ICE ICE ... MAYBE

ICE BOX CHALLENGE 2025

THE PASSIVE DOME

This proposal explores the geodesic dome as a form for passive house construction. The dome's structural system minimizes material use while offering exceptional strength and rigidity. With fewer joints and a uniform distribution of forces, the geometry reduces thermal bridges compared to conventional structures. The self-supporting shell encloses the volume with optimized surface area, creating a highly efficient envelope for thermal performance. The outer layer is composed of reclaimed wooden planks, adding an additional layer of shading and insulation while giving the structure a tactile expression of circular material use.

Through this project, the geodesic dome is tested as both a spatial and energy-efficient solution for sustainable architecture.

Visualization of the two domes placed in a generic environment

CONCEPT/IDEA

REUSE

The domes will be repurposed as shelters for animals at a small privately owned farm after the competition.

RECYCLED MATERIALS

Most of what is used to construct the domes will be from recycled or repurposed materials. The goal is to minimize the use of metals and fossil based glues, which is why the joints are made from bent plywood and birch dowels. The Isocell insulation, produced from recycled newspaper and provided by a sponsor for the duration of the experiment, will be returned and reused after the competition.

INNOVATION

Digital tools such as artificial intelligence, simulation software integrated with BIM, parametric design, 3D printers and infrared cameras enhanced the timber design process and allowed for real-time optimization.

HANDS-ON-DEVELOPMENT

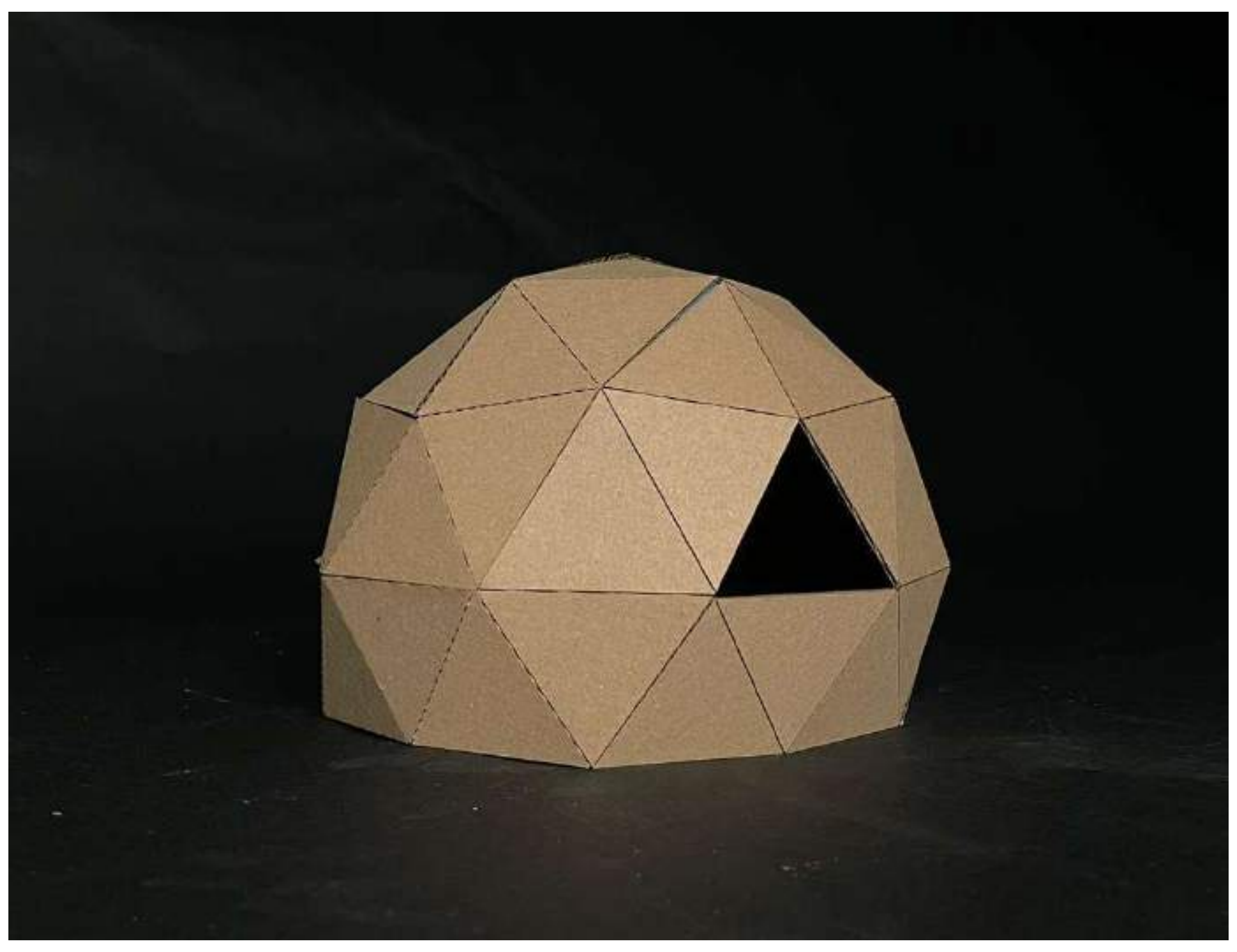
The design was developed through tireless hours of experimentation and prototyping.

While calculations and simulations are a prerequisite, hands-on knowledge of the structure was essential. To achieve this understanding, physical models were built in different scales, and experiments were carried out to test assembly methods and structural behavior.

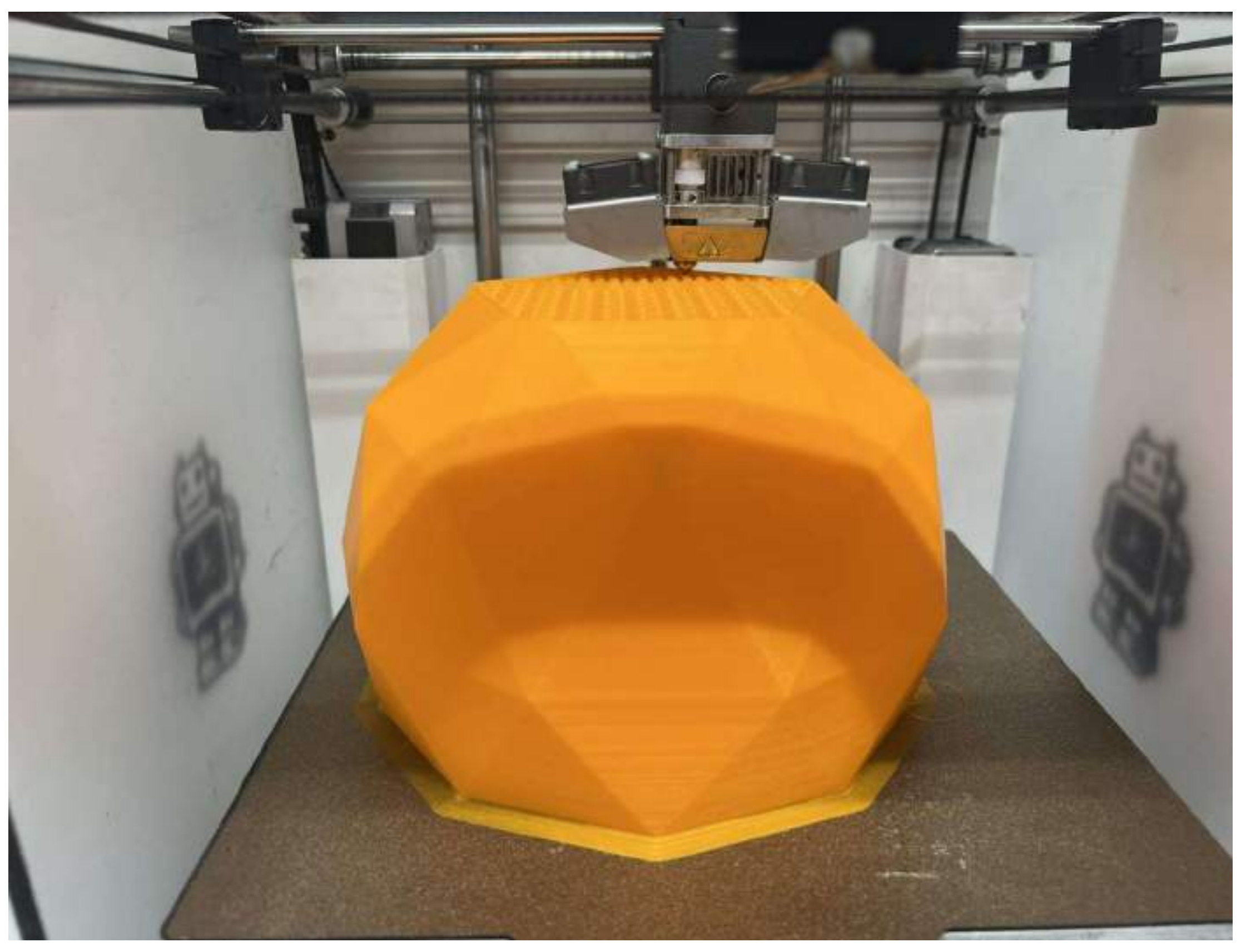
This iterative approach provided essential insight into the structural performance of the dome, bridging the gap between digital models, parametric design and the final built structure.

ASSEMBLY

The structure will be composed of lightweight, transportable hexagon and pentagon panels. They will be mounted together on site using slide-in-place wooden connectors. After the vapor tight membranes are completed at the connections, the space between the inner and outer shells will be filled with cellulose insulation, resulting in minimal thermal bridging only around the window and minimal, compressed wood fiber webs around the "door".



Model made of paper



3D-printing model

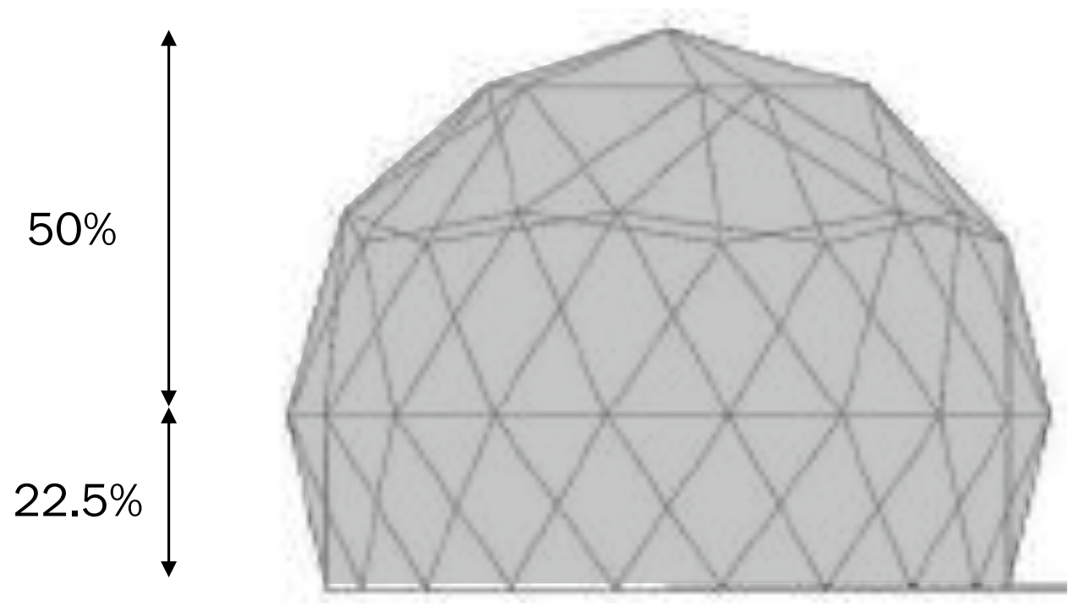
MEASUREMENTS

Inner dome: PH and BBR
Sphere radius: 1.5m
Sphere diameter: 3.0m

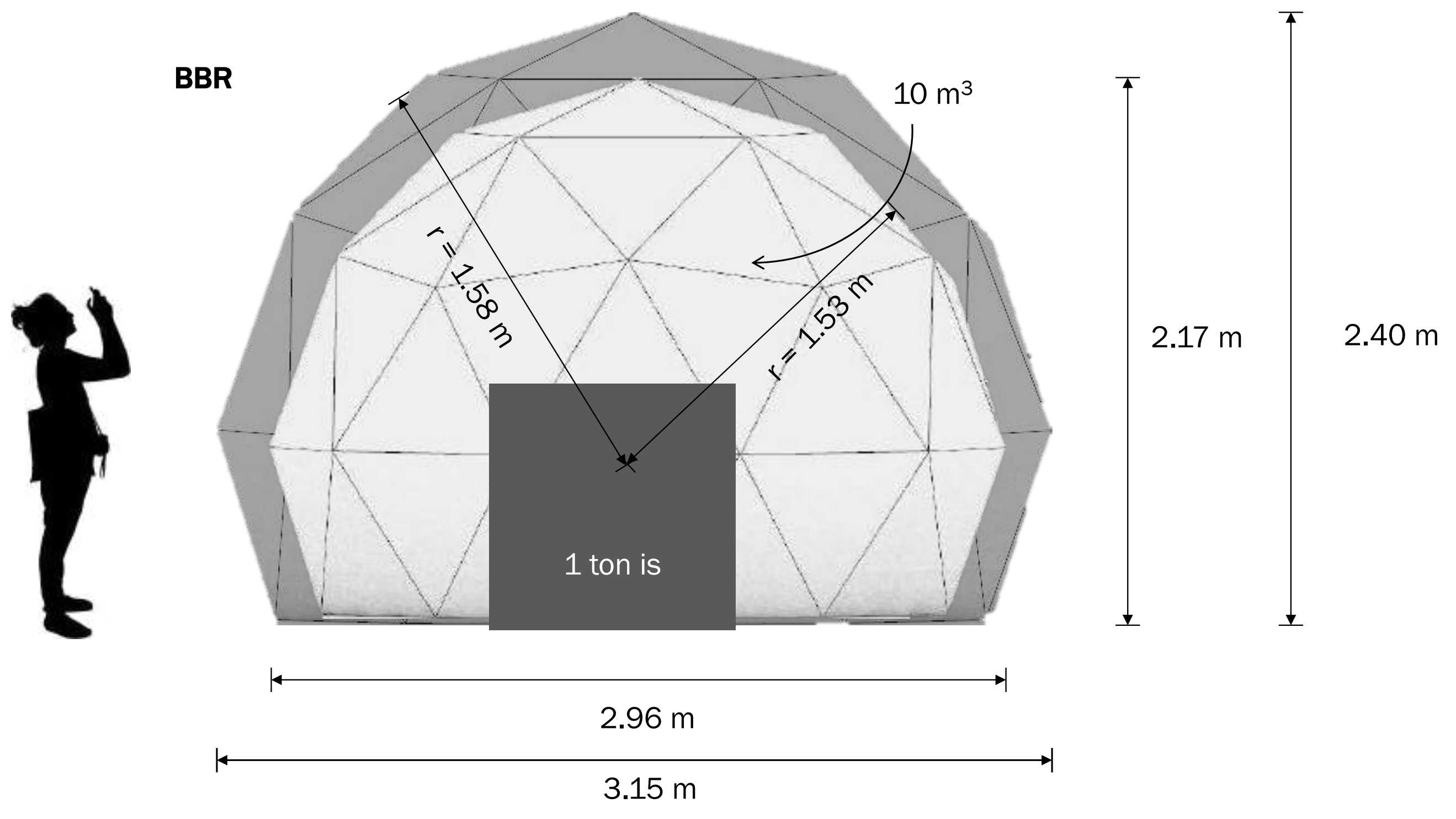
Outer dome BBR
Sphere radius: 1.61m
Sphere diameter: 3.22m

