

APPENDIX

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APPENDIX 1: BROCHURE WOODY

This brochure has been made for the marketing department of Ice-World, this brochure could help Ice-World to attract new customers.

WOODY

A WOODEN BOARDING SYSTEM

ASUSTAINABLE BOARDING SYSTEM THAT PROVIDES OPTIMAL OPPORTUNITY FOR SPONSORING AND CREATES AN ATTRACTIVE, AFFORDABLE ICE RINK.



SUSTAINABLE

ALL MATERIALS ARE 100% RECYCABLE

Woody is made out of environmentally friendly wood that is not impregnated with chemicals but it is 'platonized'. Woody is weatherproof and durable.



SPONSORING

2X AS MUCH SPONSORING OPPORTUNITY

With woody, you can easily attach sponsoring to the boarding – both on the inside and outside of the construction.



SAFETY

WOODY PREVENT ACCIDENTS FROM HAPPENING

The dimensions of Woody are fully compliant with all relevant international safety standards.



Image 1: The new boarding system on ice rink.

Woody is a boarding system that is made up from four main components:

01

The base

The base is produced from galvanized steel, enables on ice and below ice placement and is easy to (de)assemble during transport and storage.

02

The planks

The five planks are produced from Platowood – an environmentally friendly and durable material.

03

The handrail

The handrail, in Ice-World's signature colour, is a round 3cm wide rail that provides the skater with plenty of comfort when holding on to the handrail. A ridge on the backside of the handrail ensures extra grip.

04

The support

There are two supports on each side of the panel. The support structures keep the 4 planks in the right place and provide enough stiffness to endure high impact.



Image 2: Sideview from the new boarding system.

KEY ELEMENTS OF THE REDESIGN

SUSTAINABLE



Woody is made from 100% recyclable materials – including galvanized steel for the support and base and Platowood for the planks. Platowood is a special type of wood that is environmentally friendly and especially suited for recycling. Unlike commonly used woods, Platowood is not impregnated with chemicals but it is 'platonized'. Platowood is made weatherproof and more durable by just using water and heat.

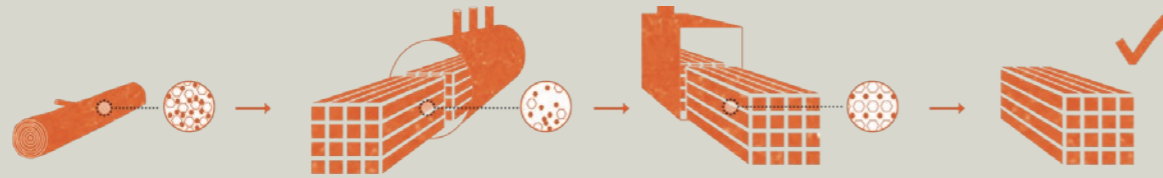


Image xx. The platoning process consists of three steps. By keeping the temperature low during the process the wood maintains its cellular structure and reinforcing the properties. Credits: www.platowood.com

LONGER LIFESPAN



Platowood exhibits properties that exceed the properties of 'normal' wood. The lifespan of Platowood is improved by approximately 23% compared to the standard impregnated wood (Source: www.platowood.com). Due to an improved construction and optimal measurement of the boarding system, a longer lifespan can be achieved as well.

LOW MAINTENANCE



Platonizing decreases the level of moisture in the wood, making it more resistance to swelling and shrinking. The improved properties of Platowood will obviate the need for repairing cracks and deformations – making it a very low maintenance material.

TWICE AS MANY SPONSORING OPPORTUNITIES



Woody offers customer twice as much surface area for sponsoring due to a symmetric design. With woody, the customer can easily attach sponsoring to the boarding – both on the inside and outside of the construction.

PERFECT FIT



The system is built to fit the need of every customer. Unlike other boarding systems, the different sized panels of woody can easily create any standard sized ice rink. The entire system consists of multiple components to be able to build a full boarding around the ice rink.

FINISH



The panels are constructed in such a way that hardware is not visible for the users inside the rink - creating a very clean and modern look. The screws on the outside of the boarding are sunken into the material to create a very smooth and clean surface. See image xx.



SAFETY

The dimensions of Woody are fully compliant with all relevant international safety standards. The height and dimensions of gaps in Woody prevent accidents from happening.



MORE ICE SURFACE

Woody is constructed to be placed both on top of and underneath the ice. Placing Woody underneath the ice layer increases the surface area of ice - on average Woody can provide an extra 9m² usable area.

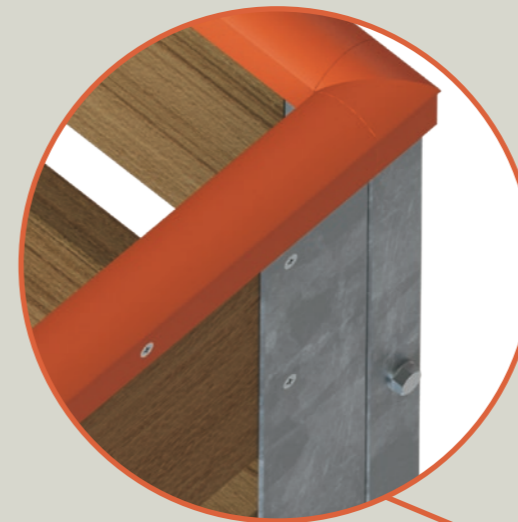


Image 3: The hardware is only visible from the outside and is sunken into the material.



Image 4: The planks are made from Platowood.

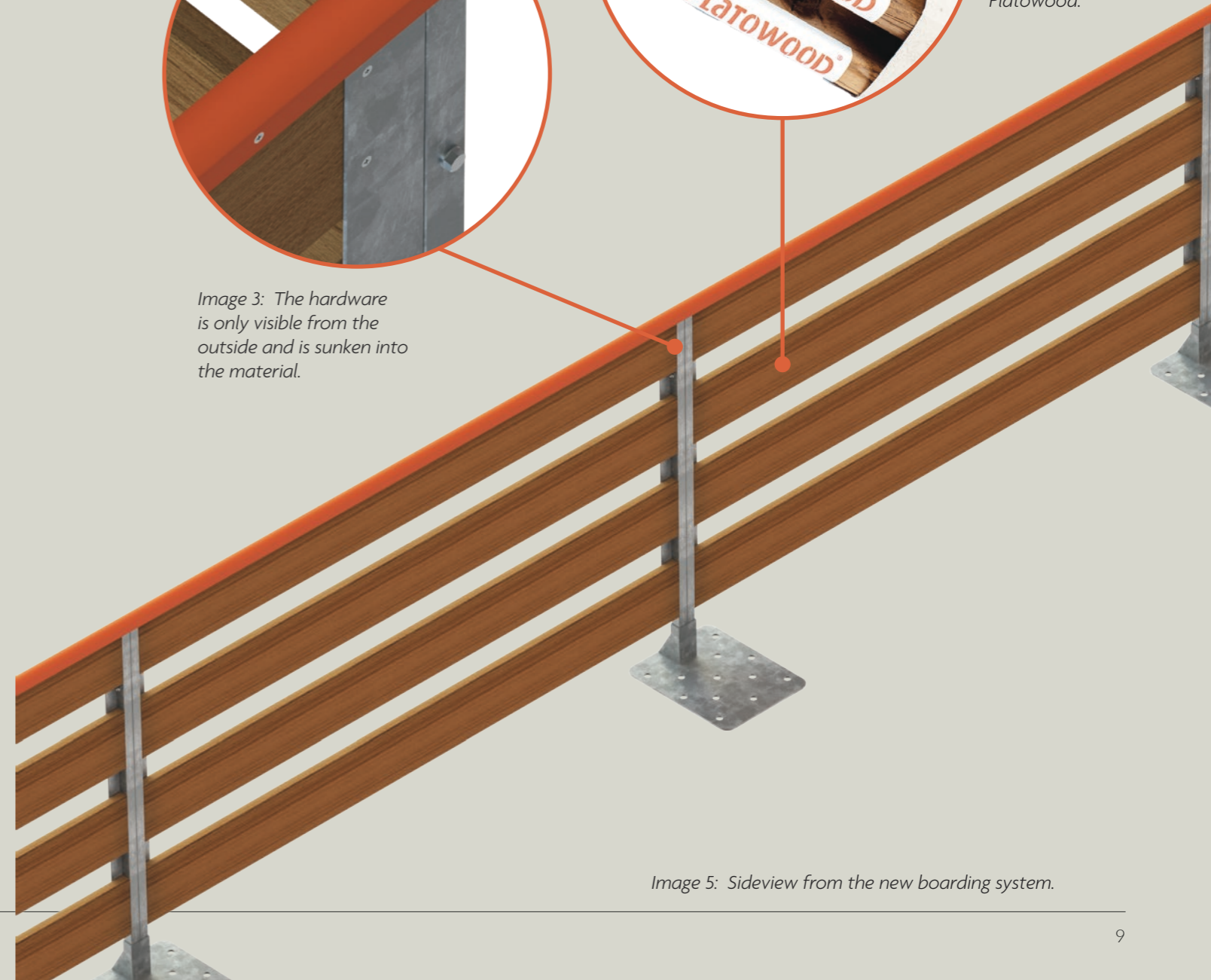


Image 5: Sideview from the new boarding system.

APPENDIX 2: CALCULATION BOARDING/AIR RATIO

This calculation shows how much air there is present in relation to boarding on 1 pallet. This includes only the boarding on top of the pallet, the pallet is not taken into account.

Volume boarding

8 boarding sections are normally transported on 1 pallet.

Dimensions wooden board:

- Length: 5000 mm
- Width: 145 mm
- Height: 27 mm
- Volume: $19575000 \times 4 = 78300000 \text{ mm}^3$

Dimensions boarding stand pole:

- Length: 1000 mm
- Width: 40 mm
- Height: 40 mm
- Volume: $1600000 \times 3 = 4800000 \text{ mm}^3$

Dimensions boarding stand base:

- Length: 400 mm
- Width: 320 mm
- Thickness: 5 mm
- Volume: $640000 \times 3 = 1920000 \text{ mm}^3$

Total volume: $85020000 \times 8 = 680160000 \text{ mm}^3$

Volume area above Palet

Length palet is 5500 mm.

- Length: 5500 mm
- Width: 1100 mm
- Height: 1027 mm
- Volume: 6213350000 mm^3

Ratio

$((6213350000 - 680160000) / 6213350000) \times 100\%$

= 89%

APPENDIX 3: HAND CALCULATIONS

A meeting with a material expert at Civil engineering, P.C.J.Hoogenboom. It was advised that simulating the wood with solidworks was possible, but the stresses present are not represented by the von mises, but by sigma one. Besides the simulations in solidworks, the expert mentioned that hand calculation were also possible in this situation.

Calculation bending stress in steel stand

E-modulus: 210 GPa

Length: 1100 mm

Surface moment of Inertia: $2 \times ((bh^3 - (b-2w)(h-2w)^3)/12)$

$30 \times 30 \times 3 = 79704 \text{ mm}^4$

$40 \times 30 \times 3 = 101664 \text{ mm}^4$

$50 \times 30 \times 3 = 123624 \text{ mm}^4$

$50 \times 30 \times 4 = 150464 \text{ mm}^4$

Force: 2021 N

Moment: 2223100 Nmm

Distance to neutral line = $y : 15 \text{ mm}$

Yield strength : 235 MPa

$\text{Sigma} = (M \cdot y) / I = (2223100 \cdot 15) / 79704 = 418,38 \text{ MPa}$

$30 \times 30 \times 3 = 418,38 \text{ MPa}$

$40 \times 30 \times 3 = 328,00 \text{ MPa}$

$50 \times 30 \times 3 = 269,74 \text{ MPa}$

$50 \times 30 \times 4 = 221,62 \text{ MPa}$

$V_{\text{max}} = (FL^3) / (3EI) = (2021 \cdot 1100^3) / (3 \cdot 210000 \cdot 79704) = 53,57 \text{ mm}$

$30 \times 30 \times 3 = 53,57 \text{ mm}$

$40 \times 30 \times 3 = 41,99 \text{ mm}$

$50 \times 30 \times 3 = 34,53 \text{ mm}$

$50 \times 30 \times 4 = 28,37 \text{ mm}$

These calculations are shown here and show the plank meets the requirements, but the frame needed for the increased load is 50x30x4. The expert also mentioned the wooden planks not having an influence on the behavior of the frame during impact of the load directly on the frame. So, simulation with only the frame would suffice.

Calculation bending stress in plank

E-modulus: 10514 MPa

Length: 1900 mm

Surface moment of Inertia: $(bh^3)/12$

$185 \times 27 = 303446,25 \text{ mm}^4$

Force: 2021 N

Moment: 959975 Nmm

Distance to neutral line = $y : 13,5 \text{ mm}$

Bending strength : 79MPa

$\text{Sigma} = (M \cdot y) / I = (959975 \cdot 13,5) / 303446,25 = 42,70 \text{ MPa}$

$V_{\text{max}} = (FL^3) / (48EI) = (2021 \cdot 1900^3) / (48 \cdot 10514 \cdot 303446,25) = 90,5 \text{ mm}$ will be the maximum deflection that will occur in the plank.

$\text{Angle} = (FL^2) / (16EI) = (2021 \cdot 1900^2) / (16 \cdot 10514 \cdot 303446,25) = 0,142 \text{ rad} = 8,14 \text{ degrees}$ is the angle the bend will make under load.

$\text{Sin}(8,14) = (A/20) \rightarrow A = 2,8 \text{ mm}$ is the distance the plank will detach from the frame.

This means the under maximum load the screws holding the plank to the frame will only be pulled out of the wood by 2,8 mm, preventing the plank from detaching.

The simulations are used to compare to the hand calculations and prove they are correct.

