

# Aluminum grid shell structures and systems for free- from envelopes



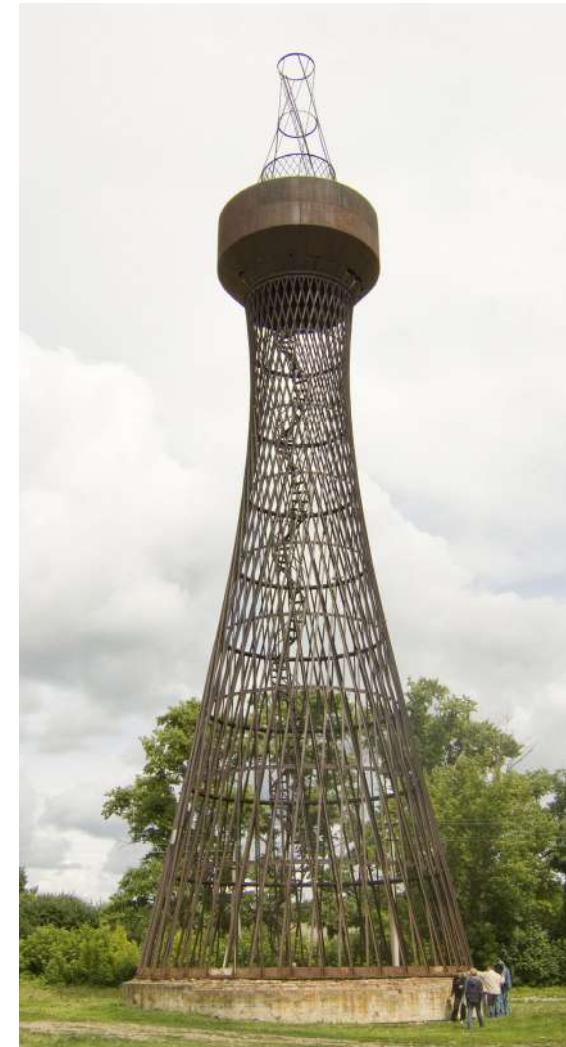
# Introduction. Grid shell structures

## *Background*

- Thin-wall rigid space frame structures of curved shape;
- Vladimir Shukhov – end of XIX century – pioneered gridshells (1896 All-Russia industrial and art exhibition (RIAE));
- End of XX century – wide spread of sophisticated free-form grid shells;



the British Museum courtyard, covered with grid shell

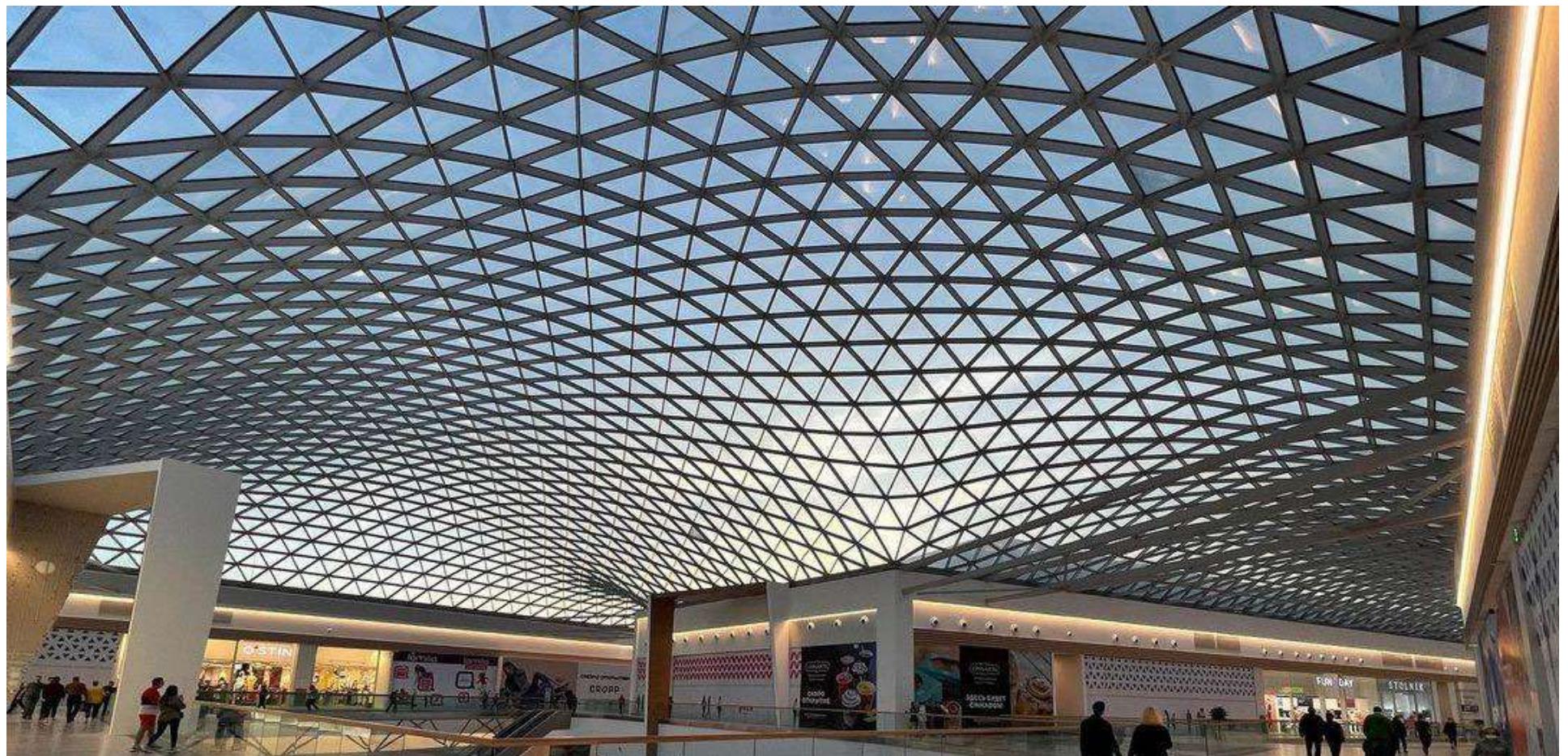


Tower from RIAE bought by Nechaev-Maltsov and moved to Polibino, Russia)

# Introduction. Grid shell structures

## *Skylights*

- Large-span shells without supporting structures (self-supporting property of the structure);



VEER MALL, Ekaterinburg, Russia

# Introduction. Grid shell structures

## Facades

- Beg of 2000 – parametric design as a brand new architectural style;
- New tasks combining facade utilitarian function (building protection) and artistic function (building as “objets d’art”);



# Supporting Systems LLC

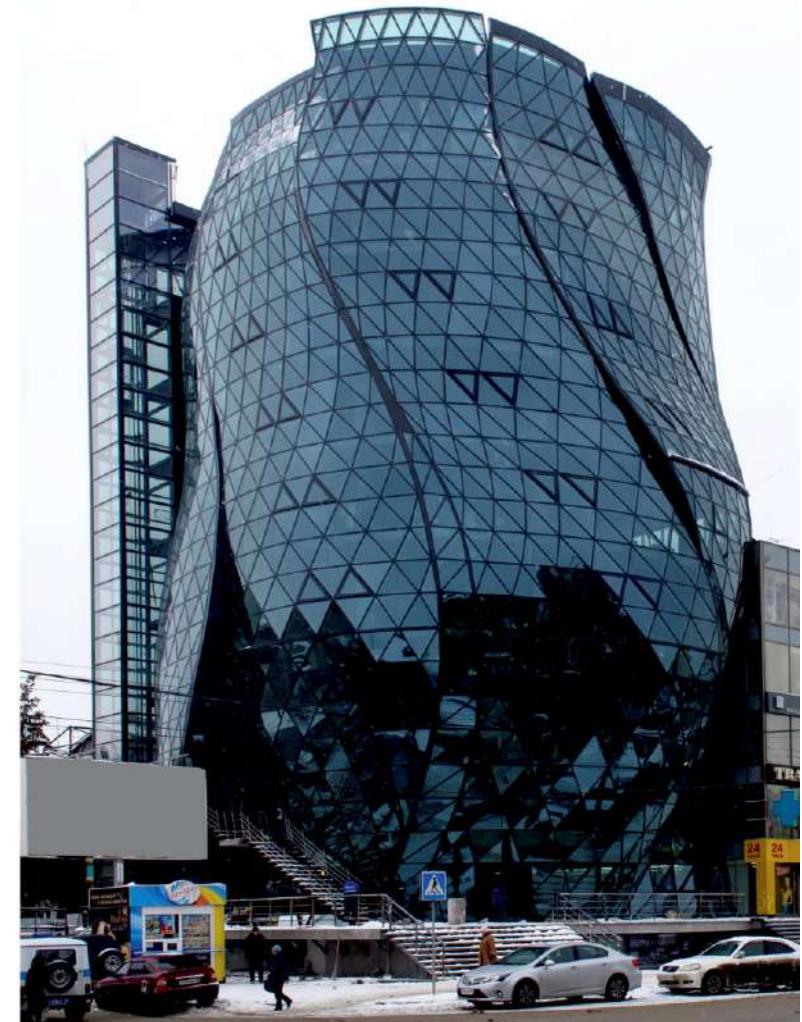
## *Company profile:*

2002 – setting up a company

- Specialization:
  - curtain wall façade installation;
  - manufacturing (certified Schüco partner);

2007 – specialization change:

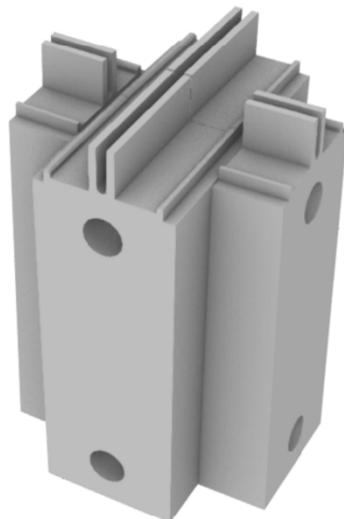
- engineering (parametric design);
- manufacturing (free form space-frame systems and structures (useful model patent №72708);



# Technical Description

## *Single layer system*

- Self-supporting grid shell structure «SpaceStructure»;
- All elements – 100% prefabricated;
- Material – high tensile aluminum alloy (AW-6082T6 and AW-2024T3);



Node

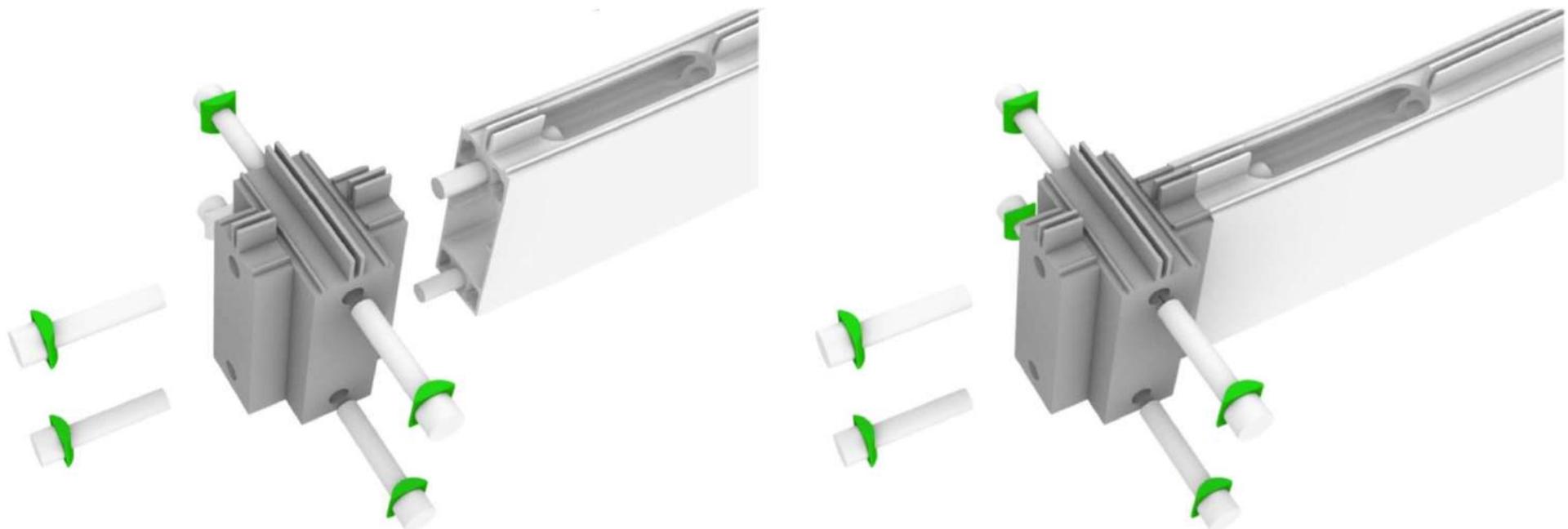


Tube (Profile)

# Technical Description

## *Single layer system*

- Self-supporting grid shell structure «SpaceStructure»;
- All elements – 100% prefabricated;
- Material – high tensile aluminum alloy (AW-6082T6 and AW-2024T3);
- Connection – bolted, stainless steel bolts A2-70 DIN 912;
- Connection without welding – high manufacturing and erection speed;

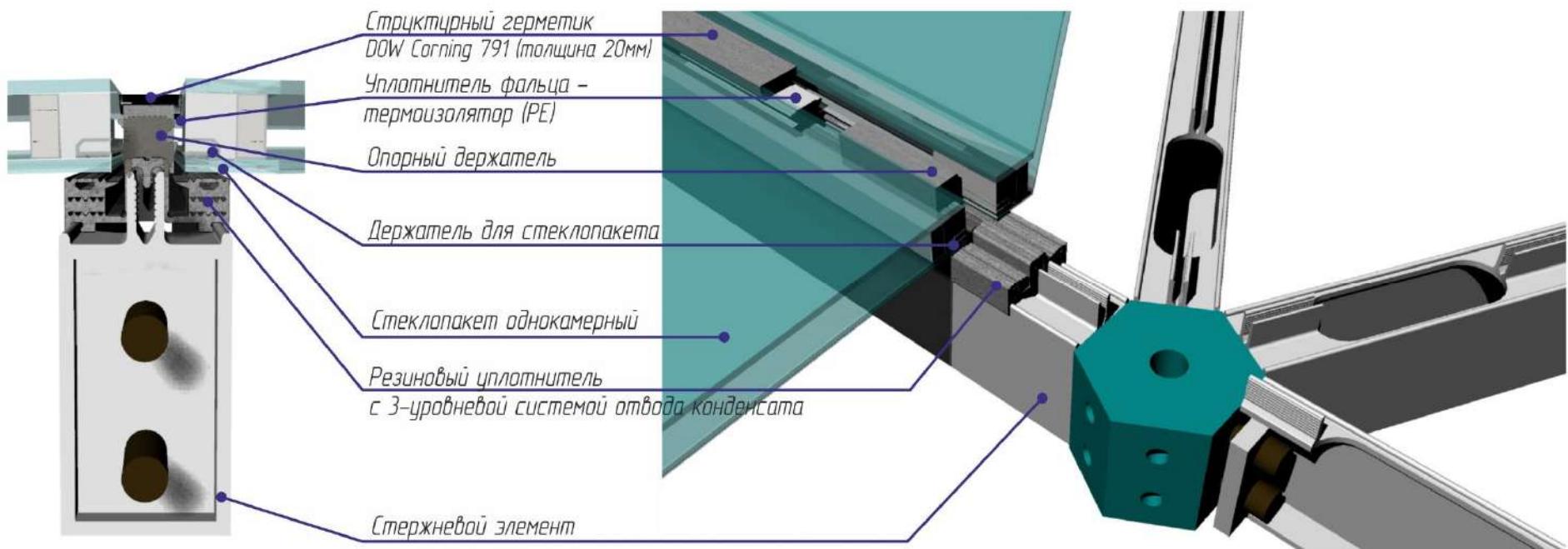


Bolted connection

# Technical Description

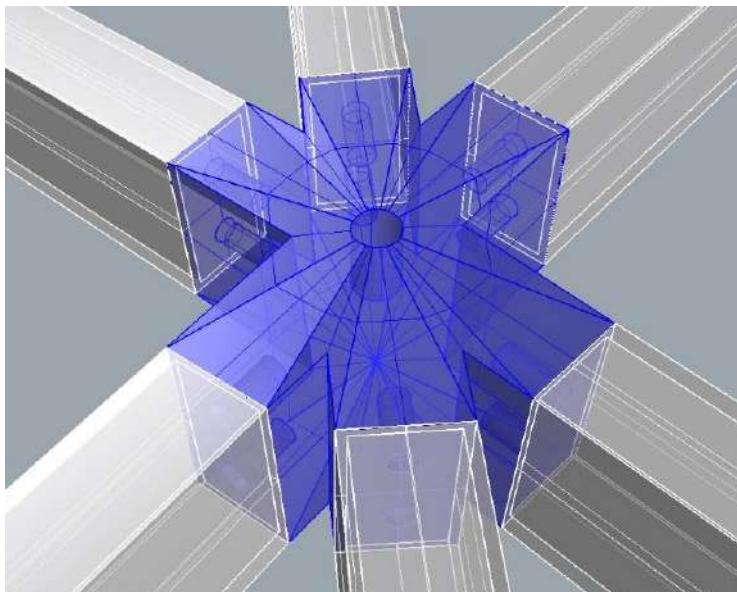
## Gasket

- EPDM gasket (2- or 3-layer) installed directly on the aluminum structure;
- Integrated in aluminum profiles;
- Certified solution with gaskets supplied by Schüco and Raico;
- Structural glazing – concealed fixing of glass units;

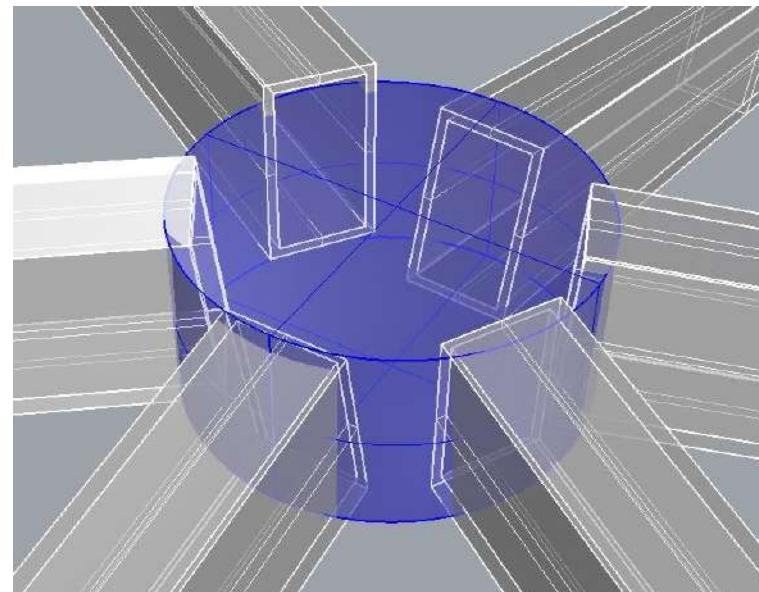


# High tensile aluminum alloys solution advantages over steel

- High corrosion resistance;
- Low dead load (important in historical buildings reconstruction);
- Strong visual appearance;
  - Anodized or powder-coated surface;
  - Nodal element additionally processed – “Star”- node;
  - EPDM gasket comprehensive fixation;



