



UHPFRC in Architecture

The future of concrete composites in a sports complex

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- Fascination and design with UHPFRC
- Context; The Brettenzone and Westerpark
- Public Sports Complex Amsterdam
- Architecture & Structural Design
- Climate design
- Conclusions and Questions



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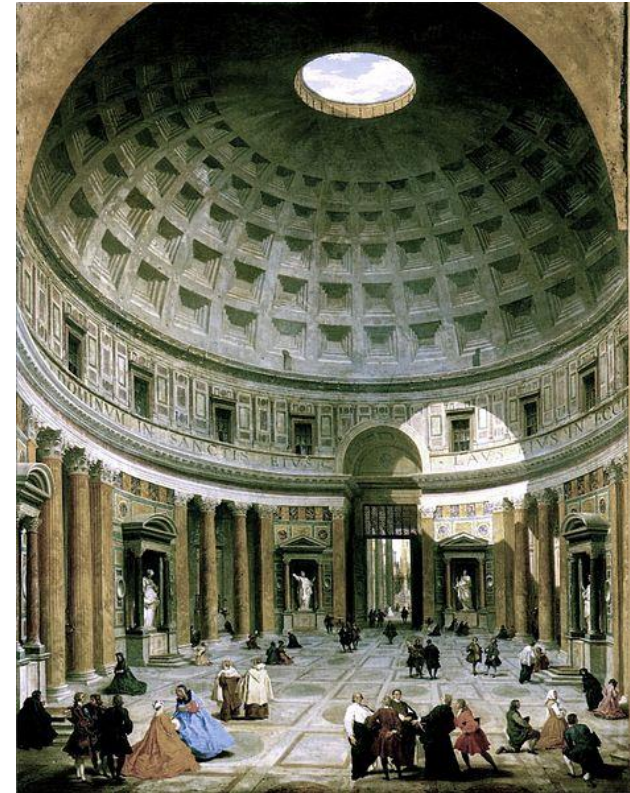
Technical Fascination;

Introduction to the world of high performance concretes

Ancient concrete



Pont du Gard 38 v. Chr.



Pantheon, 27 v. Chr.

Present day Concrete



Steinkirche Cazis – Atelier Werner Schmid



Gare de Saint-Exupéry – Santiago Calatrava



Casar de Cáceres – Justo Garcia Rubio



Wyss Garden Center – Heinz Isler

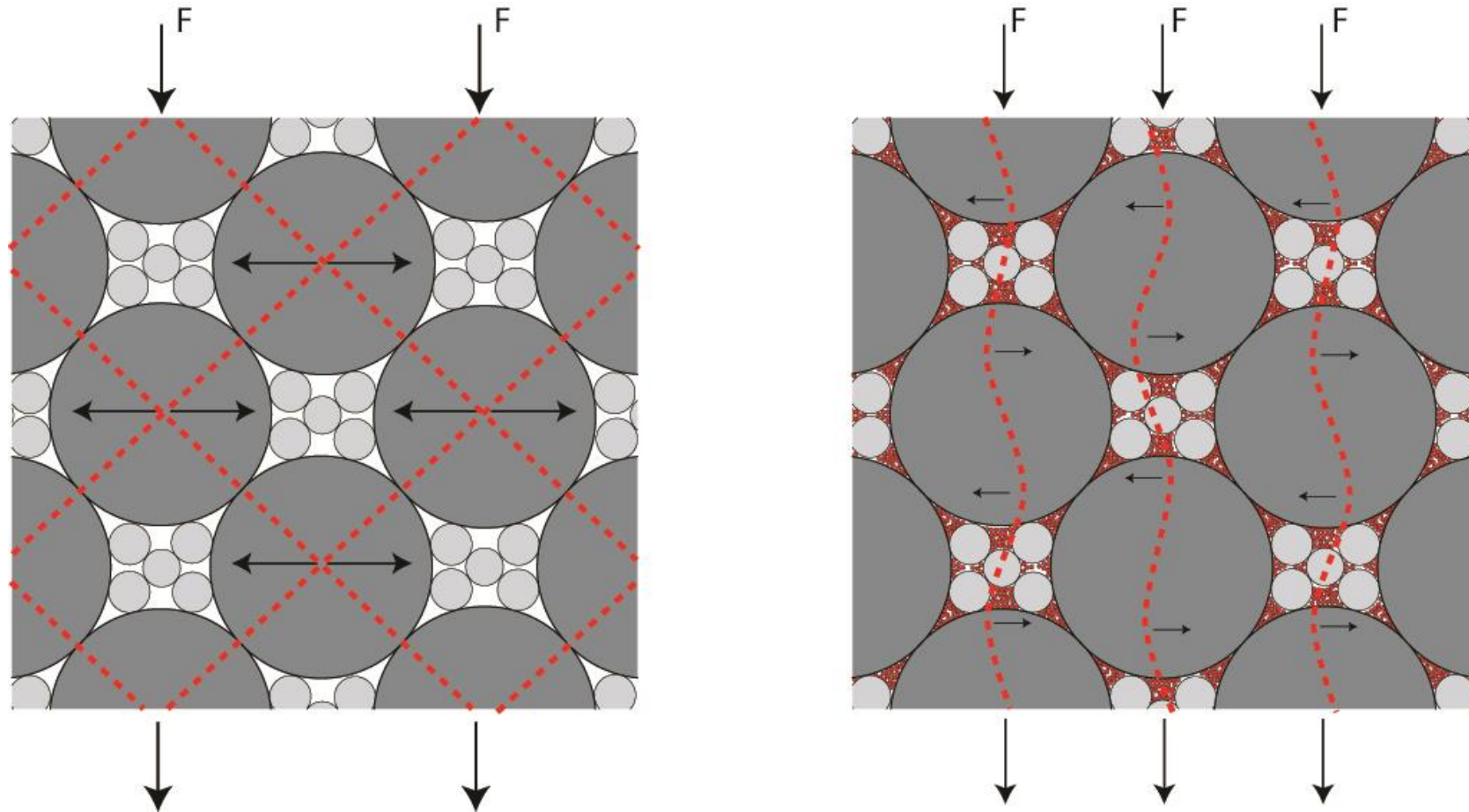
Concrete compounds

	Vol. (kg/m³)
Cement (Portland)	325
Sand (aggregate)	660
Gravel (aggregate)	1300
Water	160
Total (density)	2445

Compounds of an every day concrete

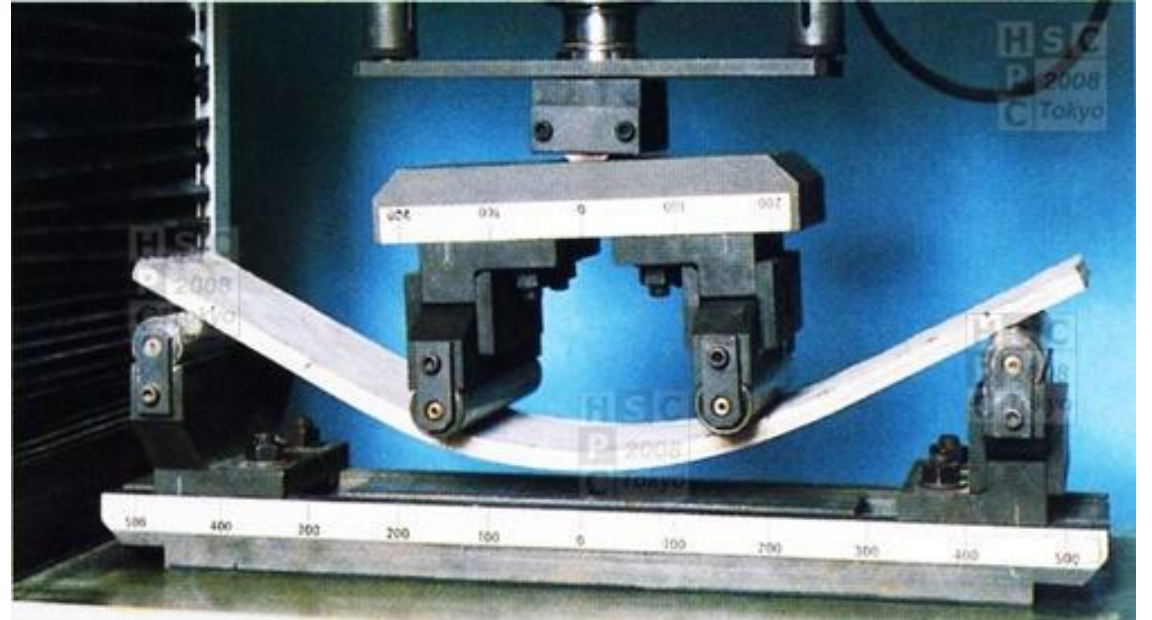
Playing with the compound ratio's or diversifying with ingredients result in better performing concretes

Increasing mechanical performance



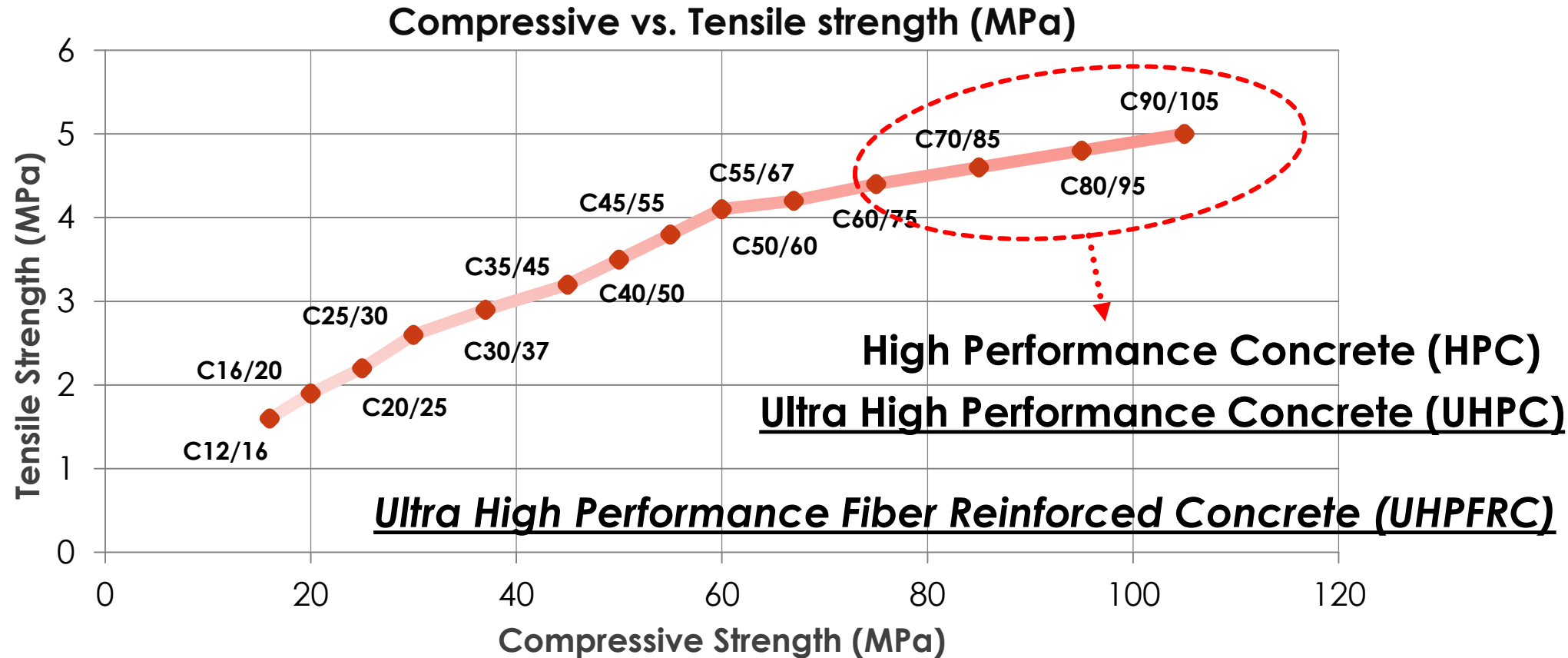
Result: Increased compressive strength

Fiber Reinforcement



UHPFRC under a 4-point bending test

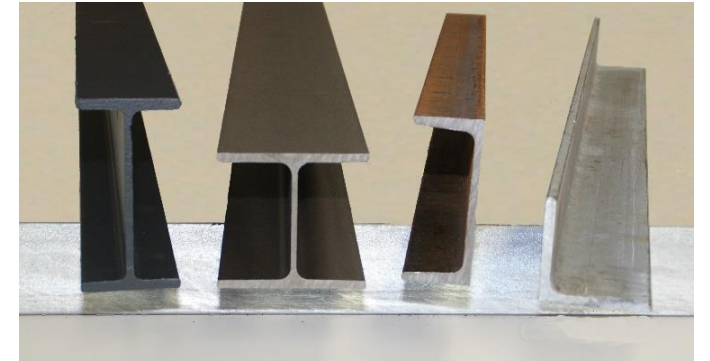
Concrete Strength



Comparing materials

Mechanical properties	OC (C35/45)	UHPC (C170/200)	UHPFRC (steel fibers)
Density (kg/m ³)	2400	2450	2600
Compressive strength (MPa)	45	200	<u>200</u>
Tensile strength (MPa)	3,2	6,0	<u>10,0</u>
Flexural strength (MPa)	4,8	10,0	<u>40,0</u>
Young's modulus (GPa)	34	55	<u>60</u>

Comparing materials



Mechanical properties	UHPFRC	Glulam (GL28)	Steel (S235JR)
Density (kg/m ³)	2600	410	7850
Compressive strength (MPa)	200	26,5	360
Axial Tensile strength (MPa)	10	19,5	360
Flexural strength (MPa)	<u>40</u>	<u>28</u>	<u>235</u>
Young's modulus (GPa)	<u>60</u>	<u>12,6</u>	<u>205</u>

Advantages in short

- Increased mechanical performance
- Less raw material needed
- Simplified reinforcement, reduced construction time and enhanced job safety
- Dense matrix causes impermeability, increased lifespan

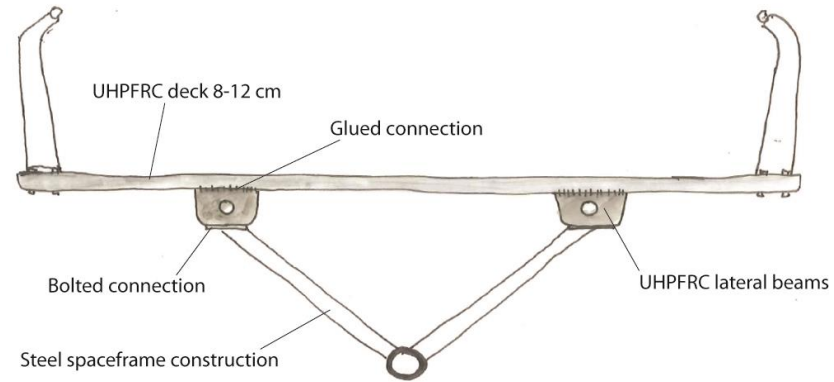
Design with UHPFRC

What has been done? What is (im)possible?

Applications – Civil Engineering



Gartnerplatz Brücke – Kassel University

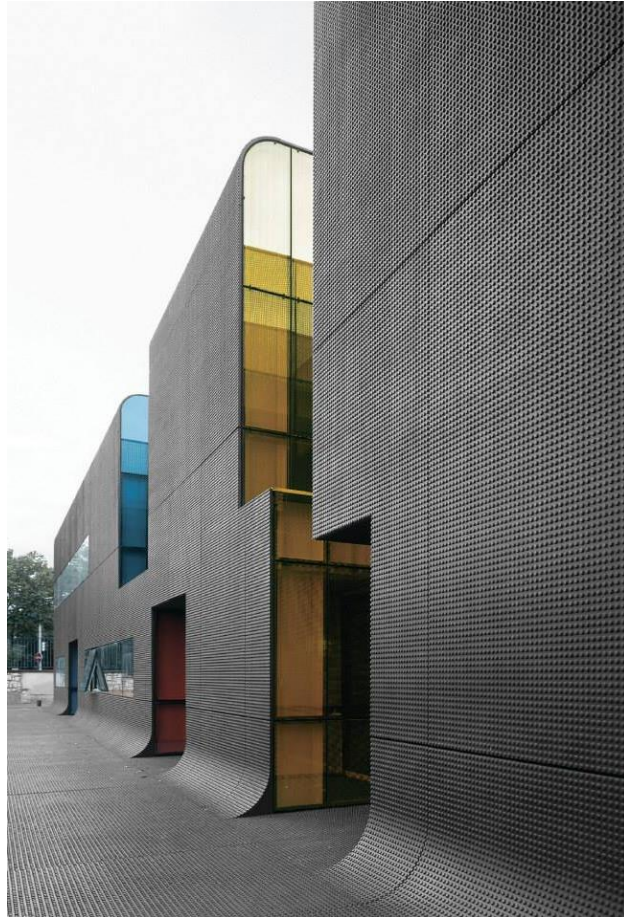


Pont du diable – Rudy Ricciotti



Seoul footbridge – Rudy Ricciotti

Architectural Applications



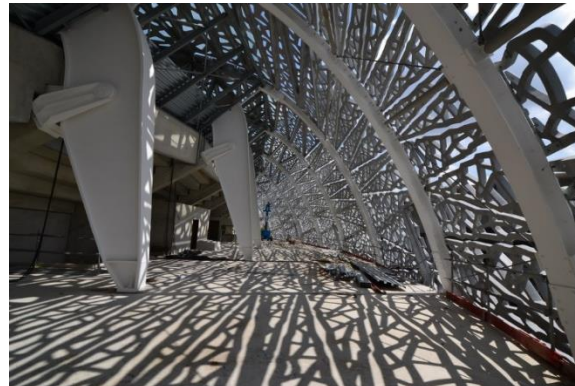
RATP – Graphic Architecture



Huize het Oosten – TenBrasWestinga



Saxon Sion – Chamion Mensens



Stade Jean de Bouin – Rudy Ricciotti



Stanze – La Ville Rayée

Architectural Applications



LandboMidtØst - Hinnerup



HiCon Staircase - Denmark



L'arch – Michel de Broin



*Parkbrug Voorstonden – Balustrade
Fragment*



LandboMidtØst - Hinnerup

Ambitions / Challenges

- ▶ Use UHPFRC in the main supporting structure of a building
- ▶ Show the structure on the outside
- ▶ Experience slenderness and elegance

- ▶ Structural design vs architecture

Design Guidelines

- Prefab application is necessary
- Outside application
- Design for compression to get best results
- Expensive (due to fibers and expertise needed)

Context: Brettenzone and Westerpark

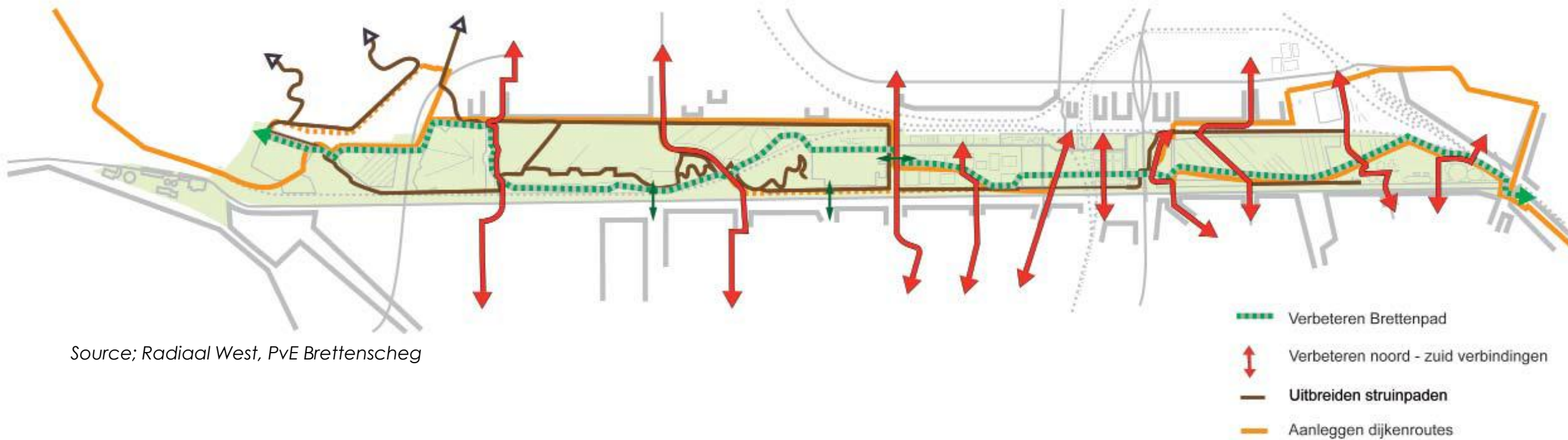
Problem statement and Design principles

Background – Brettenzone



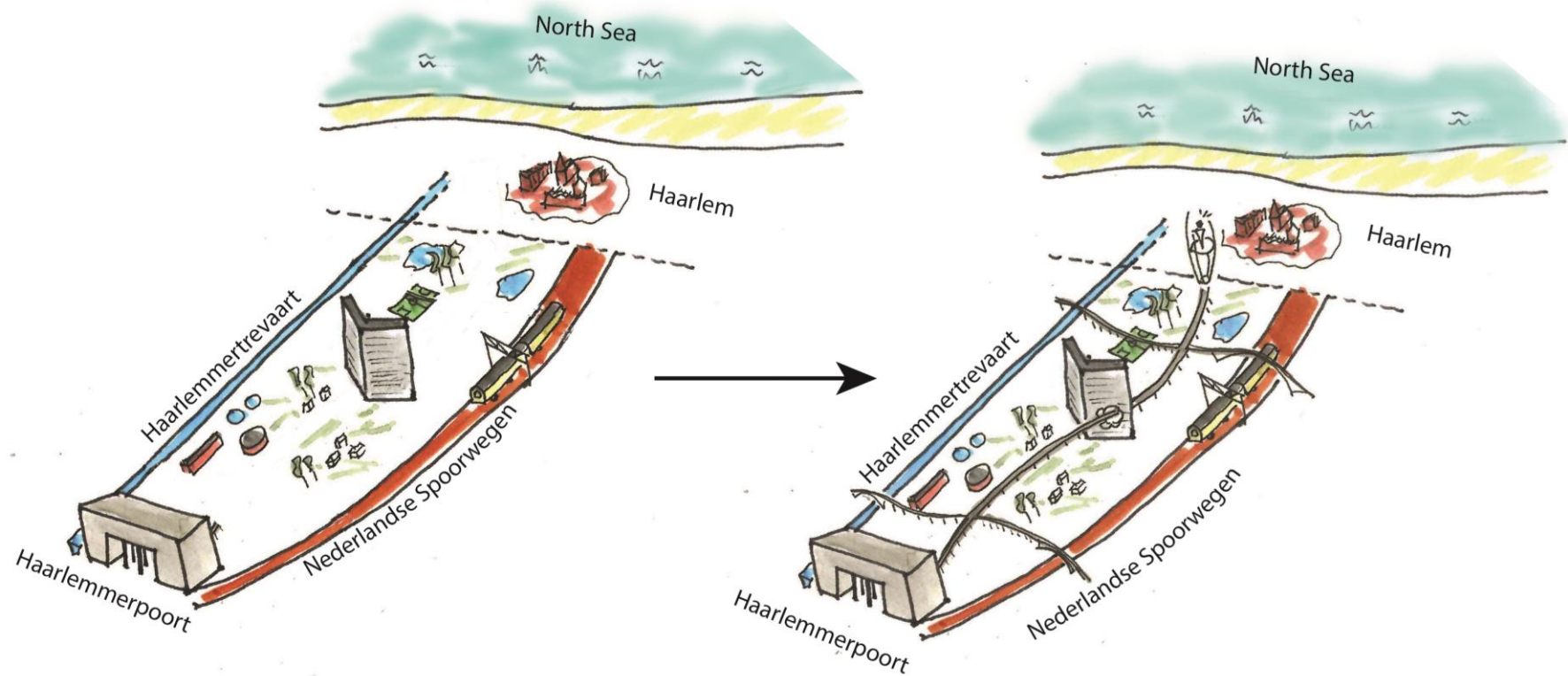
Source; Google Earth

Brettenzone – Inaccessibility



Source; Radiaal West, PvE Brettenscheg

Brettenzone - Pathway



Context westerpark

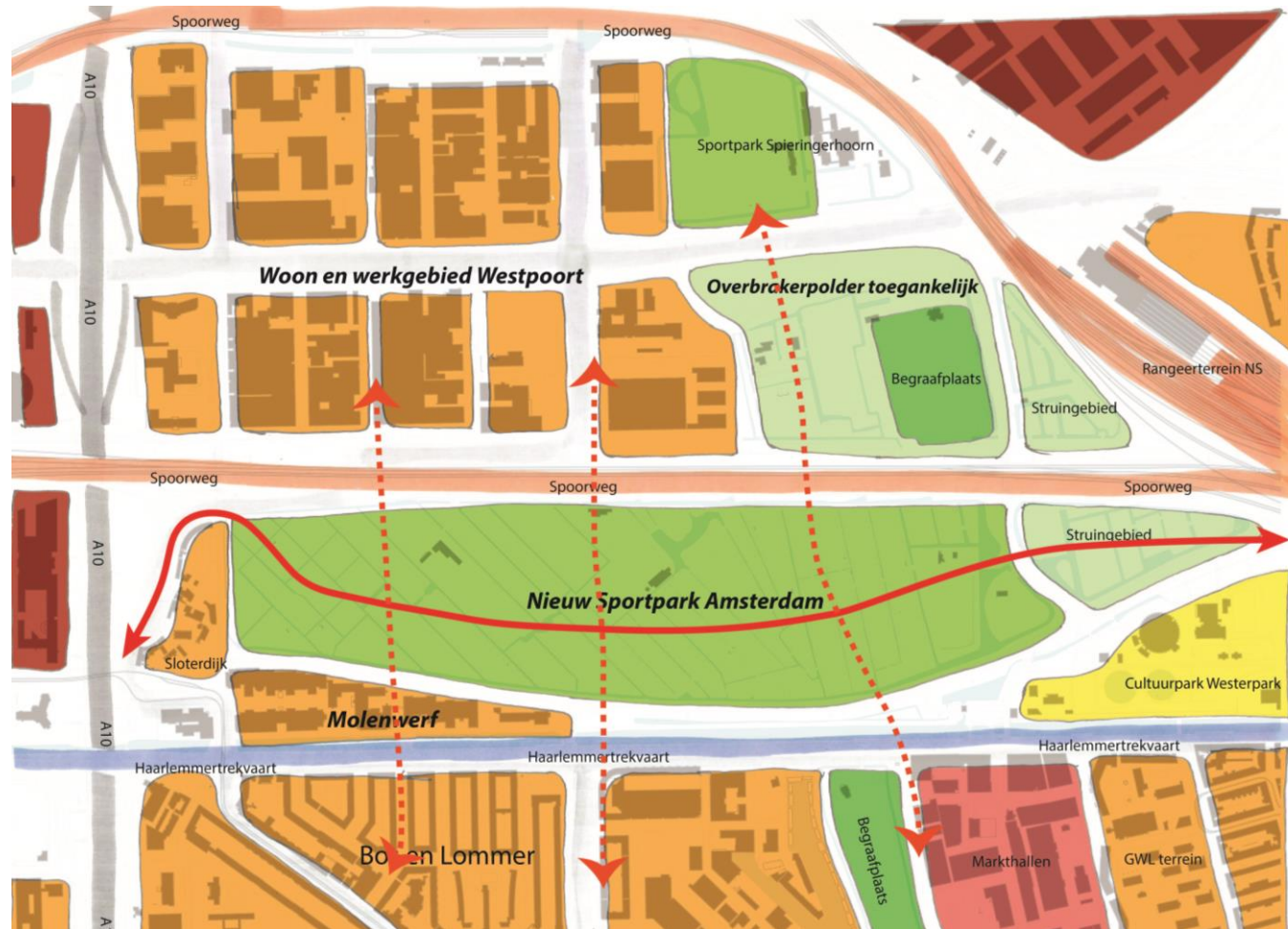


Source; Google Maps

Westerpark – Current Situation



Westerpark – New Functions



Sports Complex at Intersection





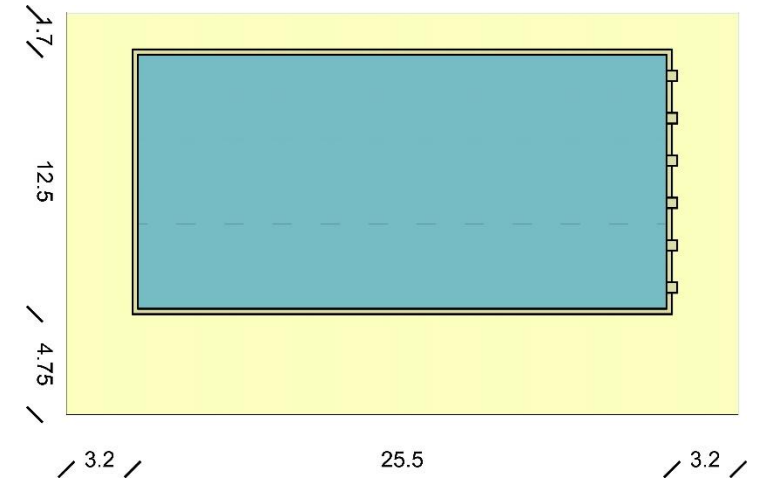
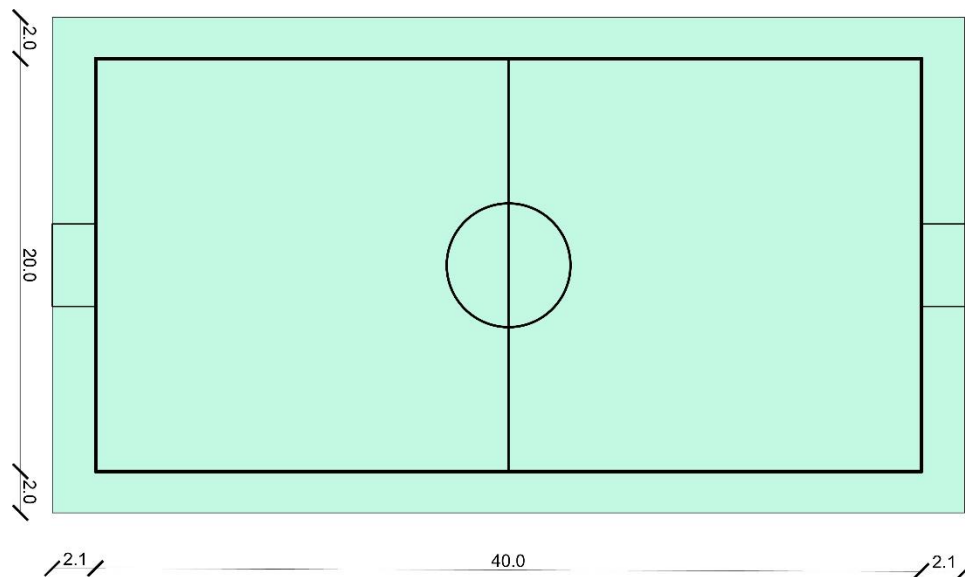
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Public Sports Complex Westerpark