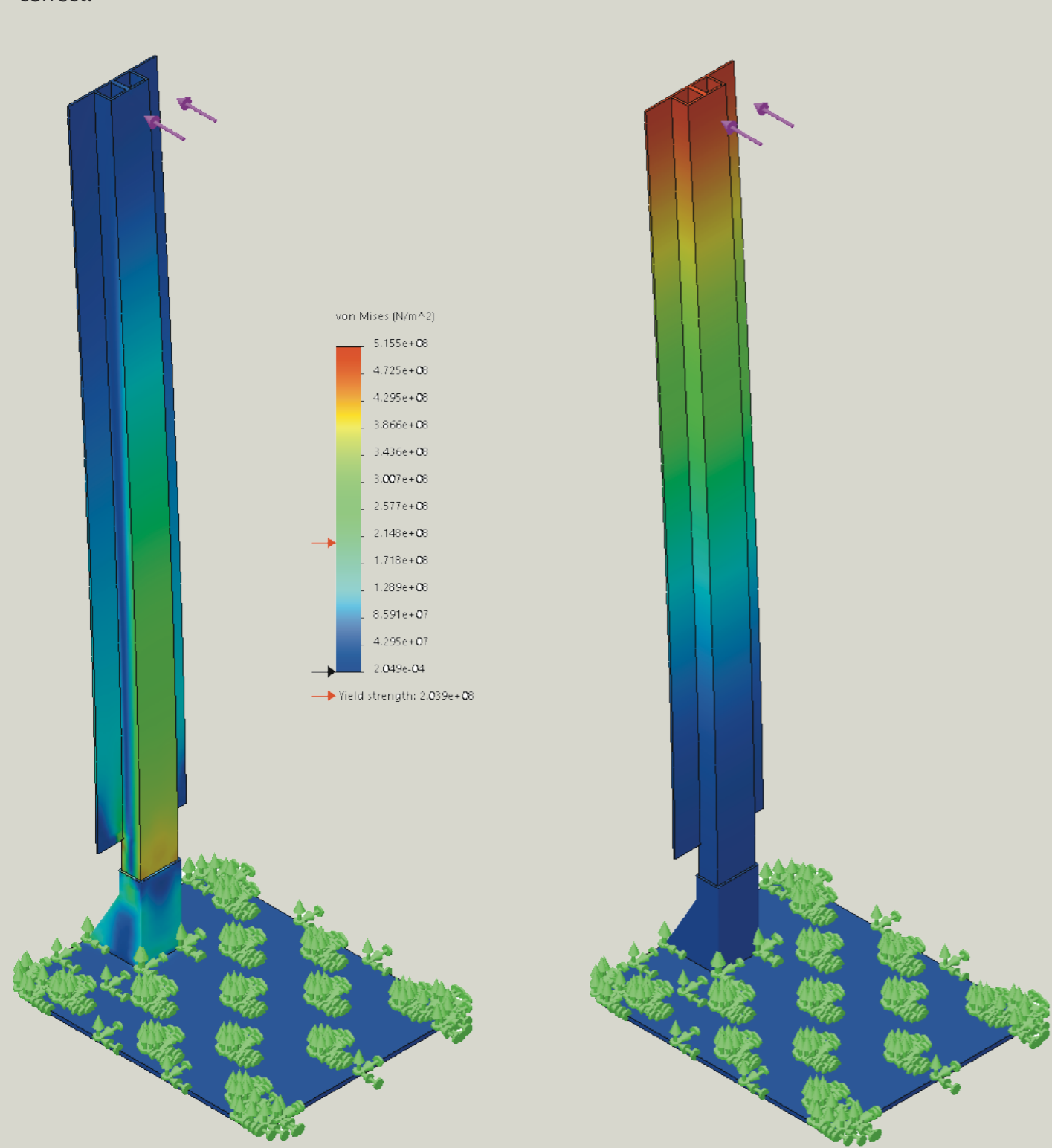


Image 6: Simulation 30x30x3

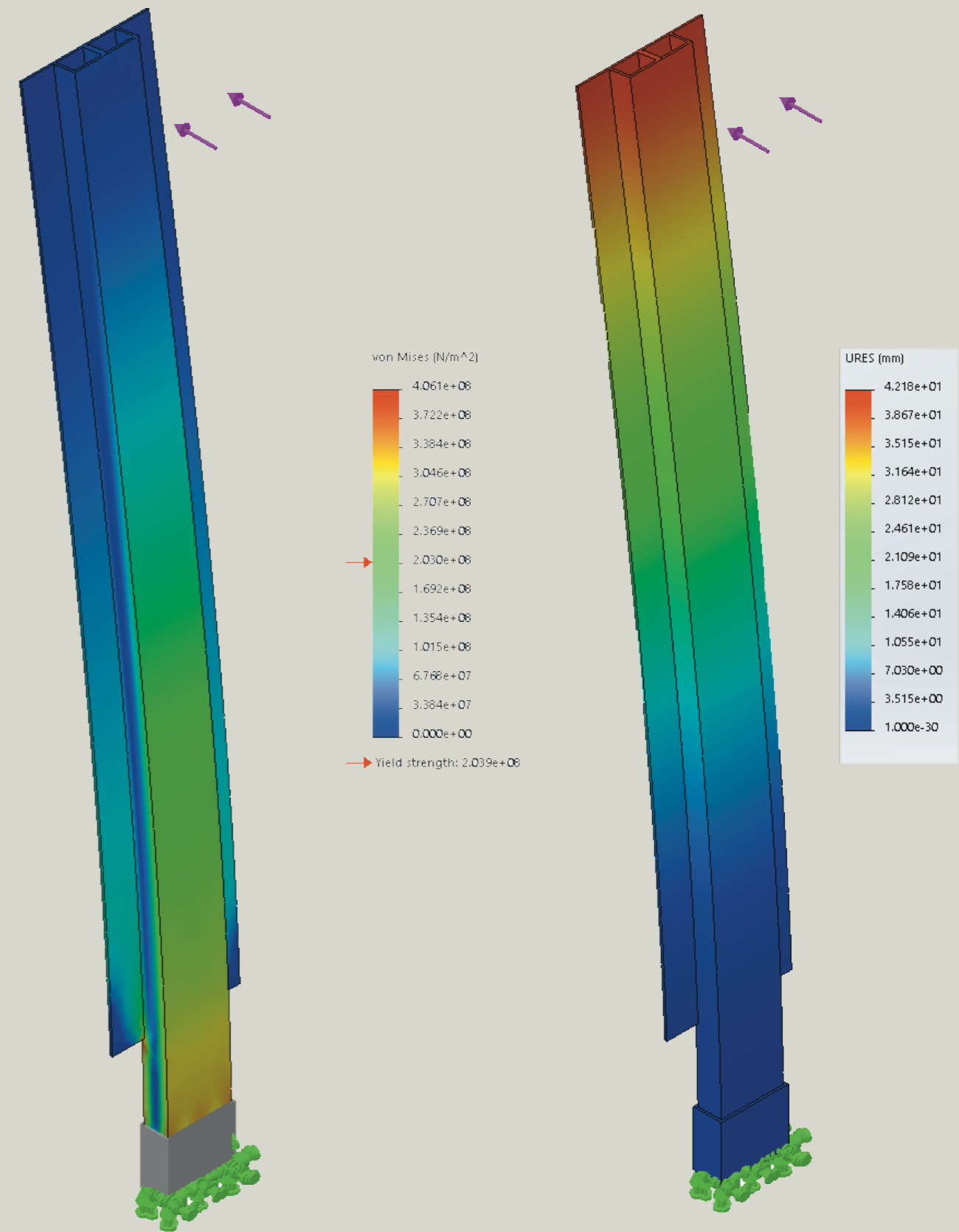


Image 7: Simulation 30x40x3

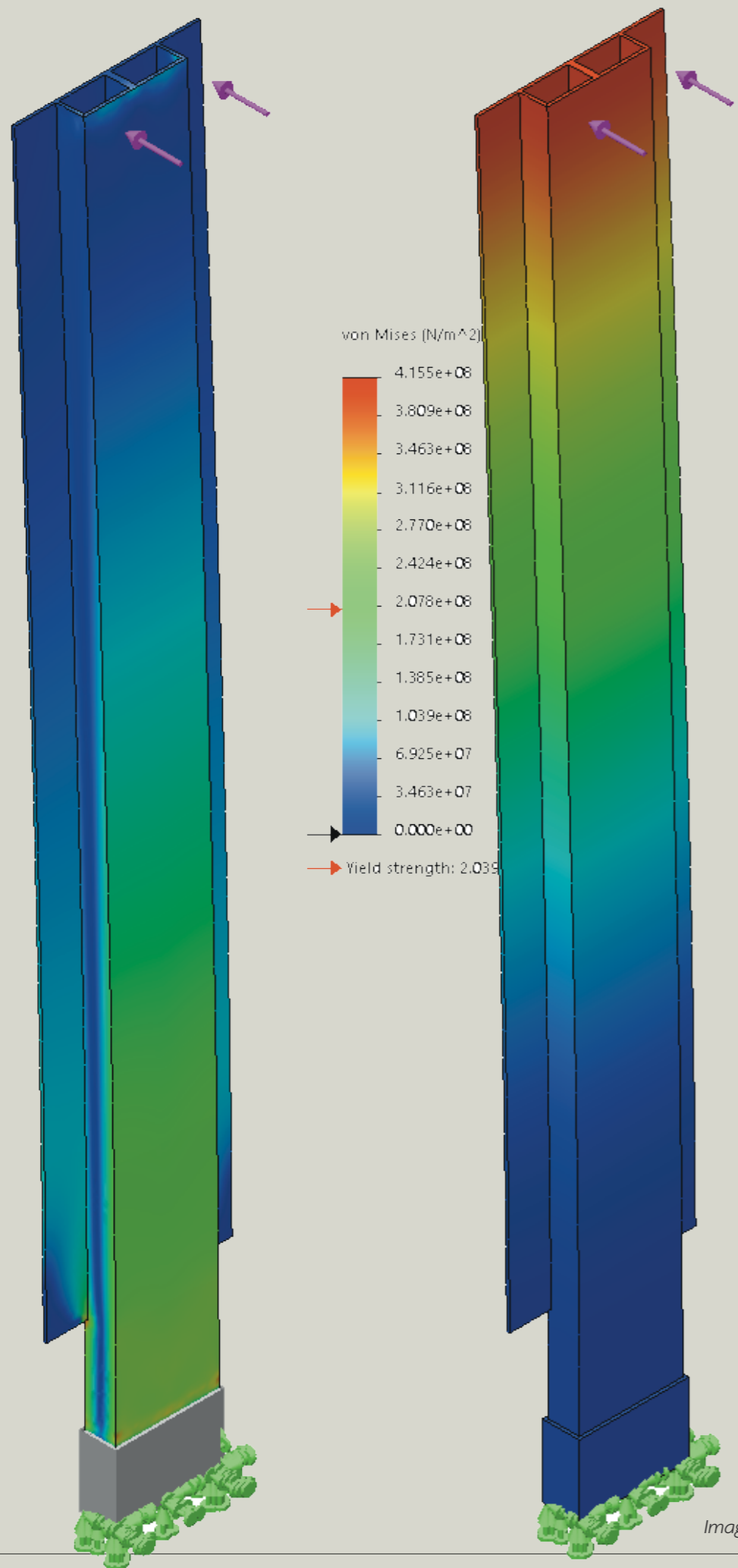


Image 8: Simulation 30x50x3

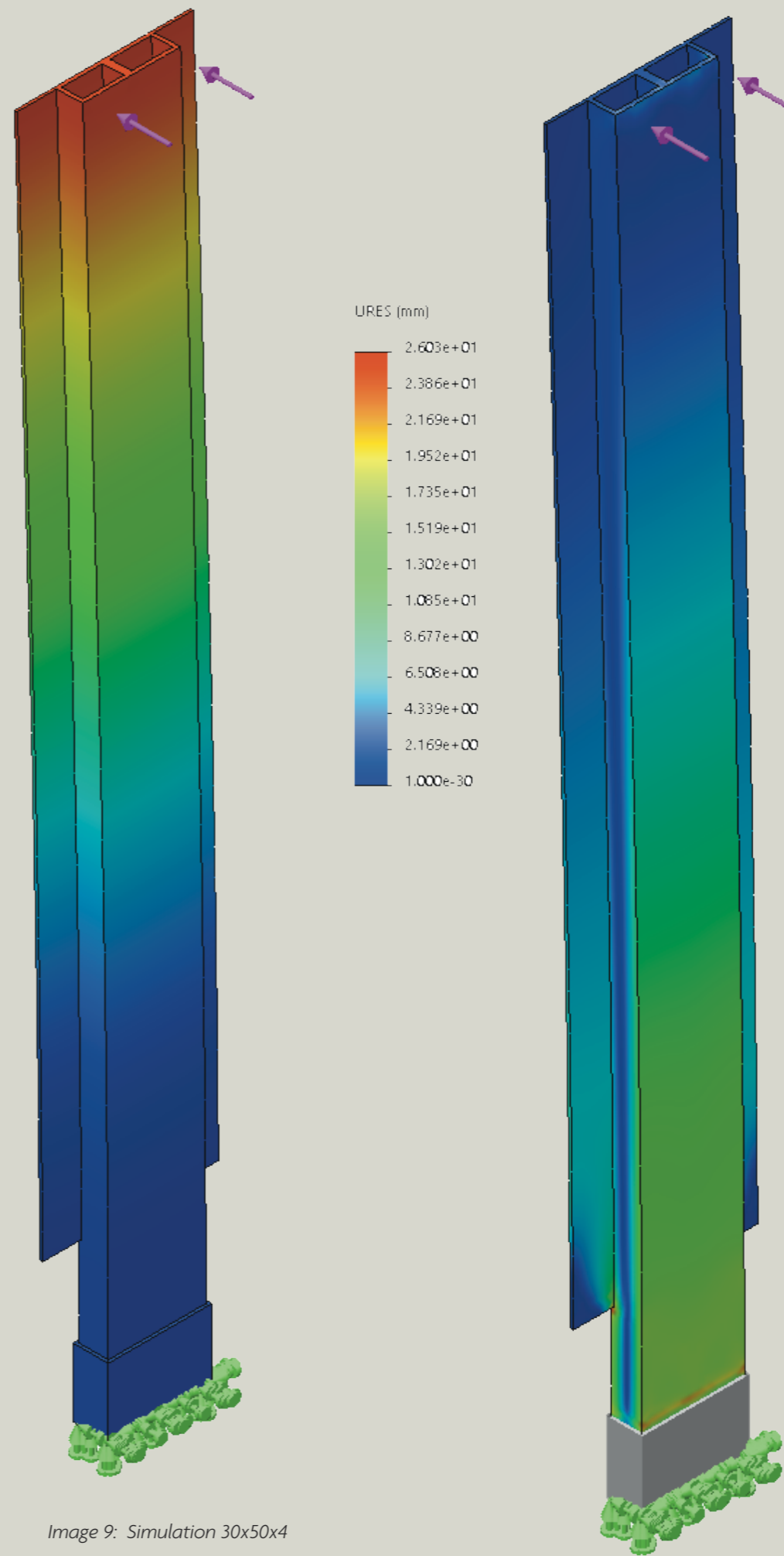


Image 9: Simulation 30x50x4

APPENDIX 4: COMPARISON TRANSPARENT VS WOODEN BOARDING

This table shows a comparison between te
wooden boarding and transparent boarding.

	Wooden	Transparent
Standard size (m)	5	2
Transport volume (m ³ /palet)	7,26	3,81
Transport amount (sections/palet)	8	50
Transport amount (m/palet)	40	100
Cost price (euro/m)	18,17	67,22
Rental price (euro/m)	15	40
Weight (kg/m)	9,2	12
Proposed life span (years)	5	5
Meters/stand	1,98	2

APPENDIX 5: PORTFOLIO

Ice-World does not stop where the ice rink ends. Ice-World offers lots of accessories that can be used to improve on the ice experience. When present at the ice rink it cannot be mistaken that ice world is active, because every accessory has in some form or way the color orange incorporated.

- Bobby the seal
- Tommy the reindeer
- Icebyk
- Curling stones
- The base
- Fun slide tube
- Protection
- Ice maintenance
- Cold Fingers

It is not only the colour orange through which Ice-World lets the user know it is their product. Ice-World also does this by putting their name on almost everything. (see fig xx.). The color orange is also solely used on rental ice rinks. Ice world sells blue skating aids for example.

This means that when visiting a certain ice rink, it makes it easy to spot which one is an Ice-World rink.

The colour orange can be seen as typical Dutch. In the Netherlands, this is acceptable, but in other countries orange is not always the preferred colour (Guido, Manager R&D, 2018) and when an ice rink is not up to company standards this could also be a disadvantage, because everyone can see who delivered the poor quality.

From certain products like the cold fingers it shows that Ice-World is innovating on how to create the best ice possible and create lots of other activities besides skating.

It must be acknowledged that even though Ice-World has all these products in their portfolio. Ice-World only assembles their own wooden boarding and ice rink piping system.

Conclusions

Ice world did not yet explore the relation between the different product groups. This might be an interesting search area.

Ice world has a clear corporate identity which revolves around the color orange. Looking at the portfolio this becomes quite clear. Besides the color Ice-World places their logo on every product. One of the reasons for this is to prevent theft, but also to have exposure.



Image 10: Portfolio impression Ice-World. Source: Ice World.

APPENDIX 6: VISIT LAREN

The visit in laren was the first site visit done. This visit showed a lot of problems with the current system and showed the entire proces of the boarding installation. This visit was done on 21 November 2018.

Foto description:

1. Wooden boarding that has been unloaded at Laren.
2. The handrail that has been bent through strapping down the sections to the pallet.
3. A boarding stand that has shifted and misalligned through strapping down the sections to the pallet.
4. An overview of how boarding sections deform through current transport method
5. Placing the first boarding section
6. A distance piece that is in the way of placing the boarding stand and needs to be moved out of the way with force.
7. A distance piece that is in the way of placing the boarding stand and needs to be moved out of the way with force.
8. Boarding sections that are not yet connected show the amount of deformation that occurs.
9. A staple used to attach sponsoring which was left from previous season.
10. Boarding sections that are not yet connected that does not allign properly.
11. Boarding placed around a tree that does not have the right size.
12. Boarding placed around a tree that does not have the right size.
A boarding stand that is bent
A boarding stand that has been fixated to the wooden floor.
2 Ice-World employees that allign the seperate sections by force, because the sections have different dimeninsions.
Connected wooden boarding sections.
Damage on the bottom board shows left over damage from multiple times of connecting the boarding to each other.

13. An Ice-World employee connecting 2 sections to each other to allign the handrail.
A piece of the metal profile used to connect the boarding in the corner sticks out. Also the boarding does not ligh up as 1 side is too long.
14. A corner of the boarding that show how the boarding does not allign properly.
15. An Ice-World employee making preparations to cut the boarding to size
16. The final result of the boarding cut to size.
17. The final result of the boarding cut to size.
18. Repurposed section to a shorter one, where the Ice-World signing now is placed out of centre.





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APPENDIX 7: VISIT RAI

This visit was done for a big recreational event in the RAI in Amsterdam. This event uses transparent boarding. This visit gives insight in the problems and proces of installing transparent boarding.

