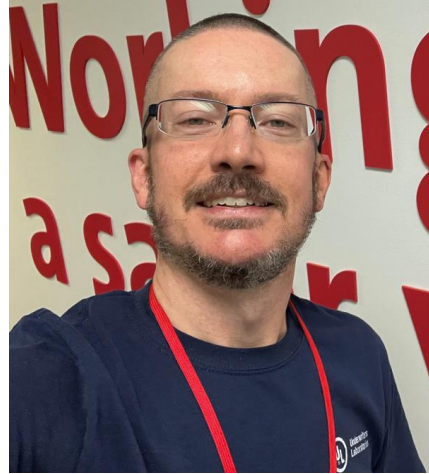


Mass Wood Timber & Fire-Resistance: Can This Work?

FCIA-NFCA Existing Building Fire-Resistance Symposium Canada
September 2023



Presenters



Kevin Hyland
(UL)



Julio Lopes (STI)



Matthew
Winston (Hilti)



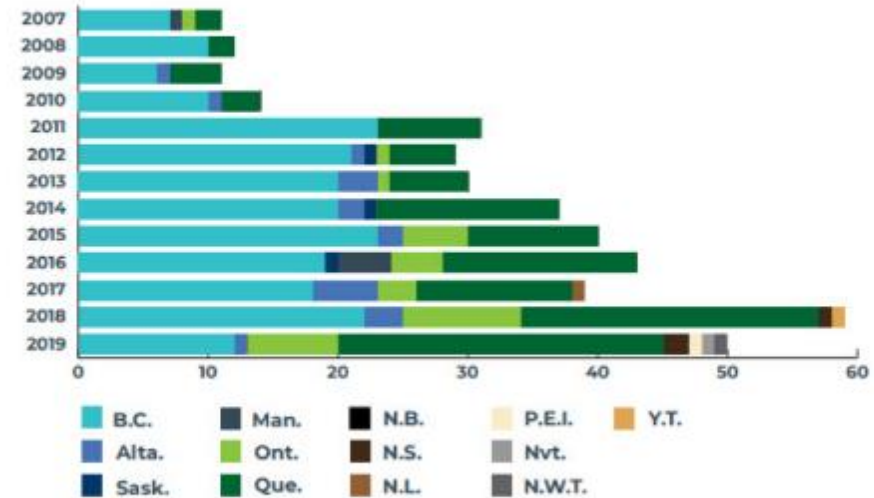
State of Mass Timber Market

Reasons to Watch Mass Timber

- Use of mass timber construction has increased
- Model building codes have expanded prescriptive language for mass timber
- Performance based designs continue to advance the size and scope of mass timber buildings.

TOTAL NUMBER OF PROJECTS PER YEAR BY PROVINCES

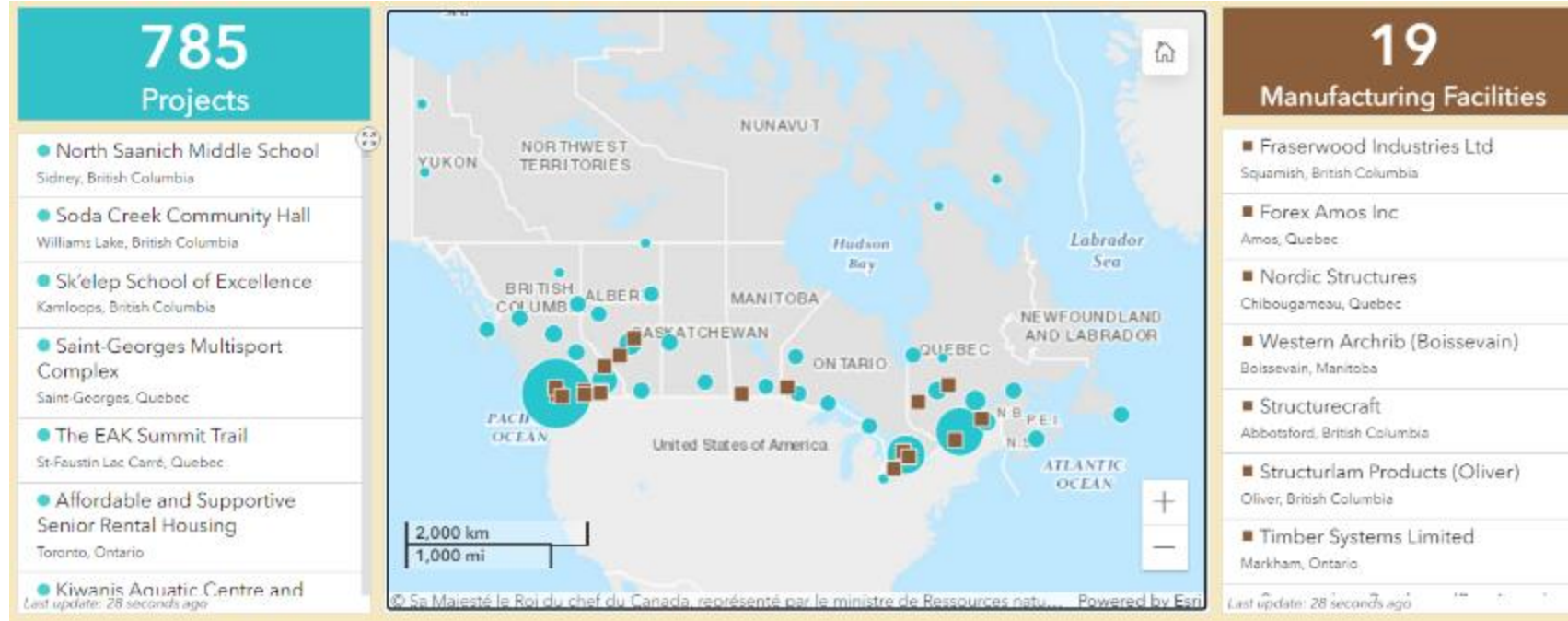
(by year of completion, 2007-2019)