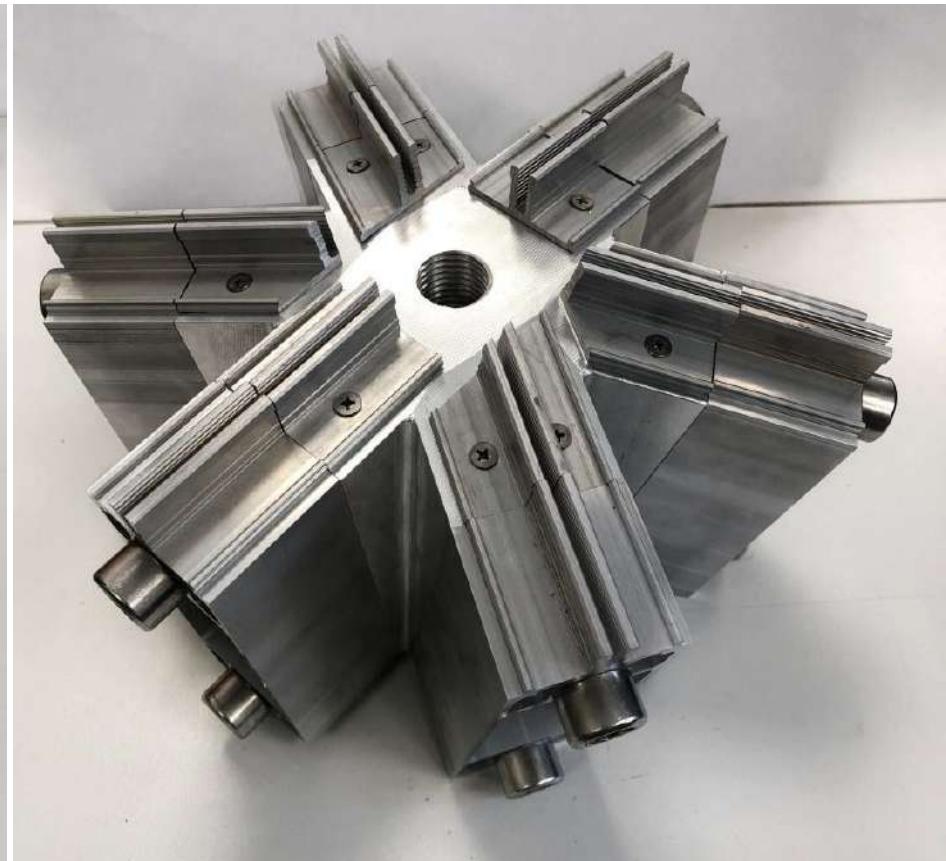
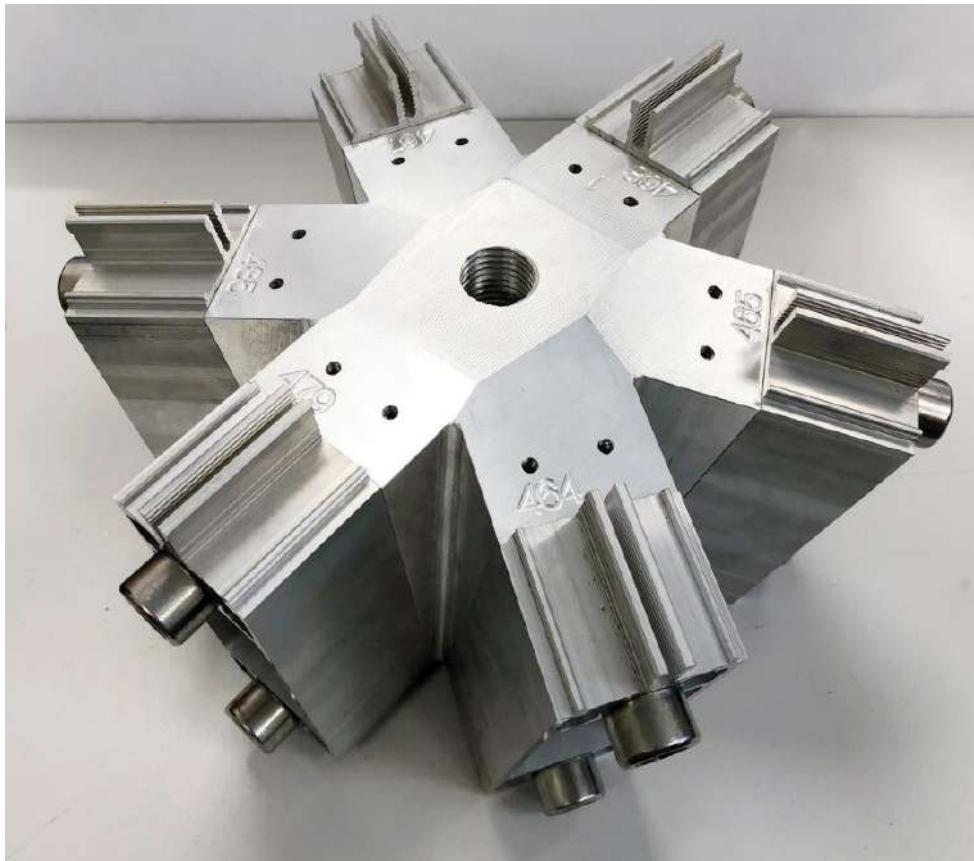
Star- node



Cylinder node

## High tensile aluminum alloys solution advantages over steel

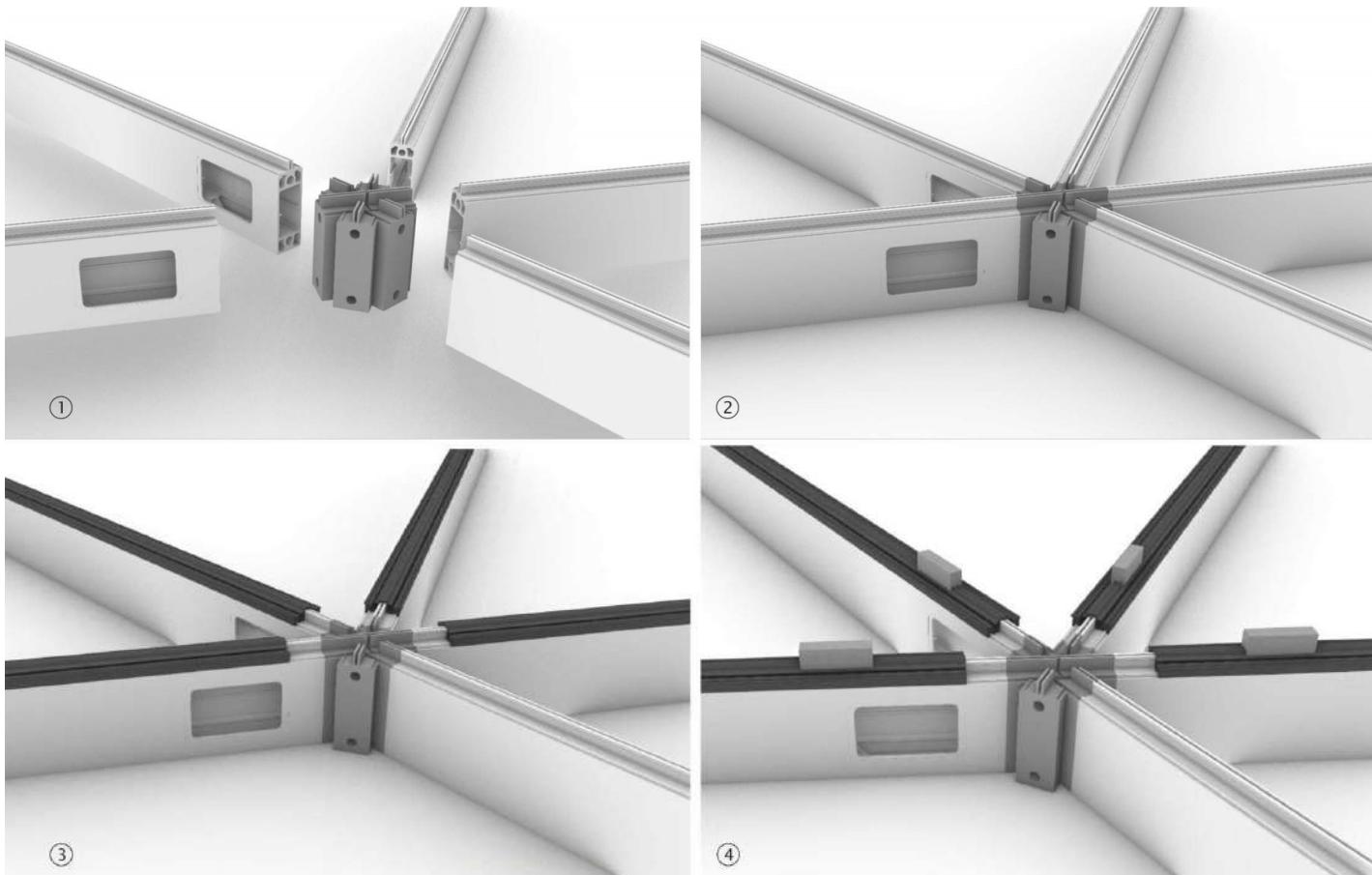
- Material – high tensile aluminum alloy (EN AW 6082T6);
- Top surface additional processing to avoid EPDM gasket dipping (comprehensive fixation);



# Technical Description

## *Single layer system*

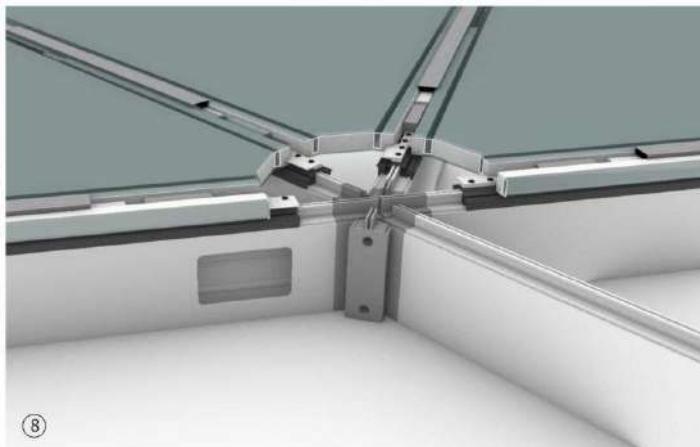
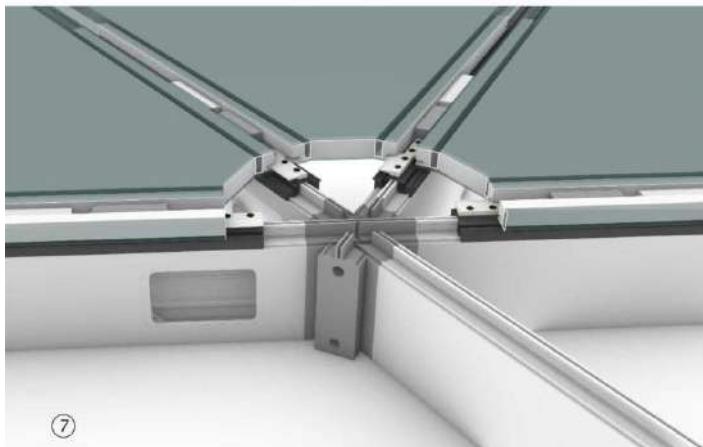
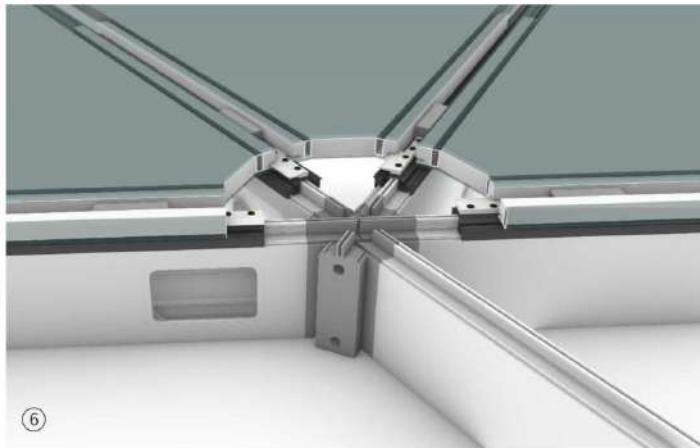
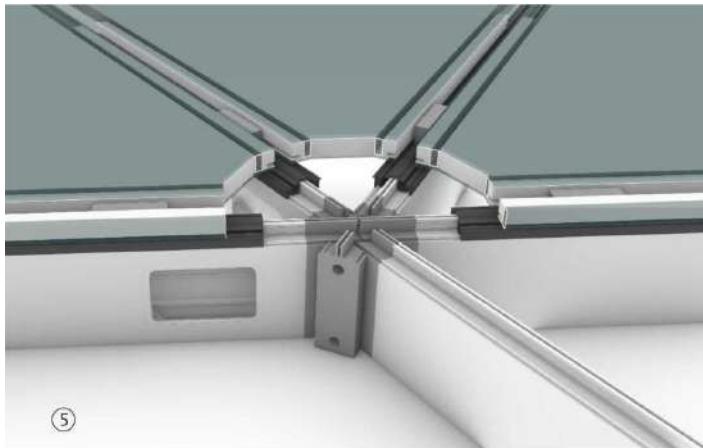
- Self-supporting grid shell structure «SpaceStructure»;
- Material – high tensile aluminum alloy (AW-6082T6 and AW-2024T3);
- EPDM gasket (2- or 3-layer) installed directly on the structure;



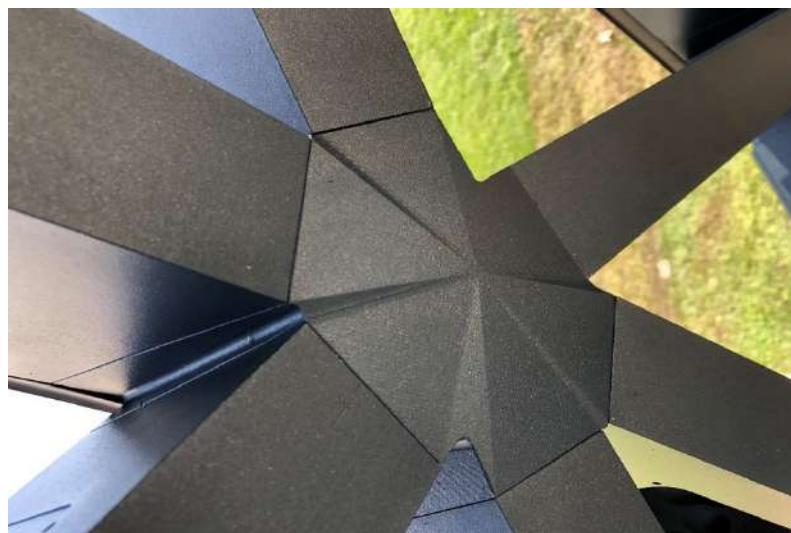
# Technical Description

## *Single layer system*

- Glass units installed directly on the structure;
- Fast and easy mounting;



## Free form construction system Visual appearance



Star- node (aluminum)

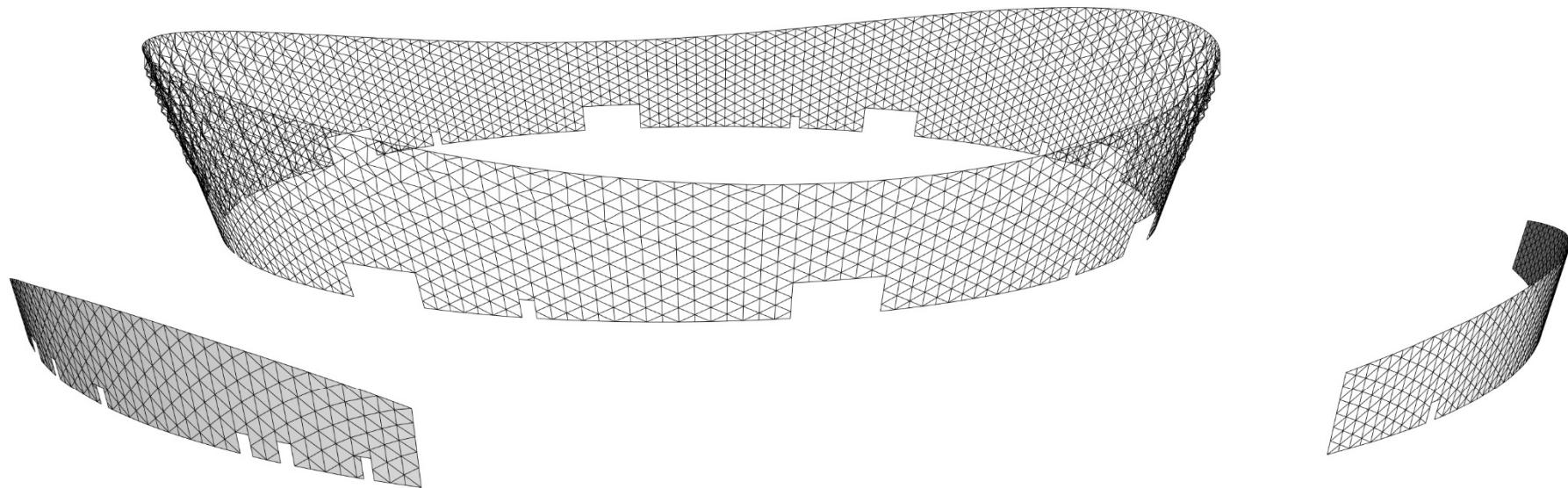


Cylinder node (steel)

# Design

## *Parametric design*

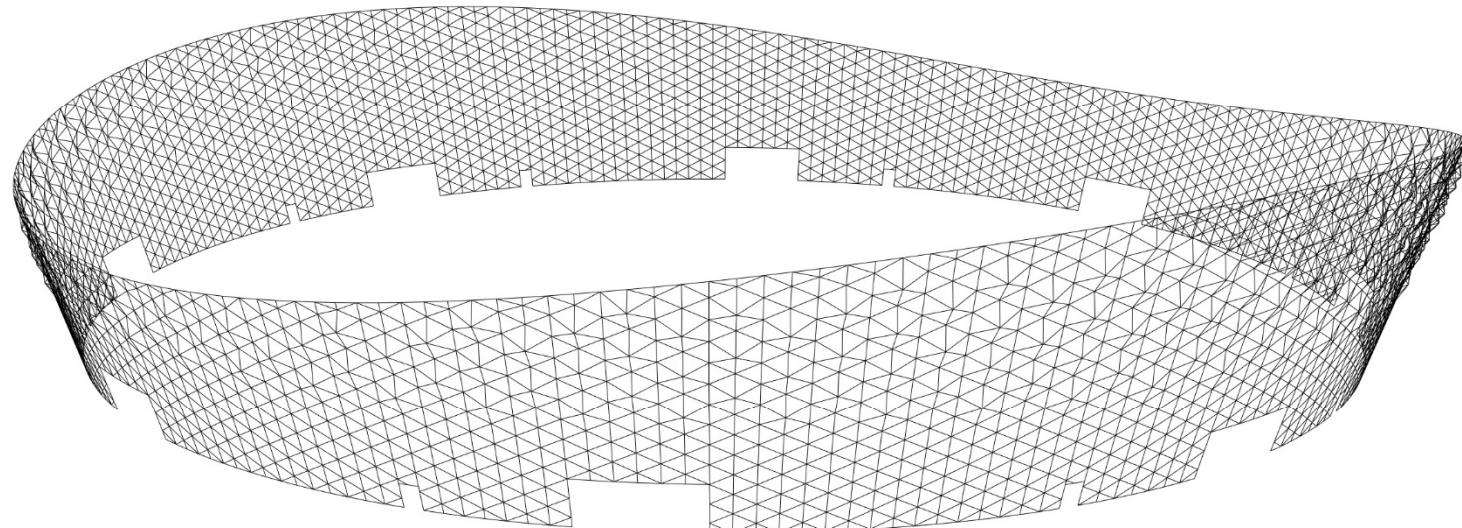
- Parametric models in Rhinoceros/ Grasshopper software generation;



# Design

## *Parametric design*

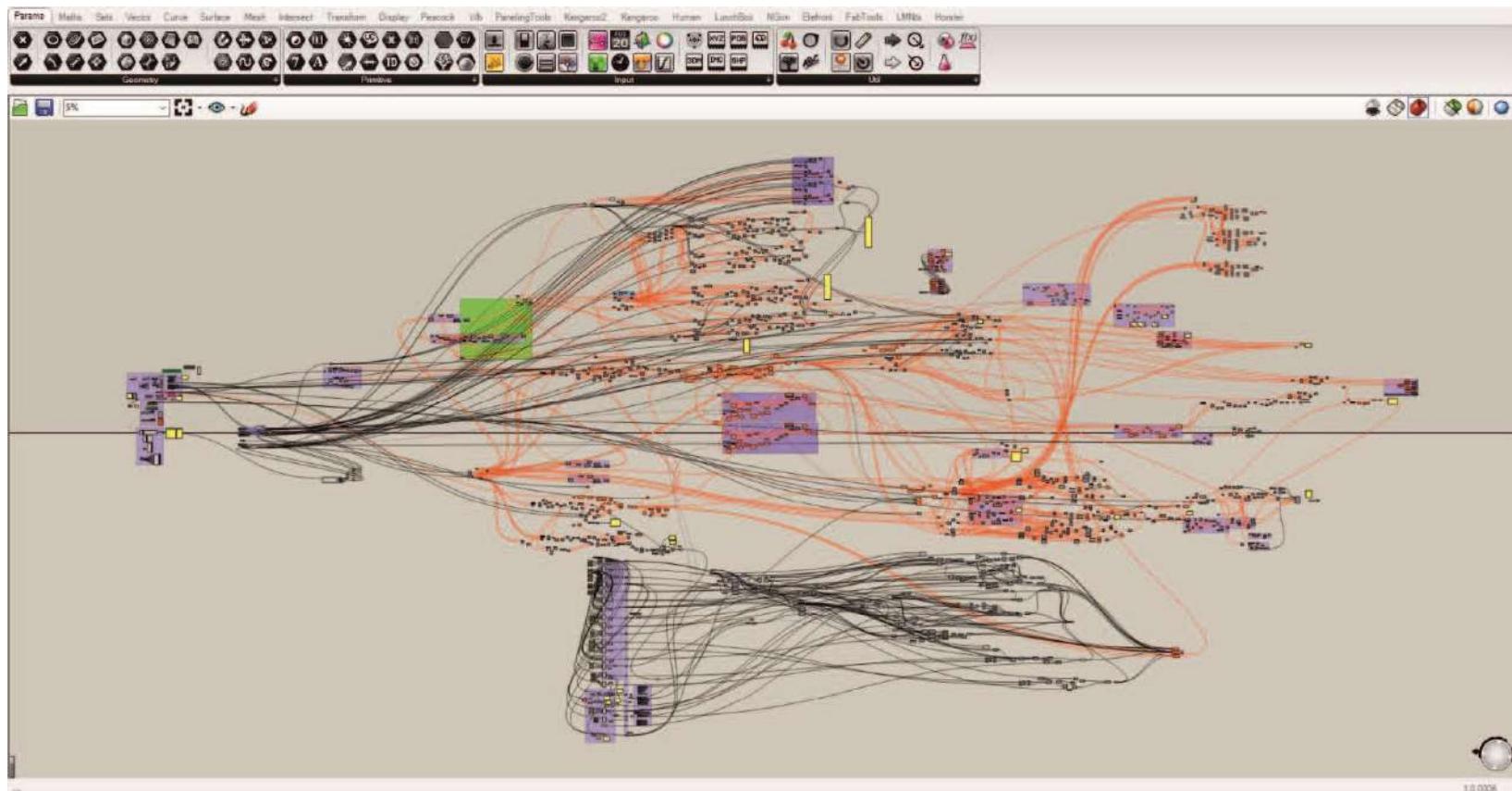
- Parametric models in Rhinoceros/ Grasshopper software generation;