Program, Concept and Design

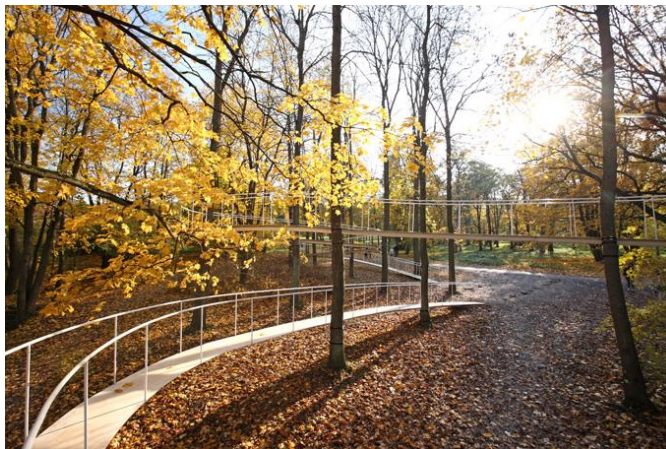
Program

- Multifunctional Sports Hall 44x24 m
- Swimming pool; 12x25 m (6 lanes)
- Central public space in park at intersection



Concept and Design

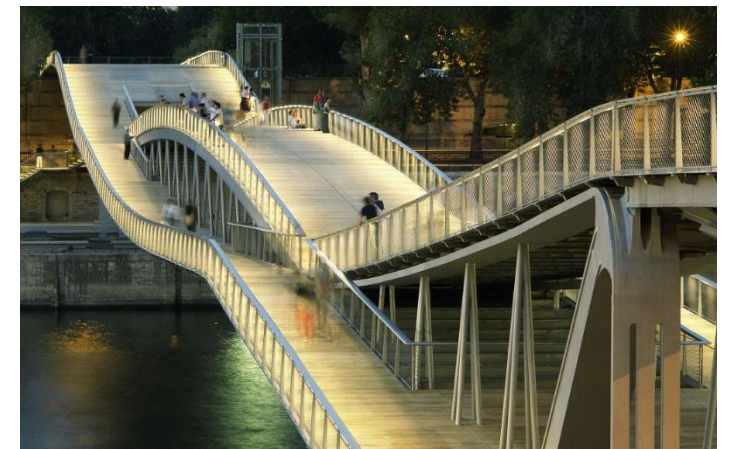
- ▶ Elevated Pathway; experience park on different levels
- ▶ Sportive and Undulating; route itself becomes part of the sports park
- ▶ Pathway determines the shape of the complex



Path in the forest – Tetsuo Kondo

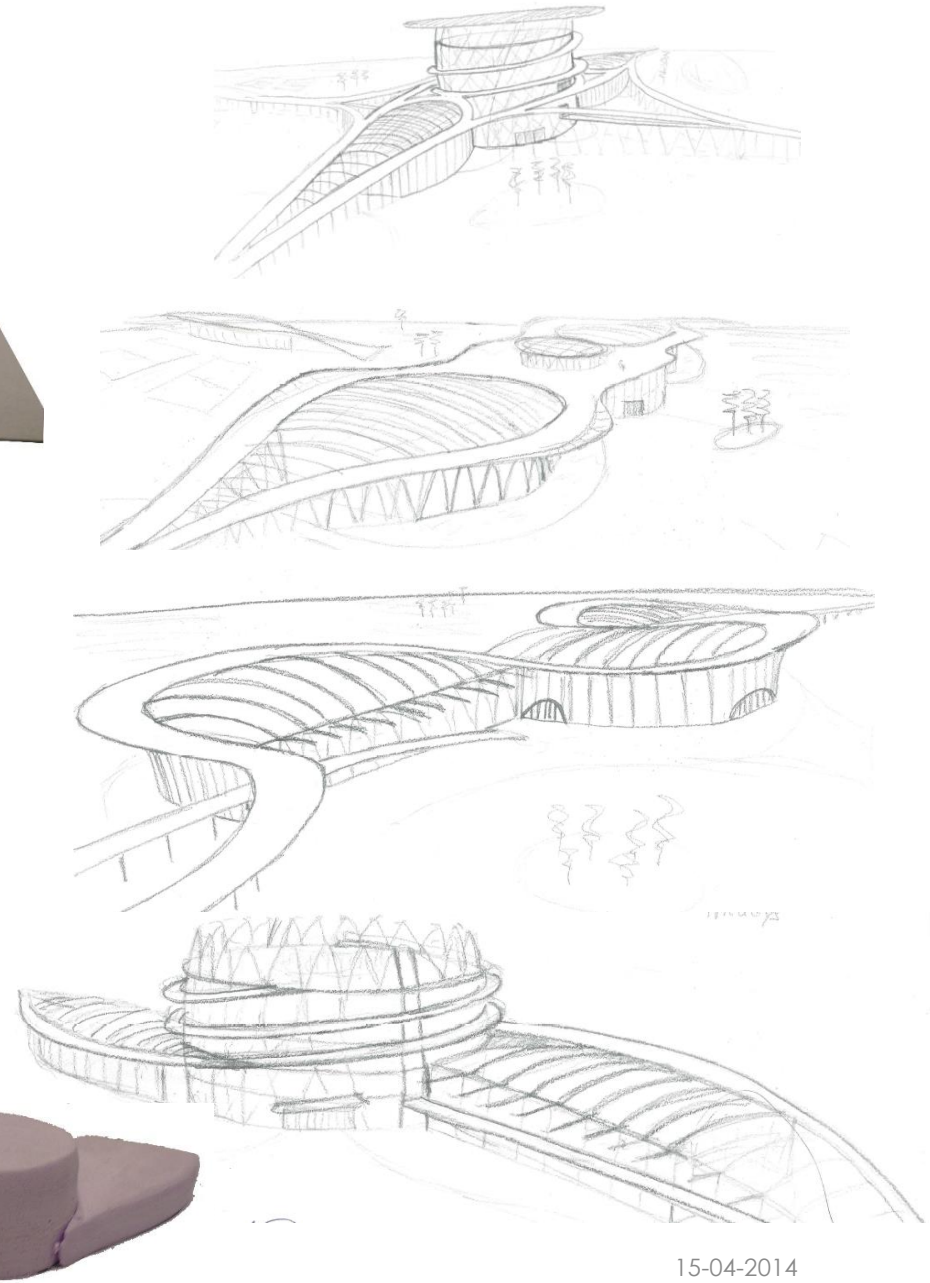
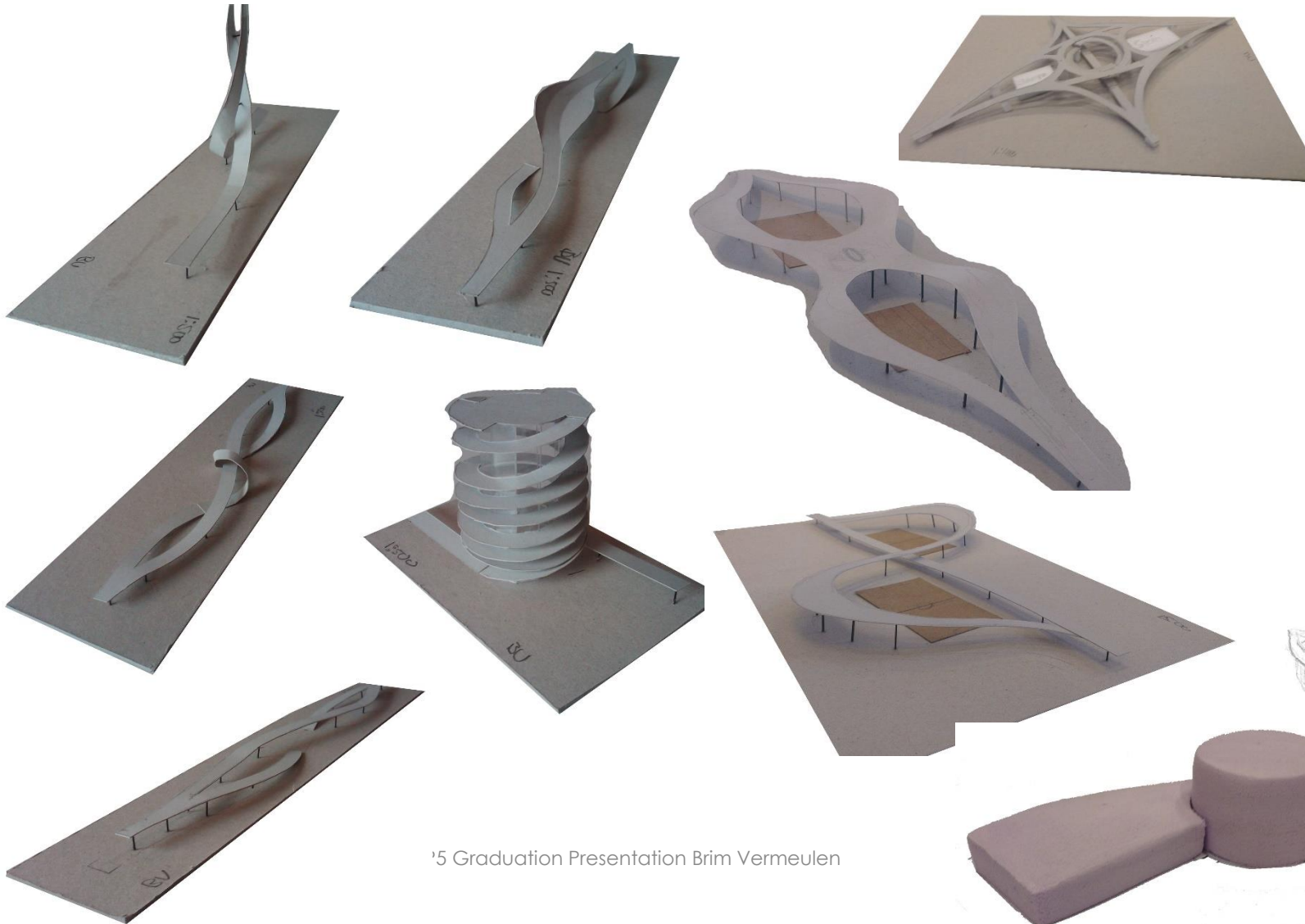