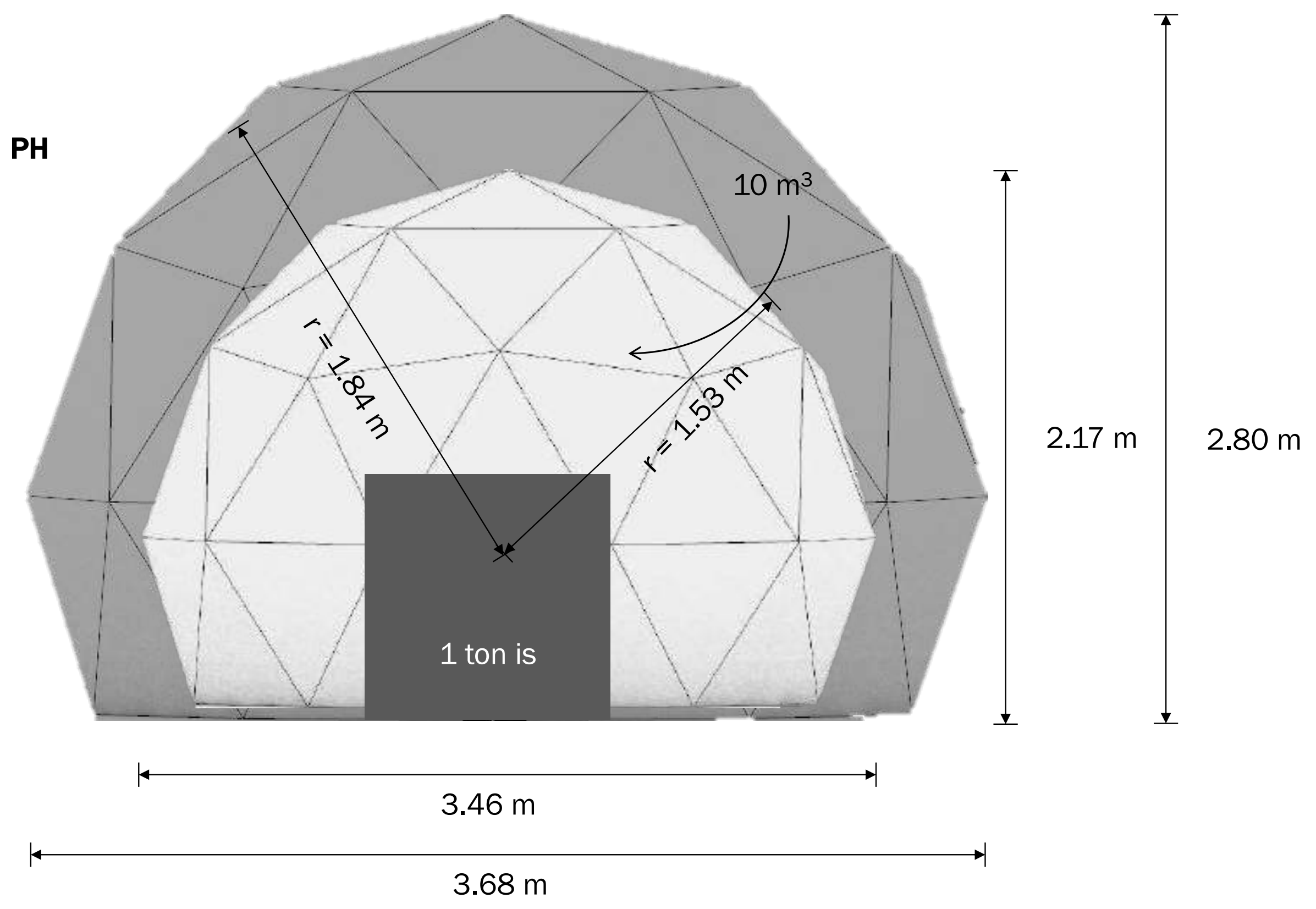
Outer dome PH
Sphere radius: 1.85m
Sphere diameter: 3.7m

Only flat area taken into account, not plywood/strut thicknesses



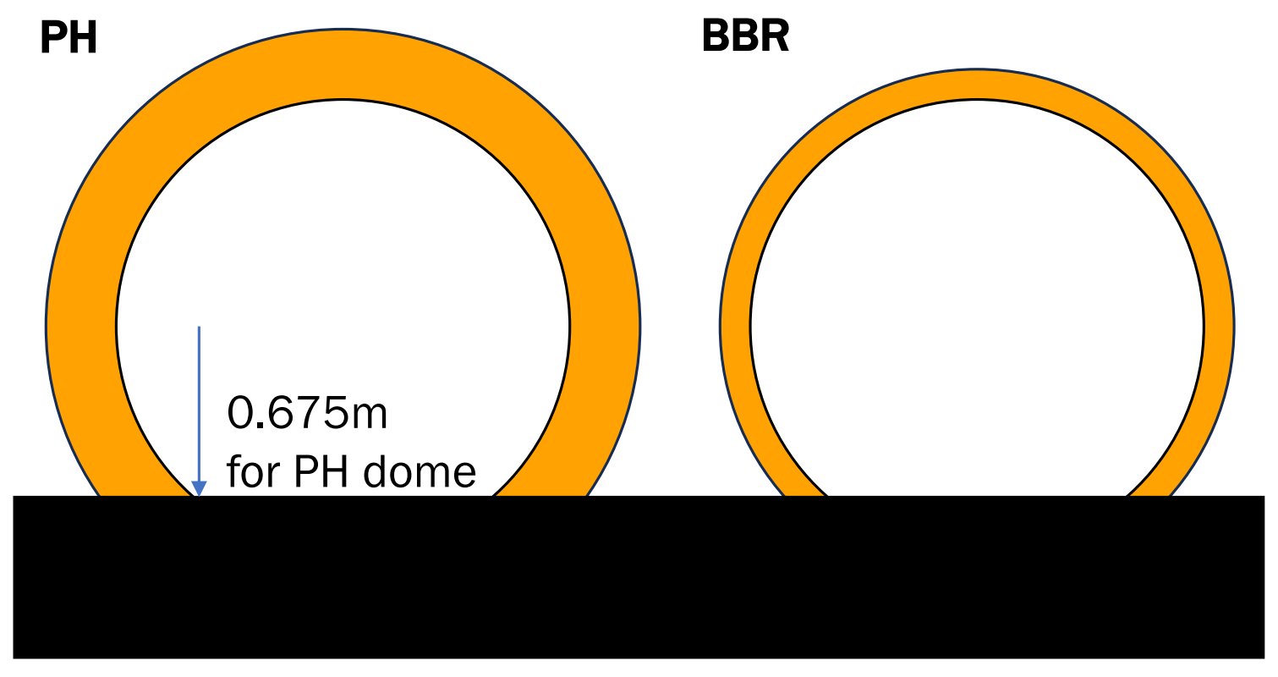
Percentage of full sphere/dome: 72.5%





CROSS SECTION – MINIMAL THERMAL BRIDGING

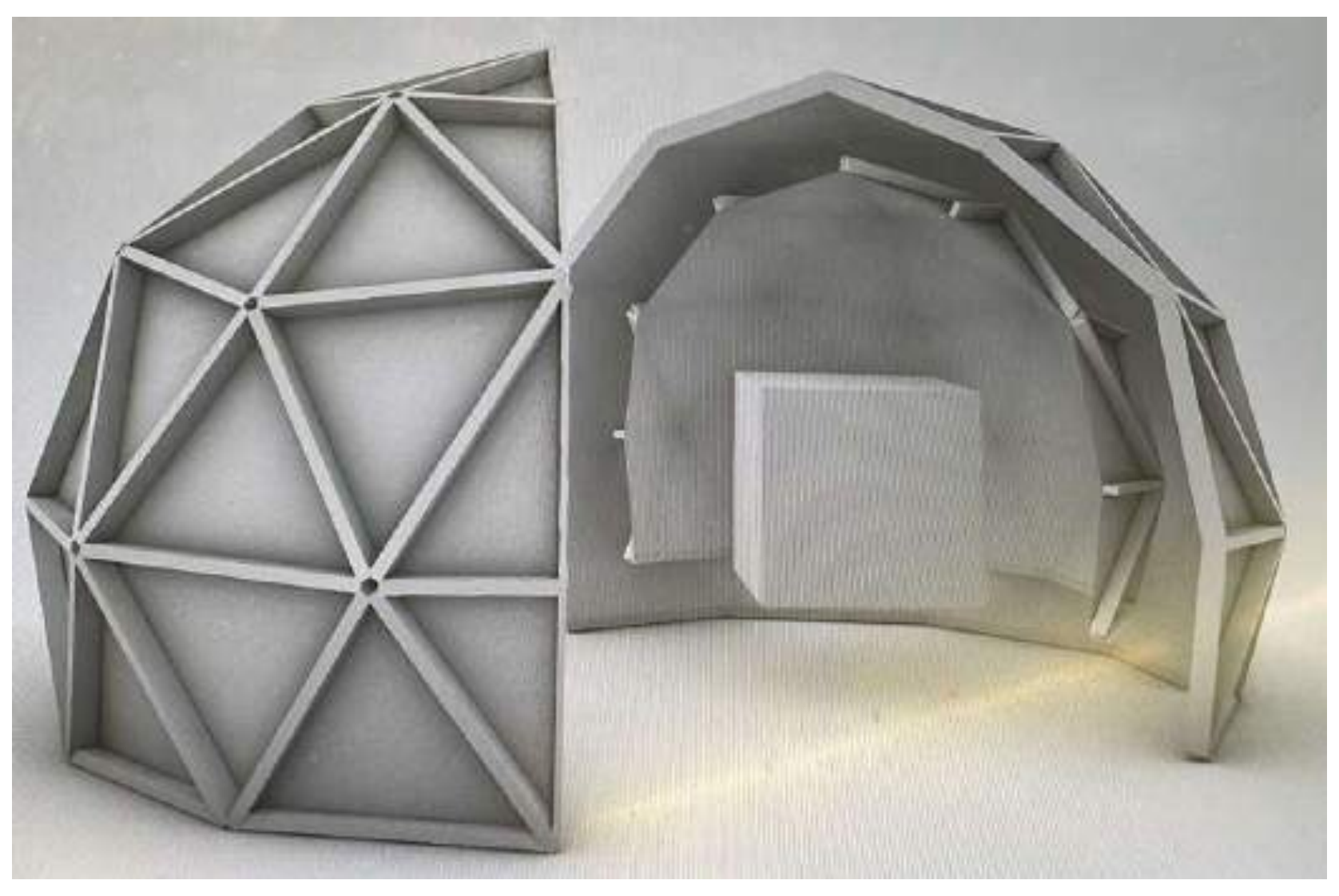
Insulation volume estimations



Outer radius: 1.965 m
Inner radius: 1.5 m

Outer radius: 1.7 m
Inner radius: 1.5 m

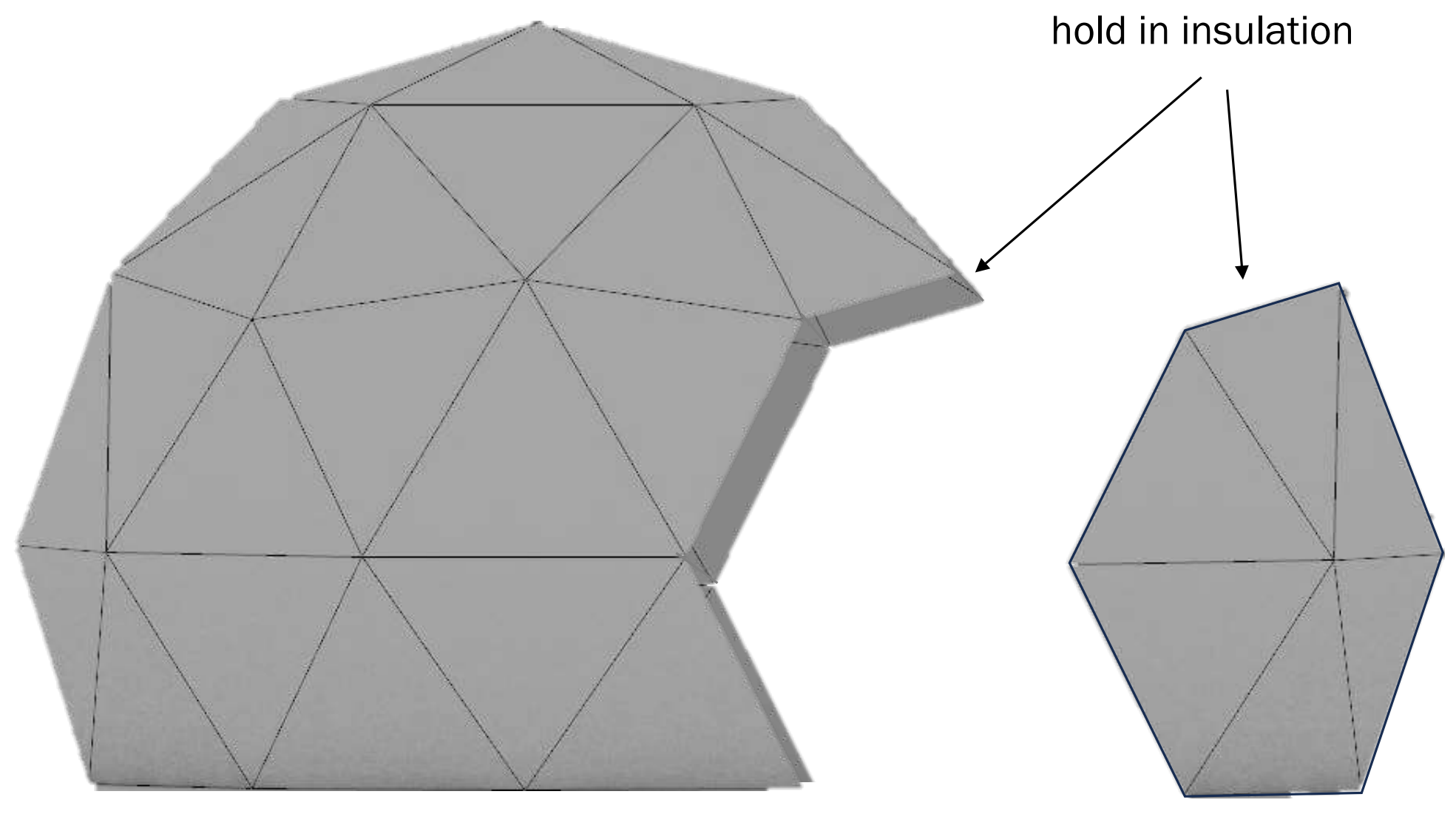
CONSTRUCTION IDEA



Insulation (cut for door to be covered with thin wood fiber board to hold in cellulose while avoiding thermal bridging)

REVEAL

A membrane or plank is needed in between to hold in insulation



Two halves; wheels under one half of the dome so it can be pulled apart during "final reveal"