# Design

## *Parametric design*

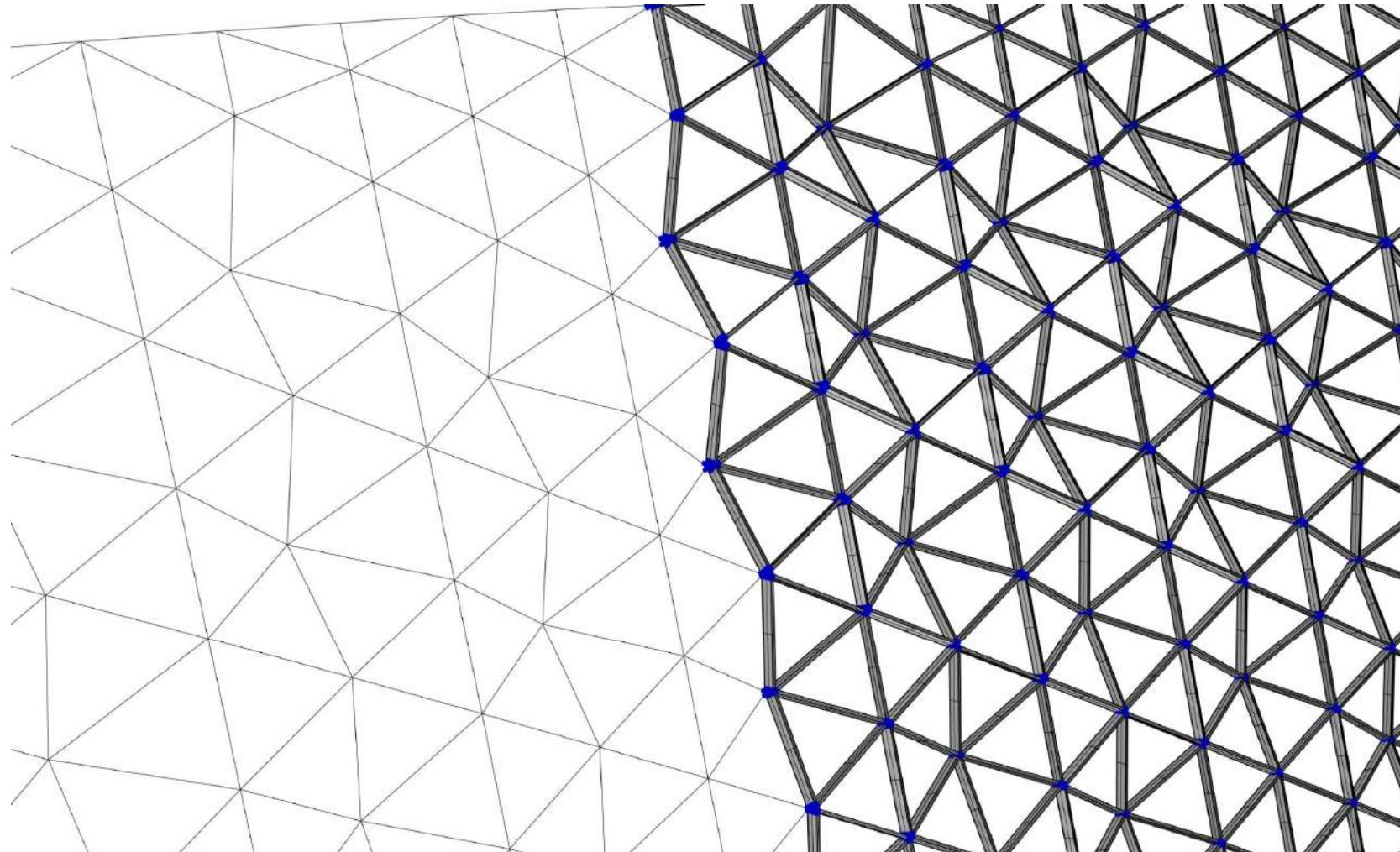
- Easy to introduce changes in the code;
- highly automated logic;



# Design

## *Parametric design*

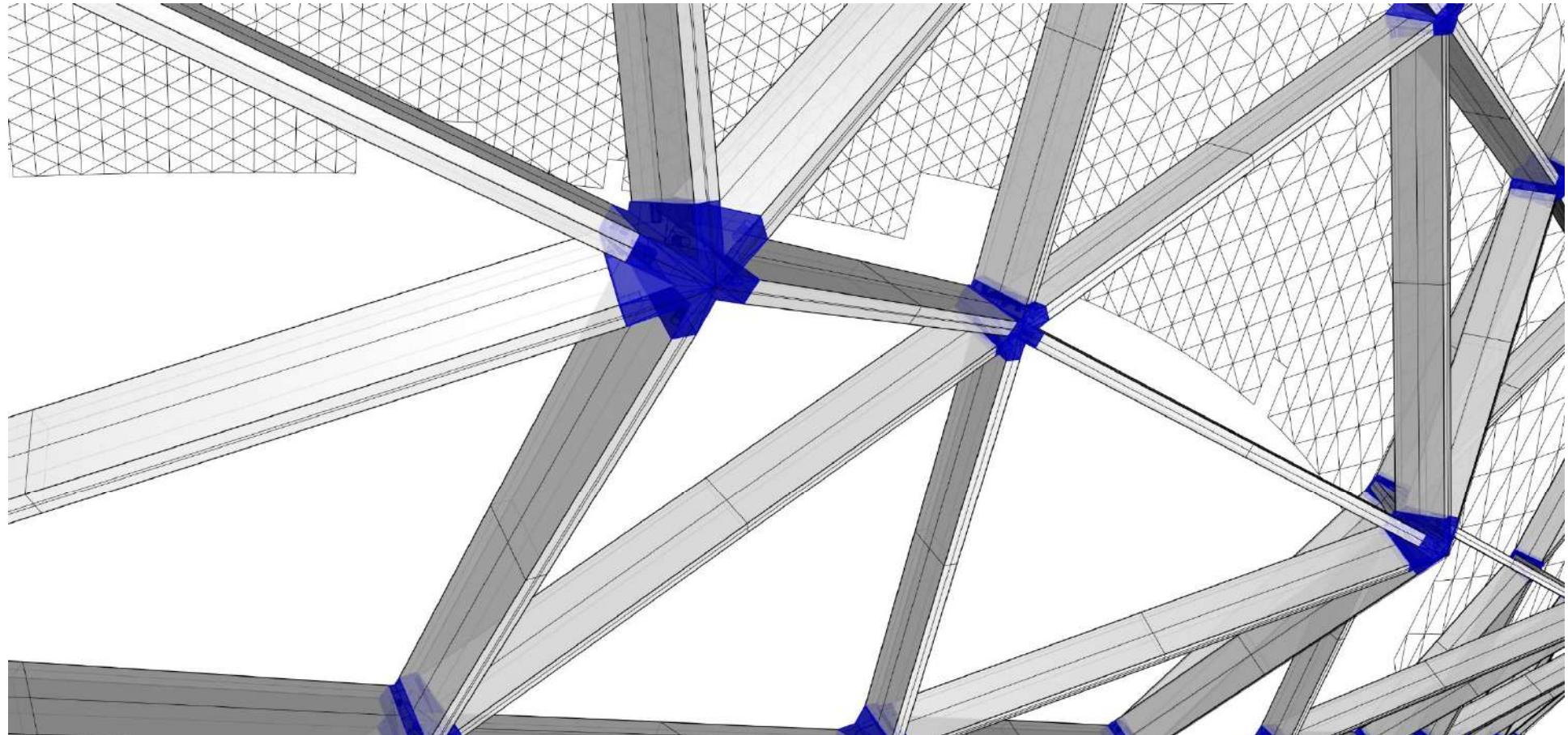
- Detailed design model generation;



# Design

## *Parametric design*

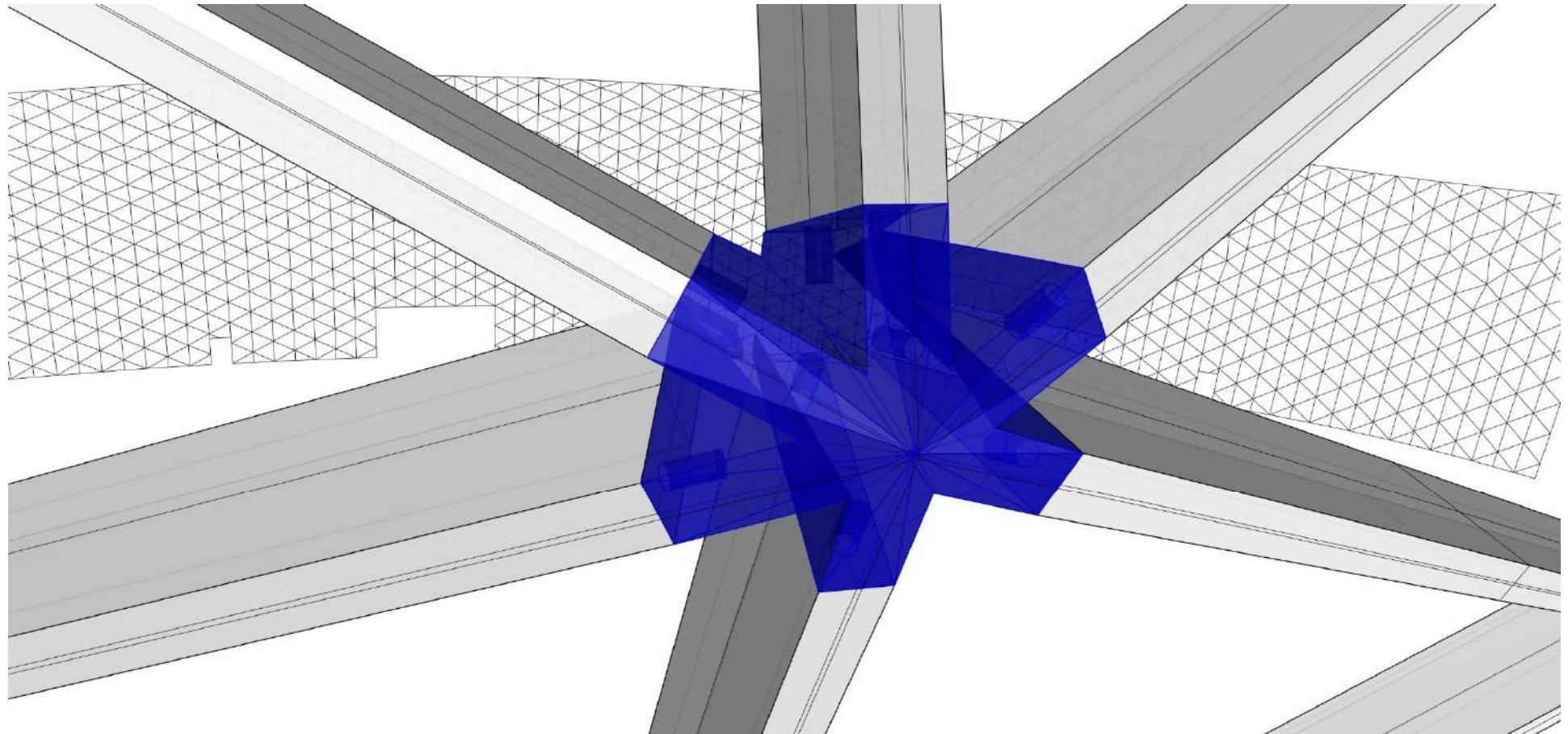
- Detailed design model generation;



# Design

## *Parametric design*

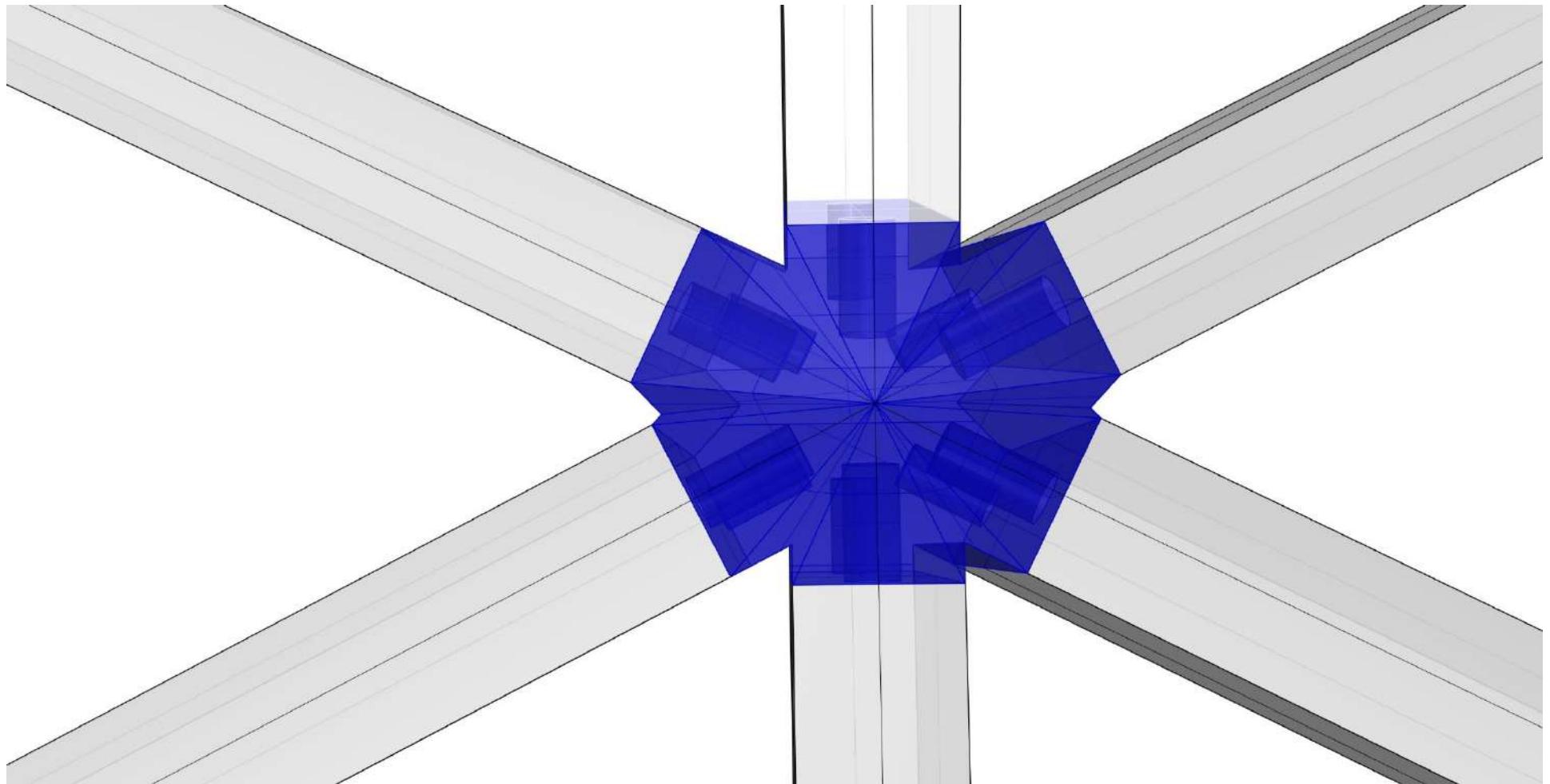
- Detailed design model generation;



# Design

## *Parametric design*

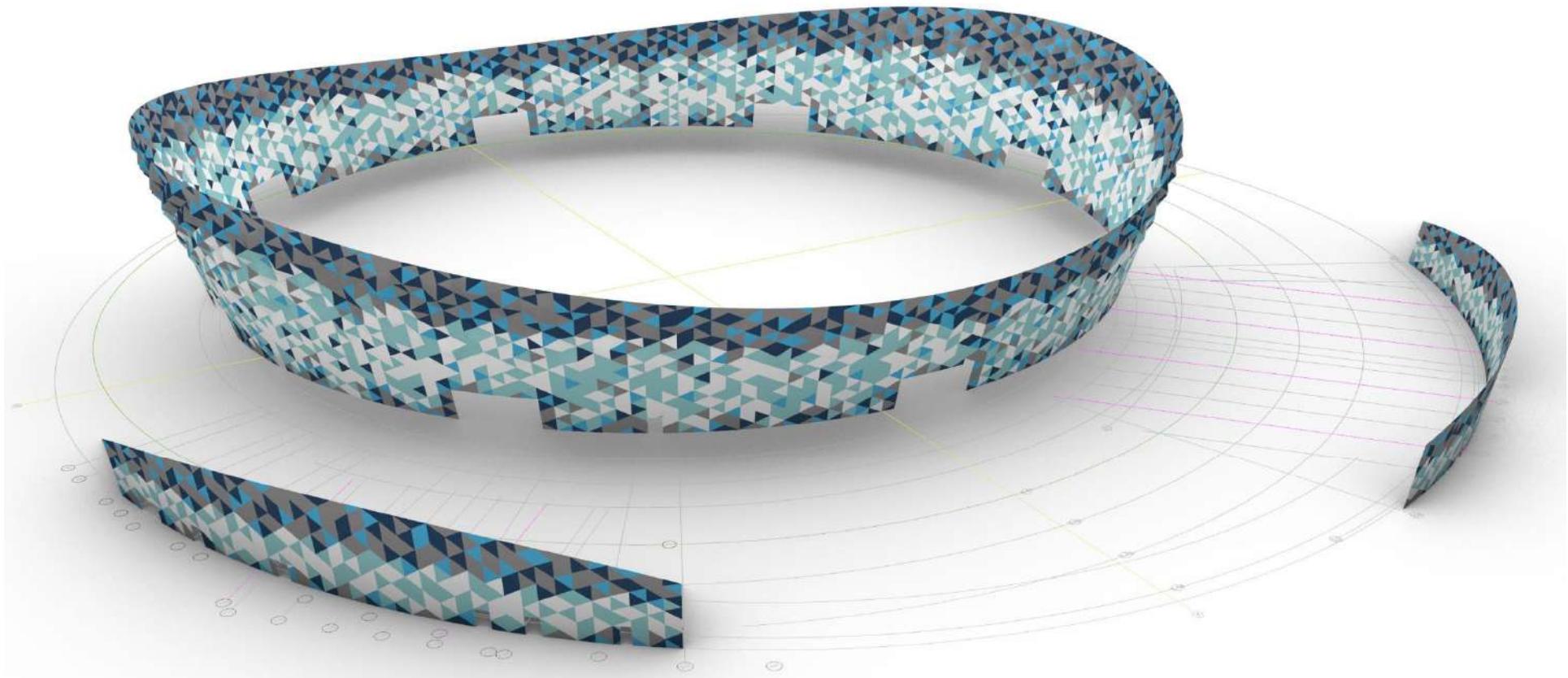
- Detailed design model generation;



# Design

## *Parametric design*

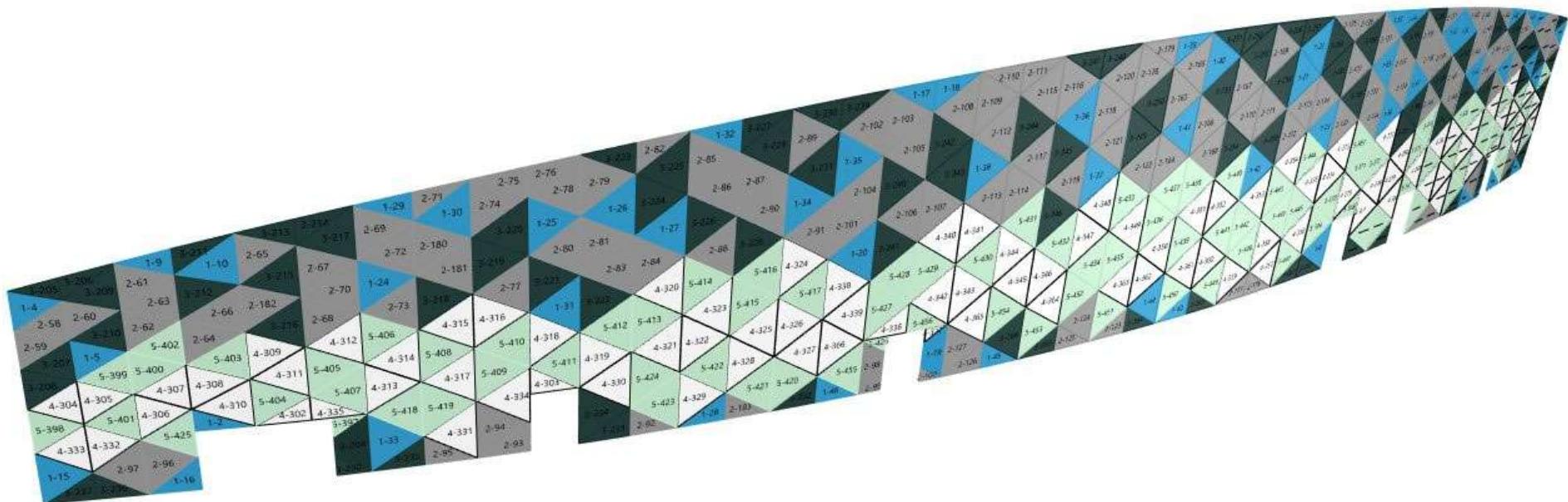
- Glass units specification automatically generated from the detailed design model;