Tiger and Turtle – Heike Mutter, Ullrich Gent

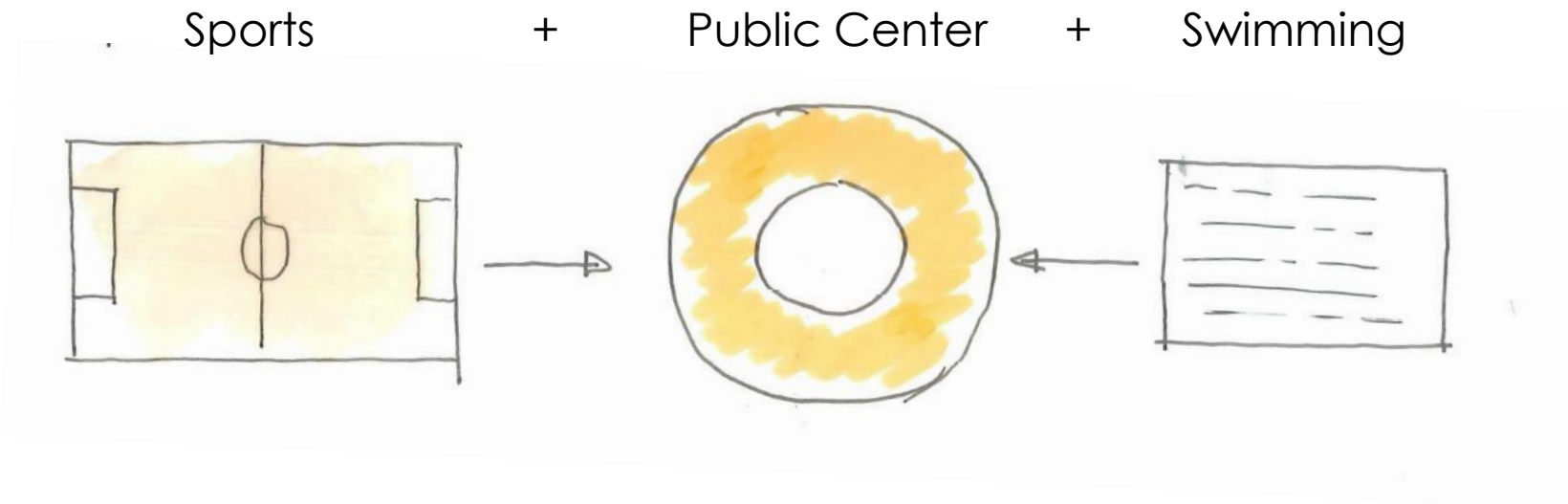


Simone de beauvoir - Dietmar Feichtinger Architectes

Formfinding

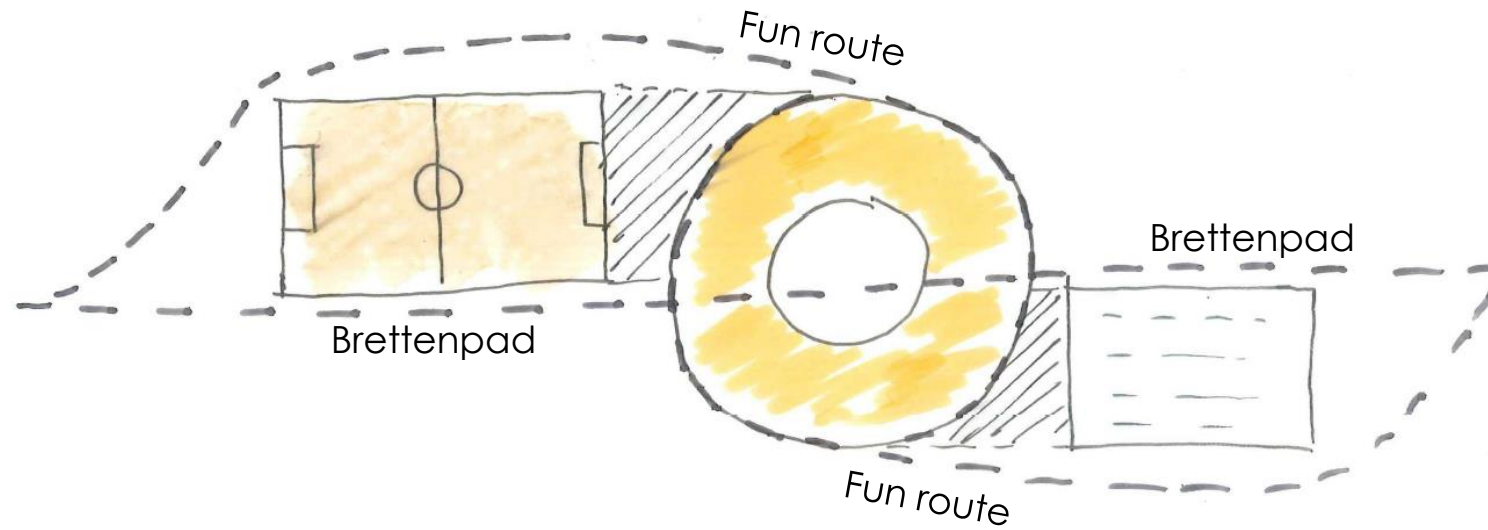


Functional Set-up

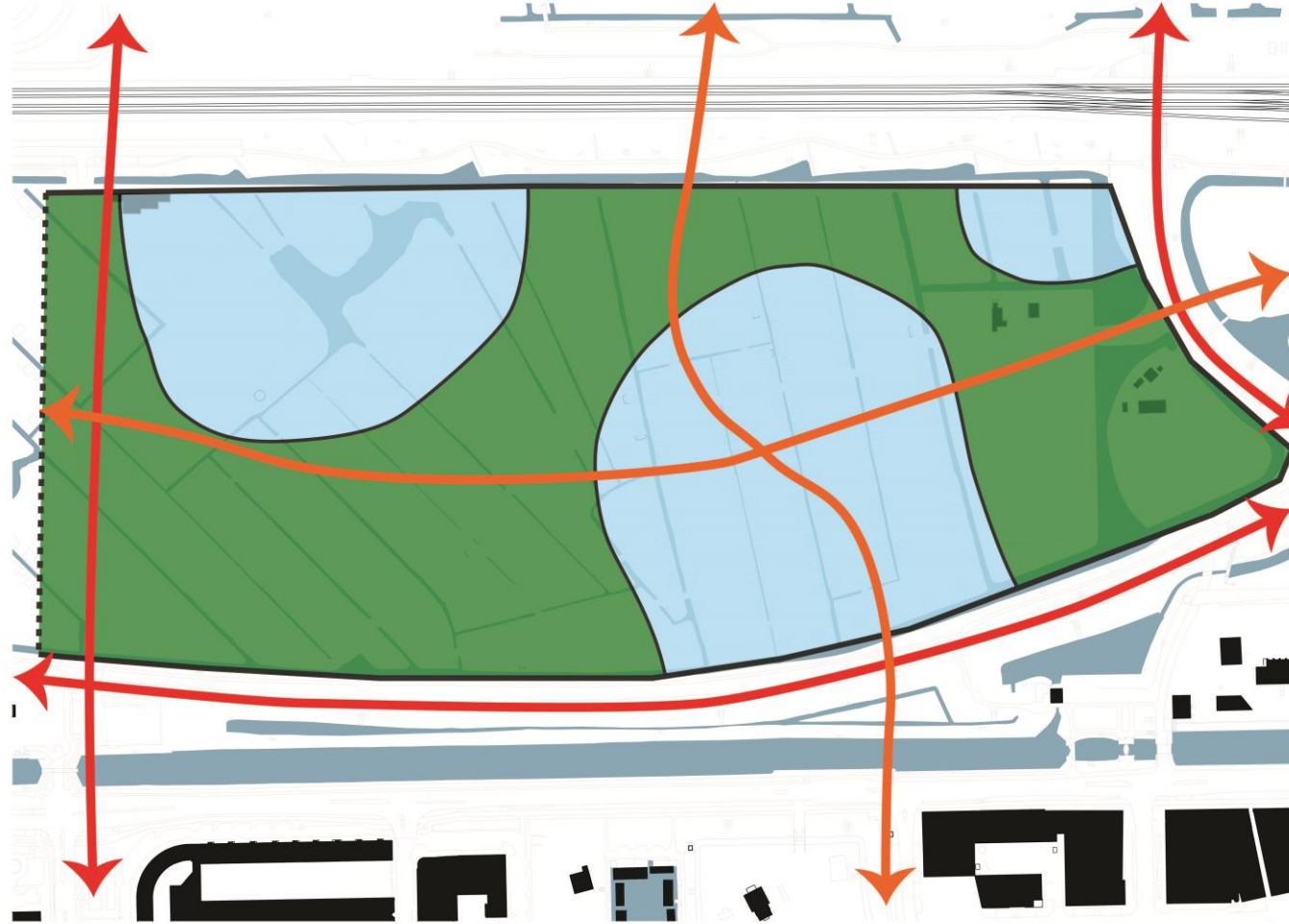


Functional Set-up

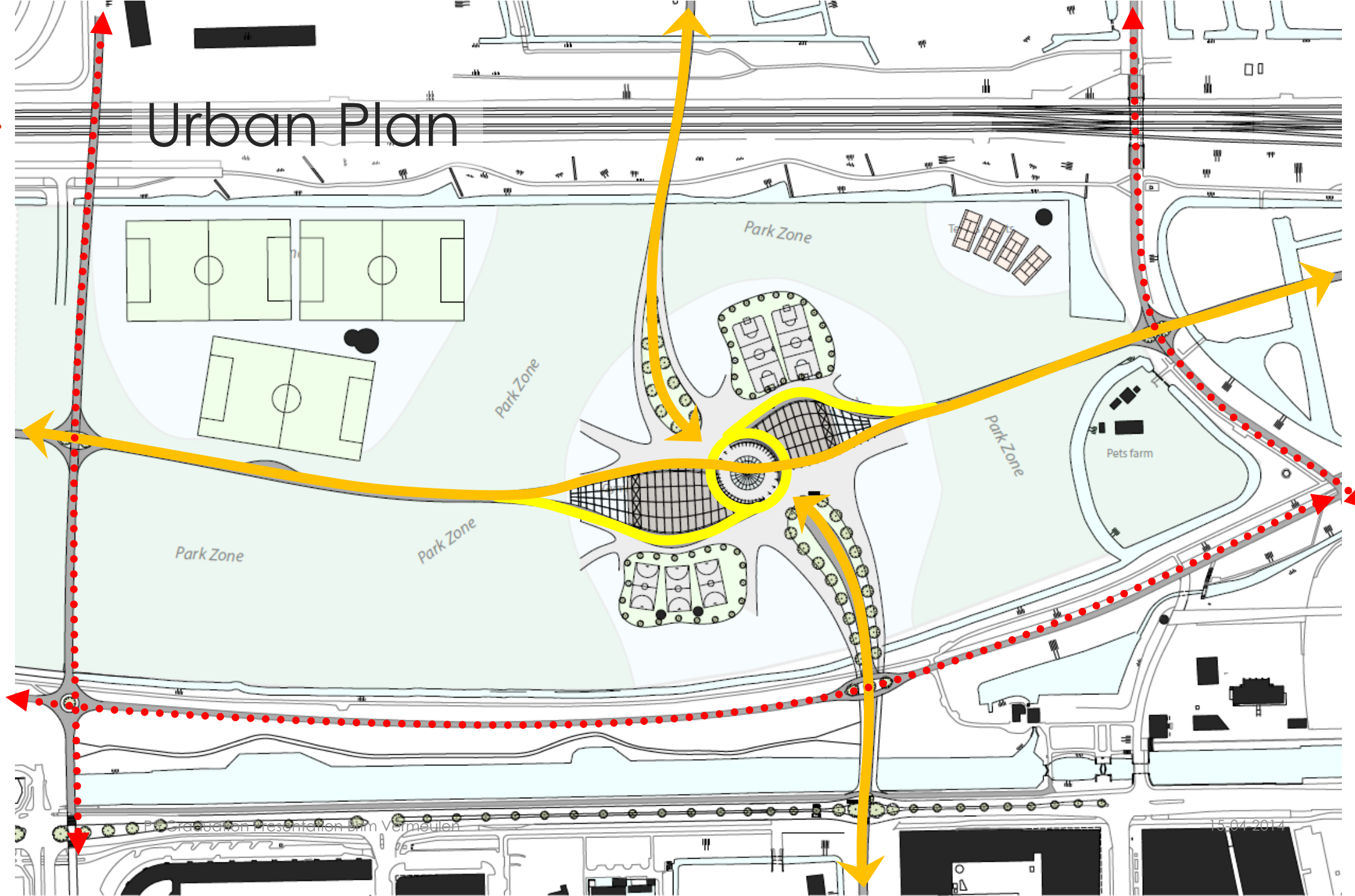
Sports + Public Center + Swimming

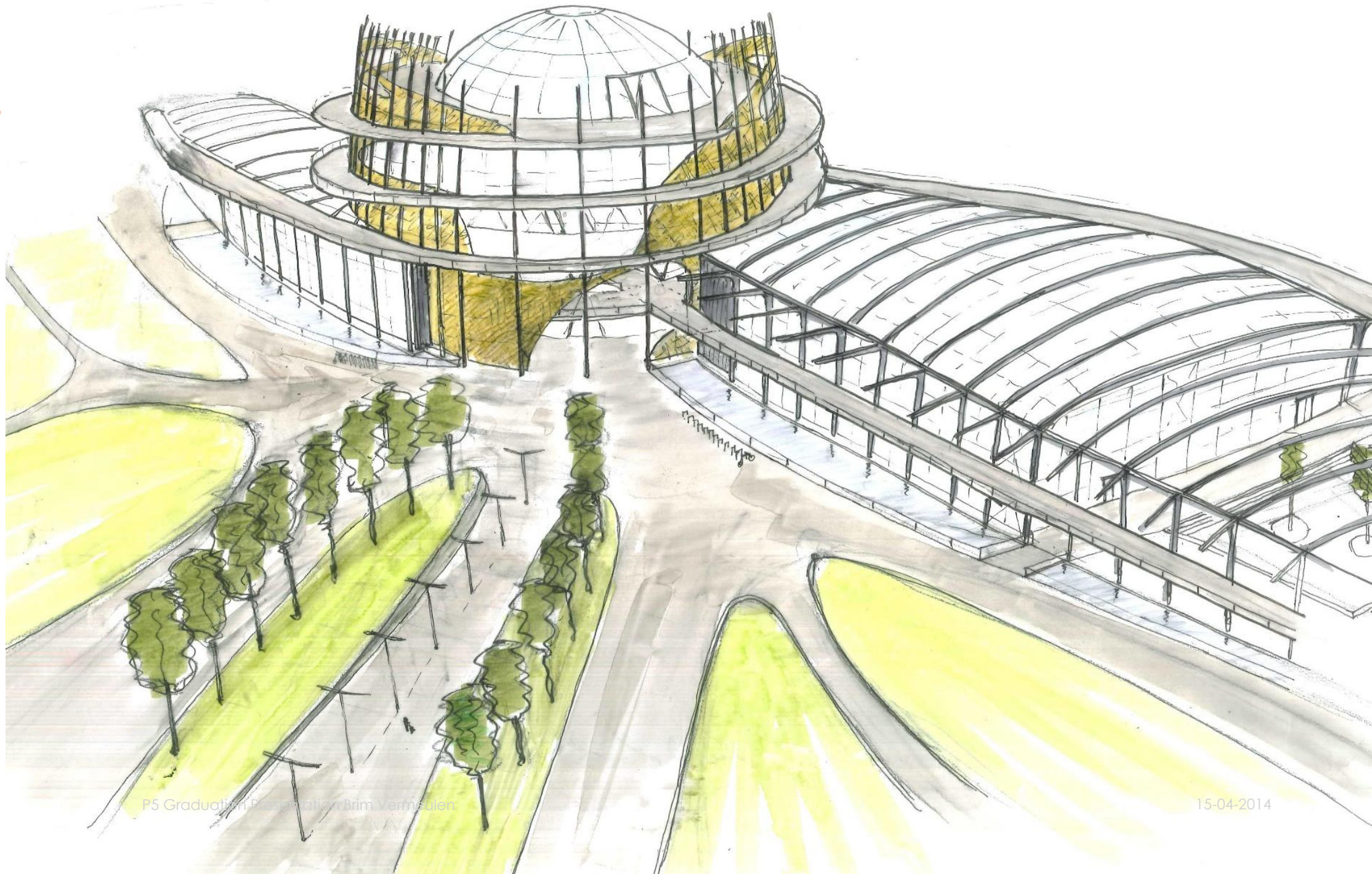


Zoom to building scale

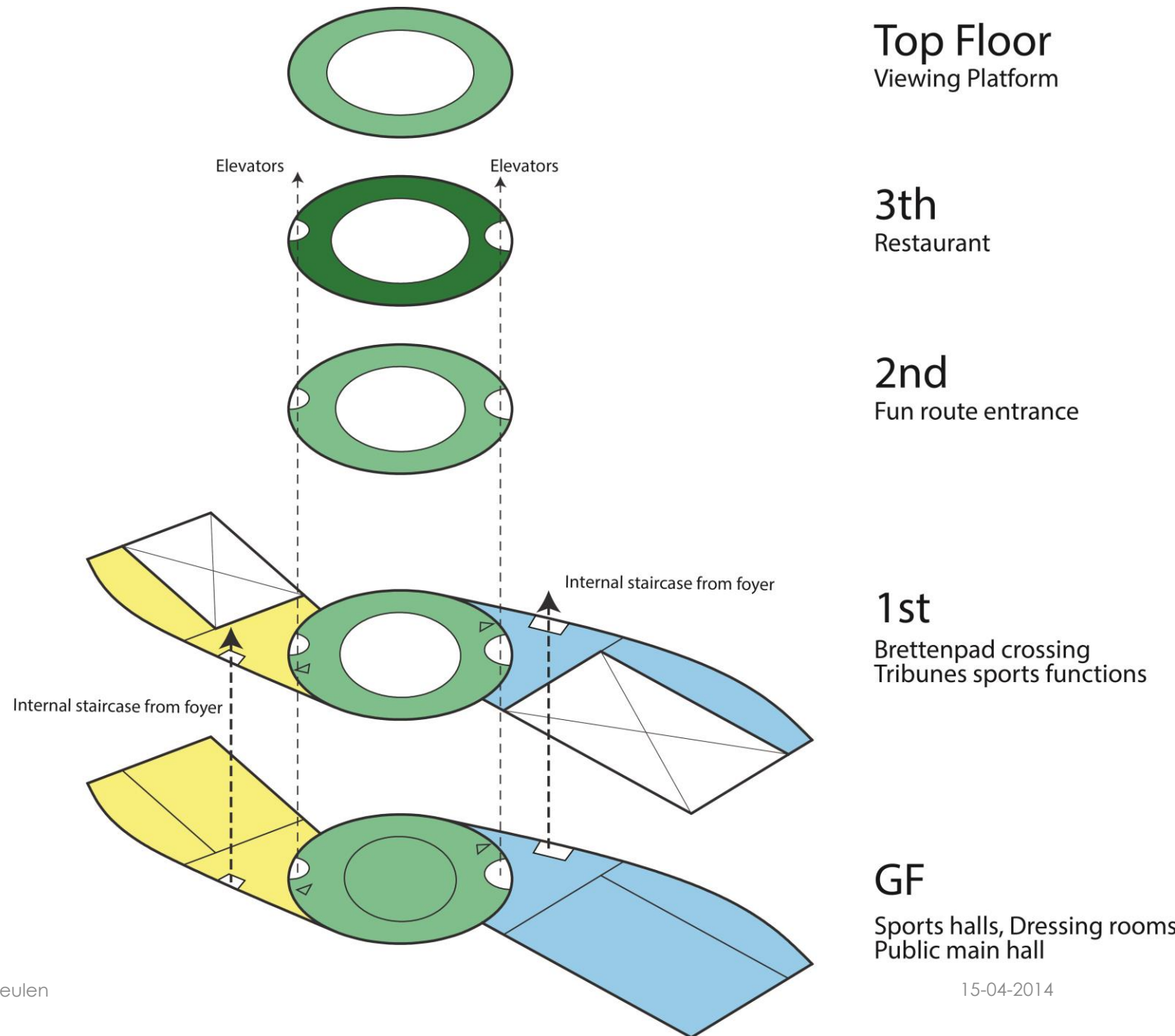


Urban Plan





Function/ Routing



Function/ Routing

Atrium staircase from GF to top floor

Elevators

Elevators

Internal staircase from foyer

Internal staircase from foyer

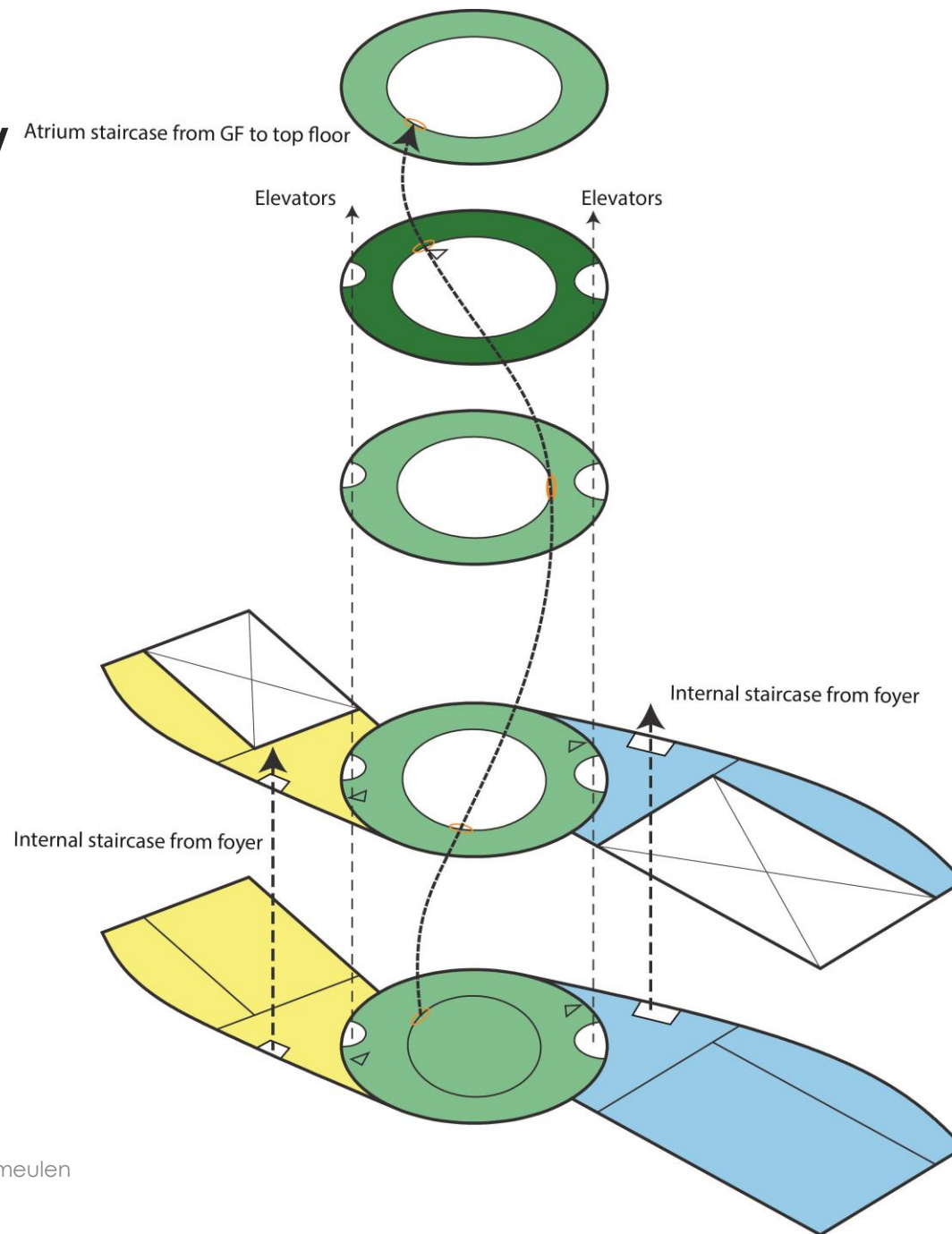
Top Floor
Viewing Platform

3th
Restaurant

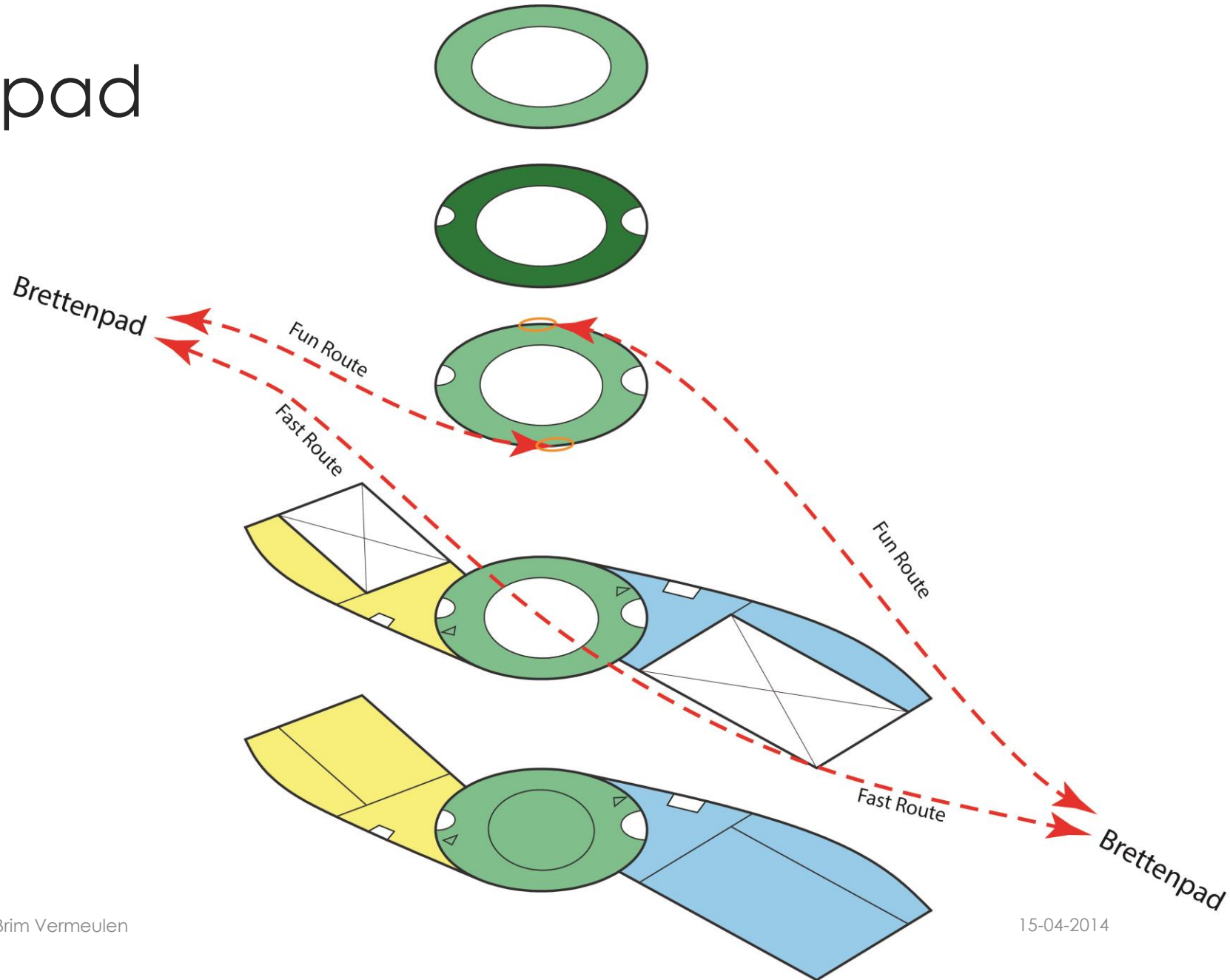
2nd
Fun route entrance

1st
Brettenpad crossing
Tribunes sports functions

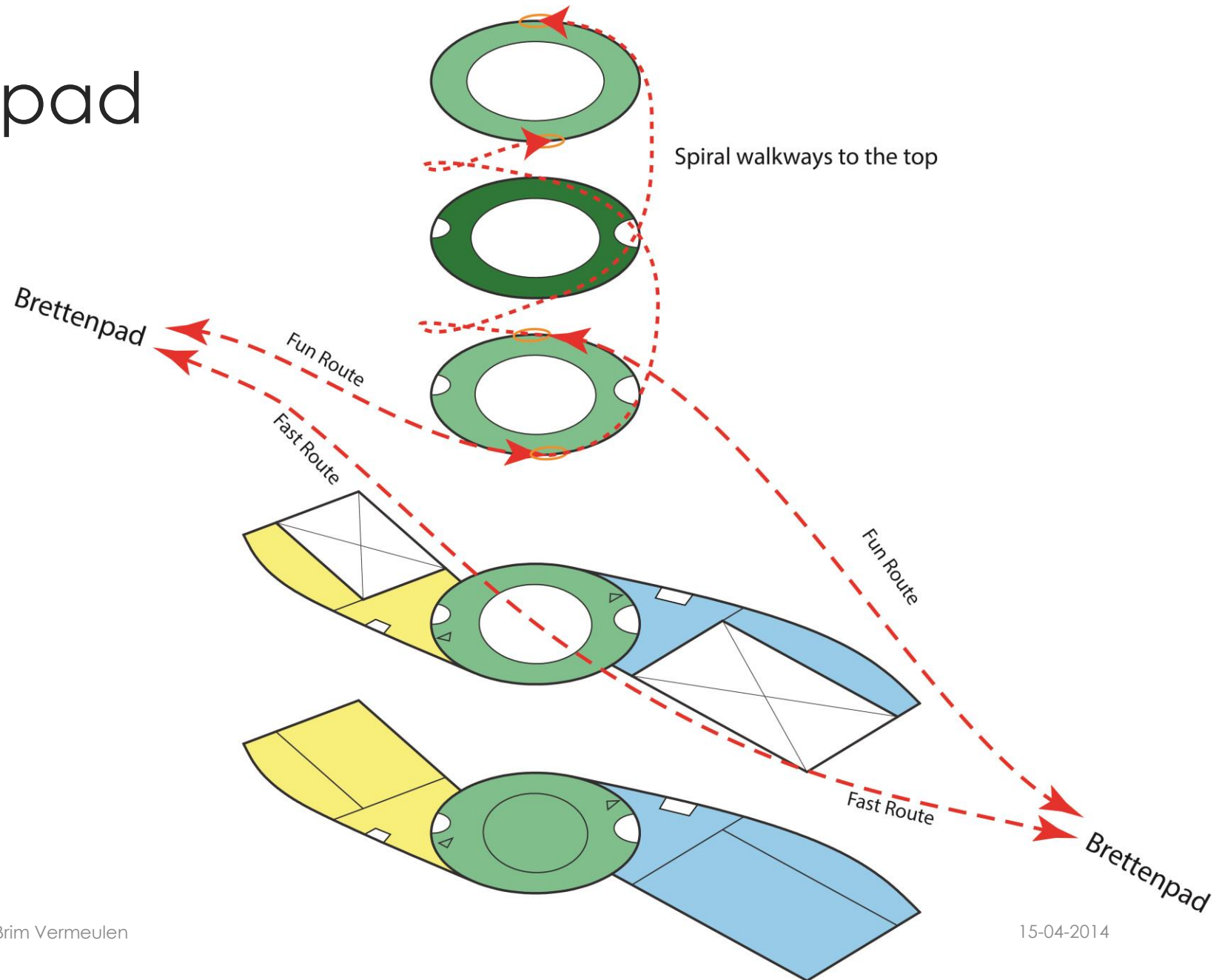
GF
Sports halls, Dressing rooms
Public main hall



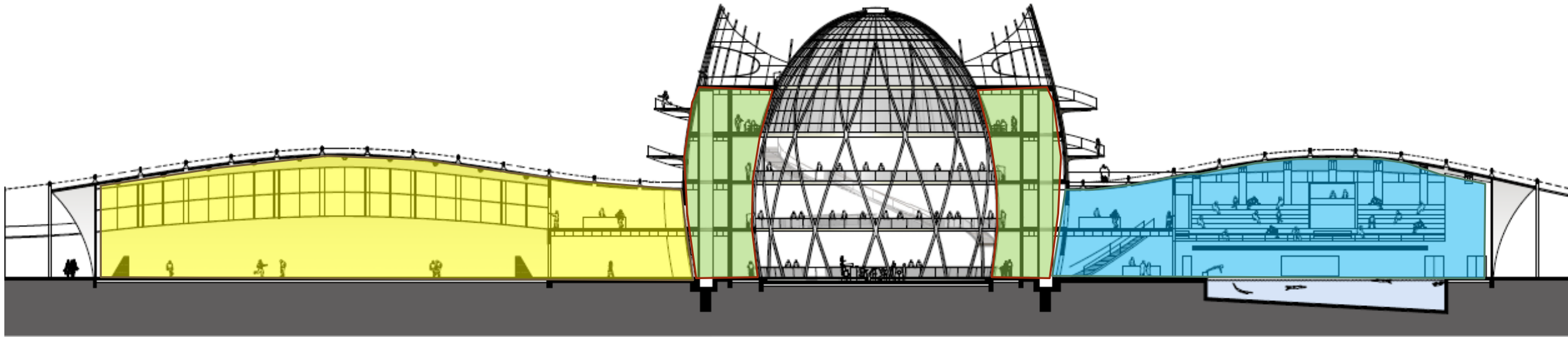
Brettenpad

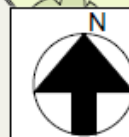
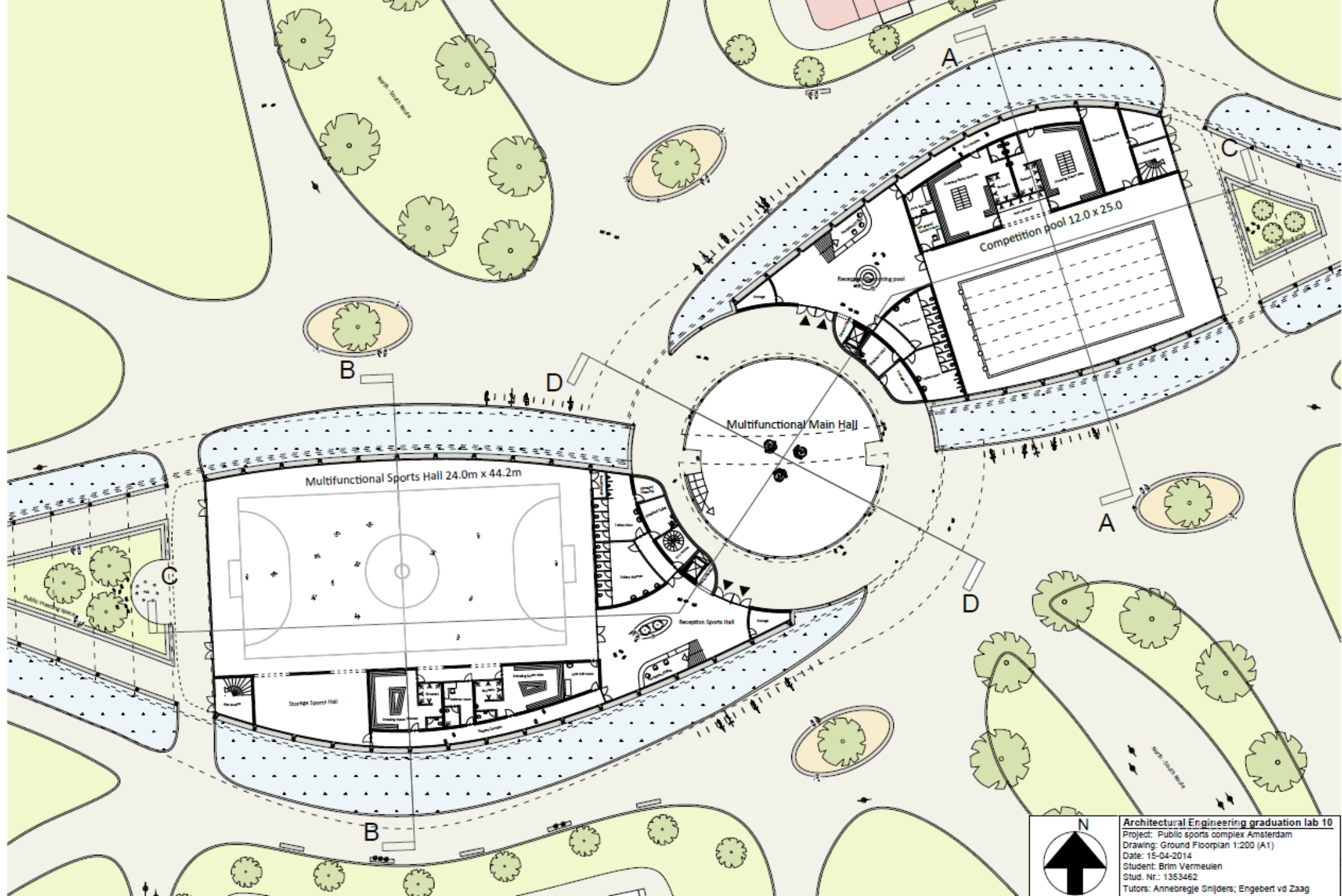