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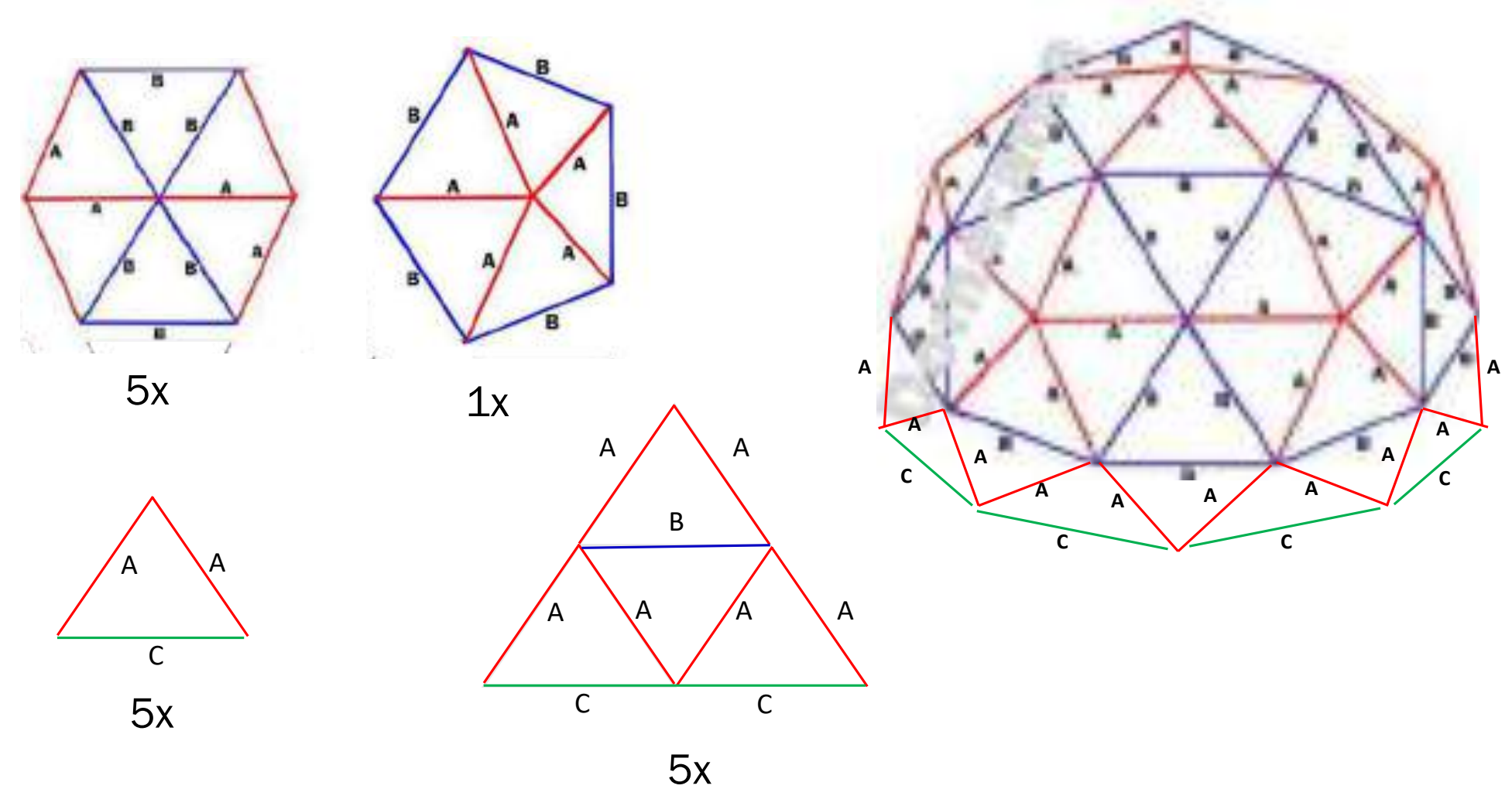
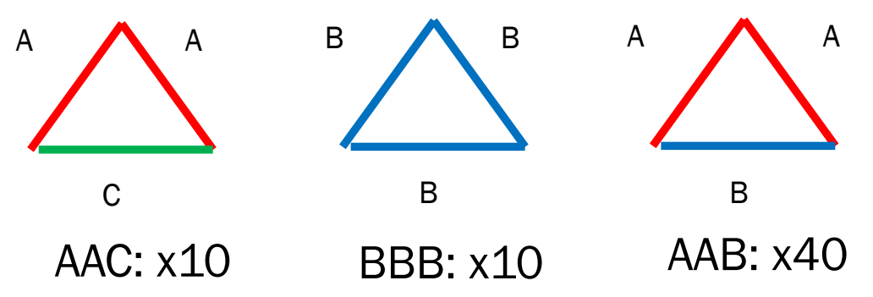
CONSTRUCTION

PANELS AND STRUTS – EXAMPELS



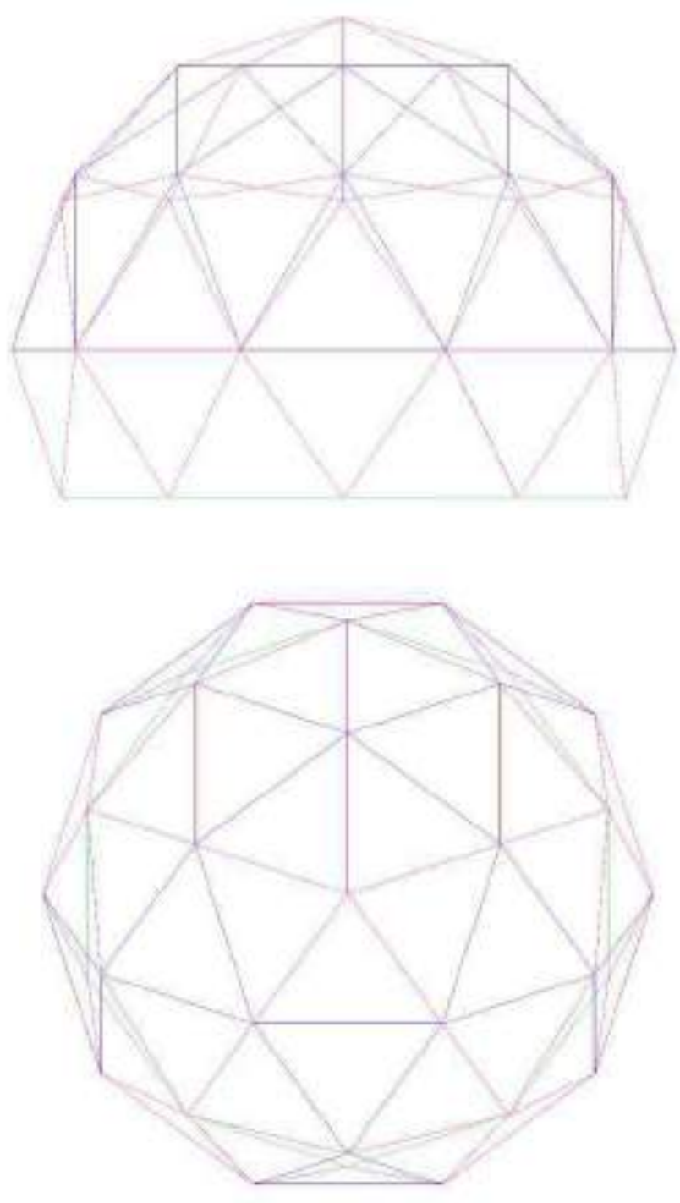
Example shows the construction of the inner dome divided into panels

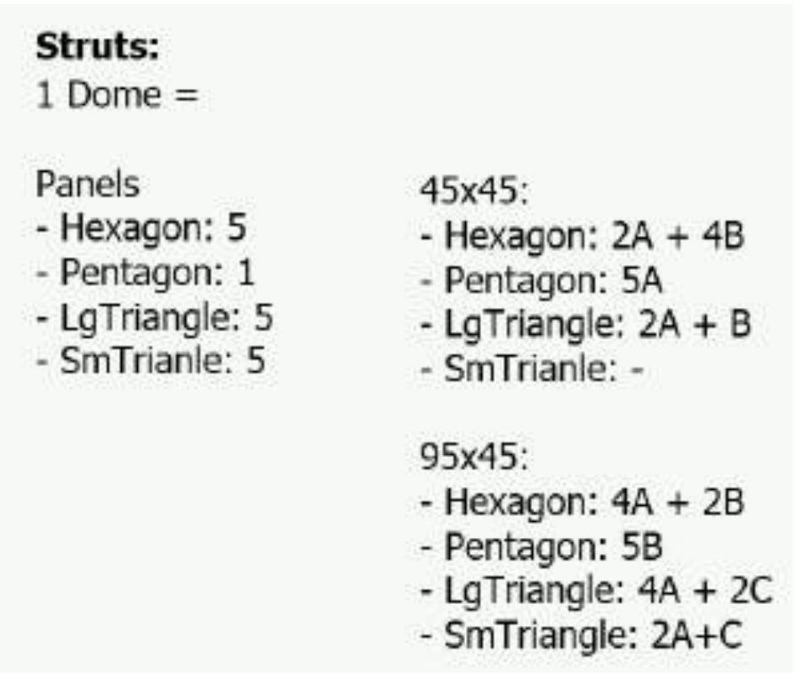


AAC: x10 BBB: x10 AAB: x40

Area	**Nr**	**Length**	**Nr**
AAB: 0.52 m²	40	A: 1.06 mm	40
BBB: 0.62 m²	10	B: 1.2 mm	35
AAC: 0.49 m²	10	C: 1.1 mm	10

Example shows the measurments of the outer PH dome



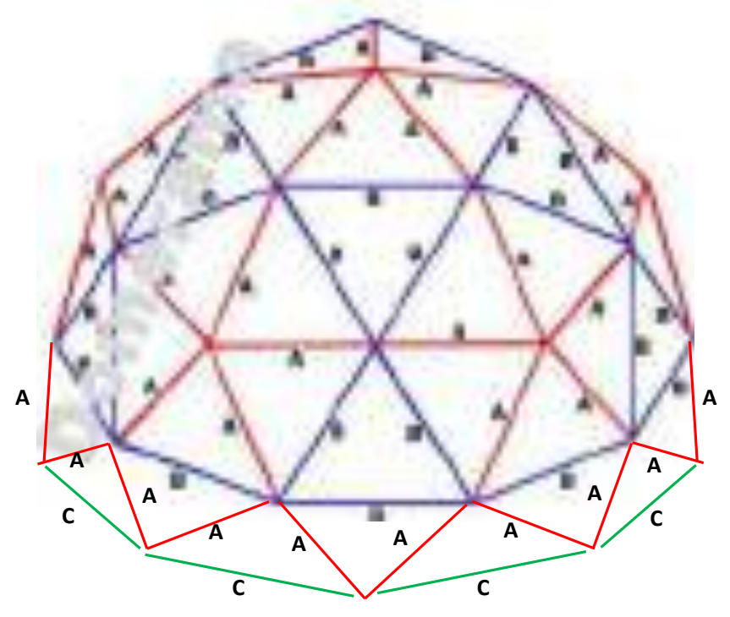


Struts:
1 Dome =

Panels
- Hexagon: 5
- Pentagon: 1
- LgTriangle: 5
- SmTrianle: 5

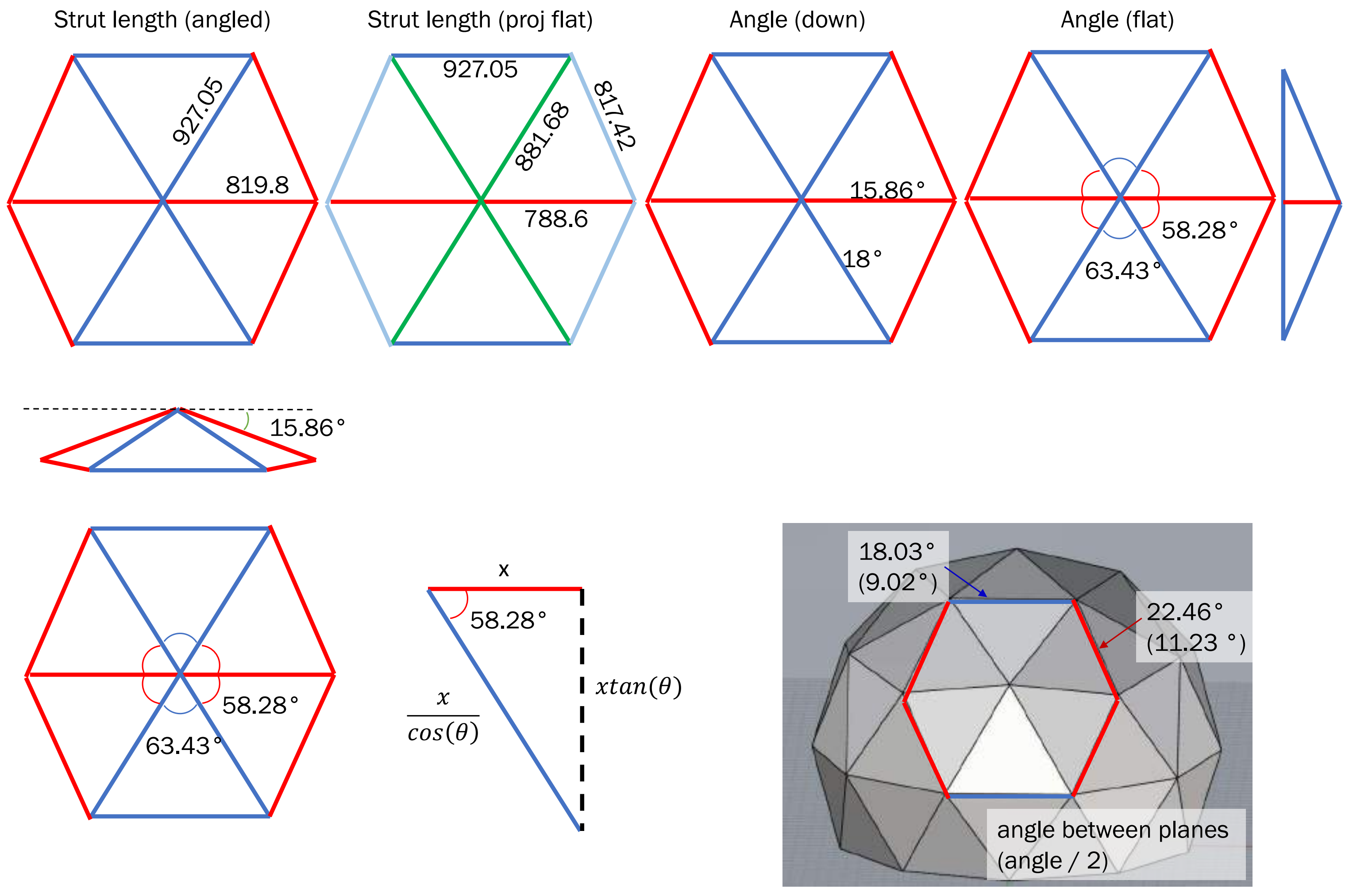
45x45:
- Hexagon: 2A + 4B
- Pentagon: 5A
- LgTriangle: 2A + B
- SmTrianle: -

95x45:
- Hexagon: 4A + 2B
- Pentagon: 5B
- LgTriangle: 4A + 2C
- SmTriangle: 2A+C

