FLOATING CLASSROOM
THE PHILIPPINES

Wietse de Haan (4562410)
P5 Presentation

04-11-2020

Source: Noel Celis

Climate design: Eric van den Ham
Structural design: Peter Eigenraam
External supervisor: Pieter Ham

MSc Architecture, Urbanism and Building sciences
Building Technology

typhoons

floods

Source: Pieter Ham

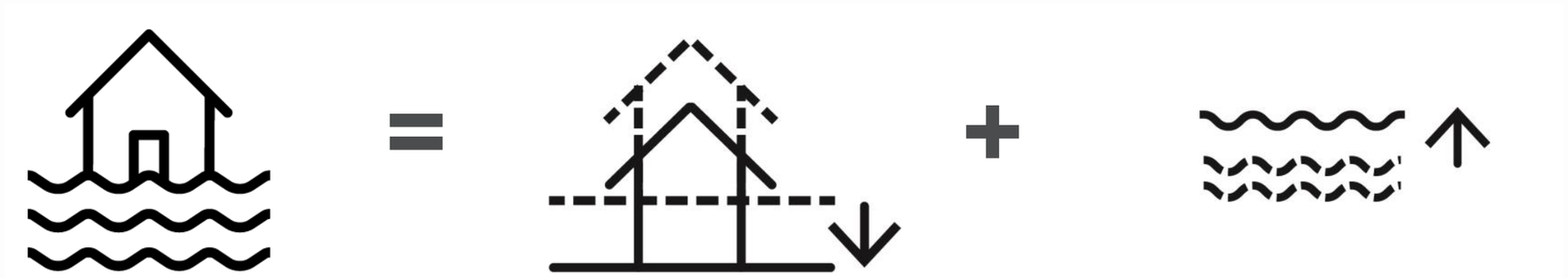
typhoons heavy rainfall high wind speeds

Source: Pieter Ham

daily floods heavy rainfall tidal movement

Source: Pieter Ham


MUNICIPALITY OF MACABEBE
BM NESTOR BAYTOLENTINO



worsening trends sinking of land sea level rise

Source: Pieter Ham

Finch Floating Home

Offers typhoon resilient housing

Used as case study floating design

Finch
Floating
Homes

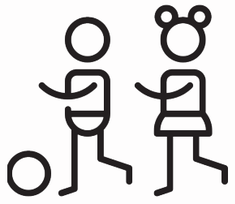
Impact of floods on schools

absence of students due to flooded routes to school

damage to the schoolbuilding and learning materials

suspension and disruption of classes

bad concentration of the students
poor learning environments



flooded schoolyards and playgrounds


MATH GARDEN


Welcome!
Cong. RIMPY BONDOC
CONG. TINGA BONDOC

Main objective

"Design a classroom that offers students living in a typhoon and flood sensitive area in South-East Asia a safe learning environment"

Design criteria

- *Provide the classroom with a floating foundation*
- *The design must be able to withstand high wind speeds*
- *Prefabricated construction made from local materials*
- *The indoor comfort must facilitate the learning conditions*
- *Create a child friendly classroom in which the students feel safe and comfortable*

Main research question

"How to design a classroom that offers students living in a typhoon and flood sensitive area in Sout-East Asia a safe learning environment"

Research questions

Location

What are the local climate characteristics ?

Is the location suitable for a floating classroom?

Schools

How are they currently designing schools and how do they existing schools deal with typhoons and floods?

How can we make a classroom more child friendly?

Materials

Which materials are locally available?

What are the challenges associated with the local materials and what solutions are there?

Indoor comfort

How can a classroom be indoor comfortable and which parameters needs to be taken into account?

What measures do they apply locally in classrooms to ensure a good indoor comfort?

Typhoon resilient

How can a school be typhoon resilient and what parameters need to be taken into account?

Location

What are the local climate characteristics ?

Macabebe, Pampanga

Average temperature between 21 and 32 degrees

Two major seasons, rainy season and dry season

The pampanga river basin experiences at least one flood event a year

Ground subsidence of an average of 5 cm/year

Satellite view of the Macabebe (source: Google Earth)

Colegio de San Lorenzo

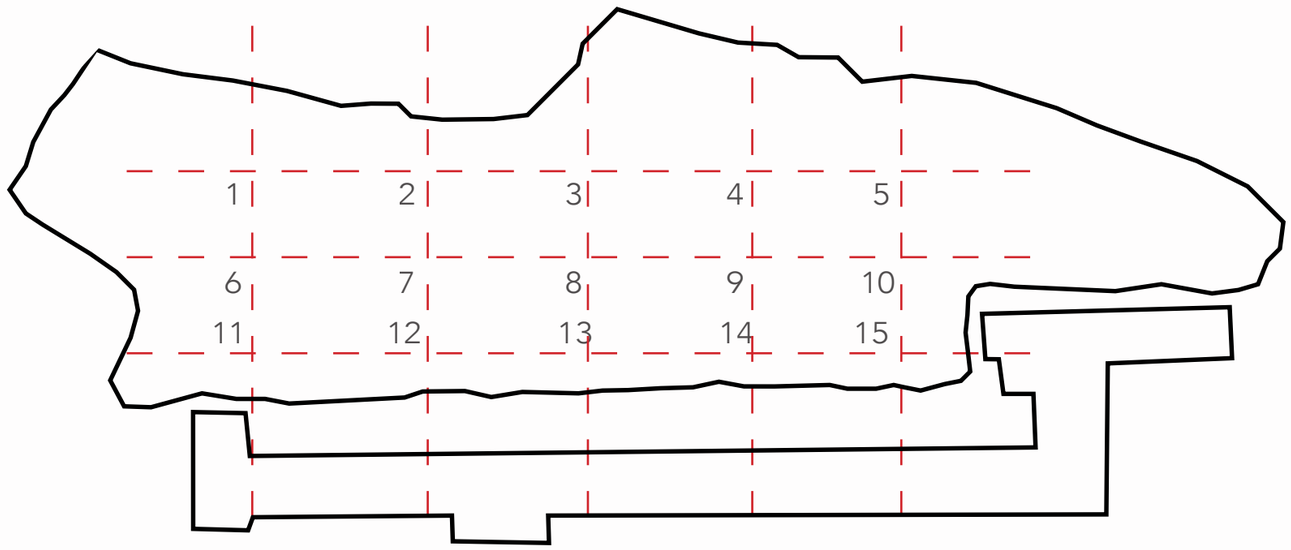
Request for 6 floating classrooms

40 students per classroom


Colegio de
San Lorenzo
Sta. Rita Macabebe

Is the location suitable for a floating classroom?

Shallowest point in the dry season: 1,45 meter
Size pond: 144 x 42 meters



1	1.7 m	2	1.9 m	3	1.55 m	4	1.9 m	5	1.9 m
6	1.9 m	7	2.05 m	8	1.65 m	9	2.2 m	10	2.2 m
11	1.75 m	12	1.75 m	13	1.8 m	14	1.8 m	15	1.45 m

Schools

How are they currently designing new school buildings ?

School design set up by DepEd

Long rectangular floorplans

Fixed colour scheme

Withstand windspeeds of 250 km/h and major earthquakes

Ground floors raised with 1 meter, against floods

Schools

How do the existing schools deal with typhoons and floods?

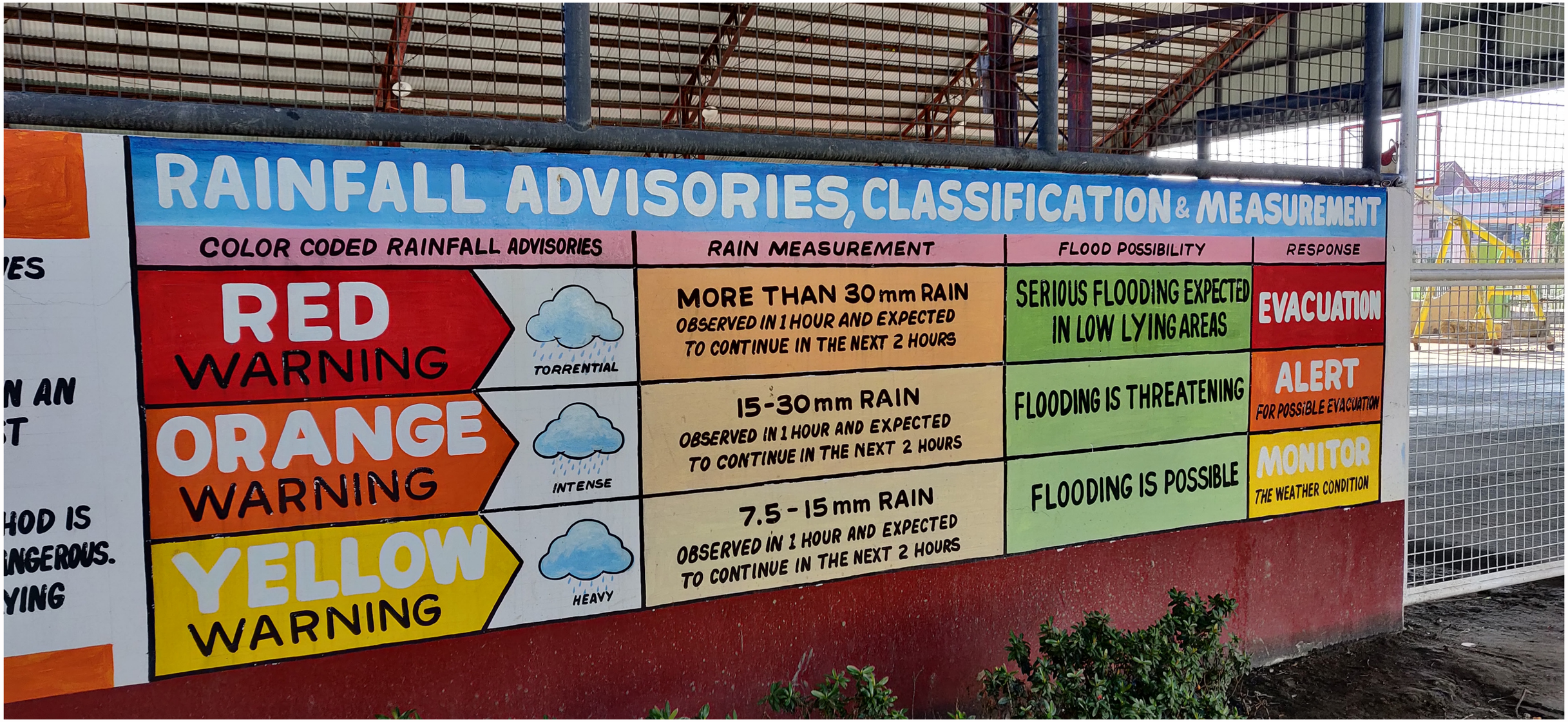
Combined classes

Raising the walkways and toilets

Raising the classroom floors

Planting of vegetation

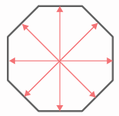
Creating awareness on how to act during a natural disaster



Schools

How can we make classrooms more child friendly ?

Based on the guidelines of Unicef



Flexible spaces - increase participation and create a more dynamic environtment

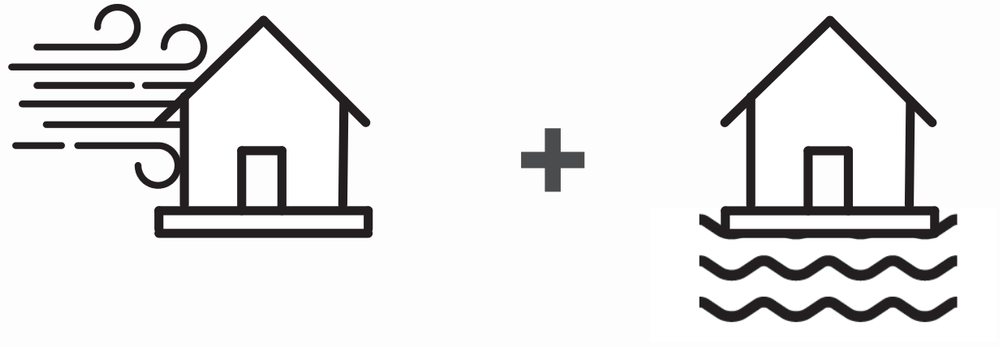
Transparancy of the building - activities inside the building are visible from outside

Open spaces - contact with the environment and space for physical activities

Protective - Enclosure and boundaries against the outside elements

Typhoon resilient

How can a school be typhoon resilient and what parameters need to be taken into account?