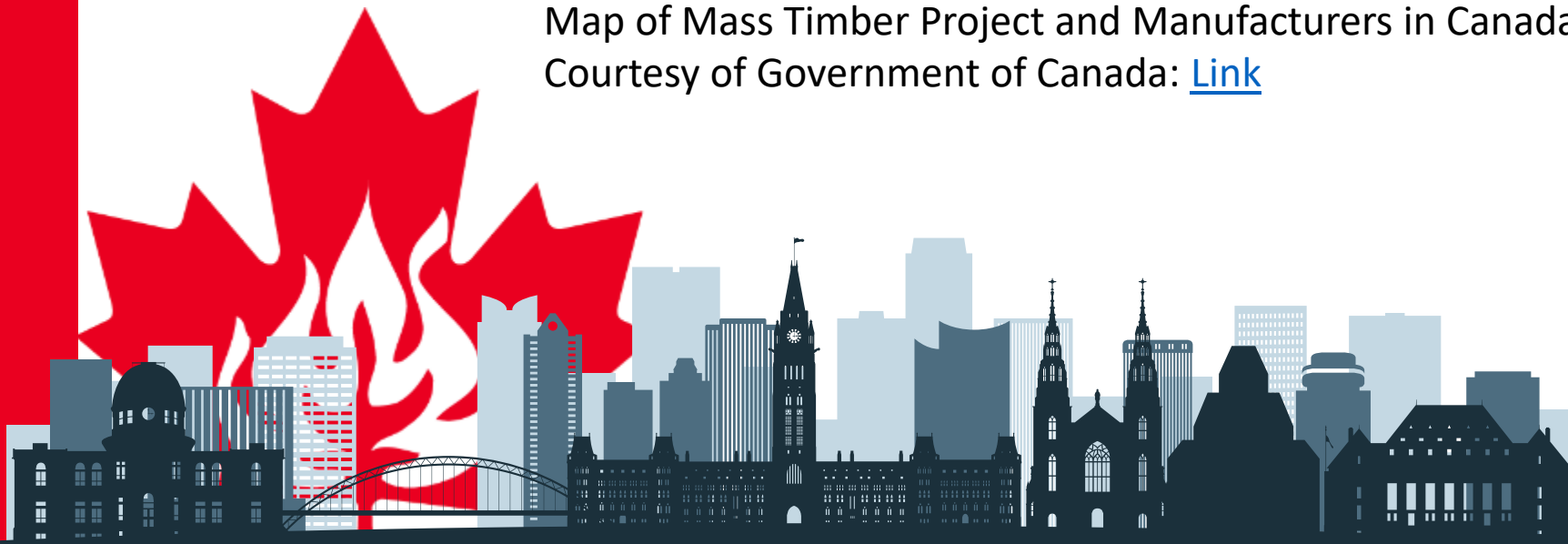
Source: Natural Resources Canada, The State of Mass Timber in Canada 2021 report



State of Mass Timber Market



Map of Mass Timber Project and Manufacturers in Canada,
Courtesy of Government of Canada: [Link](#)



State of Mass Timber Market – Recently Completed Projects – T3 Sterling

T3 Sterling Road Development Toronto, Ontario

- Completed in 2022
- 8 Stories
- Commercial, Office Space
- Glulam Post & Beam, NLT Decking



Photo Courtesy of t3sterling.com



State of Mass Timber Market – Recently Completed Projects – T3 Sterling



Photos Courtesy of t3sterling.com



State of Mass Timber Market – Recently Completed Projects – Heartwood

Heartwood On The Beach Condominium Toronto, Ontario

- Completed in 2022
- 6 Stories
- Residential, Condominiums
- Glulam and CLT beams, columns, decking



Photos Courtesy of <https://urbantoronto.ca/database/projects/heartwood-beach.18674>



Type of Mass Timber Construction

No.	Name	Description
1	Cross-Laminated Timber (CLT)	Most commonly uses 2x6 lumber boards in multiple layers (plys). Each layer is stacked at a 90-degree angle to adjacent layers, with layers glued together.
2	Glue-Laminated Timber (Glulam)	Defining feature is that the grain of the individual wood members is parallel with the length of the members. Members are glued together.
3	Dowel-Laminated Timber (DLT)(shown) & Nail-Laminated Timber (NLT)	Uses 2x4, 2x6, or 2x8 lumber stacked on end and fit together with wood dowels (CLT) or with nails (NLT) . This type can be made without any added materials besides lumber.
4	Mass Plywood Panel (MPP)	Engineered wood product consisting of layers (veneers) that are glued together.