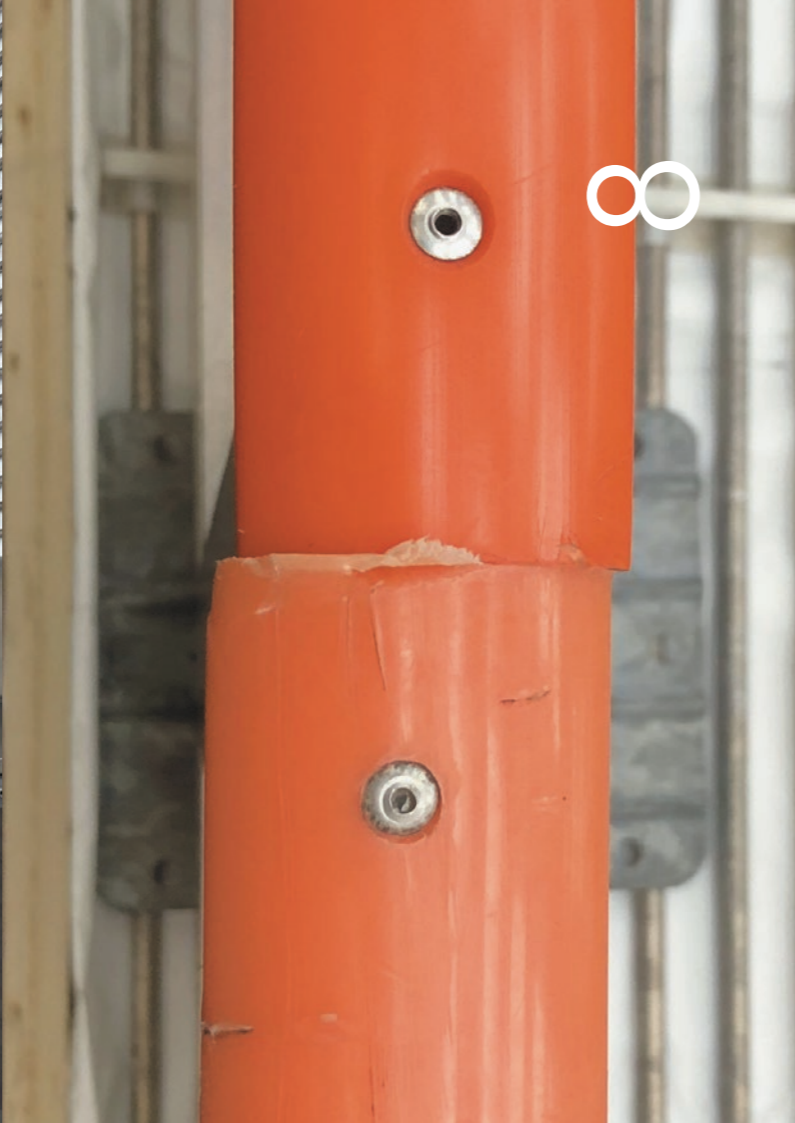
Foto description:

1. 2 Ice-World employees attaching a end piece to the boarding.
2. A smaller than standard transparent sections used to make the total boarding fit the required dimensions. The construction used to create a corner.
3. A piece of handrail previously cut at another event.
4. A curve of transparent boarding that does not align with the curve the rink requires.
5. Boarding that is too long and therefor starts bending.
6. Three different corners solved in with a different method.
7. Handrail that is misaligned and shows discoloration
8. An Ice-World employee cutting a transparent boarding section to size.





6



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APPENDIX 8: VISIT ARNHEM

In Arnhem Ice-World did a pilot test with assembling the entire boarding on site and transporting every part seperately.

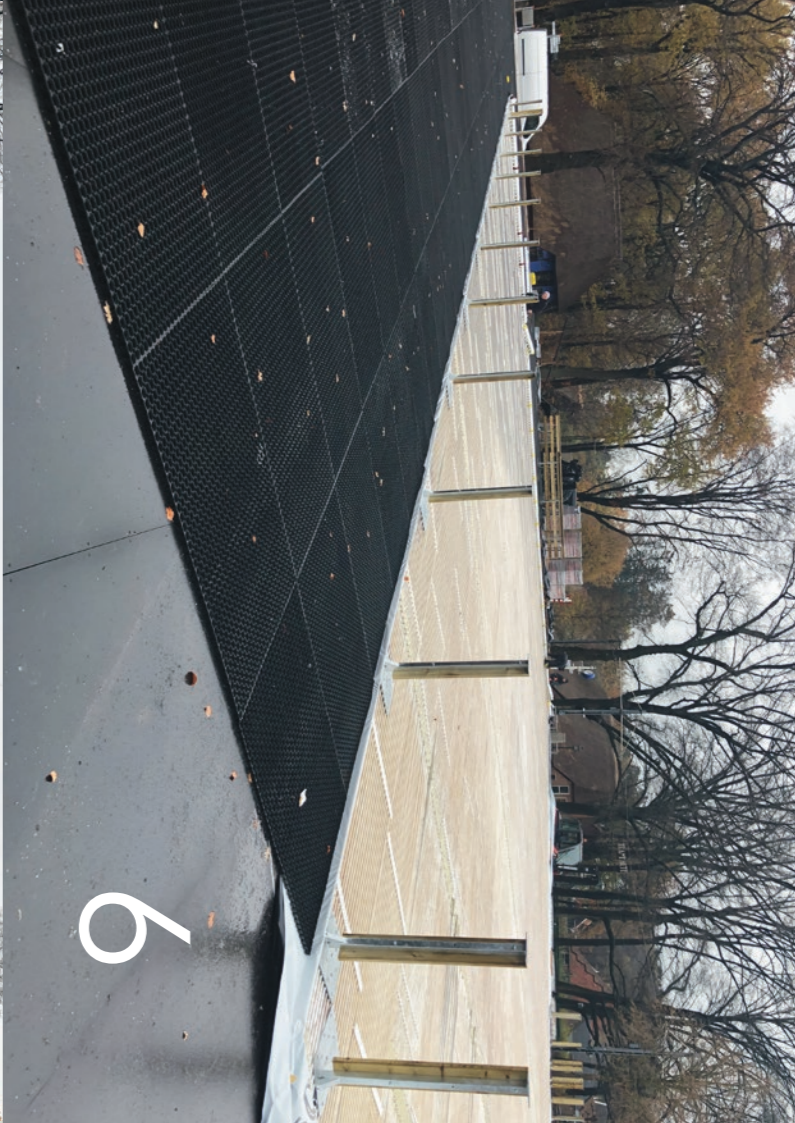
Foto description:

1. A package of boarding stands.
2. A package of 5m wooden boards.
3. 2 Ice-World employees transporting wooden boards by hand.
4. Ice-World employees using the wooden boards to place the stands at the right distance.
5. Ice-World employees using the wooden boards to place the stands at the right distance.
6. Overview of the main ice rink with most of the boarding stands placed.
7. Some of the first boards that are attached to the stands.
8. Some of the first boards that are attached to the stands.
9. 2 boarding stands interfering with eachother in the corner.
10. Corner construction of the boarding
11. Overview of main ice rink, with wooden boards placed every 5m.
12. Second rink finished half way.





5



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7



8



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11



12

APPENDIX 9: CUSTOMER LIGHTING IMPLEMENTATION

This collage shows images of customer integrating lighting onto and into the boarding and ice rink. This shows a need from the customers for lighting integration into the ice rink. This could be an interesting desing direction and business opportunity.



Image 11: Collage customer lighting

APPENDIX 10: PROFESSIONAL LIGHTING IMPLEMENTATION

This collage shows ice skating events where lighting has a significant influence on the atmosphere of the event. An interesting fact is that there is a lot invested into the illumination around the ice rink, but when you look closely the boarding play not a single role in the entire setup.



Image 12: Collage professional lighting

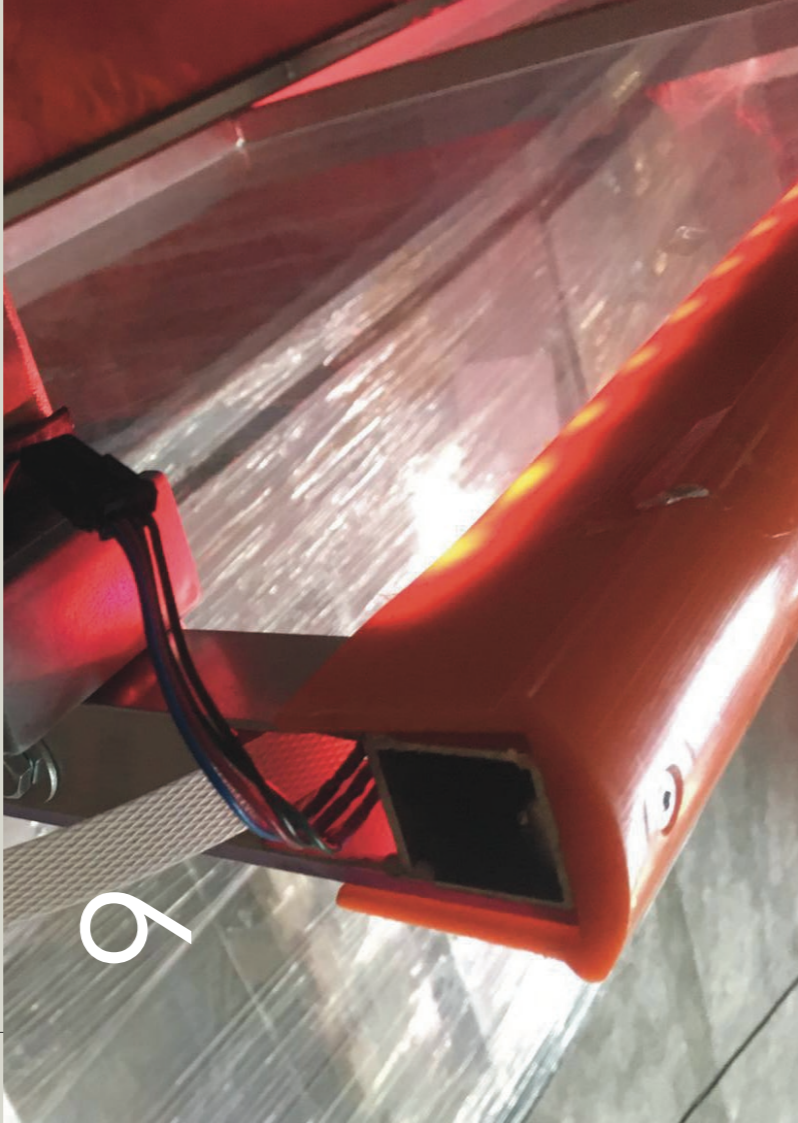
APPENDIX 11: BOARDING LIGHTING CONCEPT

Ice-World did start with boarding system with integrated lighting but did not continue with the design, as Ice-World presumed that there was no market for it. Research shows otherwise and would be a good investment.

Foto description:

1. LED-strip intergrated into transparent handrail.
2. Powersupply of the LED-strip, attached on the backside of the stand.
3. LED-strip intergrated into the current orange handrail.
4. A top view of the transparent handrail.
5. An overview of the boarding concept.
6. A close up of the connection and intergration of the LED-Boarding





APPENDIX 12: CONCEPT 1

This appendix shows extra images of concept 1. This concept is inspired by the current wooden boarding Ice-World carries.

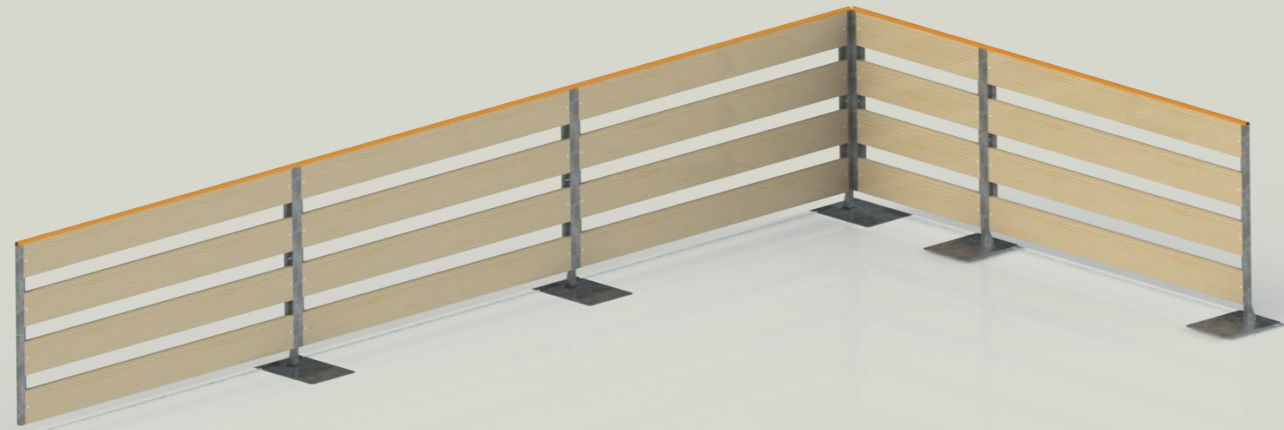


Image 13: Example setup for corner.

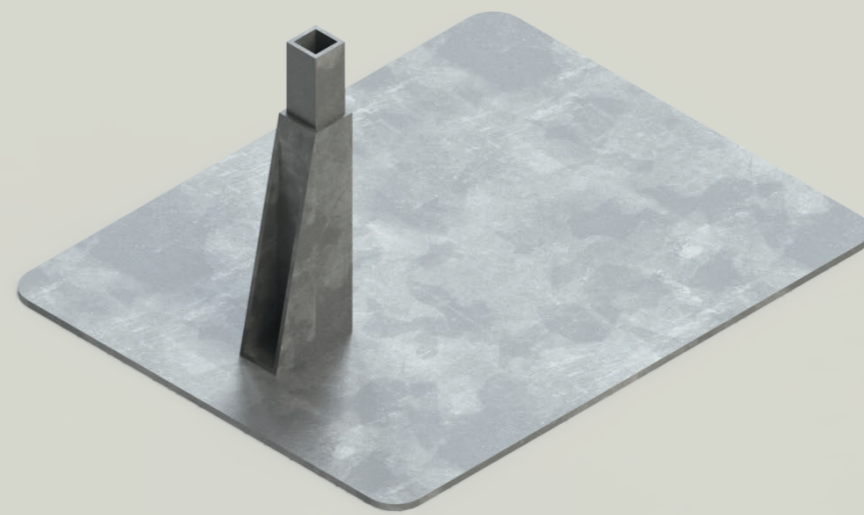


Image 15: Base concept 1.

Image 16: Right side frame



Image 17: Detail connection between planks and frame.



Image 14: Detail of left and right side frame.