Brettenpad

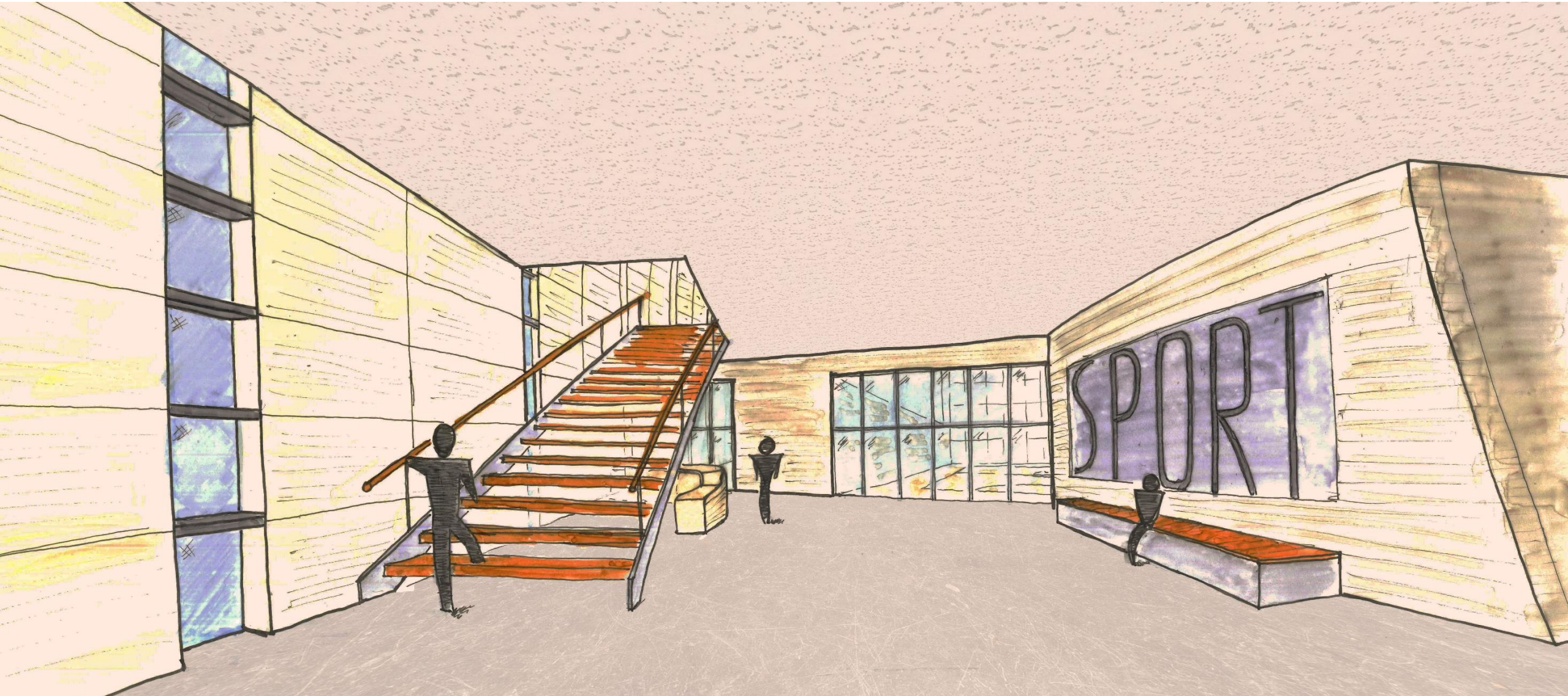


Longitudinal Section

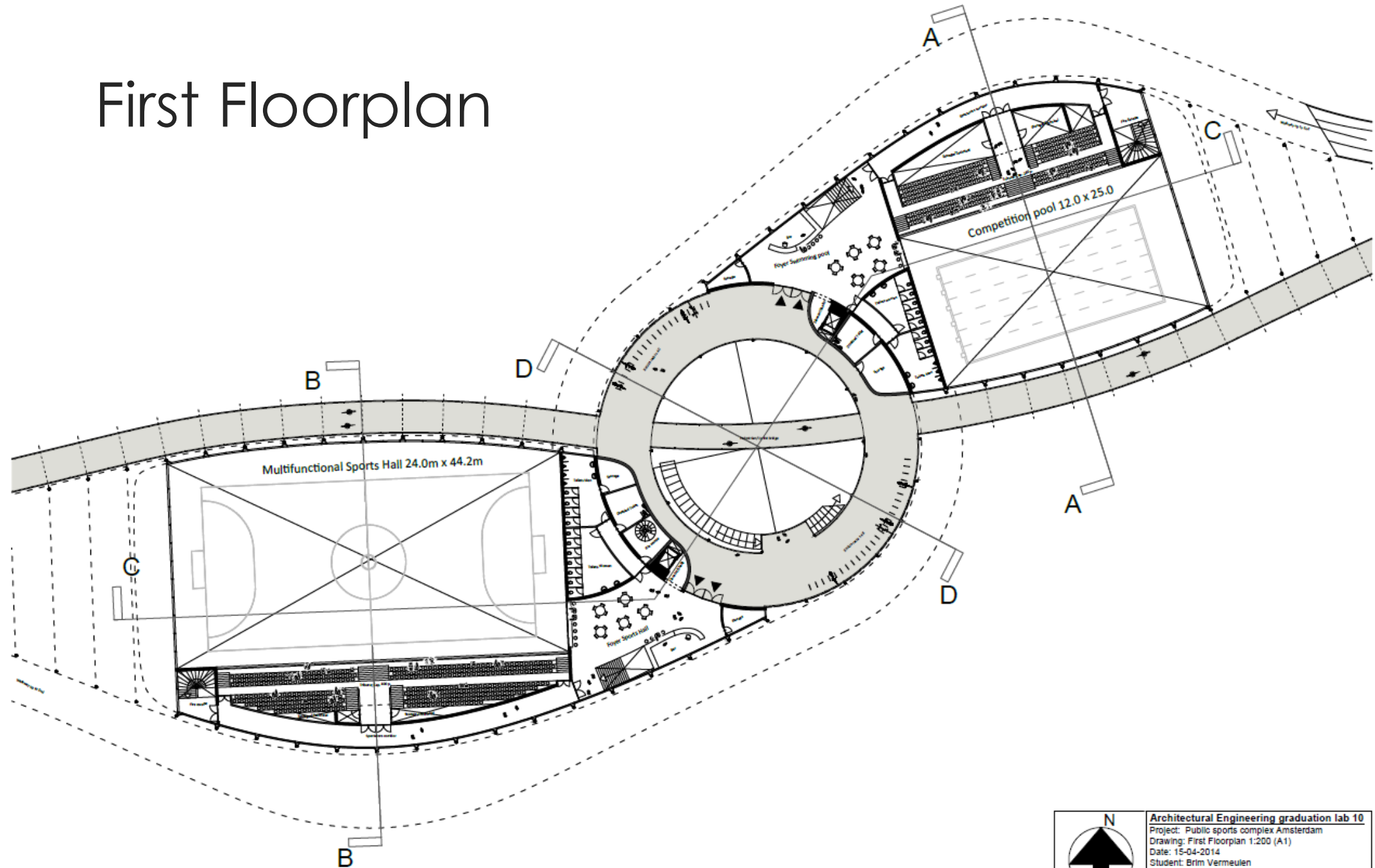




Entrance Sports Foyer



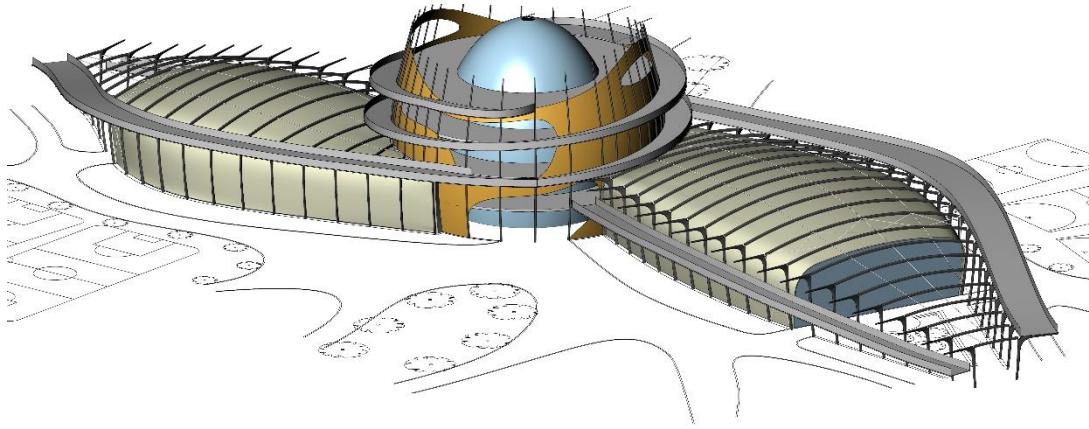
First Floorplan



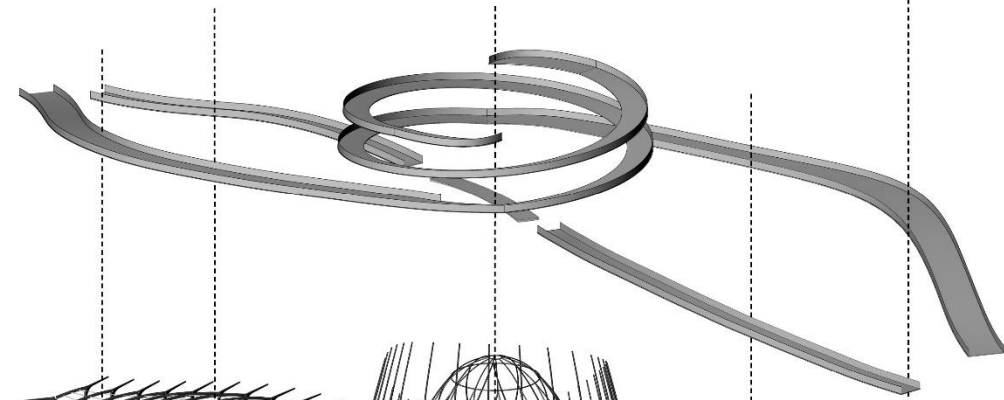
Structural Design vs Architecture

UHPFRC in design, structural systems, structural elements, experience

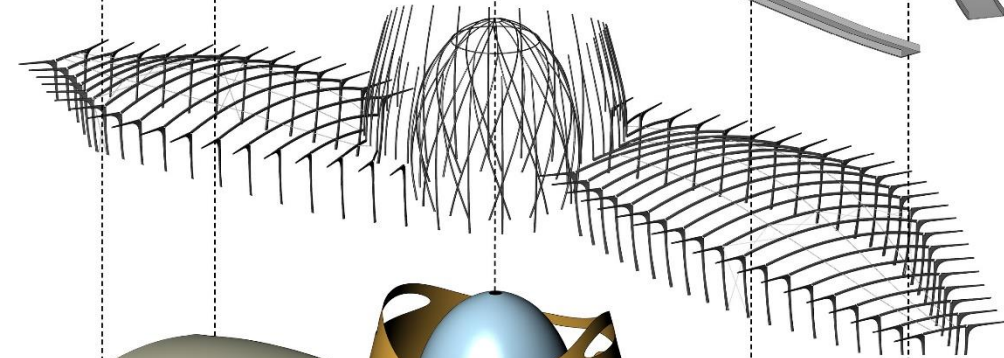
Exploded view



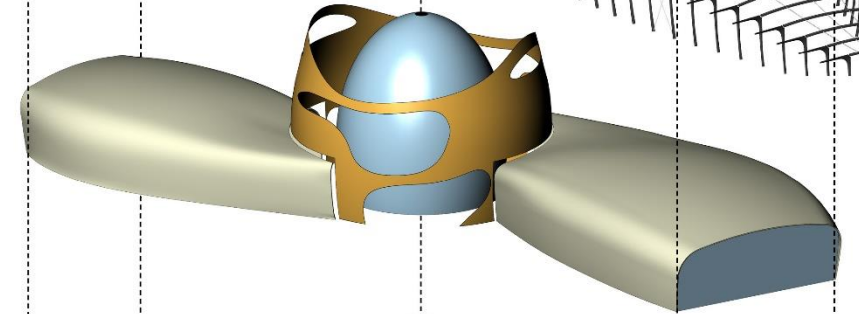
WALKWAYS UHPFRC



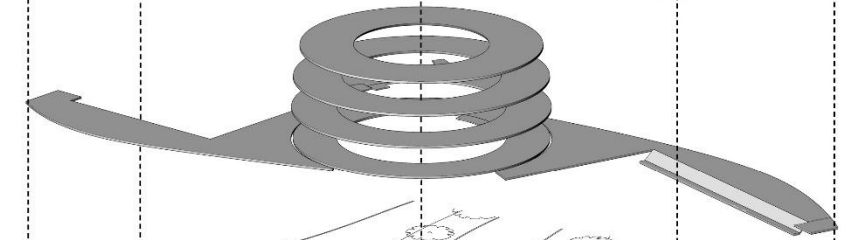
EXOSKELETON UHPFRC



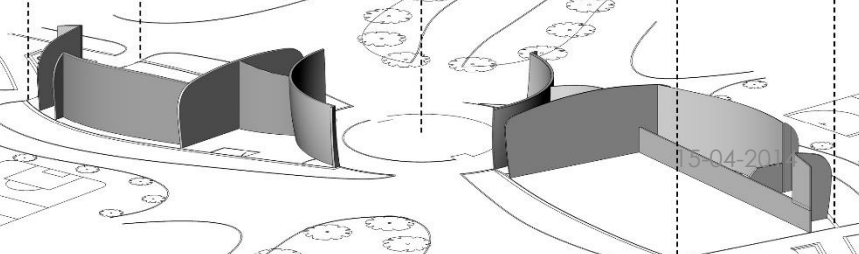
FACADES (volumes)



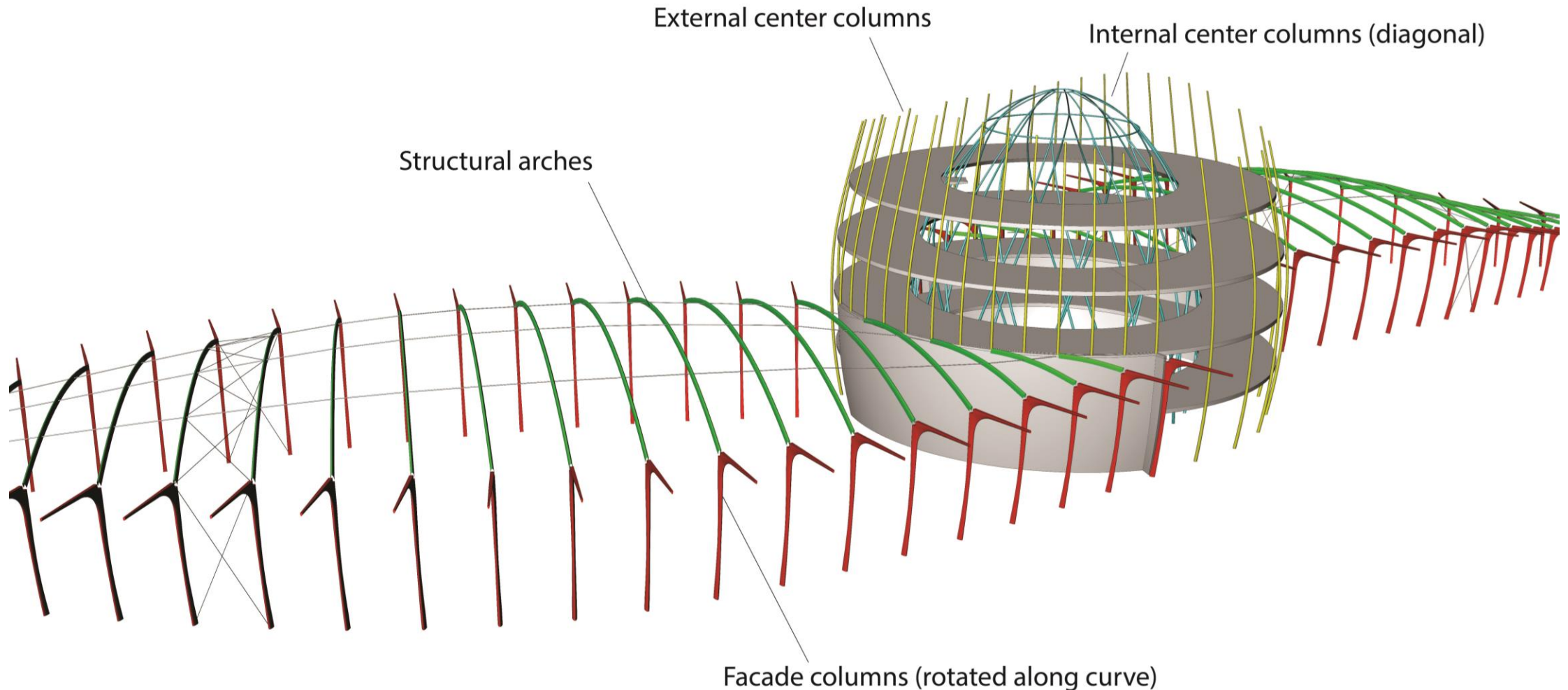
FLOORS



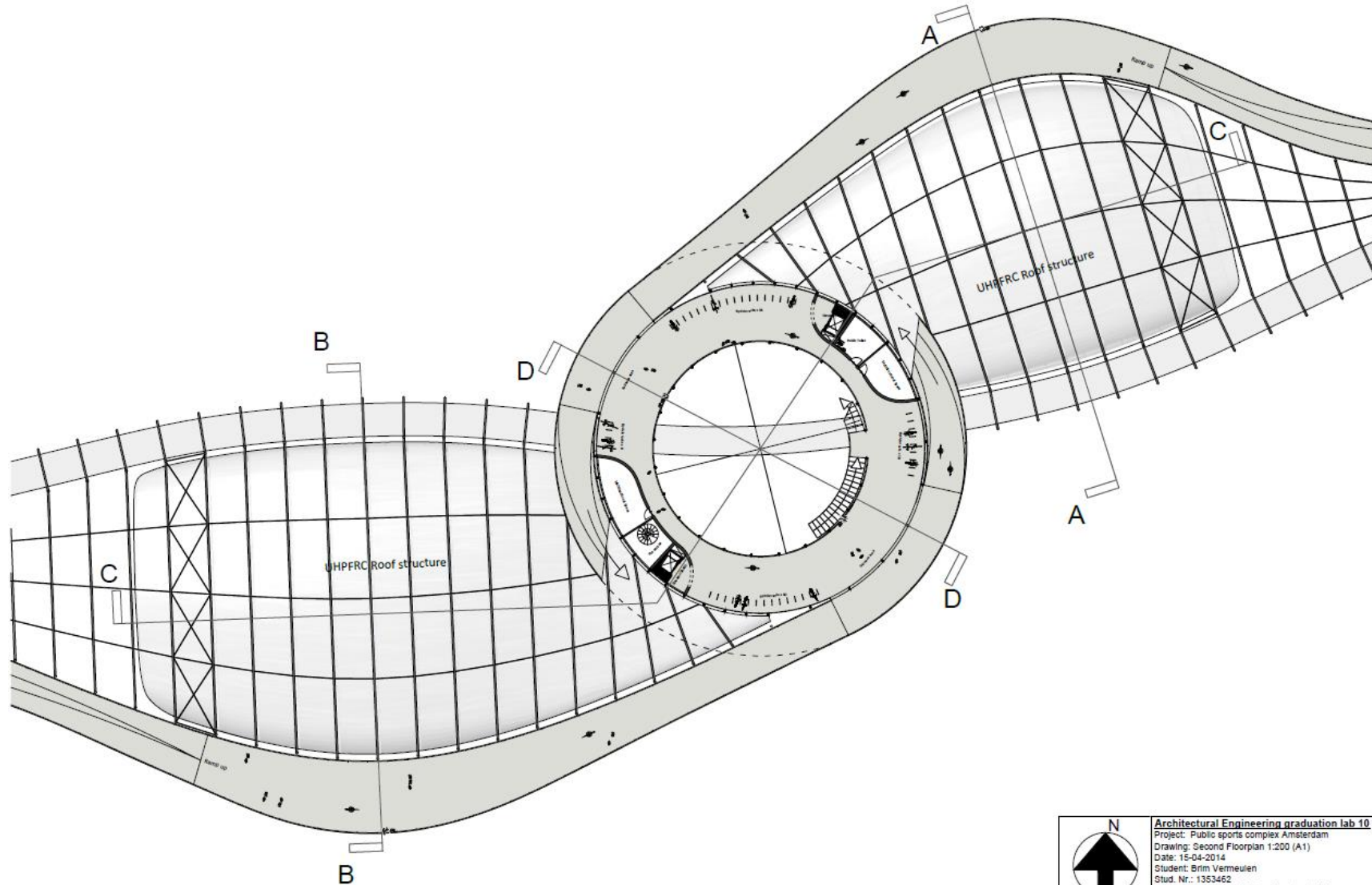
WALLS



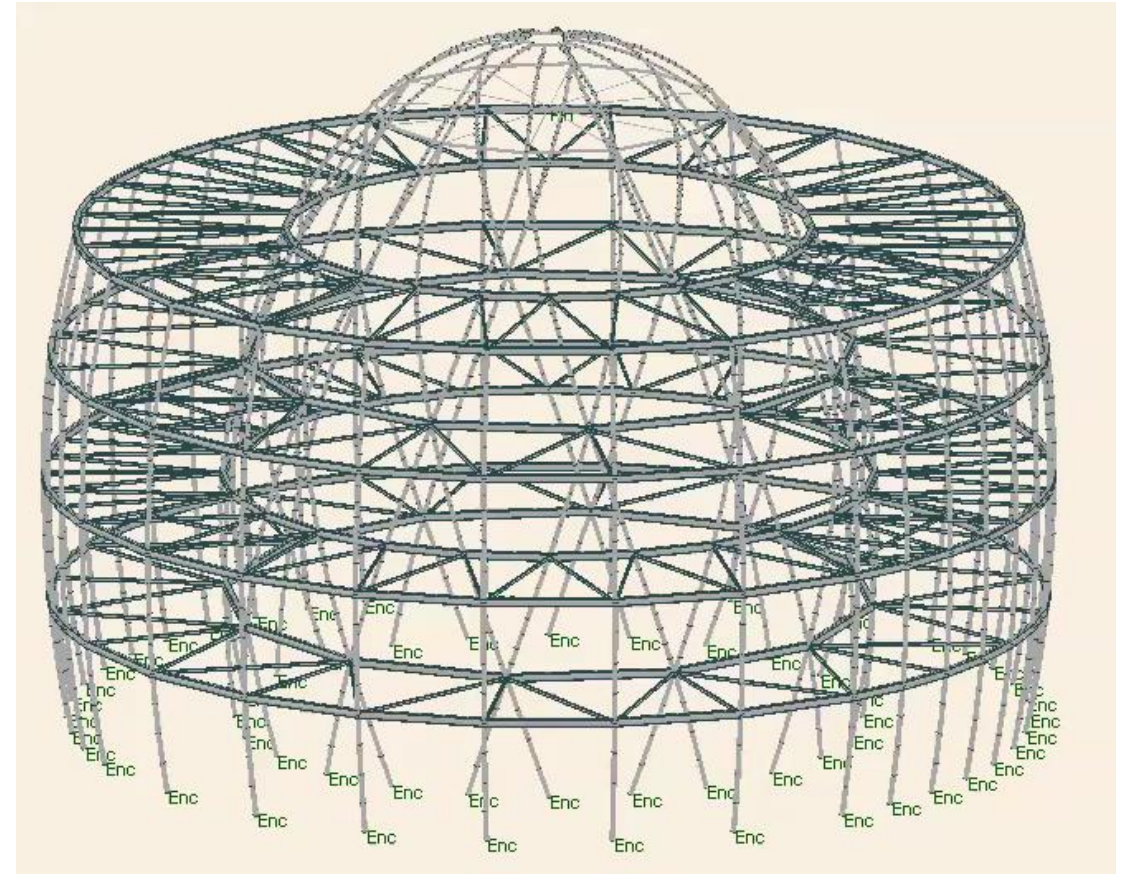
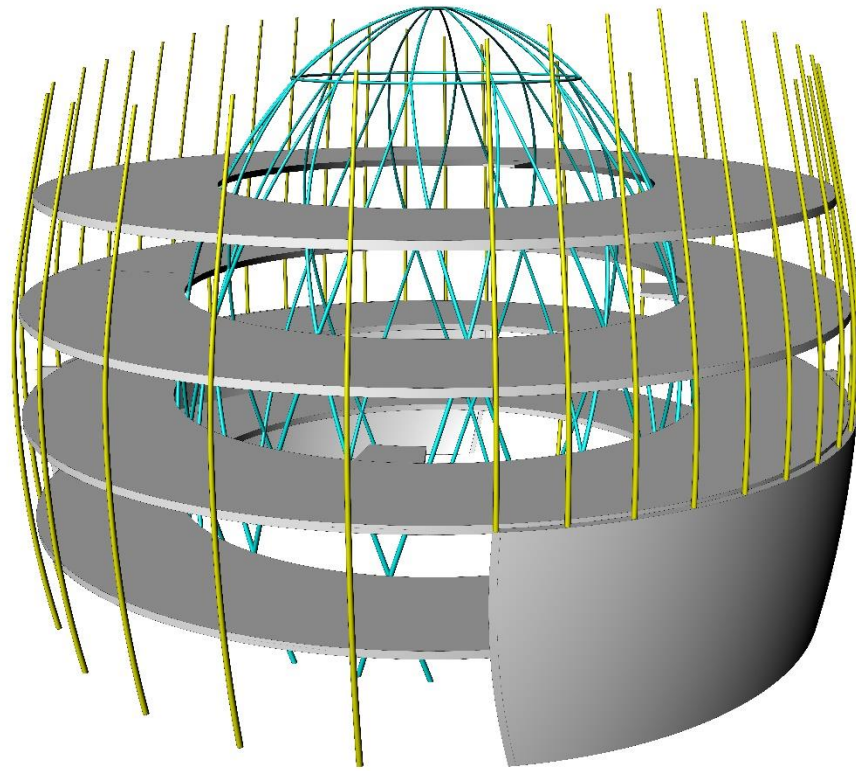
Structural Design; Prefab UHPFRC



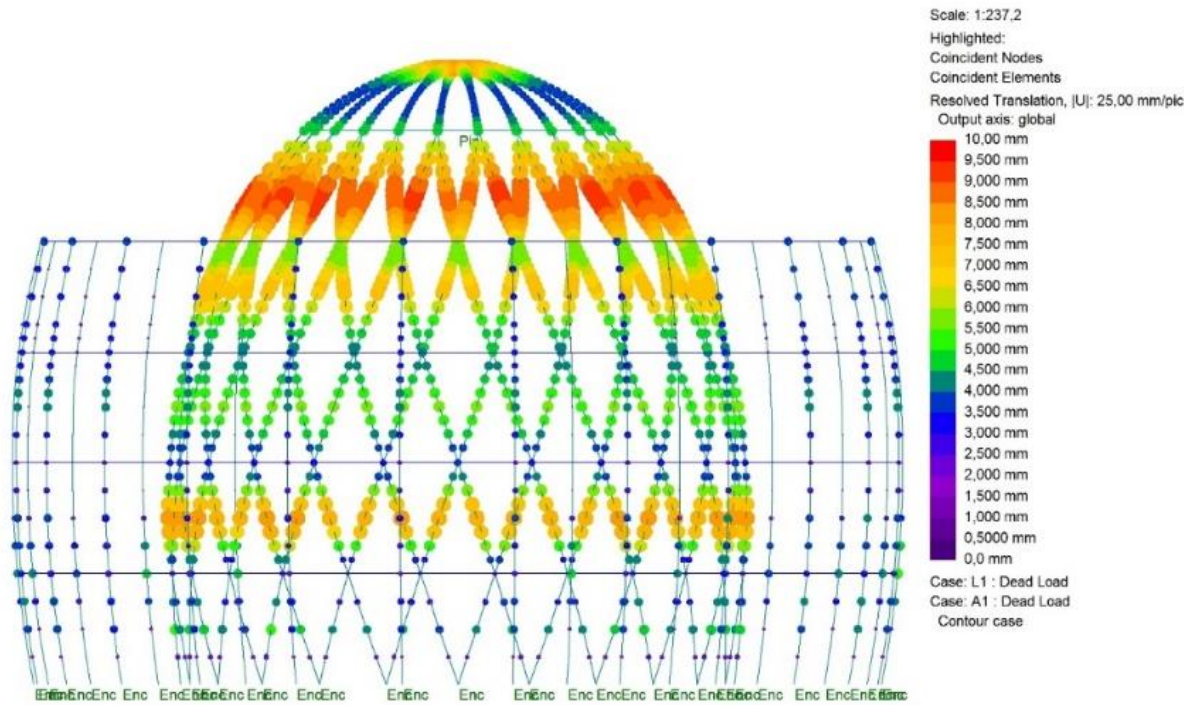
Structural Design; Second Floorplan



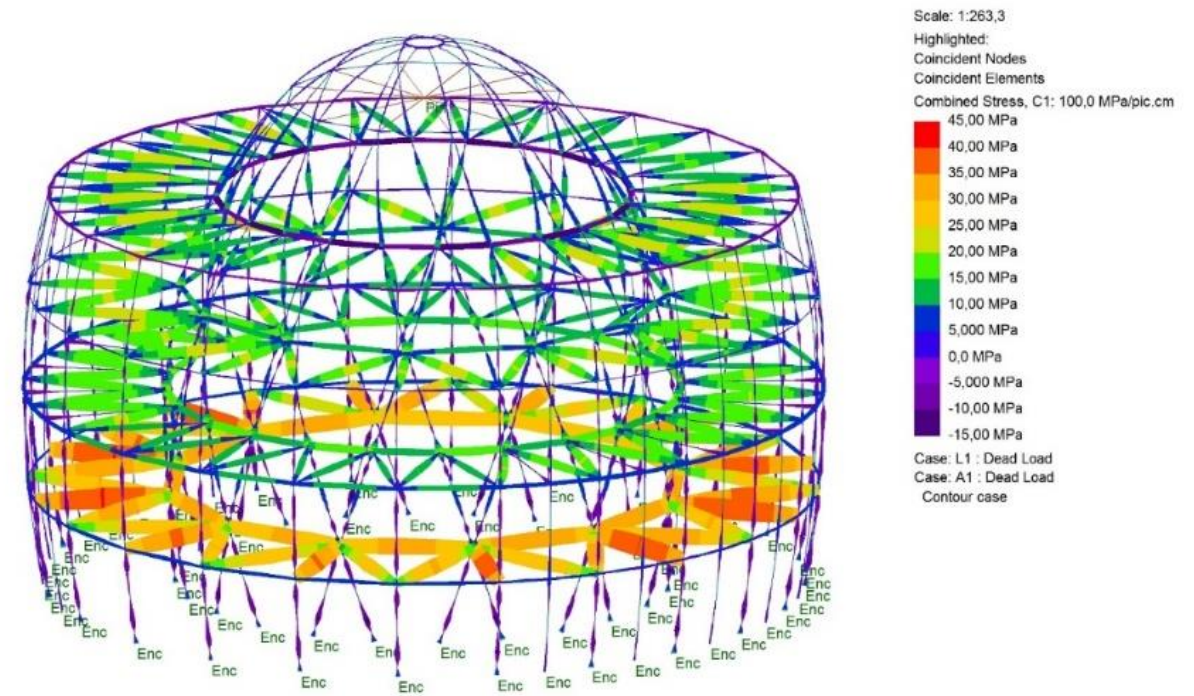
Center Structure Analysis



GSA Analysis – LC1 Dead Load

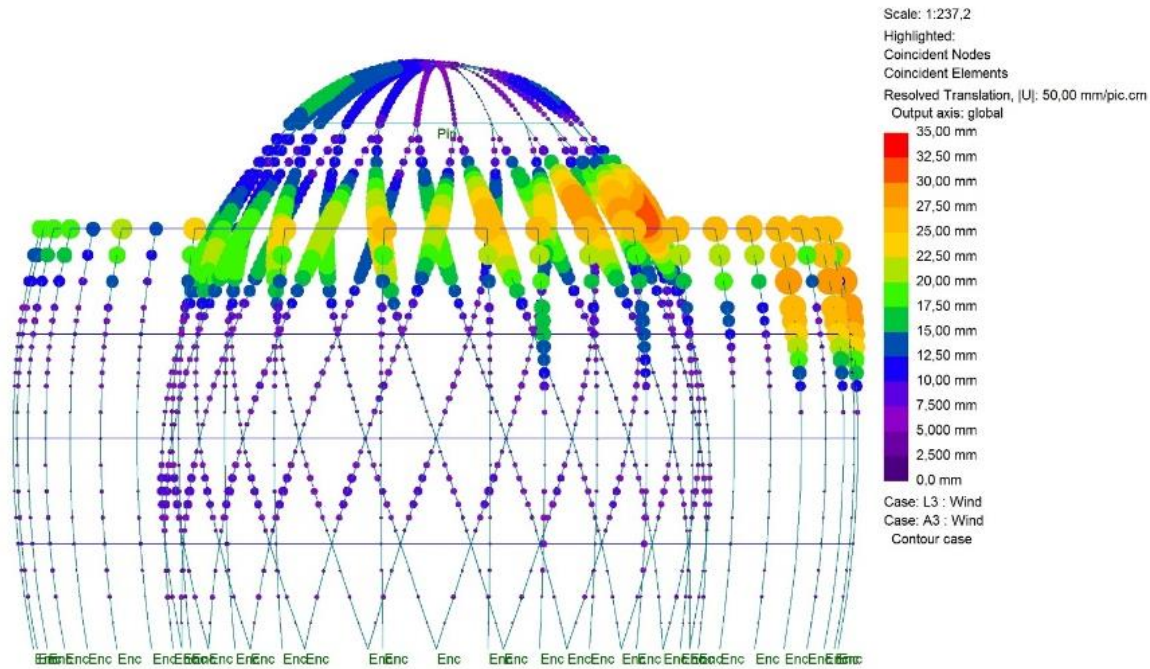


Deflections

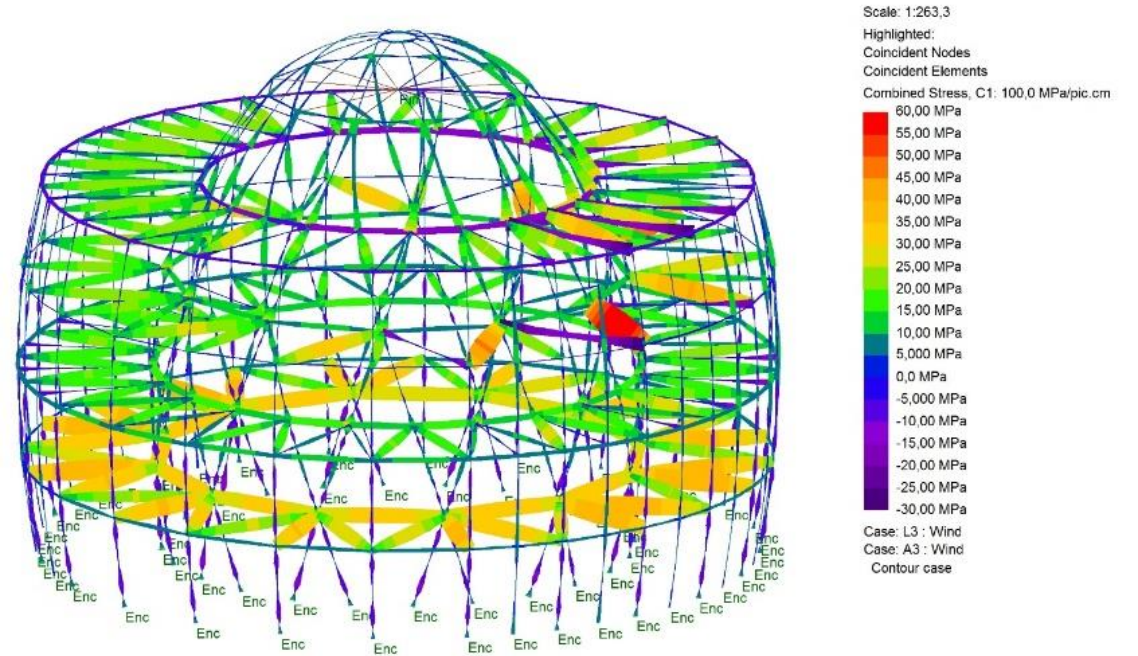


Combined stresses (C1)