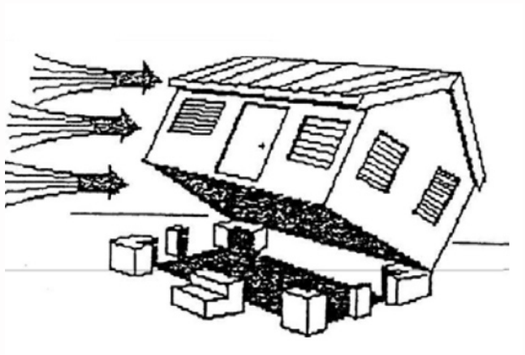


withstand high windspeeds

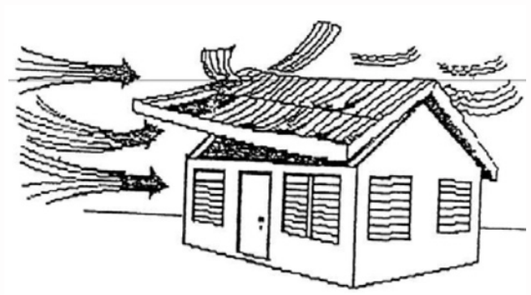
remains floating

Typhoon resilient

Problems due to high wind speeds



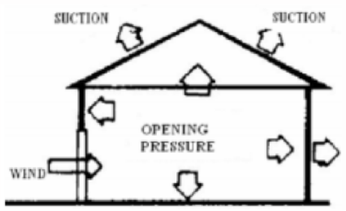
house uplifting



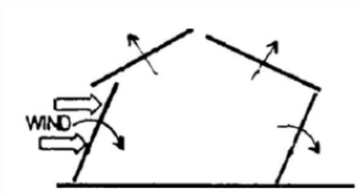
roof uplifting

porch uplifting

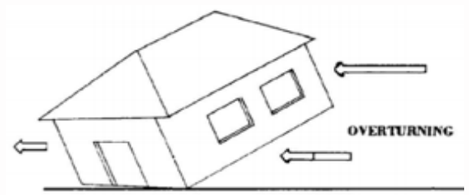
Failure models



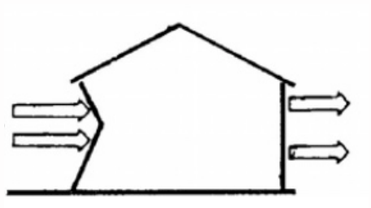
openings in facade



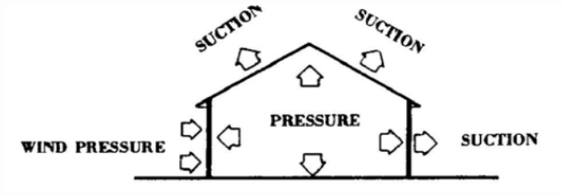
wall leaning over



overturning

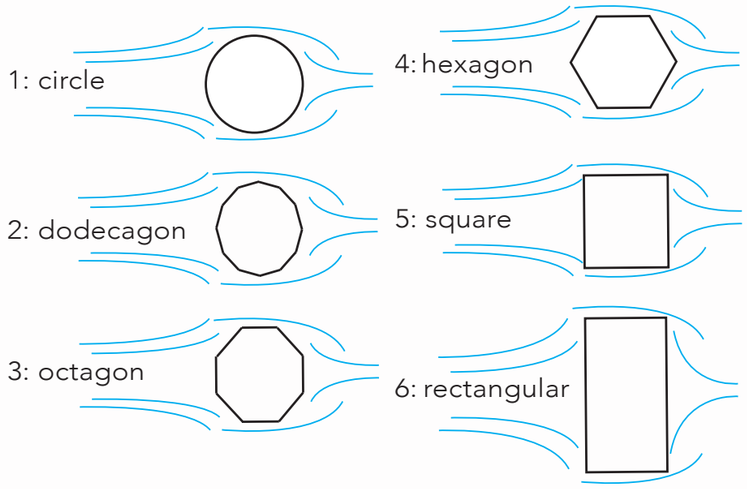


windward side collapse

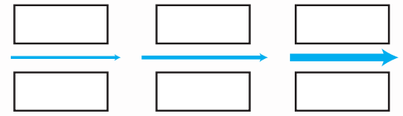


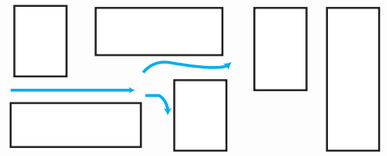
pressure difference failure

Design strategies for the building

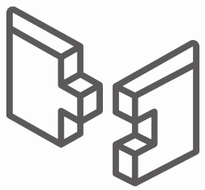


aerodynamic shape

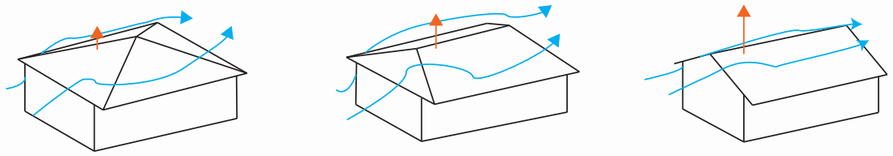




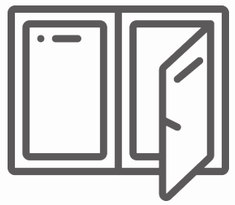
spatial planning



prefabricated parts with simple connections



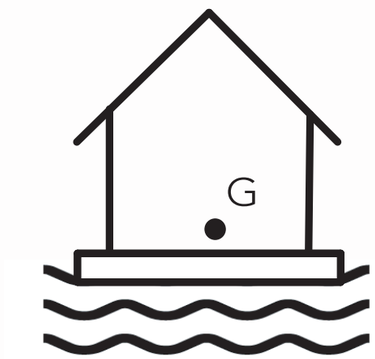
roof shape



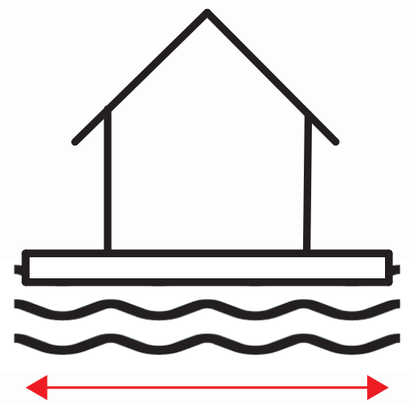
closeable openings

Design strategies for the floating foundation

lightweight structure



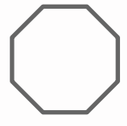
low center of gravity



increased width

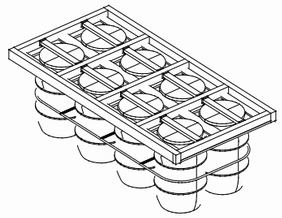
Design choices

shape

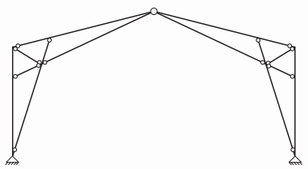


materials

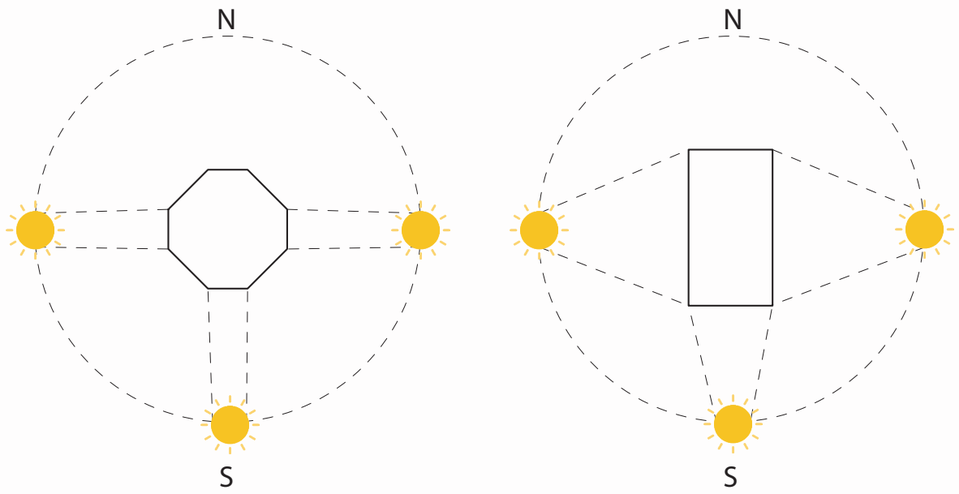
floating modules



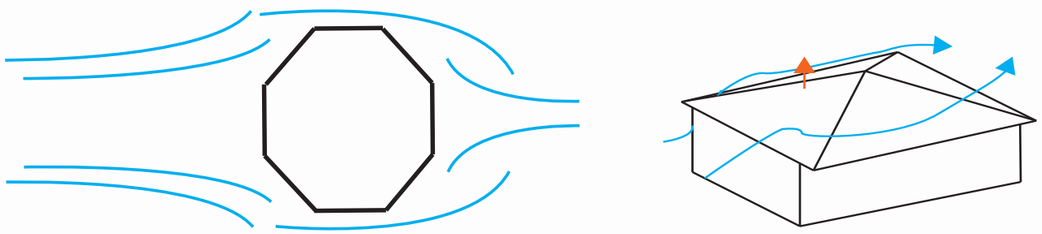
upperstructure



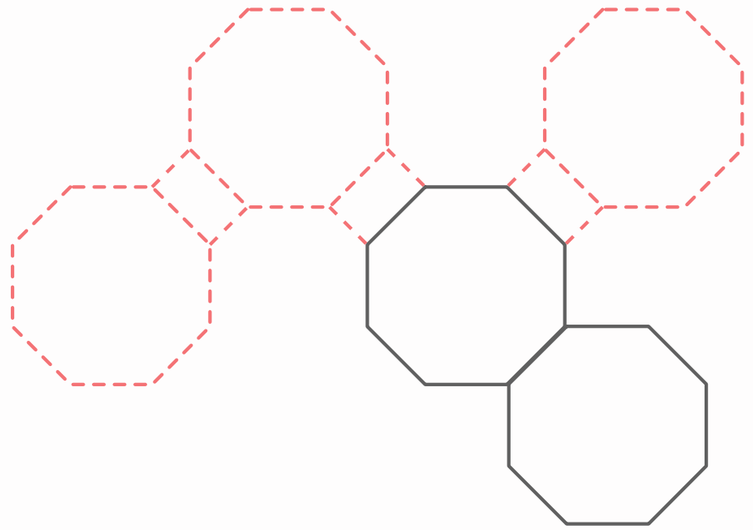
Design | Octagonal shape



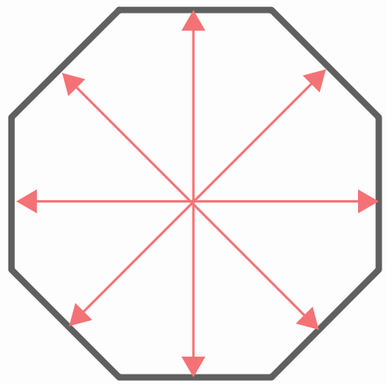
Flexibilty in orientation



Aerodynamic shape



Expandability



Same width in all directions

Design | Material

Construction: Wood

Light weight material

Sustainable

Easy workable and the local carpenters are familiar with the material

3 local suppliers visited

Local mostly available Yellow Meranti

Foundation: Recycled drums

200 litre drums

Easy to work with

Design | floating foundation

Design input

Prefabricated floating modules

Easy connections

Design criteria

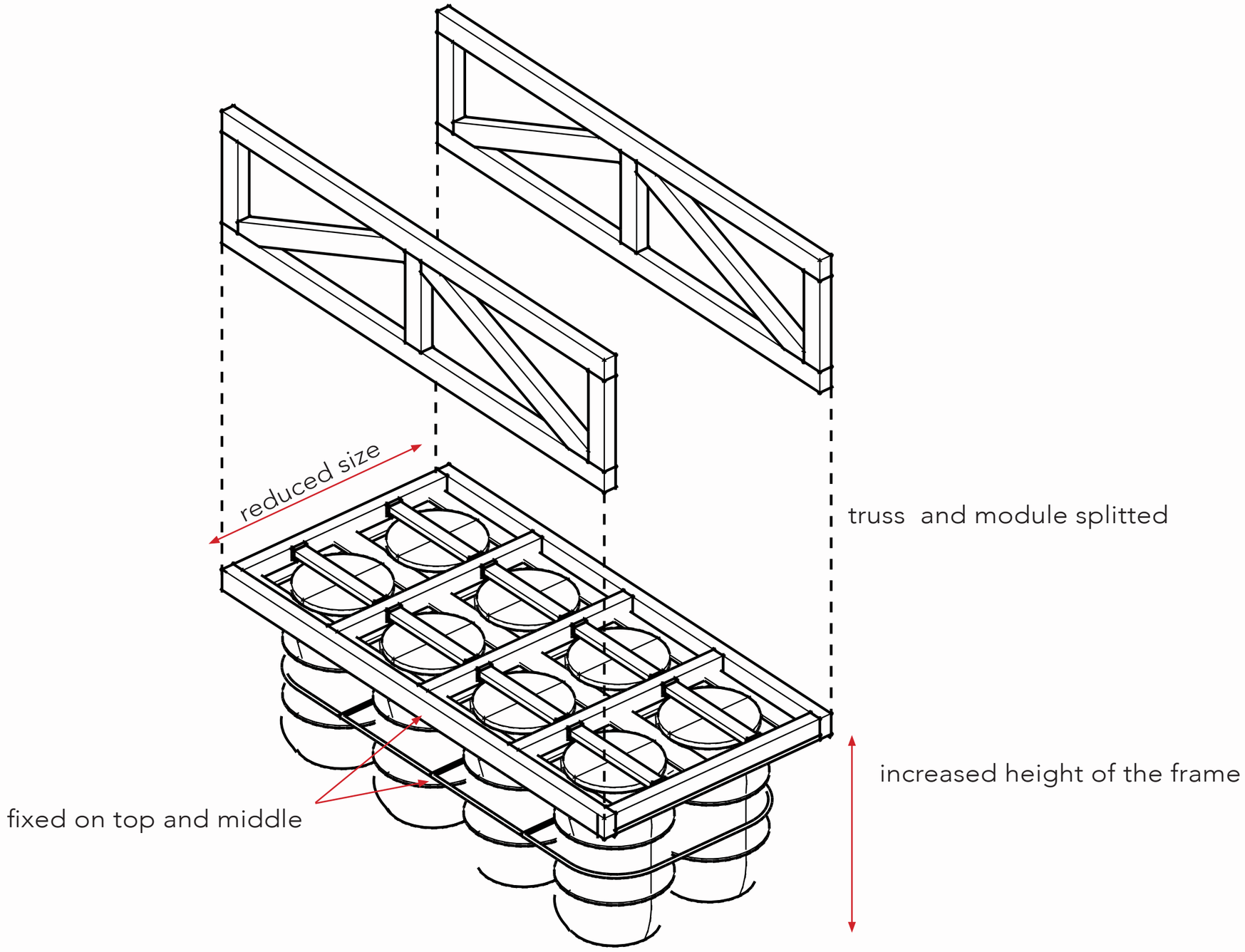
Reducing the weight

Increasing the height between the bottom of the barrel and the wooden frame.

Avoid over-dimensioning of the trusses.

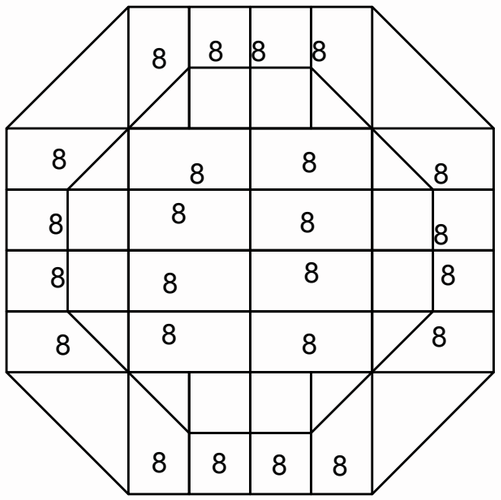
Prevent the movement of the barrels.

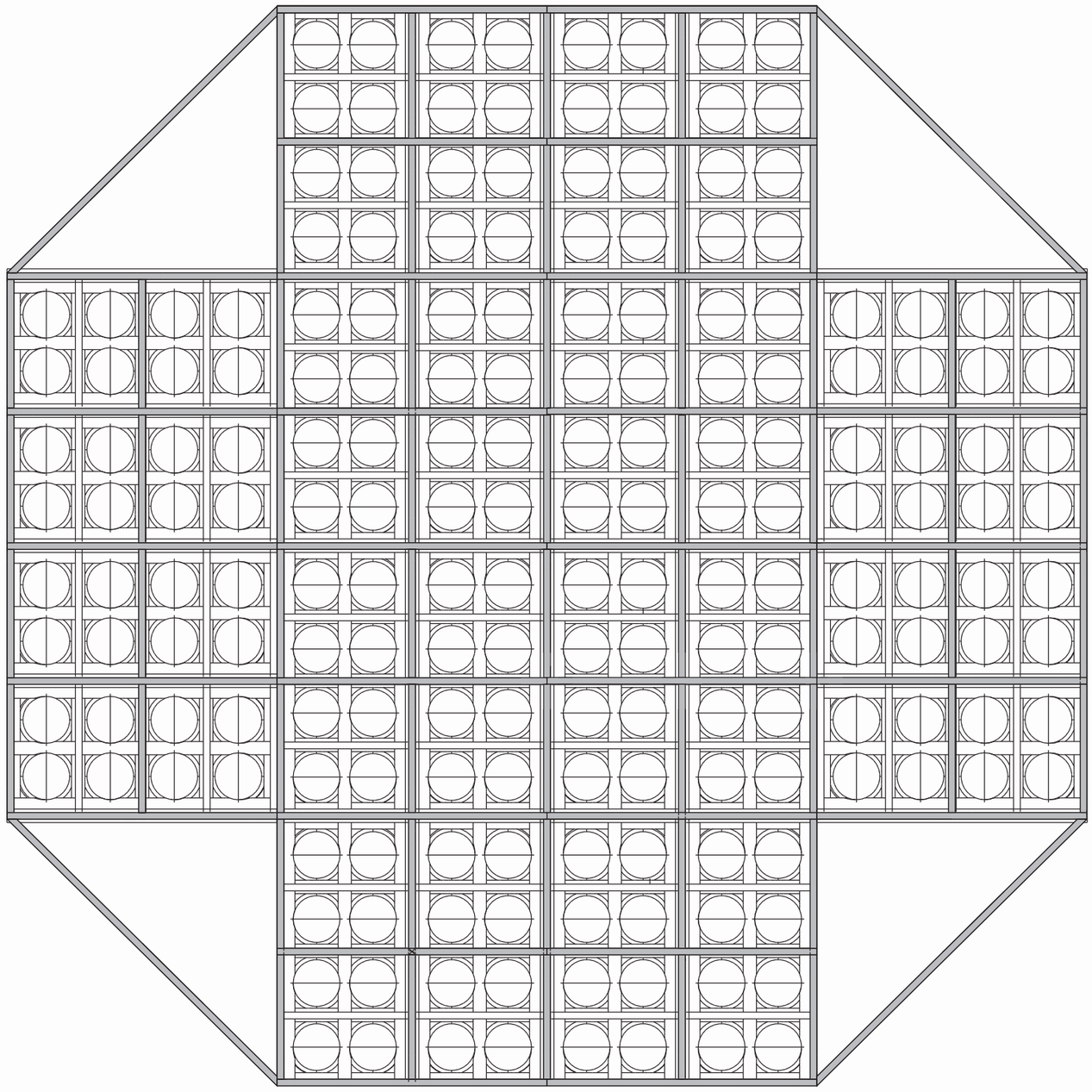
New design


reduced size
truss and module splitted
fixed on top and middle
increased height of the frame

Floating modules in the shape

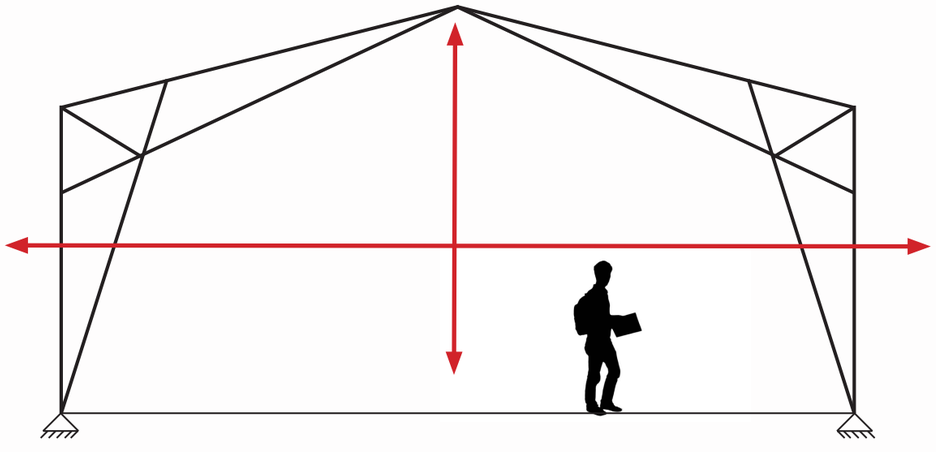
192 barrels
38.400 kg



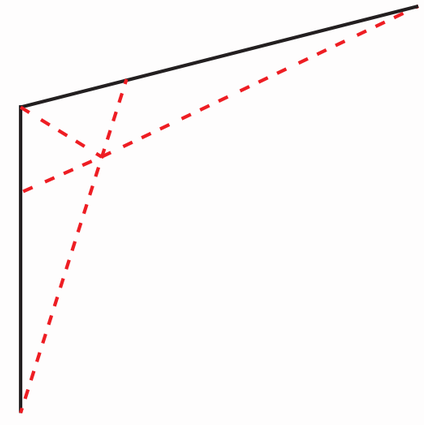


Design | upperstructure

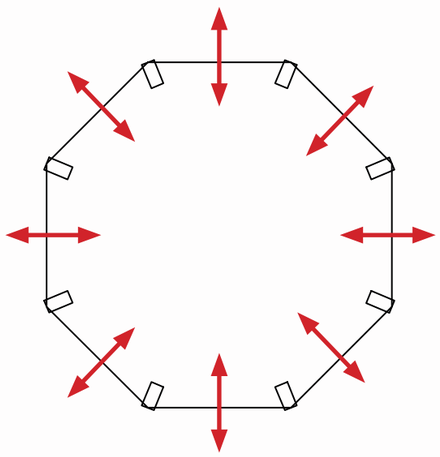
Design criteria



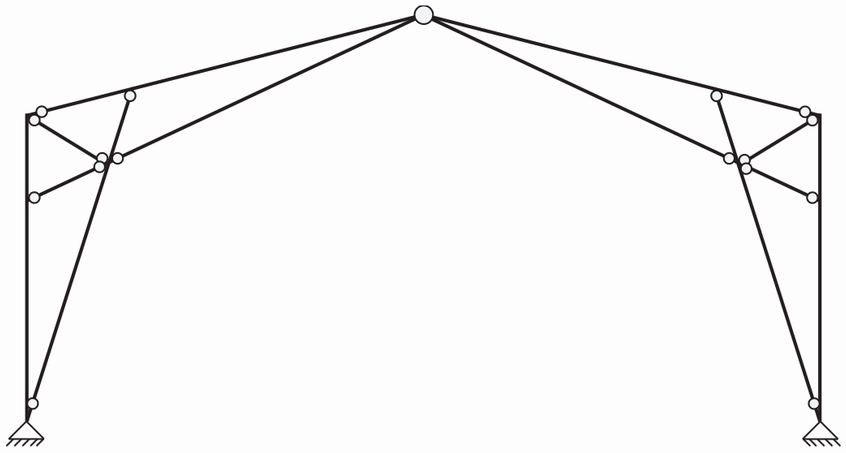
transparancy in- and outside the classroom