CLT



Glulam

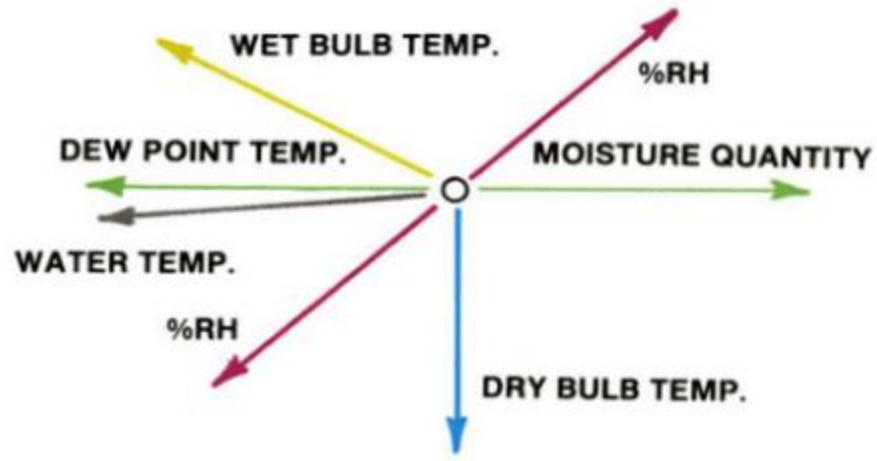


DLT



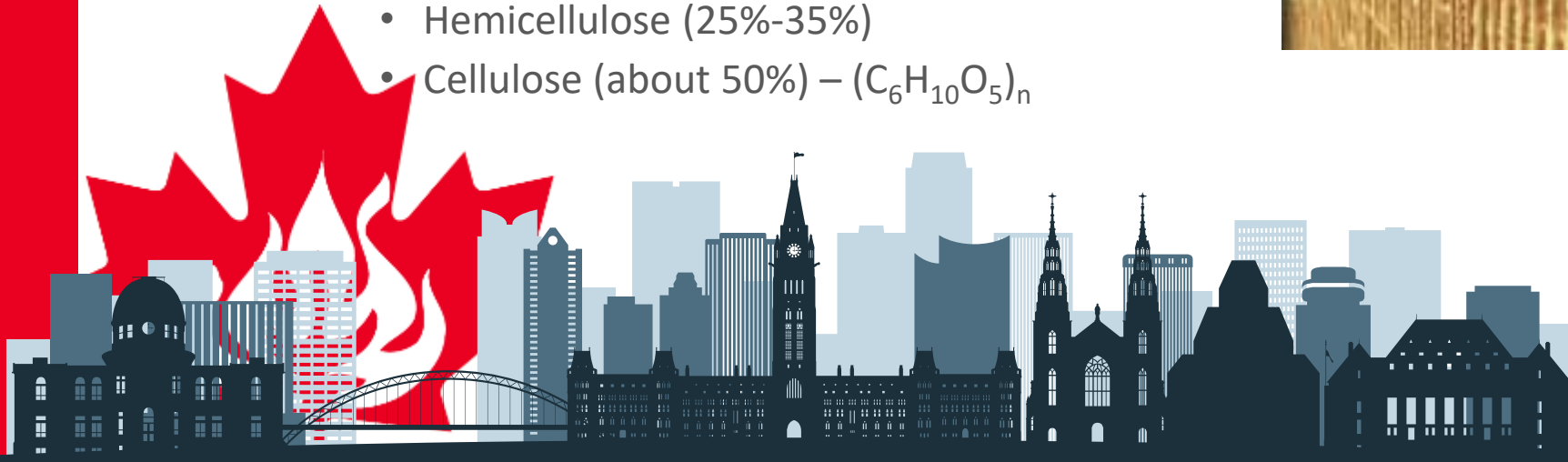
Mass Plywood Panel





Wood is Combustible? Why?

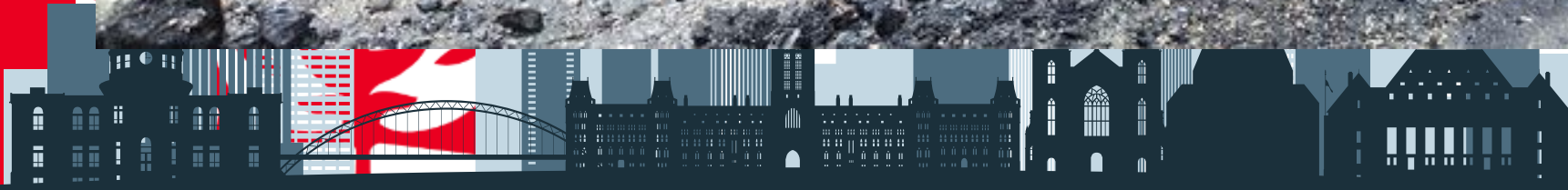
- Wood is comprised of two essential things:
 - Water
 - After drying, normal moisture content is 8% to 25% $\text{kg}_{\text{H}_2\text{O}}/\text{kg}_{\text{dry wood}}$
 - Freshly cut, up to 200% $\text{kg}_{\text{H}_2\text{O}}/\text{kg}_{\text{dry wood}}$
 - Dry Wood
 - Minerals and Metallic ions (about 4-10%)
 - Organic Polymers
 - Lignin (18%-35%)
 - Hemicellulose (25%-35%)
 - Cellulose (about 50%) – $(\text{C}_6\text{H}_{10}\text{O}_5)_n$



Comparing wood behavior in fire to typical construction products

- Concrete – absorbs heat and is intrinsically non-combustible. Biggest concern is spalling.
- Gypsum Wallboard – Calcines at around 250 °F and turns into a non-combustible mineral powder
- Steel – Expands with heat, reaches critical strength loss around 1000°F. Melts at 2600°F Non-combustible.
- Wood Framing – Encapsulated by these non-combustible elements.
- Mass Timber – ignites around 500°F. Char rate about 1.5 inches per hour. Effective char rate is dependent on ply thickness per the National Design Specification (NDS)