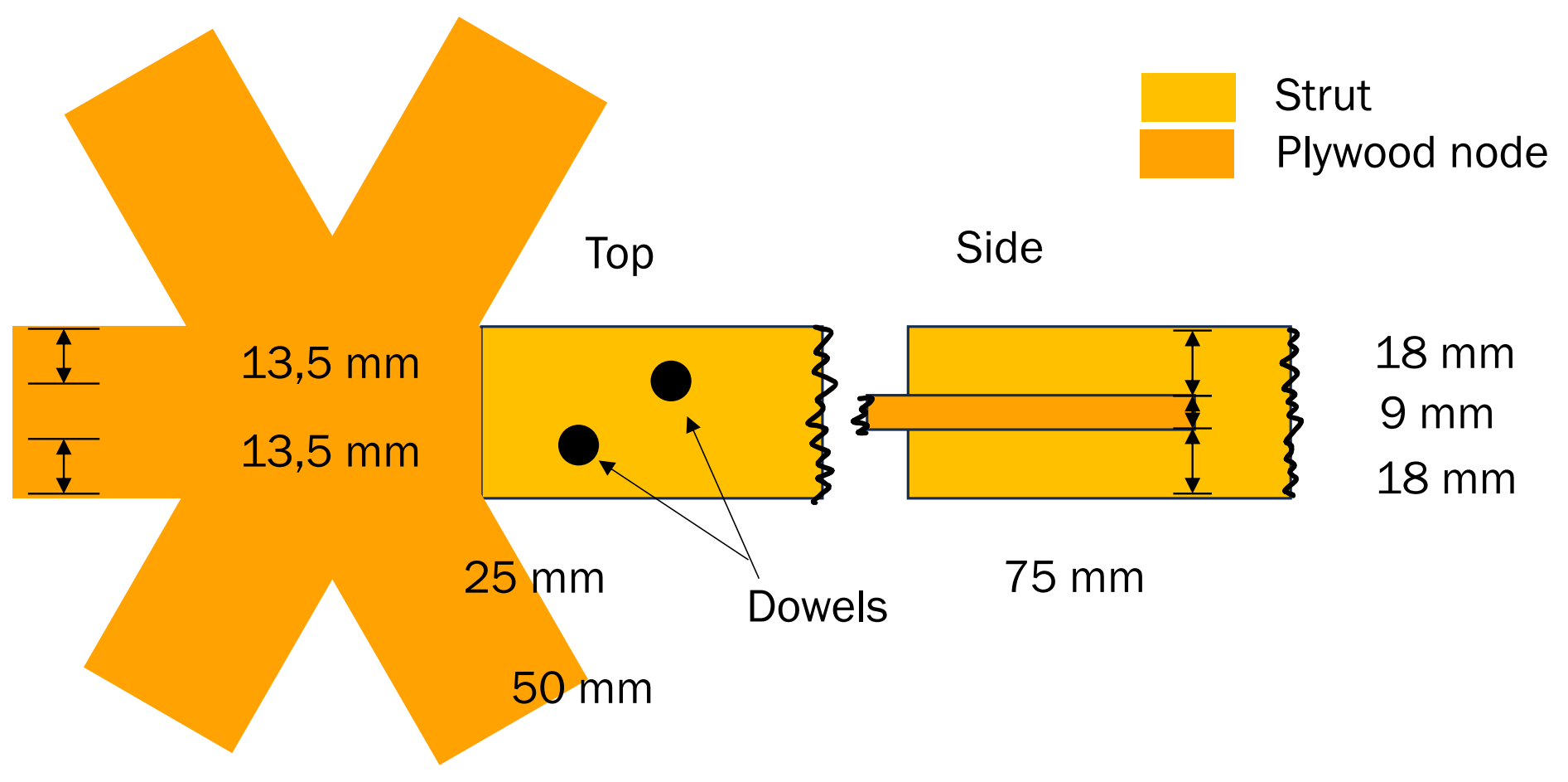


Example shows the struts for our extended 2V frequency dome

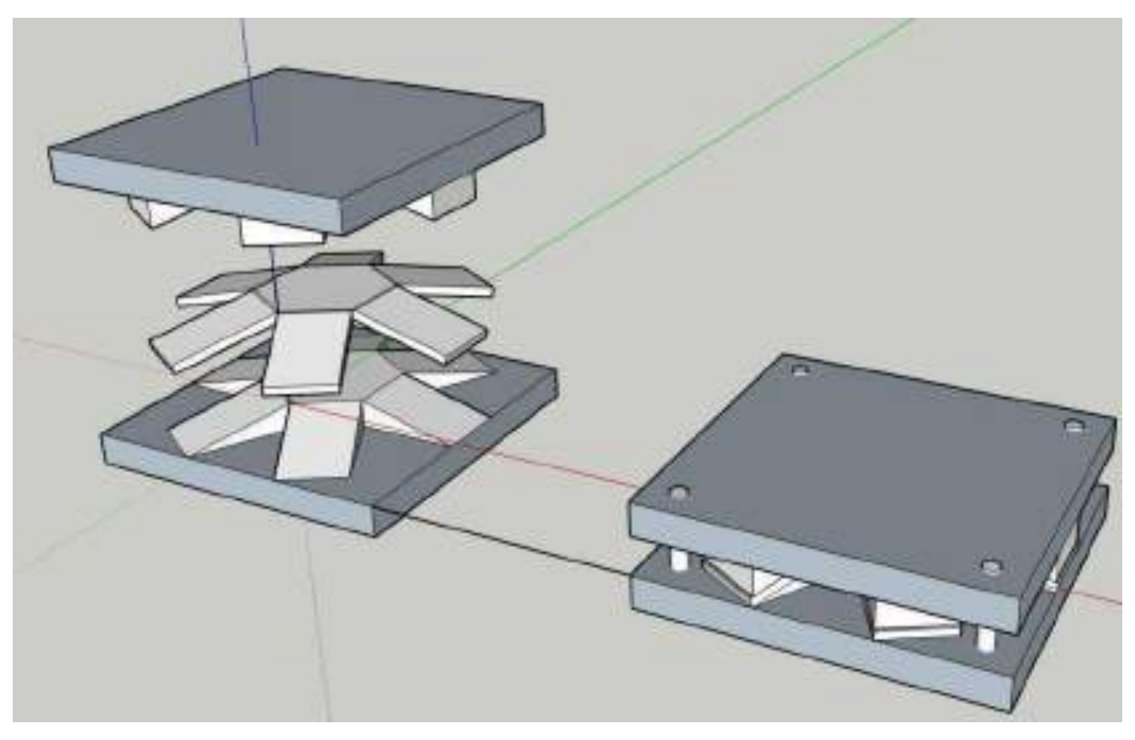
CONSTRUCTION OF HEXAGON PANEL



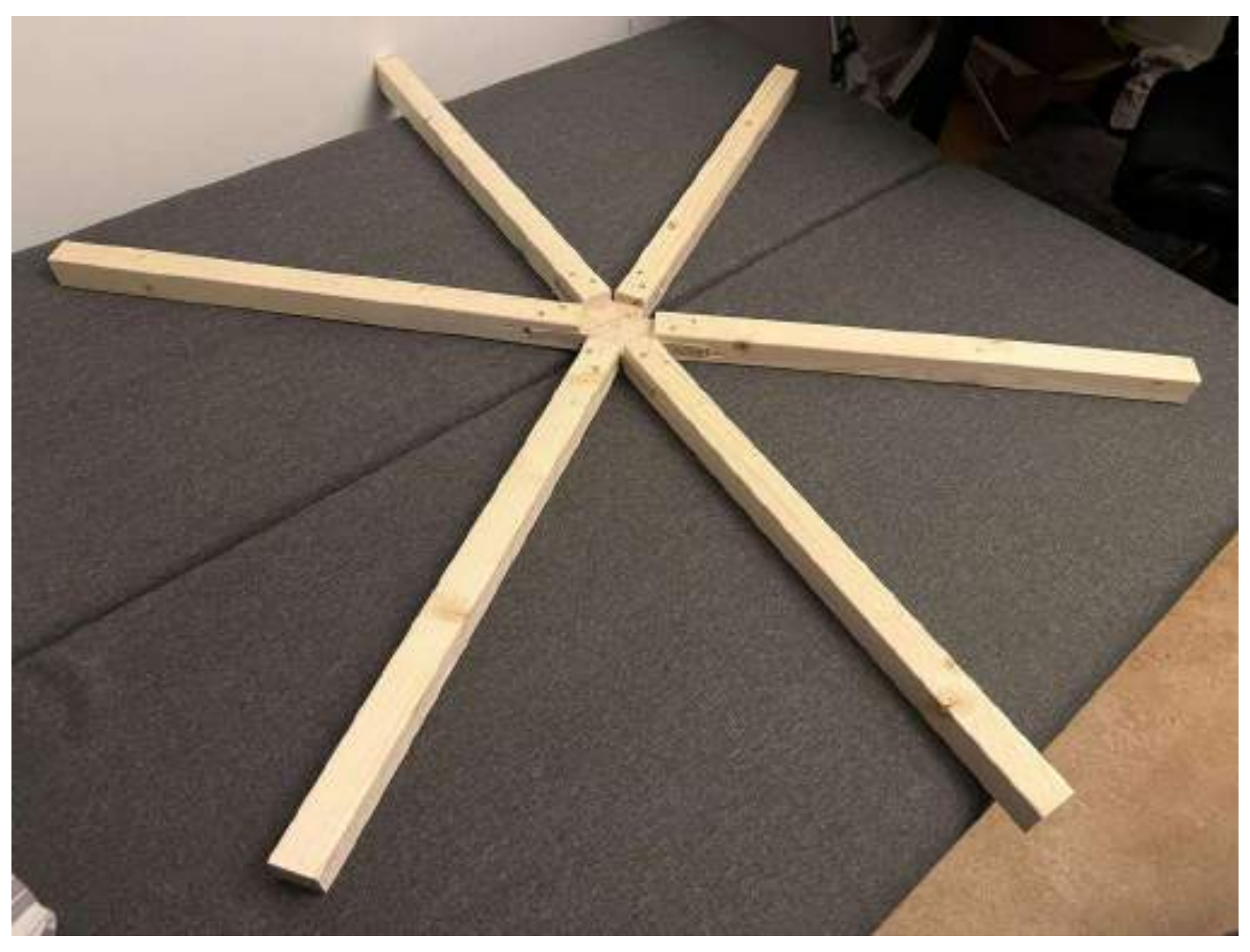
CONSTRUCTION OF NODES

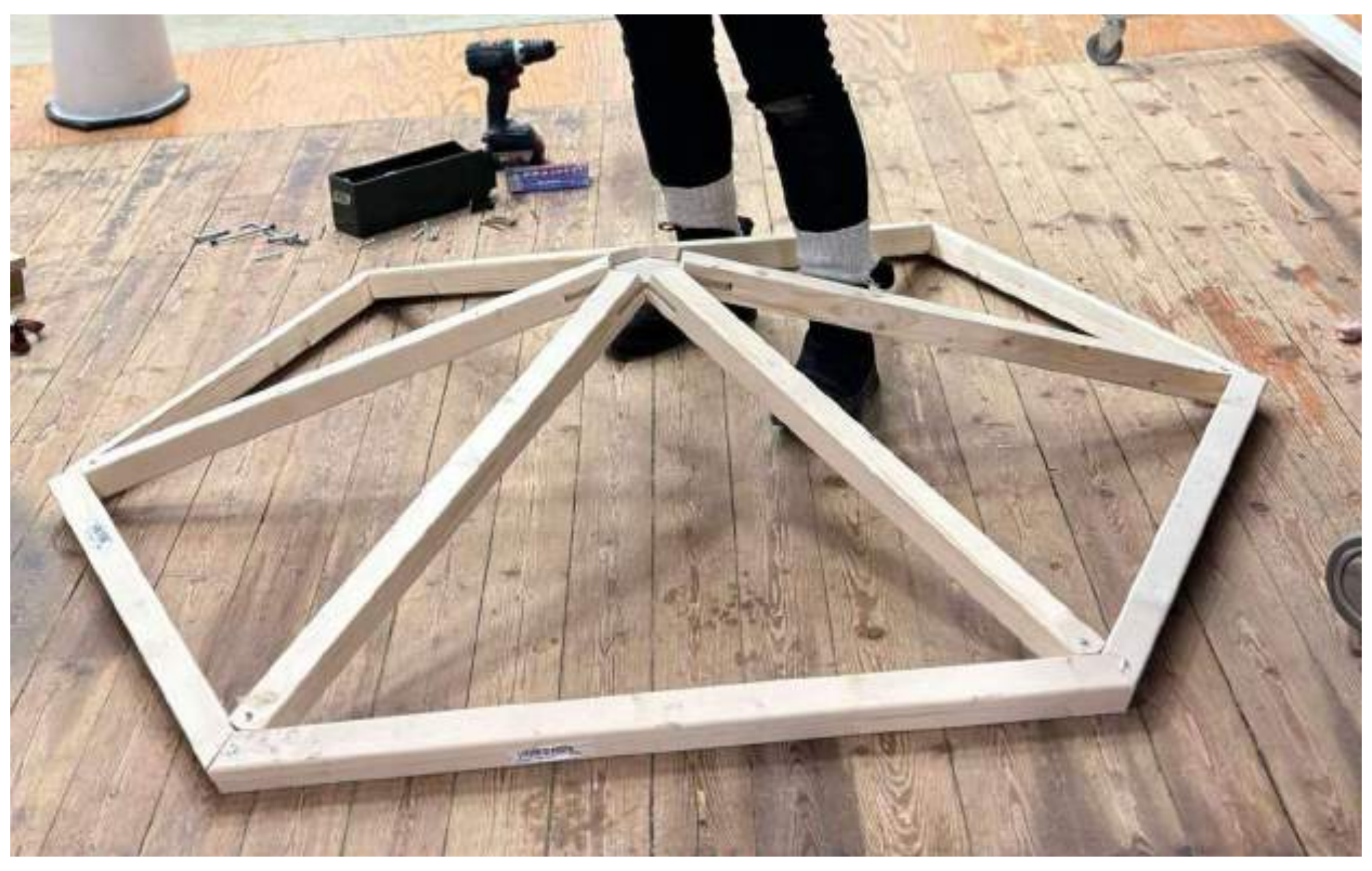


Steam bending form

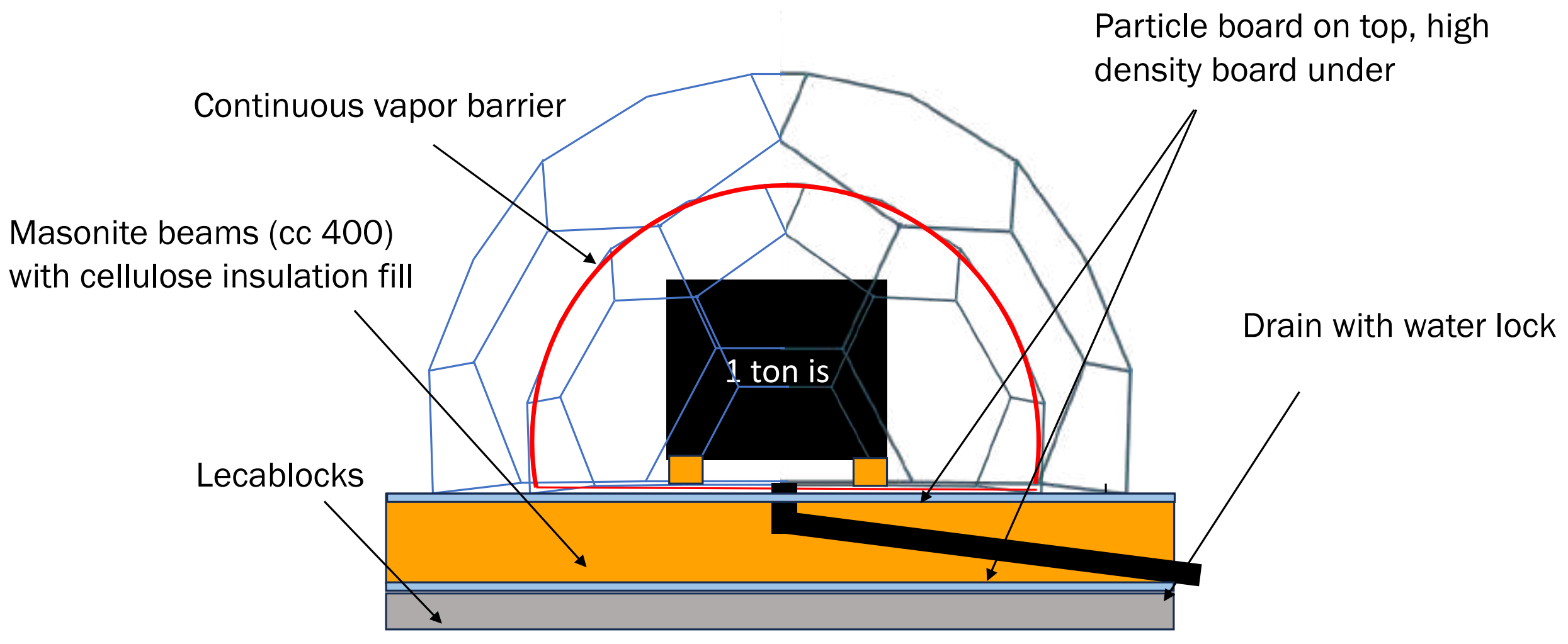


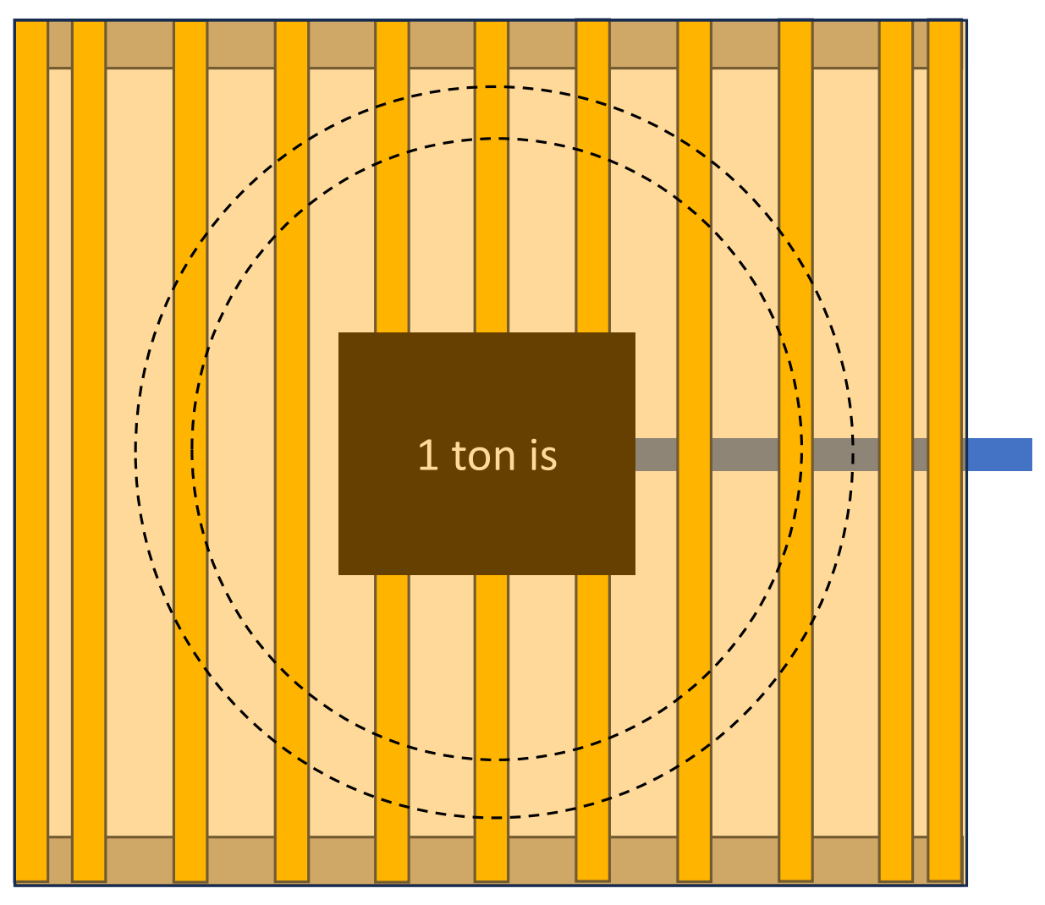
CONSTRUCTION OF HEXAGON PANEL PROTOTYPE





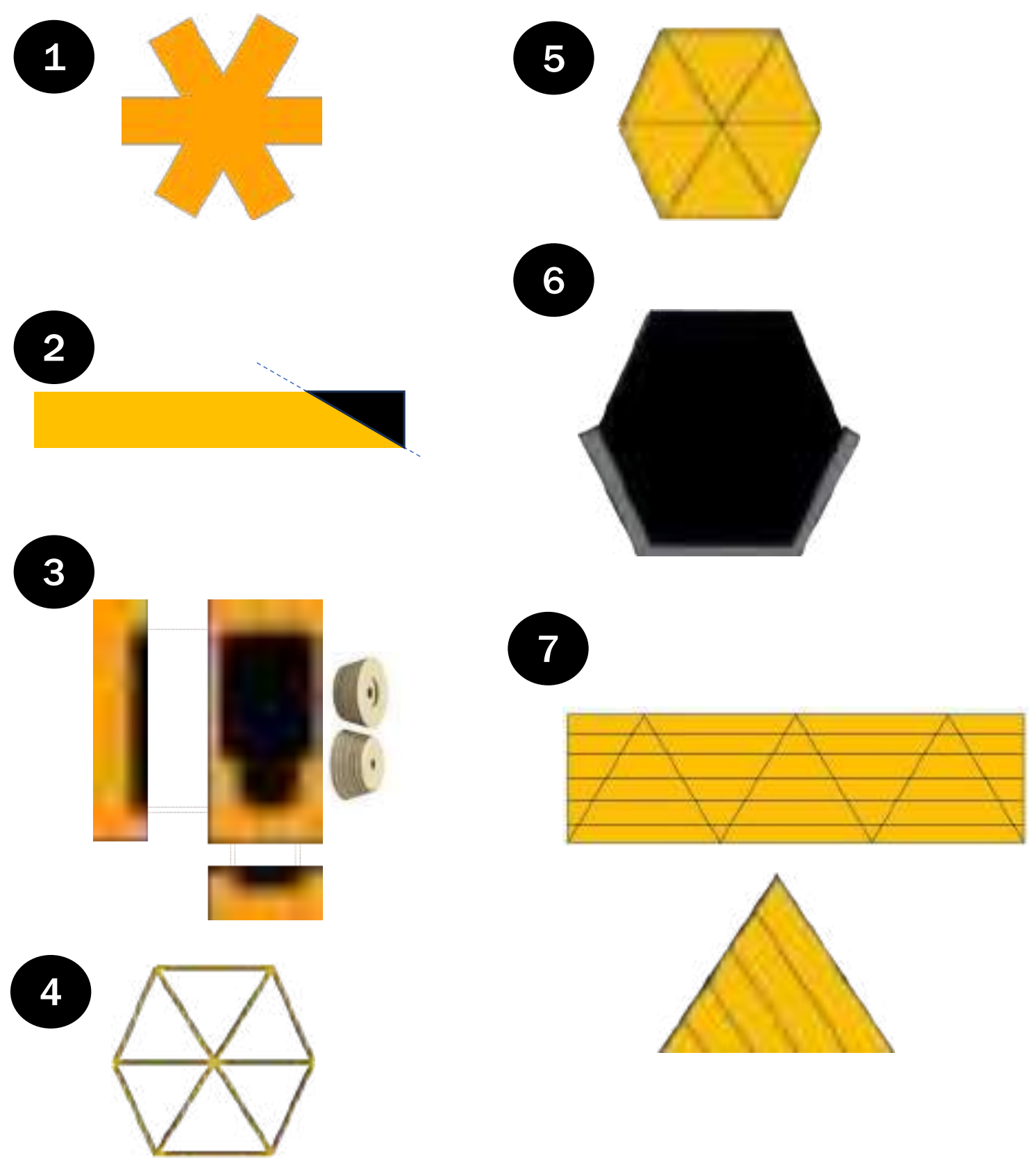
FOUNDATION





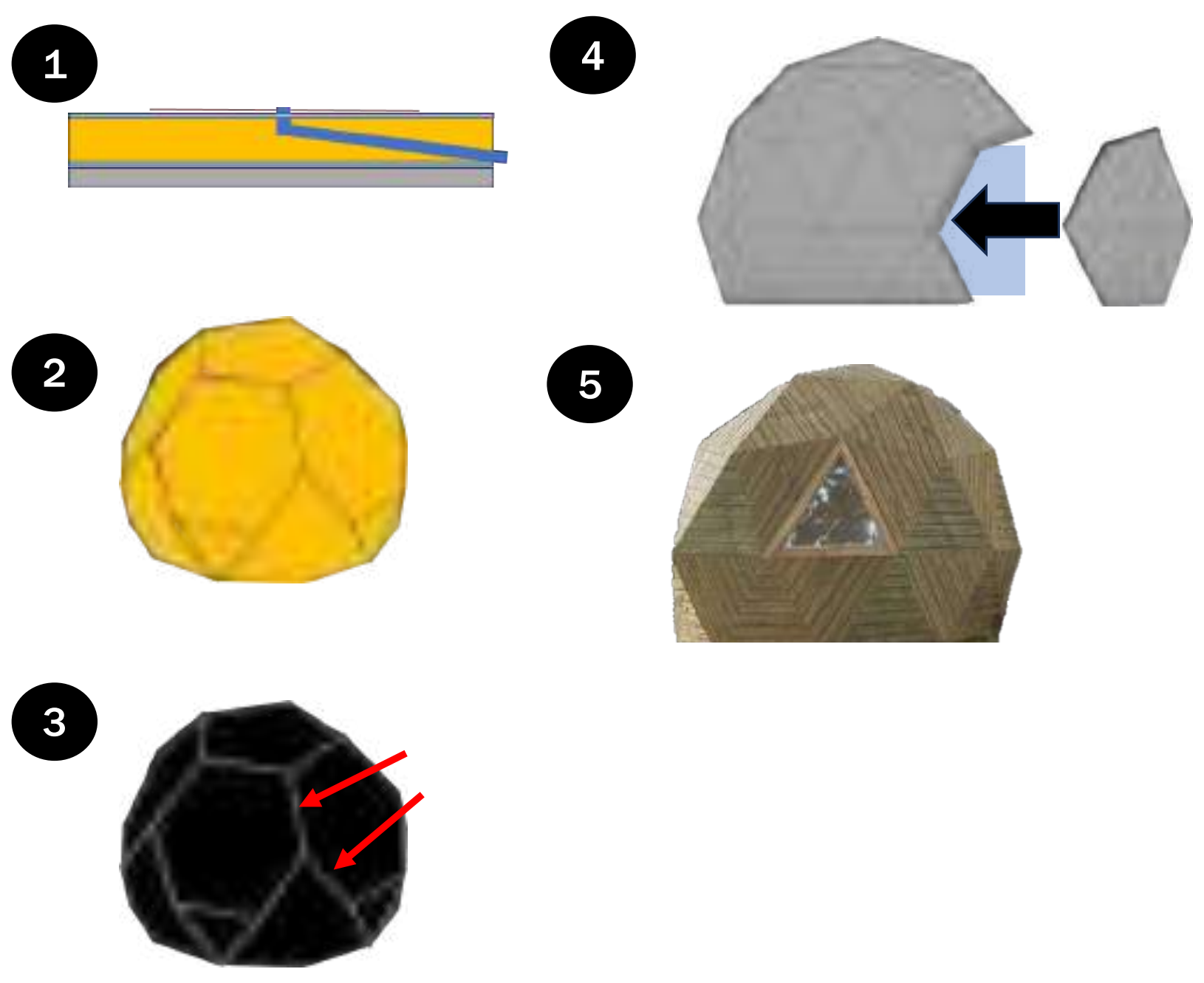
BUILDING PHASE

1. Steam bend plywood star connections
2. Cut frame components
3. Mill slip-in connections for sides of frames