strengthening the corners by triangular elements

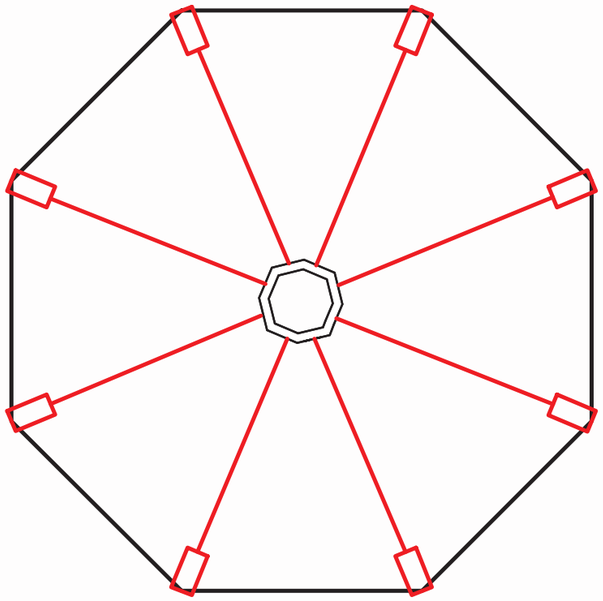


flexibility in layout of the facades

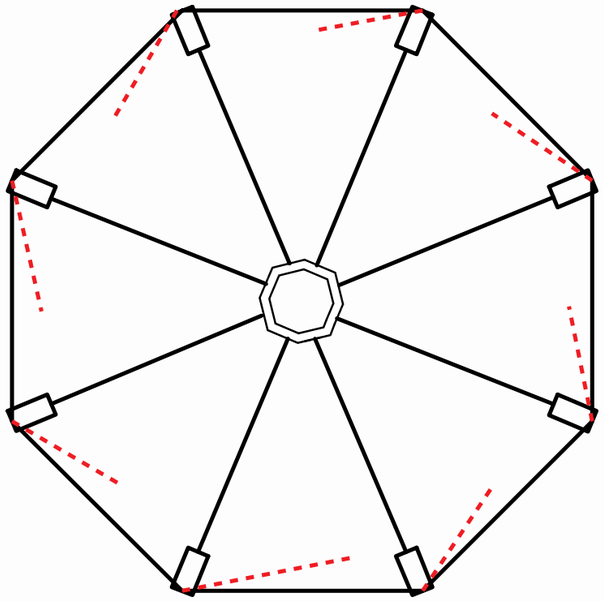


easy hinged connections

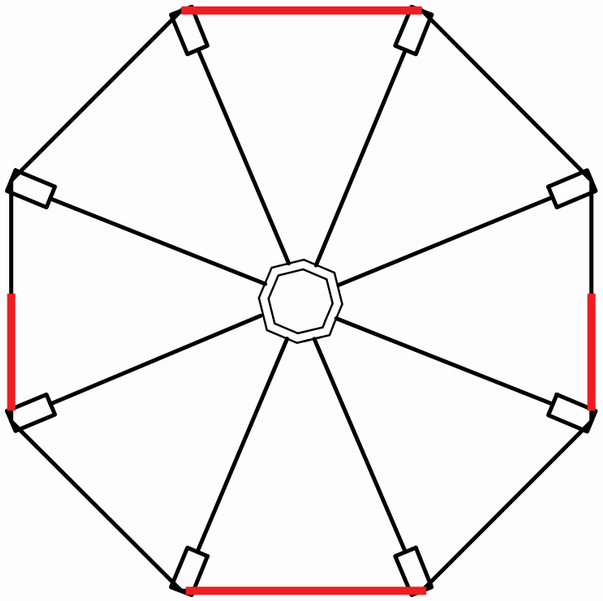
Design | stability



Placement of the frames

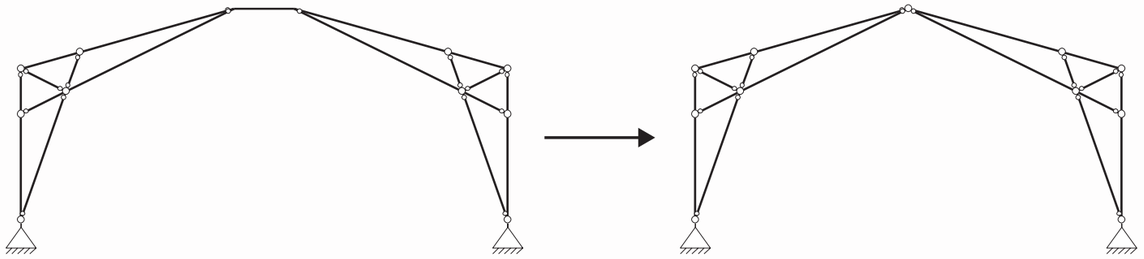


To prevent rotation and falling

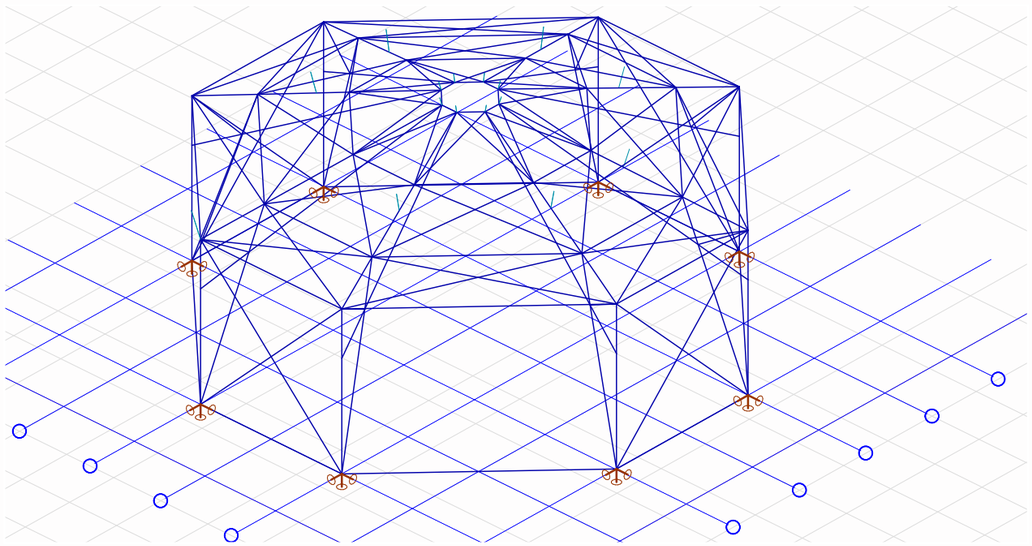


Stabilization walls

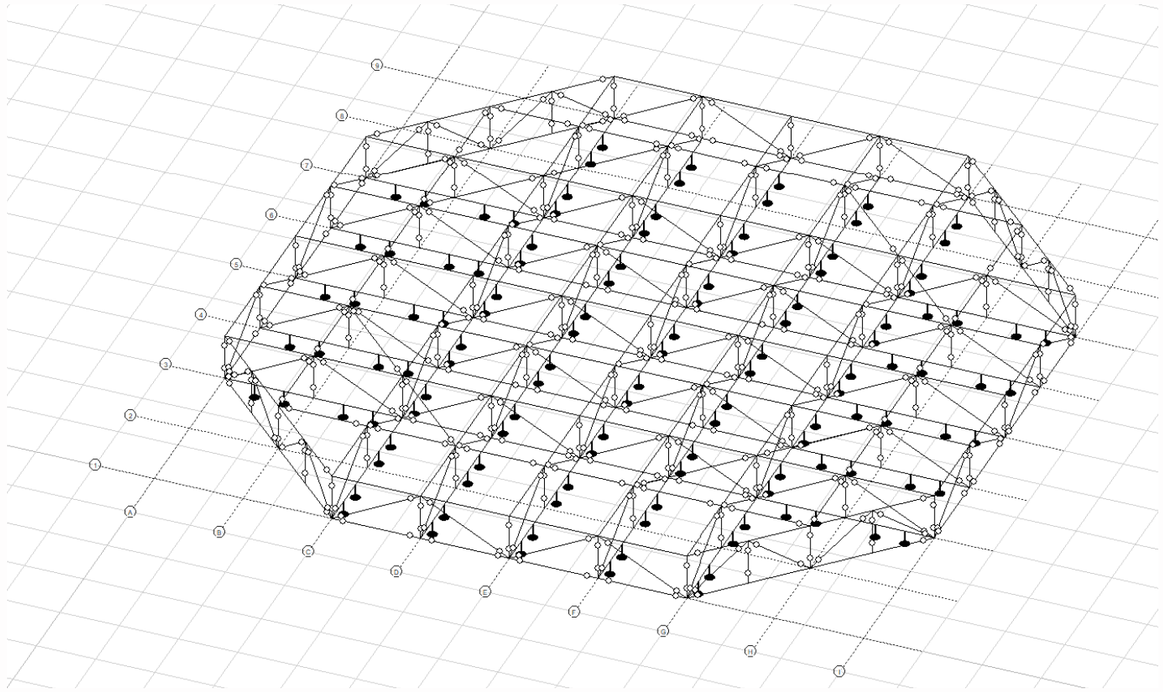
Structural analysis | structural model



2D model setup in Technosoft - strength control



3D model setup in Axisvm - displacement control



3D model setup in AxisVm - control on strenght, sinking and tilting

Structural analysis | load assumptions

Dead load: own weight of the structure

Classroom floor	0,5 kN/m^2	= 50 kg/m^2
Roofing	0,55 kN/m^2	= 55 kg/m^2
Pathway	0,5 kN/m^2	= 50 kg/m^2

Live load: for example the load of the students

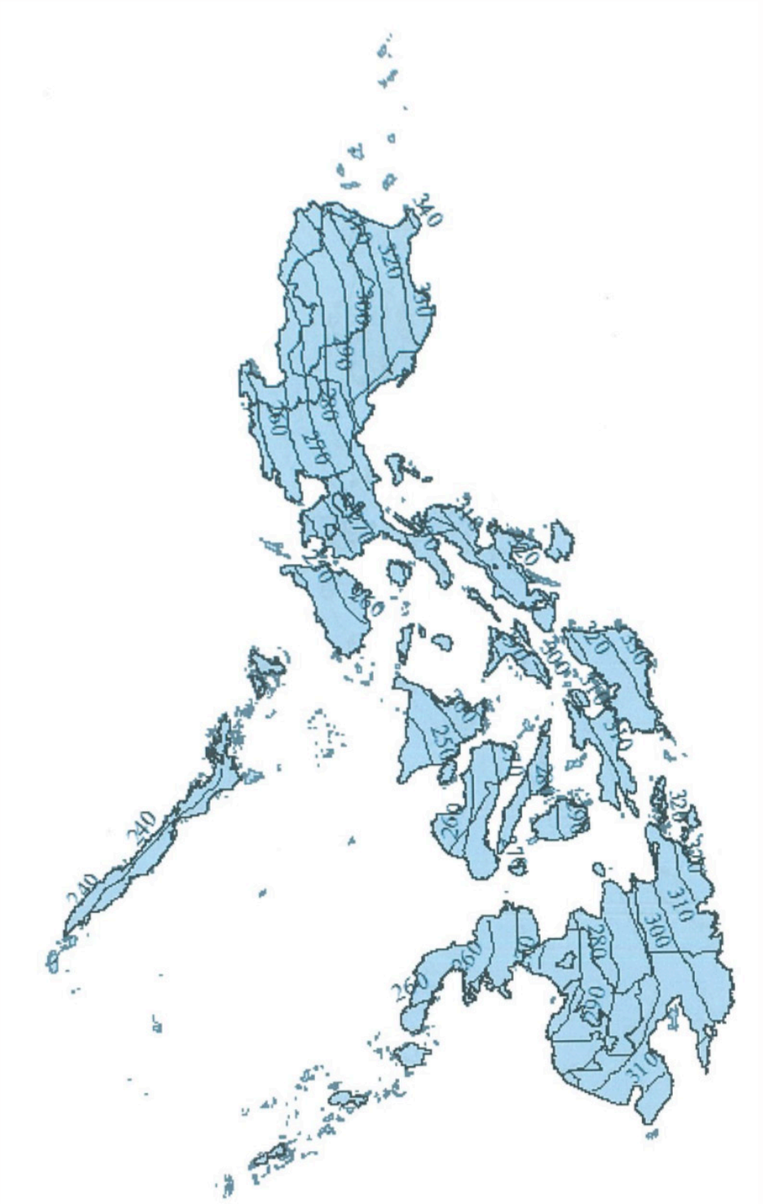
Classroom	1,9 kN/m^2	= 190 kg/m^2
Roofing	1,0 kN/m^2	= 100 kg/m^2

Wind load:

Occupancy category 1 (National Structural Code Philippines)

Gust wind speed	260 km/h
Design wind speed	174 km/h
Peak pressure	3,32 kN/m^2

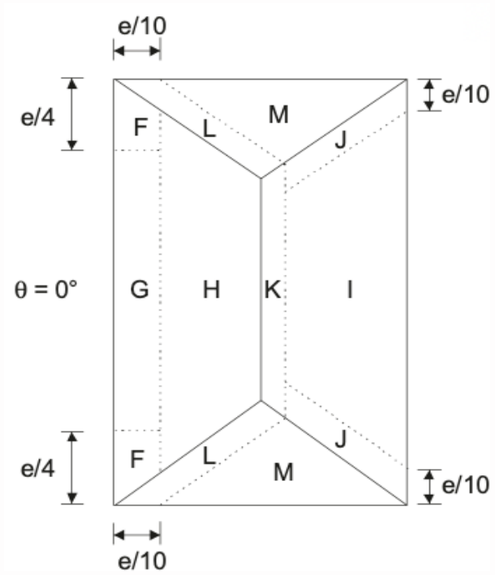
Falls in the category of **typhoons 118-220 km/h**



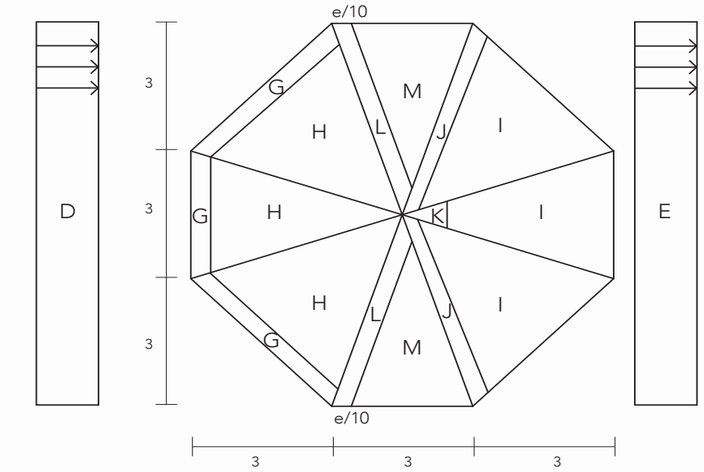
Structural analysis | wind zones

- Windzones based on the Eurcode

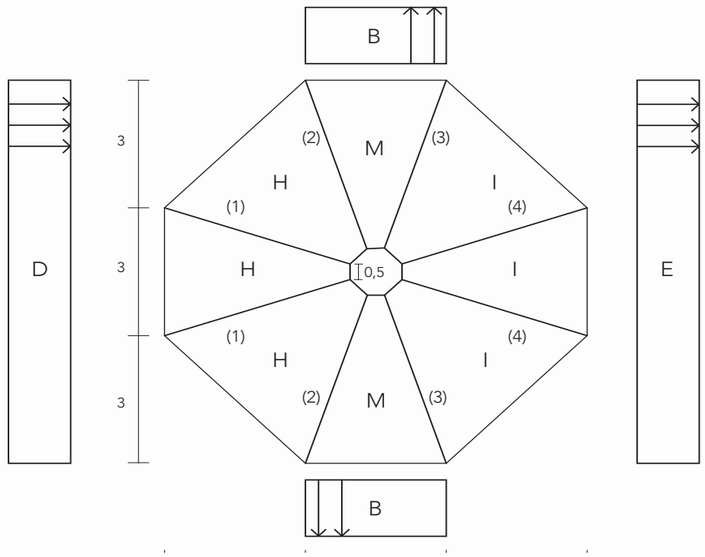
- Simplification made based on rectangular windzones



Windzones rectangular shapes Eurocode

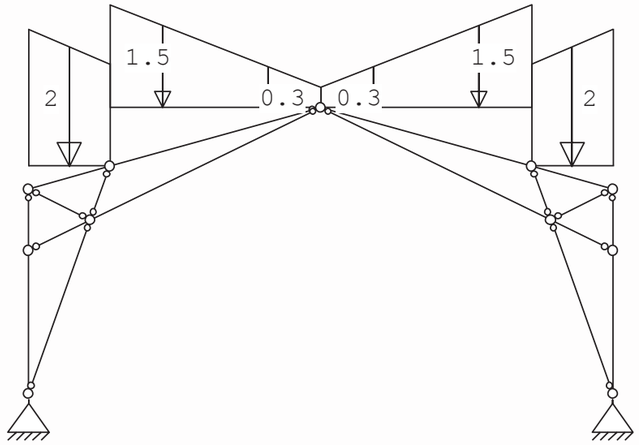


Windzones set up for 2D model

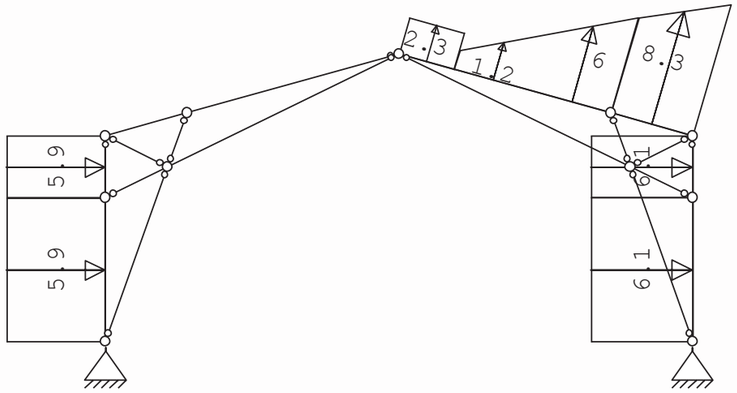


Windzones set up for 3D model

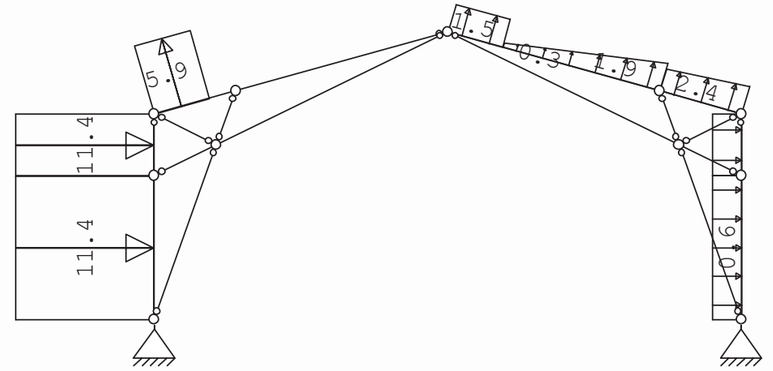
Structural analysis | load cases



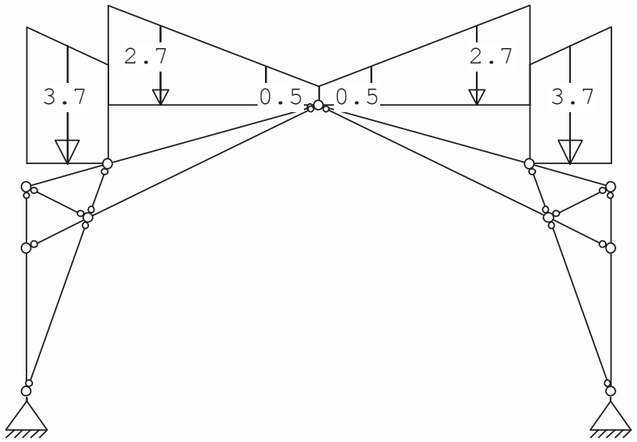
Dead load - roof



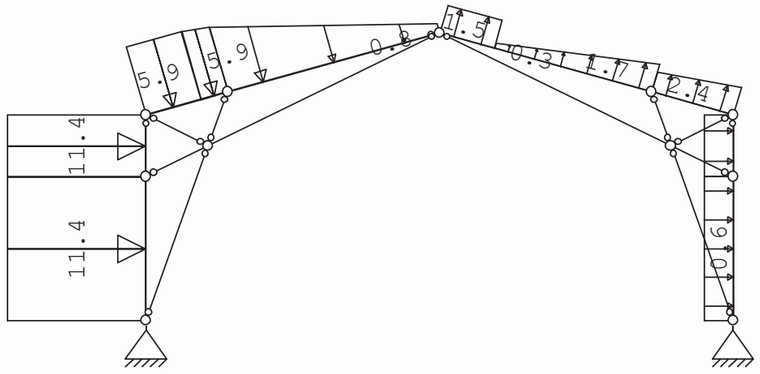
Lived load - Wind 1



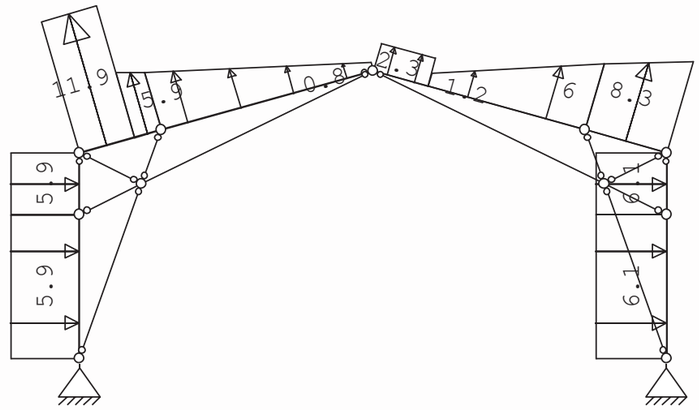
Lived load - Wind 3



Lived load - roof



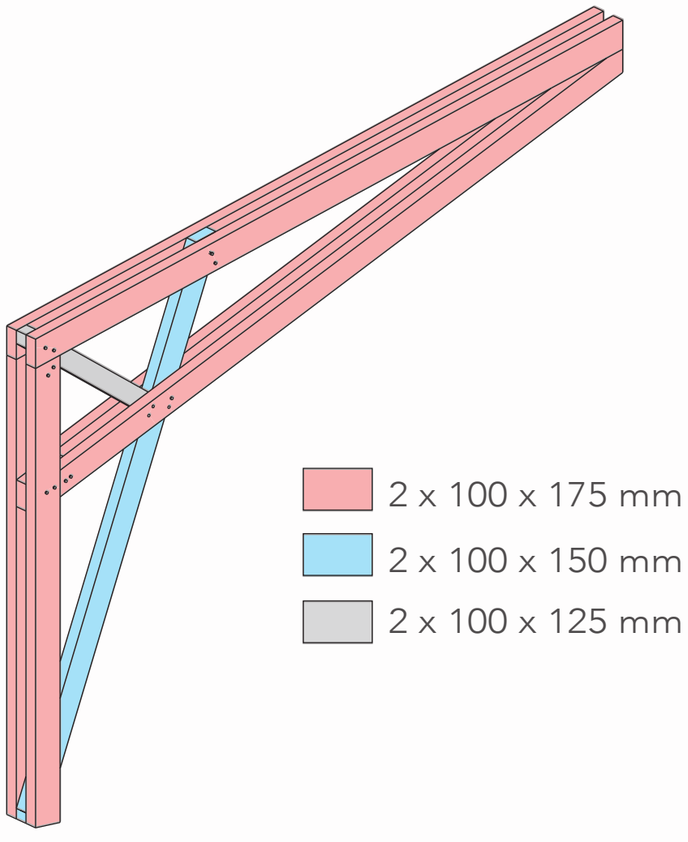
Lived load - Wind 2

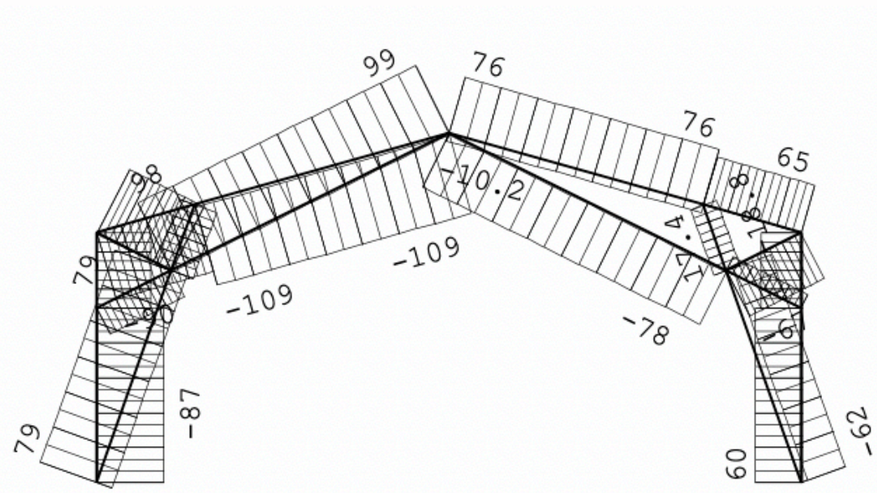


Lived load - Wind 4

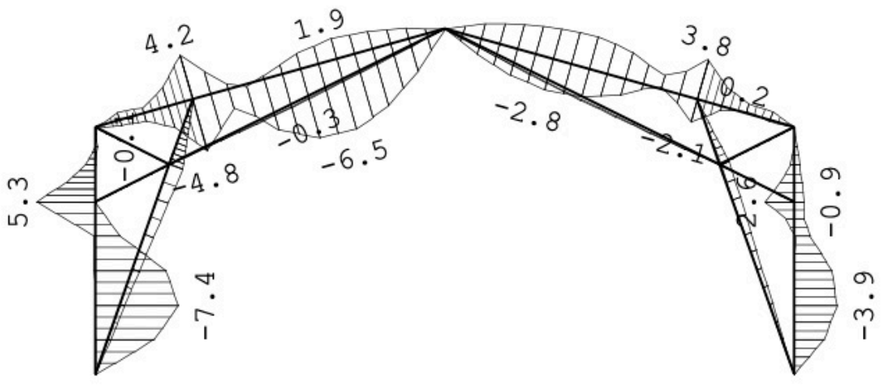
Structural analysis | cross-sections

- Due to hinged connections there are mainly normal forces
- Depends on the wind direction which elements are under pressure and which are under tension
- Highest compression force of 109 kN
- No moments in the connections
- Displacements are leading for determination profiles