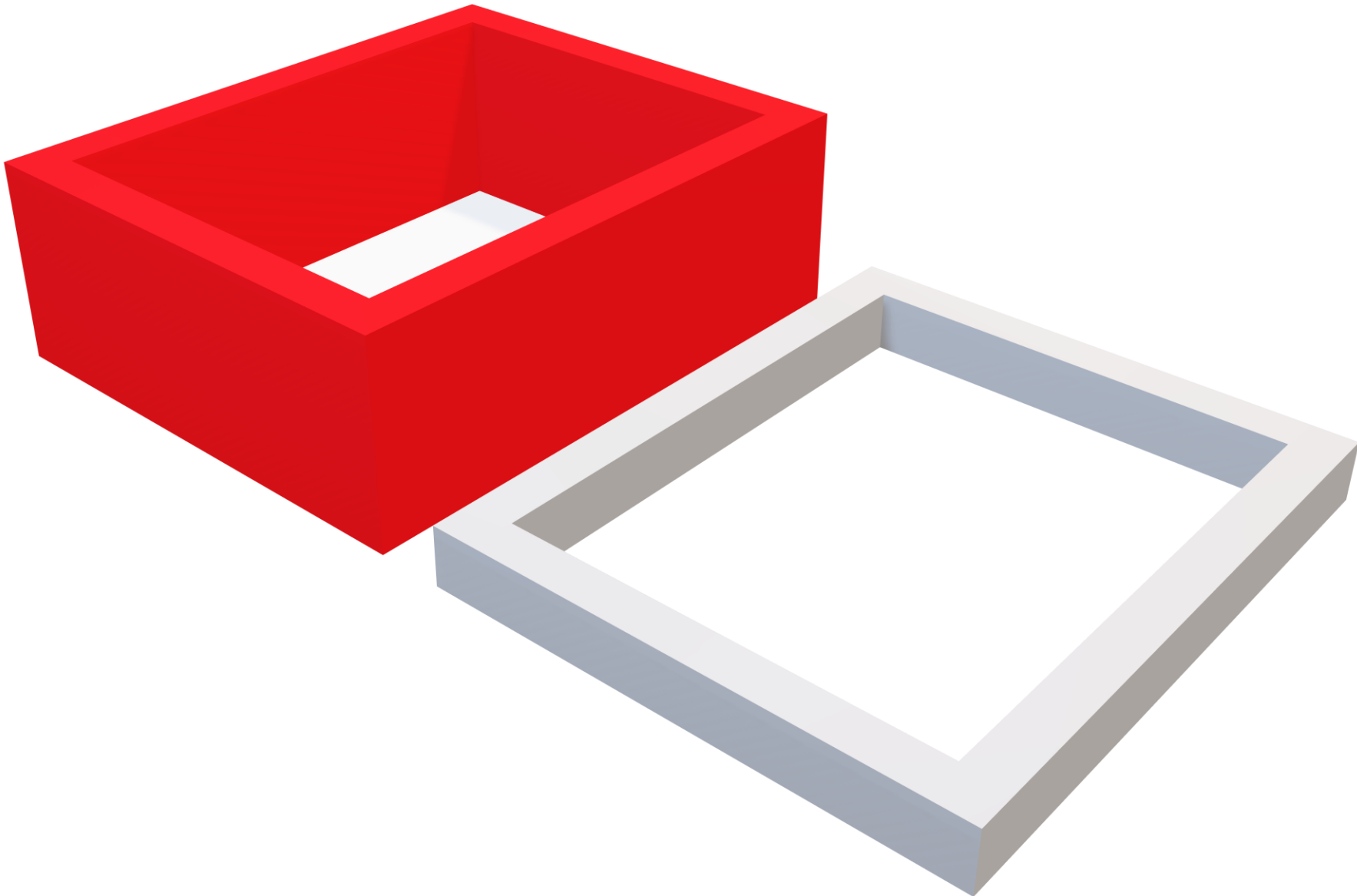


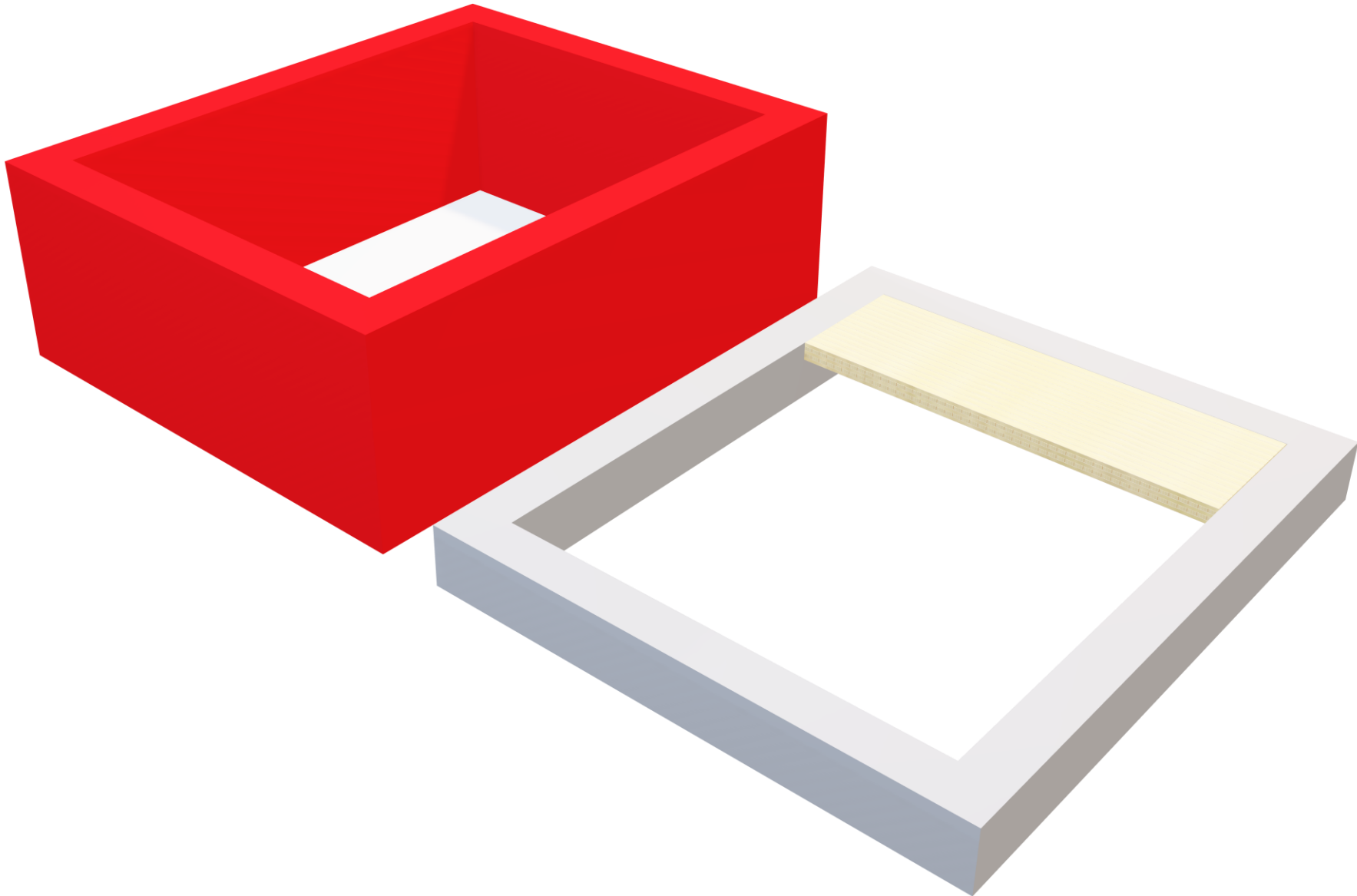
HILTI

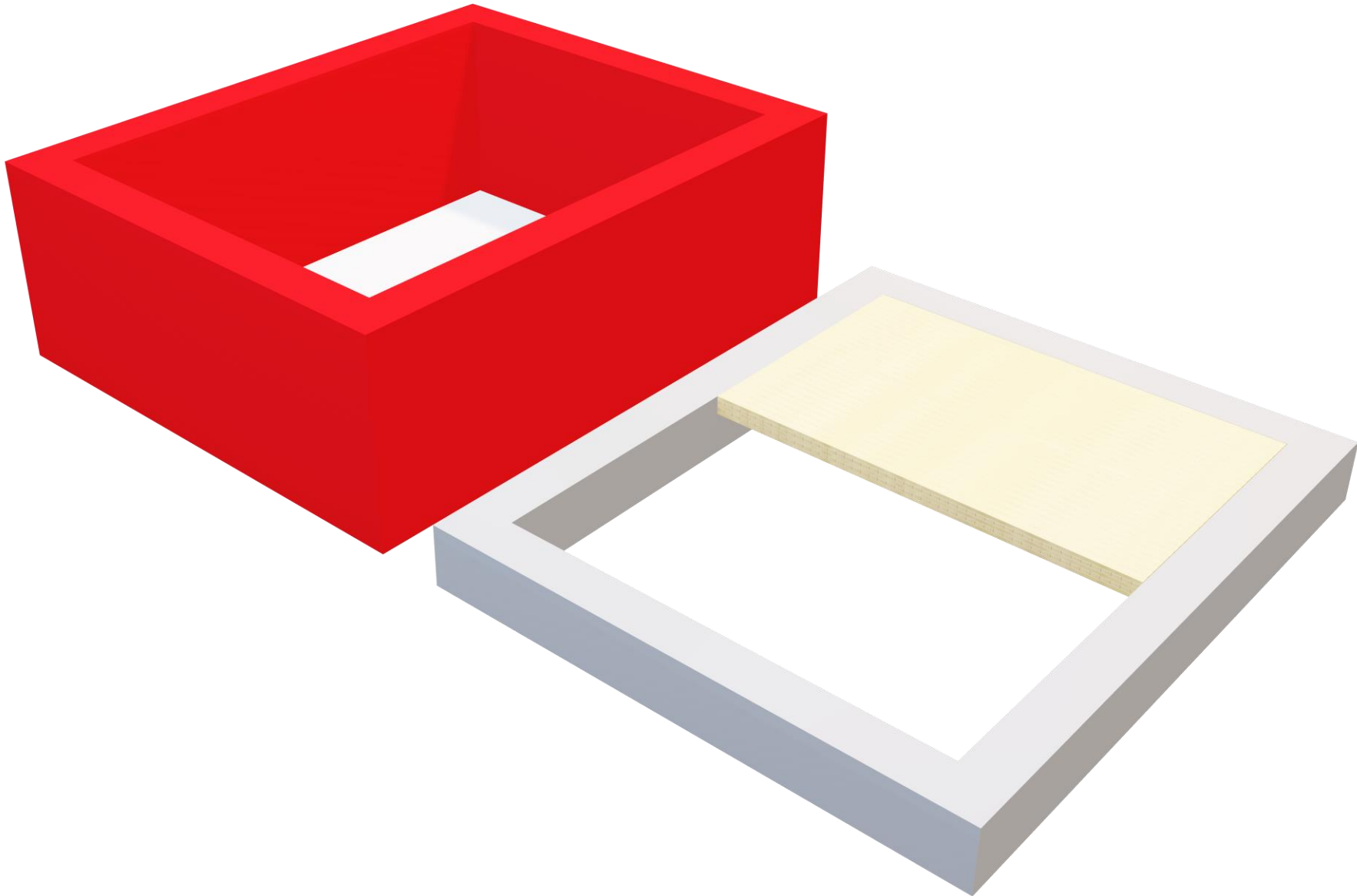
FCIA 

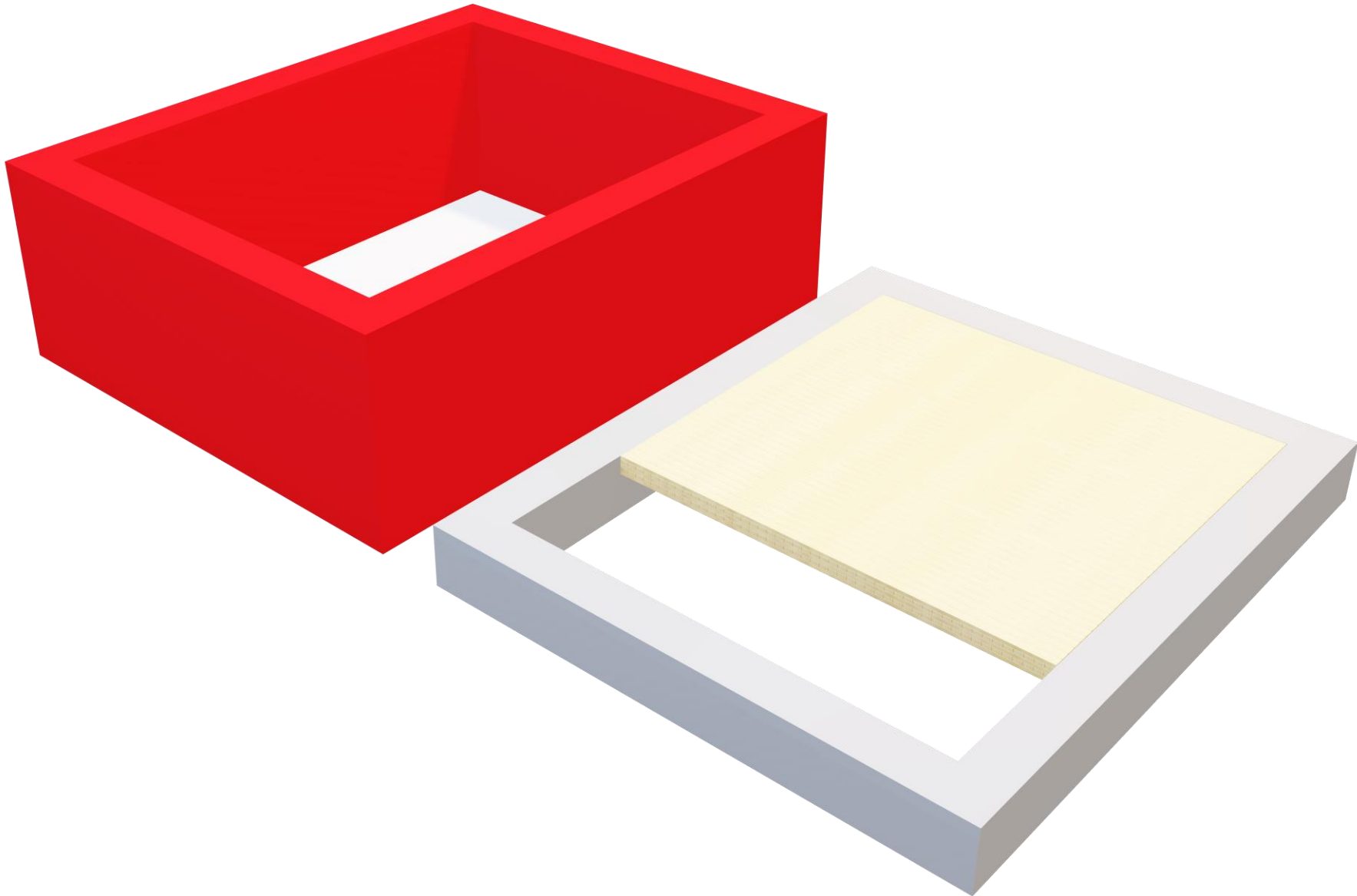
- Three essential stages of wood burning
 - Stage 1 - Smoking stage – Water is driven inward and outward. CO₂ is released. Surface charring occurs. Up to about 400F
 - Stage 2 – Pyrolysis – Conversion of compounds into volatile gases which supports flaming. 400F to 850F
 - Stage 3 – Carbon Burn – This is where the embers begin to break down into ash.