4. Assemble frames
5. Install plywood
6. Attach vapor and weatherproof membranes with prepared overhang
7. Cut facade panels and nail to plywood (waterproof sealant under nailing locations at edge)



ON-SITE BUILDING

1. Build base with masonite beams and leca-blocks
2. Slide together panels into dome form and mount onto base
3. Complete the airtight and waterproof membranes with tape at meeting points between panels
4. Place ice in box
5. Close “door” panel and complete with tape and façade panel



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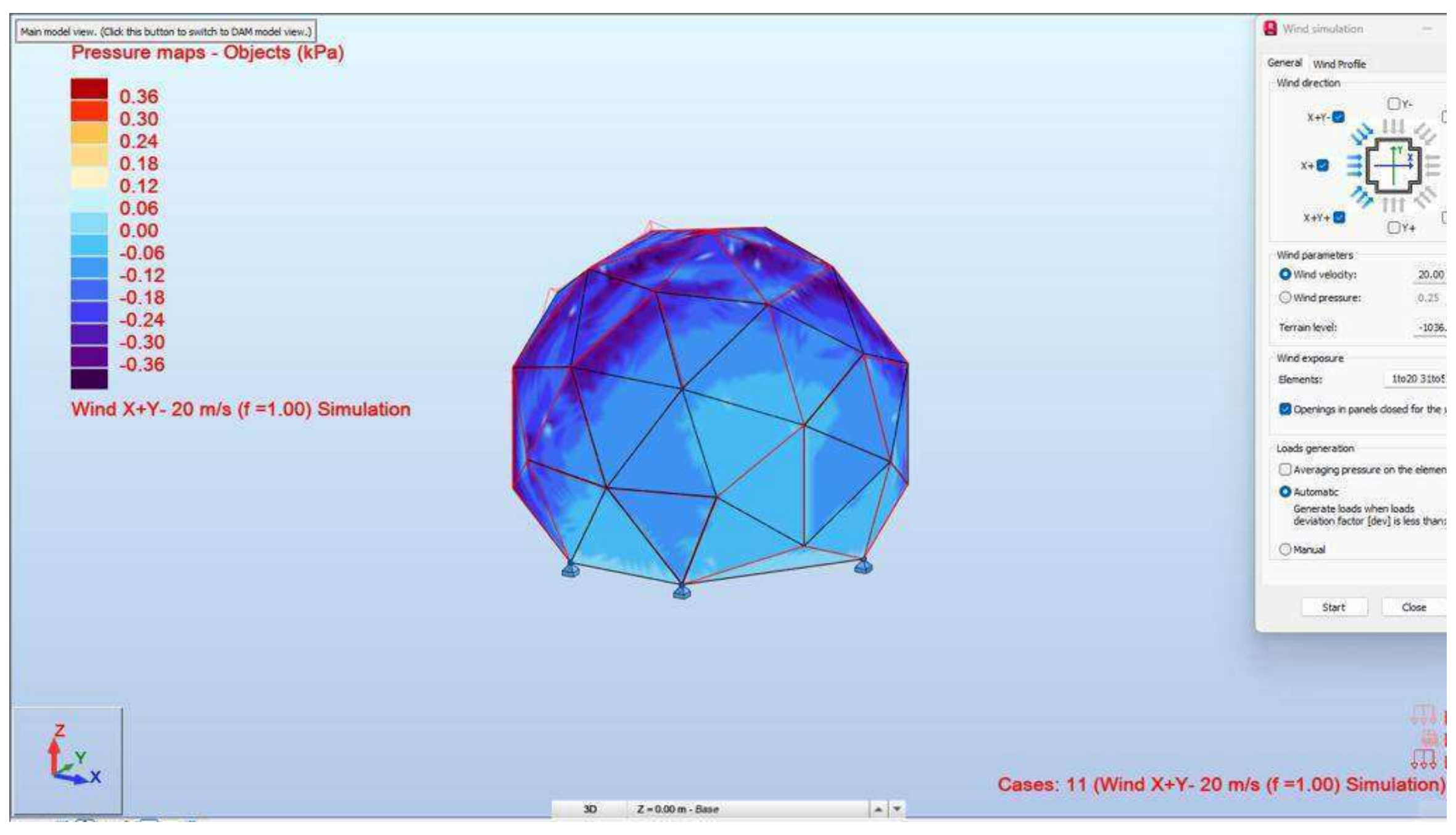
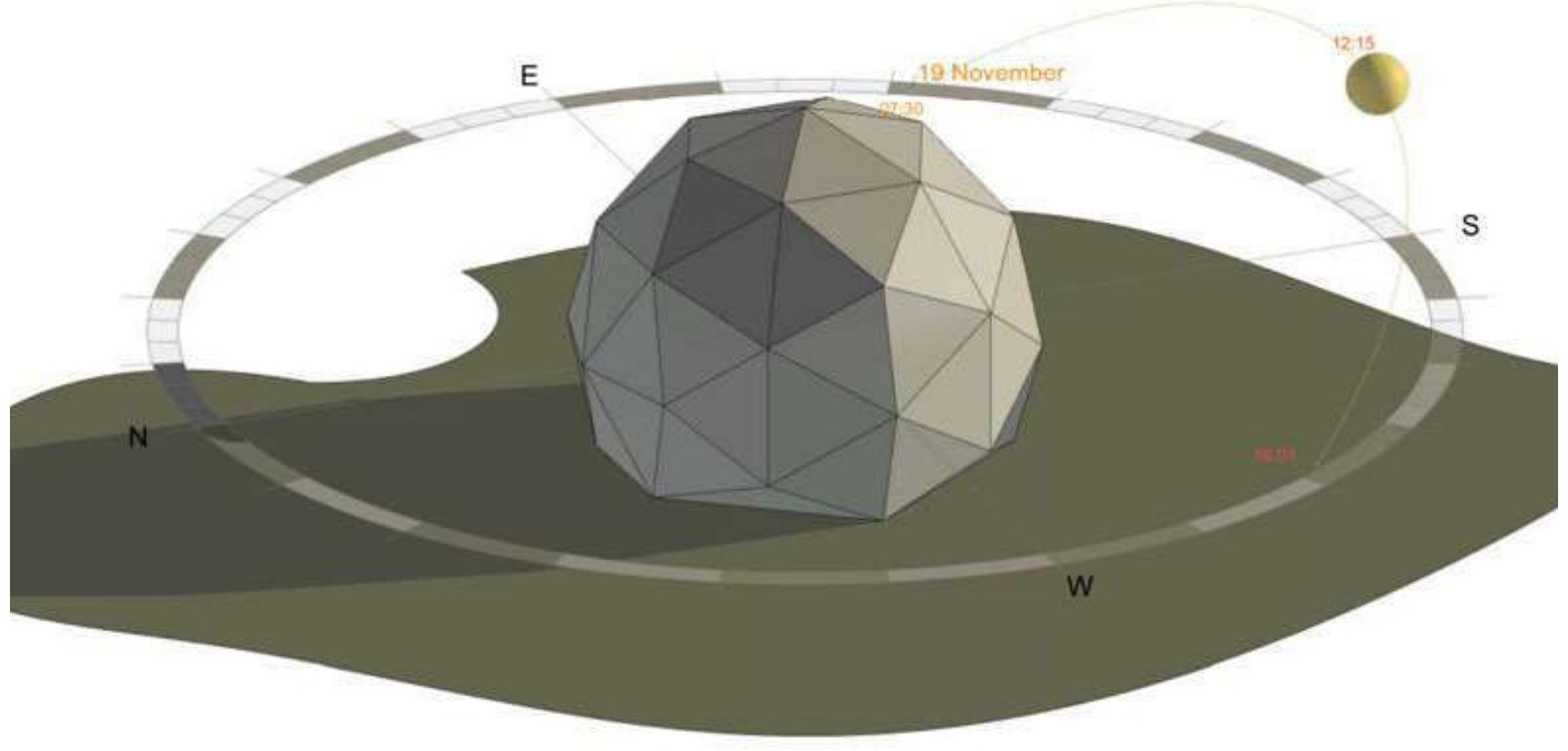
SIMULATIONS/EXPERIMENTS