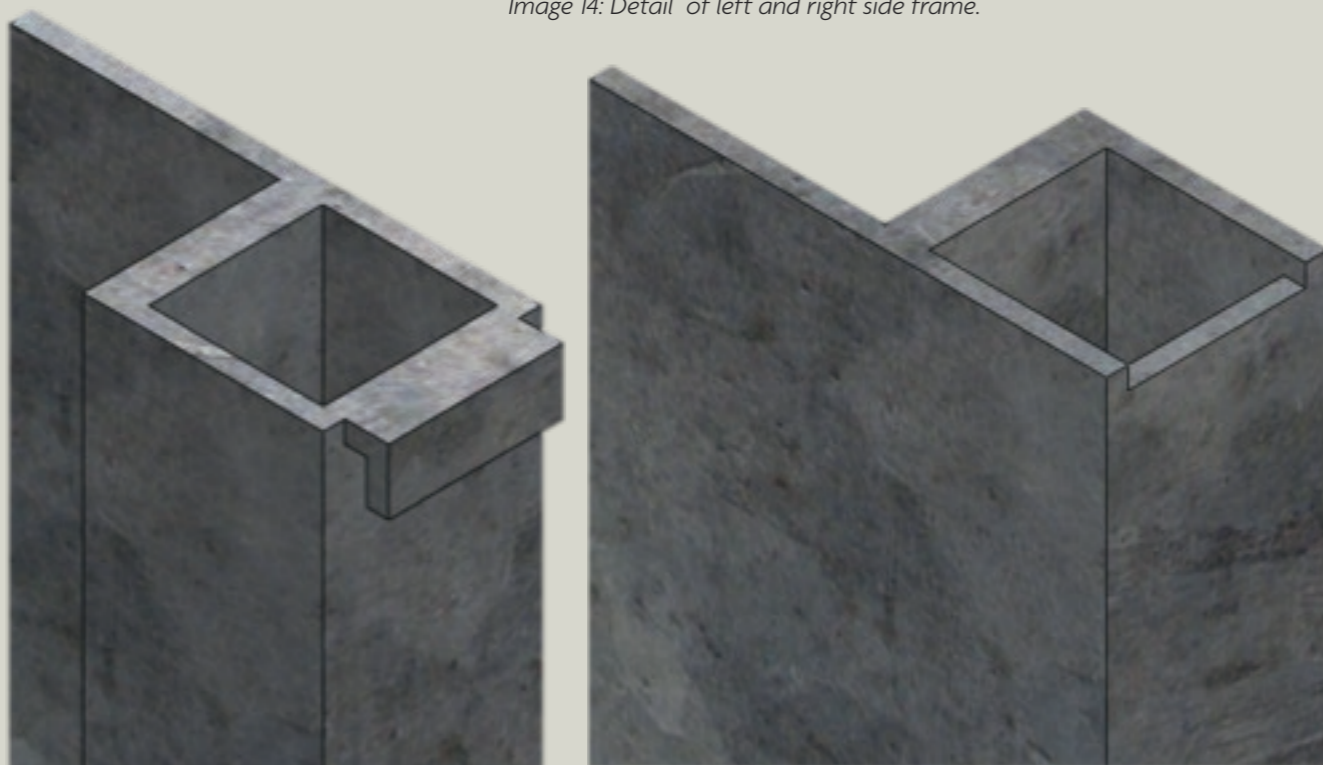


Image 18: Storage of concept 1 panels

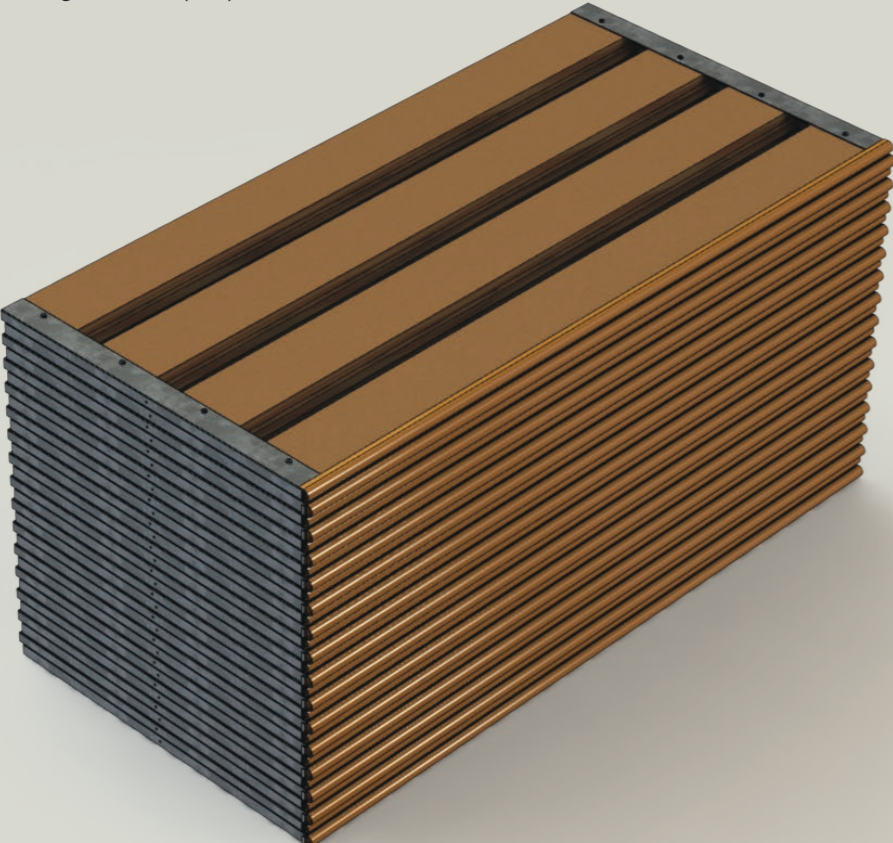


Image 20: Overview concept 1 on ice rink.



Image 21: Sideview concept 1 on ice rink.

Image 19: Storage of concept 1 bases.

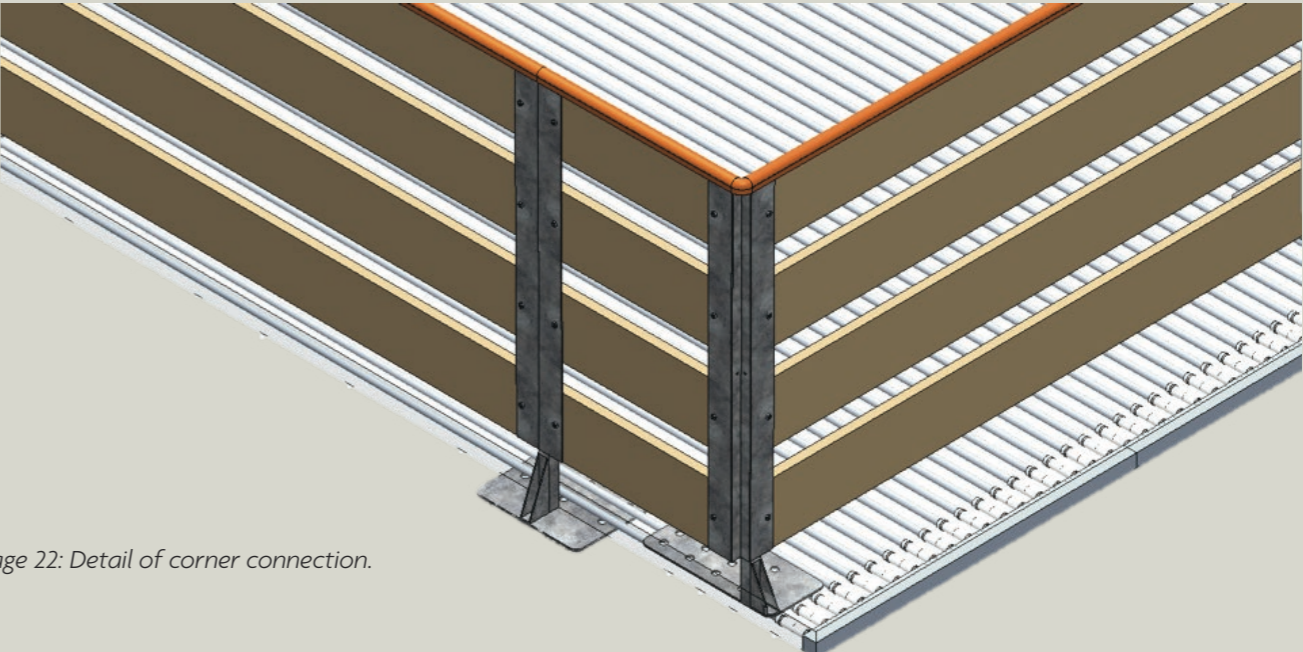
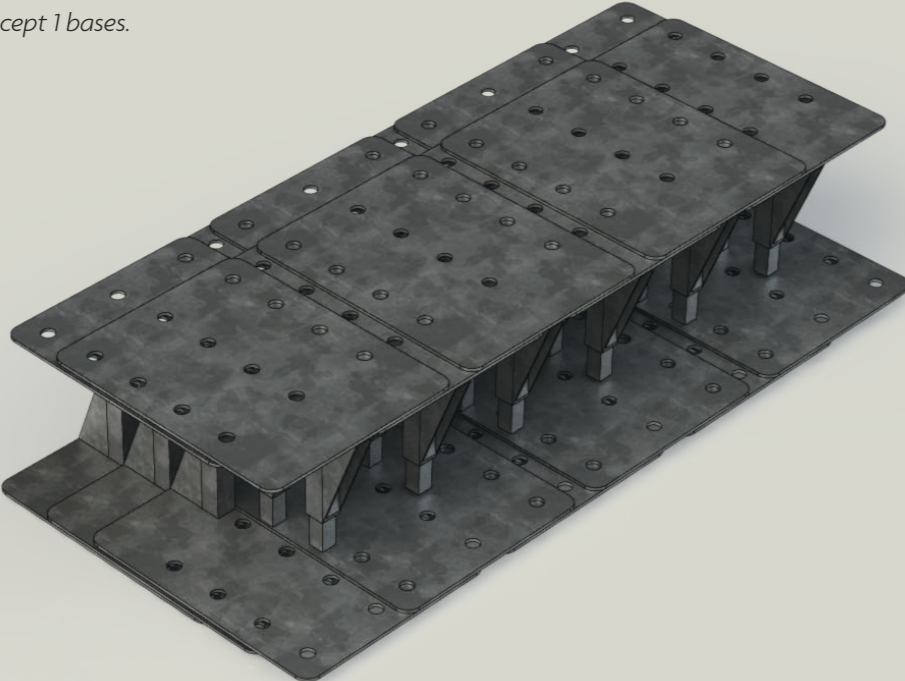


Image 22: Detail of corner connection.

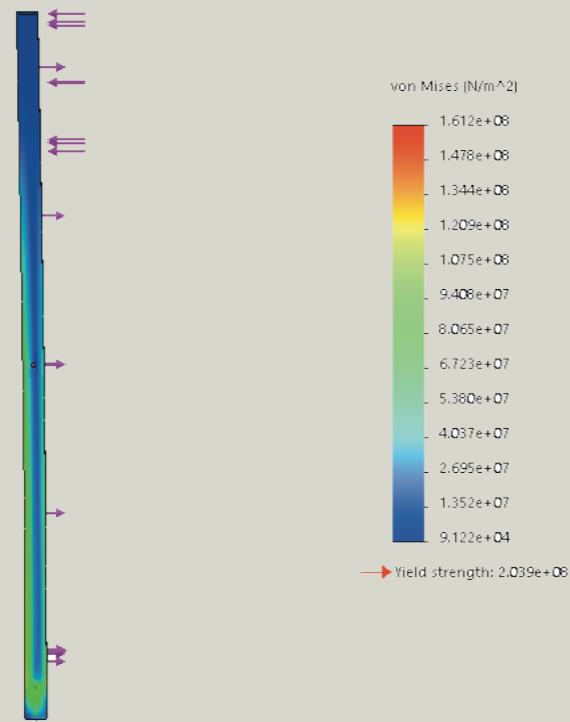


Image 23: Impact simulation of support..

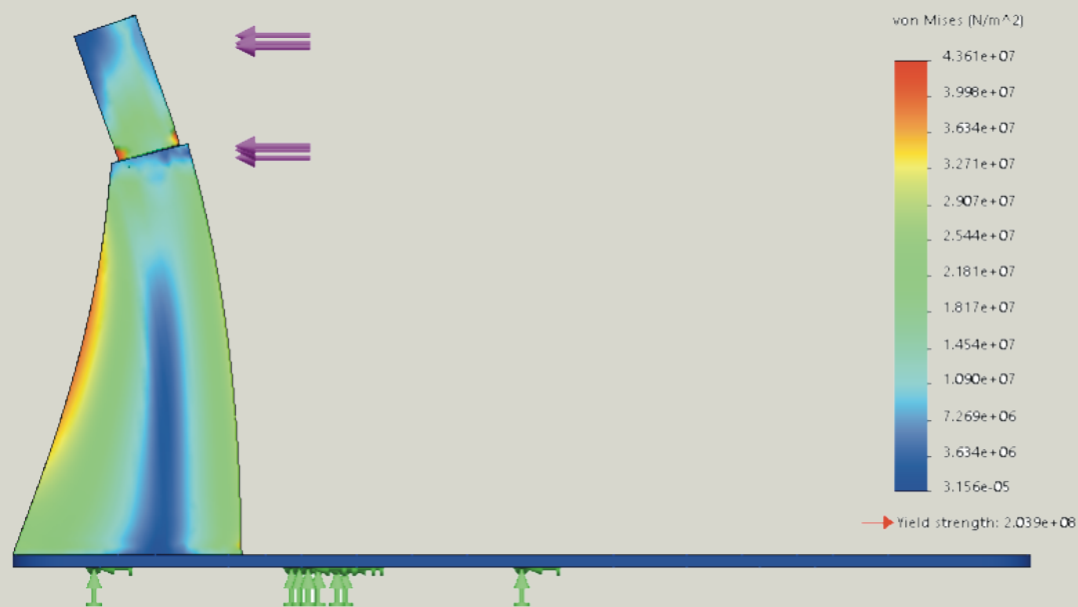


Image 24: Impact simulation of base.

Onderdeel	Concept 1
Paneel 2,04	34
Paneel 0,59	2
Paneel 1	2
Paneel 2	14
Voet laag	14
Voet hoog	36
Hoekvoet	2
Hoekprofiel	4
Handrail hoekje	4
Totaal	112
# Ver. Ond.	9

Underneath the ice rink system.

Onderdeel	Concept 1
Paneel 2,04	34
Paneel 0,59	2
Paneel 0,82	2
Paneel 2	14
Voet	48
Hoekvoet	4
Hoekprofiel	4
Handrail hoekje	4
Totaal	112
# Ver. Ond.	8

On top of the ice rink system.

These tables show the amount of different parts needed to create an entire boarding on an average ice rink. A comparison is done between a system on top of the ice rink system and underneath the ice rink system.

APPENDIX 13: CONCEPT 2

This appendix shows extra images of concept 2. This concept is inspired by the modular fencing used in architecture.

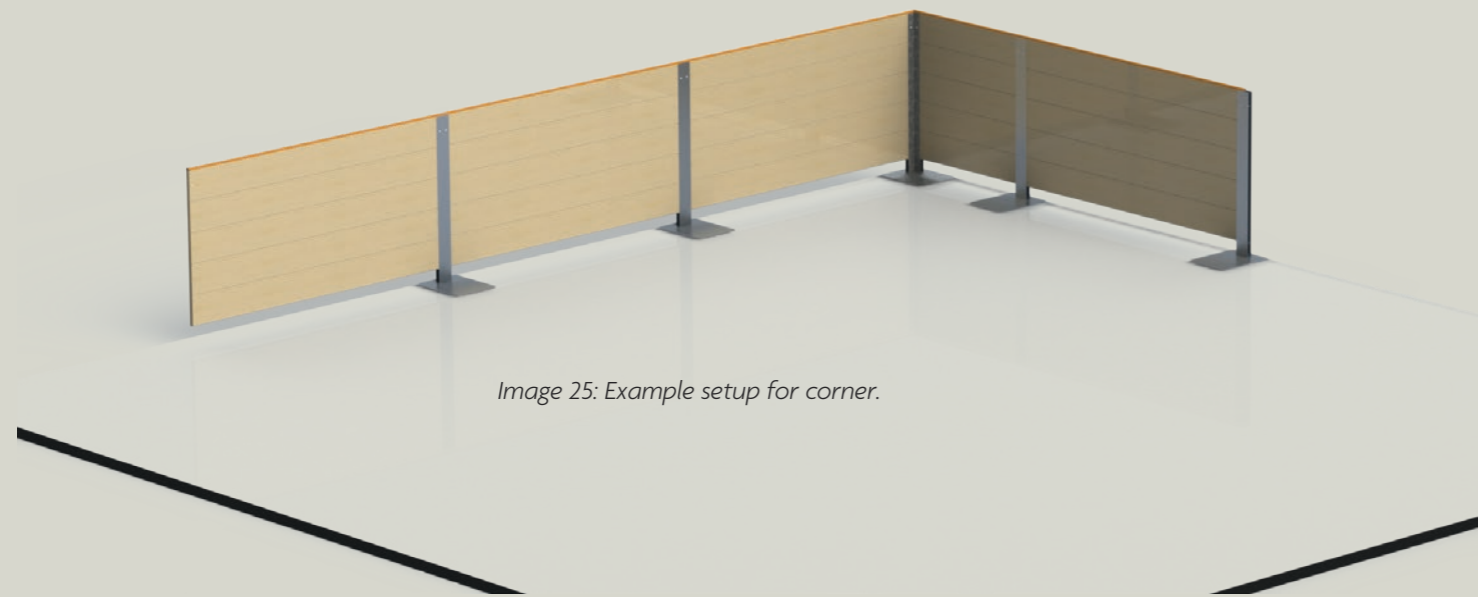


Image 25: Example setup for corner.

Image 26: Detail of support with stop plate.

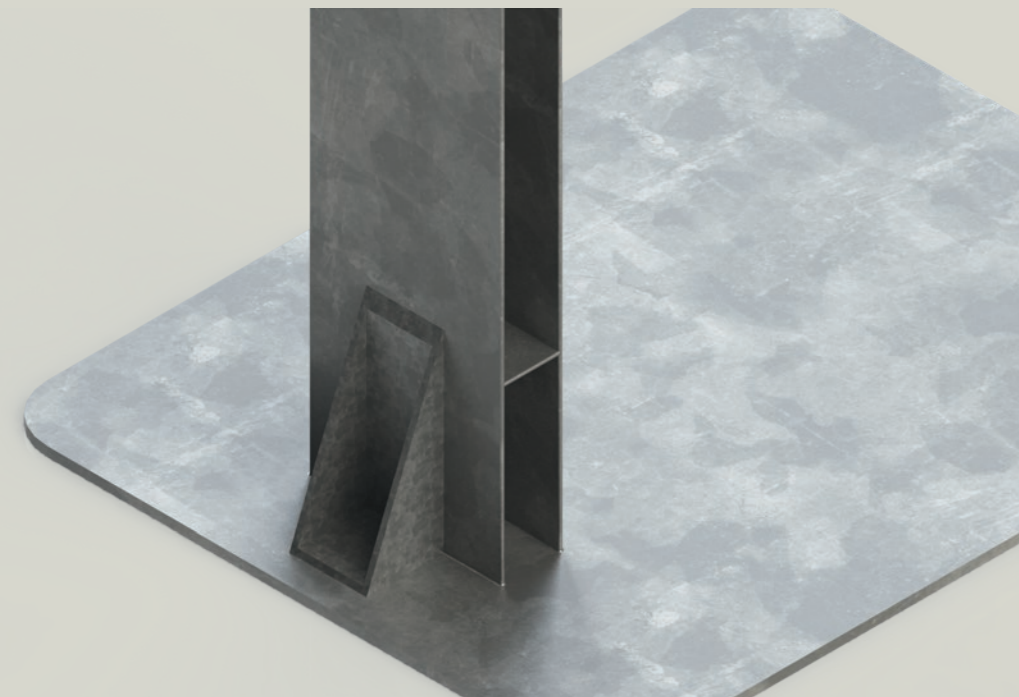


Image 27: Corner support.