GSA Analysis – LC2 Wind Load

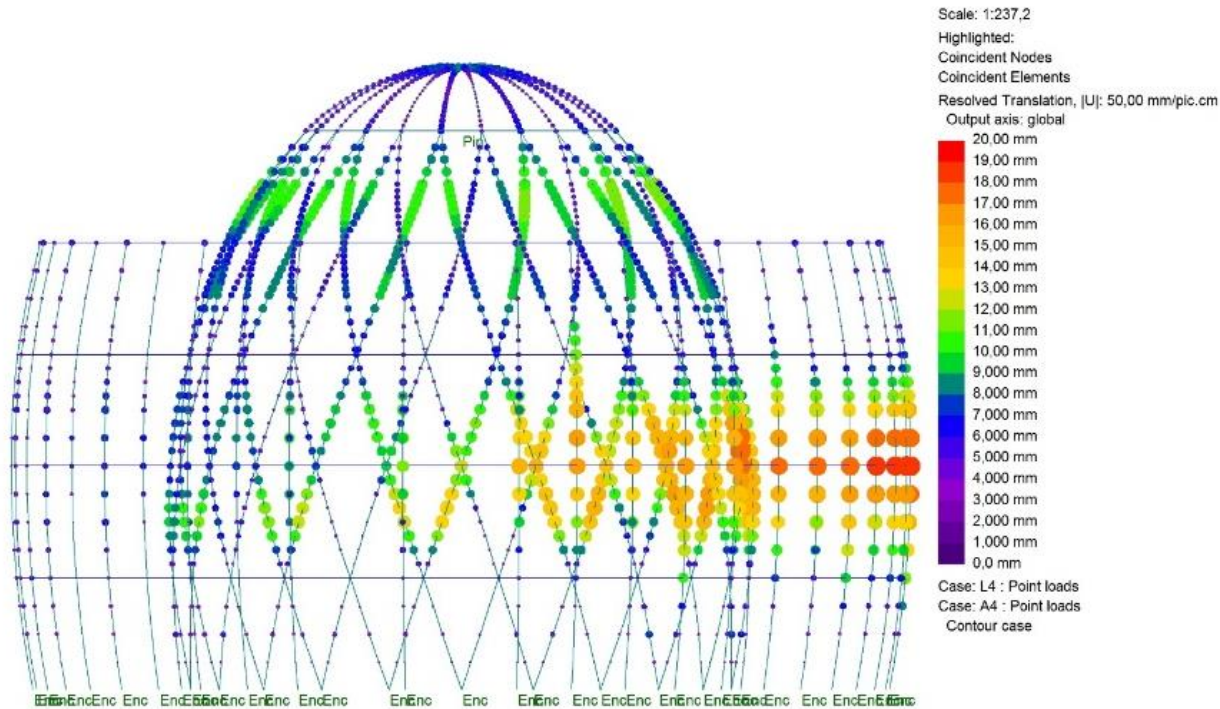


Deflections

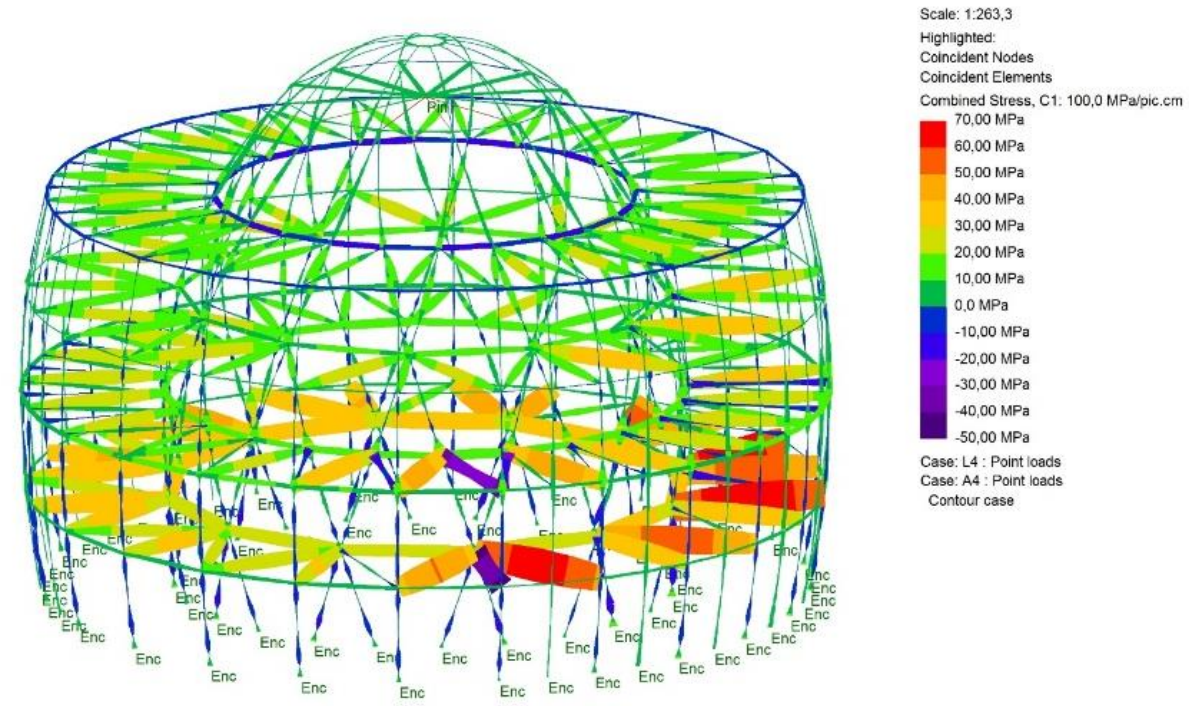


Combined stresses (C1)

GSA Analysis – LC3 Point loads



Deflections



Combined stresses (C1)

Results

External (yellow)

Top: $\varnothing 150\text{mm}$

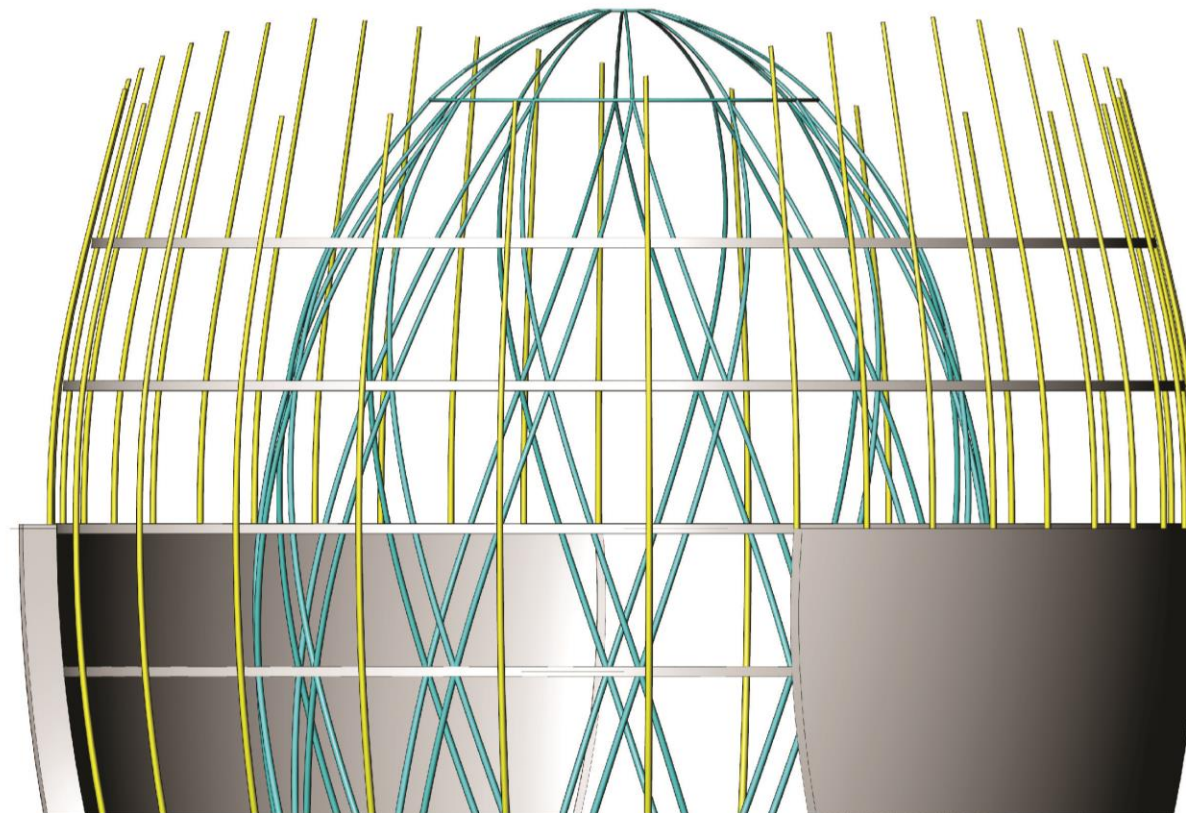
4th: $\varnothing 180\text{mm}$

3th: $\varnothing 200\text{mm}$

2nd: $\varnothing 220\text{mm}$

1st: $\varnothing 240\text{mm}$

Bottom $\varnothing 260\text{mm}$



Internal (blue)

Top: $\varnothing 100\text{mm}$

4th: $\varnothing 140\text{mm}$

3th: $\varnothing 190\text{mm}$

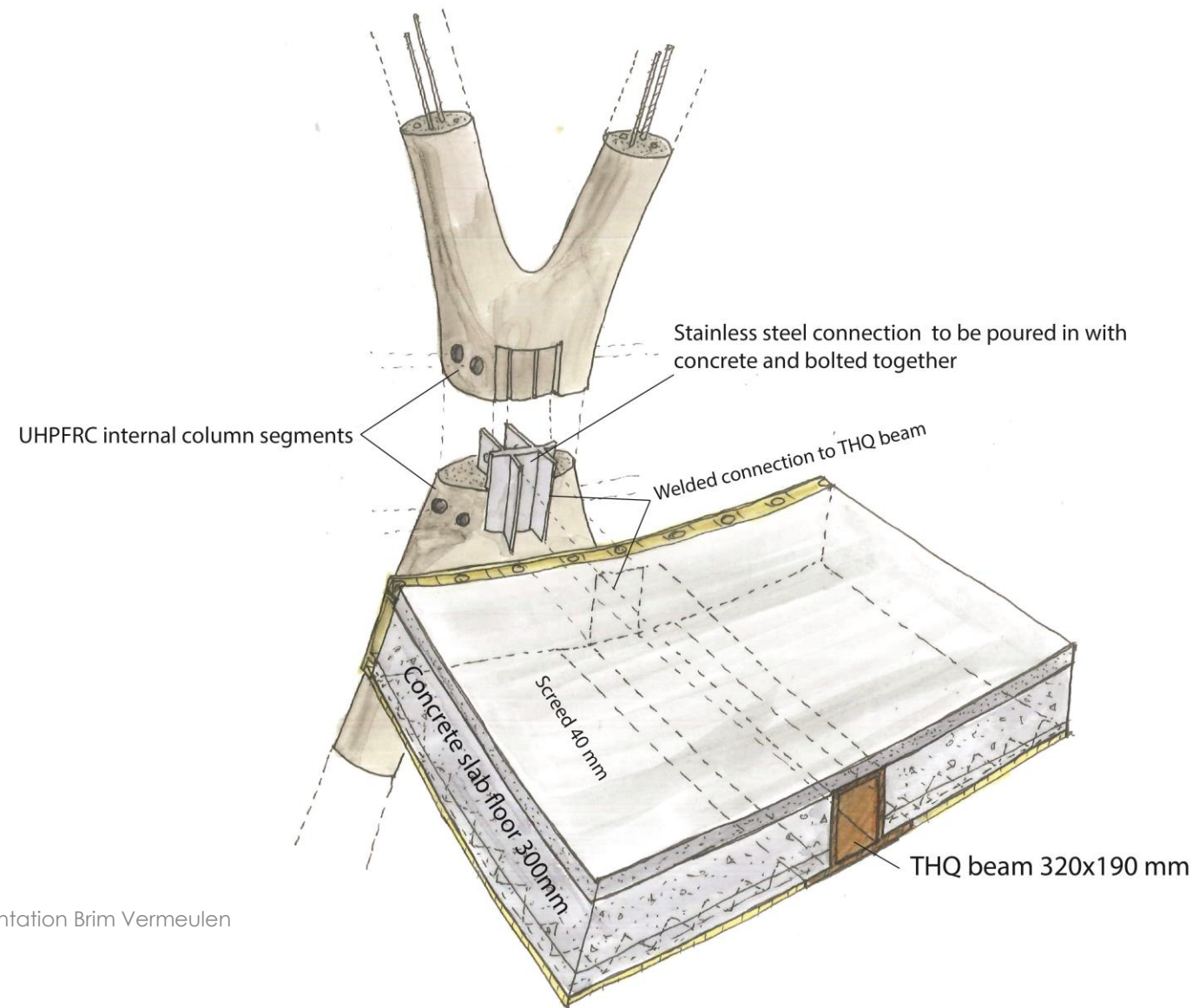
2nd: $\varnothing 190\text{mm}$

1st: $\varnothing 190\text{mm}$

Bottom $\varnothing 190\text{mm}$

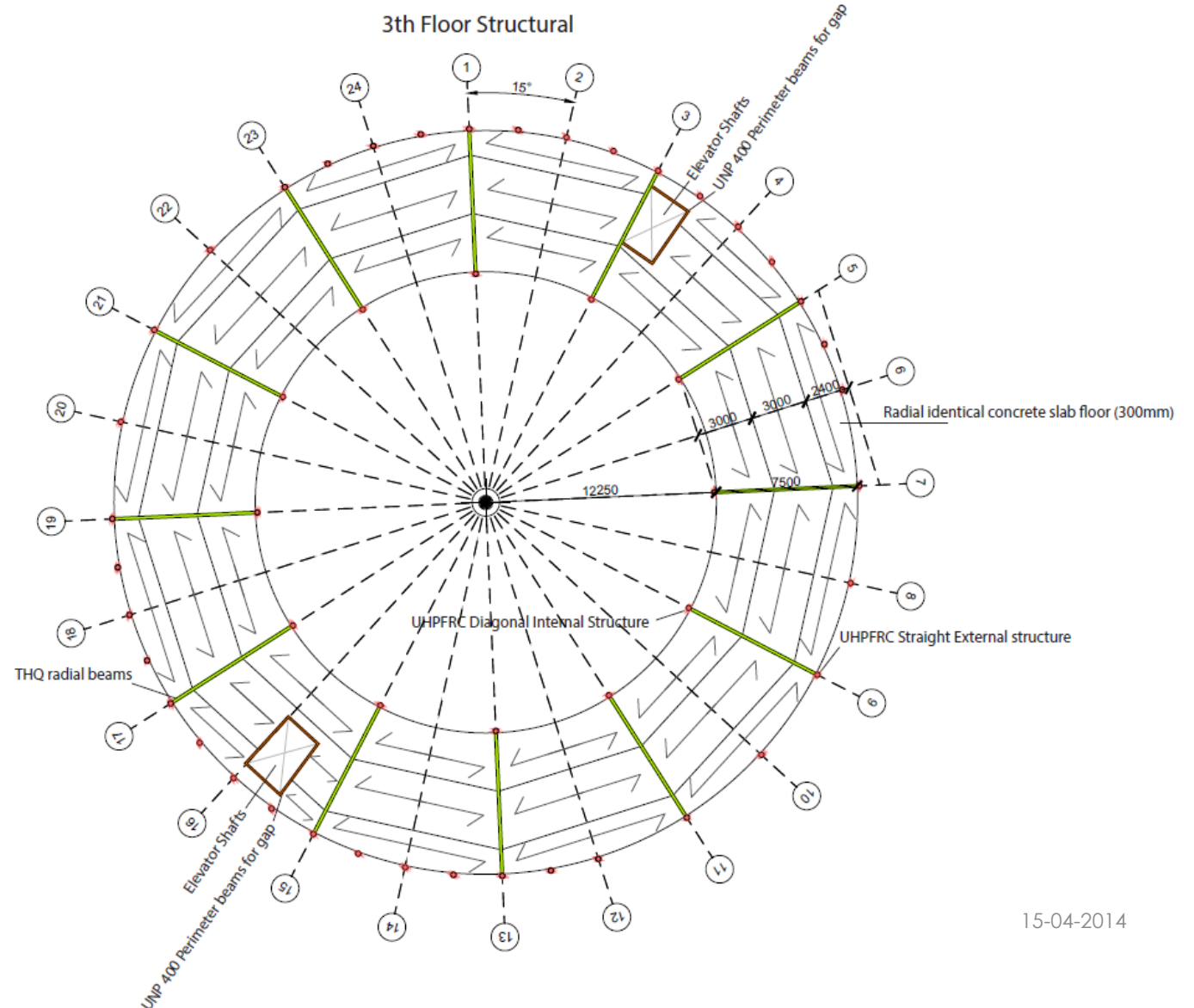


Center column floor detail



Structural Floor plan

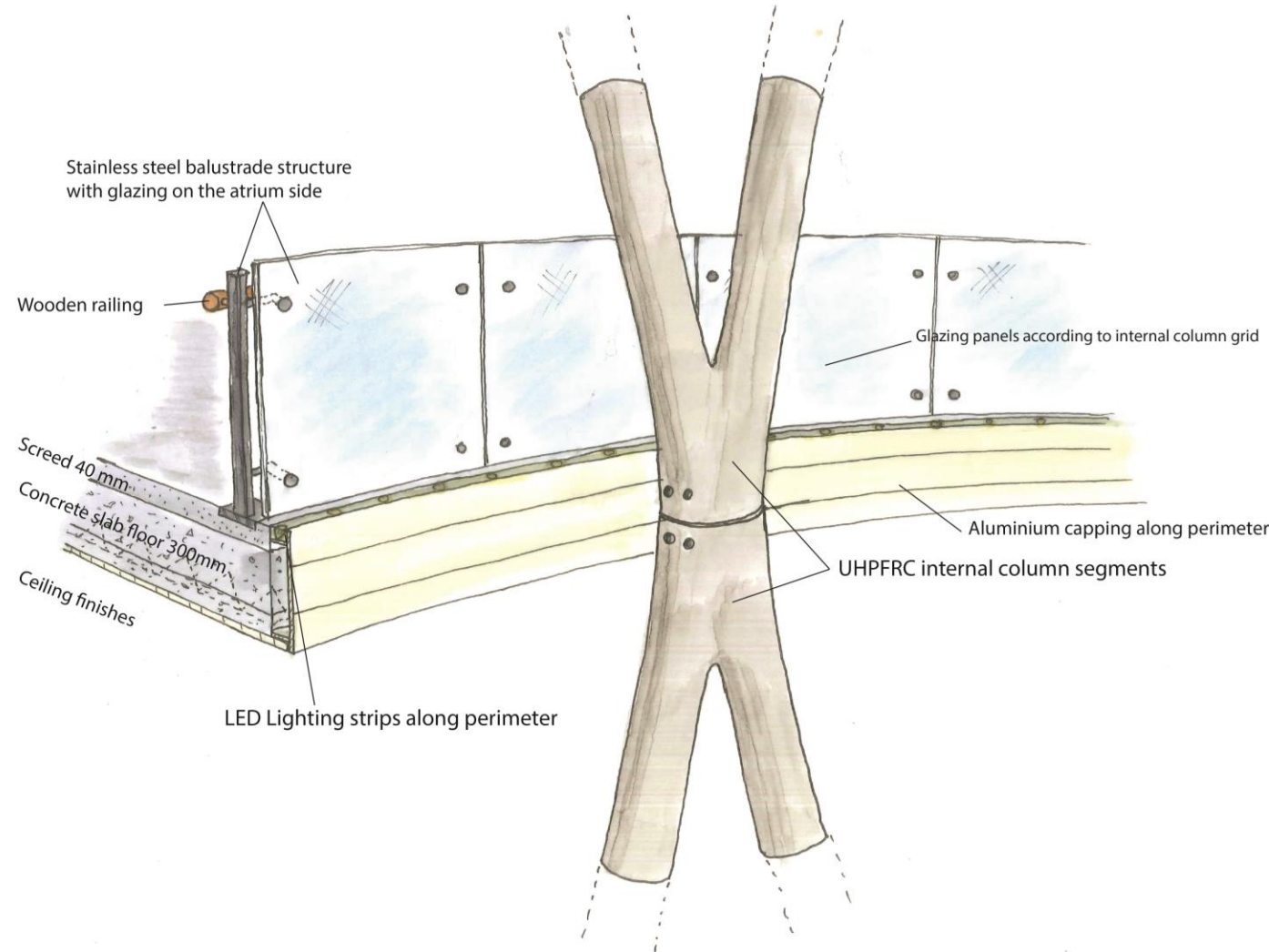
- Internal diagonal columns
- External straight columns
- Radial THQ 320x190 beams
- Lightweight concrete slab floor



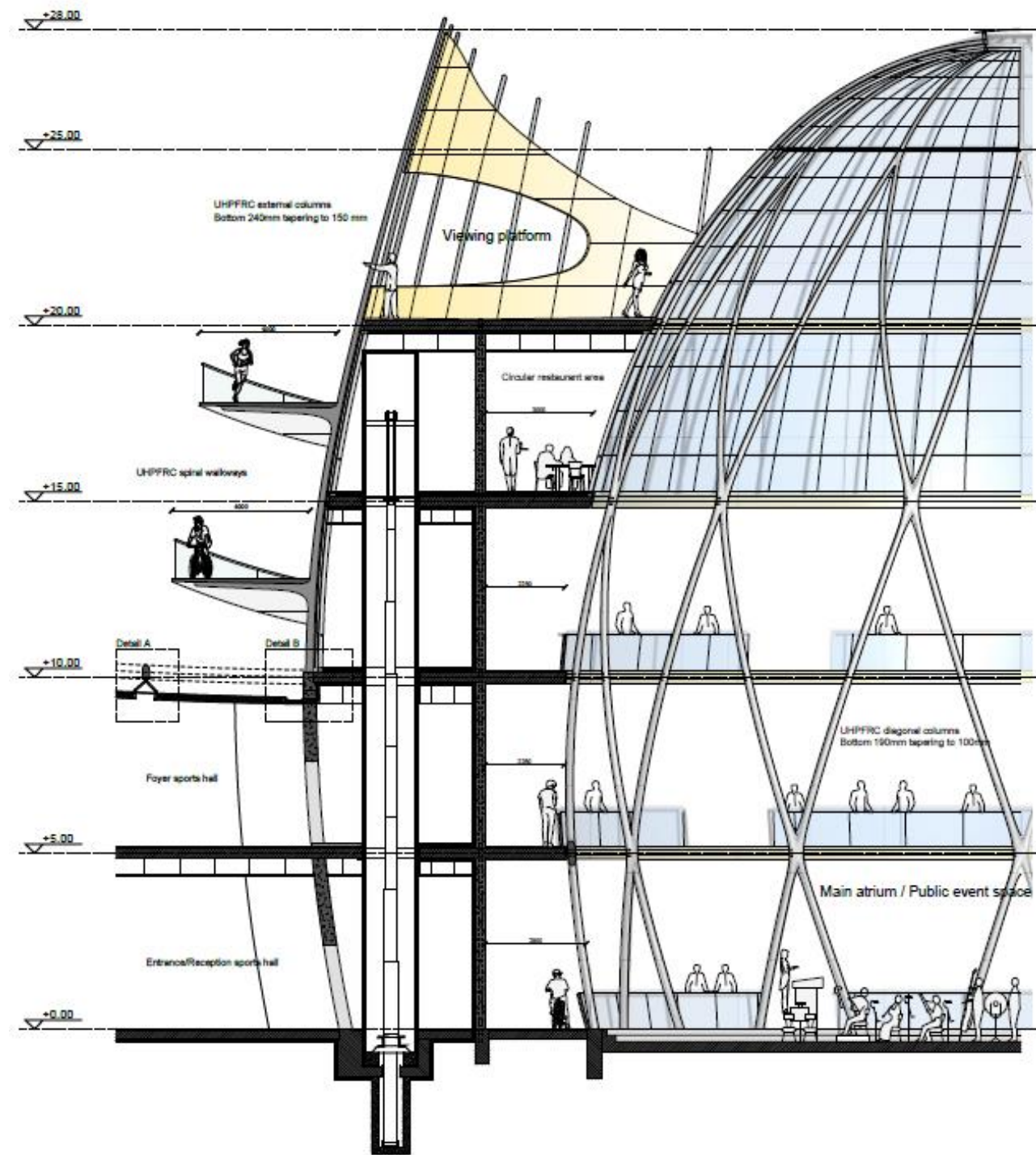
Center internal glazing

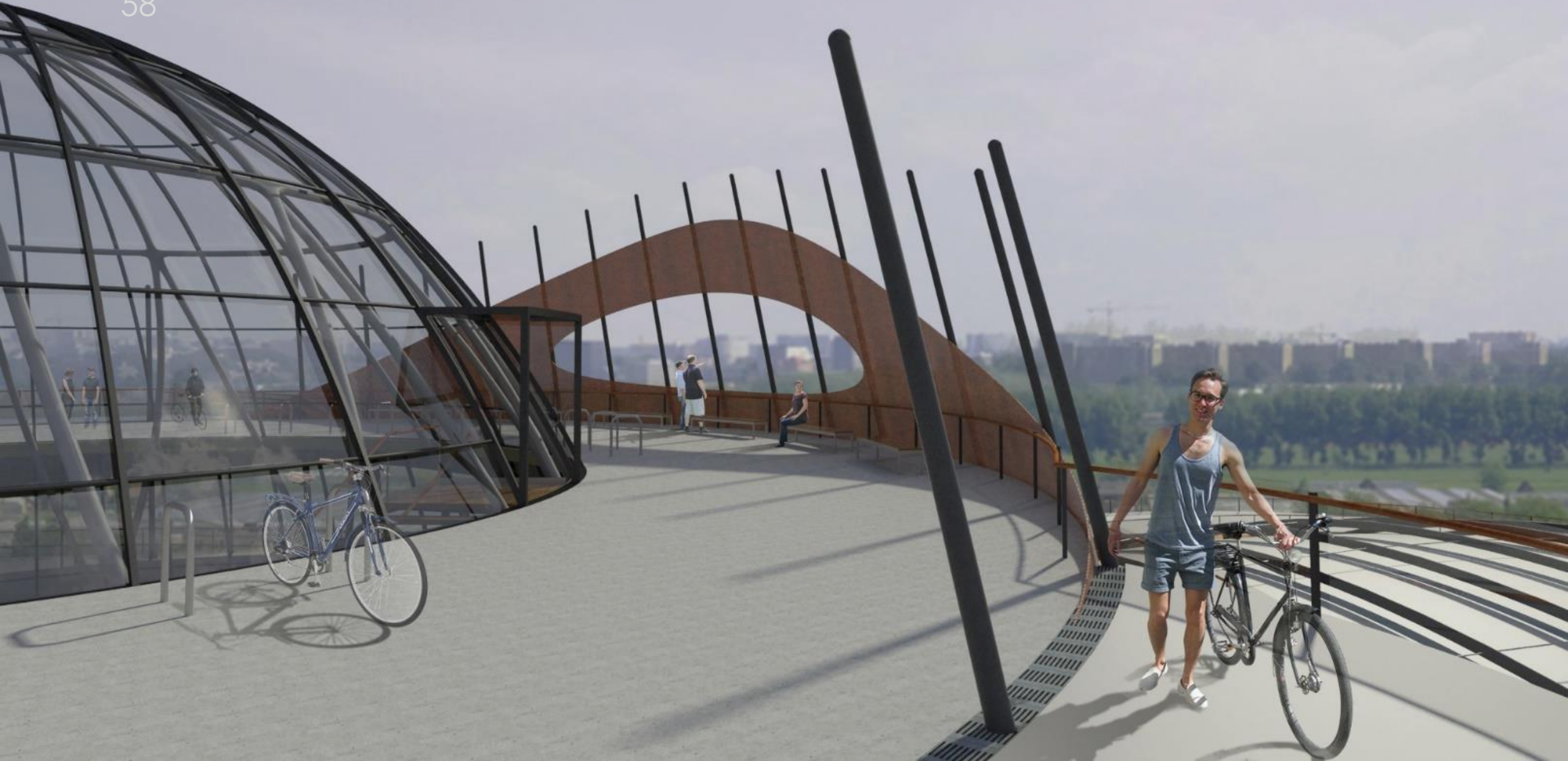


Reference balustrade (Source: Metaglas)