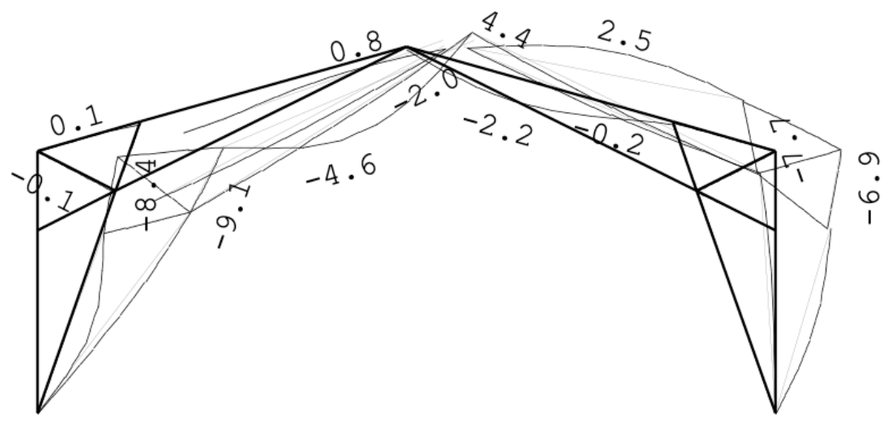




tensile and compressive forces



moments

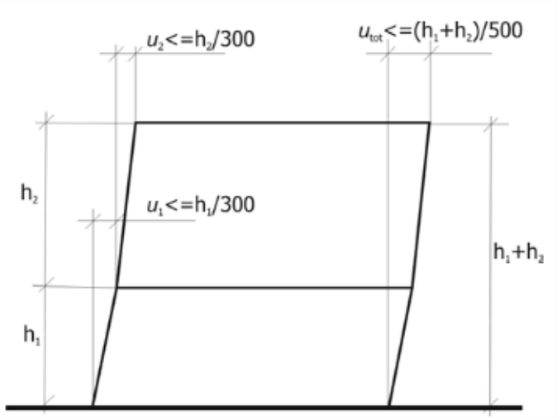


displacement

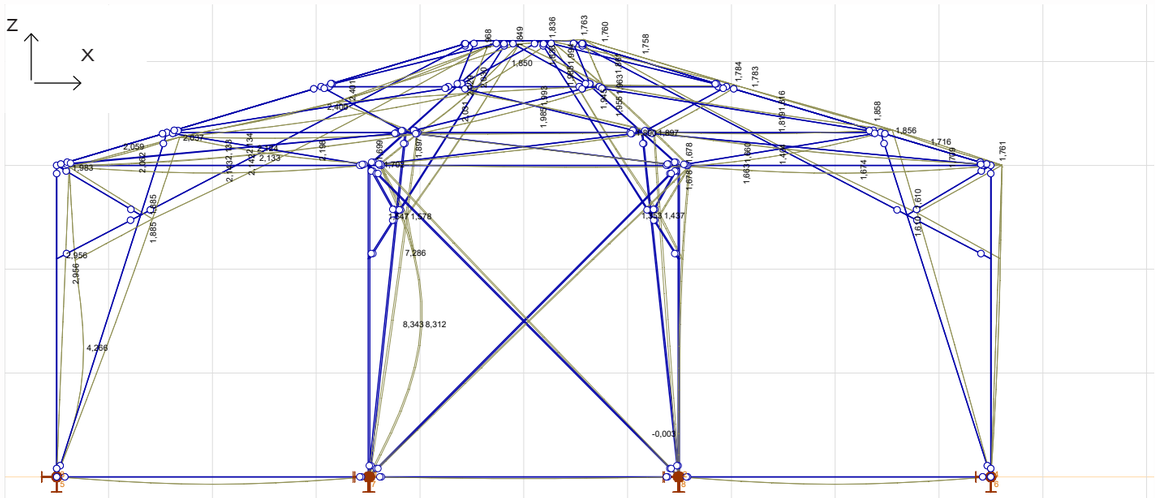
Structural analysis | stability

Displacement criteria:

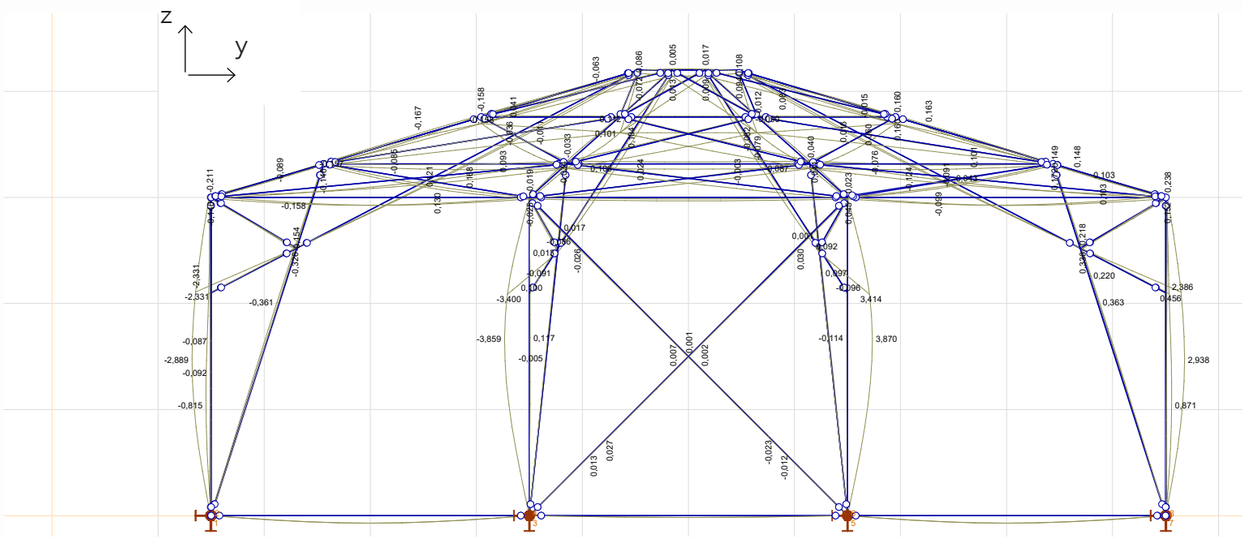
Maximumum displacement allowed of 10 mm



maximum displacement for a buiding (NEN-EN 1990)

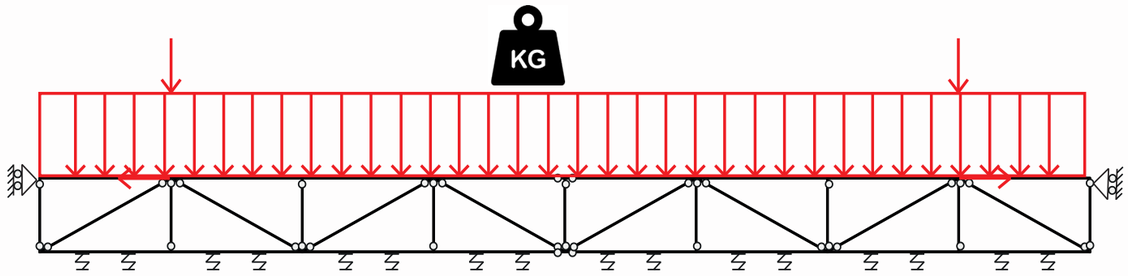


max. displacement in the x-direction 8,4 mm < 10 mm

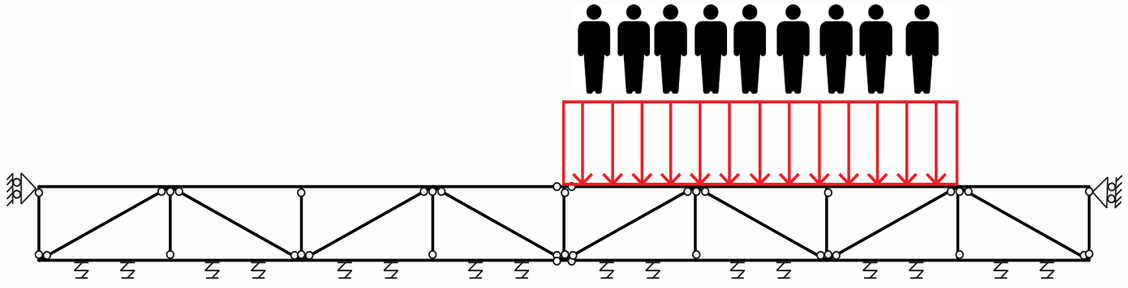


max. displacement in the y-direction 3,9 mm< 10 mm

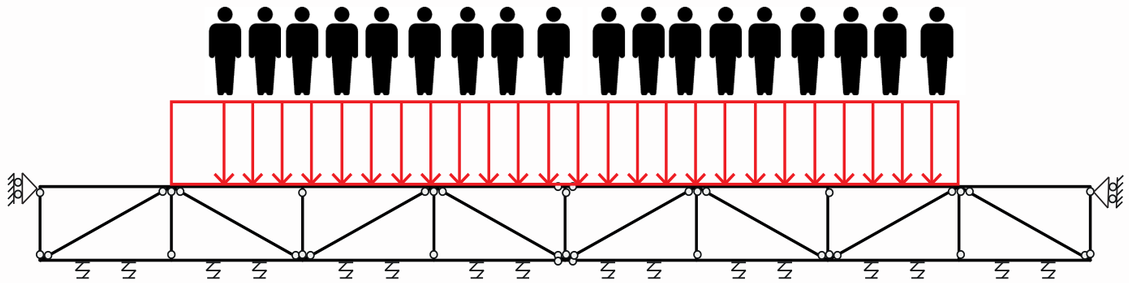
Structural analysis | load cases



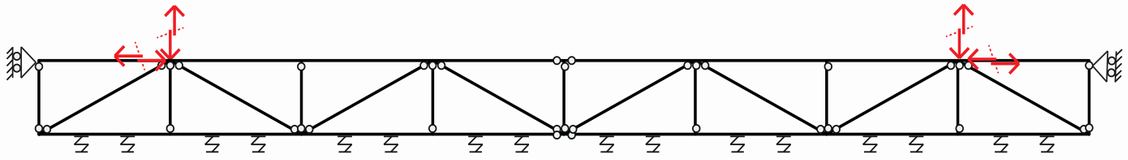
Dead load - Own weight of the building



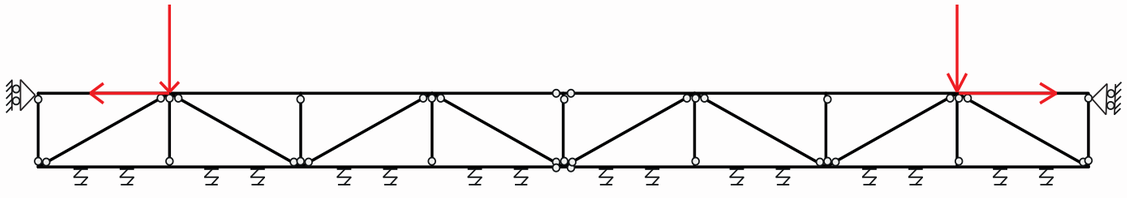
Live load - Eccentric load classroom



Lived load - Classroom



Live load - Wind loads



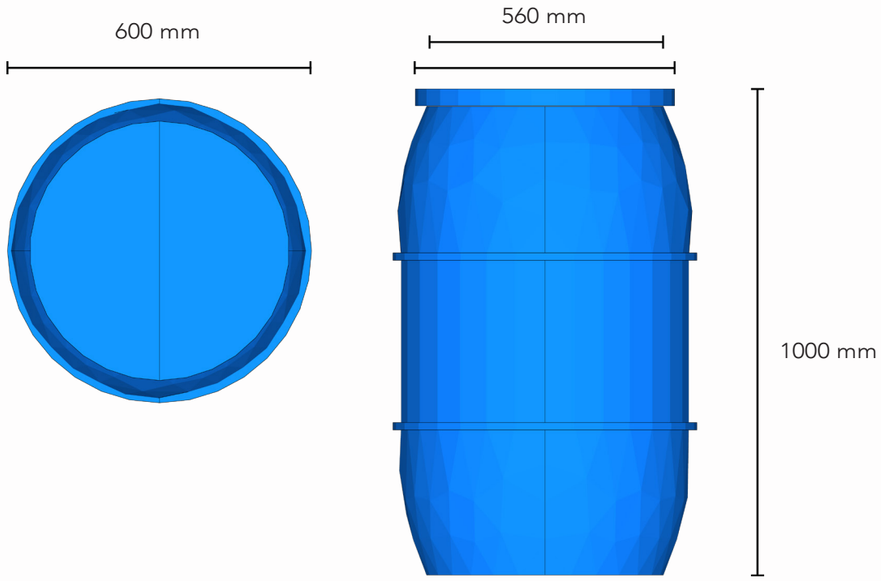
Lived load - Roof

Structural analysis | supports floating foundation

Barrels of 200 L

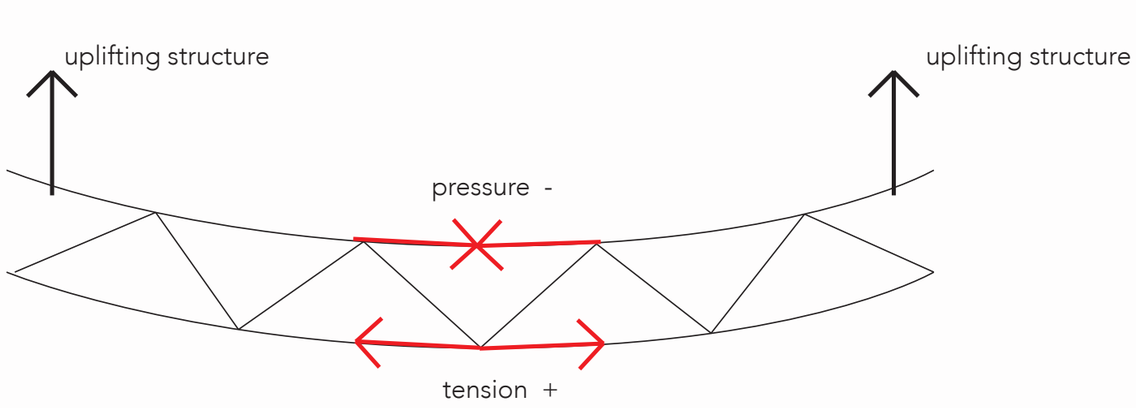
To push the barrel 1 meter down 200 kg is needed

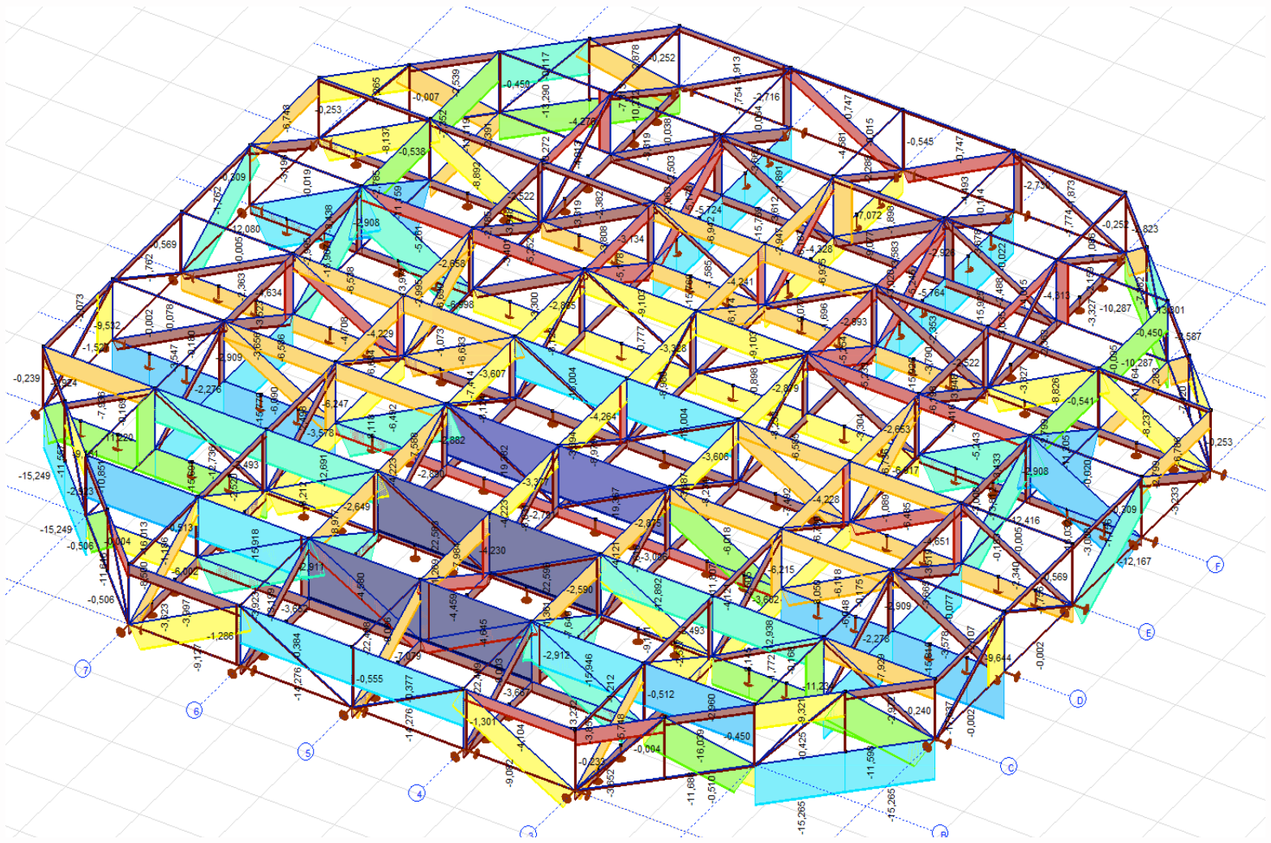
Spring rate of 2 kN/m



Structural analysis | cross-sections

- In the trusses mainly pressure and tensile forces occur
- Biggest compressive force : -32 kN
- Due to upward force from wind pulling the building up
- Dimensions for elements of the truss are 63x125 mm

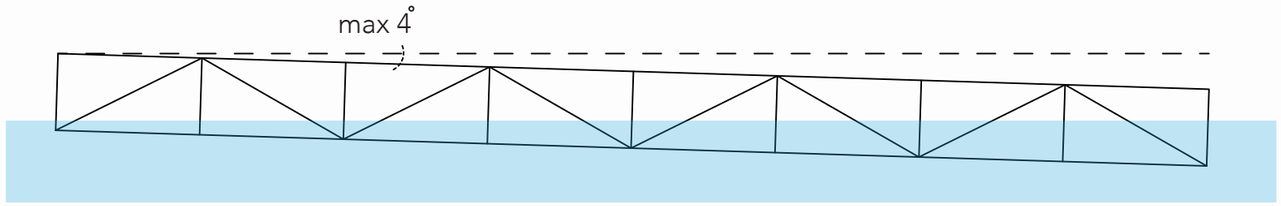




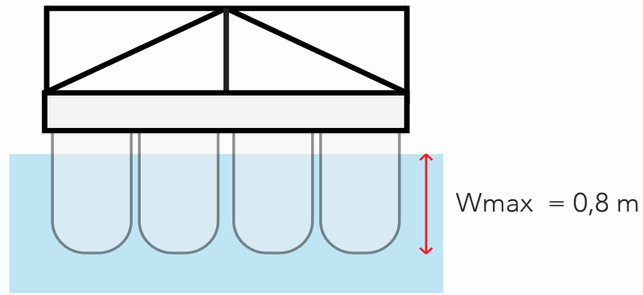
Compressive forces in the floating foundation

