way of structural design given to this roof. Where on other stadiums in the world, retractable roofs are actually above the carriers and each section has direct access to the tracks above these carriers, in this case, we have a completely different situation. Here, first two sections of retractable roof are actually hanging downwards and only the third one is above the carrier and the tracks. This results in a quite good exterior look of the stadium without something topping out the roof.

Another interesting fact about this roof is the way of force transfering. To reduce the maximum moment on the primary steel carriers and bring the forces as close as possible to the bearings of the steel carriers and concrete pillars, all of the rear forces of the middle and upper section of the roof are transfered to the lower sections with a system of tracks and wheels. The front forces are transfered to the carrier via bigger wheels. This allows a single track to be implemented on the primary carriers, while sections are not topping eachother out by having separate tracks, but instead are all addicted one to eachother and are moving as a single element. The force focus and maximum moment are set near the bearings. Maximum moment is, therefore, located somewhere near the 60.00m of the primary carrier lenght (full span 156,00m). This means that dimensions of primary carriers are drastically reduced, and force focus is set near the bearing and concrete pillars.

Wheels have hydraulic suspensions to absorb certain amount of load which is influencing the structure. They are made out of durable steel and each one of them has a small electro-engine, producing enough power to move the roof at a speed rate of 1m/s. This means that process of opening /closing the roof is completed in less than 10 minutes. Concerning the weight of the roof and other aspects, this is quite fast for a structure of these proportions, to be moved in such a short period.

Roof is covered with lightweight metal panel plates set at a slight 1° gradient towards left and right due to rain and other sources of water. The roof is designed to not allow water pouring in from anywhere. There is also a system of heating pipes which can melt the snow on the retractable roof to prevent collapse in case of too much weight and pressure.
STADIUM EQUIPMENT

When speaking about the equipment, this stadium has two 700×385cm (800 diagonal) LED scoreboards, many quality speakers for great sound effects, which are pointed towards the stand. The sound then reflects away and is than echoing around, creating a great atmosphere and sound effects. Stadium is covered with CCTV equipment and everything can be seen and monitored just from one single command center. Those speakers and scoreboards, as well as floodlights, and other stuff on the roof, are all accessed via catwalks for easy and fast maintenance and repairs. VIP seats are both very comfortable and heated. A good fire safety and protection was implemented within the stadium, where there is one fire extinguisher and one hydrant with fire hose at every 28,00m. As already mentioned, all exits and gates are properly marked and are very easy to navigate. On the side of the field, there are LED advertising boards and very comfortable players and staff canopies. Fences are made out of hard durable aluminum to assure safety of the visitors. Floors are covered with polished black granite tiles, but are also somewhere rough to prevent floor from being slippery when wet.

FACADE DESIGN

Main facade was made to integrate the stadium into industrial architecture of Jankomir. Therefore, the stadium is covered with metal plates which are both matted and chromed afterwards. This means that stadium facade will not always have the same shiny silver colour, but will instead adopt to the weather, sky or time of the day. This simple design and metal plates resemble other industrial buildings in the area. This makes the stadium look like some kind of warehouse or factory building, but is still special and unique towards others with its colourful facade and blue LED lights covering exterior of the stadium. Those lights are especially noticeable during the night, when the facade is black due to the night sky. That makes this stadium a special landmark of Zagreb both during the day and night. Other facades, like the one of the offices which are protruding outside of the main metal facade and have their own blue plaster facade in mixture with reflective glass and sun stoppers. In interior and on the secondary content containers there is a pale gray facade to match the concrete pillars and beams.

LANDSCAPE

Landscape of the stadium is very symmetrically. In the front and on the sides, an interesting approach towards main plaza (promenade) with water fountains and flags in the middle is placed. Everything else is covered with pine trees. In the back, three football fields are located. Now why is the main plaza divided by a forest of pine trees from the outside world? Well, simply to make the people relax while approaching the stadium. To make them forget about their everyday activities and problems, and to make them focus on the event ahead held within the stadium. Those pine trees are representing a barrier from a very hasty and chaotic industrial distric of Jankomir, and a completely different type of activity which is in the stadium. Those two branches (sport, culture etc. and industry, traffic etc.) aren’t very similar. In fact, they are exactly opposite. Therefore, this barrier of pine trees was created, to separate them in a way, and change visitors minds and thoughts towards what’s ahead, and not on what’s behind. The reverse effect is while visitors are leaving, to prepare them back to their everyday activities and life. Parking lots are covered with regular potted trees. There are no divisions in between, except access paths. Just one big mass of asphalt for easier implementation and less construction costs. All of this is then fenced with shrubs and bushes to mark and divide the area of the stadium site.

CONSTRUCTION

Due to stadiums prefabricated element structure, vicinity of concrete plant and very simplistic industrial design, stadium is expected to be built in cca. 20 months since groundbreak. The construction cost should not surpass 150 mil. € by our expectations and calculations.
CREDITS

Architectural design: Ivan Tahlin
Structural design: Ivan Tahlin
Landscape design: Ivan Tahlin
Urban design: Ivan Tahlin
Architect: -
Structural engineer: -
Urban engineer: -
Electrical engineer: -
Mechanical engineer: -
Surveying engineer: -
Environmental engineer: -
3D artist: Ivan Tahlin
Rendering: Ivan Tahlin
Postproduction: Ivan Tahlin
Project presentation: Ivan Tahlin
Project management: Ivan Tahlin

Made with: 3D Modeling – Trimble SketchUp 2016 (basic modeling), Blender (steel construction wireframes conversion to solids via curves), 3D Object Converter
  Rendering – Blender (all images are rendered in FULL HD (1920×1080) resolution at 500 samples, composited only with glare filter, exported as .png)
  Postproduction – Adobe Photoshop CS6 (filters, image canvas size editing, blurring etc.)
  2D drawings – Trimble SketchUp 2016 (direct 2D image export from 3D model section planes into .png graphic)
  Technical documentation: OpenOffice Writer (.odt and .pdf export)
  2D drawings – Trimble SketchUp 2016

Stadium was designed following "UEFA's Guide to Quality Stadium" architects handbook.

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Thank you for your time and understanding. Sincerely, Ivan Tahlin – creator of the project.