# Design

## *Parametric design*

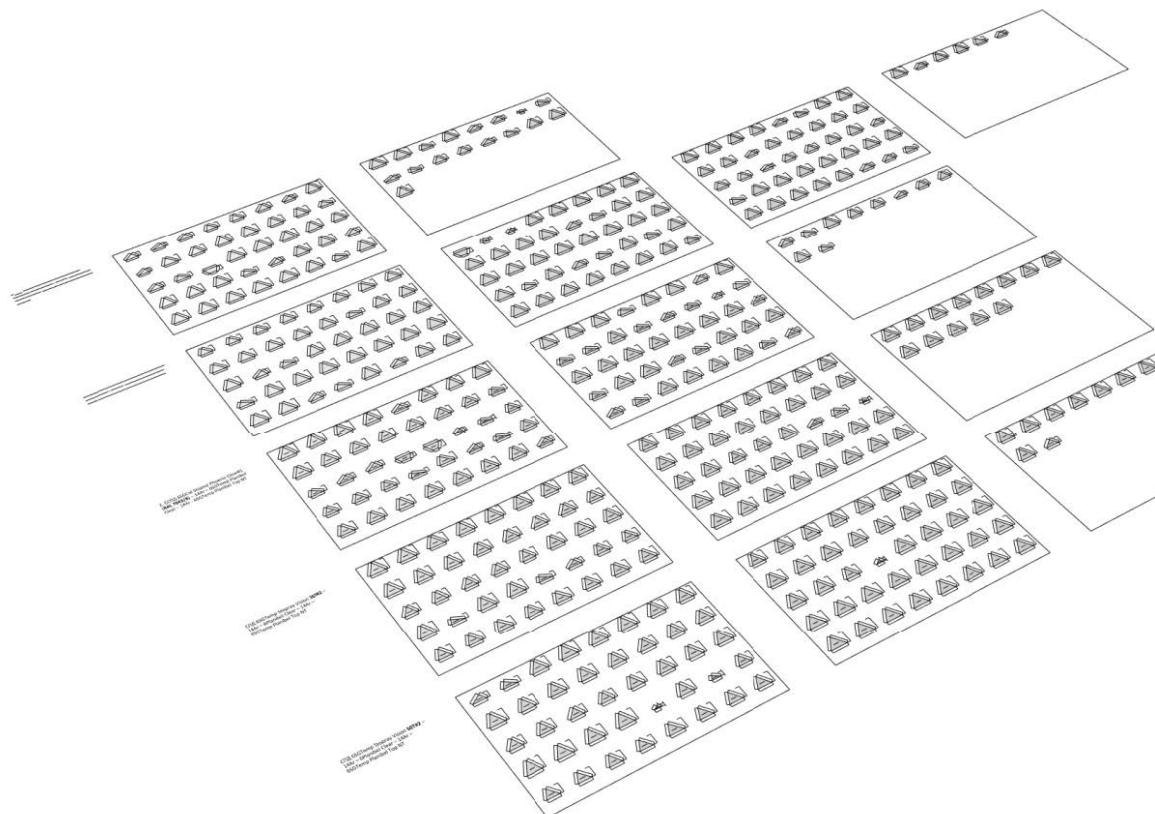
- Glass units specification automatically generated from the detailed design model;



# Design

## Parametric design

- Glass units specification automatically generated from the detailed design model;

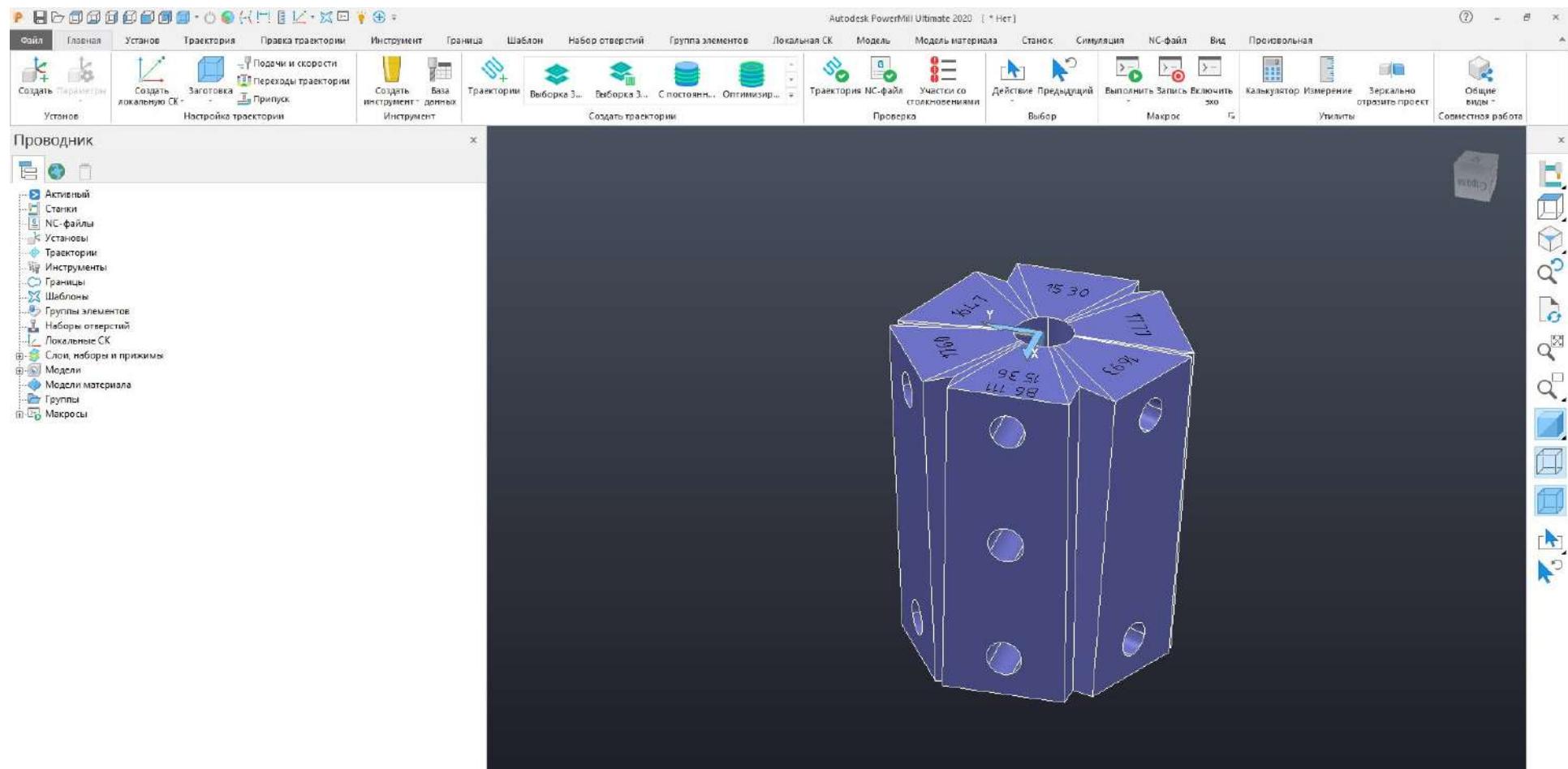


№ п/п	Наименование изделия	Модификация	Количество	Основание, мк	Высота, мм	Ширина I	Страна I	Страна II	Страна III	Площадь, м2	Вес, кг
1	CSD:Glass Unit Type 1	1-1	1	2100	910	1000	1000	1000	1000	0,8	85,6
2	CSD:Glass Unit Type 1	2-1	1	2100	1100	1000	1000	1000	1000	0,8	102,4
3	CSD:Glass Unit Type 1	3-1	1	2100	1200	1000	1000	1000	1000	0,8	119,2
4	CSD:Glass Unit Type 1	4-1	1	2100	1300	1000	1000	1000	1000	0,8	136,0
5	CSD:Glass Unit Type 1	5-1	1	2100	1400	1000	1000	1000	1000	0,8	152,8
6	CSD:Glass Unit Type 1	6-1	1	2100	1500	1000	1000	1000	1000	0,8	169,6
7	CSD:Glass Unit Type 1	7-1	1	2100	1600	1000	1000	1000	1000	0,8	186,4
8	CSD:Glass Unit Type 1	8-1	1	2100	1700	1000	1000	1000	1000	0,8	203,2
9	CSD:Glass Unit Type 1	9-1	1	2100	1800	1000	1000	1000	1000	0,8	220,0
10	CSD:Glass Unit Type 1	10-1	1	2100	1900	1000	1000	1000	1000	0,8	236,8
11	CSD:Glass Unit Type 1	11-1	1	2100	2000	1000	1000	1000	1000	0,8	253,6
12	CSD:Glass Unit Type 1	12-1	1	2100	2100	1000	1000	1000	1000	0,8	270,4
13	CSD:Glass Unit Type 1	13-1	1	2100	2200	1000	1000	1000	1000	0,8	287,2
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15	CSD:Glass Unit Type 1	15-1	1	2100	2400	1000	1000	1000	1000	0,8	320,8
16	CSD:Glass Unit Type 1	16-1	1	2100	2500	1000	1000	1000	1000	0,8	337,6
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21	CSD:Glass Unit Type 1	21-1	1	2100	3000	1000	1000	1000	1000	0,8	421,6
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33	CSD:Glass Unit Type 1	33-1	1	2100	4200	1000	1000	1000	1000	0,8	623,2
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37	CSD:Glass Unit Type 1	37-1	1	2100	4600	1000	1000	1000	1000	0,8	690,4
38	CSD:Glass Unit Type 1	38-1	1	2100	4700	1000	1000	1000	1000	0,8	707,2
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78	CSD:Glass Unit Type 1	79-1	1	2100	8700	1000	1000	1000	1000	0,8	1379,2
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93	CSD:Glass Unit Type 1	94-1	1	2100	10200	1000	1000	1000	1000	0,8	1631,2
94	CSD:Glass Unit Type 1	95-1	1	2100	10300	1000	1000	1000	1000	0,8	1648,0
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# Design

*Detailed design model transfer from Rhinoceros to PowerMILL*

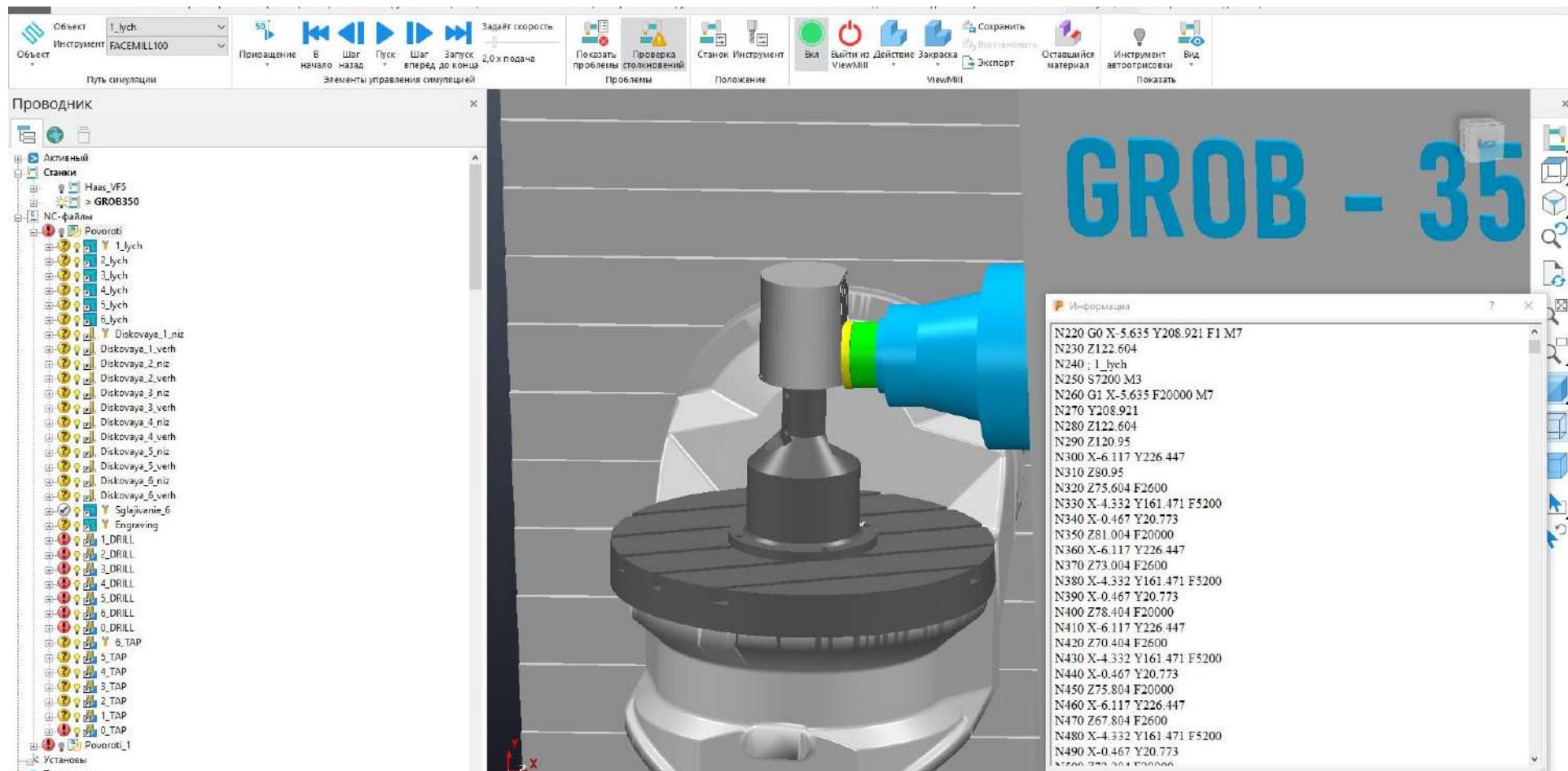
- CNC machinery automatic coding;
- Nodal element after transferring to PowerMILL;



# Design

*Detailed design model transfer from Rhinoceros to PowerMILL*

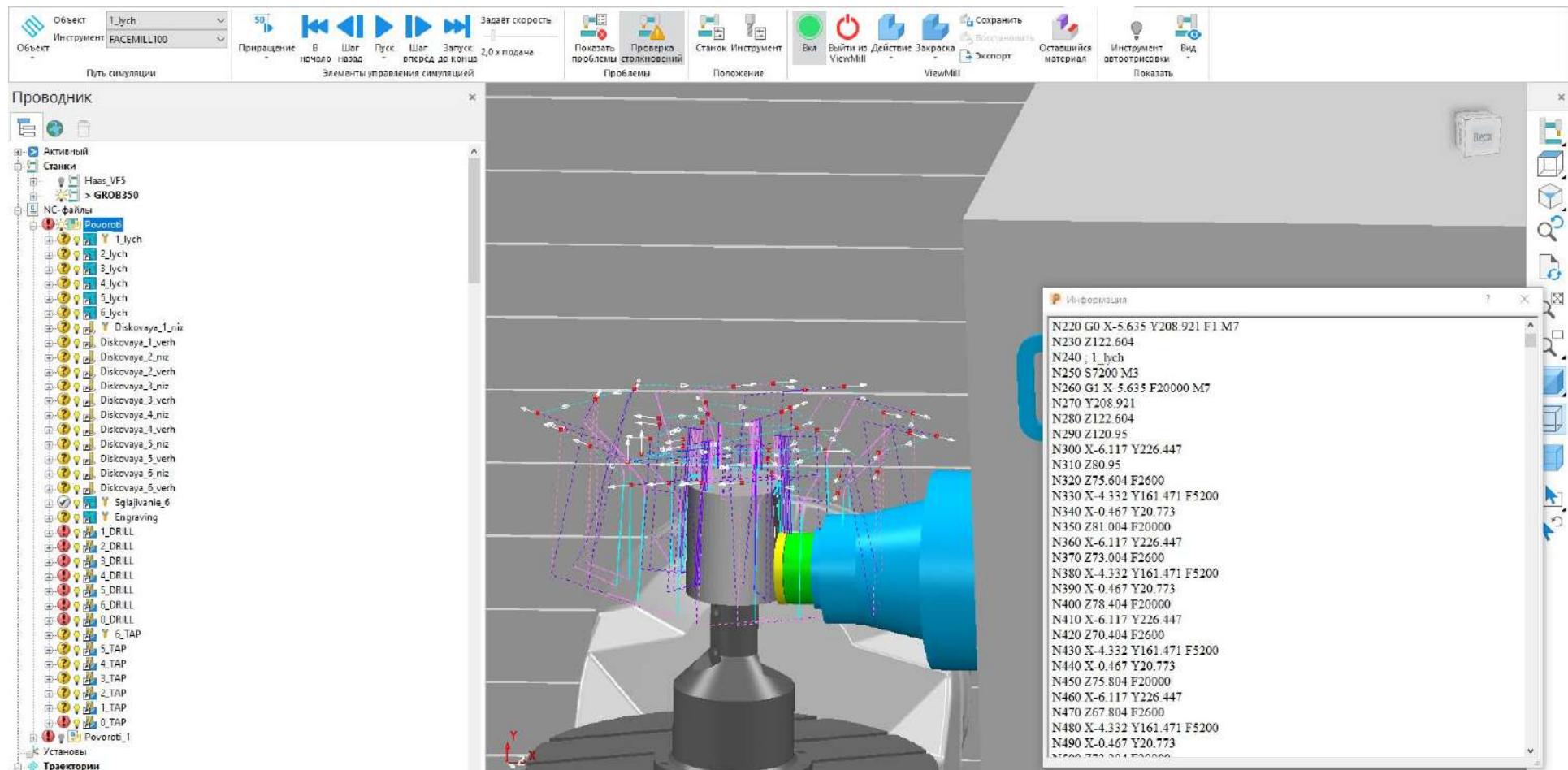
- CNC machinery automatic coding;
- NC cutter path;



# Design

*Detailed design model transfer from Rhinoceros to PowerMILL*

- CNC machinery automatic coding;
- NC cutter path + G code;



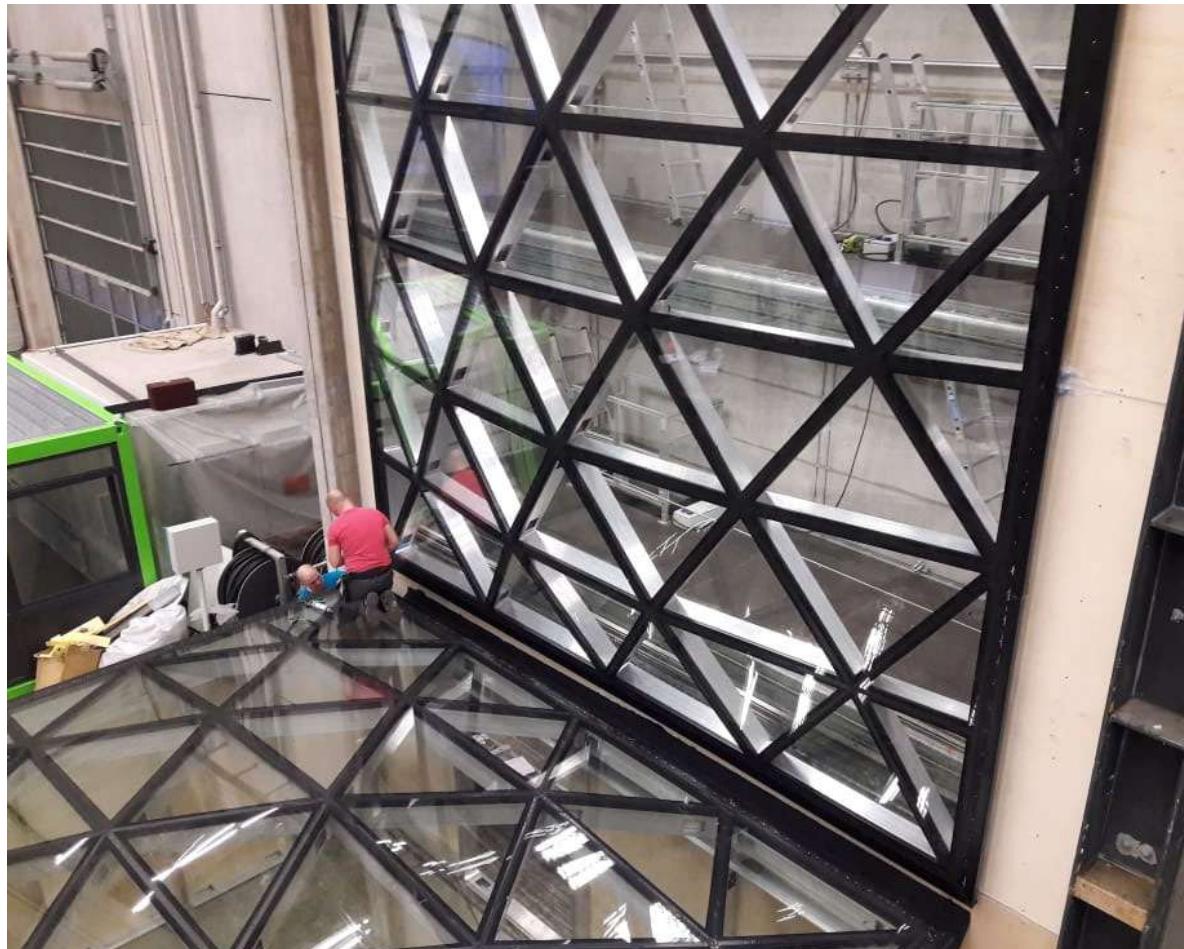
# Certification

## *Certification testing (ift Rosenheim GmbH)*

**Air permeability** – Class A4 (EN 12152) / ГОСТ 26602.2-99 ;

**Water tightness** – Class RE<sub>1200</sub> (EN 12154) / ГОСТ 26602.2-99 ;

**Resistance to wind load** – +/- 4,5 kN/sqm (EN 13116); **snow load** – + 6,0 kN/sqm (EN 12179);



### Evidence of Performance

Air permeability, Watertightness static, Resistance to wind load



#### Test Report

No. 19-004424-PR01  
(PB-B01-02-en-01)

**Client** Supporting Systems  
Novosibirsk, Sovetskaya street, 10  
Russia

**Product** Roof in stick construction  
**Designation** Supporting system  
**Material** Aluminium profiles and solid aluminium

**Overall dimensions** (W x H)  
(5.680 mm x 3.850 mm (roof part))  
**Construction project**<sup>1)</sup> G2S, Novosibirsk

**Special features** The vertical facade part has not been evaluated

#### Results

 Air permeability  
In accordance with EN 12152:2002-02  
**Class A4**<sup>2)</sup>

 Watertightness - static  
In accordance with EN 12154:1999-12  
**Class RE<sub>1200</sub>**

 Resistance to wind load  
In accordance with EN 13116:2001-07  
**Design load Safety load**  
± 3.0 kN/m<sup>2</sup> ± 4.5 kN/m<sup>2</sup>

Resistance to wind load (simulated snow load)  
In accordance with EN 12179:2000-06  
**Snow load**  
+ 6.0 kN/m<sup>2</sup>

<sup>1)</sup>Classification applies for joint related air permeability.

ift Rosenheim  
23.04.2020

  
Thomas Krichbaum  
Deputy Head of Testing Department  
Building Component Testing

  
Thomas Stefan, Dipl.-Ing. (FH)  
Operating Testing Officer  
Building Component Testing



**Instructions for use**  
The results obtained can be used by the manufacturer for preparing the Declaration of Performance in accordance with the Construction Products Regulation 305/2011/EU. The provisions of the applicable product standard have to be observed.  
According to the manufacturer, the facade originates from the specified construction project and was selected by the client as representative building component.