Image 28: Detail of connection plank to support.

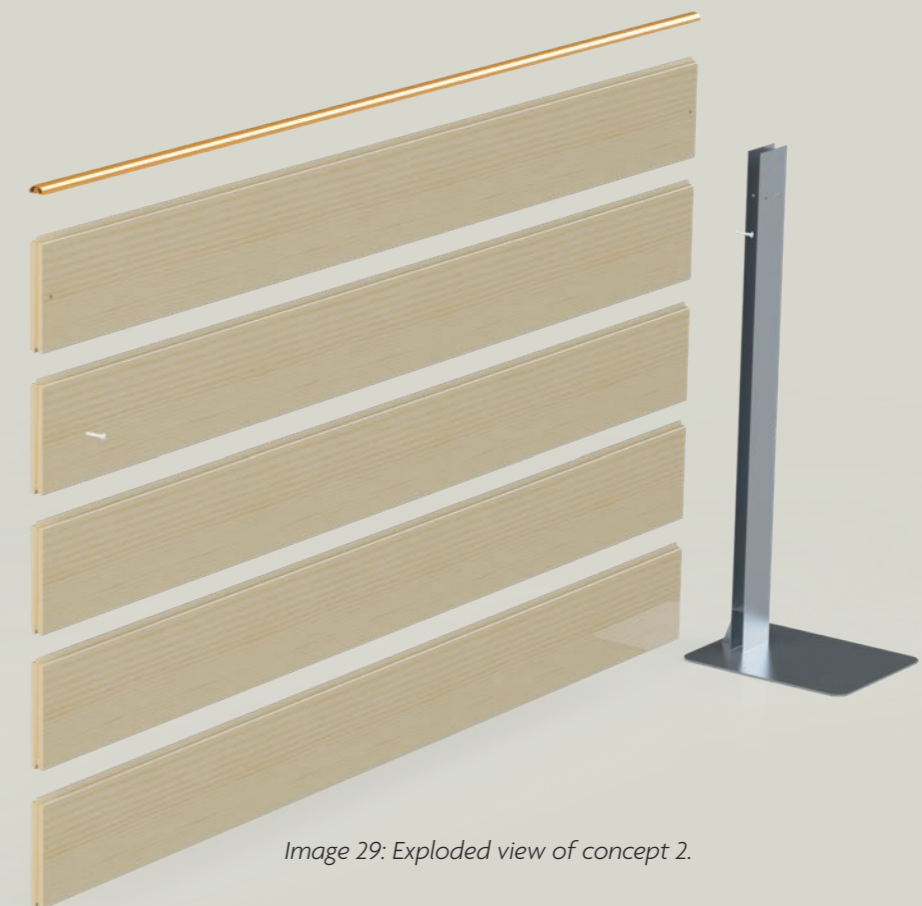
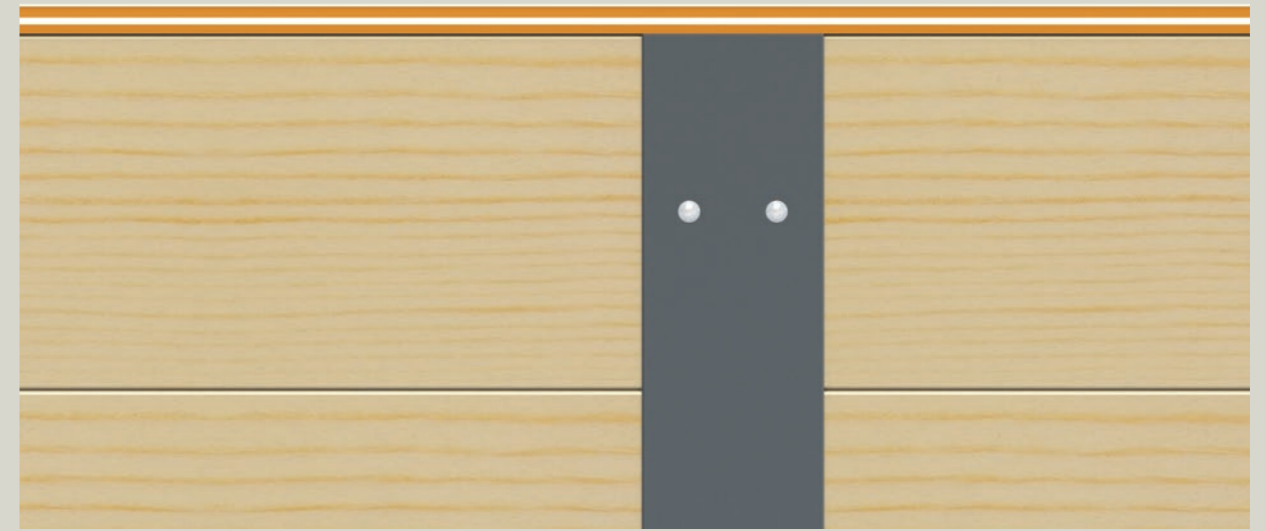


Image 29: Exploded view of concept 2.

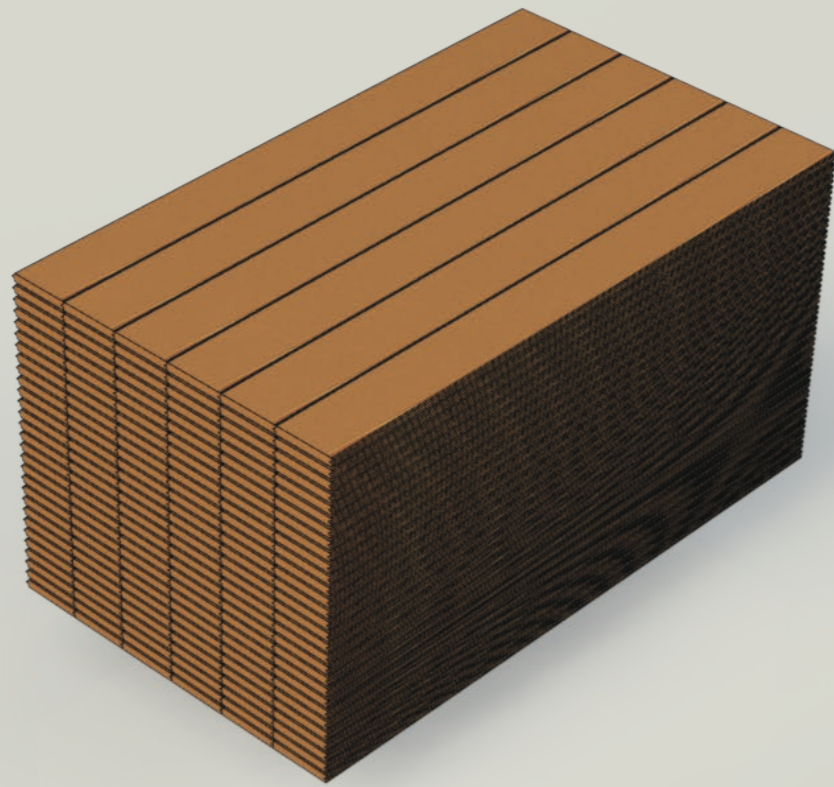


Image 30: Storage of concept 2 planks.



Image 32: Overview concept 2 on ice rink.

Image 31: Storage of concept 2 supports.

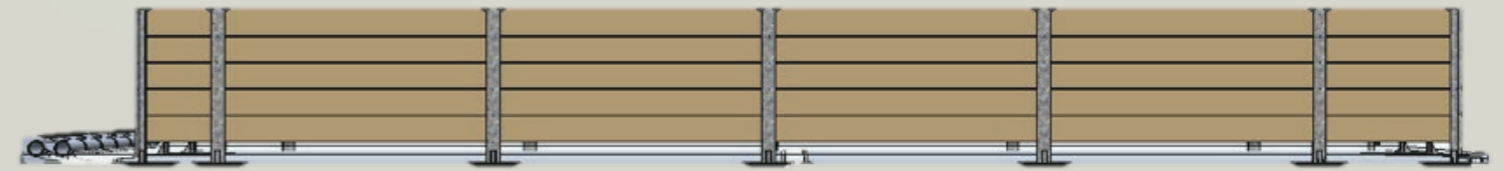
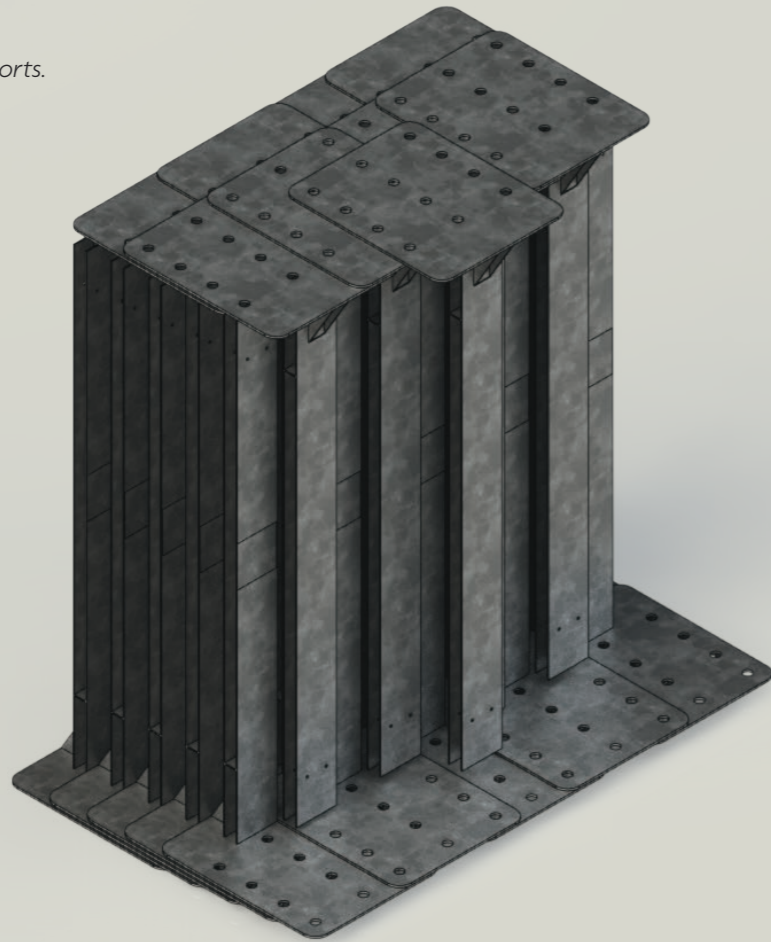


Image 33: Sideview concept 2 on ice rink.

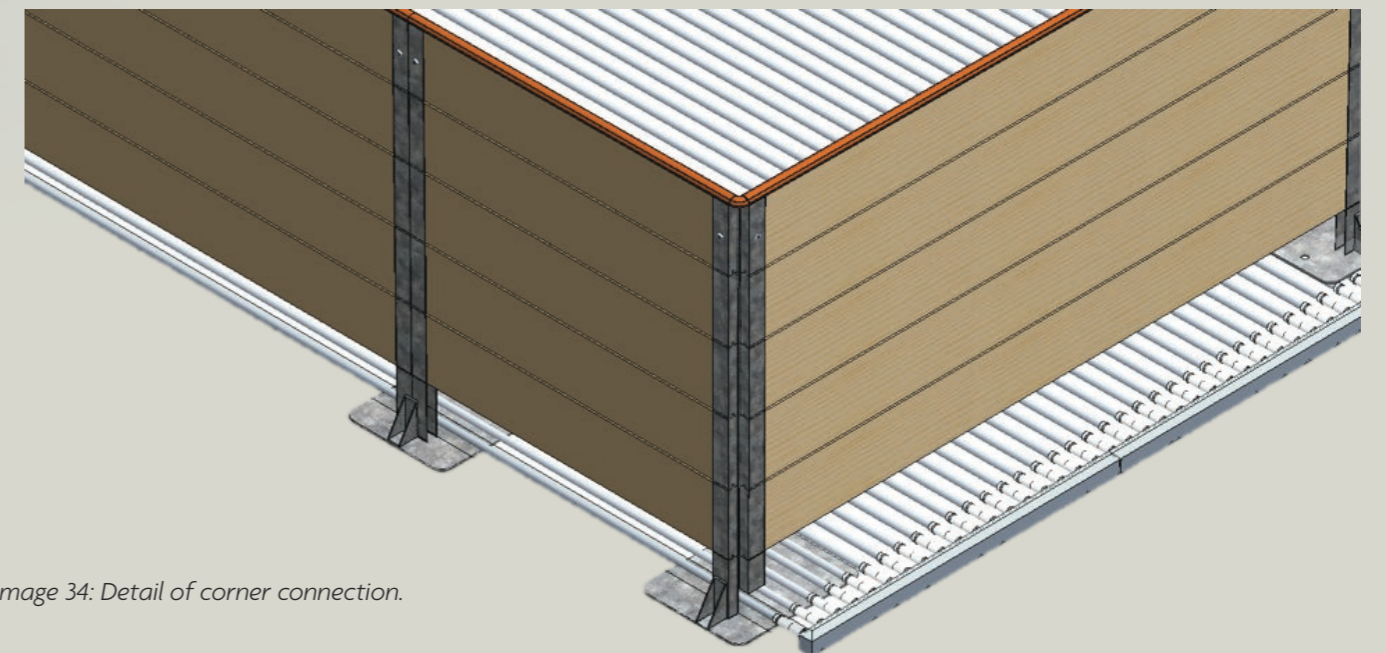
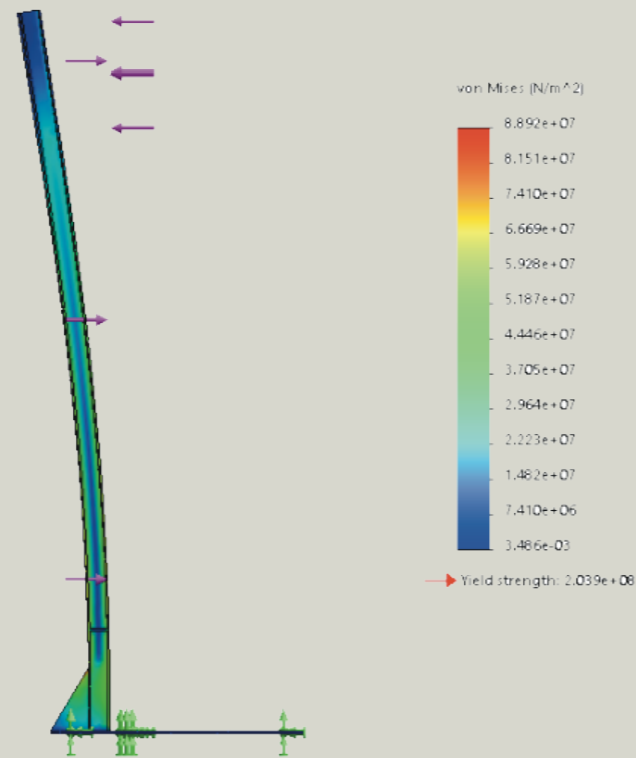


Image 34: Detail of corner connection.



product. For Instructional Use Only.

Image 35: Impact simulation of support.