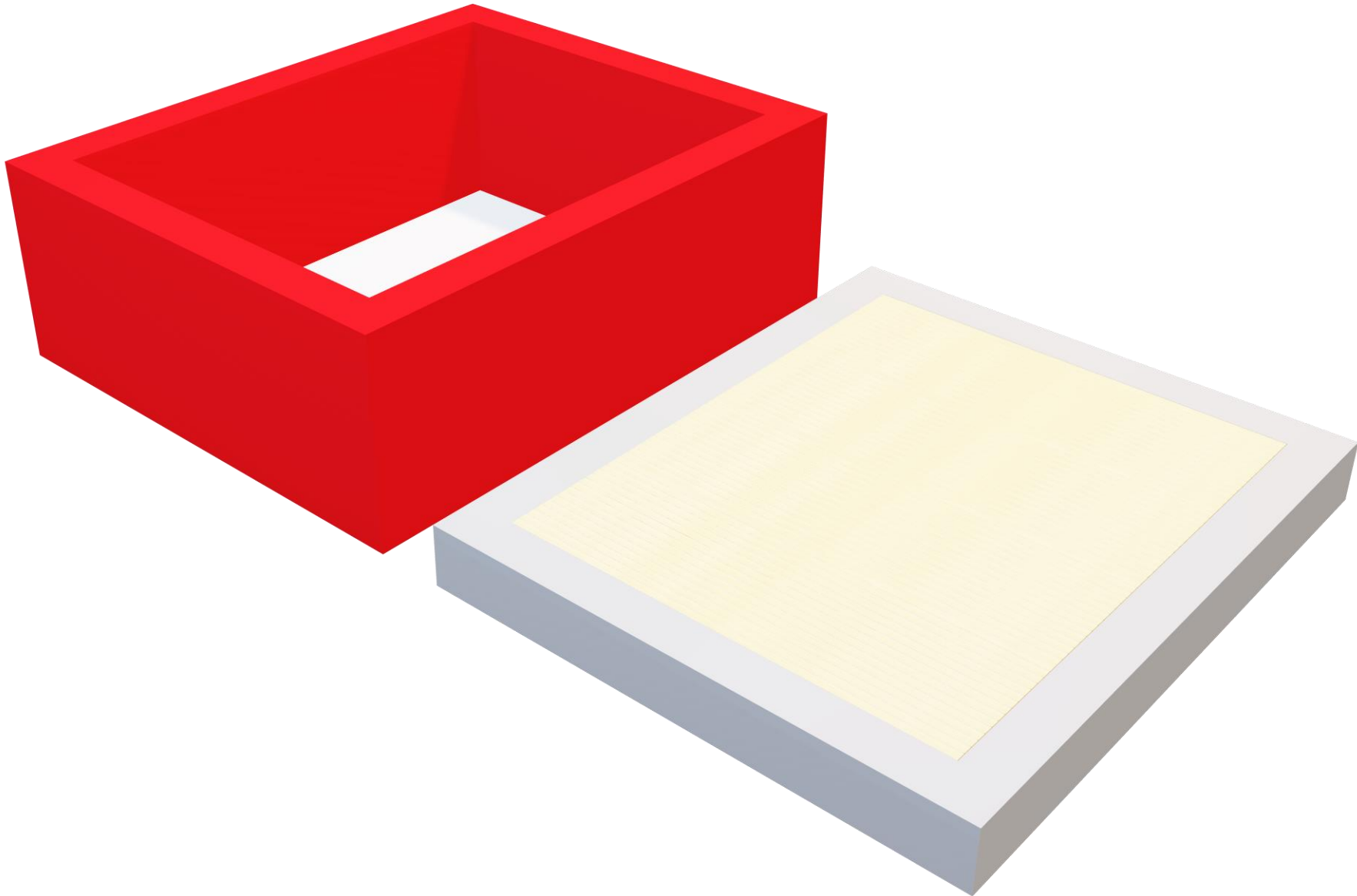


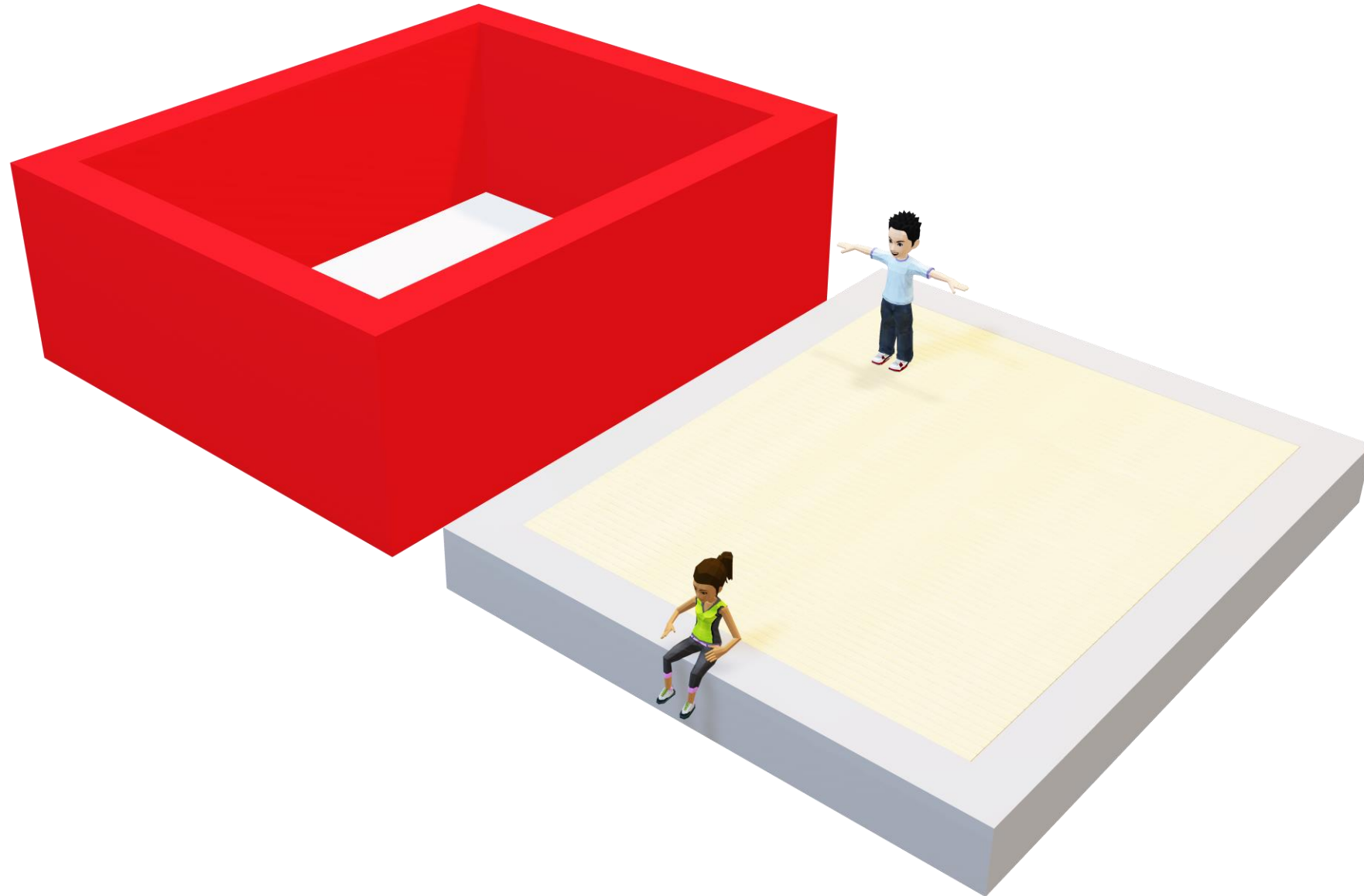


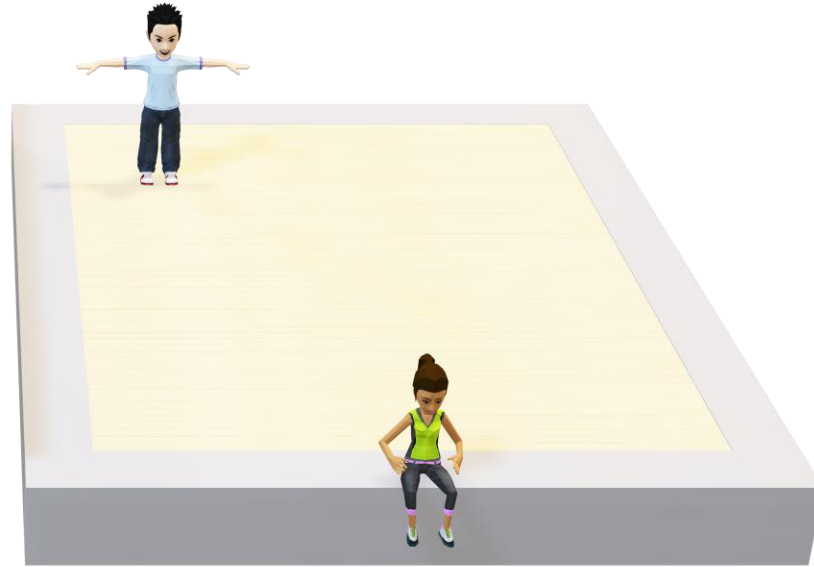