**Validity**

The data and results refer solely to the tested and described specimen. Classification remains valid as long as the product and the assembly conditions remain unchanged.

The results can be extrapolated under the manufacturer's own liability subject to observance of the relevant specifications set out in the applicable product standard.

This test evaluation does not allow any statement to be made on any further characteristics regarding performance or quantity of the construction presented, in particular the effects of weathering and ageing were not taken into account.

**Notes on publication**

The Ift-Guideline Sheet "Advertising using the term 'certified'" applies. The cover sheet cannot be used as an abstract.

The report contains a total of 41 pages.

# Supporting systems IIC

*Manufacturing plant , Novosibirsk*



# Supporting systems IIc

*Manufacturing plant , Novosibirsk*

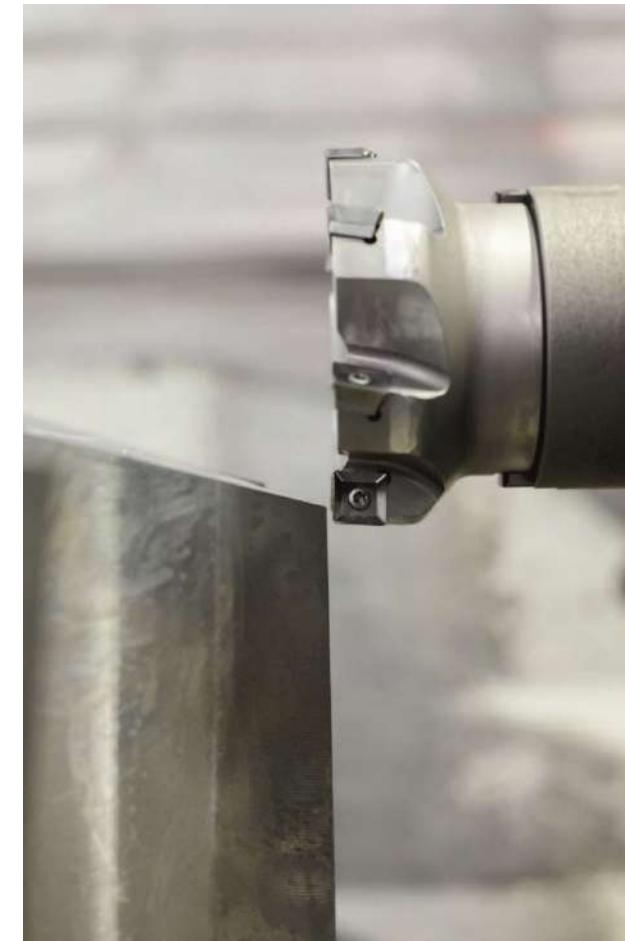
- 5-axis CNC machinery Grob (Germany) and Haas (USA);
- Manufacturing capacity – 10 000 sqm/month;



## Supporting systems IIc

*Manufacturing plant , Novosibirsk*

- 5-axis CNC machinery Grob (Germany) and Haas (USA);
- Manufacturing capacity – 10 000 sqm/month;



# Grid shell structures

## *High tensile aluminum alloys extrusion*

- Large-size profiles special extrusion;
- High tensile aluminum alloy AW-6082T6 and AW-6063T66 ;
- Modern high tensile aluminum alloys have characteristics equal to steel;

Alloy AW- 6082T6 – yield strength 250 MPa;

Alloy AW- 6063T66 – yield strength 200 MPa;

Steel S235J2G3 or S235J0 – yield strength 235 MPa and 255 MPa;



# Grid shell structures

## *High tensile aluminum alloys extrusion*

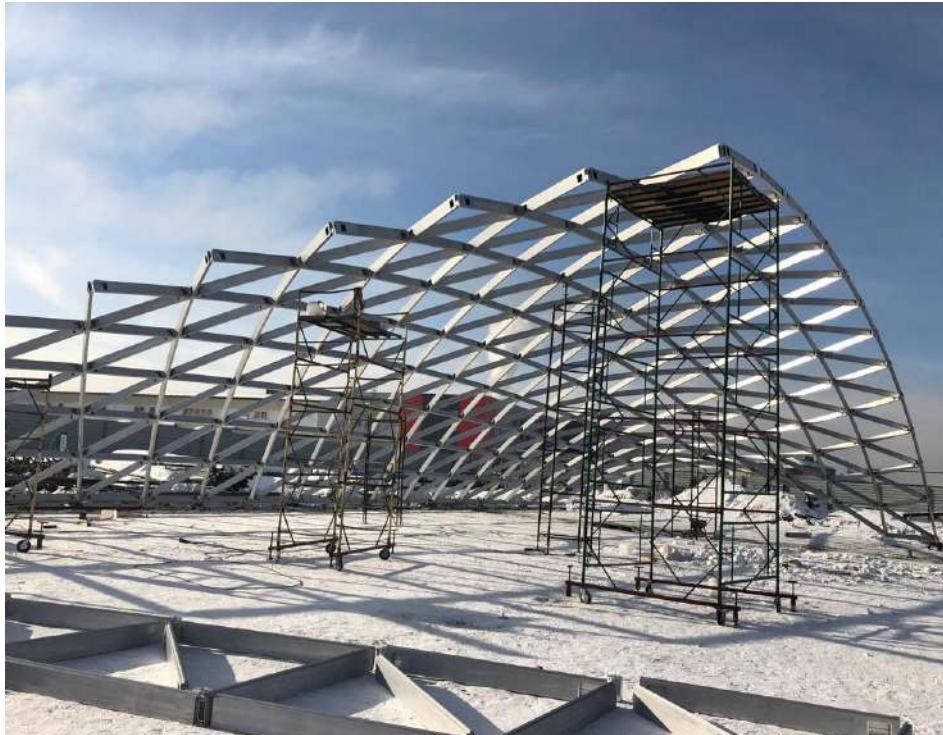
- Large-size profiles special extrusion;
- High tensile aluminum alloy AW-6082T6 and AW-6063T66;



## Supporting systems IIc

### *Product quality control*

- All elements of the structure – fit-up assembly test and geometry check;



## Single layer system erection

- On site enlarge assembly and installation;



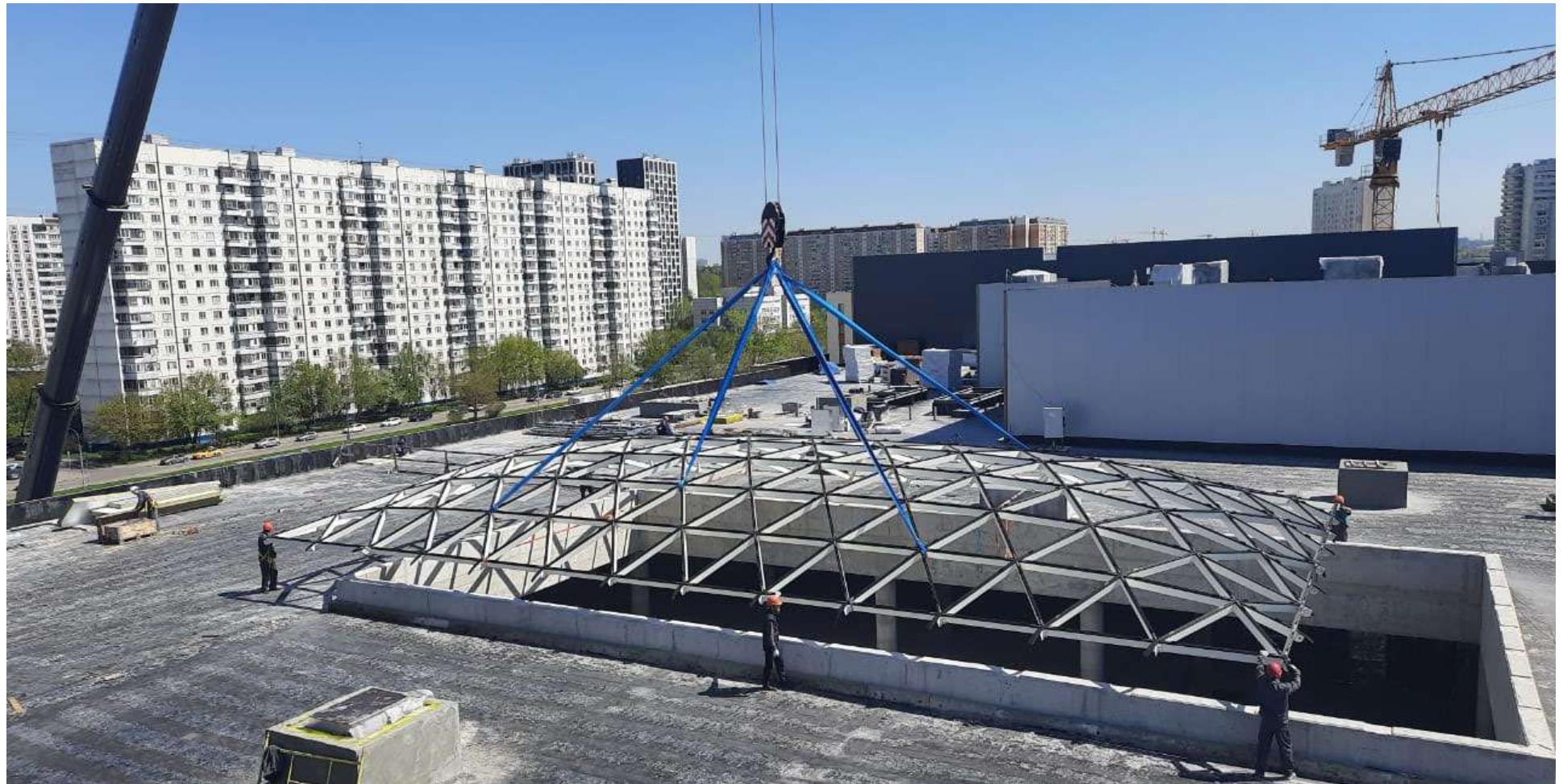
## Single layer system erection

- On site enlarge assembly and installation;



## Single layer system erection

- On site enlarge assembly and installation;



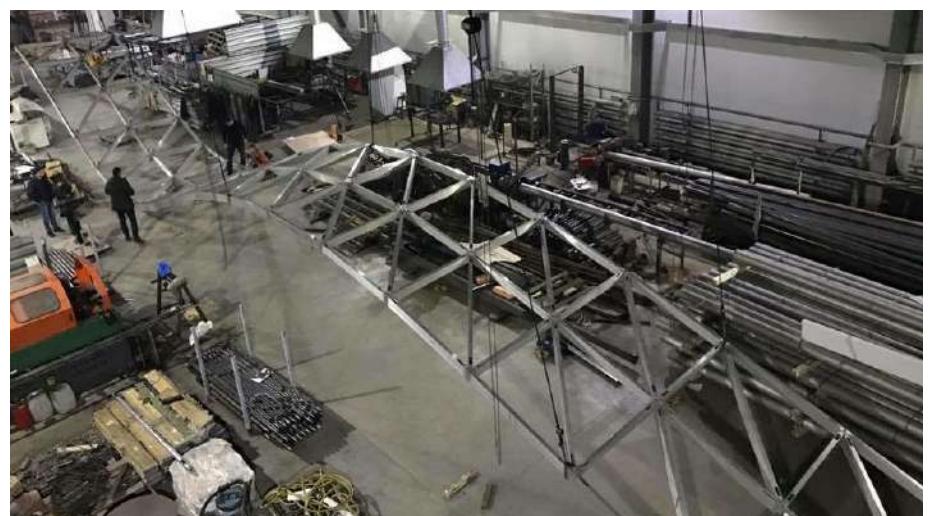
## Single layer system erection

- On site enlarge assembly and installation;



## Single layer system erection

- On site enlarge assembly in temporary rubb shelter ;



## Single layer system erection

- On site enlarge assembly in temporary rubb shelter ;



## Single layer system erection

- On site enlarge assembly in temporary rubb shelter ;



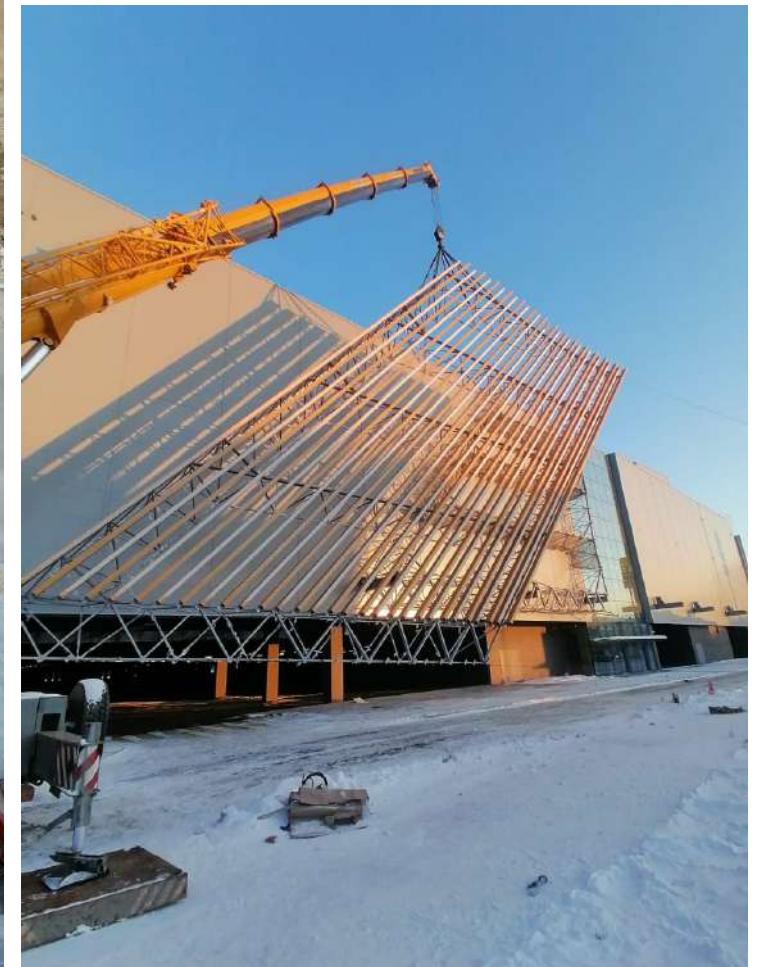
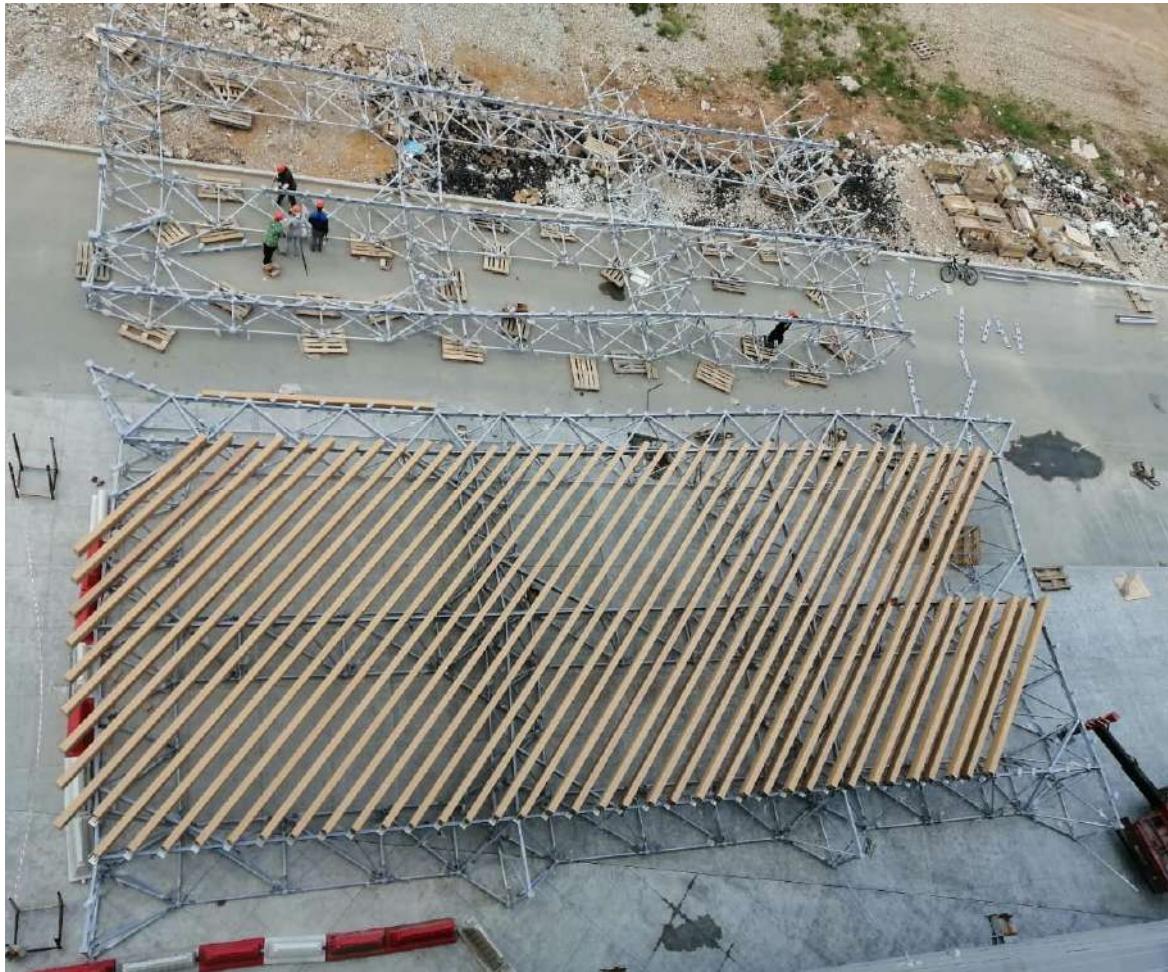
## Single layer system erection

- On site enlarge assembly in temporary rubb shelter ;