Structural analysis | stability

Maximum tilting of the platform: 4°



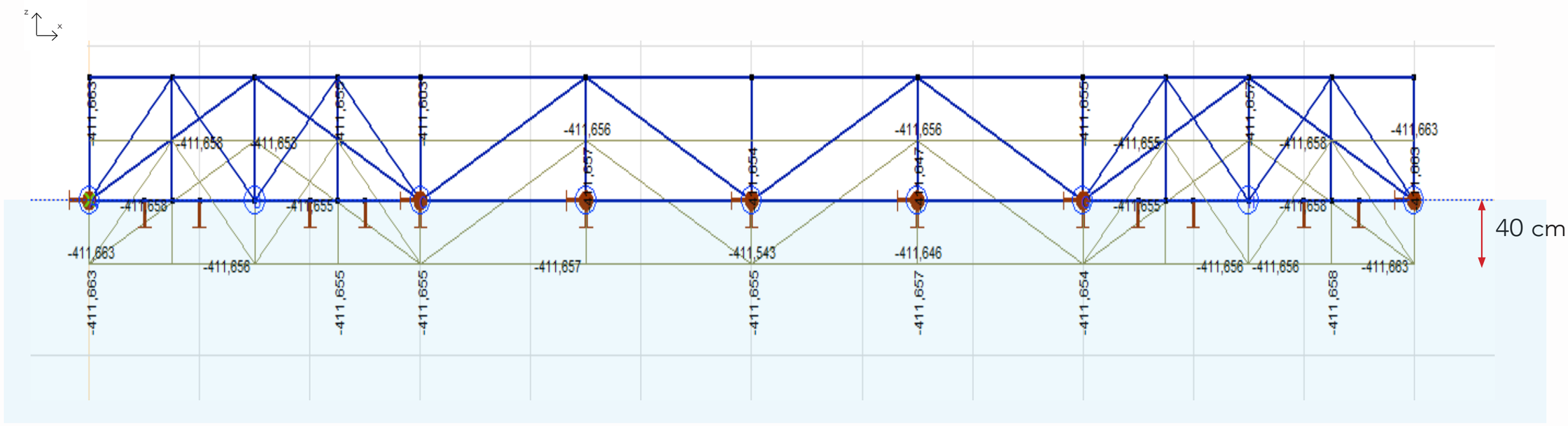
Maximum sinking of the platform: 80 cm



Structural analysis | stability

Floating platform - own weight

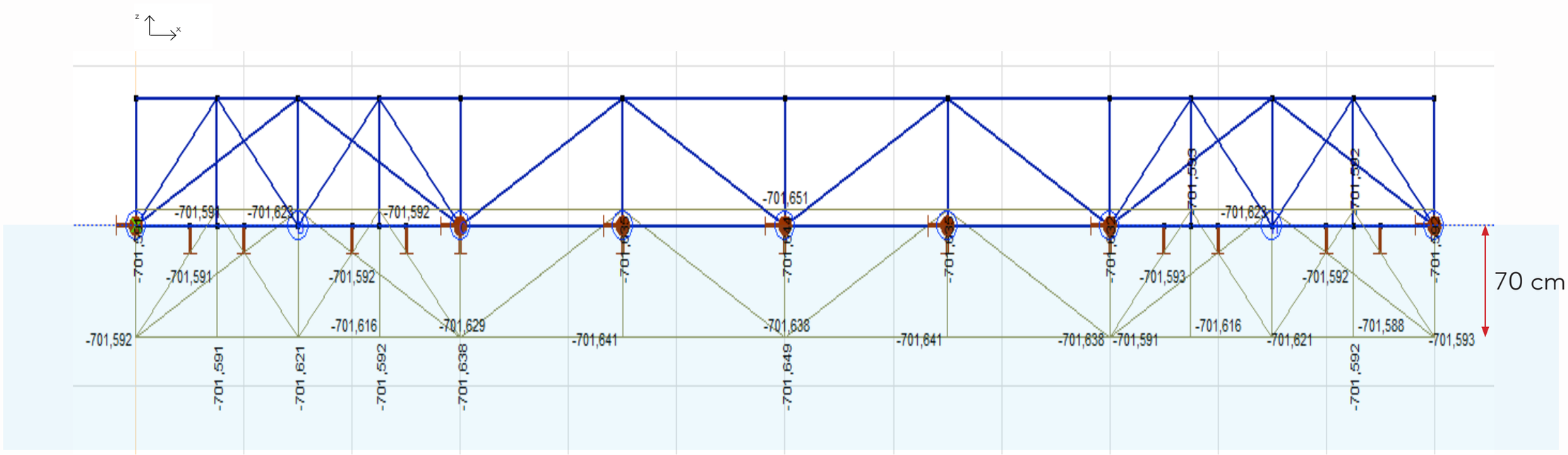
Sinks 411 mm < 800 OK
Tilt 0 degrees < 4 degrees OK



Structural analysis | stability

Floating platform - own weight + full classroom

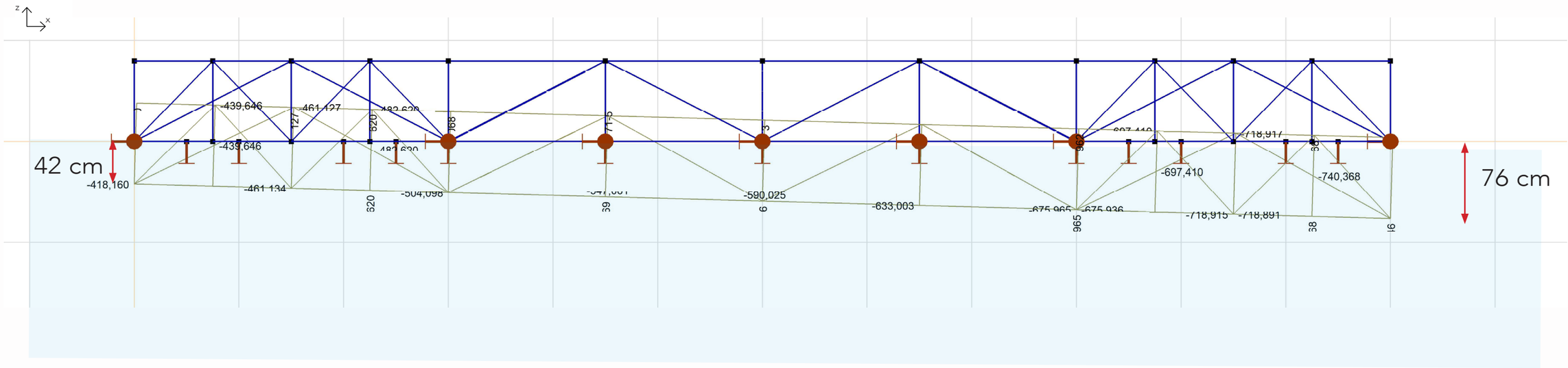
Sinks 701 mm < 800 OK
Tilt 0 degrees < 4 degrees OK



Structural analysis | stability

Floating platform - own weight + eccentric load classroom

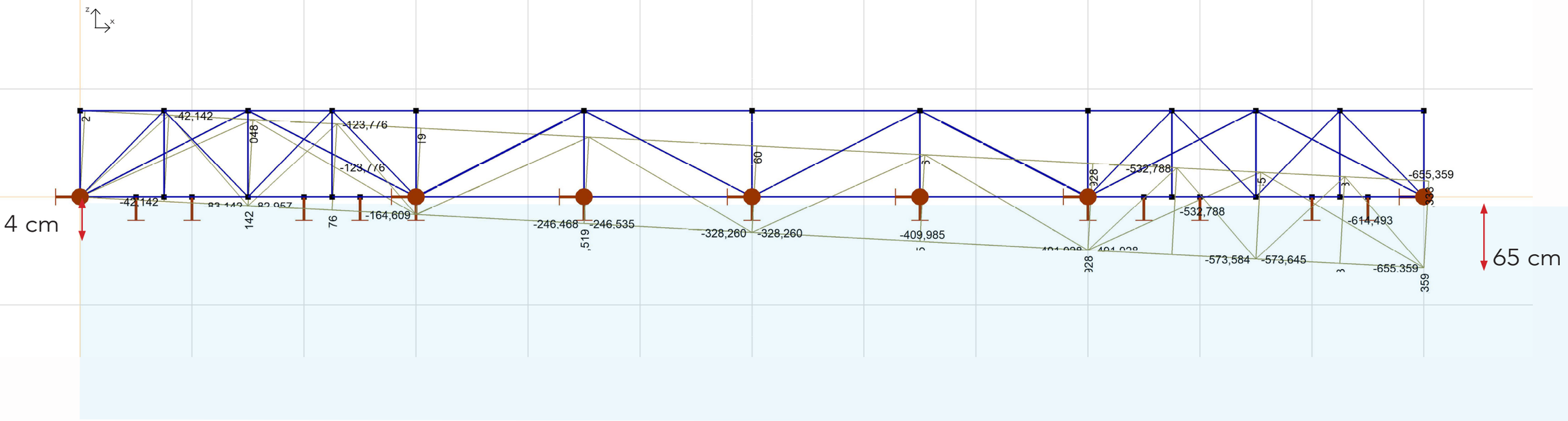
Sinks,max 761 mm < 800 OK
Tilt 2 degrees < 4 degrees OK



Structural analysis | stability

Floating platform - own weight + wind 3

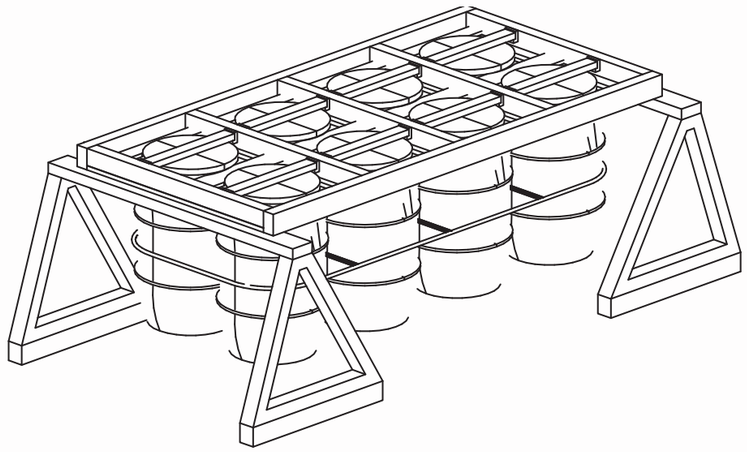
Sinks,max 655 mm < 800 OK
Tilt 3 degrees < 4 degrees OK

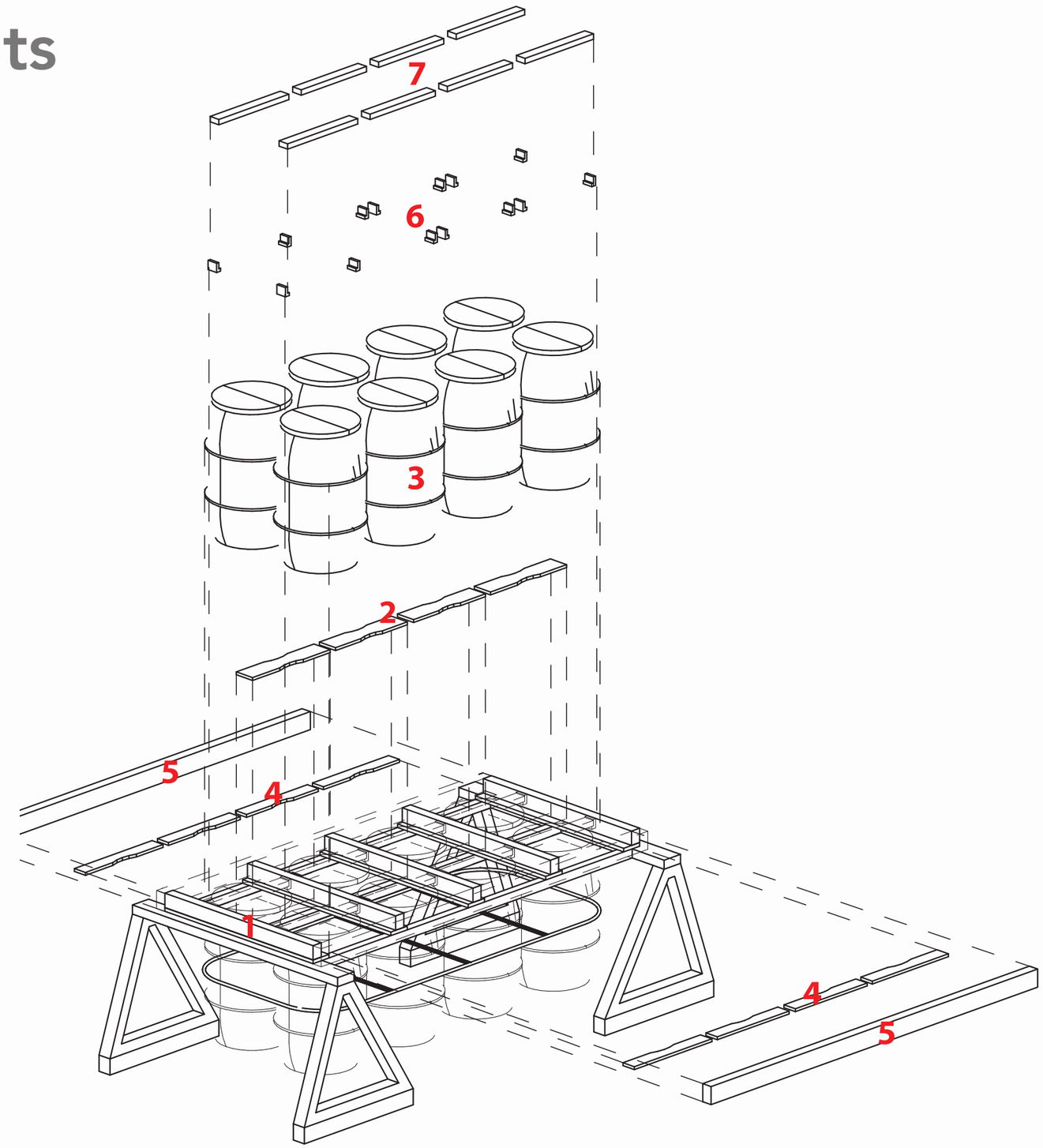


How can it be built?