LOADING AND SUNLIGHT SIMULATIONS

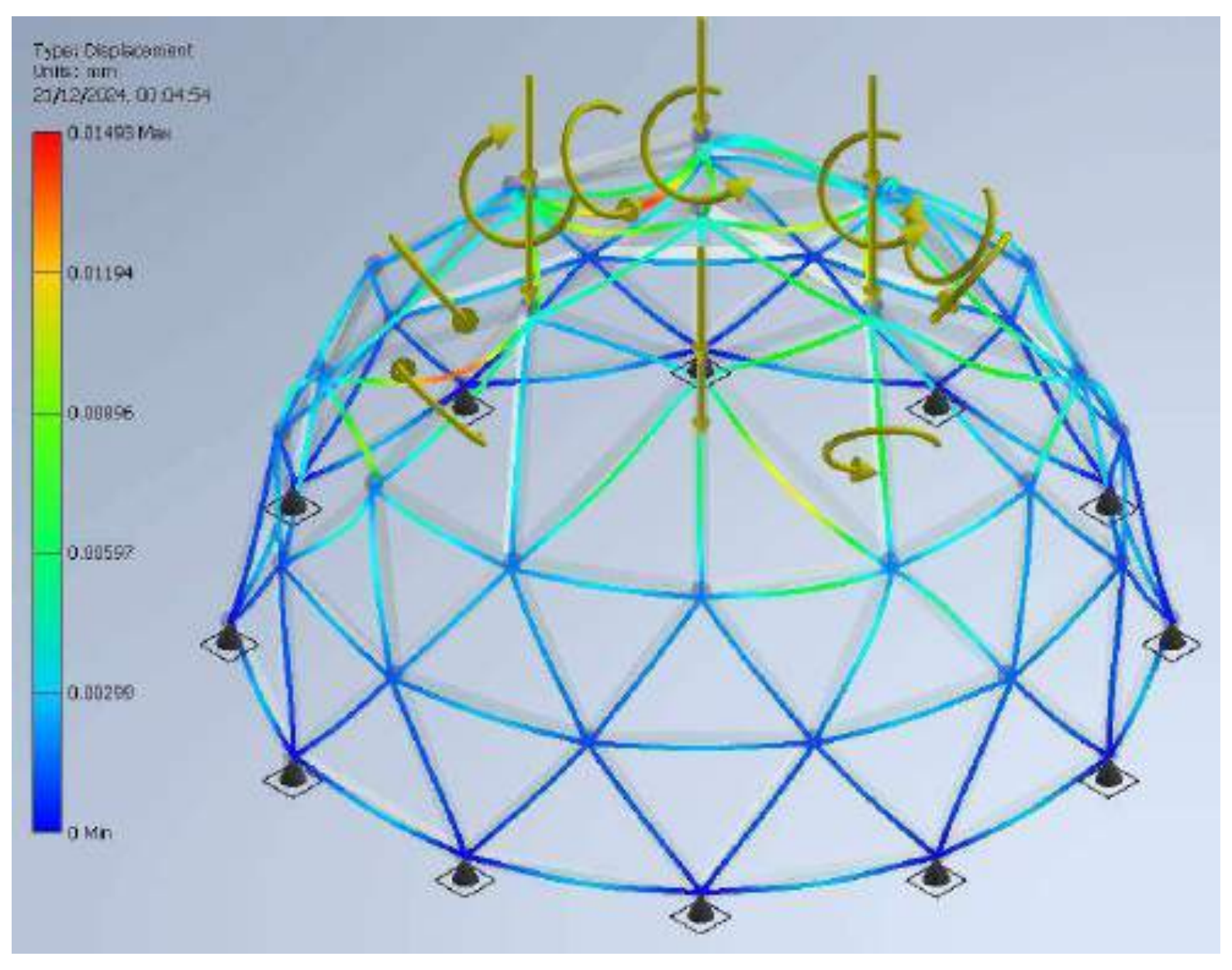


Wind velocity: 20.00
Wind pressure: 0.25
Terrain level: -1036.
Elements: 1to20 31to5
☑ Openings in panels closed for the
● Automatic
Generate loads when loads deviation factor [dev] is less than
Cases: 11 (Wind X+Y- 20 m/s (f =1.00) Simulation)

Windload simulation



Sunlight study



Load deformation simulation

EXPERIMENT – MOISTURE/HEAT

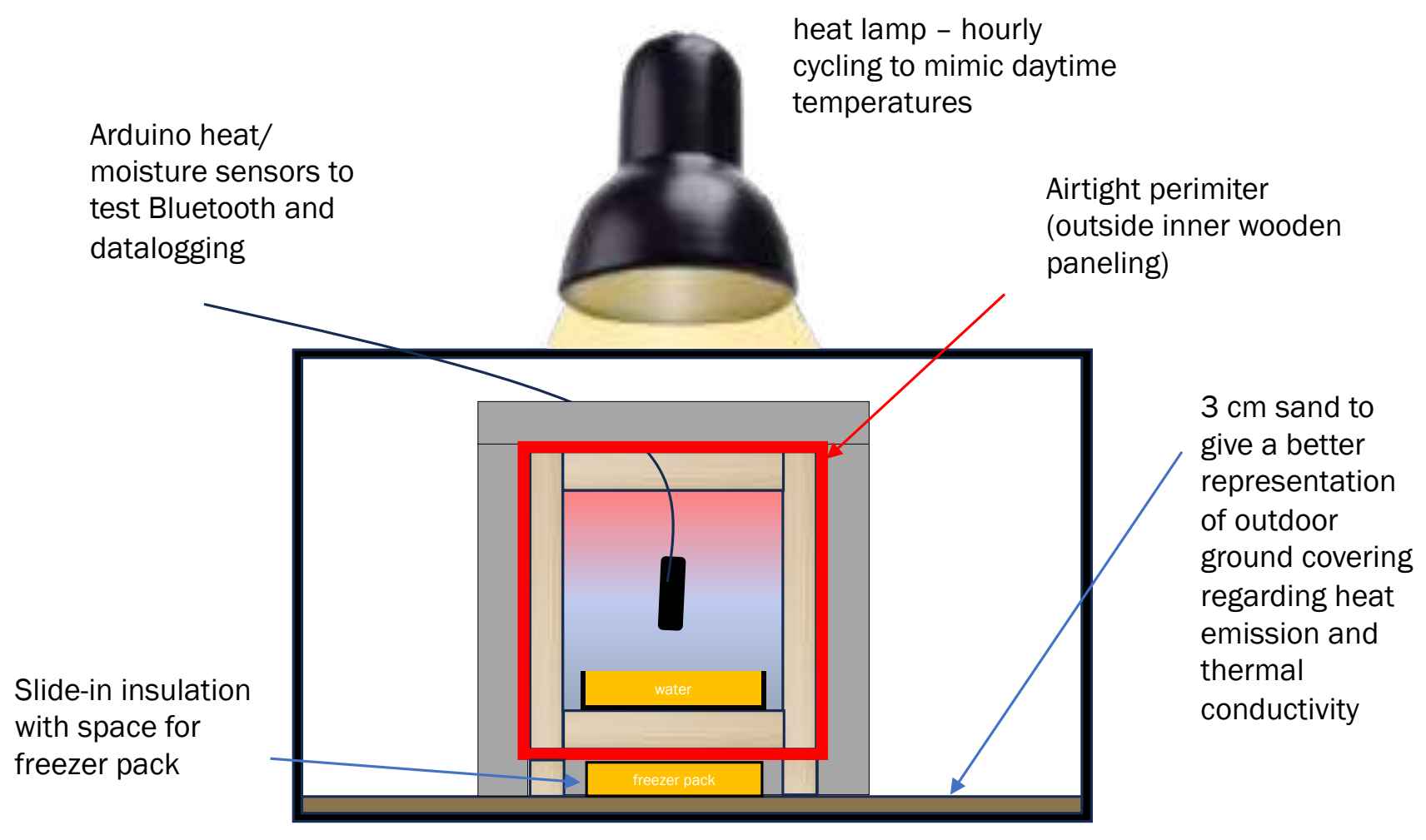
SETUP

To test if the internal plywood paneling will carry risk for molding, experiments were performed over the period of one month. Testing was performed in a control room-temperature environment, chilled environment (refrigerator), cold environment (freezer), varying temperature environment.

1. Wood sample in refrigerator 7 °C±4)
2. Wood sample in freezer (-17 °C±2)

3. Wood sample placed at room temperature at 100% RH for 2 days
+ Shows impact of cold and mold development
- Lacks thermal gradient to warm outdoor climate

4. Wood sample under heat lamp simulating sun phases
+ Shows thermal gradient
- Doubtful if ice will last long enough in scaled model
- Temperature fluxuations during the day



heat lamp – hourly cycling to mimic daytime temperatures

Arduino heat/ moisture sensors to test Bluetooth and datalogging

Airtight perimiter (outside inner wooden paneling)

3 cm sand to give a better representation of outdoor ground covering regarding heat emission and thermal conductivity

Slide-in insulation with space for freezer pack

Schematic illustration of heat lamp simulating extreme warm heat cycle from climate data between May and June

RESULT

The results show that having plywood in freezing environment should not show mold growth, even if the outdoor temperature is warm and fluxuating. However, after the ice has melted, the structure must be ventilated.

1. Refrigerator (7 °C±4)
Black mold

2. Freezer (-17 °C±2)
No mold

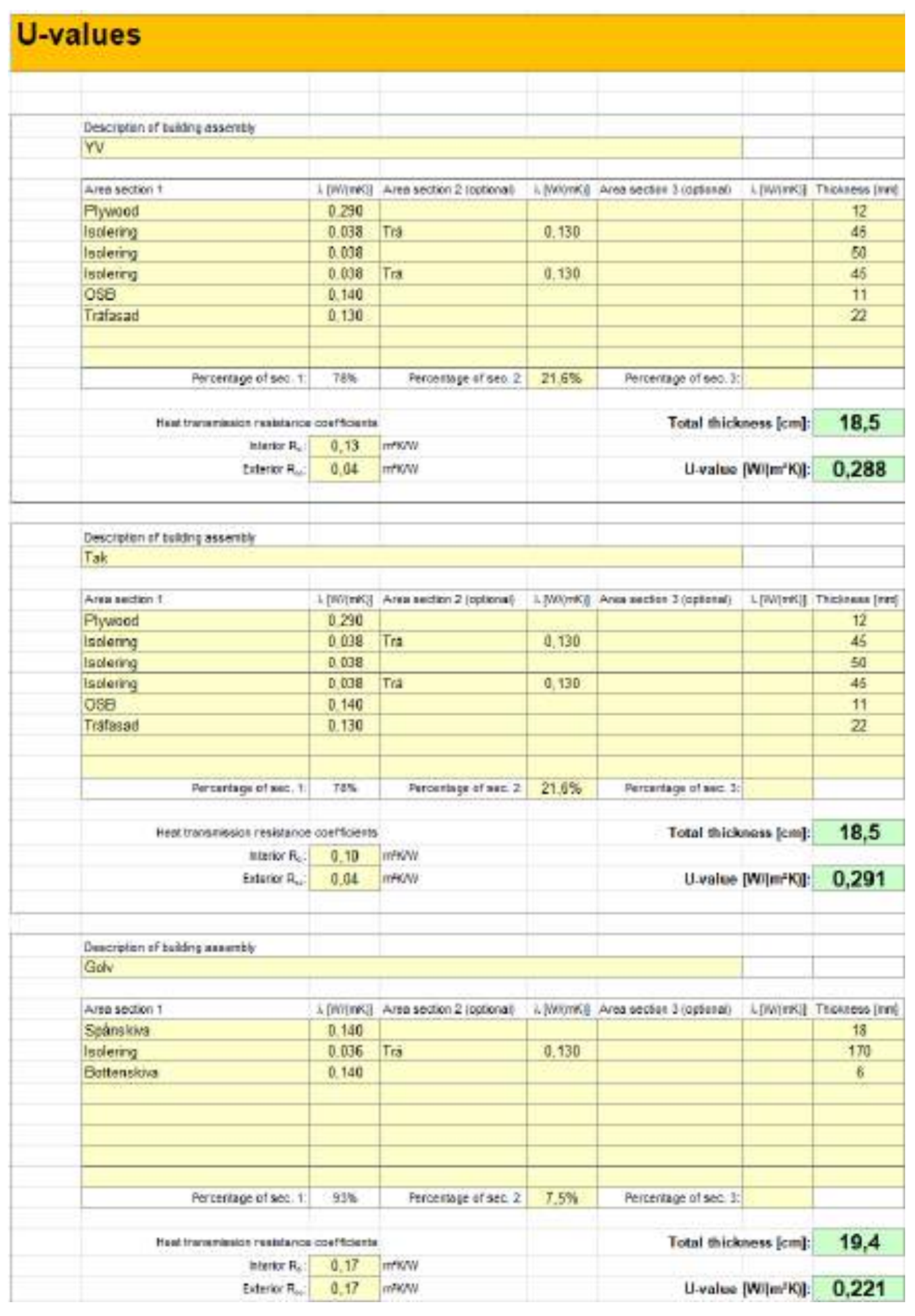
3. Room temp (22 °C±3)
Grey mold

3. Varying temp box
No mold

Experimental setup of heat lamp simulating extreme warm heat cycle

PHPP AND CO$_2$e CALCULATIONS

BBR U-values



U-values

Description of building assembly
YV

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Plywood	0,290					12
Isolering	0,038	Trä	0,130			45
Isolering	0,038					50
Isolering	0,038	Trä	0,130			45
OSB	0,140					11
Träfasad	0,130					22
Percentage of sec. 1:	78%	Percentage of sec. 2:	21,6%	Percentage of sec. 3:		

Heat transmission resistance coefficients
Interior R_{si}: 0,13 m²K/W
Exterior R_{se}: 0,04 m²K/W
Total thickness [cm]: 18,5
U-value [W/(m²K)]: 0,288

Description of building assembly
Tak

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Plywood	0,290					12
Isolering	0,038	Trä	0,130			45
Isolering	0,038					50
Isolering	0,038	Trä	0,130			45
OSB	0,140					11
Träfasad	0,130					22
Percentage of sec. 1:	78%	Percentage of sec. 2:	21,6%	Percentage of sec. 3:		