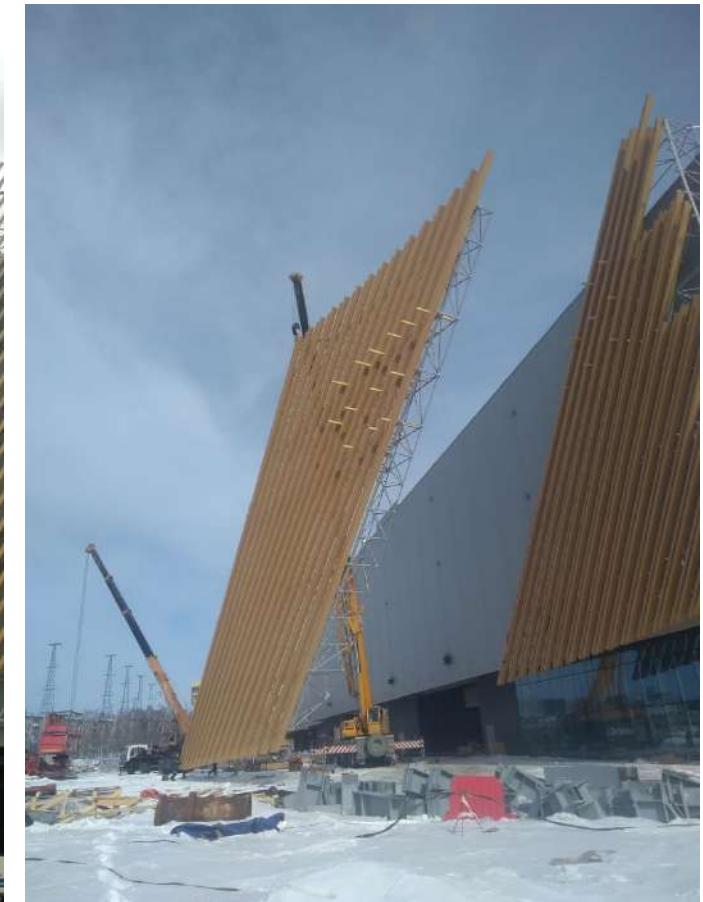
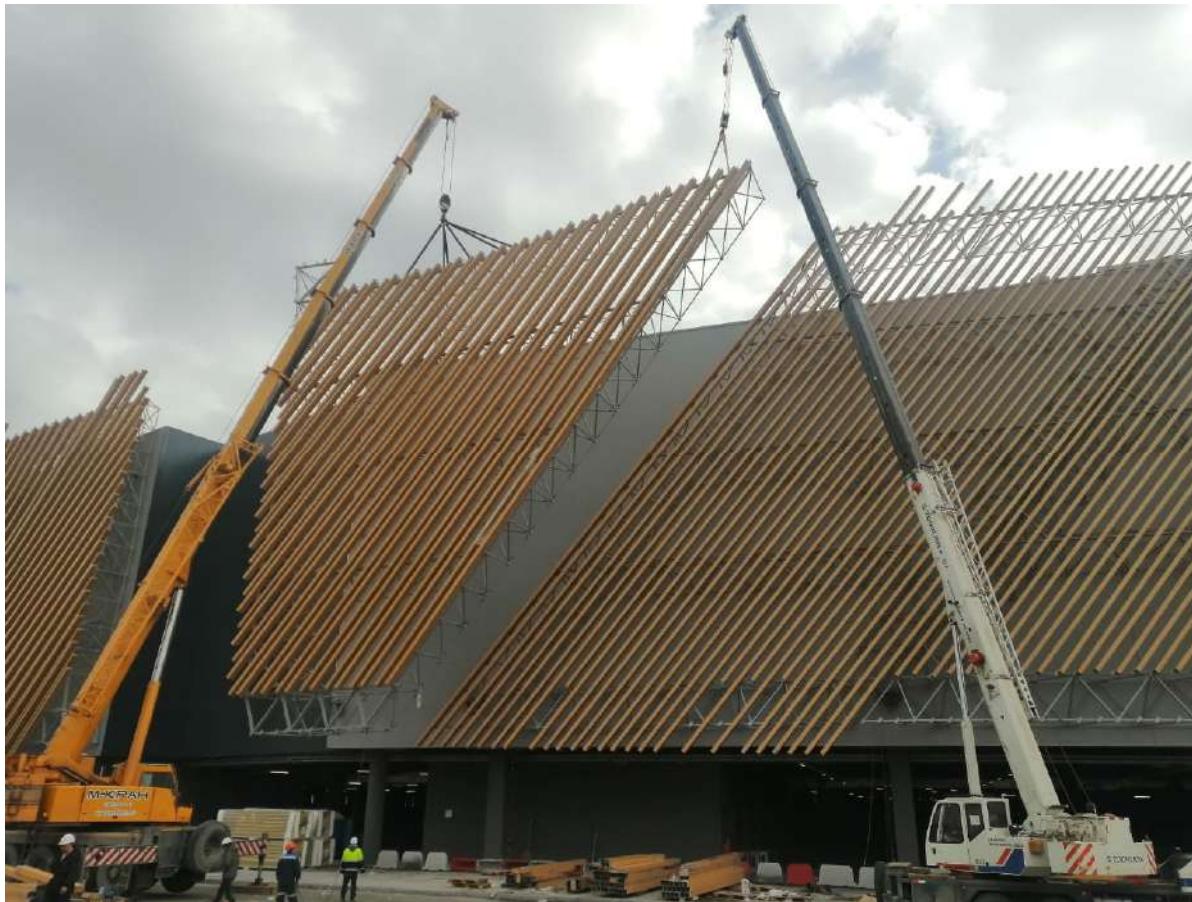
## Single layer system erection

- Installation of several pre-assembled parts simultaneously;



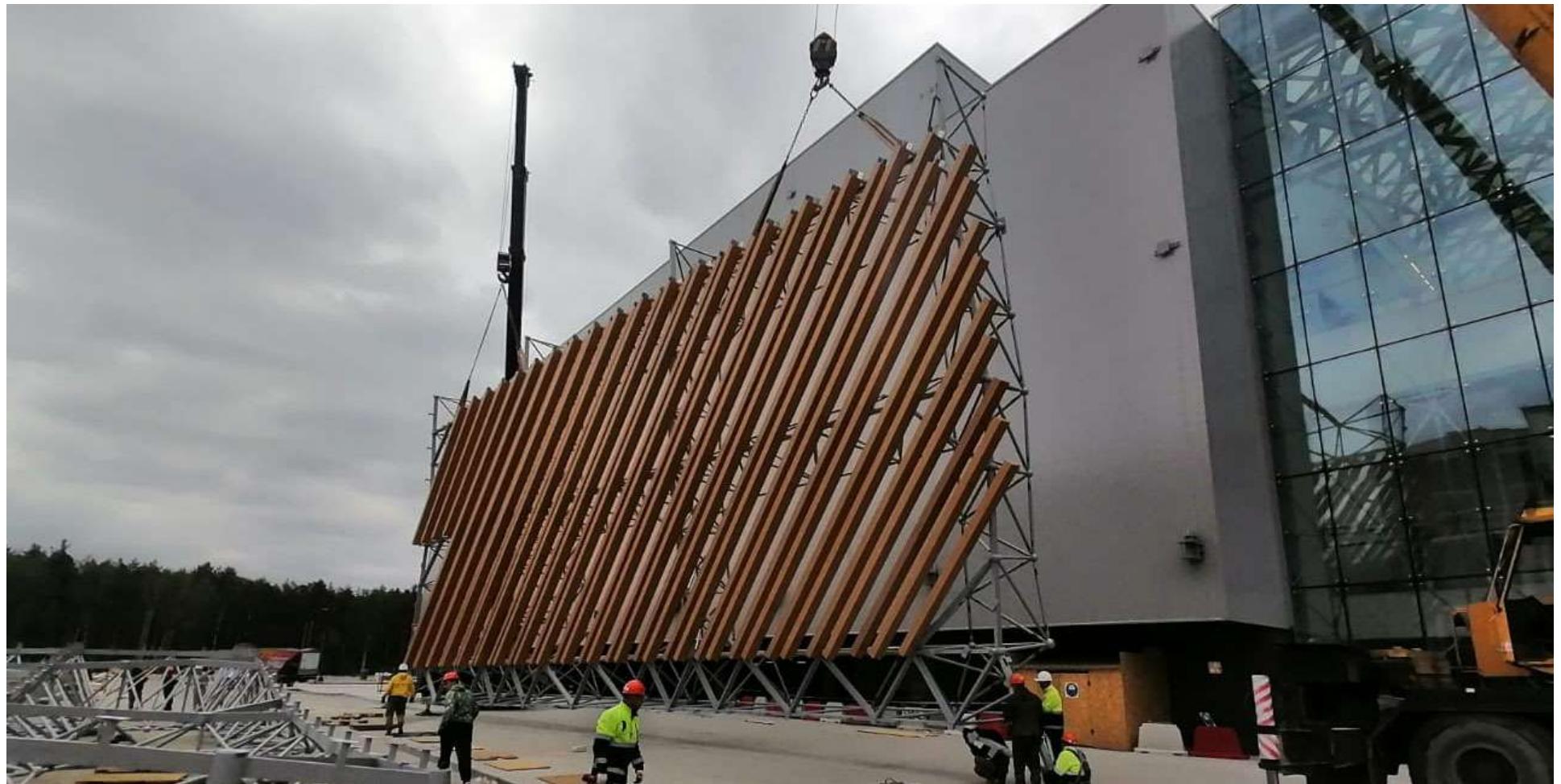
## Single layer system erection

- Installation of several pre-assembled parts simultaneously;



## Single layer system erection

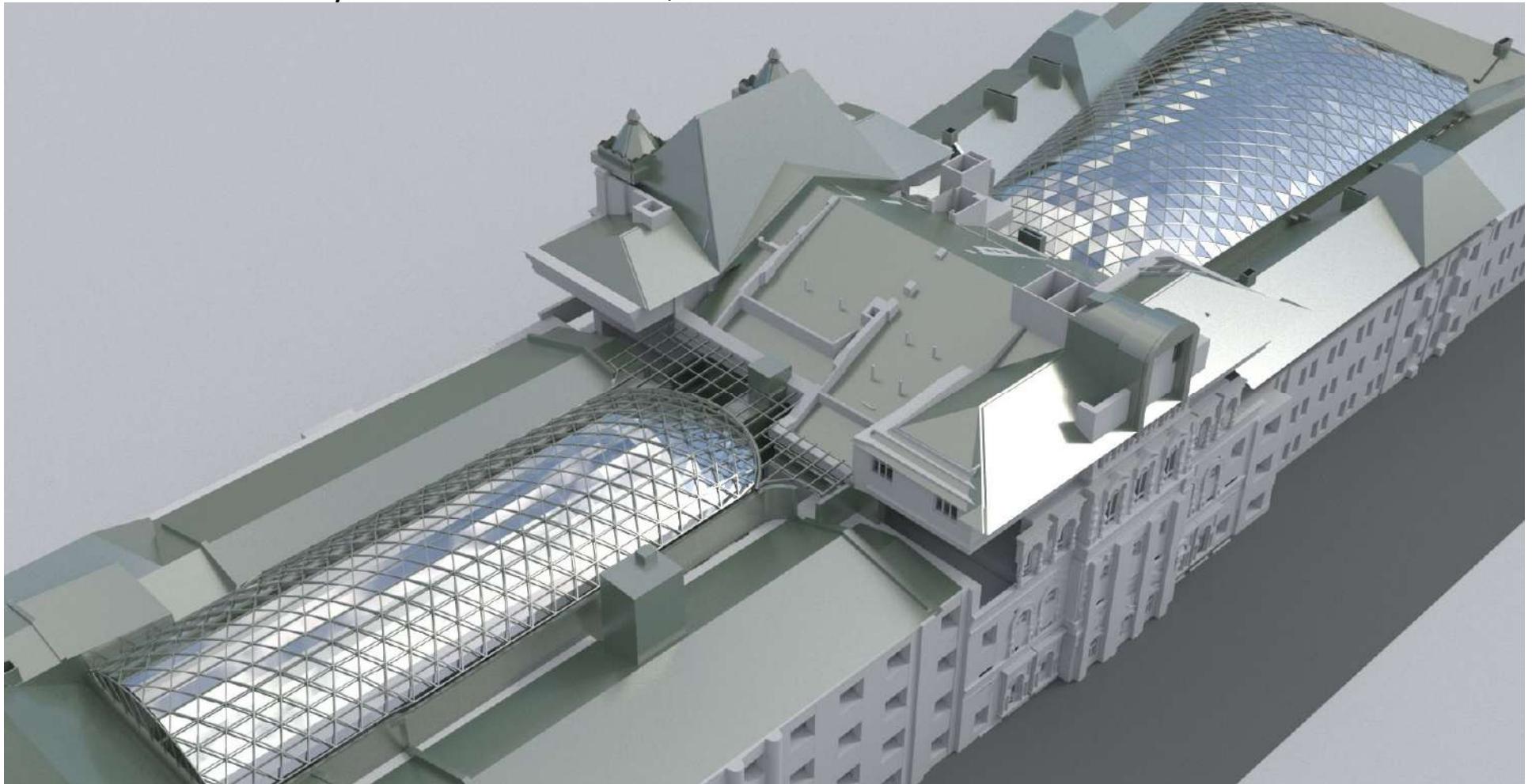
- Installation of several pre-assembled parts simultaneously;



## Single layer system erection

*Example of Moscow Polytechnique museum*

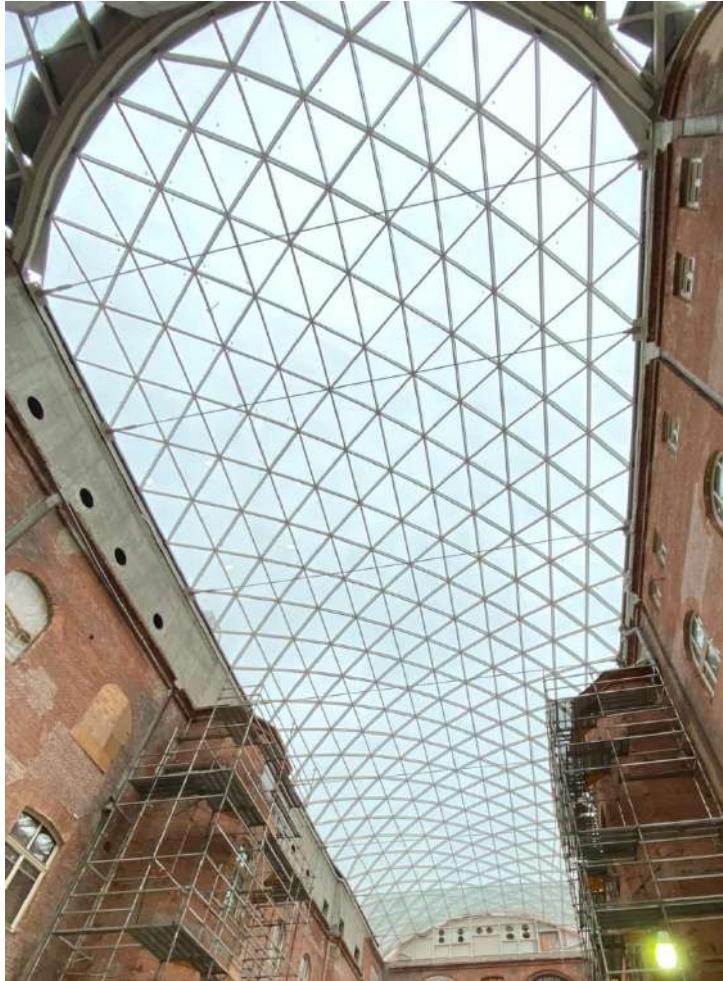
- Element-by-element installation;



## Single layer system erection

*Example of Moscow Polytechnique museum*

Erected structure



Concept



## Single layer system erection

*Example of Moscow Polytechnique museum*

- Step 1. Perimetral steel beam installation;



## Single layer system erection

*Example of Moscow Polytechnique museum*

- Step 2. Platform erection and element-by-element skylight structure assembly;



## Single layer system erection

*Example of Moscow Polytechnique museum*

- Step 3. Platform erection and element-by-element skylight structure assembly;



## Single layer system erection

*Example of Moscow Polytechnique museum*

- Gasket installation;



## Single layer system erection

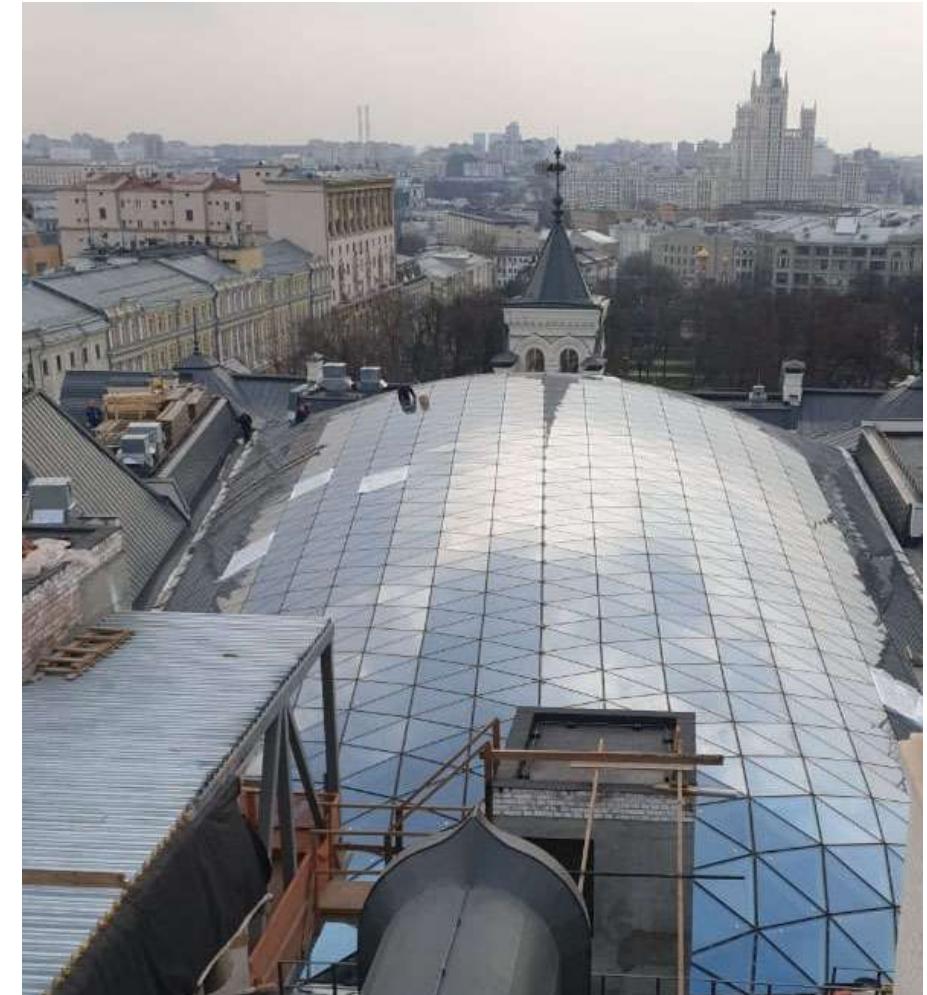
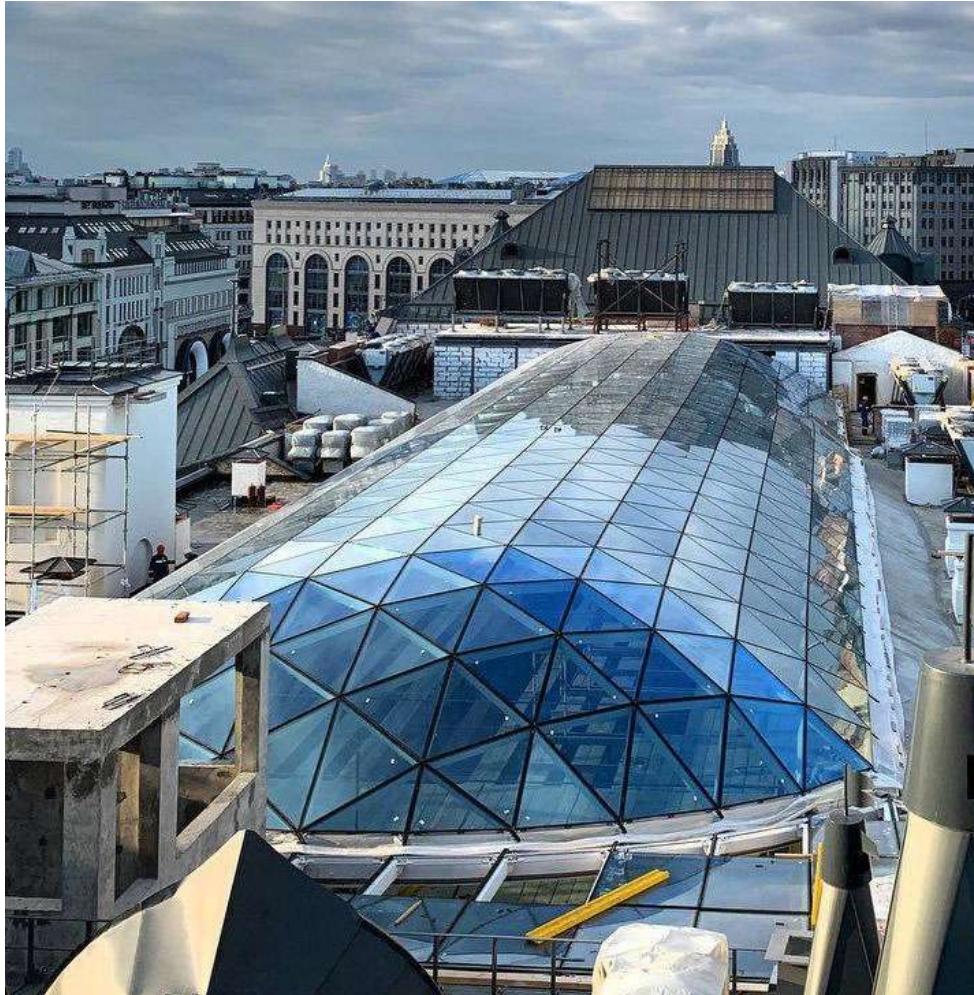
*Example of Moscow Polytechnique museum*

- Glass units installation;