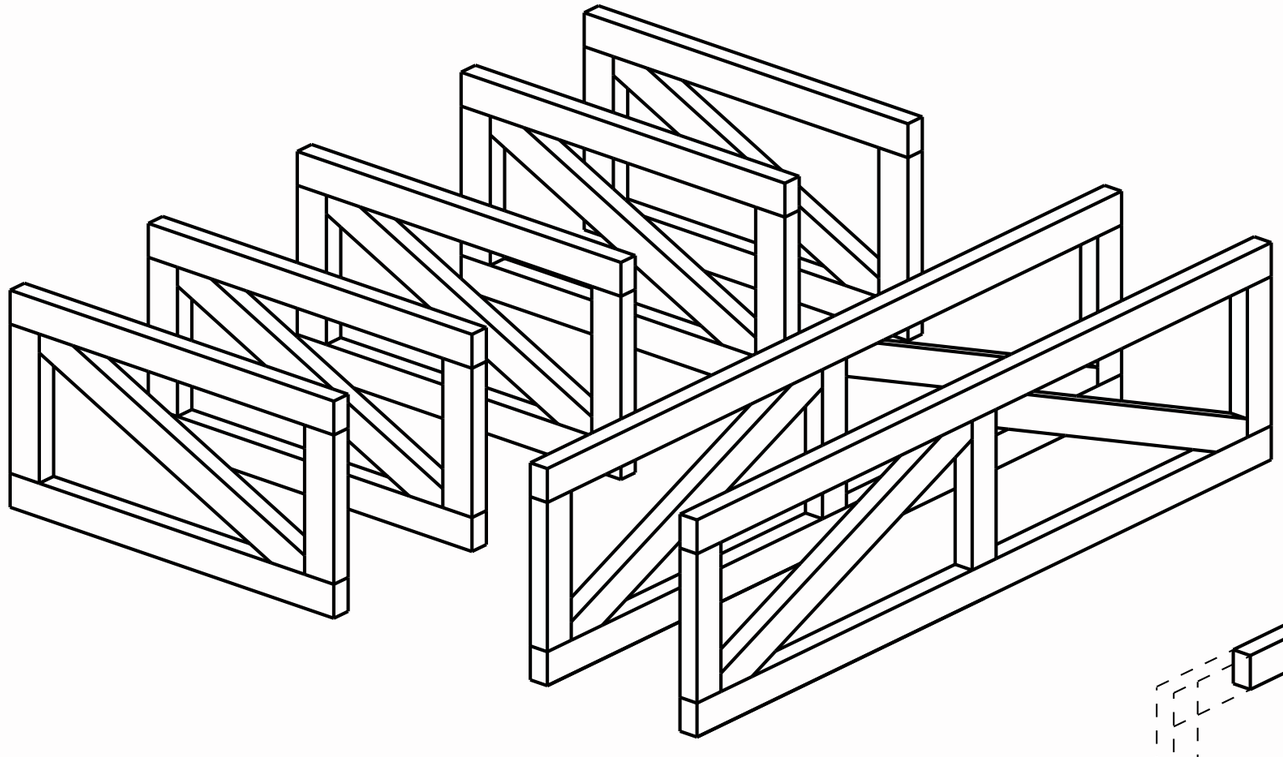
Step 1: Prefabricated elements

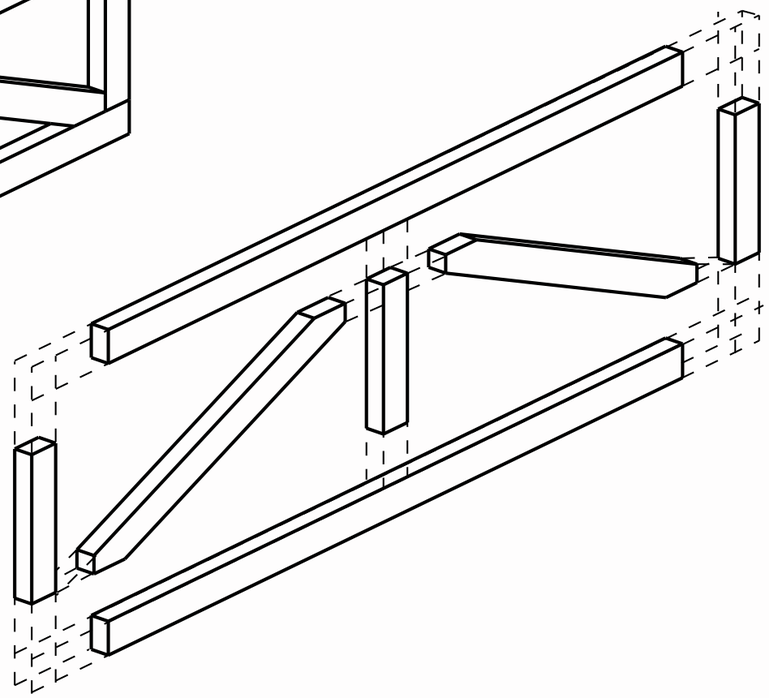
floating modules



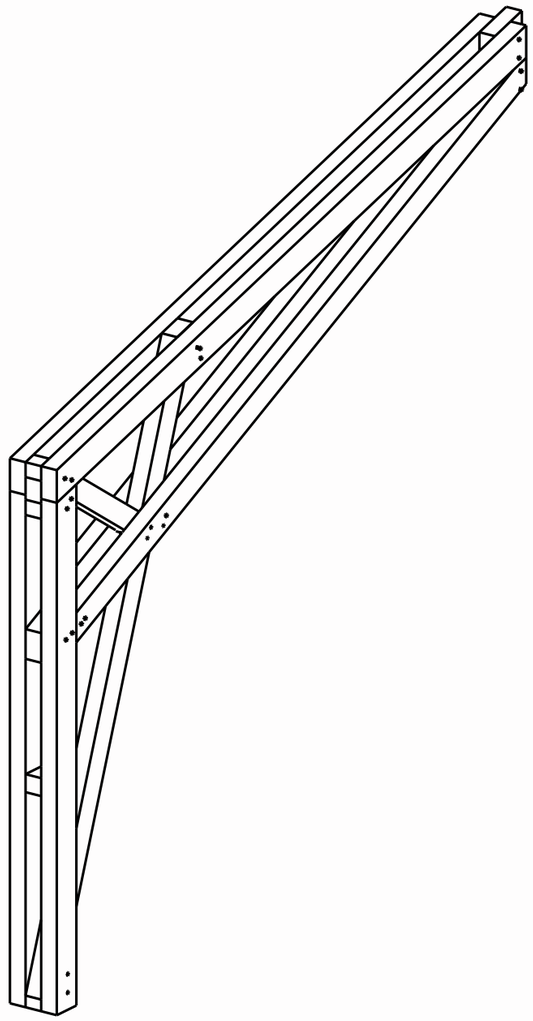


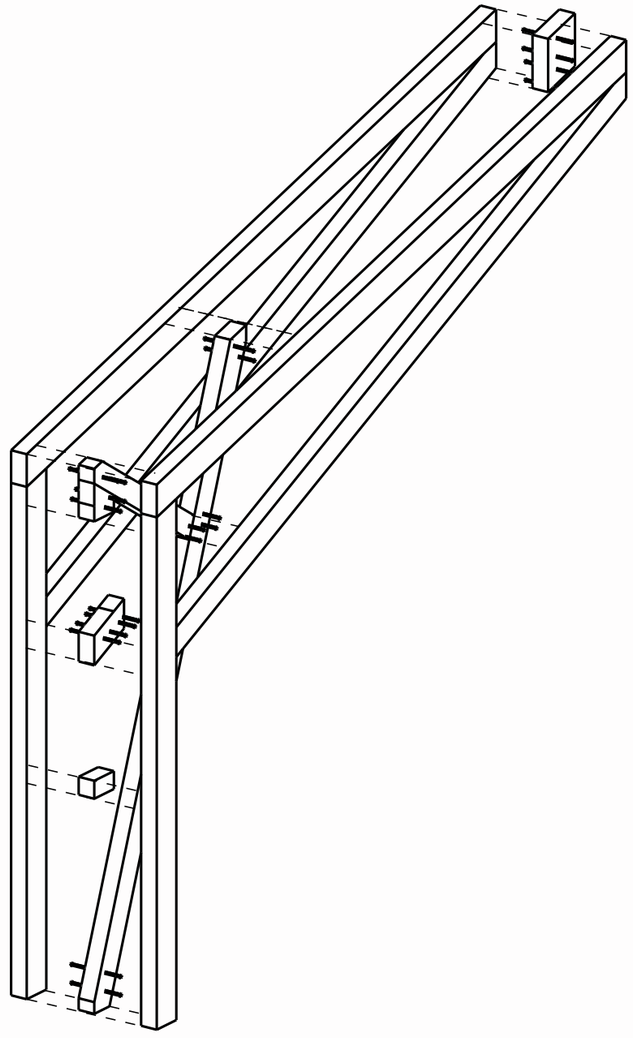
trusses



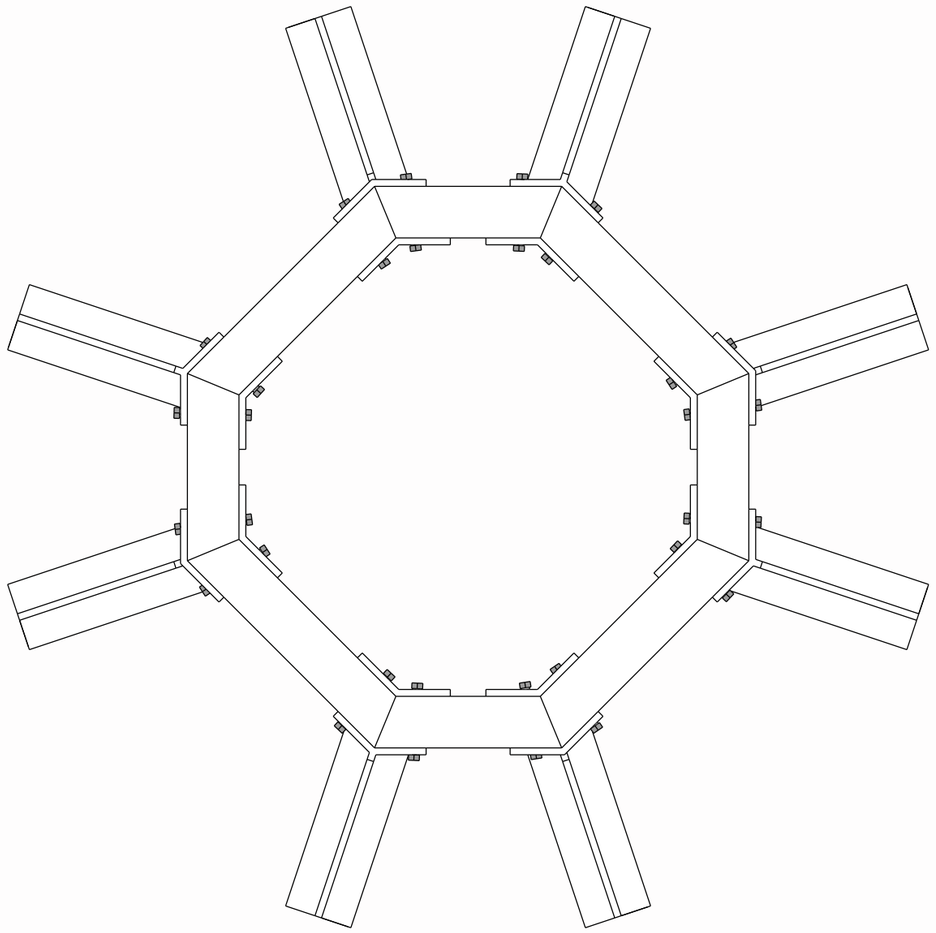


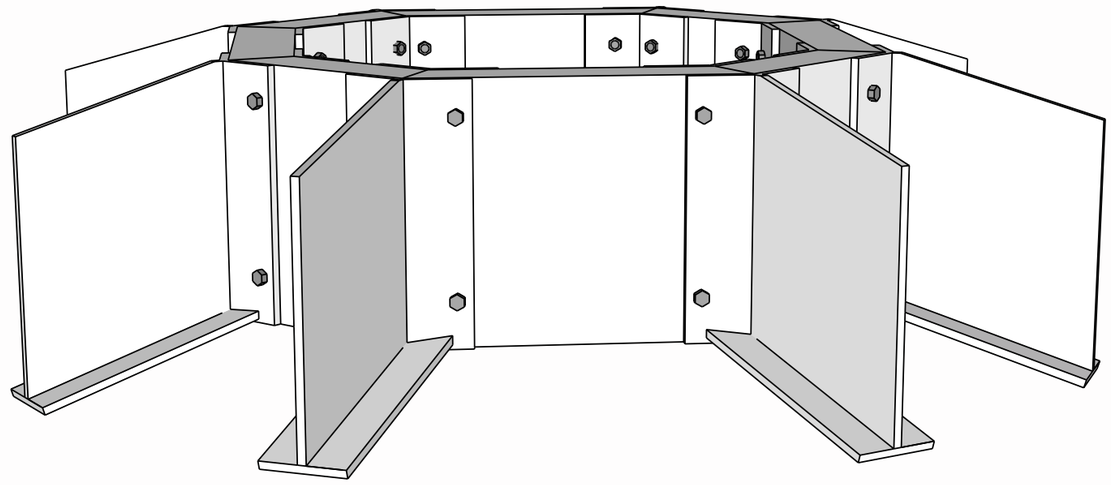
frame





pressure ring

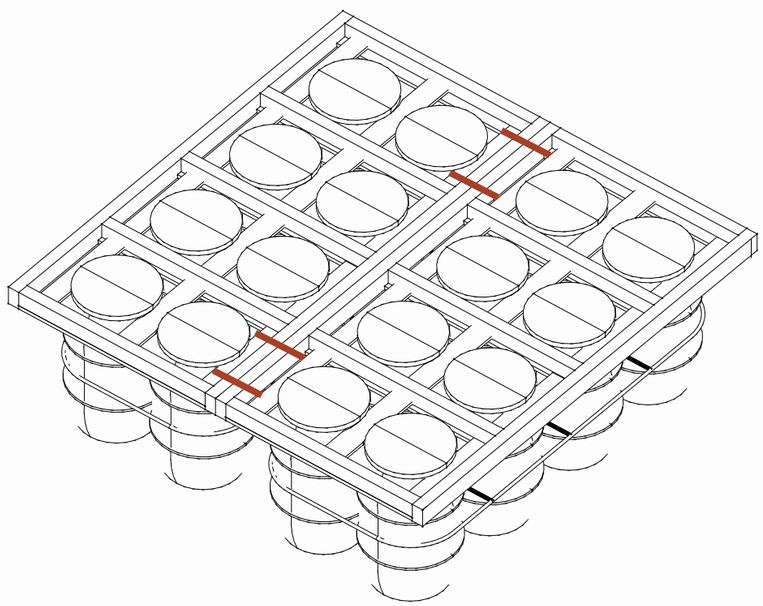


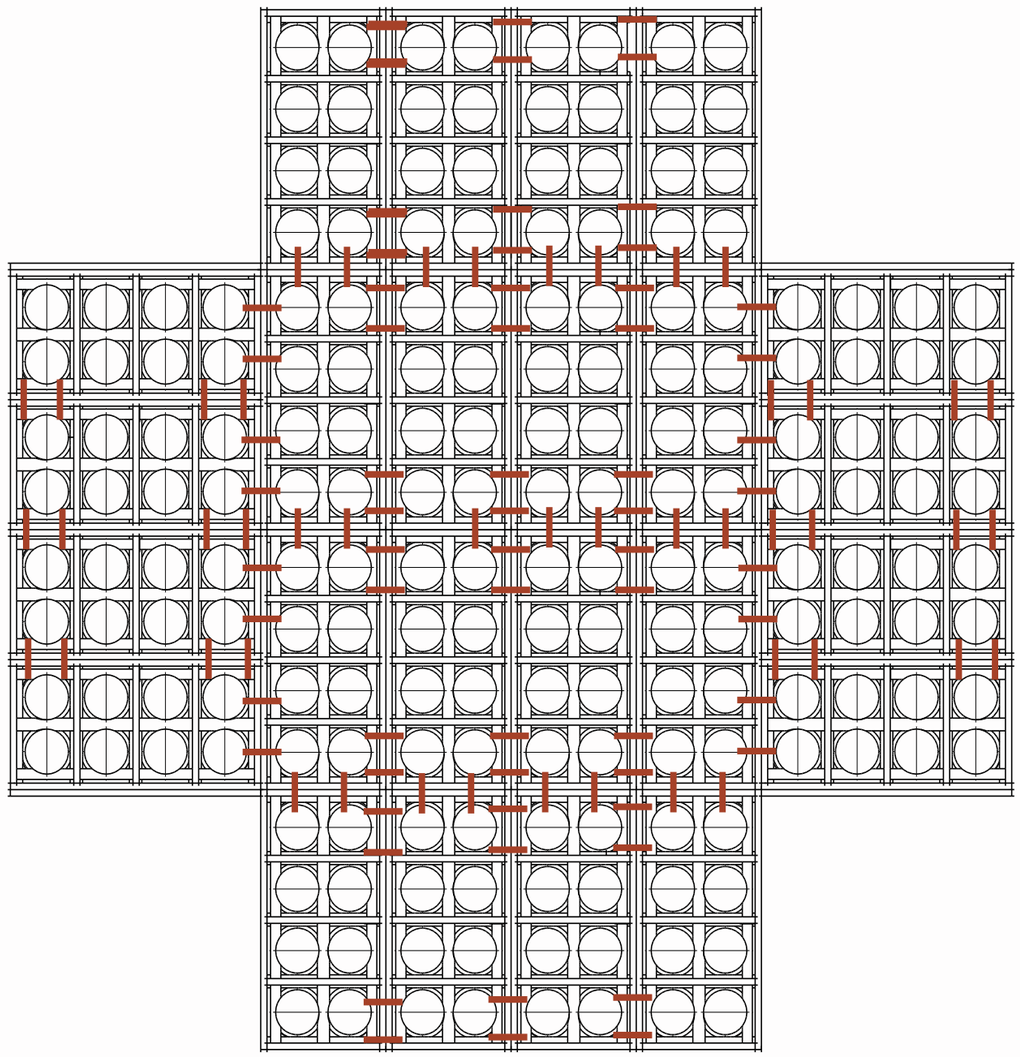


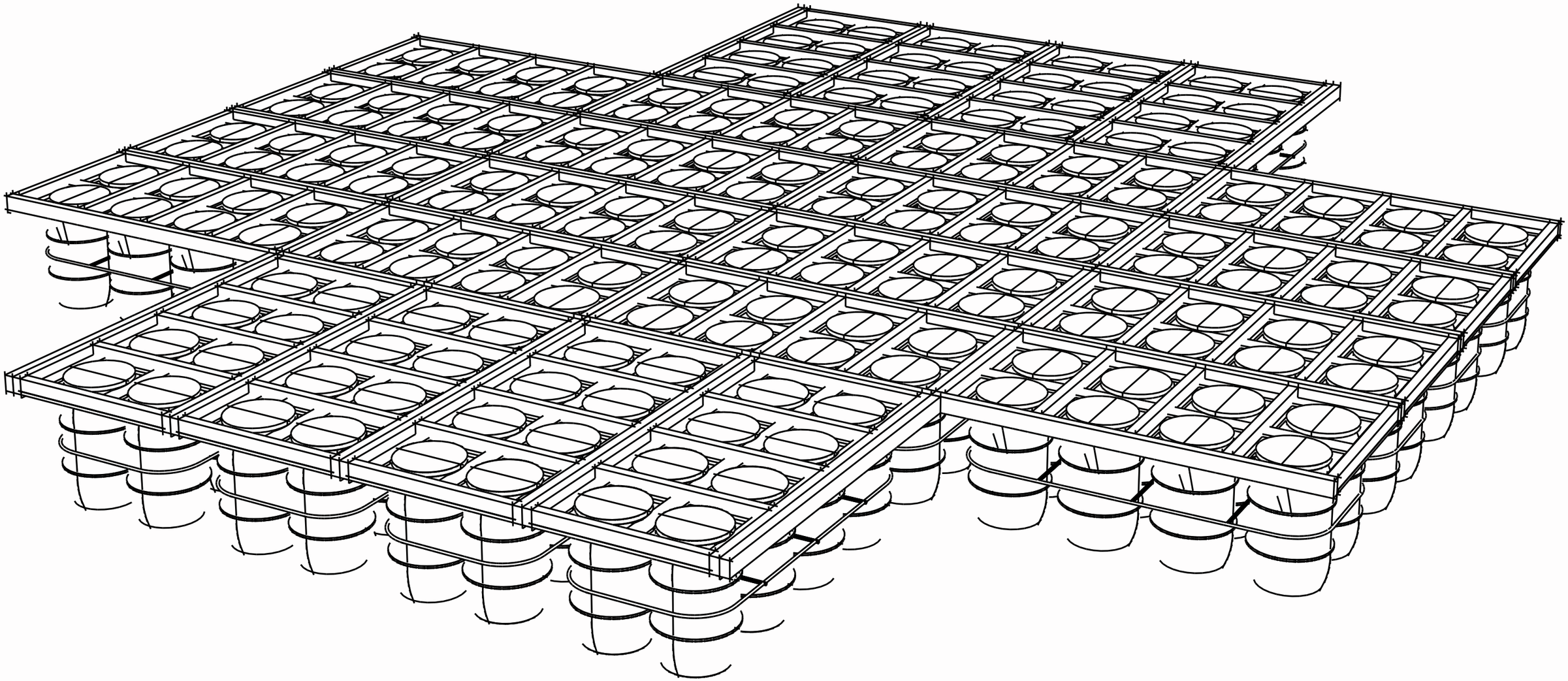
Step 2: connecting prefabricated modules

Total of 24 modules, 192 barrels

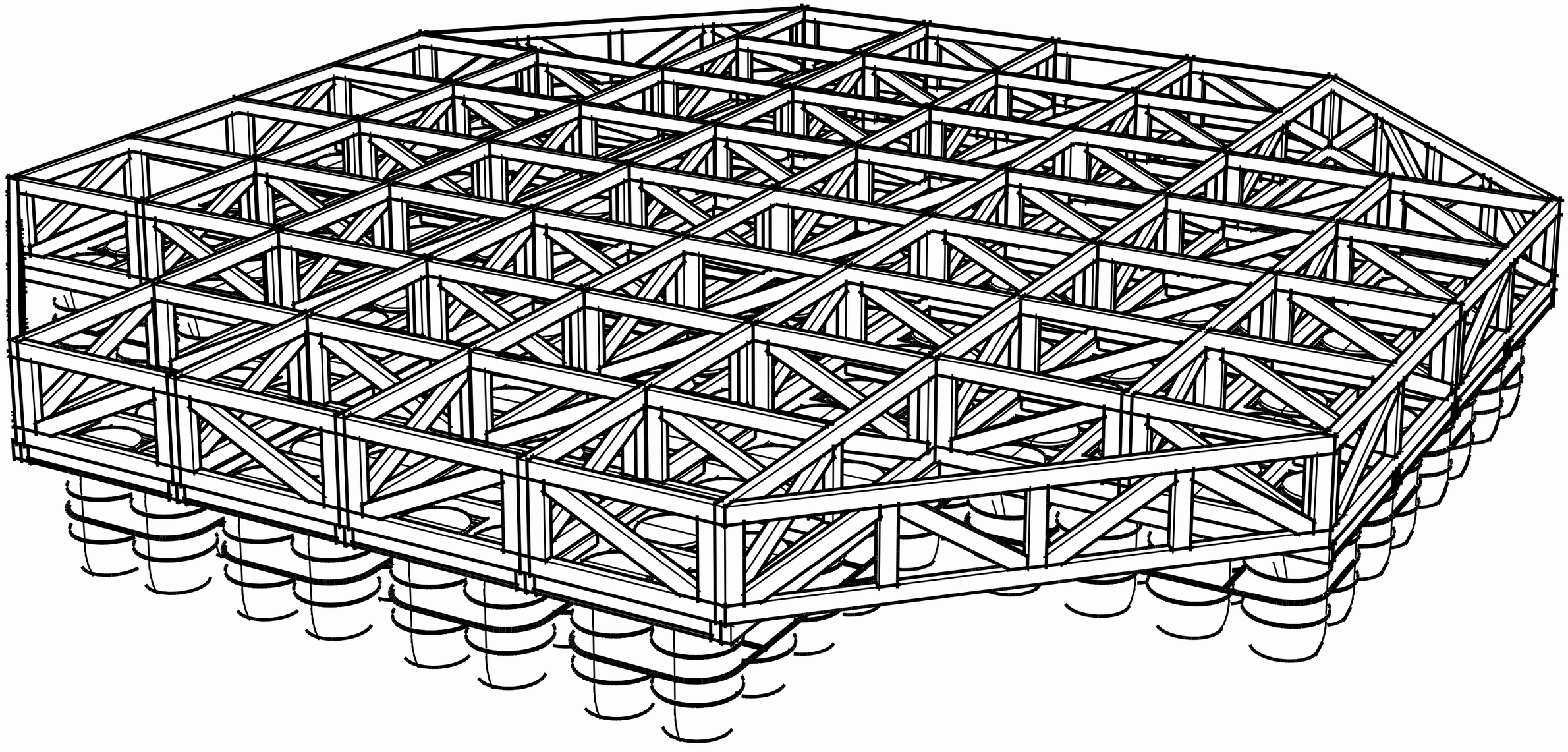
Total lengt and width of the whole foundation is 12 meters