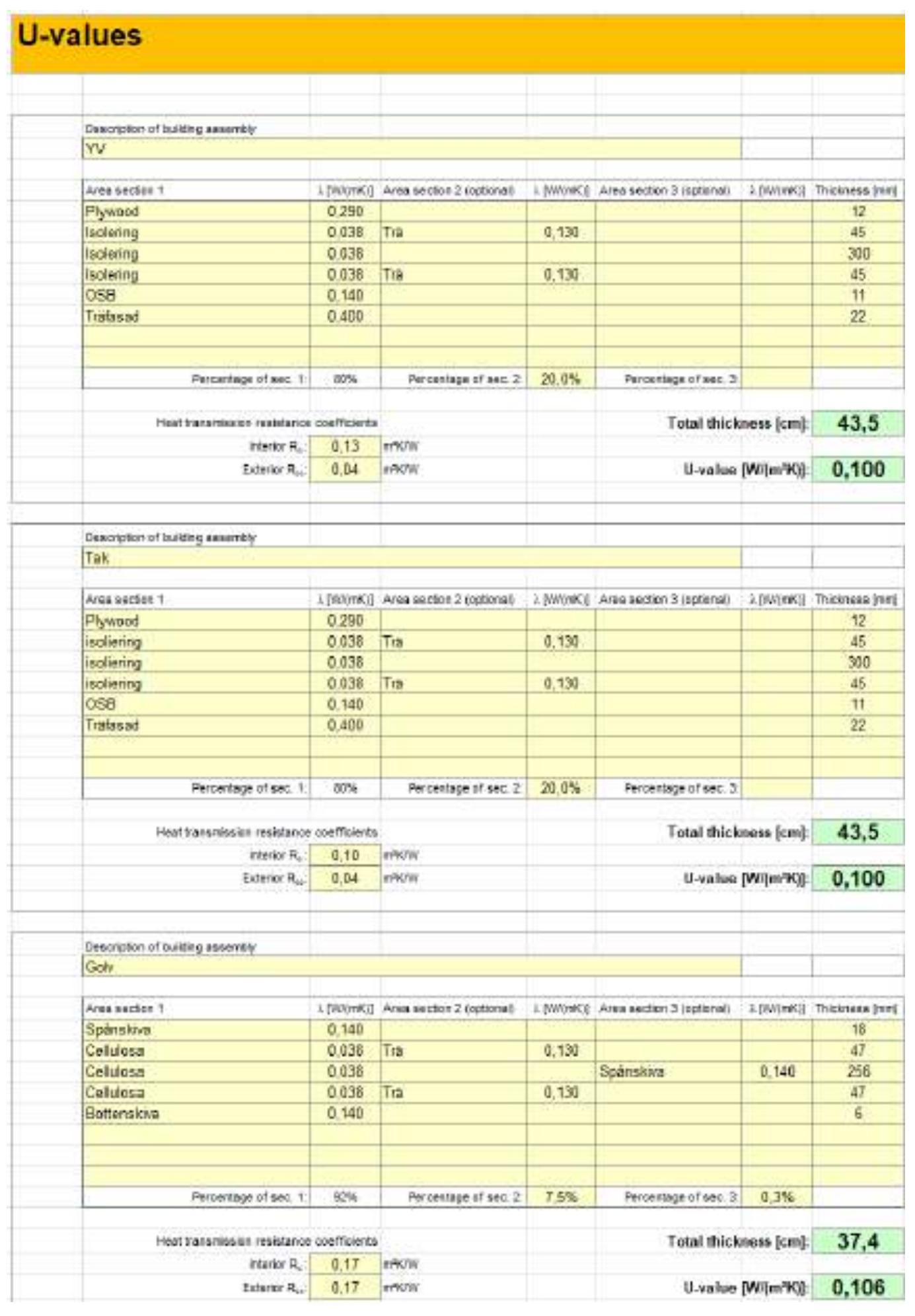
Heat transmission resistance coefficients
Interior R_{si}: 0,10 m²K/W
Exterior R_{se}: 0,04 m²K/W
Total thickness [cm]: 18,5
U-value [W/(m²K)]: 0,291

Description of building assembly
Golv

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Spånskiva	0,140					18
Isolering	0,036	Trä	0,130			170
Bottenskiva	0,140					6
Percentage of sec. 1:	93%	Percentage of sec. 2:	7,5%	Percentage of sec. 3:		

Heat transmission resistance coefficients
Interior R_{si}: 0,17 m²K/W
Exterior R_{se}: 0,17 m²K/W
Total thickness [cm]: 19,4
U-value [W/(m²K)]: 0,221

PH U-values



U-values

Description of building assembly
YV

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Plywood	0,290					12
Isolering	0,038	Trä	0,130			45
Isolering	0,038					300
Isolering	0,038	Trä	0,130			45
OSB	0,140					11
Träfasad	0,400					22
Percentage of sec. 1:	80%	Percentage of sec. 2:	20,0%	Percentage of sec. 3:		

Heat transmission resistance coefficients
Interior R_{si}: 0,13 m²K/W
Exterior R_{se}: 0,04 m²K/W
Total thickness [cm]: 43,5
U-value [W/(m²K)]: 0,100

Description of building assembly
Tak

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Plywood	0,290					12
isoliering	0,038	Trä	0,130			45
isoliering	0,038					300
isoliering	0,038	Trä	0,130			45
OSB	0,140					11
Träfasad	0,400					22
Percentage of sec. 1:	80%	Percentage of sec. 2:	20,0%	Percentage of sec. 3:		

Heat transmission resistance coefficients
Interior R_{si}: 0,10 m²K/W
Exterior R_{se}: 0,04 m²K/W
Total thickness [cm]: 43,5
U-value [W/(m²K)]: 0,100

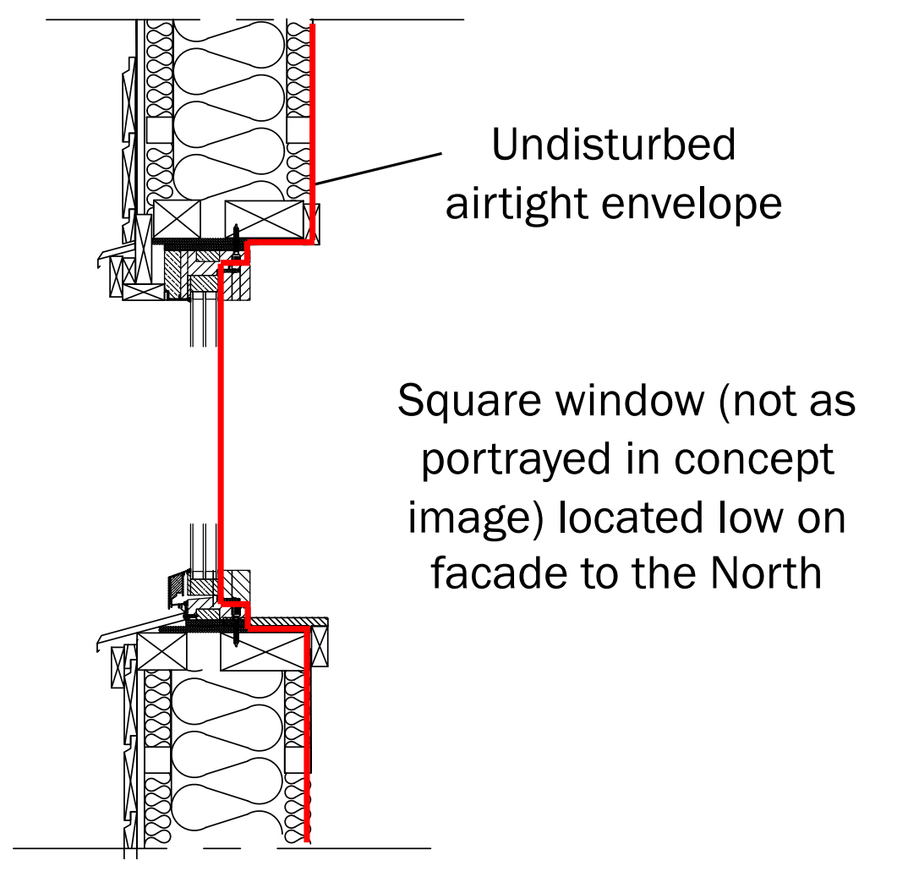
Description of building assembly
Golv

Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Spånskiva	0,140					18
Cellulosa	0,038	Trä	0,130			47
Cellulosa	0,038			Spånskiva	0,140	256
Cellulosa	0,038	Trä	0,130			47
Bottenskiva	0,140					6
Percentage of sec. 1:	92%	Percentage of sec. 2:	7,5%	Percentage of sec. 3:	0,3%	

Heat transmission resistance coefficients
Interior R_{si}: 0,17 m²K/W
Exterior R_{se}: 0,17 m²K/W
Total thickness [cm]: 37,4
U-value [W/(m²K)]: 0,106

CROSS SECTIONS

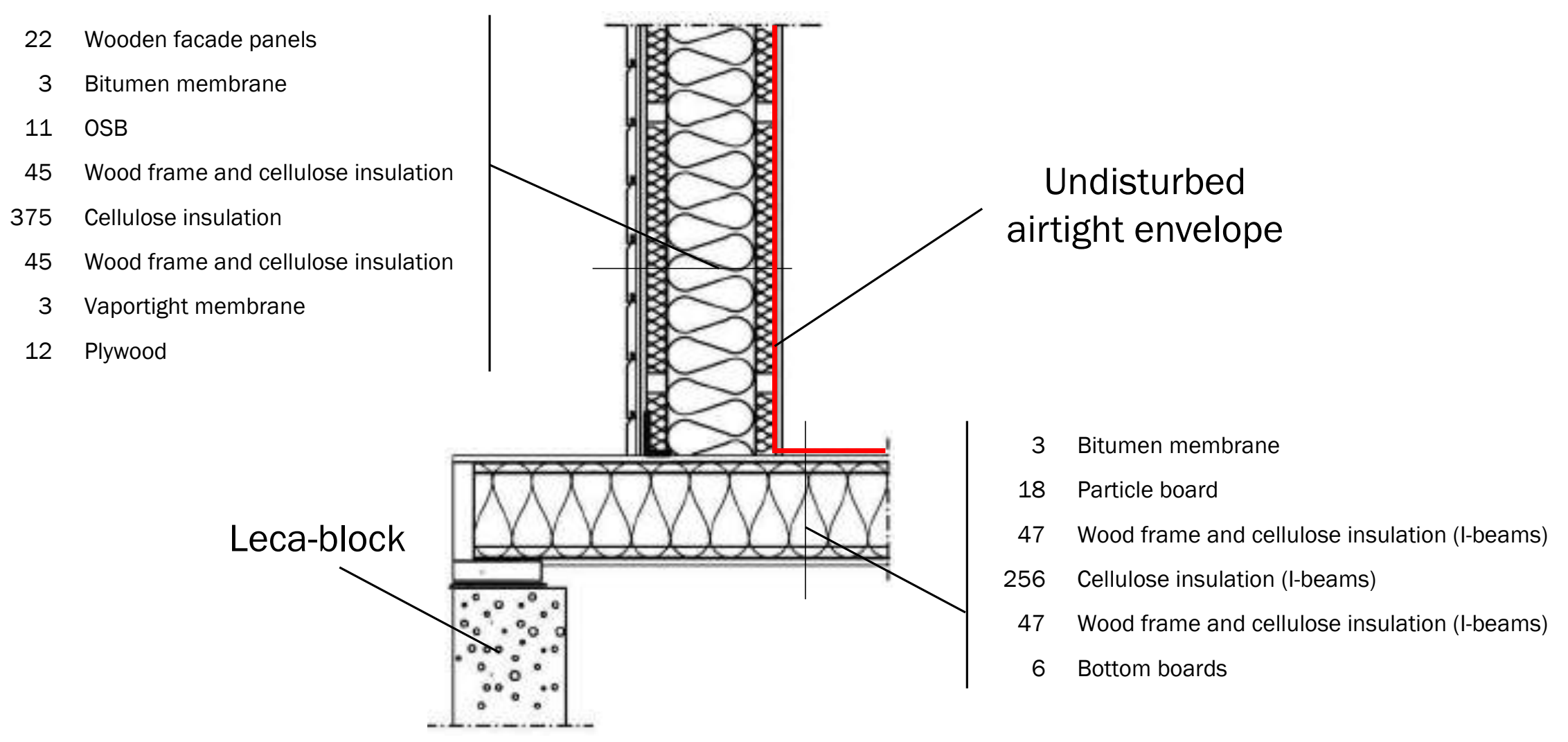
PH window cross section



Undisturbed airtight envelope

Square window (not as portrayed in concept image) located low on facade to the North

PH foundation cross section



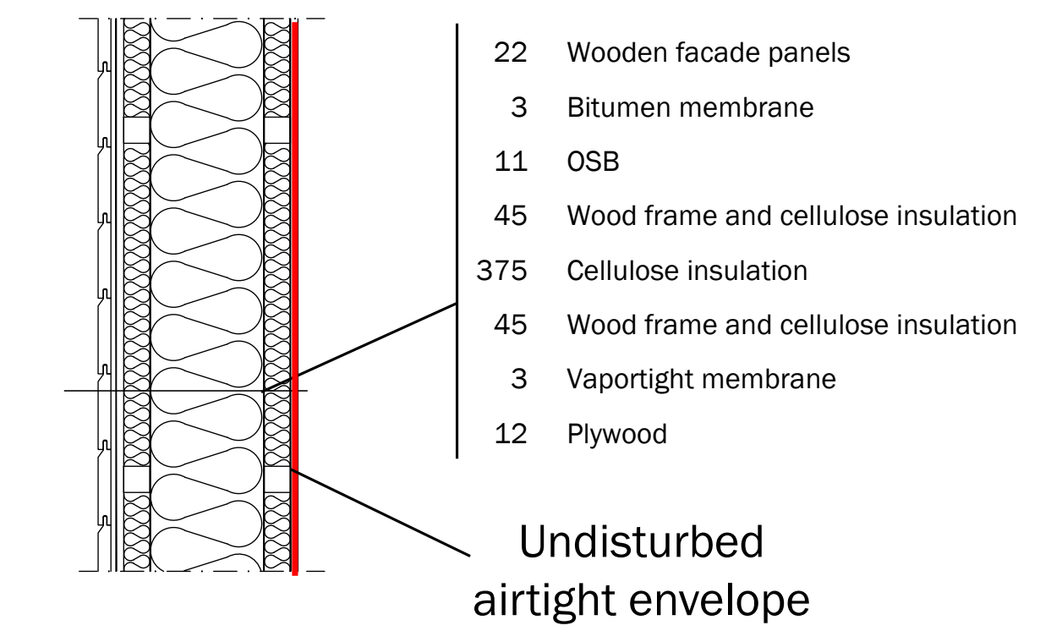
22	Wooden facade panels
3	Bitumen membrane
11	OSB
45	Wood frame and cellulose insulation
375	Cellulose insulation
45	Wood frame and cellulose insulation
3	Vaportight membrane
12	Plywood

Undisturbed airtight envelope

Leca-block

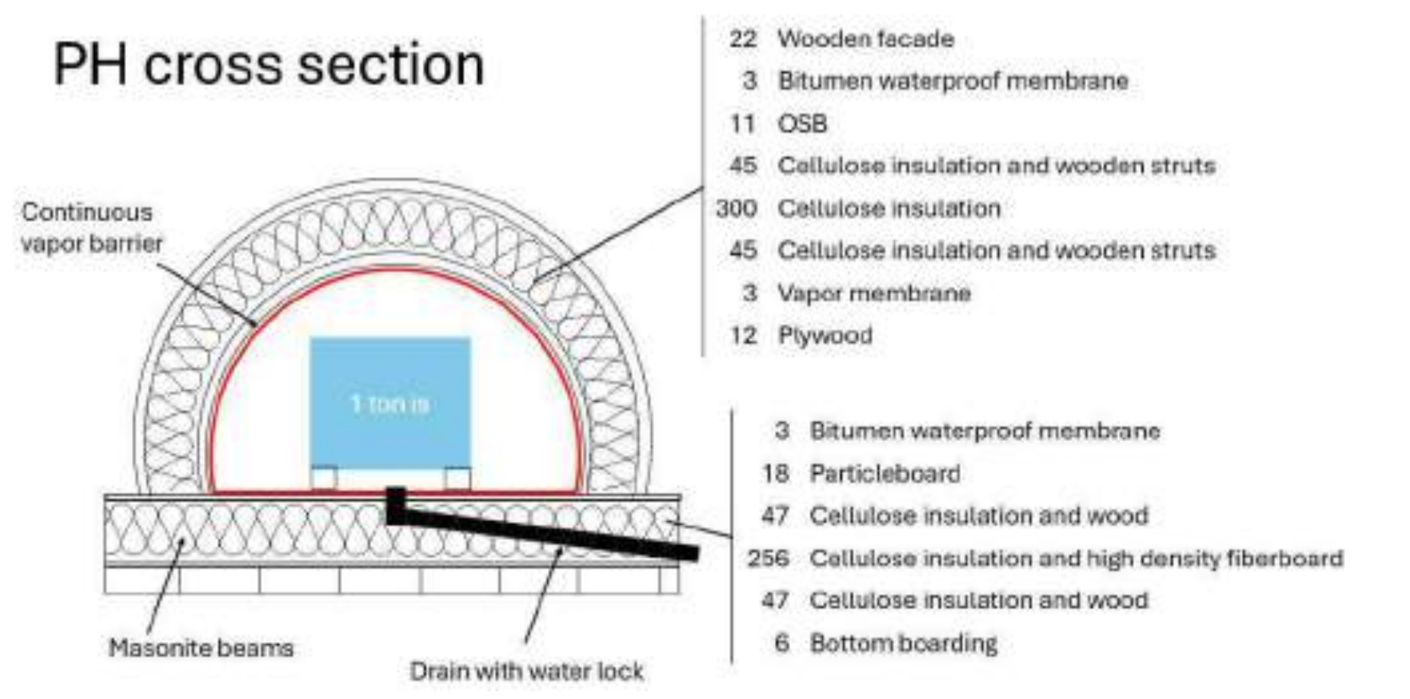
3	Bitumen membrane
18	Particle board
47	Wood frame and cellulose insulation (I-beams)
256	Cellulose insulation (I-beams)
47	Wood frame and cellulose insulation (I-beams)
6	Bottom boards