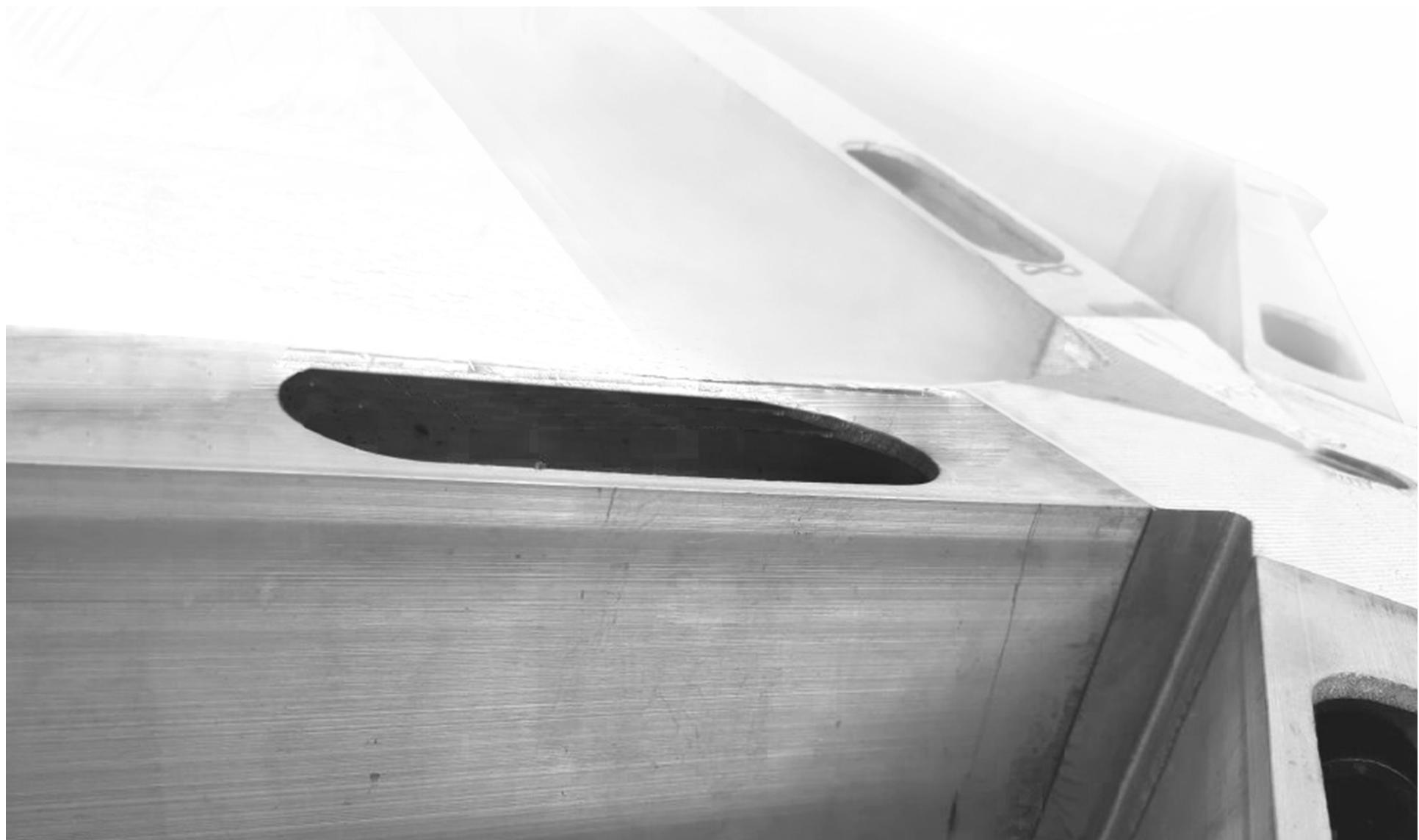


## Single layer system erection

*Example of Moscow Polytechnique museum*



## Reference list



## Reference list

*Veer mall, Yekaterinburg, Russia*



## Reference list

*Veer mall, Yekaterinburg, Russia*

*Project activities :*

*-Design  
(Schematic drawings  
Workshop drawings  
Detailed design model);  
-Free form skylight  
manufacturing and on-site supervision;*

*Surface area:  
16000 sqm (skylight)  
3000 sqm (facade)  
20000 sqm (lamellas)*



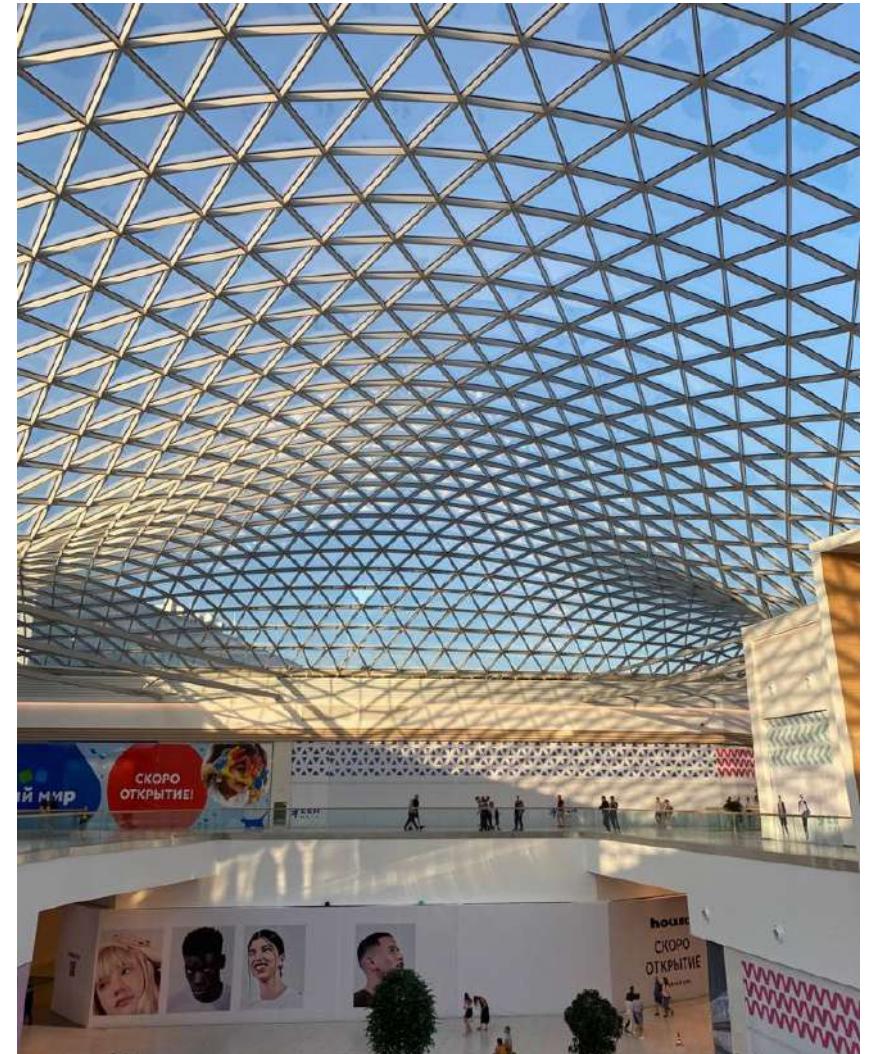
## Reference list

*Veer mall, Yekaterinburg, Russia*



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## Reference list

*Veer mall, Yekaterinburg, Russia*



## Reference list

*Planeta shopping mall, Perm, Russia*



## Reference list

*Planeta shopping mall, Perm, Russia*

*Project activities :*

- Design*  
*(Schematic drawings*  
*Workshop drawings*  
*Detailed design model);*
- Free form skylight*  
*manufacturing and on-site*  
*supervision;*

*Surface area: 15500 sqm*



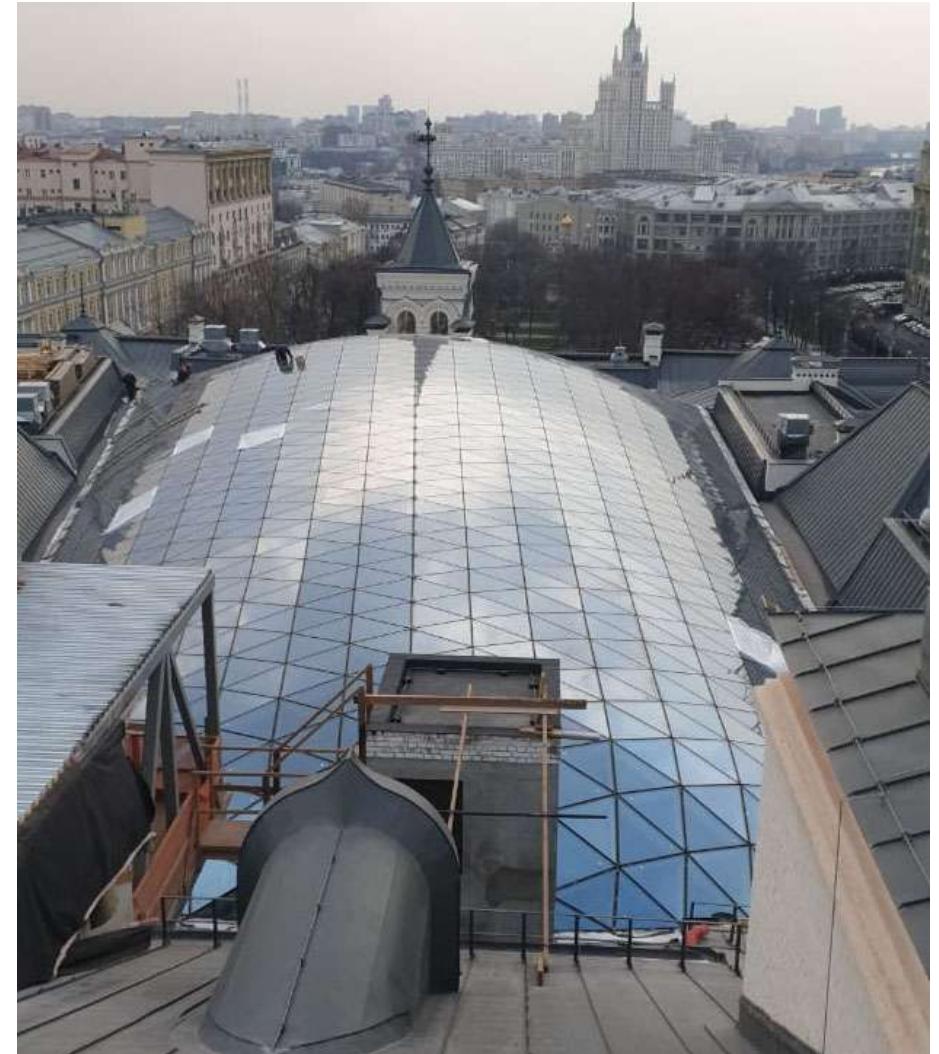
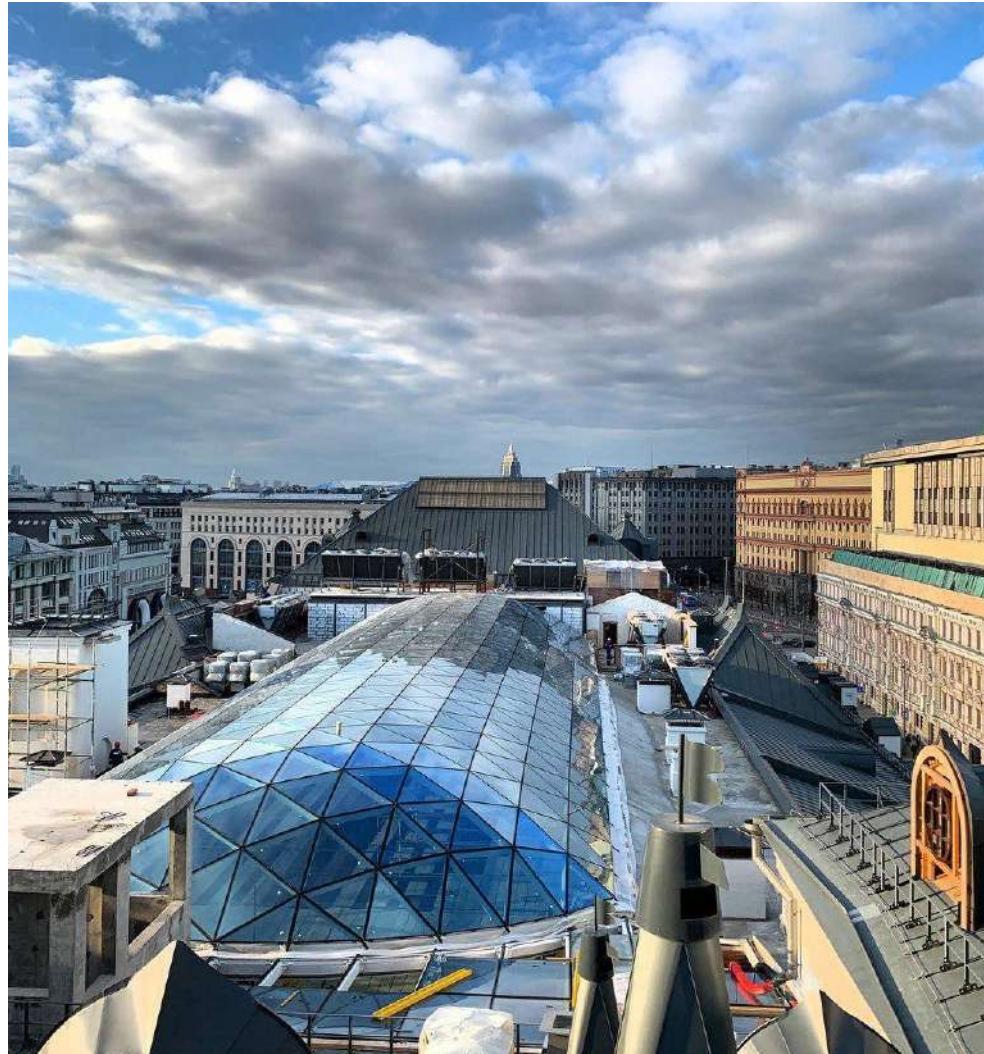
## Reference list

*Planeta shopping mall, Perm, Russia*



## Reference list

*Polytechnical Museum (south court), Moscow, Russia*



## Reference list

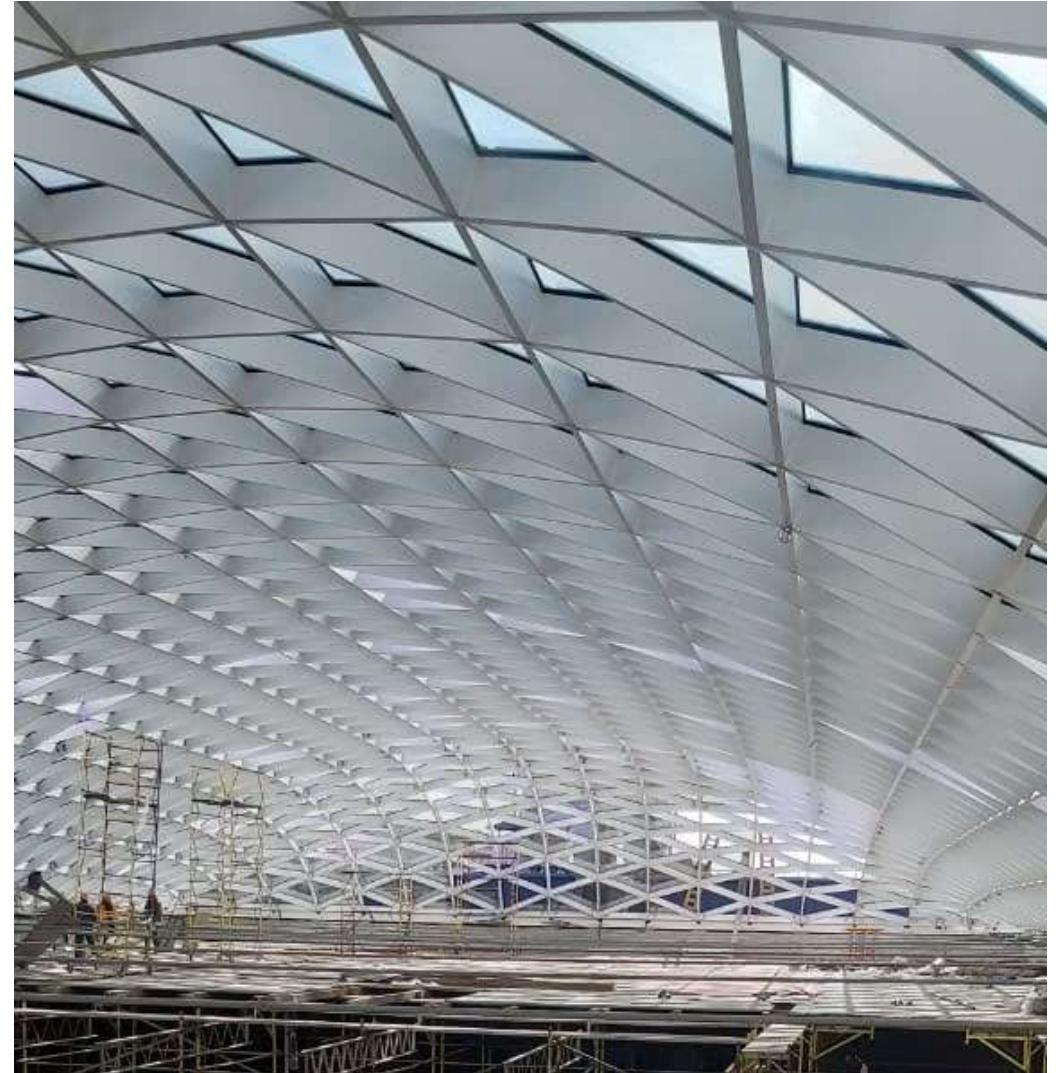
*Polytechnical Museum (south court), Moscow, Russia*

*Project activities :*

- Design*  
*(Schematic drawings*  
*Workshop drawings*  
*Detailed design model);*
- Free form skylight*  
*manufacturing and on-site*  
*supervision;*

*Surface area: 3000 sqm*

*Client: PolytechStroy*



## Reference list

*Polytechnical Museum (south court), Moscow, Russia*



## Reference list

*Simferopol International airport, Russia*



## Reference list

*Simferopol International airport, Russia*

*Project activities :*

-*Design*  
*(Schematic drawings*  
*Workshop drawings*  
*Detailed design model);*  
-*Free form façade*  
*manufacturing and on-site*  
*supervision;*

*Surface area: 13000 sqm*

*Client: AlphaStroy*



## Reference list

*Simferopol International airport, Russia*



# Reference list

*Simferopol International airport, Russia*



## Reference list

*Simferopol International airport, Russia*

June 2017



October 2017

*Execution of work - 5 month*



## Reference list

*Igora Drive leisure center, St. Petersburg, Russia*



## Reference list

*Igora Drive leisure center, St. Petersburg, Russia*

*Project activities :*

- Design
  - (Schematic drawings
  - Workshop drawings
  - Detailed design model);
- Free form skylight
  - manufacturing and on-site supervision;

*Surface area: 3700 sqm*

*Client: Alumstroy*



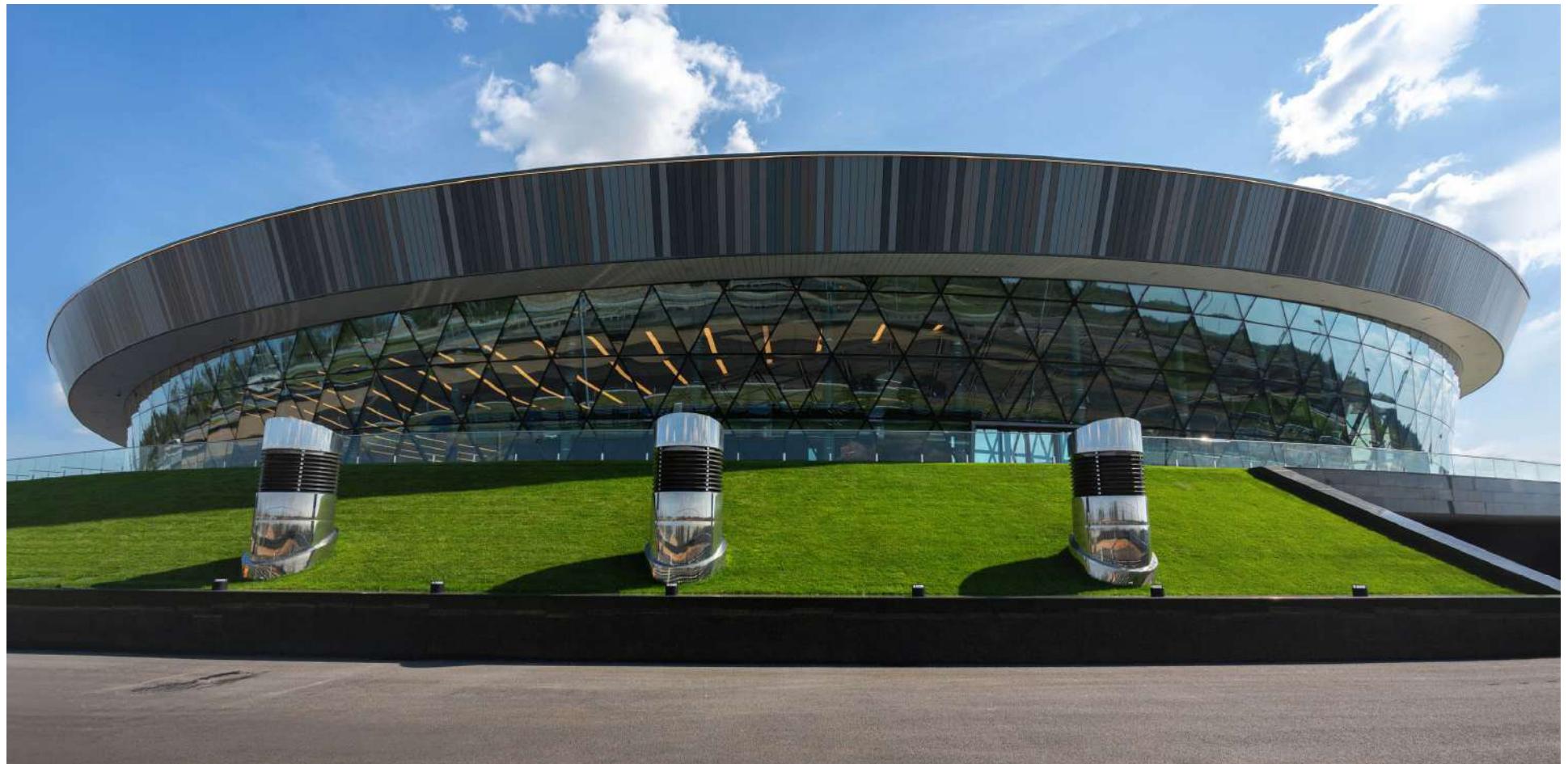
## Reference list

*Igora Drive leisure center, St. Petersburg, Russia*



## Reference list

*Igora Drive leisure center, St. Petersburg, Russia*



## Reference list

*Igora Drive leisure center, St. Petersburg, Russia*



## Reference list

*Moscow Metro Coordination center, Moscow*



## Reference list

*Moscow Metro Coordination center, Moscow*

*Project activities :*

-*Design*  
*(Schematic drawings*  
*Workshop drawings*  
*Detailed design model);*  
-*Free form skylight*  
*manufacturing and on-*  
*site supervision;*