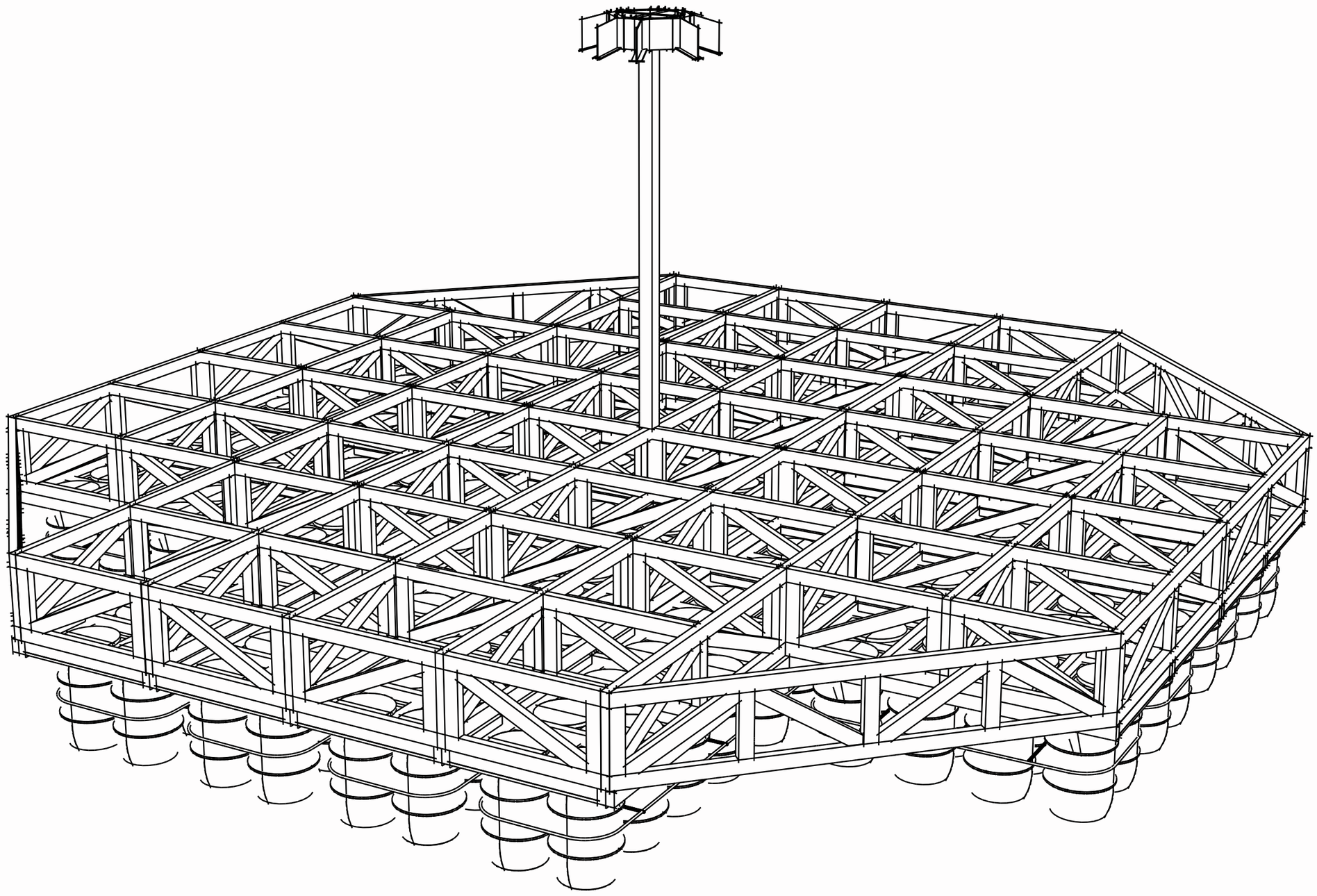




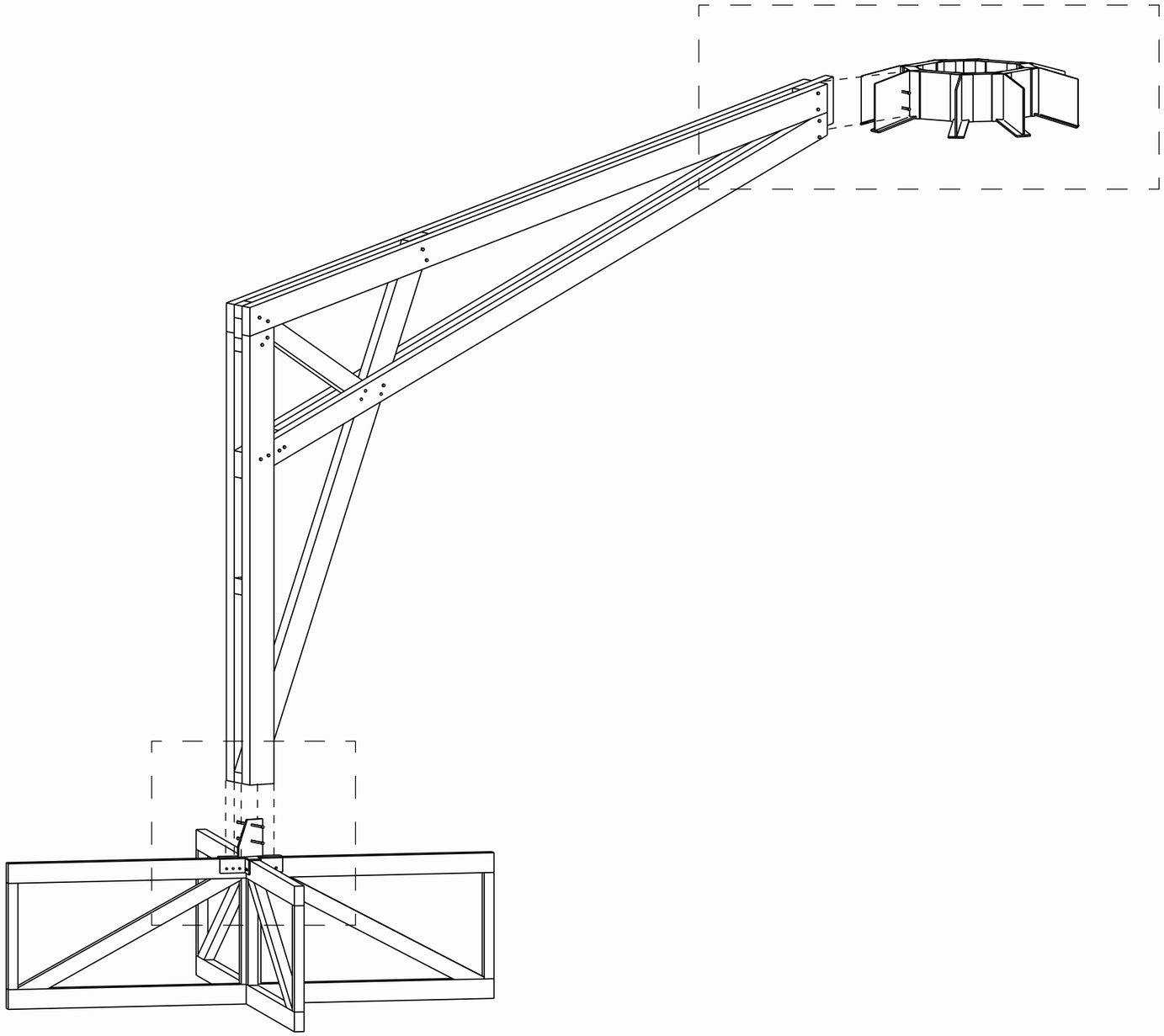
Step 3: Placing of trusses

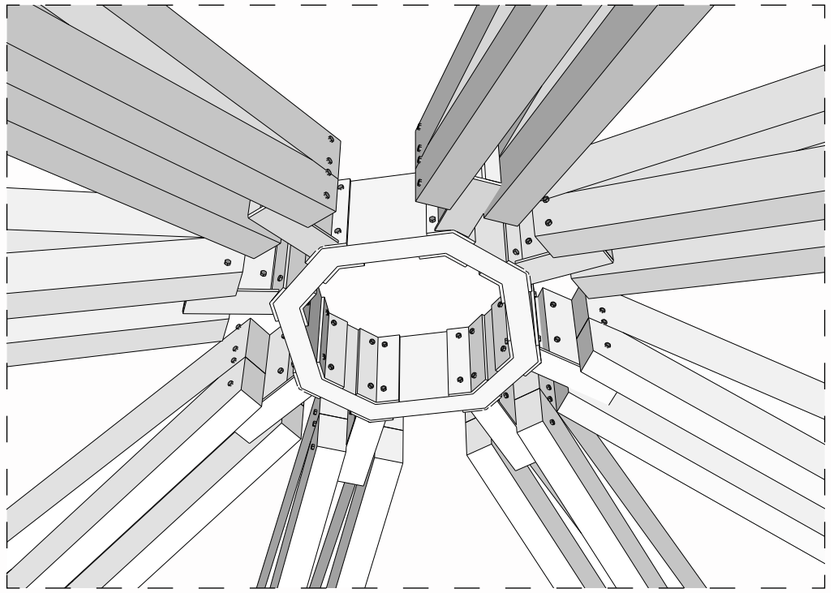


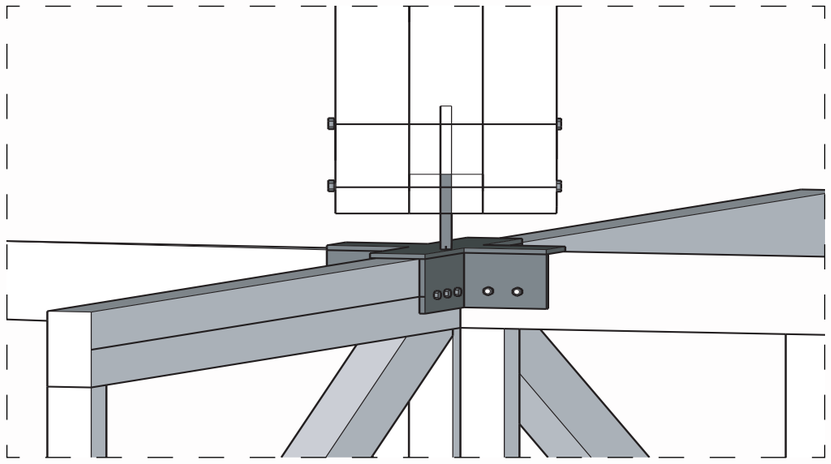
Step 4: Placing of pressure ring on temporary column

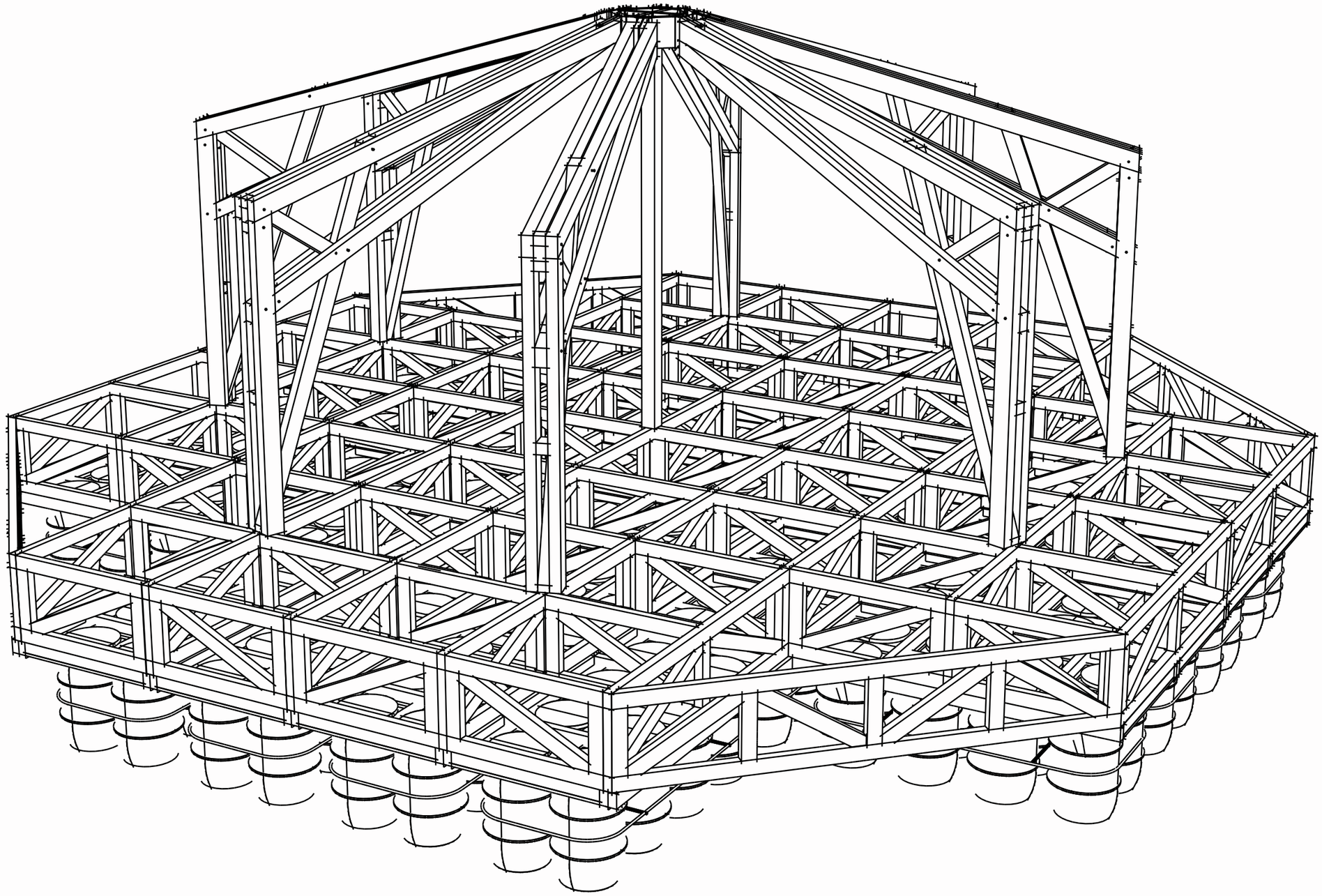


Step 5: Connecting the frames

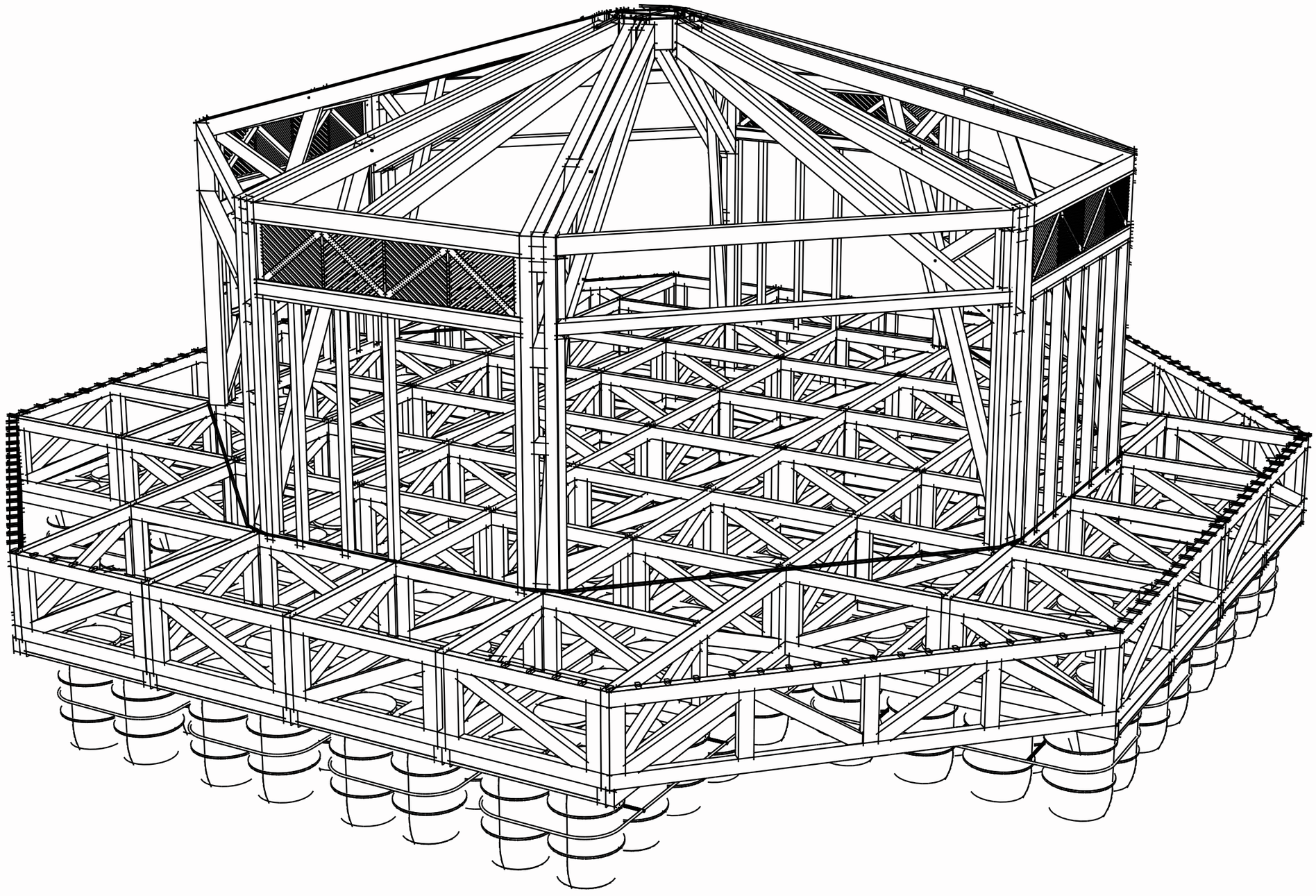






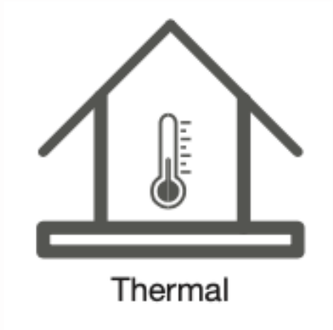


Step 6: Placing stabilization walls



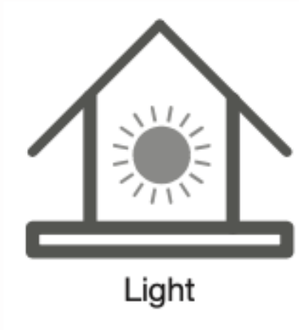
Indoor comfort

How can a classroom be indoor comfortable and which parameters needs to be taken into account?



Ventilation to cool down the building

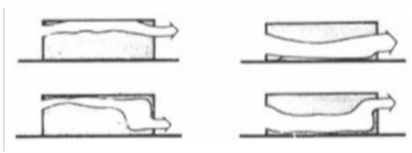
Protection against direct sunlight



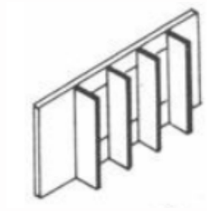
Daylight to create a pleasant atmosphere

Reduce noise from other classes

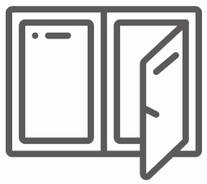
Provide enough personal space



cross ventilation



louvres and eaves



windows and openings

location regarding ambient noise

provide 1,4 m² per student

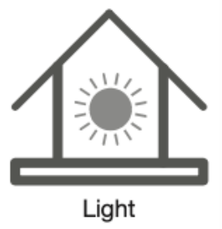
stack ventilation

reflective colours

interior finish with a high acoustic value

Preferences students and teachers

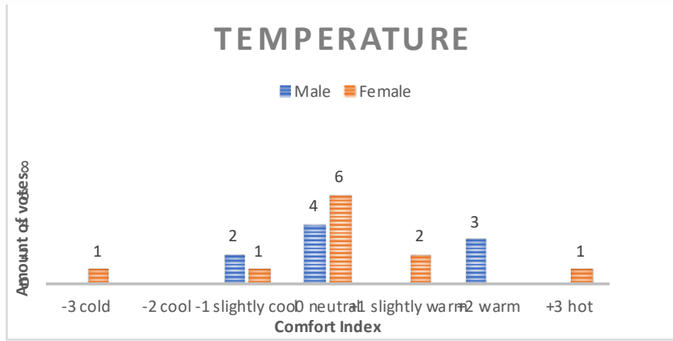
Majority of the students felt cold due to airconditiong.
Prefere natural ventilation

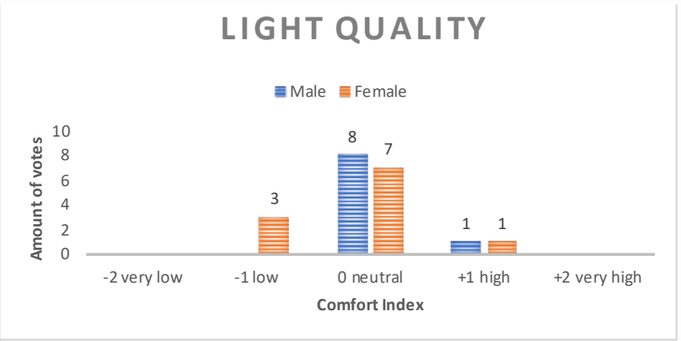


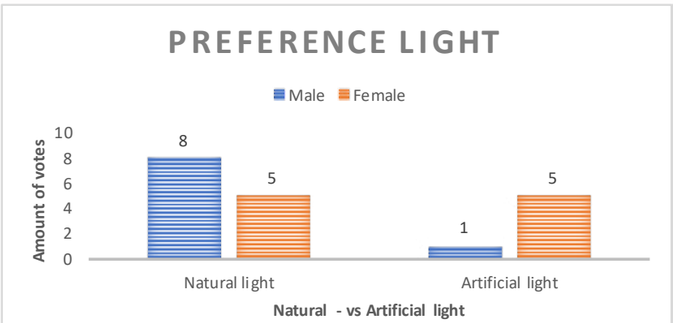
Most of the student prefer natural light

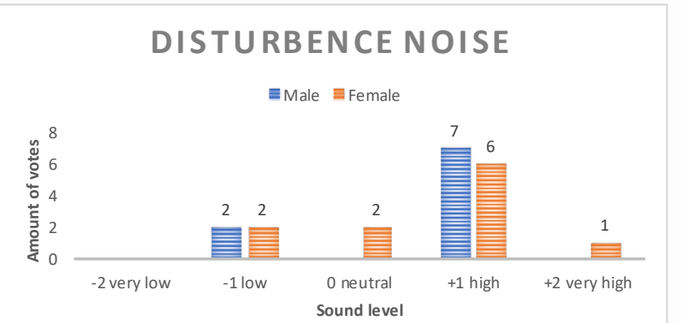
Disturbed by noises from other classrooms

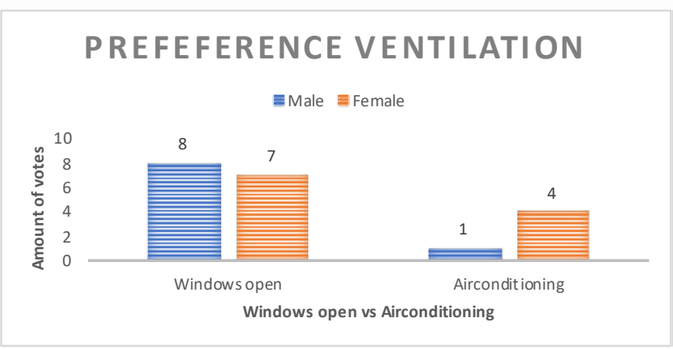
Most of the studens were satisfied with the space