PH wall cross section



22	Wooden facade panels
3	Bitumen membrane
11	OSB
45	Wood frame and cellulose insulation
375	Cellulose insulation
45	Wood frame and cellulose insulation
3	Vaportight membrane
12	Plywood

Undisturbed airtight envelope



PH cross section

Continuous vapor barrier

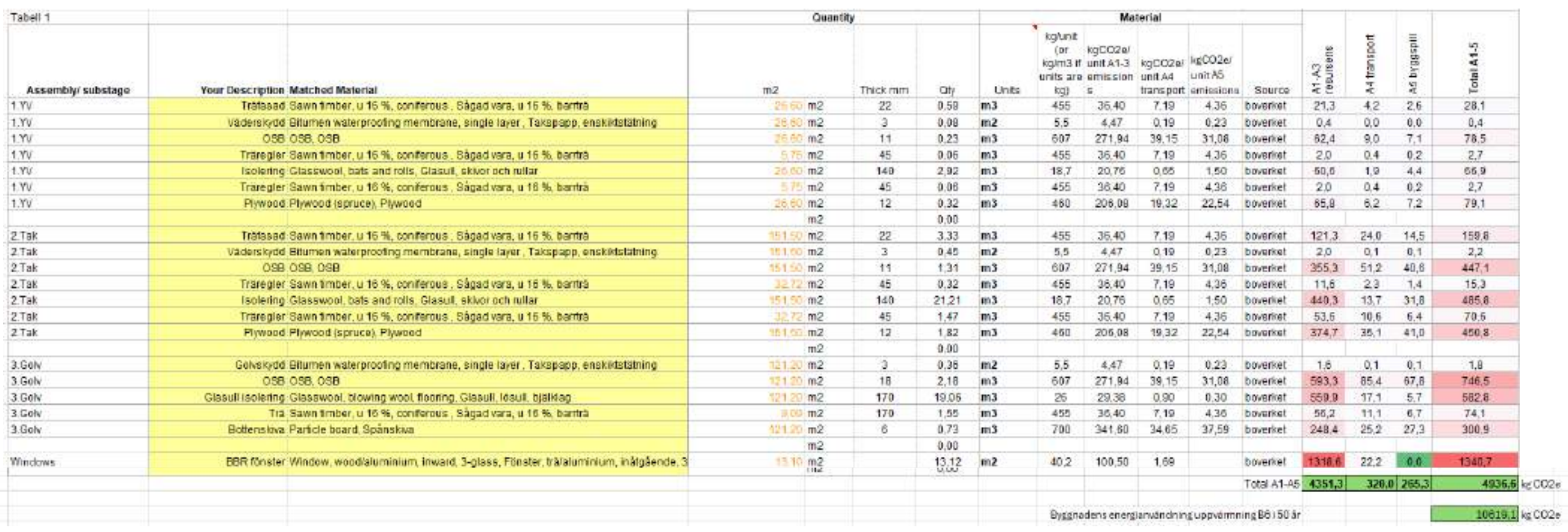
22	Wooden facade
3	Bitumen waterproof membrane
11	OSB
45	Cellulose insulation and wooden struts
300	Cellulose insulation
45	Cellulose insulation and wooden struts
3	Vapor membrane
12	Plywood

3	Bitumen waterproof membrane
18	Particleboard
47	Cellulose insulation and wood
256	Cellulose insulation and high density fiberboard
47	Cellulose insulation and wood
6	Bottom boarding

Masonite beams

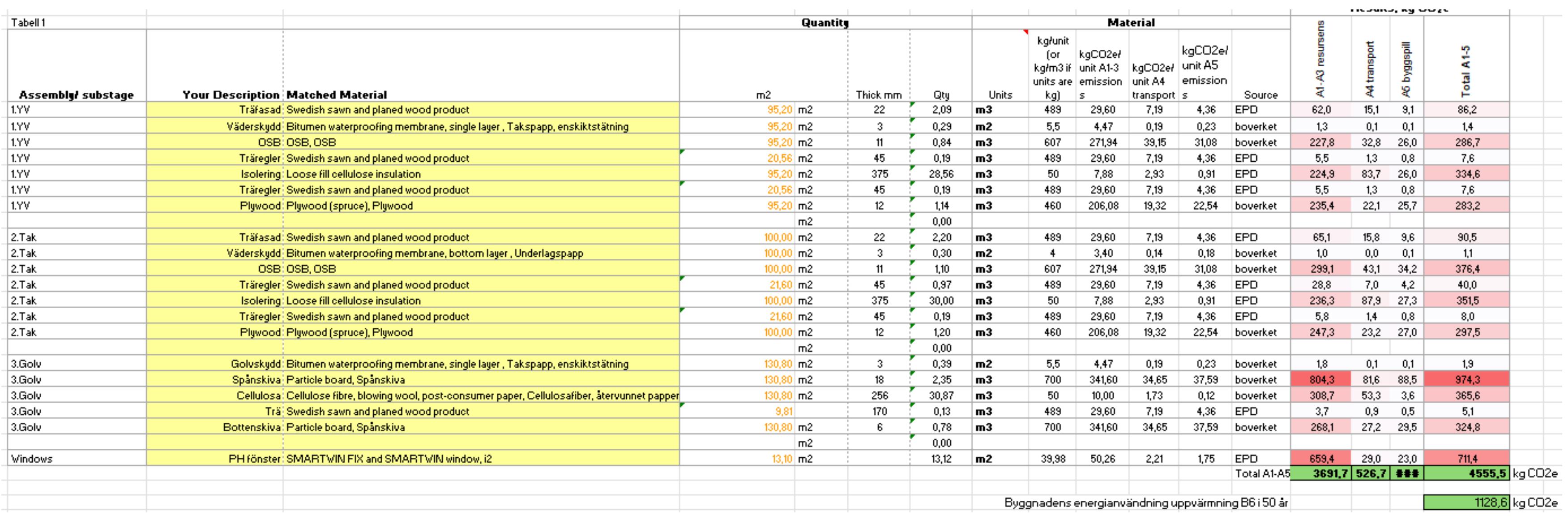
Drain with water lock

BBR KD



Tabell 1			Quantity				Material										
Assembly/ substage	Your Description	Matched Material	m2		Thick mm	Qty	Units	kg/unit (or kg/m3 if units are kg)	kgCO2e/ unit A1-3 emissions	kgCO2e/ unit A4 transport	kgCO2e/ unit A5 emissions	Source	A1-A3 resursens	A4 transport	A5 byggspill	Total A1-5	
1.YV	Träfasad	Sawn timber, u 16 %, coniferous , Sågad vara, u 16 %, barrträ	26,60	m2	22	0,58	m3	455	36,40	7,19	4,36	boverket	21,3	4,2	2,6	28,1	
1.YV	Väderskydd	Bitumen waterproofing membrane, single layer , Takspapp, enskiktstätning	26,60	m2	3	0,08	m2	5,5	4,47	0,19	0,23	boverket	0,4	0,0	0,0	0,4	
1.YV	OSB	OSB, OSB	26,60	m2	11	0,23	m3	607	271,94	39,15	31,08	boverket	62,4	9,0	7,1	78,5	
1.YV	Träregler	Sawn timber, u 16 %, coniferous , Sågad vara, u 16 %, barrträ	5,75	m2	45	0,06	m3	455	36,40	7,19	4,36	boverket	2,0	0,4	0,2	2,7	
1.YV	Isolering	Glasswool, bats and rolls, Glasull, skivor och rullar	26,60	m2	140	2,92	m3	18,7	20,76	0,65	1,50	boverket	50,6	1,9	4,4	56,9	
1.YV	Träregler	Sawn timber, u 16 %, coniferous , Sågad vara, u 16 %, barrträ	5,75	m2	45	0,06	m3	455	36,40	7,19	4,36	boverket	2,0	0,4	0,2	2,7	
1.YV	Plywood	Plywood (spruce), Plywood	26,60	m2	12	0,32	m3	460	206,08	19,32	22,54	boverket	65,8	6,2	7,2	79,1	
				m2		0,00											
2.Tak	Träfasad	Sawn timber, u 16 %, coniferous , Sågad vara, u 16 %, barrträ	151,50	m2	22	3,33	m3	455	36,40	7,19	4,36	boverket	121,3	24,0	14,5	159,8	
2.Tak	Väderskydd	Bitumen waterproofing membrane, single layer , Takspapp, enskiktstätning	151,50	m2	3	0,45	m2	5,5	4,47	0,19	0,23	boverket	2,0	0,1	0,1	2,2	
2.Tak	OSB	OSB, OSB	151,50	m2	11	1,31	m3	607	271,94	39,15	31,08	boverket	355,3	51,2	40,6	447,1	
2.Tak	Träregler	Sawn timber, u 16 %, coniferous , Sågad vara, u 16 %, barrträ	32,72	m2	45	0,32	m3	455	36,40	7,19	4,36	boverket	11,6	2,3	1,4	15,3	
2.Tak	Isolering	Glasswool, bats and rolls, Glasull, skivor och rullar	151,50	m2	140	21,21	m3	18,7	20,76	0,65	1,50	boverket	440,3	13,7	31,8	485,8	
2.Tak	Träregler	Sawn timber, u 16 %, coniferous , Sågad vara, u 16 %, barrträ	32,72	m2	45	1,47	m3	455	36,40	7,19	4,36	boverket	53,6	10,6	6,4	70,6	
2.Tak	Plywood	Plywood (spruce), Plywood	151,50	m2	12	1,82	m3	460	206,08	19,32	22,54	boverket	374,7	35,1	41,0	450,8	
				m2		0,00											
3.Golv	Golvskydd	Bitumen waterproofing membrane, single layer , Takspapp, enskiktstätning	121,20	m2	3	0,36	m2	5,5	4,47	0,19	0,23	boverket	1,6	0,1	0,1	1,8	
3.Golv	OSB	OSB, OSB	121,20	m2	18	2,18	m3	607	271,94	39,15	31,08	boverket	593,3	85,4	67,8	746,5	
3.Golv	Glasull isolering	Glasswool, blowing wool, flooring, Glasull, lösull, bjälklag	121,20	m2	170	19,06	m3	26	29,38	0,90	0,30	boverket	559,9	17,1	5,7	582,6	
3.Golv	Trä	Sawn timber, u 16 %, coniferous , Sågad vara, u 16 %, barrträ	9,00	m2	170	1,55	m3	455	36,40	7,19	4,36	boverket	56,2	11,1	6,7	74,1	
3.Golv	Bottenskiva	Particle board, Spånskiva	121,20	m2	6	0,73	m3	700	341,60	34,65	37,59	boverket	248,4	25,2	27,3	300,9	
				m2		0,00											
Windows	BBR fönster	Window, wood/aluminium, inward, 3-glass, Fönster, trä/aluminium, inåtgående, 3	13,10	m2		13,12	m2	40,2	100,50	1,69		boverket	1318,6	22,2	0,0	1340,7	
												Total A1-A5	4351,3	320,0	265,3	4936,6	kg CO2e
								Byggnadens energianvändning uppvärmning B6 i 50 år								10619,1	kg CO2e

PH KD



Tabell 1			Quantity				Material										
Assembly/ substage	Your Description	Matched Material	m2		Thick mm	Qty	Units	kg/unit (or kg/m3 if units are kg)	kgCO2e/ unit A1-3 emissions	kgCO2e/ unit A4 transport	kgCO2e/ unit A5 emissions	Source	A1-A3 resursens	A4 transport	A5 byggspill	Total A1-5	
1.YV	Träfasad	Swedish sawn and planed wood product	95,20	m2	22	2,09	m3	489	29,60	7,19	4,36	EPD	62,0	15,1	9,1	86,2	
1.YV	Väderskydd	Bitumen waterproofing membrane, single layer , Takspapp, enskiktstätning	95,20	m2	3	0,29	m2	5,5	4,47	0,19	0,23	boverket	1,3	0,1	0,1	1,4	
1.YV	OSB	OSB, OSB	95,20	m2	11	0,84	m3	607	271,94	39,15	31,08	boverket	227,8	32,8	26,0	286,7	
1.YV	Träregler	Swedish sawn and planed wood product	20,56	m2	45	0,19	m3	489	29,60	7,19	4,36	EPD	5,5	1,3	0,8	7,6	
1.YV	Isolering	Loose fill cellulose insulation	95,20	m2	375	28,56	m3	50	7,88	2,93	0,91	EPD	224,9	83,7	26,0	334,6	
1.YV	Träregler	Swedish sawn and planed wood product	20,56	m2	45	0,19	m3	489	29,60	7,19	4,36	EPD	5,5	1,3	0,8	7,6	
1.YV	Plywood	Plywood (spruce), Plywood	95,20	m2	12	1,14	m3	460	206,08	19,32	22,54	boverket	235,4	22,1	25,7	283,2	
				m2		0,00											
2.Tak	Träfasad	Swedish sawn and planed wood product	100,00	m2	22	2,20	m3	489	29,60	7,19	4,36	EPD	65,1	15,8	9,6	90,5	
2.Tak	Väderskydd	Bitumen waterproofing membrane, bottom layer , Underlagspapp	100,00	m2	3	0,30	m2	4	3,40	0,14	0,18	boverket	1,0	0,0	0,1	1,1	
2.Tak	OSB	OSB, OSB	100,00	m2	11	1,10	m3	607	271,94	39,15	31,08	boverket	299,1	43,1	34,2	376,4	
2.Tak	Träregler	Swedish sawn and planed wood product	21,60	m2	45	0,97	m3	489	29,60	7,19	4,36	EPD	28,8	7,0	4,2	40,0	
2.Tak	Isolering	Loose fill cellulose insulation	100,00	m2	375	30,00	m3	50	7,88	2,93	0,91	EPD	236,3	87,9	27,3	351,5	
2.Tak	Träregler	Swedish sawn and planed wood product	21,60	m2	45	0,19	m3	489	29,60	7,19	4,36	EPD	5,8	1,4	0,8	8,0	
2.Tak	Plywood	Plywood (spruce), Plywood	100,00	m2	12	1,20	m3	460	206,08	19,32	22,54	boverket	247,3	23,2	27,0	297,5	
				m2		0,00											
3.Golv	Golvskydd	Bitumen waterproofing membrane, single layer , Takspapp, enskiktstätning	130,80	m2	3	0,39	m2	5,5	4,47	0,19	0,23	boverket	1,8	0,1	0,1	1,9	
3.Golv	Spånskiva	Particle board, Spånskiva	130,80	m2	18	2,35	m3	700	341,60	34,65	37,59	boverket	804,3	81,6	88,5	974,3	
3.Golv	Cellulosa	Cellulose fibre, blowing wool, post-consumer paper, Cellulosafiber, återvunnet papper	130,80	m2	256	30,87	m3	50	10,00	1,73	0,12	boverket	308,7	53,3	3,6	365,6	
3.Golv	Trä	Swedish sawn and planed wood product	9,81		170	0,13	m3	489	29,60	7,19	4,36	EPD	3,7	0,9	0,5	5,1	
3.Golv	Bottenskiva	Particle board, Spånskiva	130,80	m2	6	0,78	m3	700	341,60	34,65	37,59	boverket	268,1	27,2	29,5	324,8	
				m2		0,00											
Windows	PH fönster	SMARTWIN FIX and SMARTWIN window, i2	13,10	m2		13,12	m2	39,98	50,26	2,21	1,75	EPD	659,4	29,0	23,0	711,4	
												Total A1-A5	3691,7	526,7	###	4555,5	kg CO2e
								Byggnadens energianvändning uppvärmning B6 i 50 år								1128,6	kg CO2e