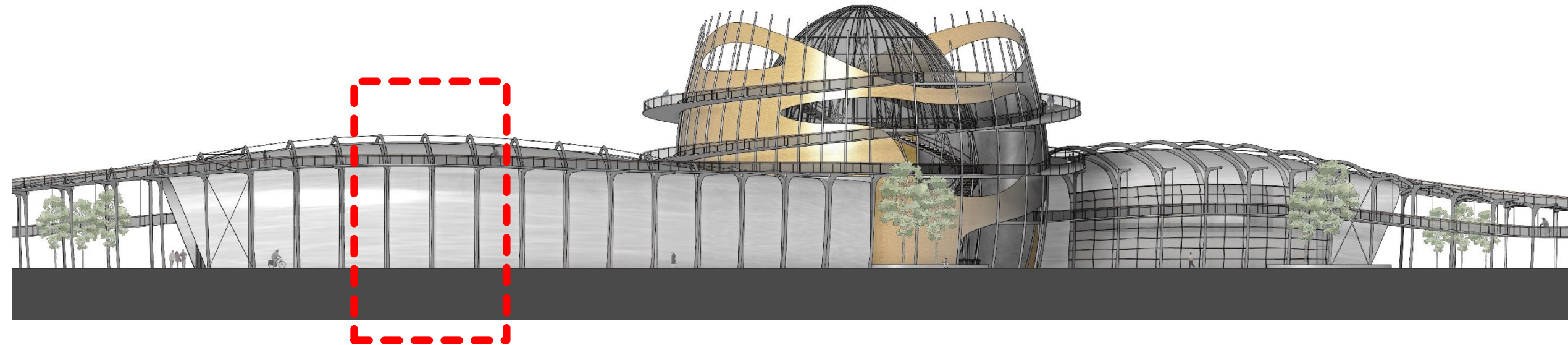


Center Detail Fragment

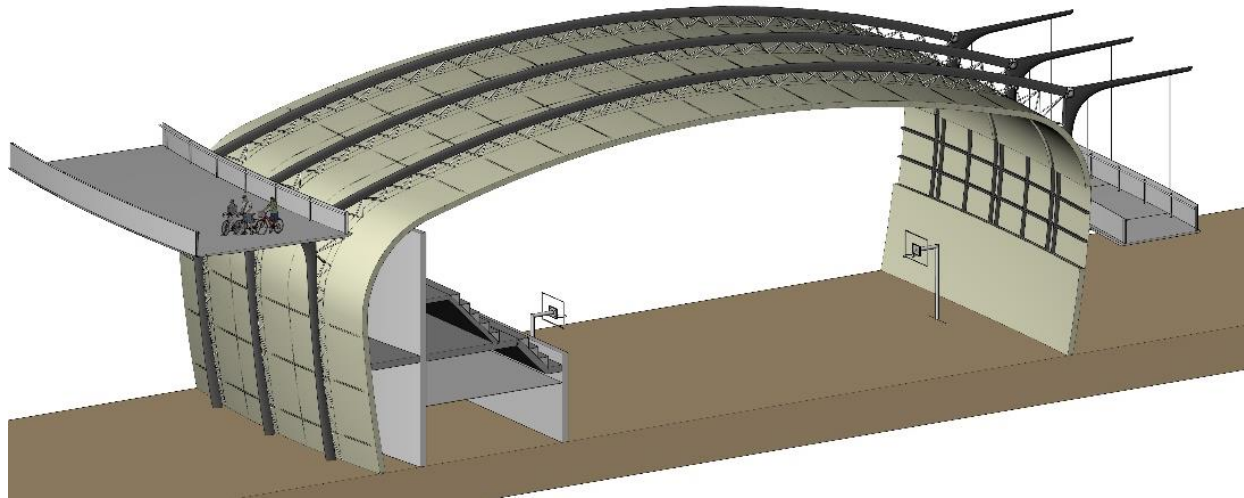




Elevation



Isometric

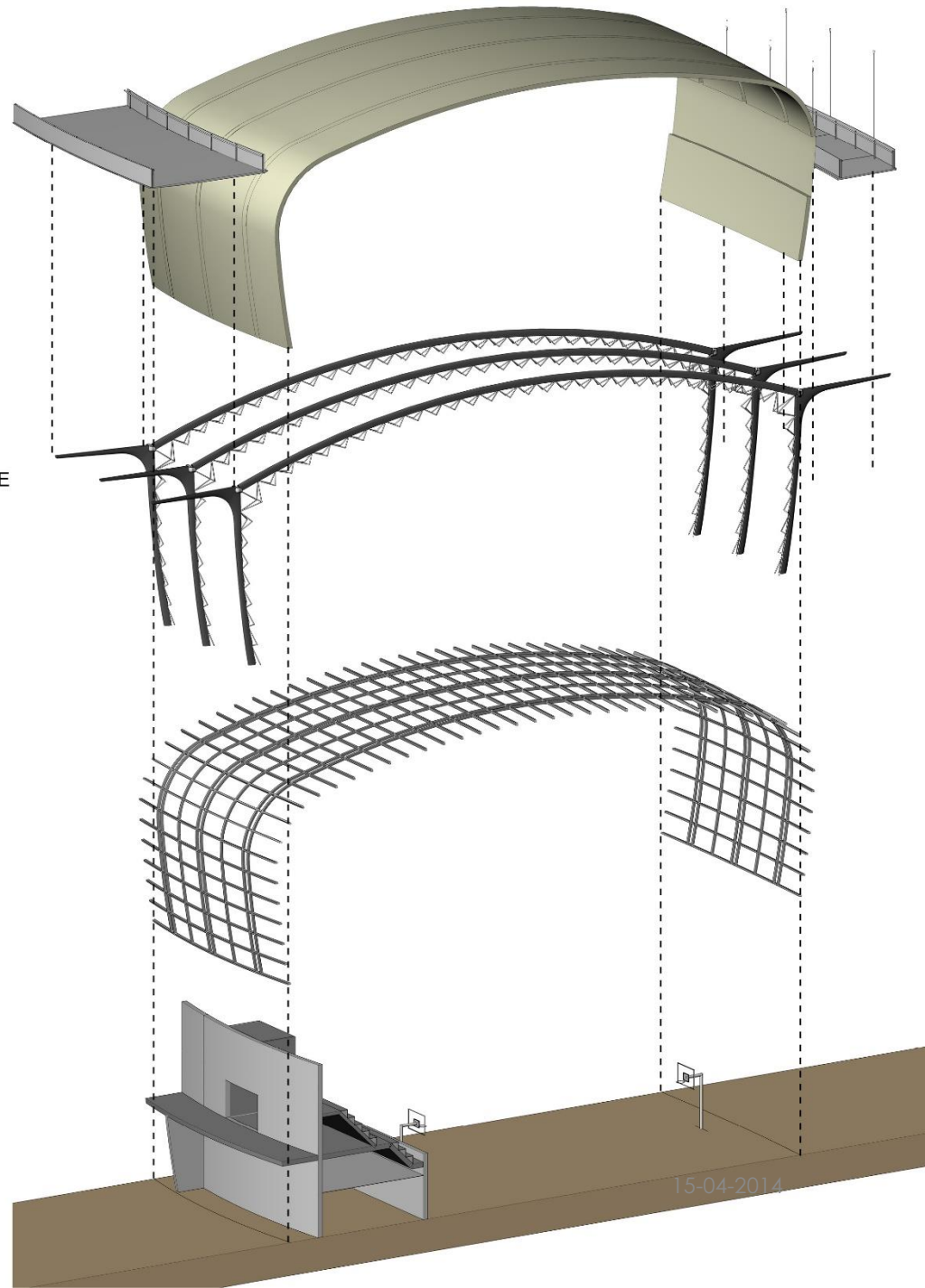


WALKWAYS + FACADE

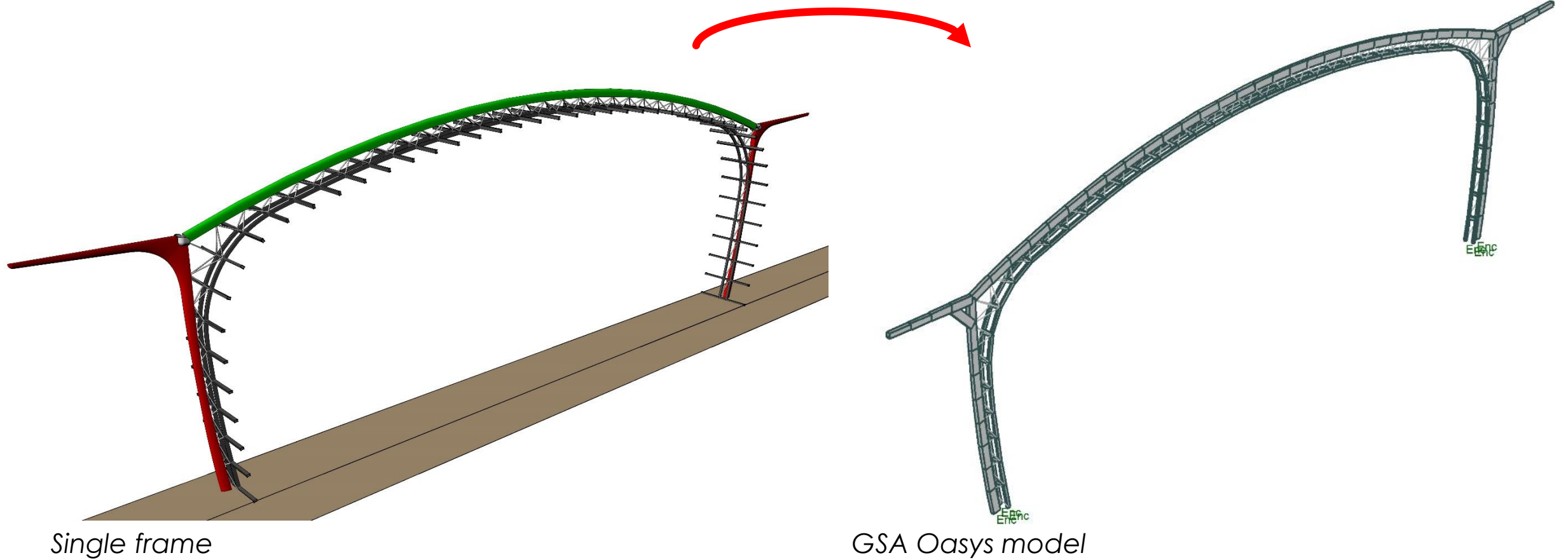
UHPFRC COLUMNS
UHPFRC ARCHES
STEEL BAR SPACEFRAME

STEEL VOLUME FRAME

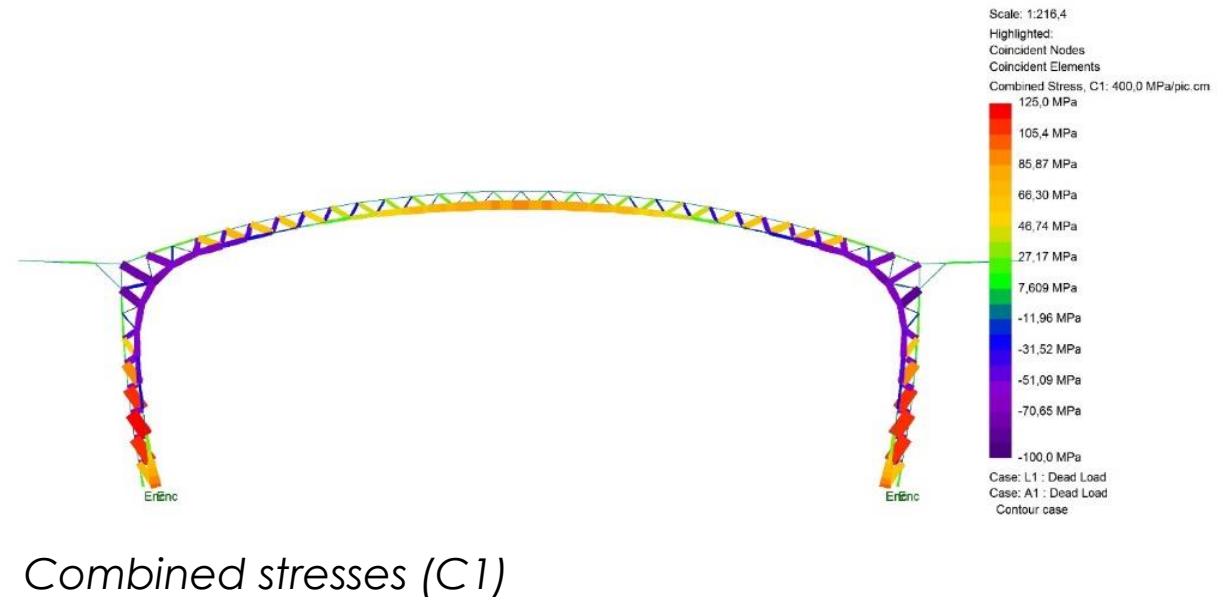
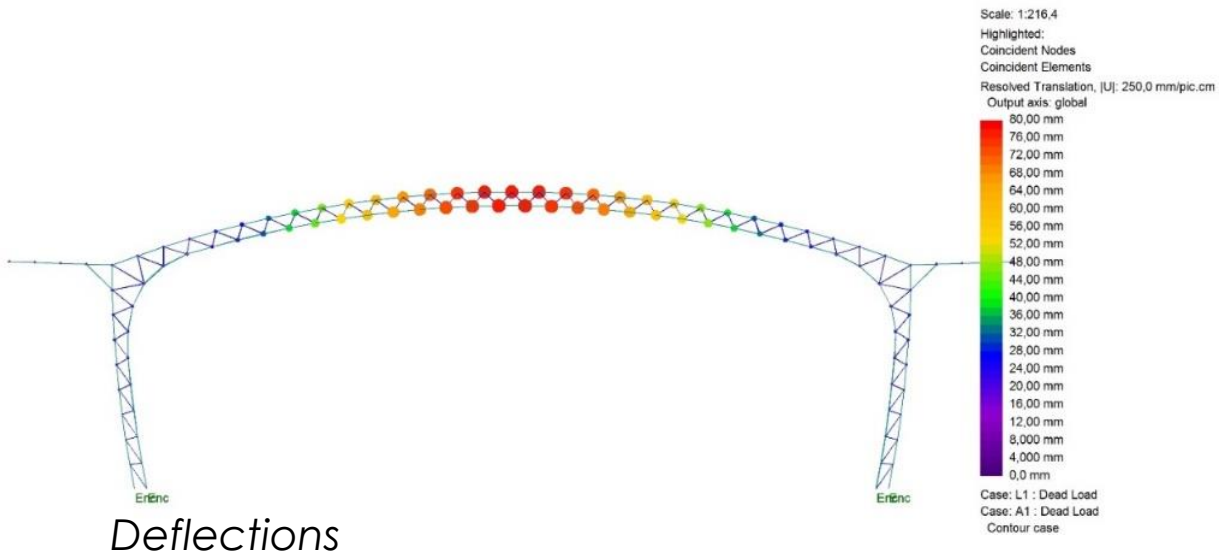
GRAND STAND



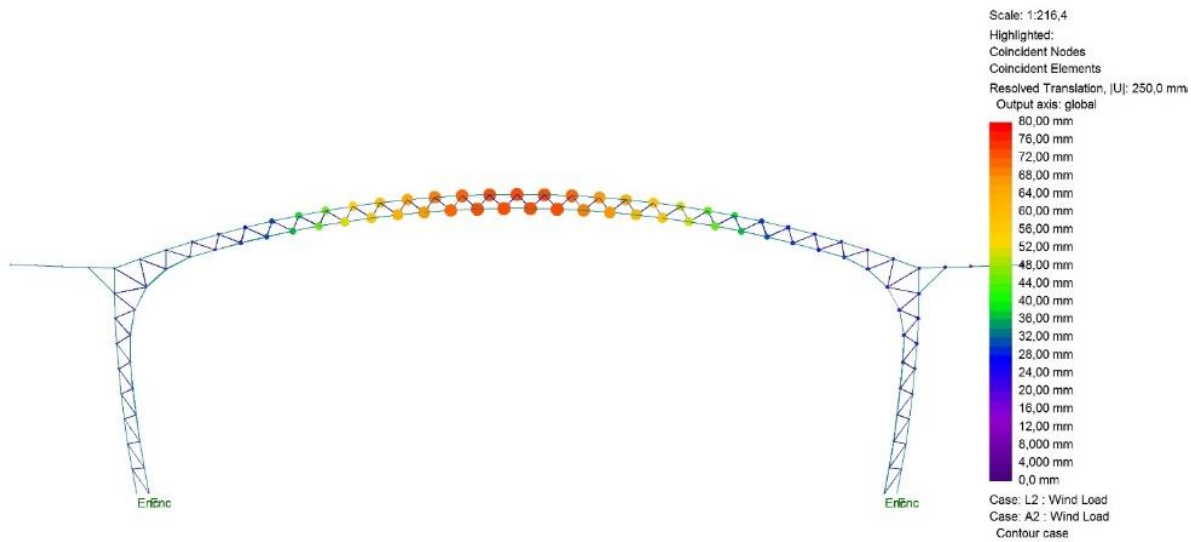
GSA Analysis



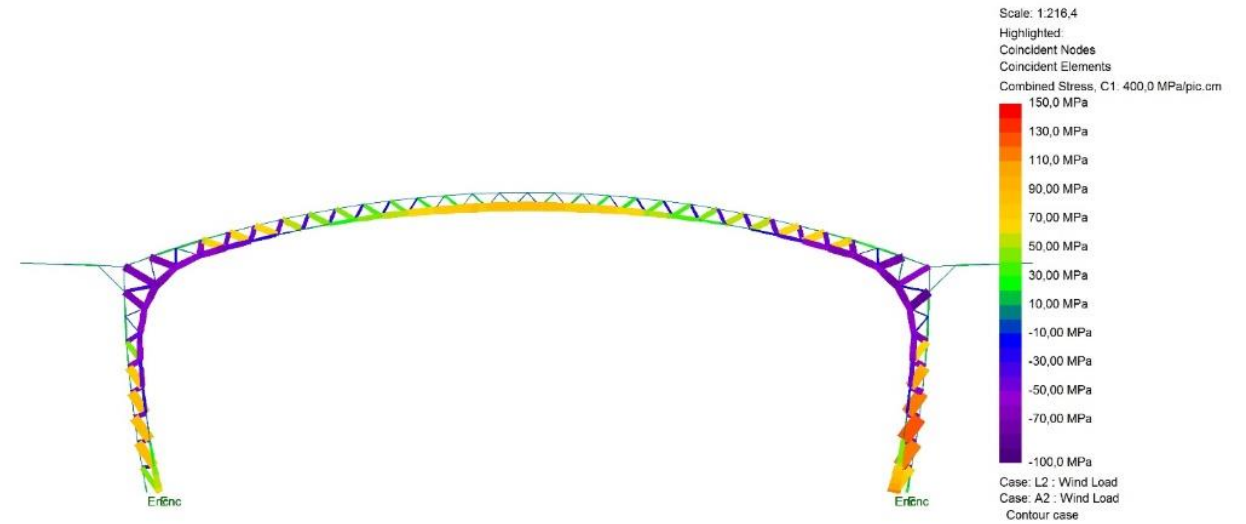
GSA Analysis – LC1 Dead Load



GSA Analysis – LC2 Wind Load

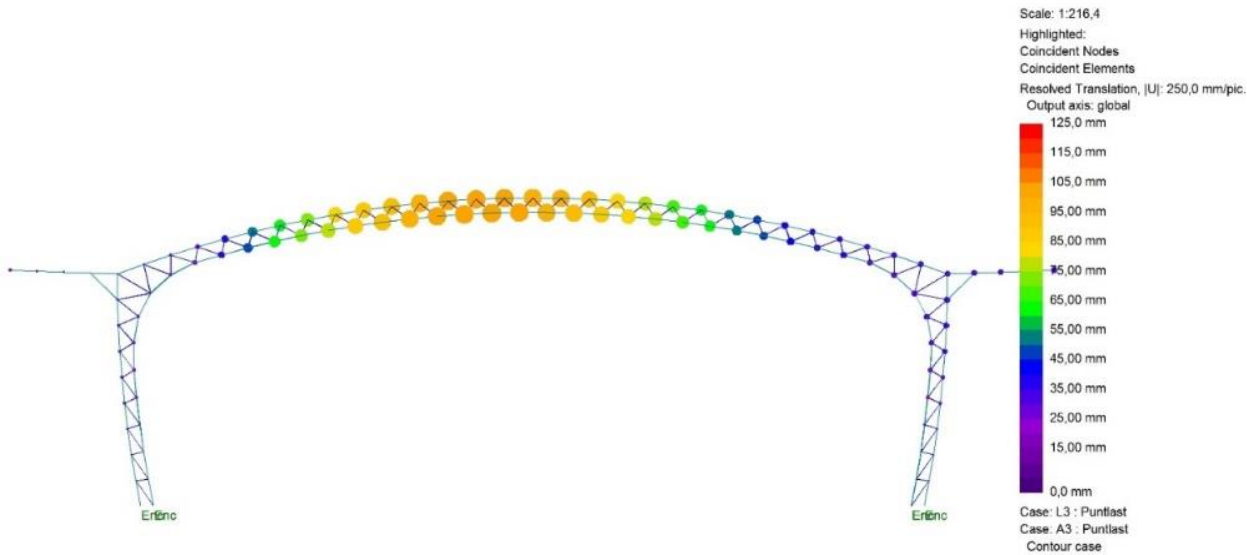


Deflections

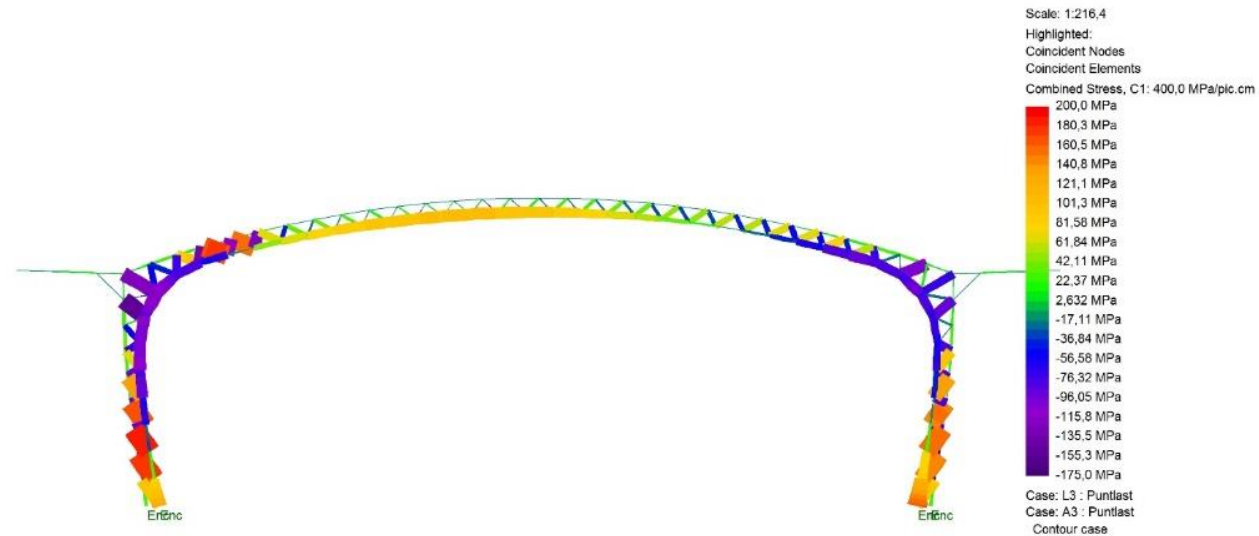


Combined stresses (C1)

GSA Analysis – LC3 Point Load

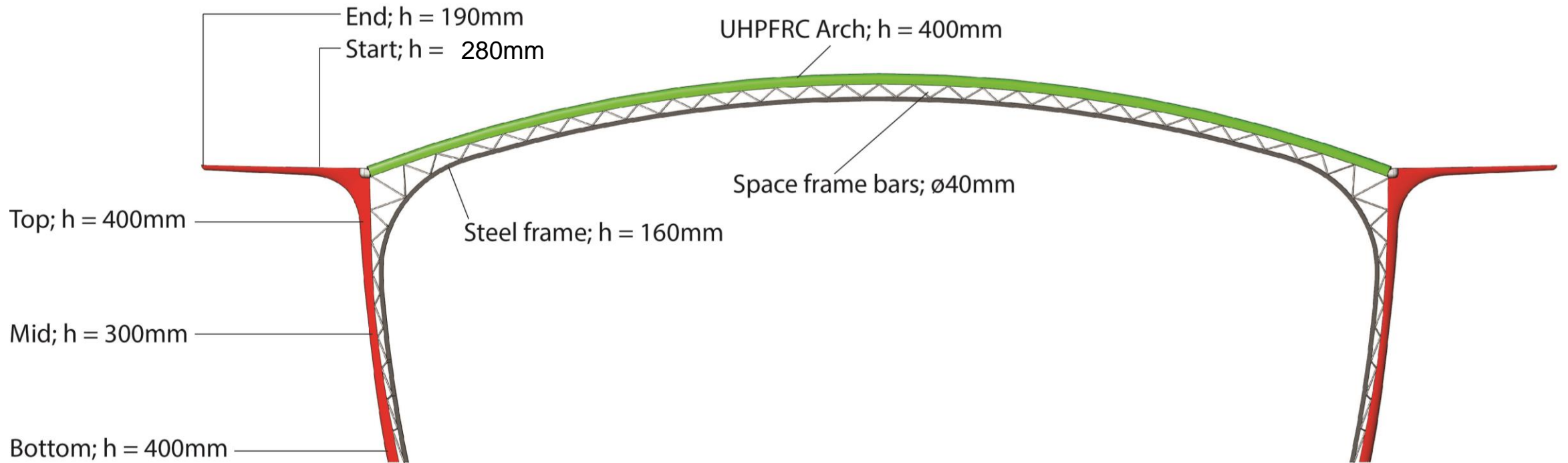


Deflections

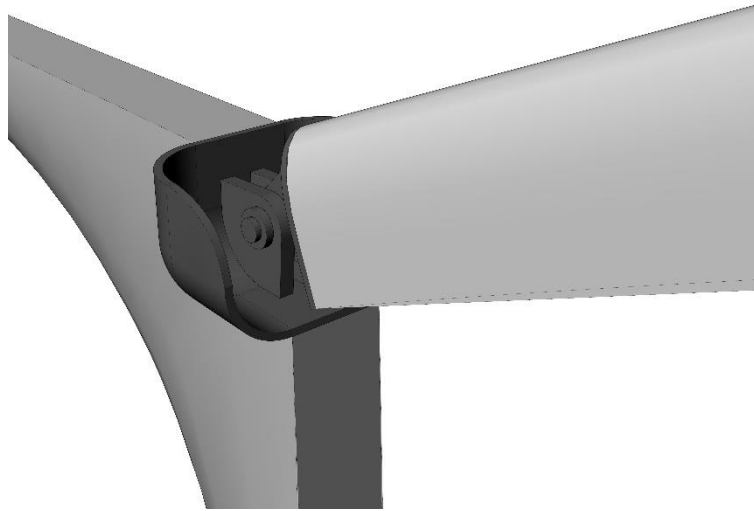


Combined stresses (C1)