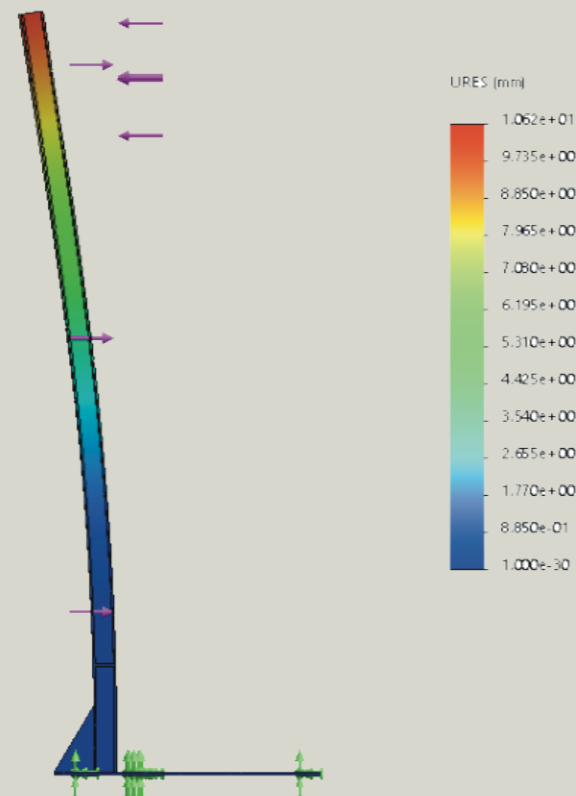


Image 36: Impact simulation of support.

Onderdeel	Concept 2
Plank 2,04	136
Plank 2,04 hr	34
Plank 0,582	8
Plank 0,582 hr	2
Plank 1	8
Plank 1 hr	2
Plank 2	56
Plank 2 hr	14
Poot laag	14
Poot hoog	34
Hoekpoot l	2
Hoekpoot r	2
Handrail hoekje	4
Totaal	326
# Ver. Ond.	15

Underneath the ice rink system.

These tables show the amount of different parts needed to create an entire boarding on an average ice rink. A comparison is done between a system on top of the ice rink system and underneath the ice rink system.

Onderdeel	Concept 2
Plank 2,04	136
Plank 2,04 hr	34
Plank 0,582	8
Plank 0,582 hr	2
Plank 2	56
Plank 2 hr	14
Plank 0,812	8
Plank 0,812 hr	2
Poot	48
Hoekpoot	4
Plank 2	56
Plank 2 hr	14
Handrail hoekje	4
Totaal	326
# Ver. Ond.	13

On top of the ice rink system.

APPENDIX 14: CONCEPT 3

This appendix shows extra images of concept 3. This concept is inspired by the transparent boarding of Ice-World with the angled profiles used to create the water basing intergrated into the support.



Image 37: Example setup for corner.



Image 39: Detail of handrail of concept 3 with sponsor ridge.

Image 38: Rear view of concept 3 panel and support.



Image 40: Concept 3 support.



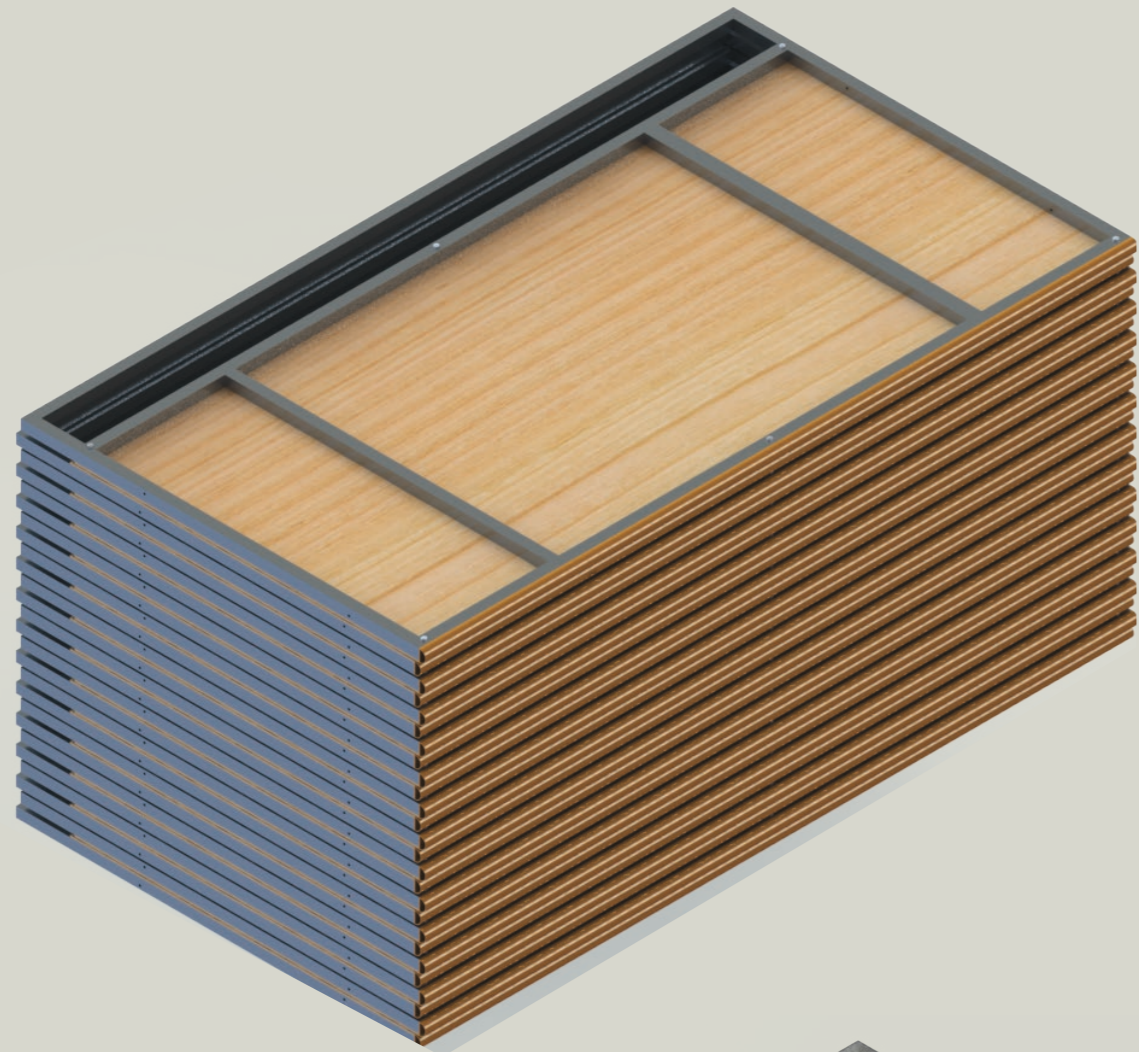


Image 41: Storage of concept 3 panels

Image 42: Storage of concept 3 supports.

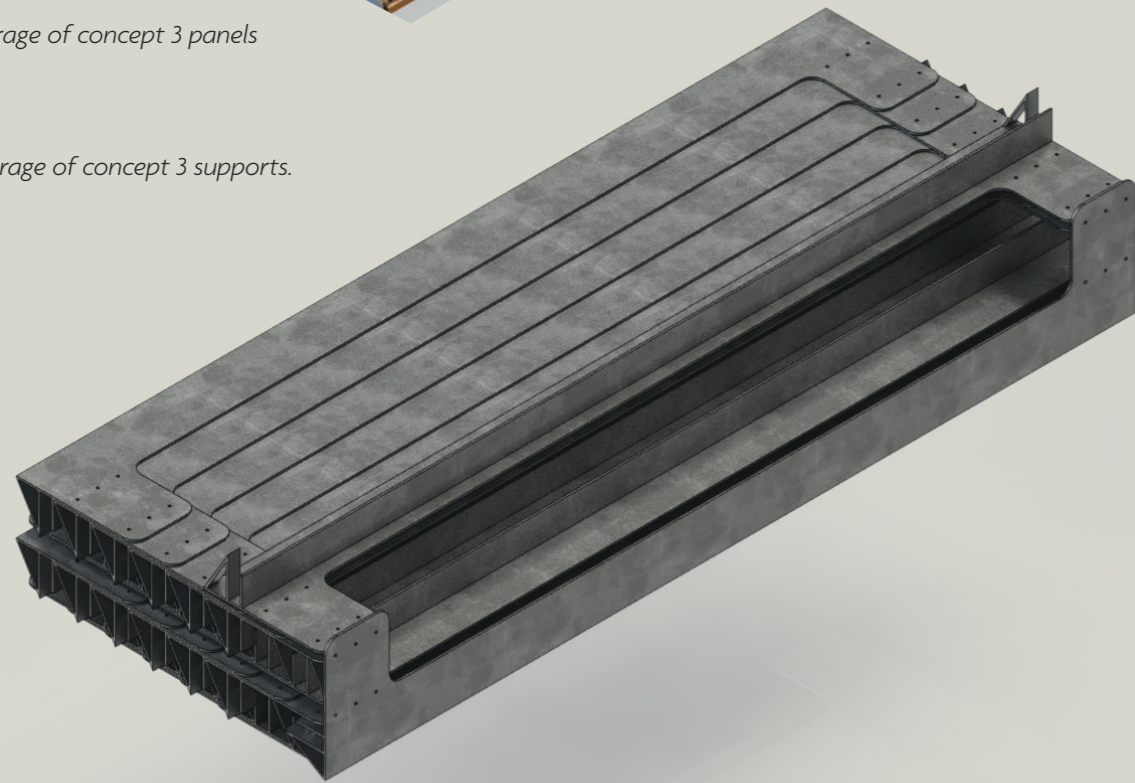


Image 43: Overview concept 3 on ice rink.



Image 44: Sideview concept 3 on ice rink.

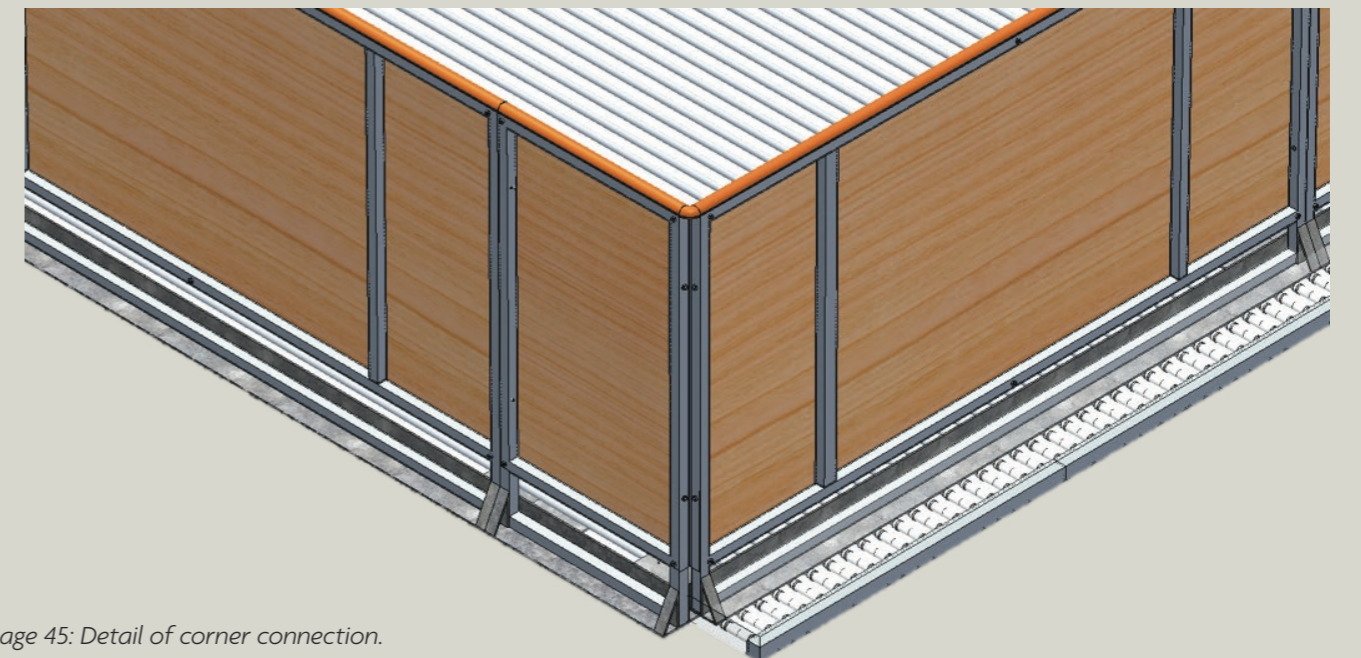


Image 45: Detail of corner connection.

Model name: Concept 3 rails
 Study name: Static 1(-Default-)
 Plot type: Static nodal stress Stress1

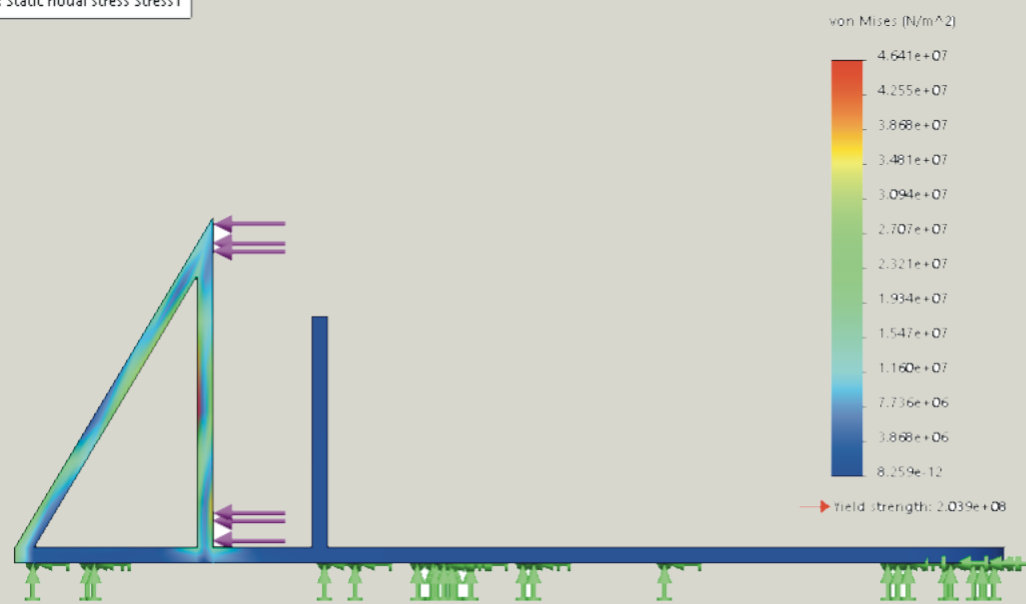


Image 46: Impact simulation of support..

Onderdeel	Concept 3
Paneel 2,04	34
Paneel 0,58	2
Paneel 1	2
Paneel 2	14
Rails 2,04	34
Rails 0,58	2
Rails 100	2
Rails 200	14
Hoekprofiel	4
Handrail hoekje	4
Totaal	112
# Ver. Ond.	10

Underneath the ice rink system.

These tables show the amount of different parts needed to create an entire boarding on an average ice rink. A comparison is done between a system on top of the ice rink system and underneath the ice rink system.

Onderdeel	Concept 3
Paneel 2,04	34
Paneel 0,46	2
Paneel 0,395	4
Paneel 2	14
Rails 2,04	34
Rails 2	14
Hoekrails 0,46	2
Hoekrails 0,395	4
Hoekrails 2,04	2
Hoekprofiel	4
Handrail hoekje	4
Totaal	118
# Ver. Ond.	11

On top of the ice rink system.

APPENDIX 15: ASSEMBLY AND INSTALLATION TIME COMPARISON

This table shows the comparison between the three concepts on assembly and installation time. Concept one and concept three are both panels that are pre-assembled once. Concept two will be assembled and disassembled every year at the ice rink. This comparison was made to research the effects of a pre-assembled system or assembling on site.

Forty-five panels of two-meter have been used for this comparison. The table show concept two has the lowest assembly time, and concept three has the most economical installation time. For concept one and three, the assembly time is taken into account only the first year, but for concept two, the install time is including 'assembly time'. For the first year concept, two has the lowest overall time, which is expected, but for the other years, concept 3 has the lowest overall time. When comparing concept one and two, the table shows that after five years, a pre-assembled concept is preferred.

	Concept 1	Concept 2	Concept 3
Assembly time	10 min	3 min	8 min
Install time	4 min	6 min	3 min
Year 1	630 min	405 min	495 min
Year 2	810 min	675 min	630 min
Year 3	990 min	945 min	765 min
Year 4	1170 min	1215 min	900 min
Year 5	1350 min	1485 min	1035 min
Year 6	1530 min	1755 min	1170 min
Year 7	1710 min	2025 min	1305 min
Year 8	1890 min	2295 min	1440 min

APPENDIX 16: RANKING THE CRITERION

This table shows how the criteria have been ranked. These method places every criterion against each other to be able to decide if it is more important or not. When this is done for every criterion, a ranking is a final outcome.

These criteria have been selected in collaboration with Ice-World.