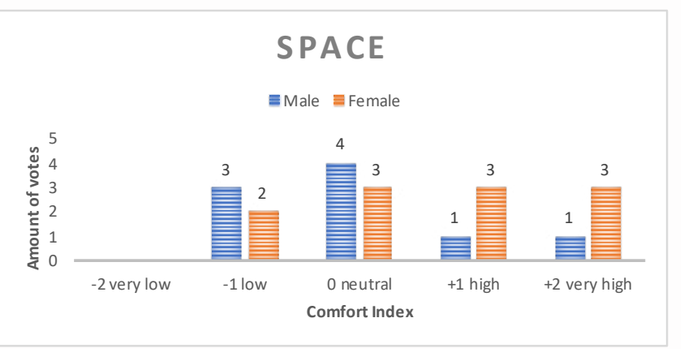




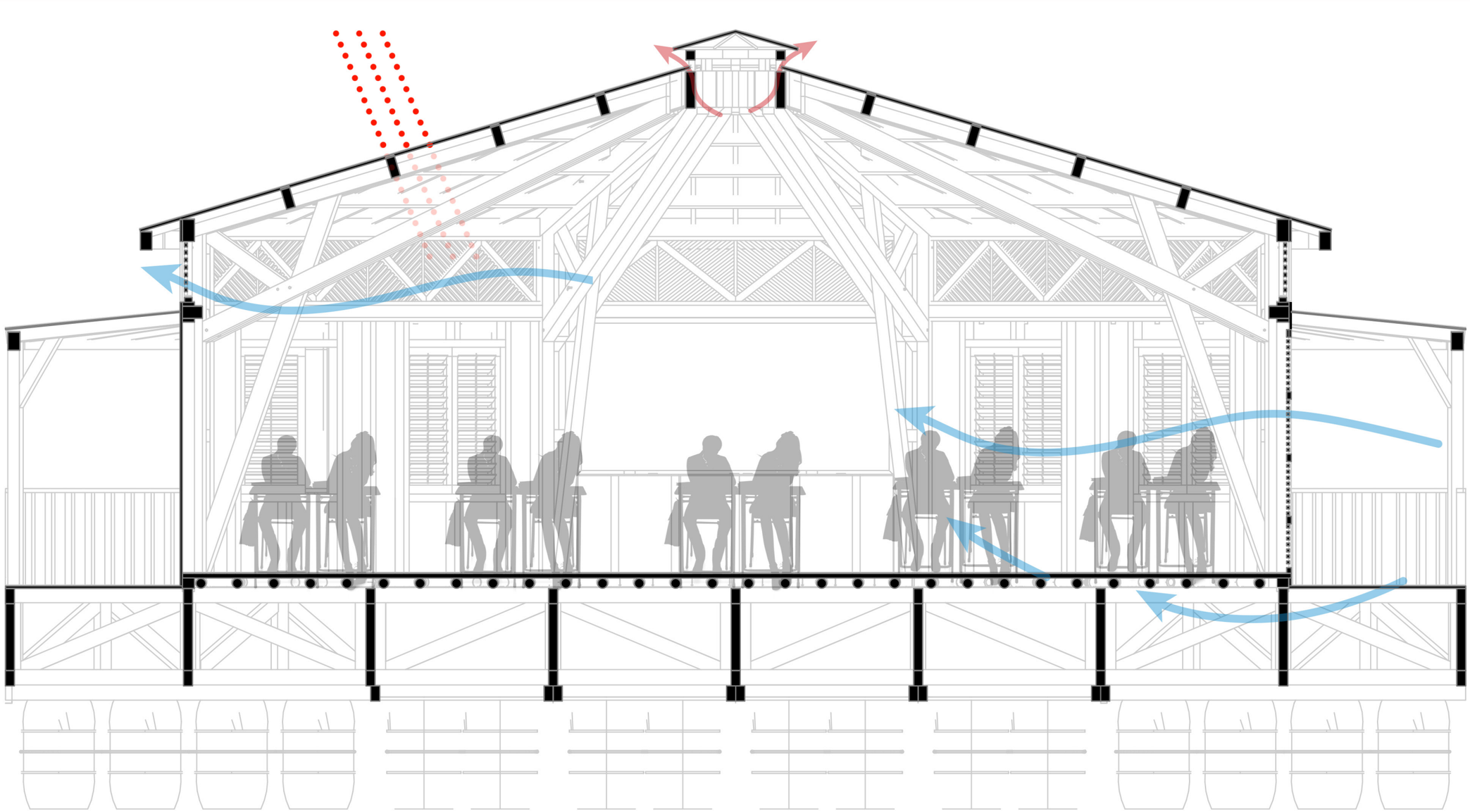




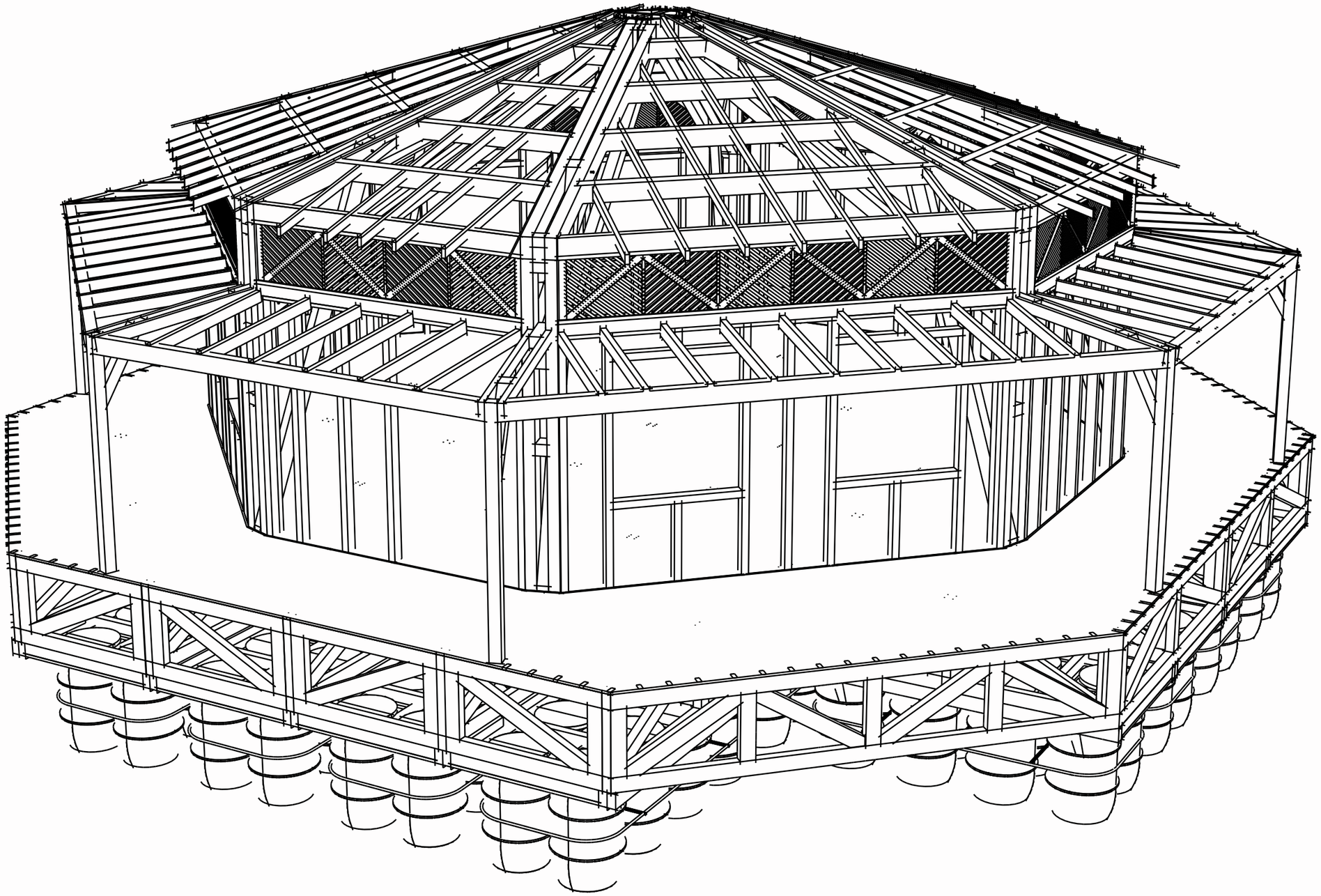




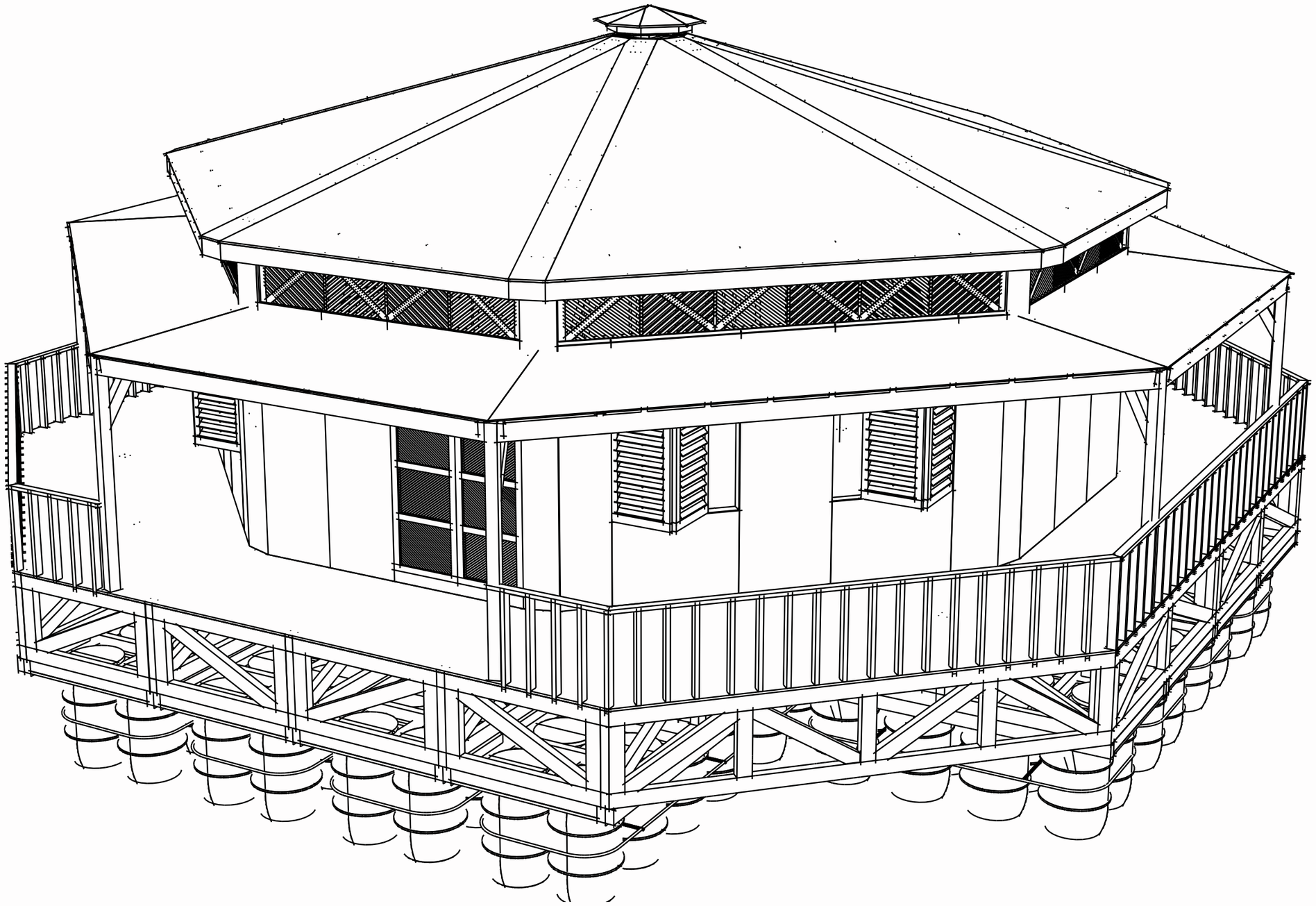
Climate aspects



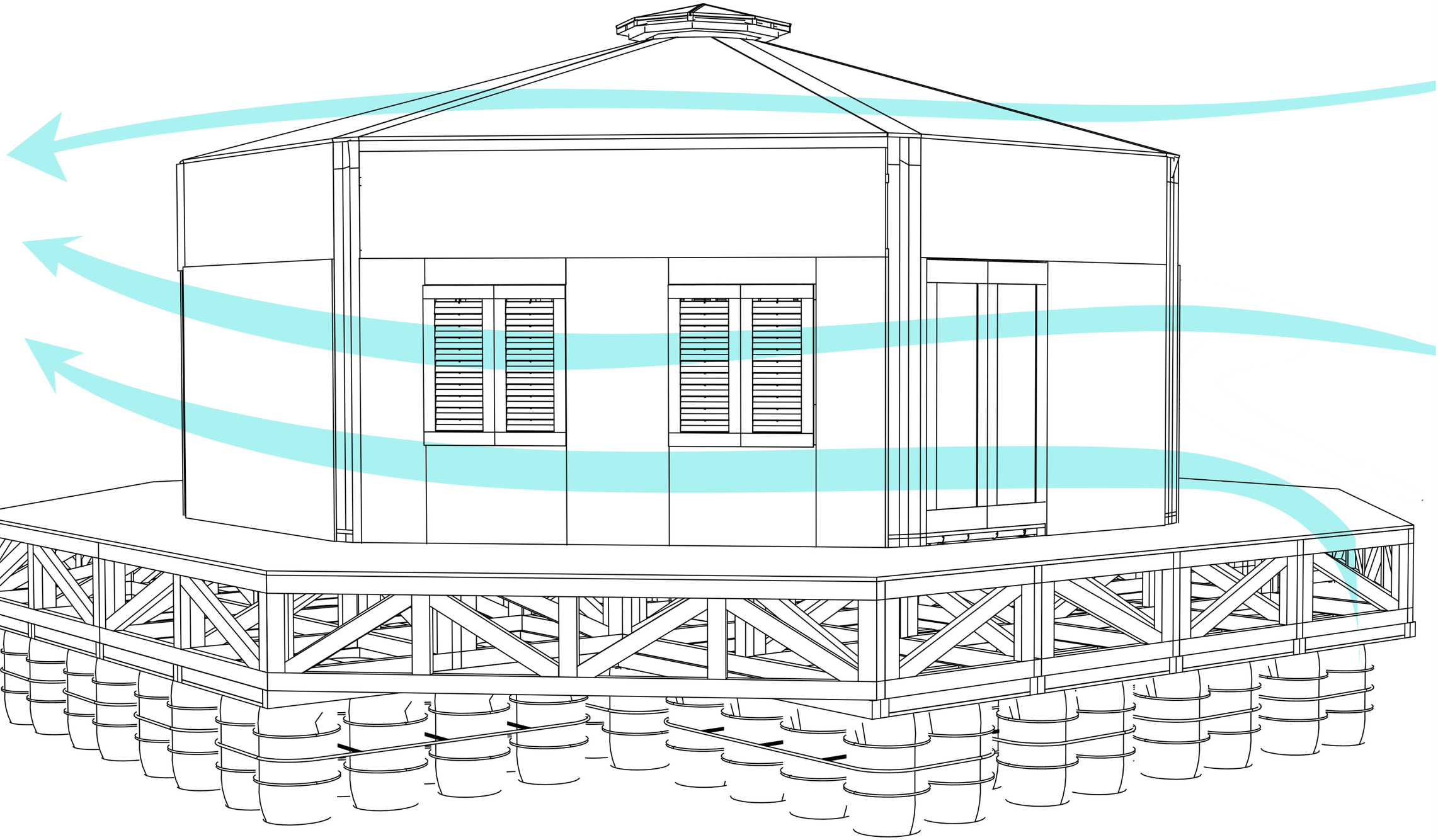
Step 7: placing eaves, flooring and roof rafters



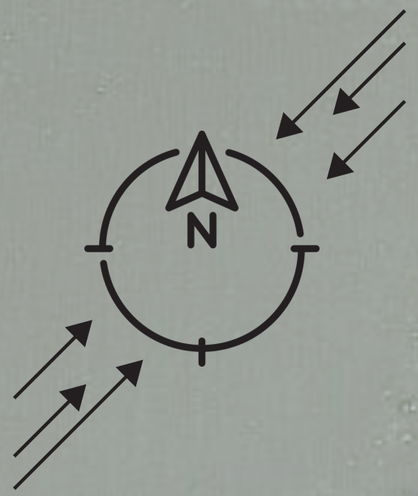
Step 8: finishing of the roof, facades and fences



During typhoon



wind from march till may



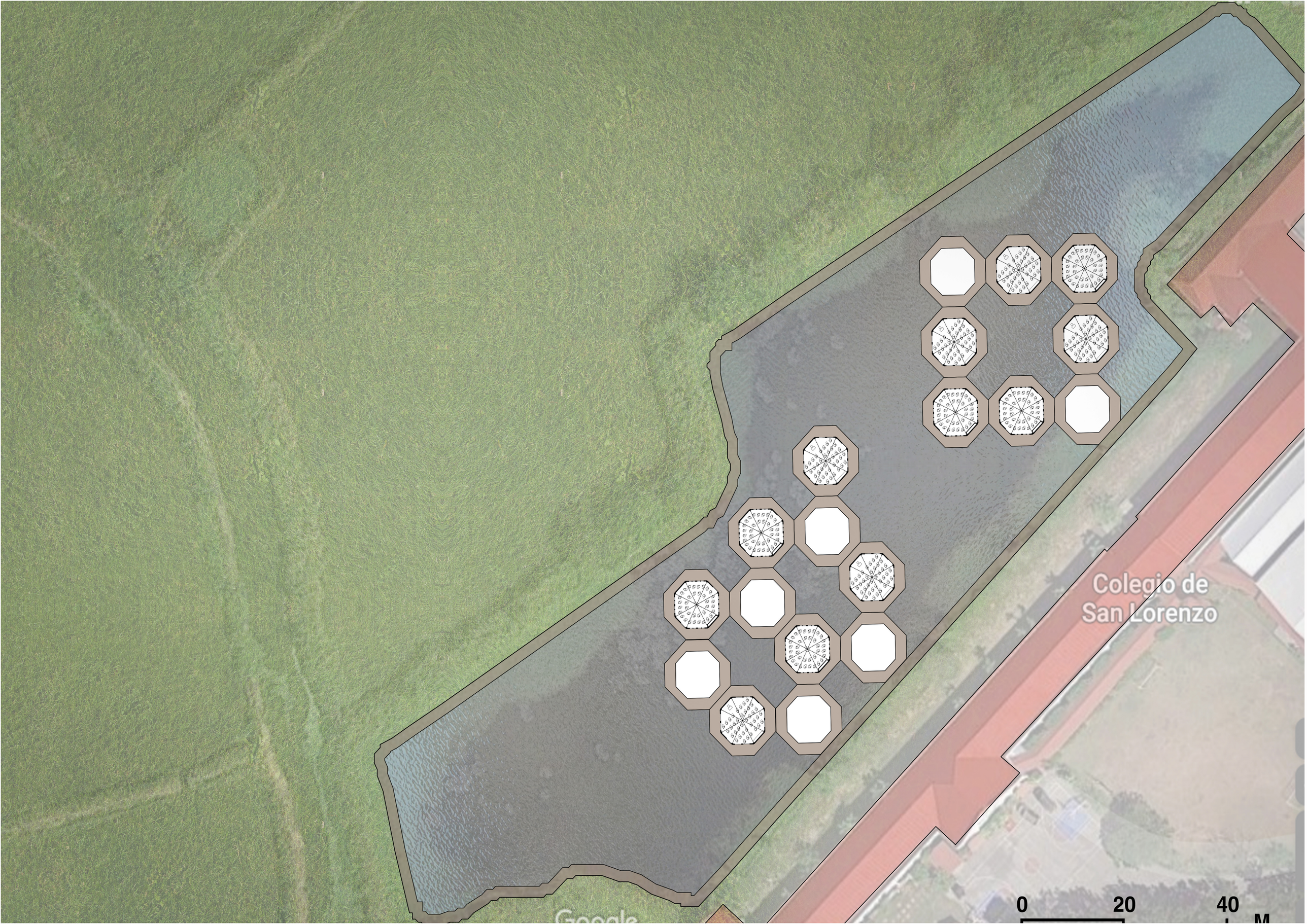
wind from june untill october

stairs to platform

main entrance school

canteen


Colegio de
San Lorenzo
0
20
40


Colegio de
San Lorenzo
Google
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M

Conclusion

“This design is able to provide students that live in a flood and typhoon sensitive area a safe and comfortable learning environment “

Thank you,

Questions?