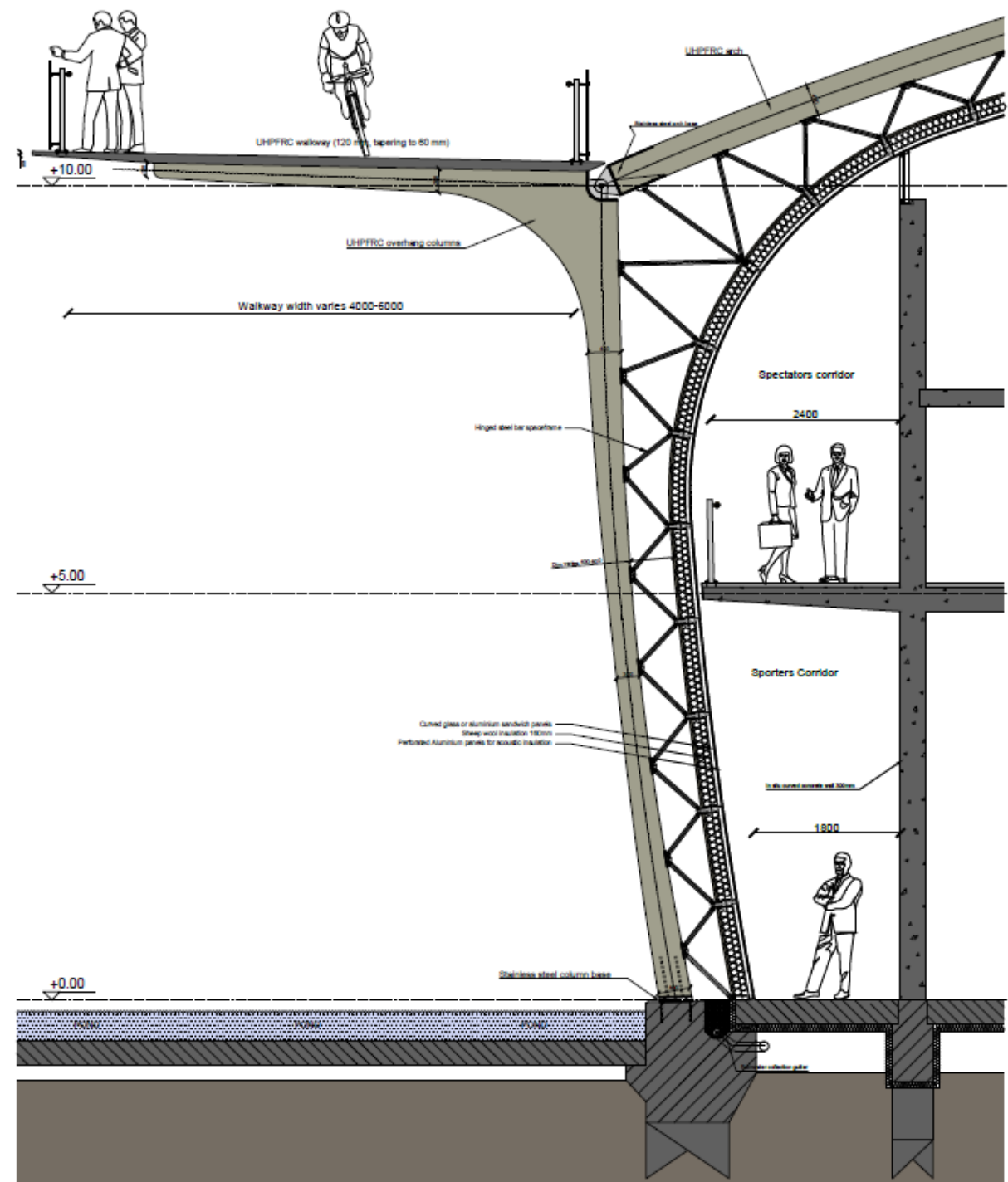
Results



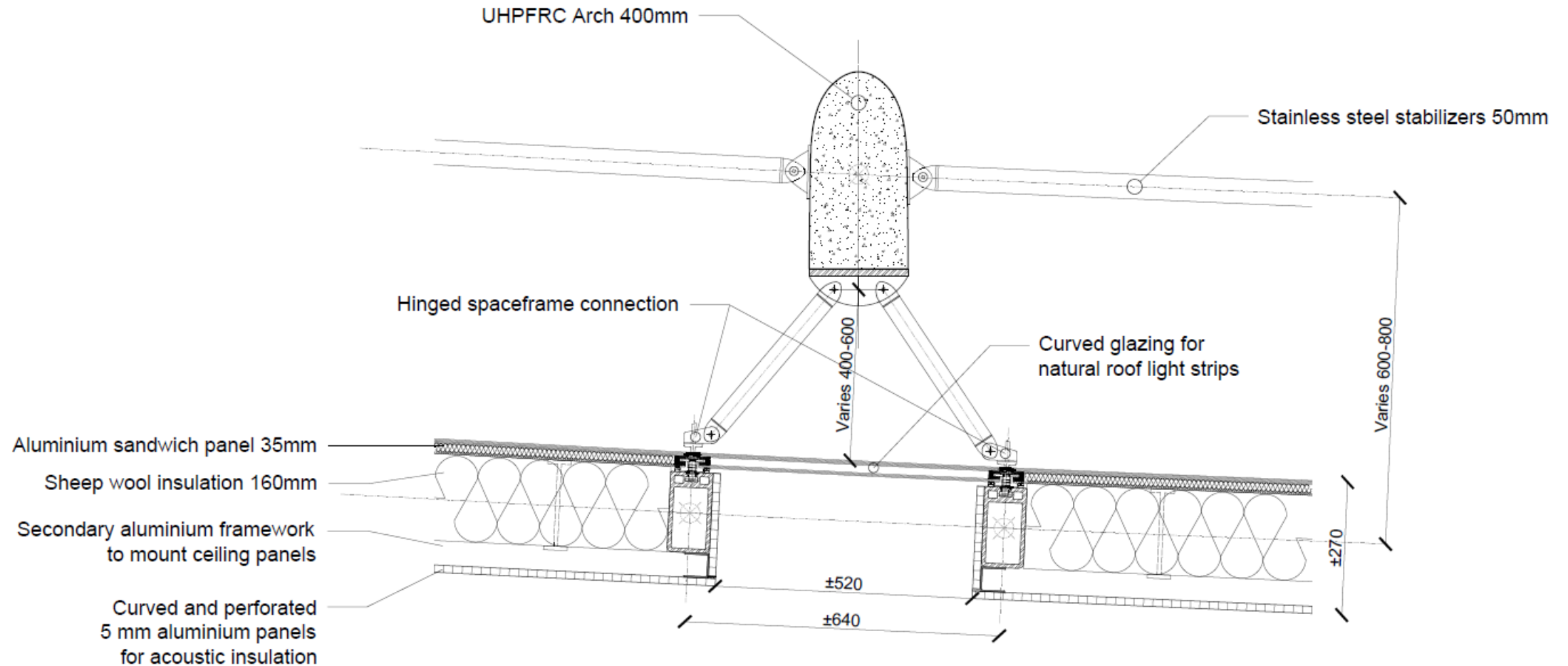
Sports Hall Fragment



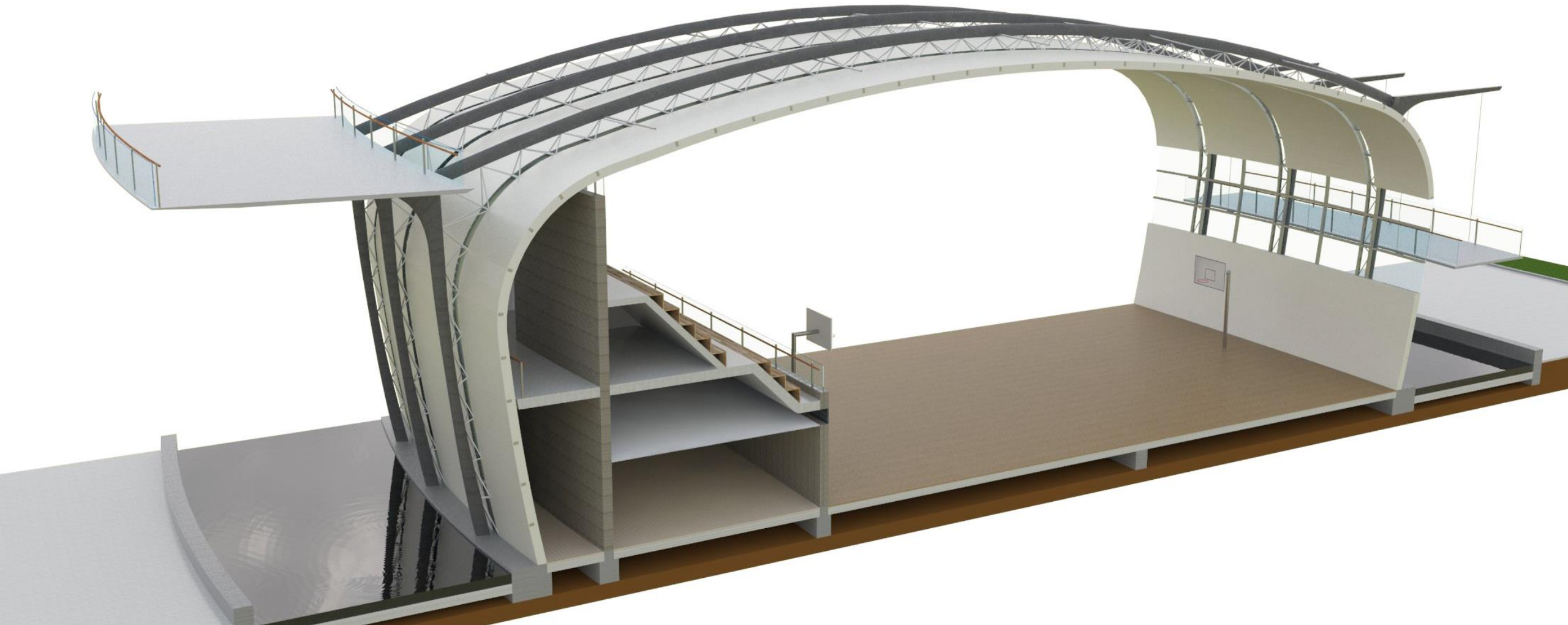
P5 Graduation Presentation Brim Vermeulen