	Product Cost	Storage Volume	Looks and fini	Maintenance c	Expected Lifespan	Ease of install	Installation time	Handling	Size adjustability
Product cost	1	1	1	0	0	0	0	0	0
Storage volume	0	1	0	0	0	0	0	0	0
Looks and finish	0	1	1	0	0	0	0	0	0
Maintenance cost	1	1	1	1	0	1	0	0	0
Expected lifespan	1	1	1	1	1	1	0	0	0
Ease of install	1	1	1	0	0	1	0	0	0
Installation time	1	1	1	1	1	1	1	1	1
Handling	1	1	1	1	1	1	0	1	0
Size adjustability	1	1	1	1	1	1	0	1	1
total	6	8	7	4	3	5	0	2	1

	Storage Volume	Looks and finish	Product Cost	Ease of install	# Items at location	Expected Lifespan	Handling	Size adjustability	Installation time
Storage Volume	1	1	0	0	0	0	0	0	0
Looks and finish	0	1	0	0	0	0	0	0	0
Product Cost	1	1	1	1	0	0	0	0	0
Ease of install	1	1	1	1	1	0	0	0	0
# Items at location	1	1	1	1	1	1	0	0	0
Expected Lifespan	1	1	1	1	1	1	1	1	1
Handling	1	1	1	1	1	1	1	1	1
Size adjustability	1	1	1	1	1	1	1	1	1
Installation time	1	1	1	1	1	1	1	1	1
total	8	7	6	5	4	3	2	1	0

APPENDIX 17: OVERVIEW PROPERTIES POSSIBLE MATERIALS

This table was made to compare the different materials that have been analysed as possible materials for the boarding. The table shows that Platowood is the best choice compared to the other alternatives. Impregnated Vuren is what is currently used.

	Govaplast	KLP	Duofuse	Platowood	Nobelwood	Imp. Vuren
E-mod (N/mm ²)	572	1000	1832	10514	12000	10800
Bending strenght (Mpa)	15,7	12	16,9	79	18	24
Density (kg/m ³)	960	850	1300	400	580	600
Cost (euro/m)	9,55	9,83	9,1	6,32	14,5	1,88
Splinter	nee	nee	nee	ja	ja	ja
Moisture absorption	nee	nee	ja	ja	ja	ja
Recyclability	Ja	Ja	Ja	ja	ja	Nee
Coloring	nee	nee	ja	ja	ja	ja
Lifespan	50	50	50	50	50	15

APPENDIX 18: CONCEPT COST PRICE ESTIMATION AND STORAGE VOLUME

Concept 1	Prijs (euro)	Gewicht (kg)
2 poot	20,335	8,134
1 voet	14,2575	5,703
4 plank	50,56	13,136
	85,1525	26,973
Concept 2		
5 planken	63,2	18,515
1 poot	22,64	9,056
	85,84	27,571
Concept 3		
plaat	26,3	4,721
frame	9,92	6,197
rails	43,995	17,598
	80,215	28,516

This table shows the cost price estimation of the concepts. It can be concluded that the prices and weights of the concepts are very close to each other.

	Concept 1	Concept 2	Concept 3
Paneel volume	55906200	55851390	83538000
Support volume	1193500	11404000	20604000
m/m ³	16	14	14
# panelen op pallet 1m hoog	32	28	28
aantal supports in bak	965	101	55

This table shows the storage volume of the different concepts.

APPENDIX 19: CALCULATION BOARDING LENGTH AND PANELS NEEDED

Boarding length	2,04	1,02	0,815
9,95	4	0	2
20,15	9	0	2
30,35	14	0	2
35,45	16	1	2
40,55	19	0	2
45,65	21	1	2
55,85	26	1	2
66,05	31	1	2
106,85	51	1	2

This table shows examples solutions of the formula that describes the actual length of the ice rink system where boarding can be placed upon. This shows the length is not straightforward, which explains the fact boarding has to be adjusted on site.

Although the maximum length of a ice rink is 55m, the system is capable for use on even longer systems.

APPENDIX 20: ALTERNATIVE CONFIGURATIONS



Image 47: Configuration 195mm x4



Image 48: Configuration 147mm x5



Image 49: Configuration 195mm x5

APPENDIX 21: SPONSOR FASTENING CHOICE

Concept	Screws	Hooks	Handrail
Investment cost	D	-	-
Dimension virsitivity	A	=	-
Sponsor material freedom	T	-	-
Complexity	U	-	-
Vulnrability	M	-	-
Damaging the boarding	.	+	+
Total +	.	1	1
Total -	.	4	5
Total =	.	1	0

Concept	Screws	Hooks	Handrail
Investment cost	+	D	=
Dimension virsitivity	=	A	-
Sponsor material freedom	+	T	-
Complexity	+	U	-
Vulnrability	+	M	-
Damaging the boarding	-	.	+
Total +	4	.	1
Total -	1	.	4
Total =	1	.	1

The table shows the datum method that was used to see what method would fit the boarding best. The outcome is that the screws currently used still have the most benefits and should be used in the redesign aswell.

Using hooks is a prinicple used in the market of field sports like hockey. you often see the surrounding fence covered in sponsoring. The sponsor panels have hooks attached to them that attach to the handrailing of the fence.

APPENDIX 22: COST CALCULATION BOARDING PANELS

2m Platowood	Unit	Price/unit	Total
Screws	21	0,04	0,84
Planks	8	6,32	50,56
Frames	4,369	2,5	21,845
Base	6,443	2,5	16,1075
Handrailing	2	8,75	17,5
Labor	0,11	17	1,87
			108,7225

2m Imp. wood	Unit	Price/unit	Total
Screws	21	0,04	0,84
Planks	8	1,88	15,04
Frames	4,369	2,5	21,845
Base	6,443	2,5	16,1075
Handrailing	2	8,75	17,5
Labor	0,11	17	1,87
			73,2025

2,04m Platowood	Unit	Price/unit	Total
Screws	21	0,04	0,84
Planks	8,16	6,32	51,5712
Frames	4,369	2,5	21,845
Base	6,443	2,5	16,1075
Handrailing	2,04	8,75	17,85
Labor	0,11	17	1,87
			110,0837

2,04m Imp. wood	Unit	Price/unit	Total
Screws	21	0,04	0,84
Planks	8,16	1,88	15,3408
Frames	4,369	2,5	21,845
Base	6,443	2,5	16,1075
Handrailing	0,931	8,75	8,14625
Labor	0,11	17	1,87
			64,14955

This overview shows the cost calculation of all the differen panels within the boarding system. A comparison has been done between platwood and impregnated wood, the total shows the difference in price.

1m Platowood	Unit	Price/Unit	Total
Screws	19	0,04	0,76
Planks	4	6,32	25,28
Frames	4,369	2,5	21,845
Bases	6,443	2,5	16,1075
Handrailing	1	8,75	8,75
Labor	0,11	17	1,87
			74,6125

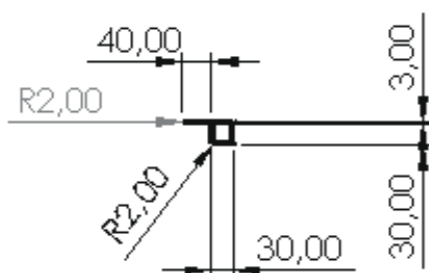
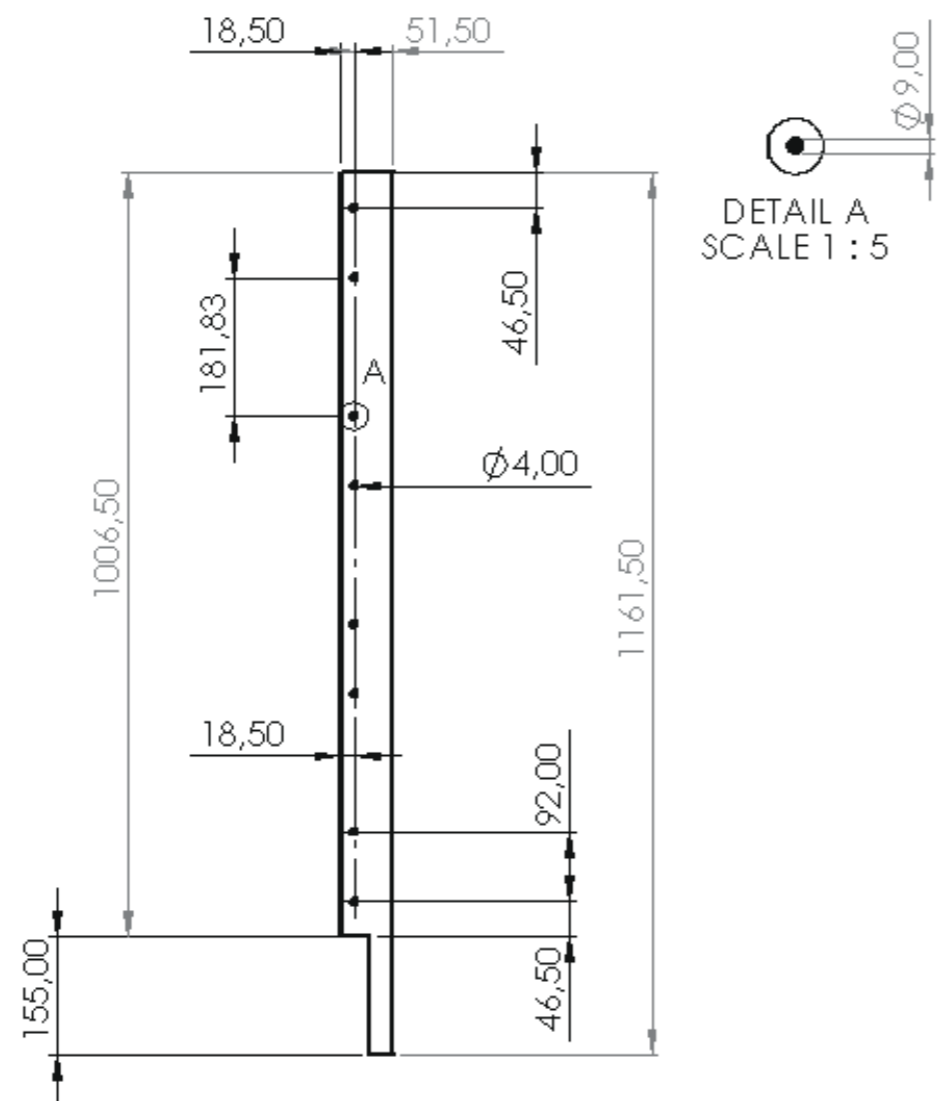
1m Imp. wood	Unit	Price/unit	Total
Screws	19	0,04	0,76
Planks	4	1,88	7,52
Frames	4,369	2,5	21,845
Base	6,443	2,5	16,1075
Handrailing	1	8,75	8,75
Labor	0,11	17	1,87
			56,8525

1,02 m Platowood	Unit	Price/unit	Total
Screws	19	0,04	0,76
Planks	4,08	6,32	25,7856
Frames	4,369	2,5	21,845
Base	6,443	2,5	16,1075
Handrailing	1,02	8,75	8,925
Labor	0,11	17	1,87
			75,2931

1,02m Imp. wood	Unit	Price/unit	Total
Screws	19	0,04	0,76
Planks	4,08	1,88	7,6704
Frames	4,369	2,5	21,845
Base	6,443	2,5	16,1075
Handrailing	1,02	8,75	8,925
Labor	0,11	17	1,87
			57,1779

0,815m Platowood	Unit	Price/unit	Total
Screws	19	0,04	0,76
Planks	3	6,32	18,96
Frames	4,369	2,5	21,845
Bases	6,443	2,5	16,1075
Handrailing	0,8	8,75	7
Labor	0,11	17	1,87
			66,5425

0,815m Imp. wood	Unit	Price/unit	Total
Screws	19	0,04	0,76
Planks	3	1,88	5,64
Stands	4,369	2,5	21,845
Bases	6,443	2,5	16,1075
Handrailing	0,8	8,75	7
Labor	0,11	17	1,87
			53,2225



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBURR AND
BREAK SHARP
EDGES

DO NOT SCALE DRAWING

REVISION

NAME	SIGNATURE	DATE	TITLE:
DRYER	Jeroen van Erven		Eindontwerp frame rechts hoog
CHKD			
APP'D			
MTC			
QA			

MATERIAL:
Galvanized Steel

DWG NO.

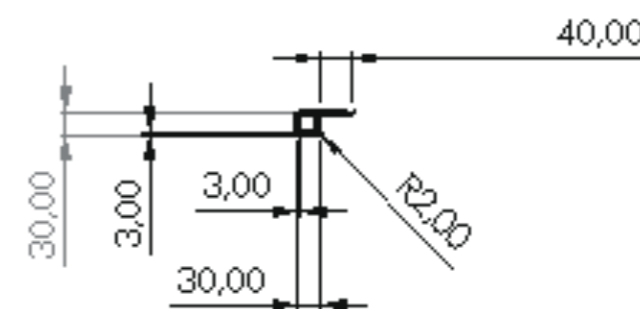
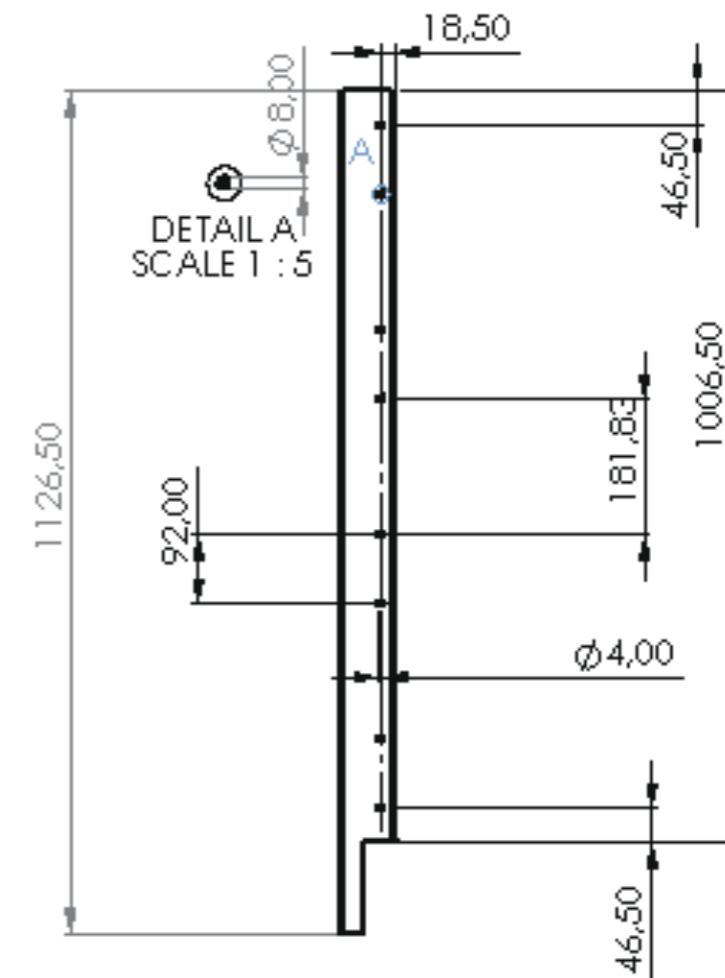
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SHEET 1 OF 1



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LINEAR:
ANGULAR:

FINISH:

DEBURR AND
BREAK SHARP
EDGES

DO NOT SCALE DRAWING

REVISION

NAME	SIGNATURE	DATE	TITLE:
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CHKD			
APP'D			
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QA			

MATERIAL:
Galvanized Steel

DWG NO.