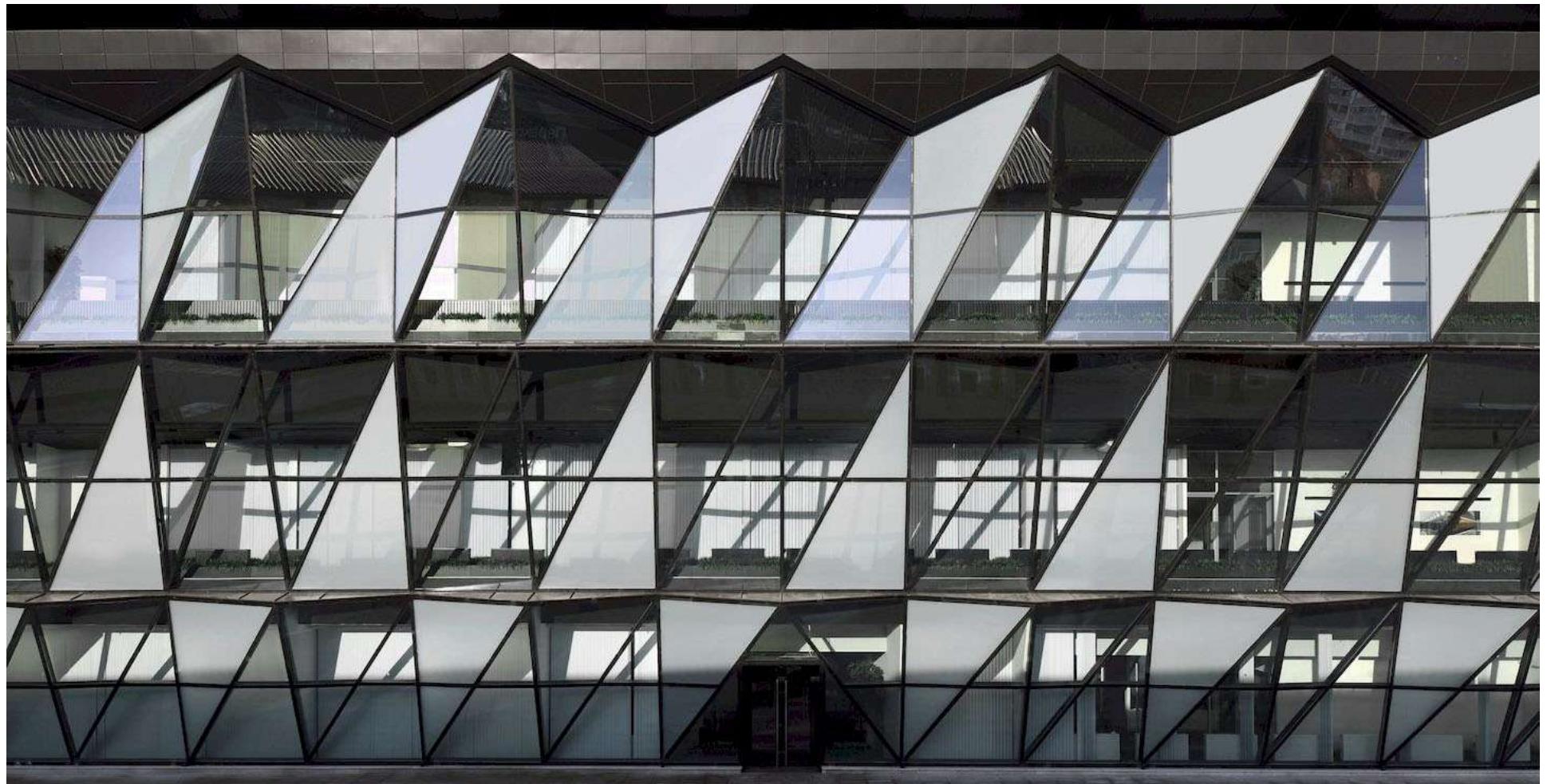
*Surface area: 800 sqm*

*Client: FGUP SVEKO*



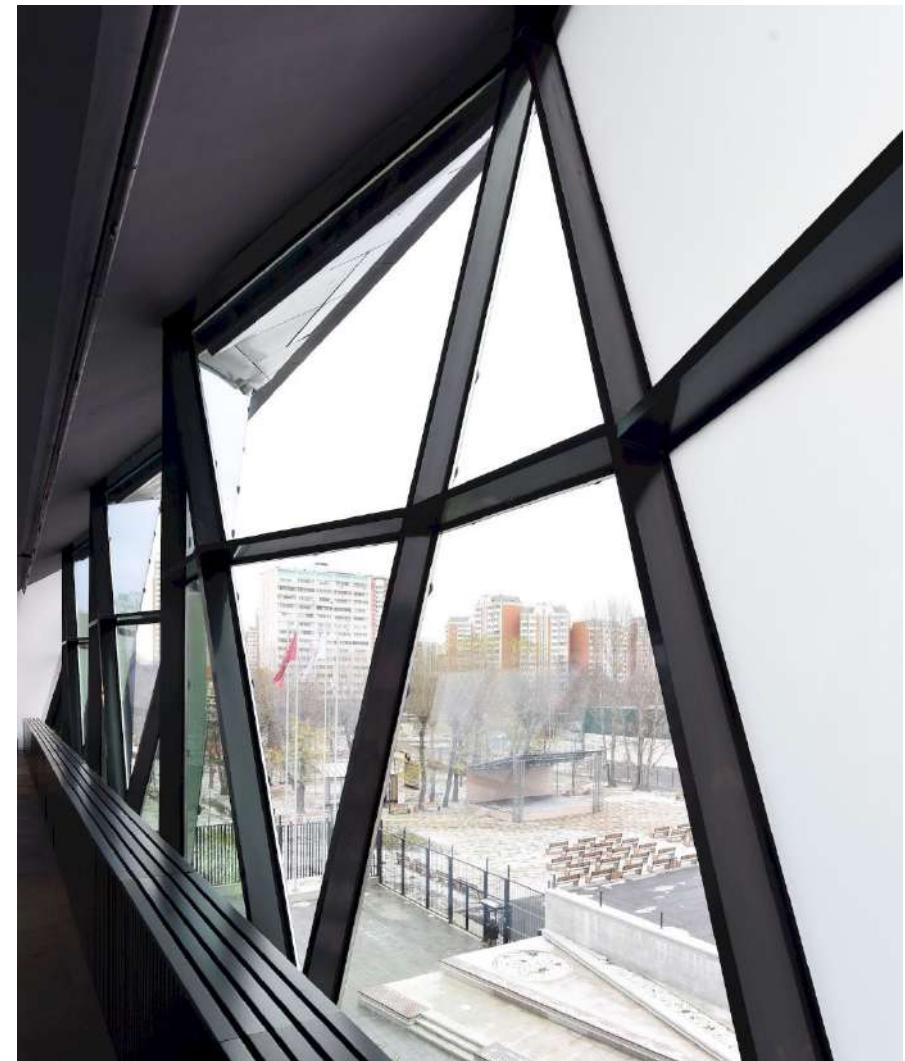
## Reference list

*Moscow Metro Coordination center, Moscow*



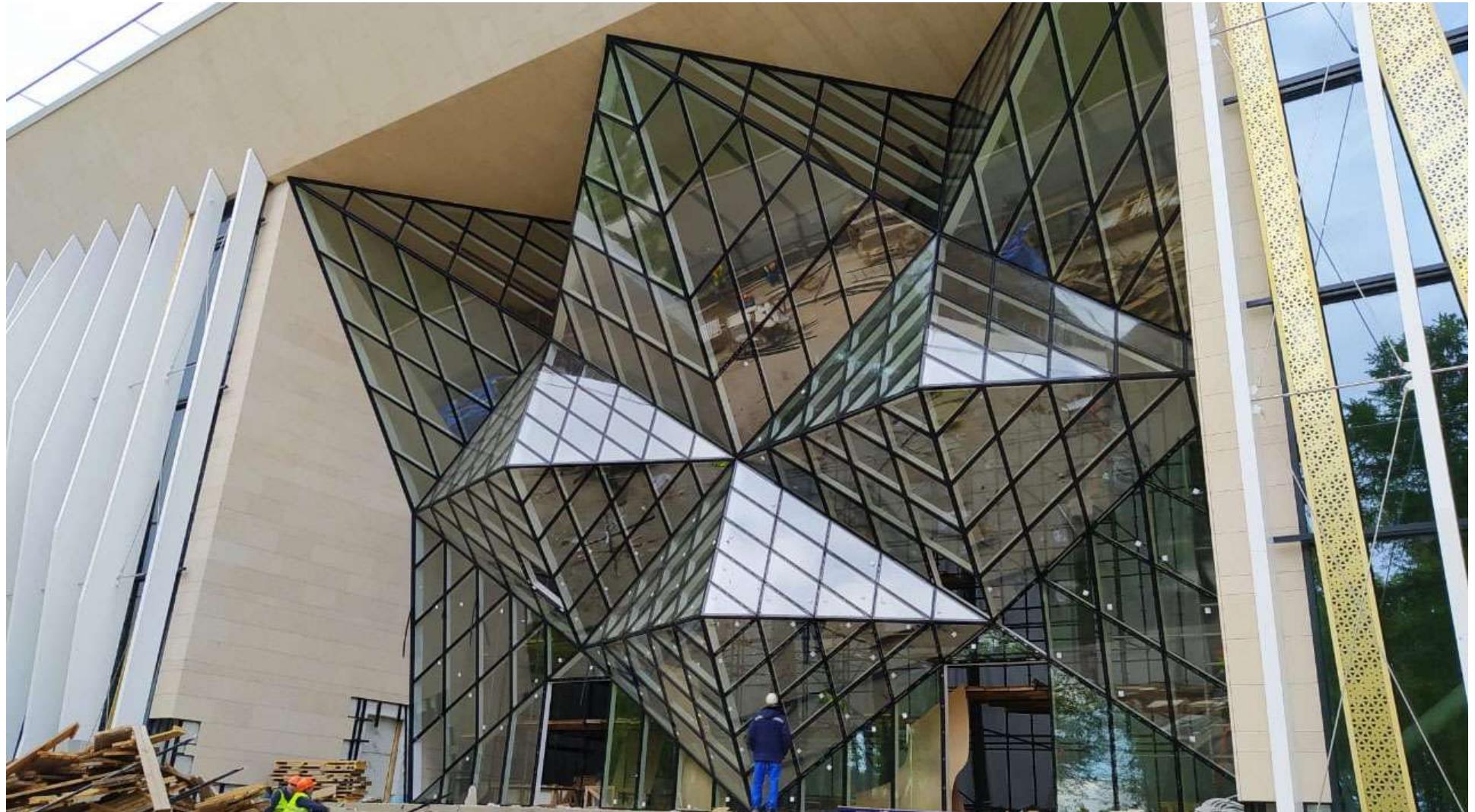
## Reference list

*Moscow Metro Coordination center, Moscow*



## Reference list

*Kristall hockey arena, Moscow, Russia*



## Reference list

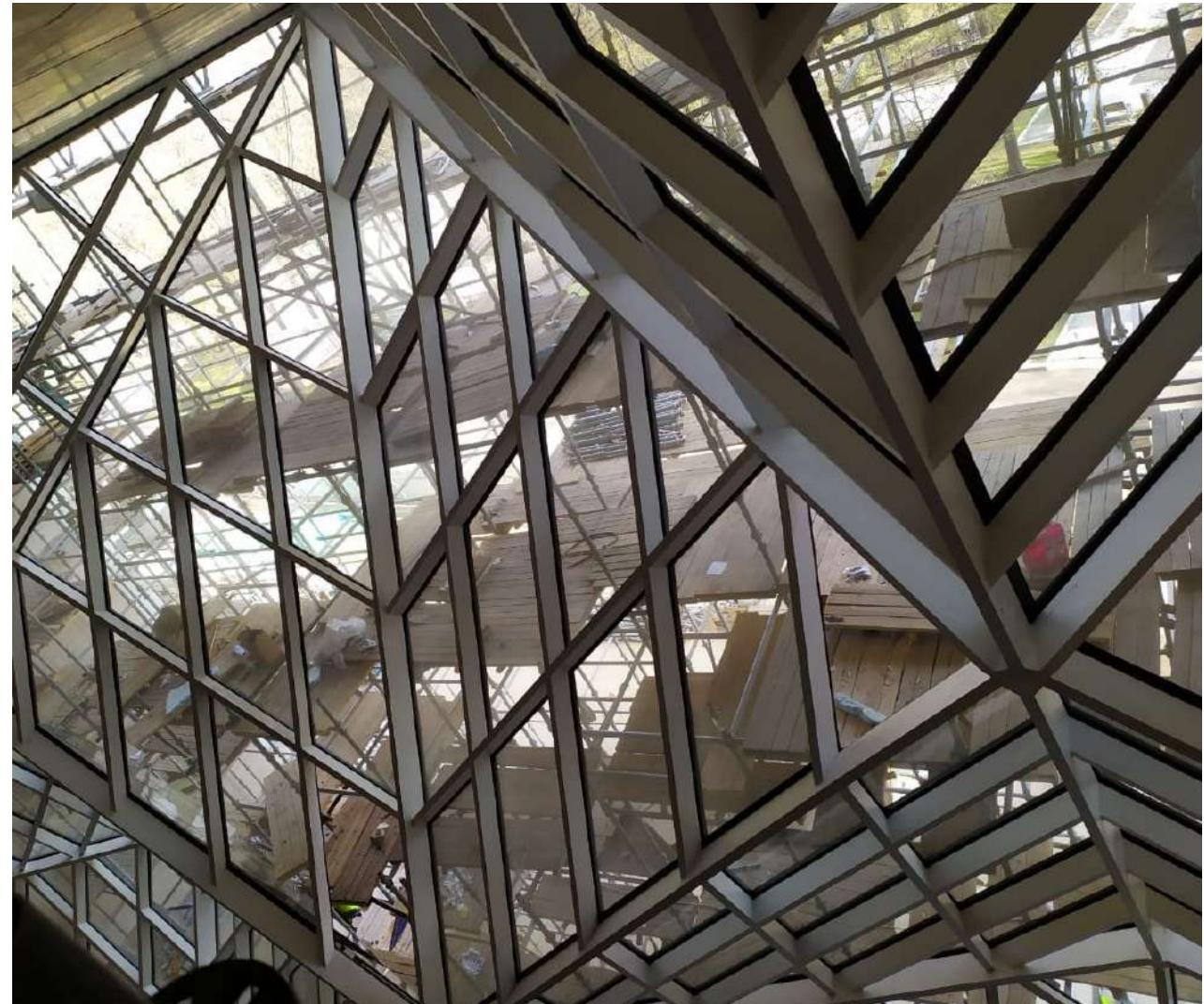
*Kristall hockey arena, Moscow, Russia*

*Project activities :*

*-Design  
(Schematic drawings  
Workshop drawings  
Detailed design model);  
-Free form facade  
manufacturing and on-  
site supervision;*

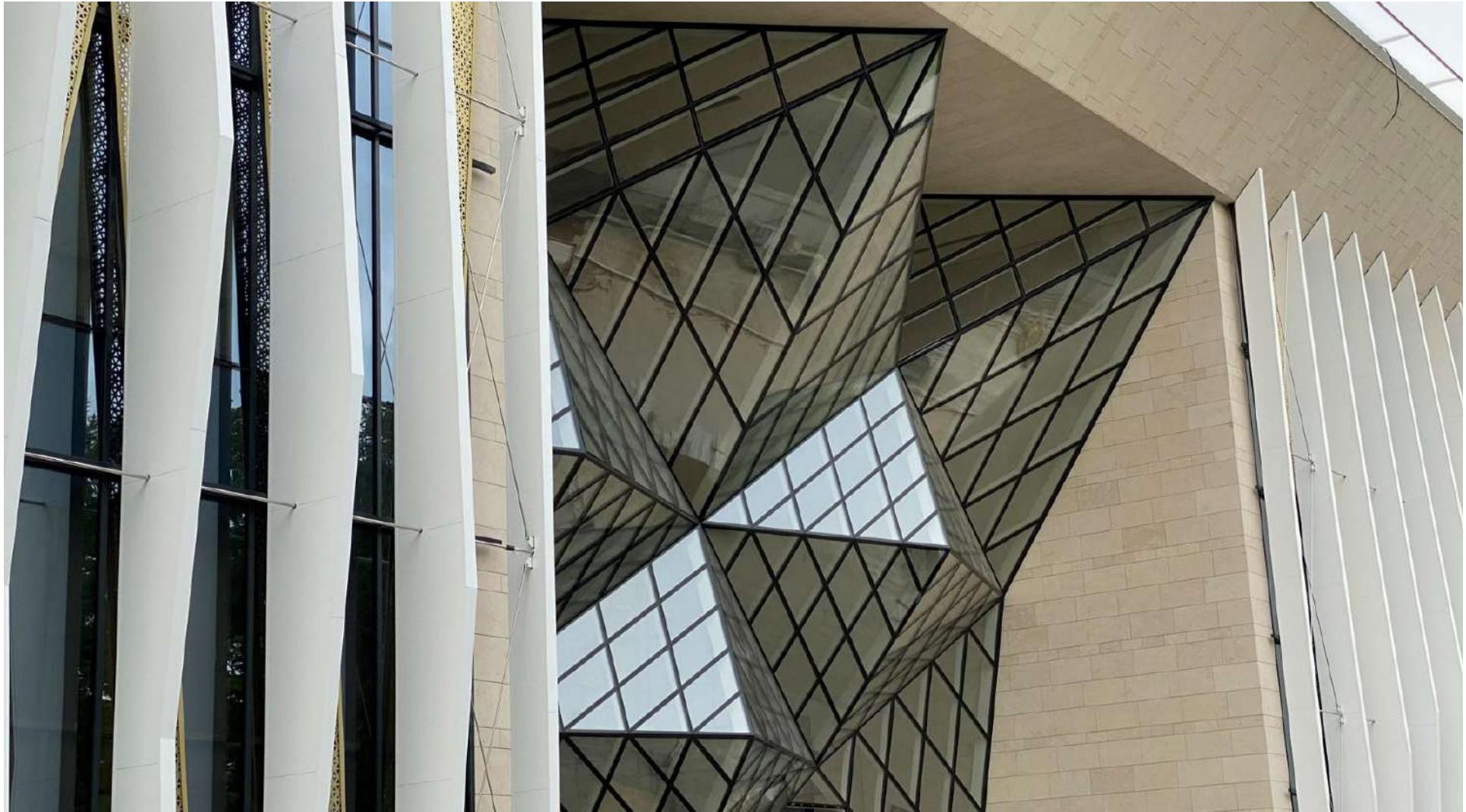
*Surface area: 600 sqm*

*Client: Kvalitet*



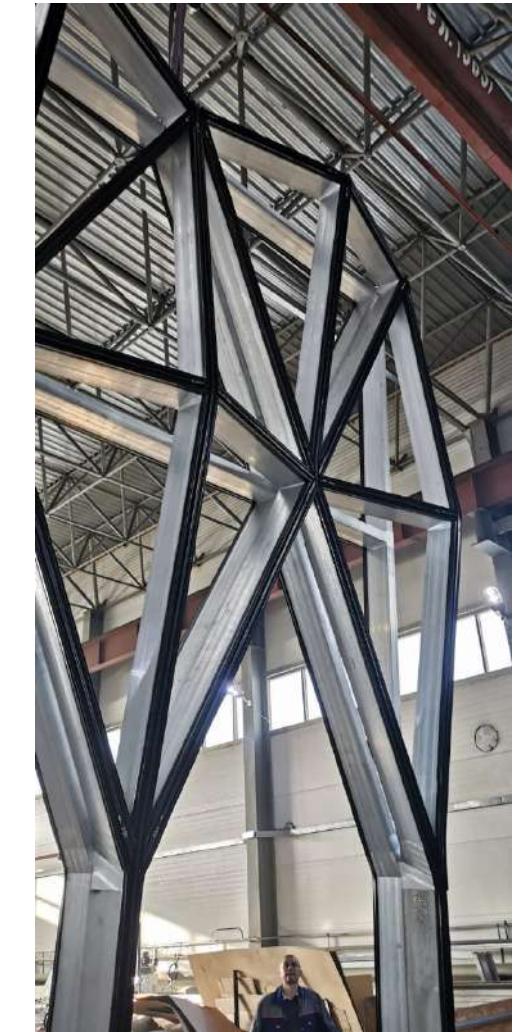
## Reference list

*Kristall hockey arena, Moscow, Russia*



# Reference list

## Mock-up





**SPACE  
STRUCTURE**

ООО «Несущие Системы»  
г. Новосибирск,  
ул. Советская, 10  
Т.: +7-913-950-55-21  
Кашин Алексей

Представительство в Москве  
Т.: +7-964-647-26-72  
Александр Аверин

[www.spacestructure.ru](http://www.spacestructure.ru)