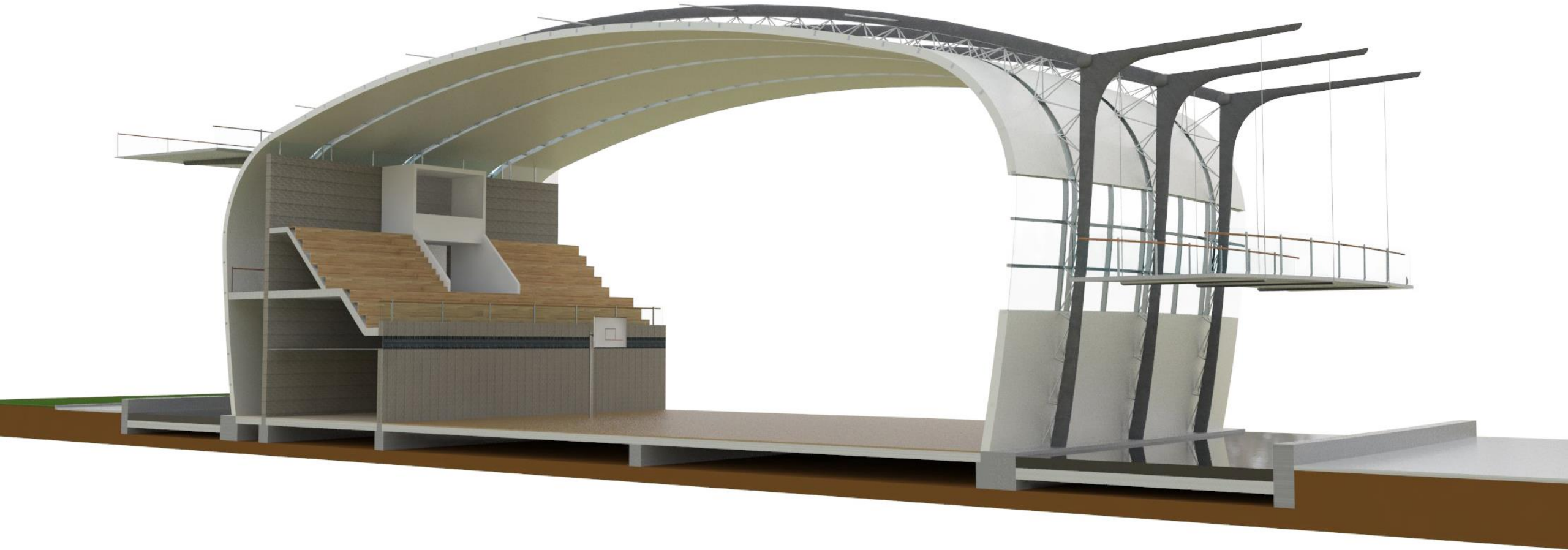
Arch Facade Connection

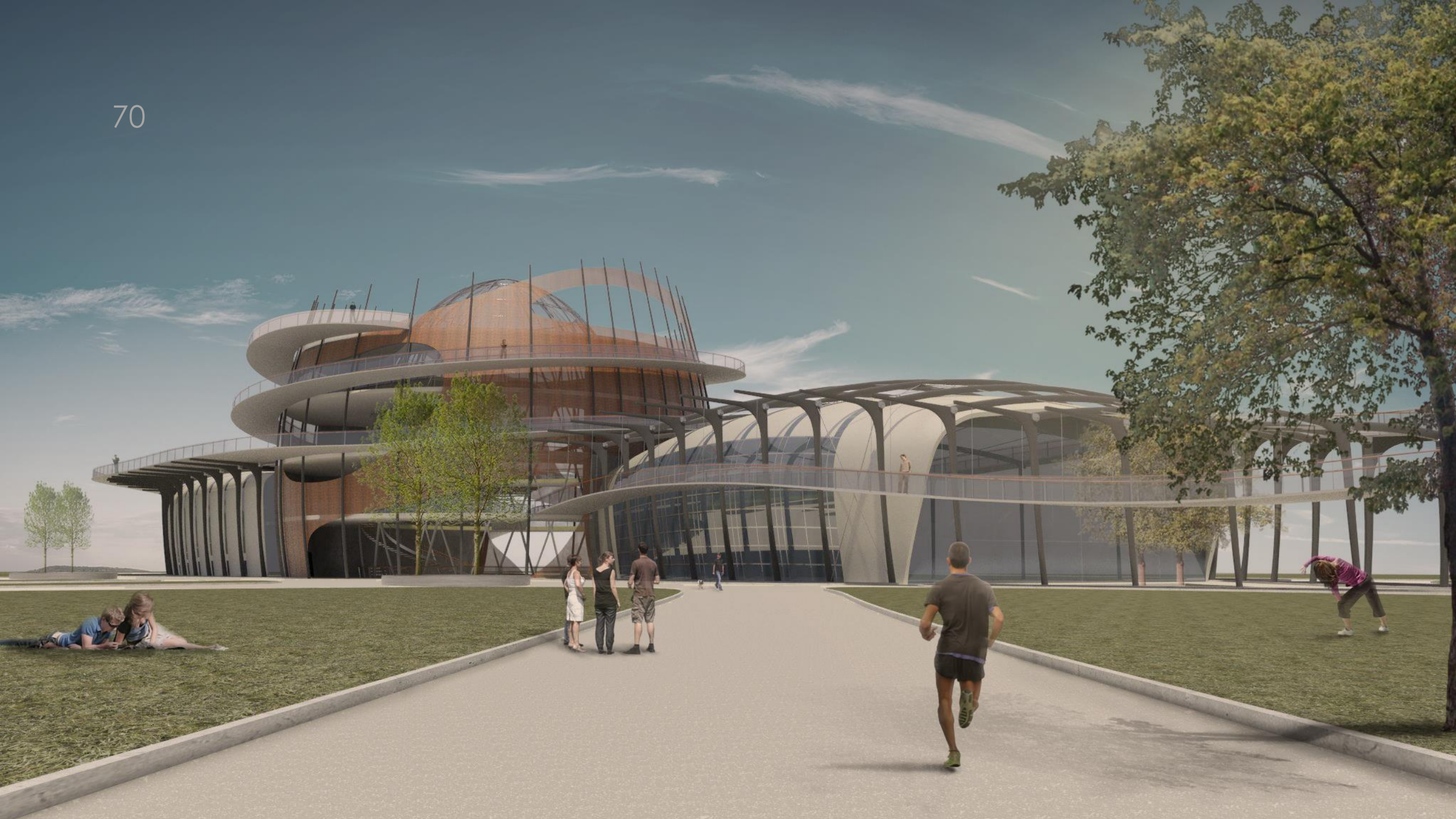


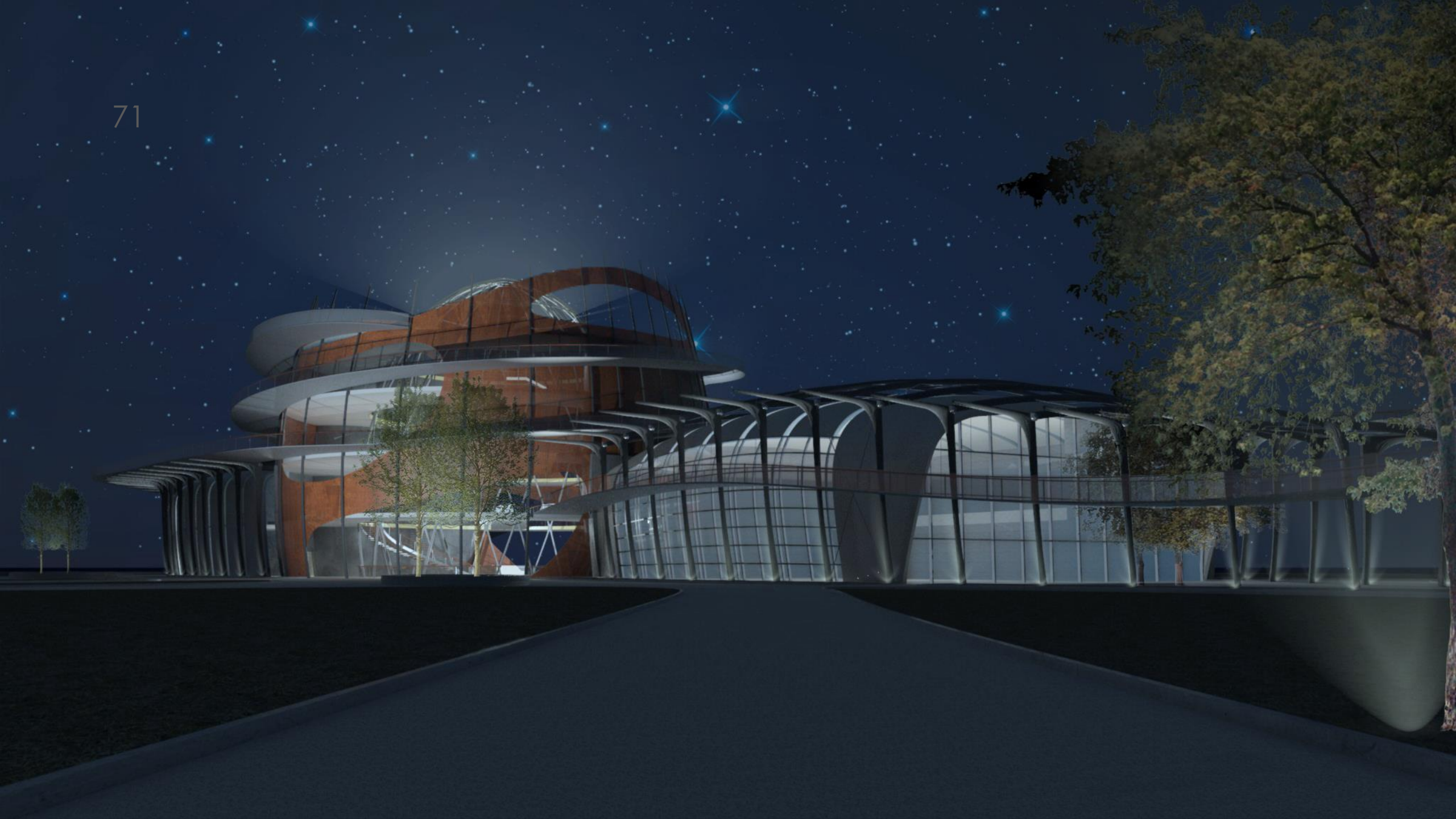
Section Sports Hall

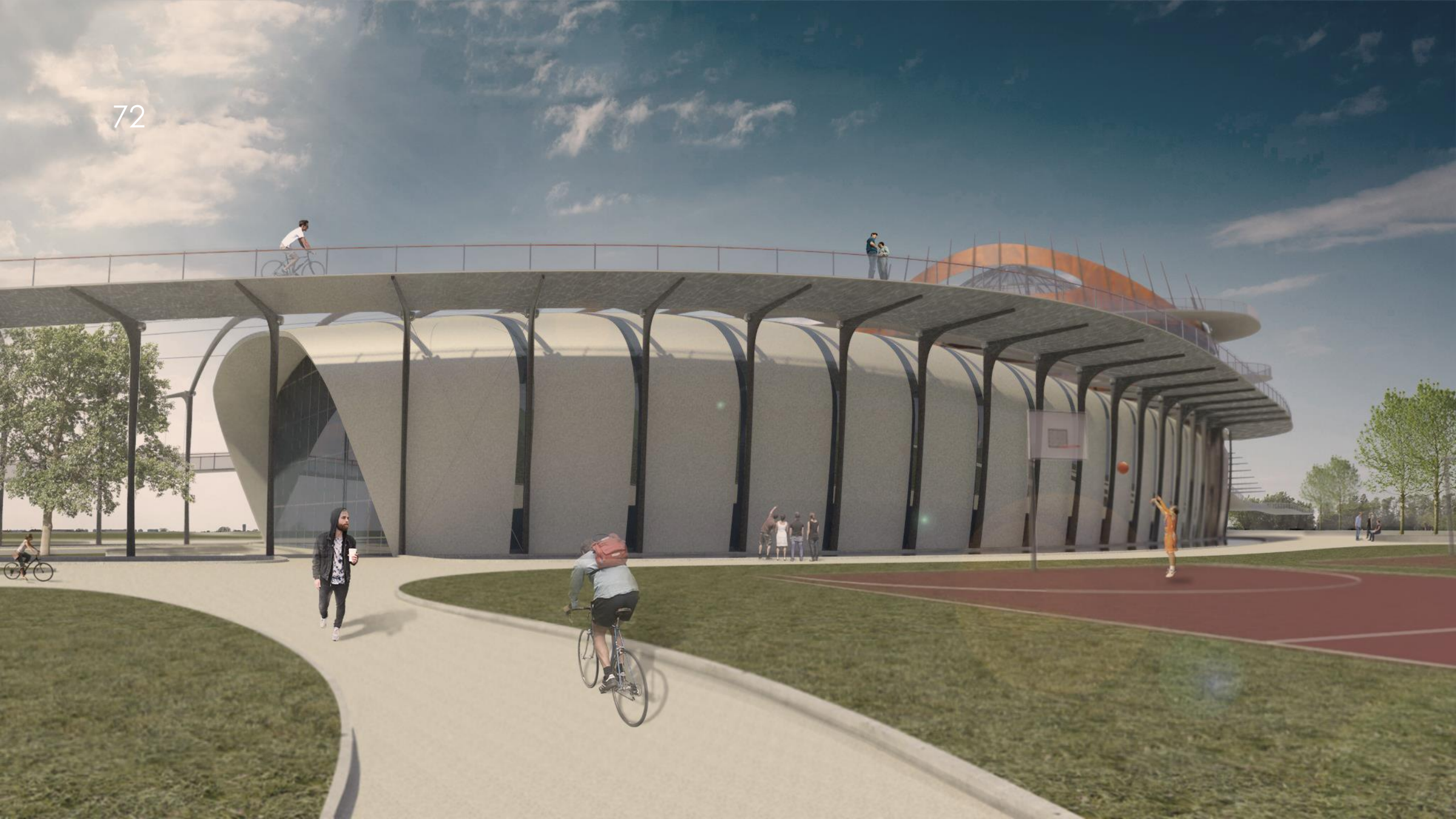


Section Sports Hall

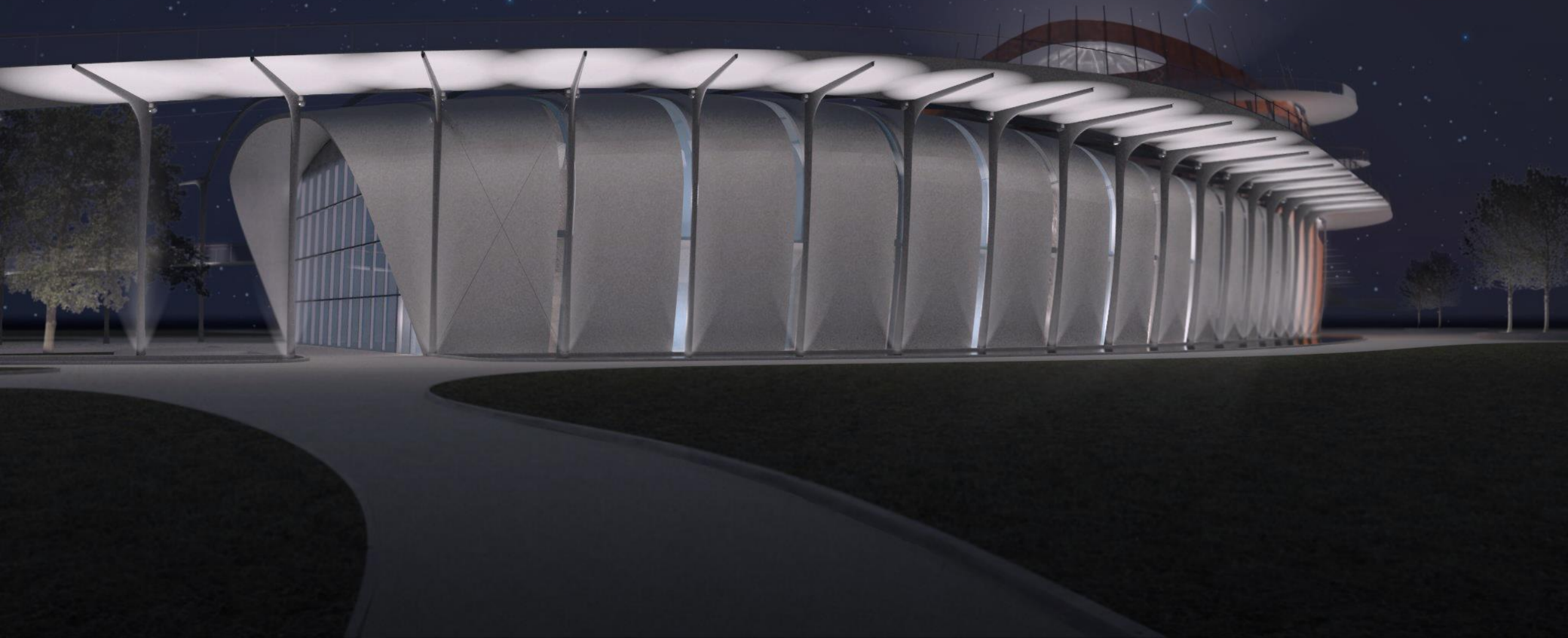




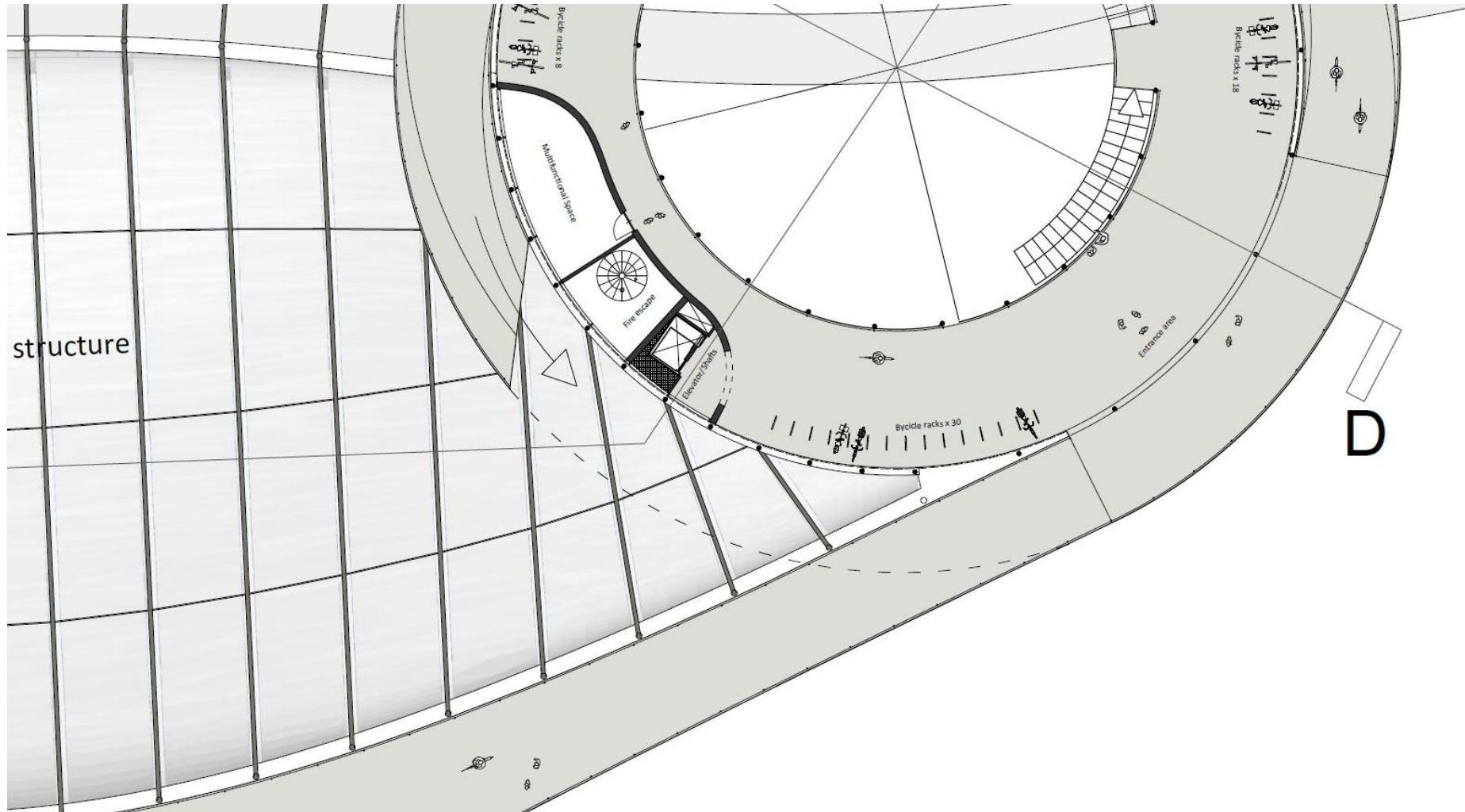




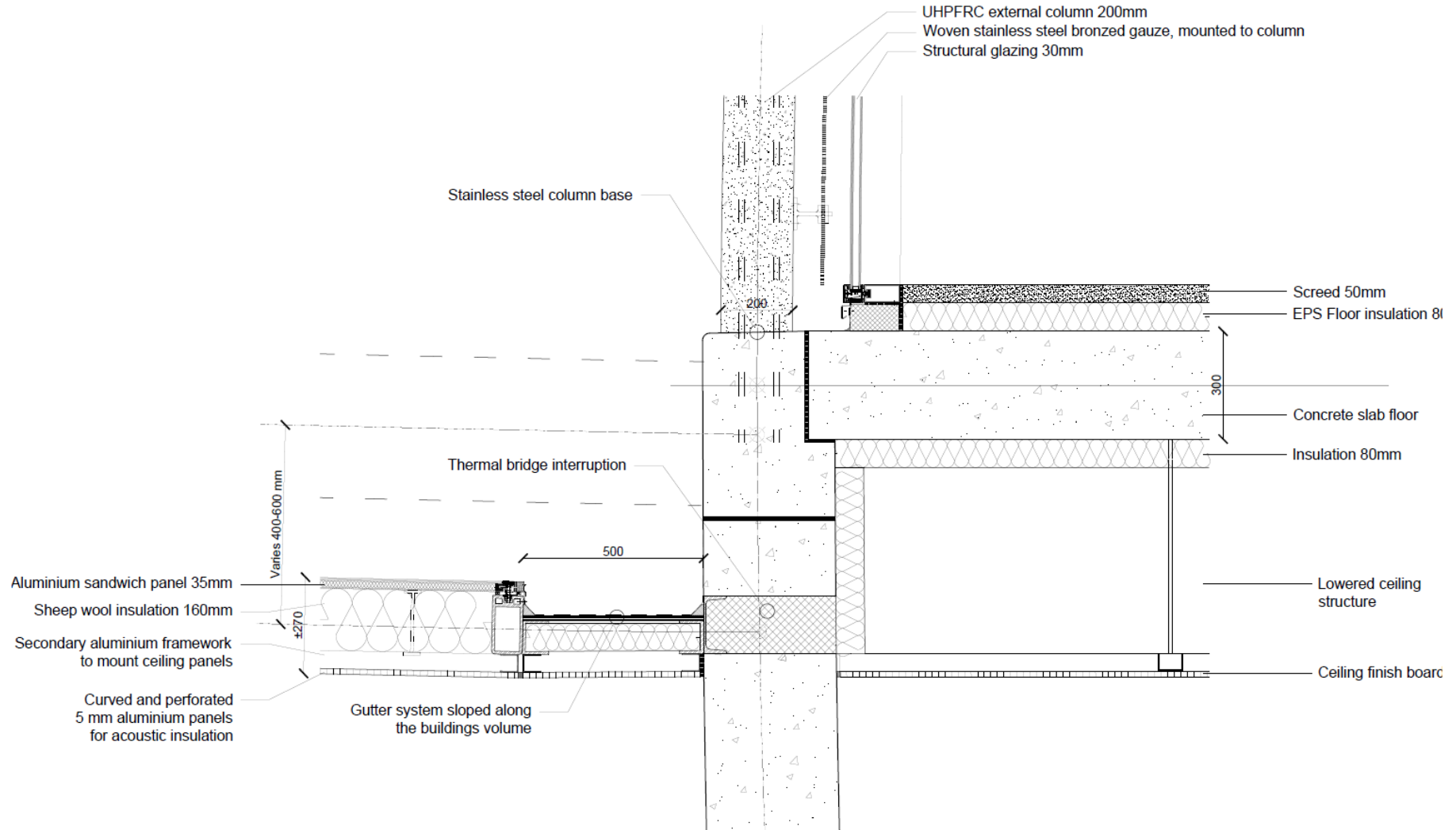
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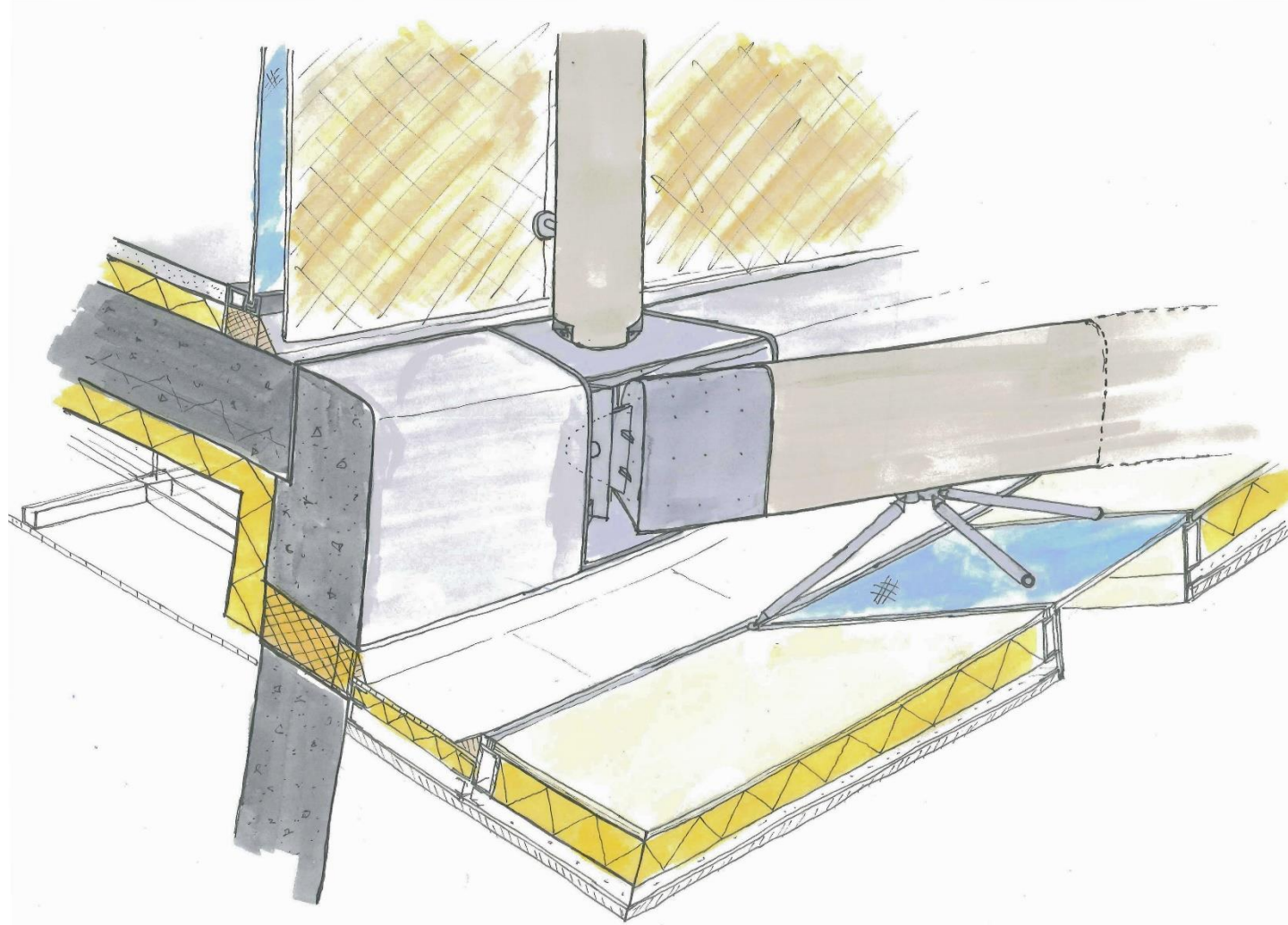
Connection of volumes



Structural connection

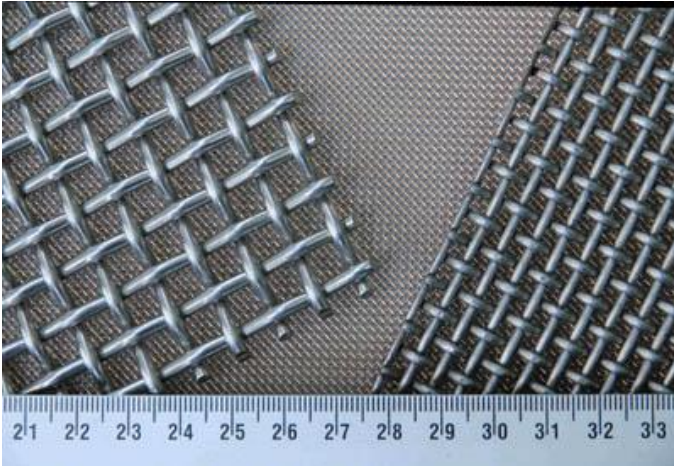


Structural connection

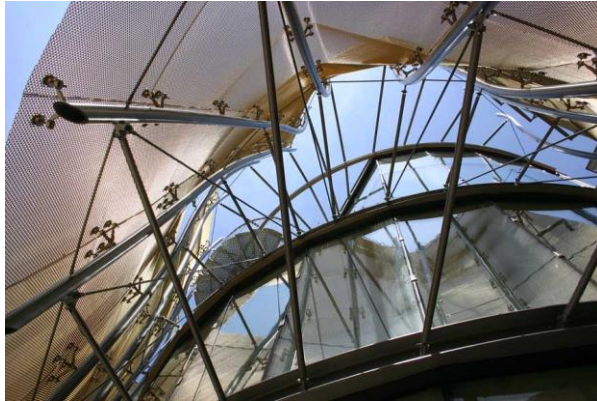


Materialization

Center; bronzed metal gauze



Reference; de Baljur, The Hague



Sports halls; single curved aluminium panels



Reference; Floriade Paviljon Haarlemmermeer

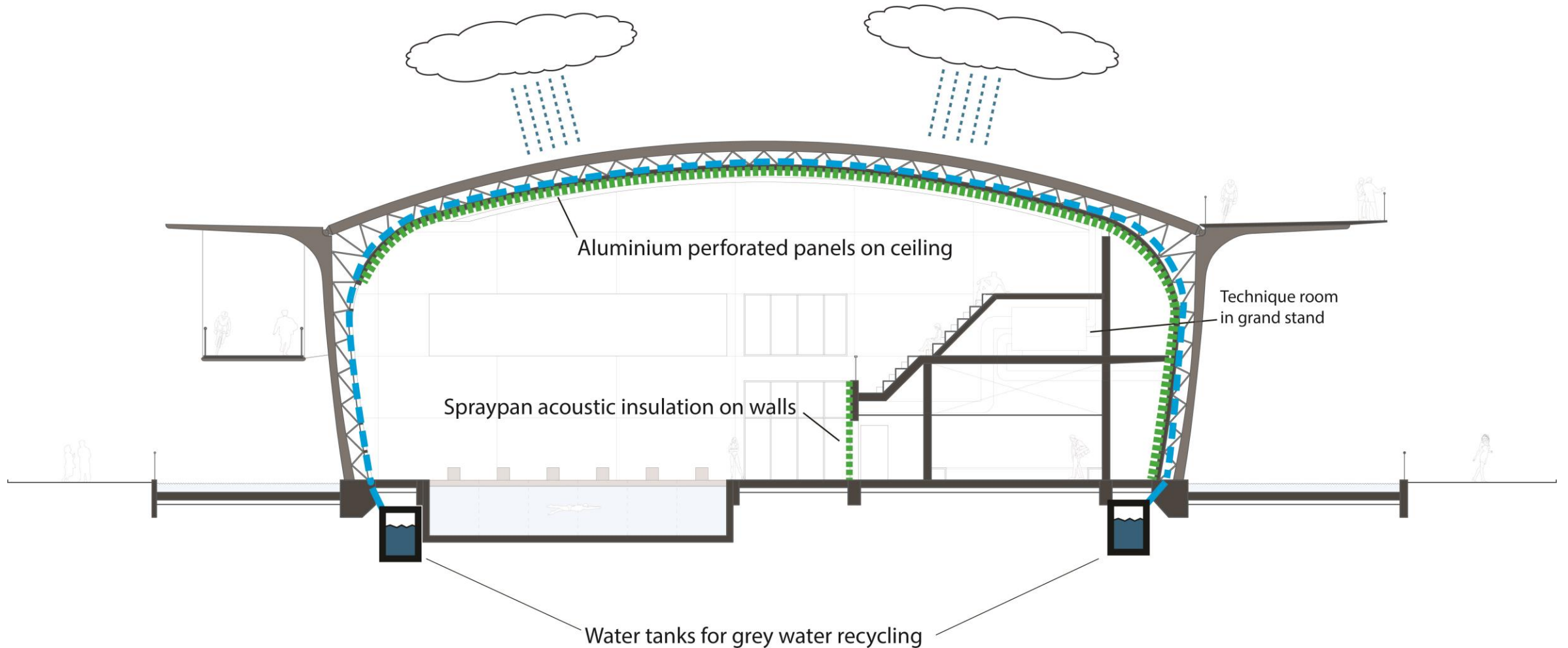


78

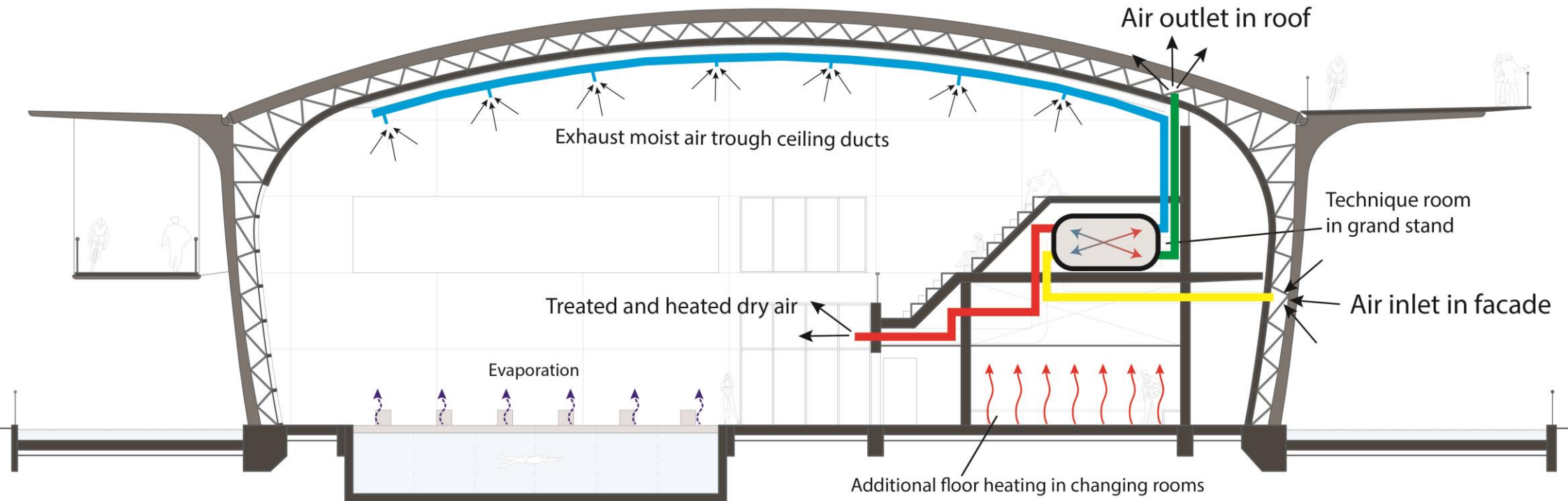
Climate design

Heating, ventilation and acoustics

Swimming pool Acoustics

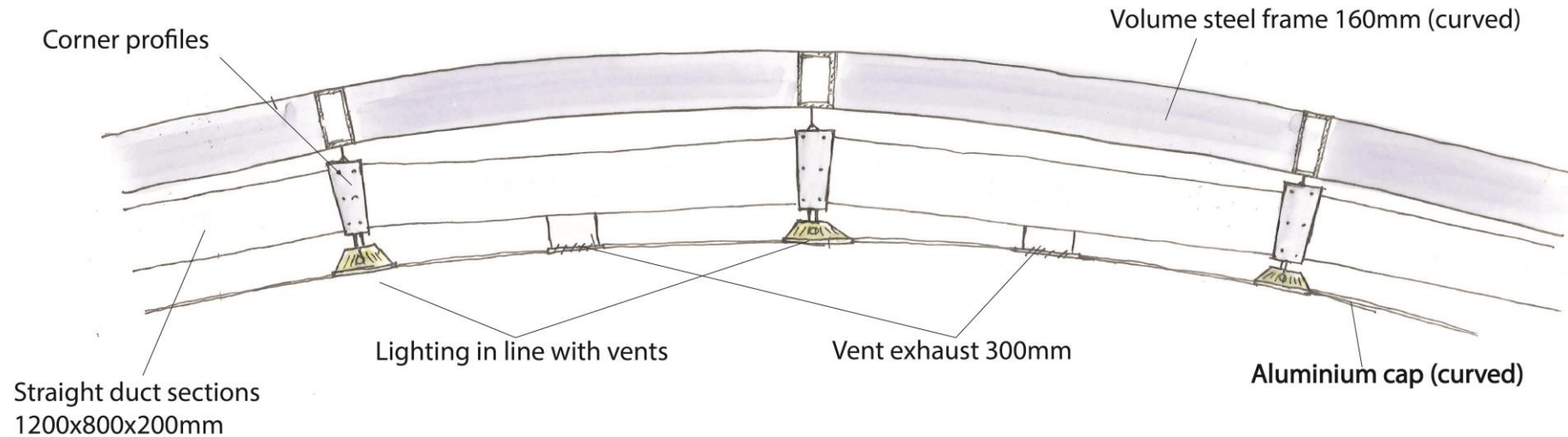


Swimming pool Heating/ventilation



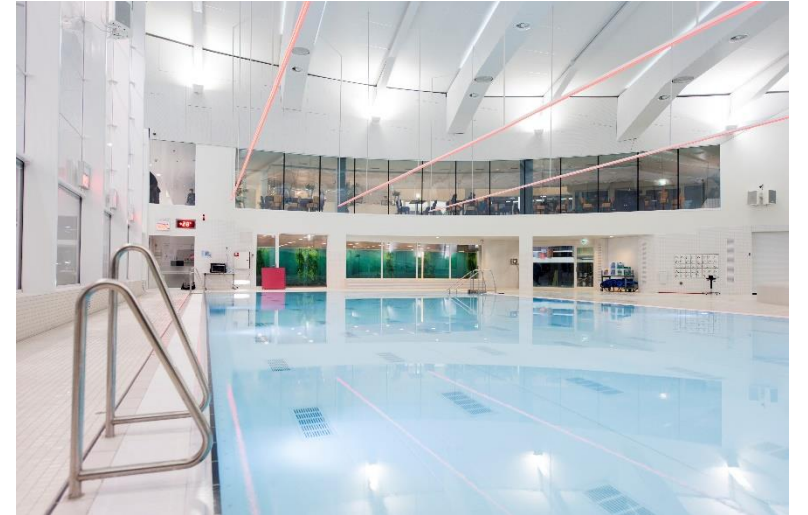
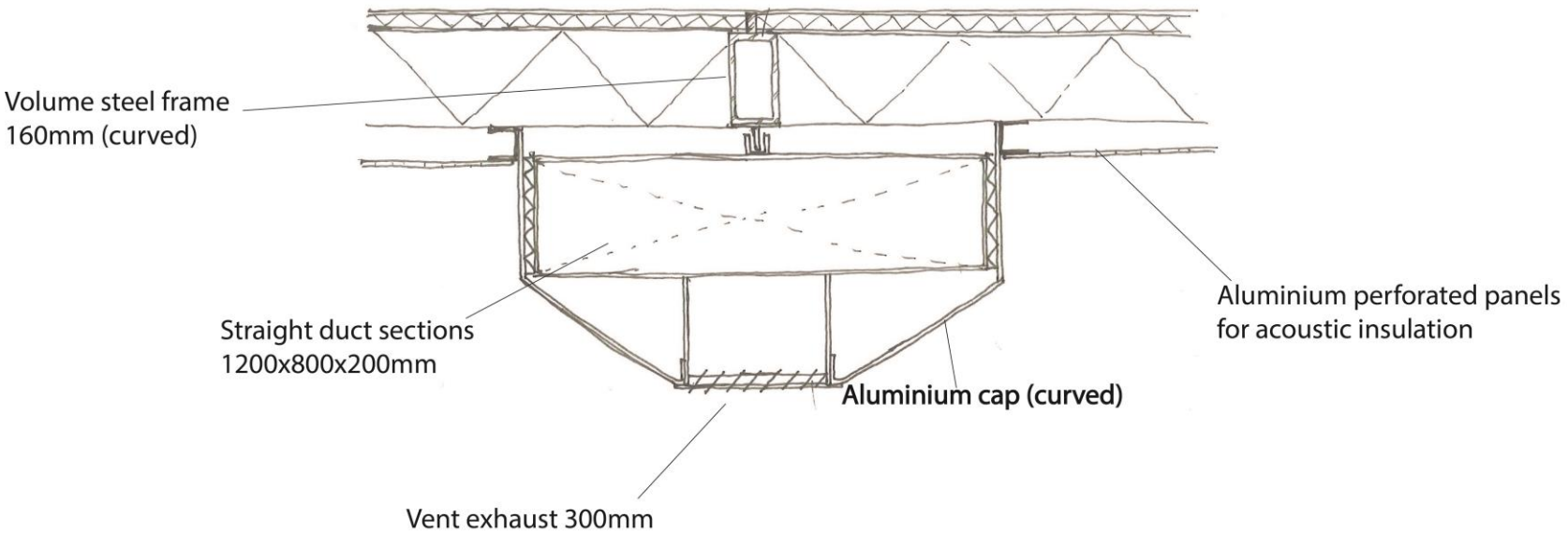
Ventilation and Lighting

Principle duct system



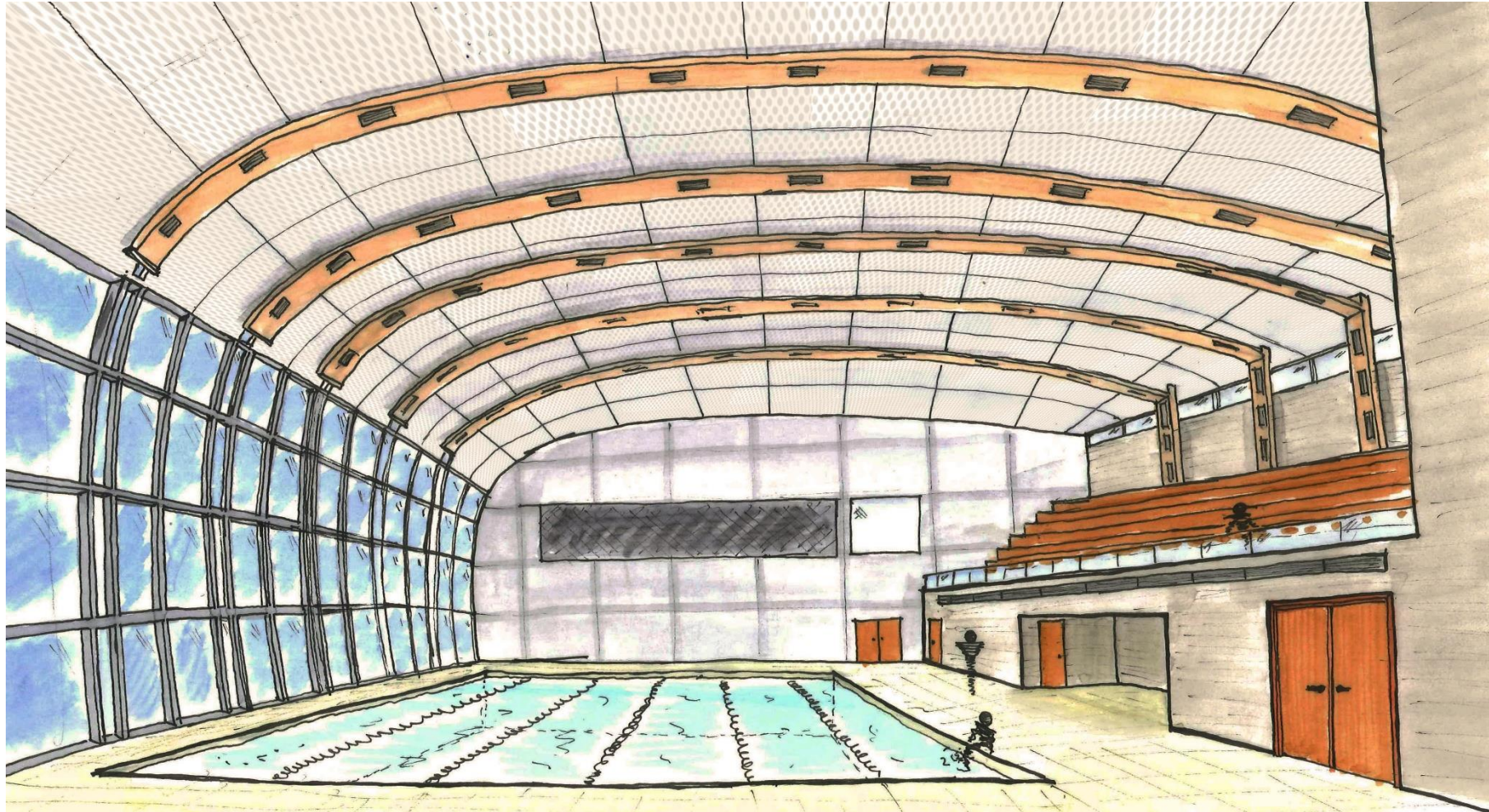
Ventilation and Lighting

Principle duct detail



Reference; Haagse Hofbad, Venhoeven CS

Swimming pool perspective



Conclusive

Achievements and next steps

Achievements

- Design on all scales
- Adding a valuable function to the Westerpark, giving new meaning to the park in relation to its surroundings
- Working with a new construction material and turning it into architecture
- Elegant and slender design with the help of static structural analysis
- Creating experience

Experience

SHORT FILM

Questions