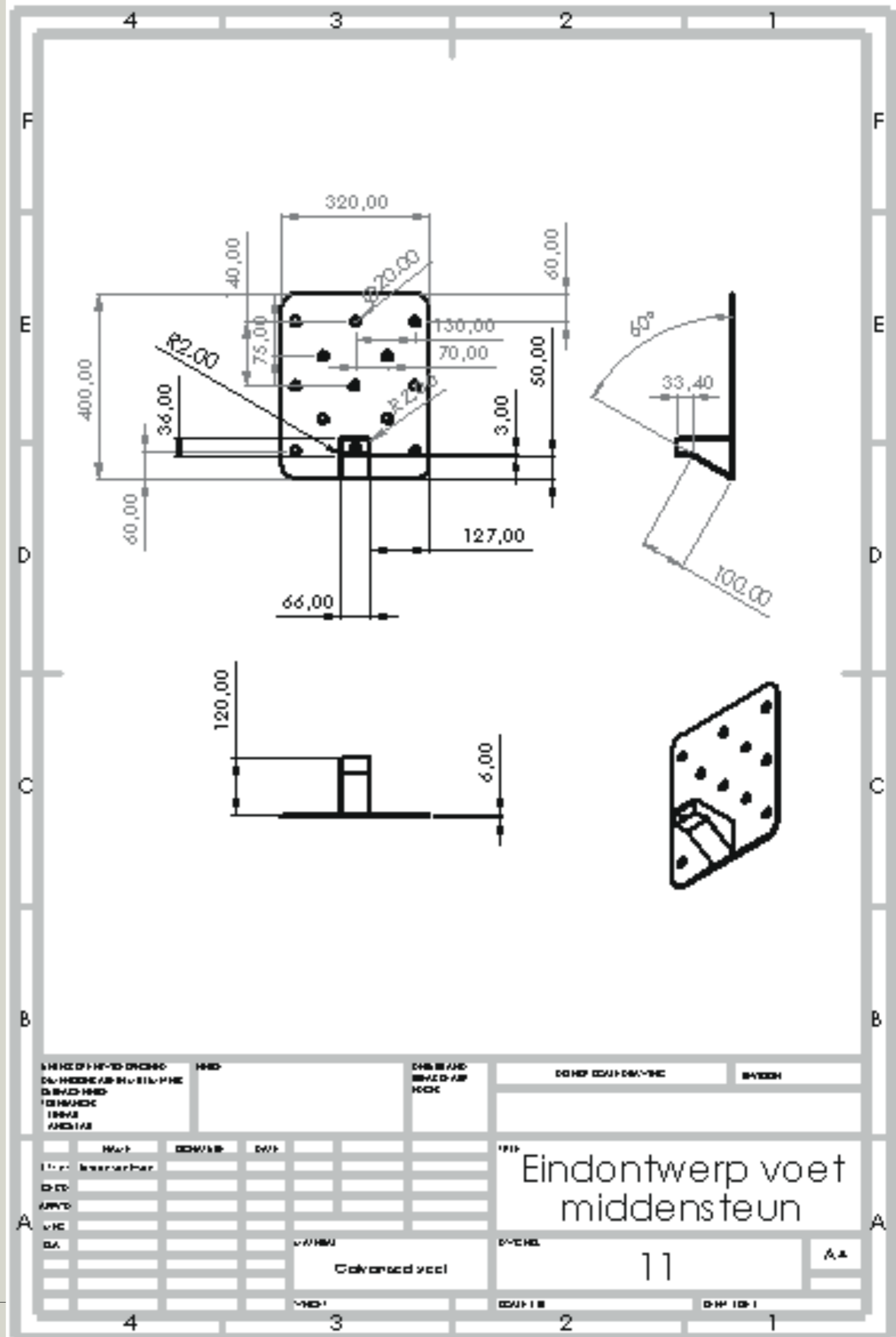
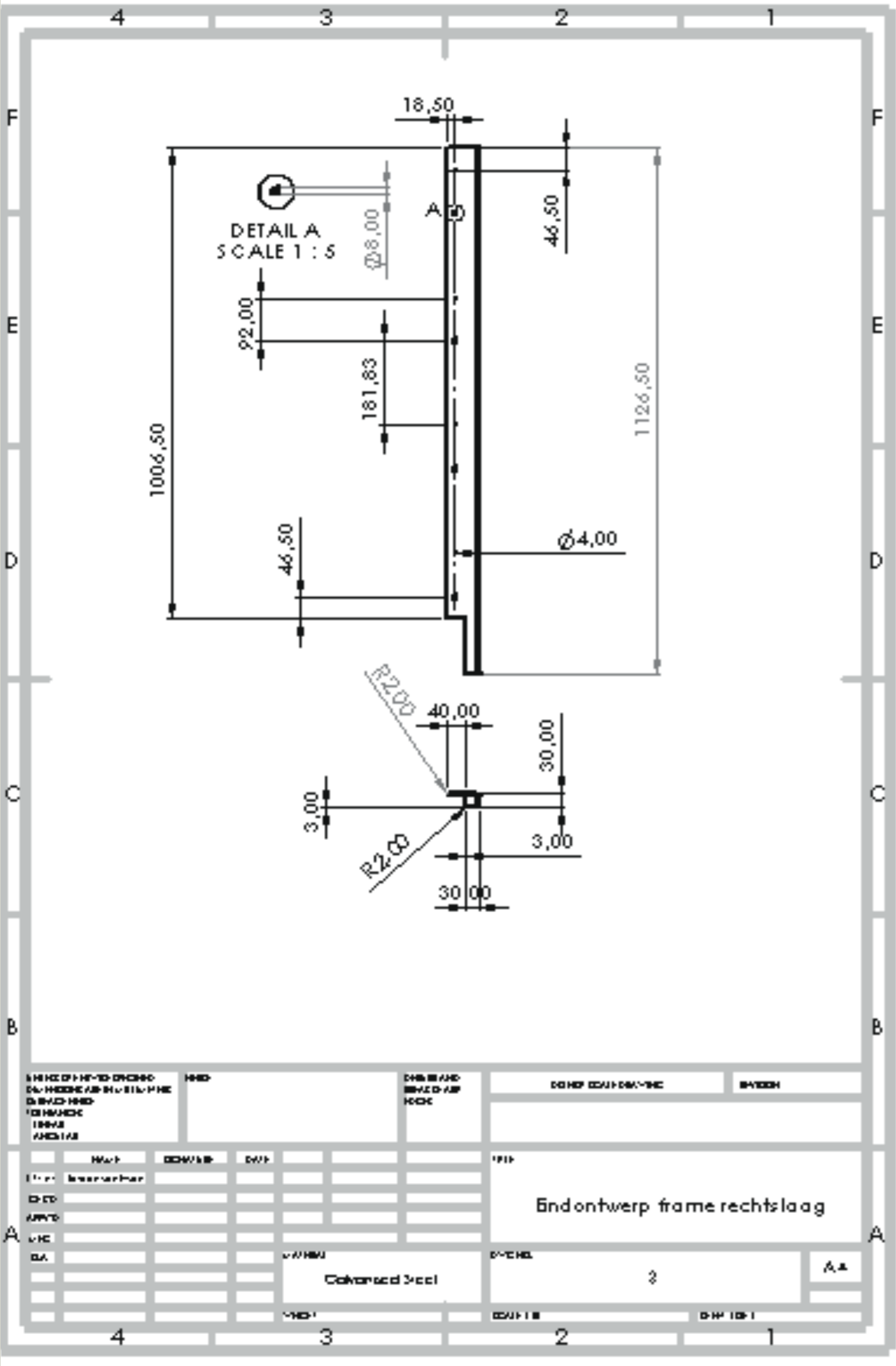
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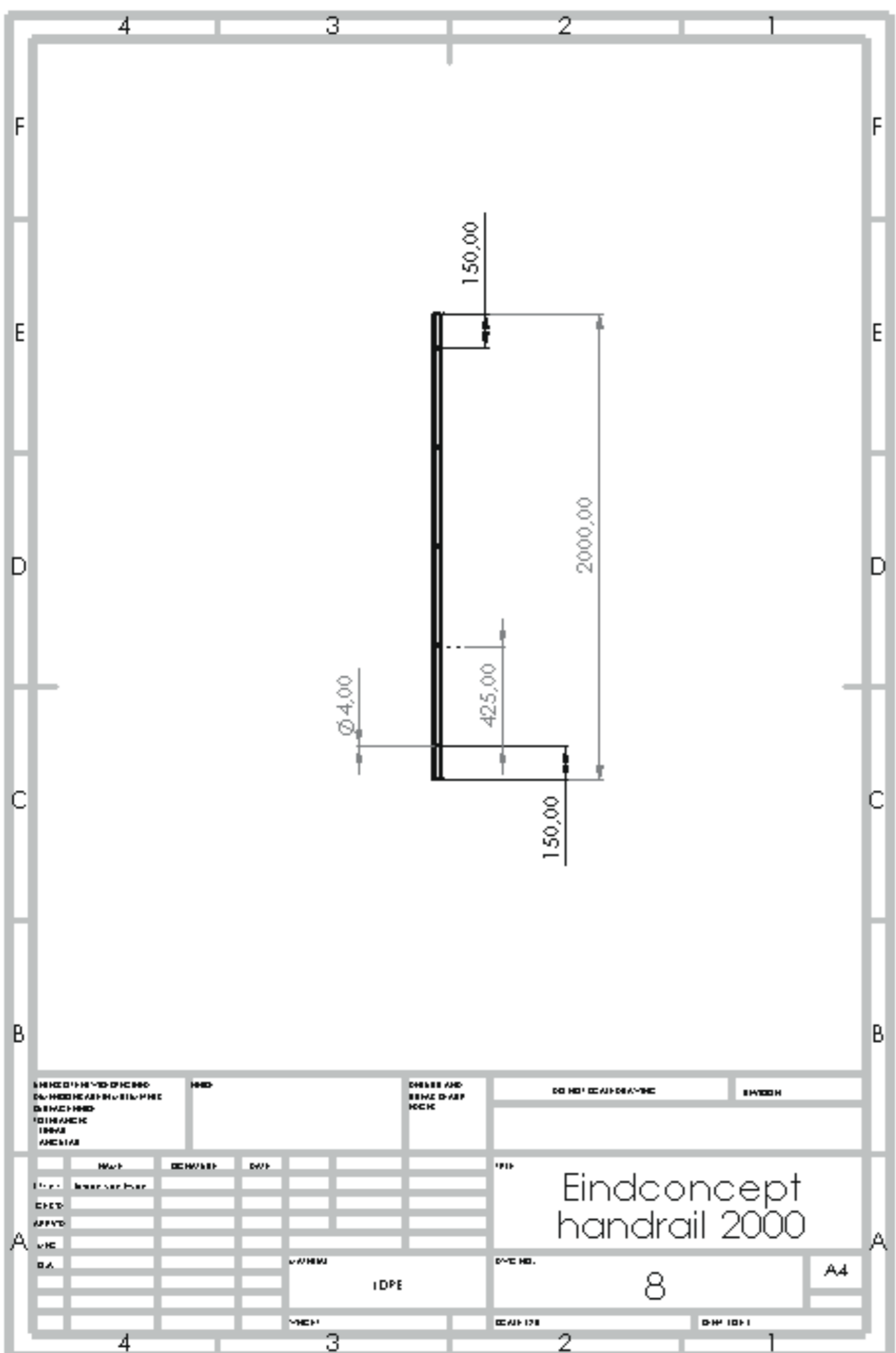
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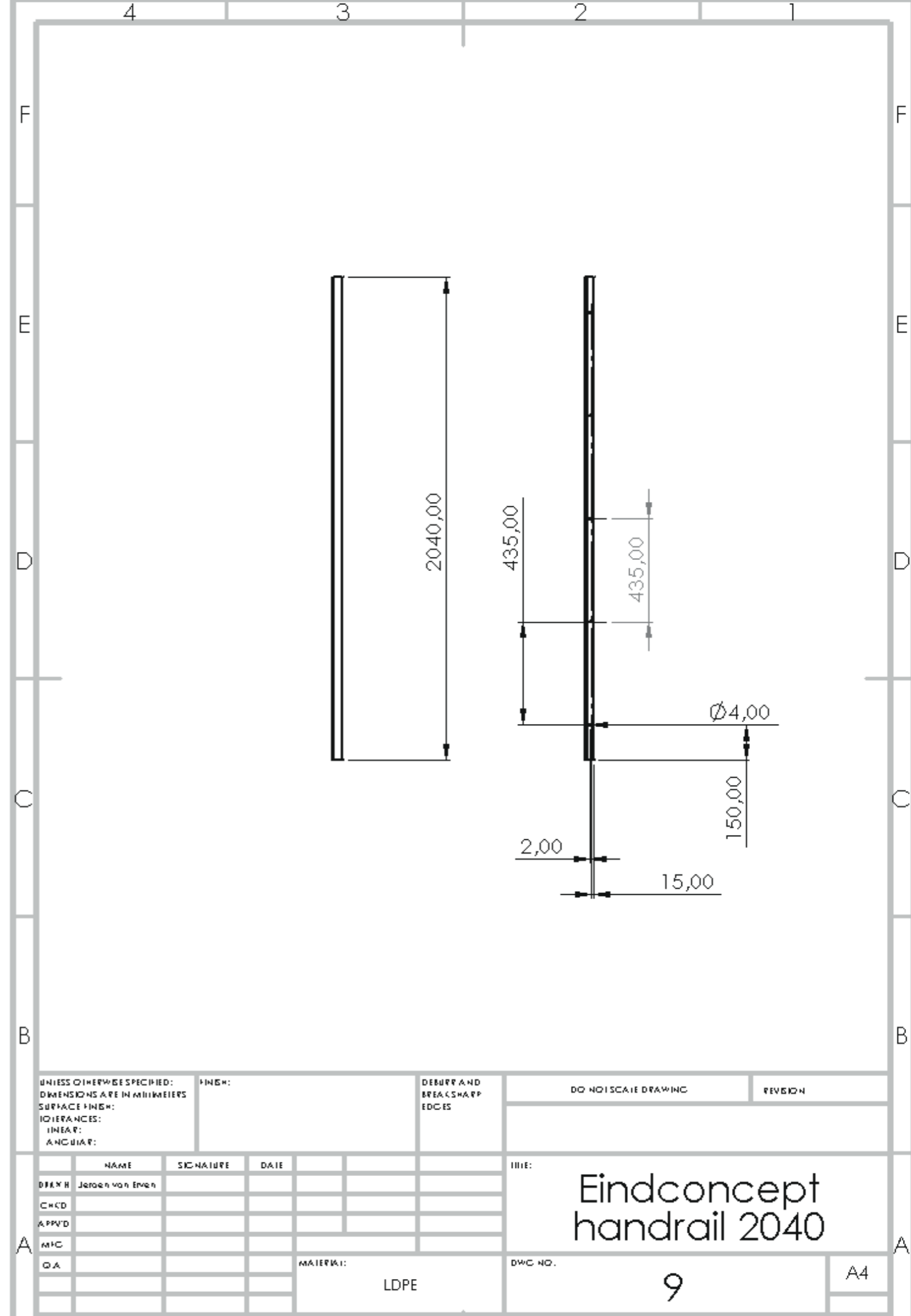
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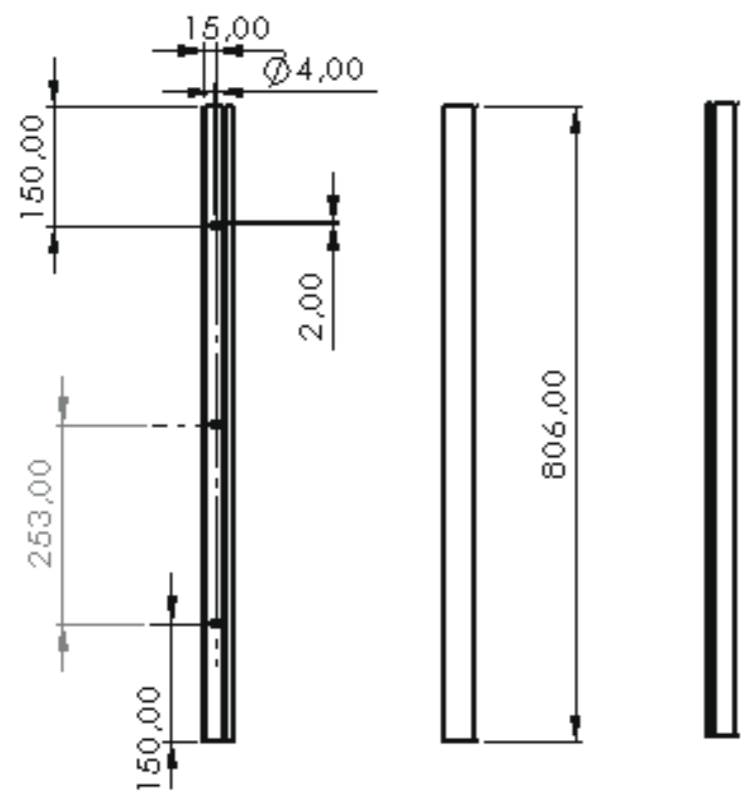




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DRY H	Jeroen van Erven	SIGNATURE	DATE					Eindconcept handrail 2000	
CHKD								8	
APPVD								A4	
MFC				MATERIAL:		DWC NO.		LDPE	
Q.A.				WEIGHT:		SCALE: 20		SHEET 1 OF 1	



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS		FINISH:		DEBURR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING		REVISION	
TOLERANCES: LINEAR: ANGULAR:									
DRY H	Jeroen van Erven	SIGNATURE	DATE					Eindconcept handrail 2040	
CHKD								9	
APPVD								A4	
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Q.A.				WEIGHT:		SCALE: 20		SHEET 1 OF 1	



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TEXTURE: ANGLE:			GROUP AND EDGE SHARP EDGES		DO NOT SCALE DRAWING	REVISION
NAME	SIGNATURE	DATE	REF			
DESIGNED			Eindconcept handrail 882			
APPROVED						
DATE			MATERIAL	DWG NO	A4	
			LDPE	10		
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