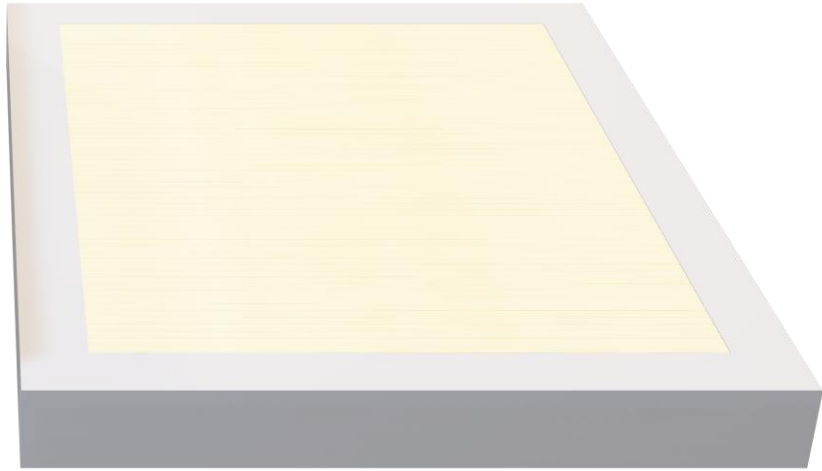


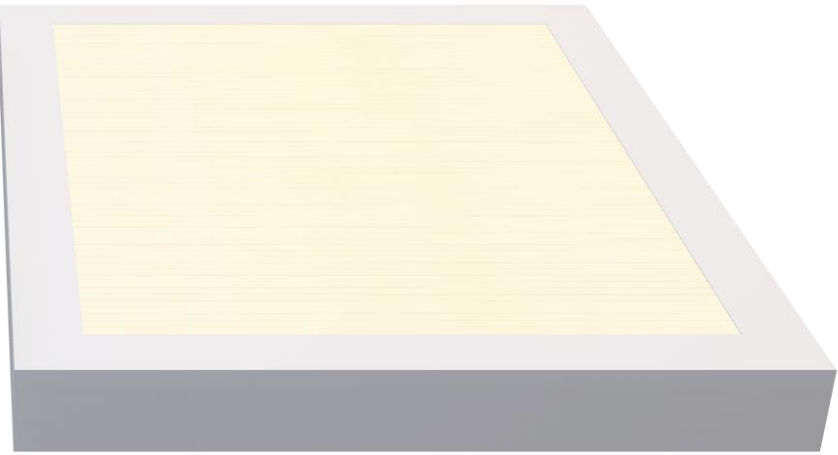


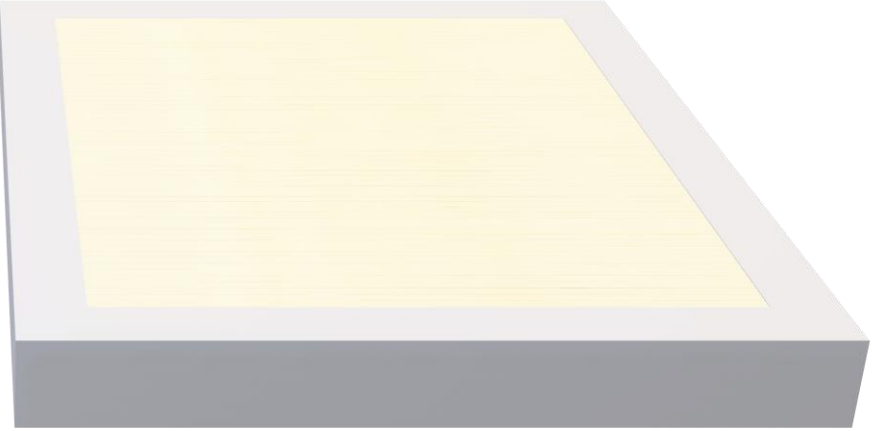


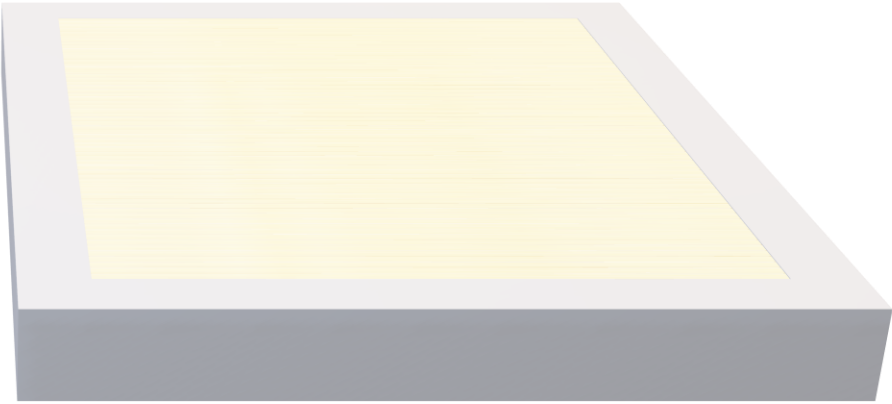


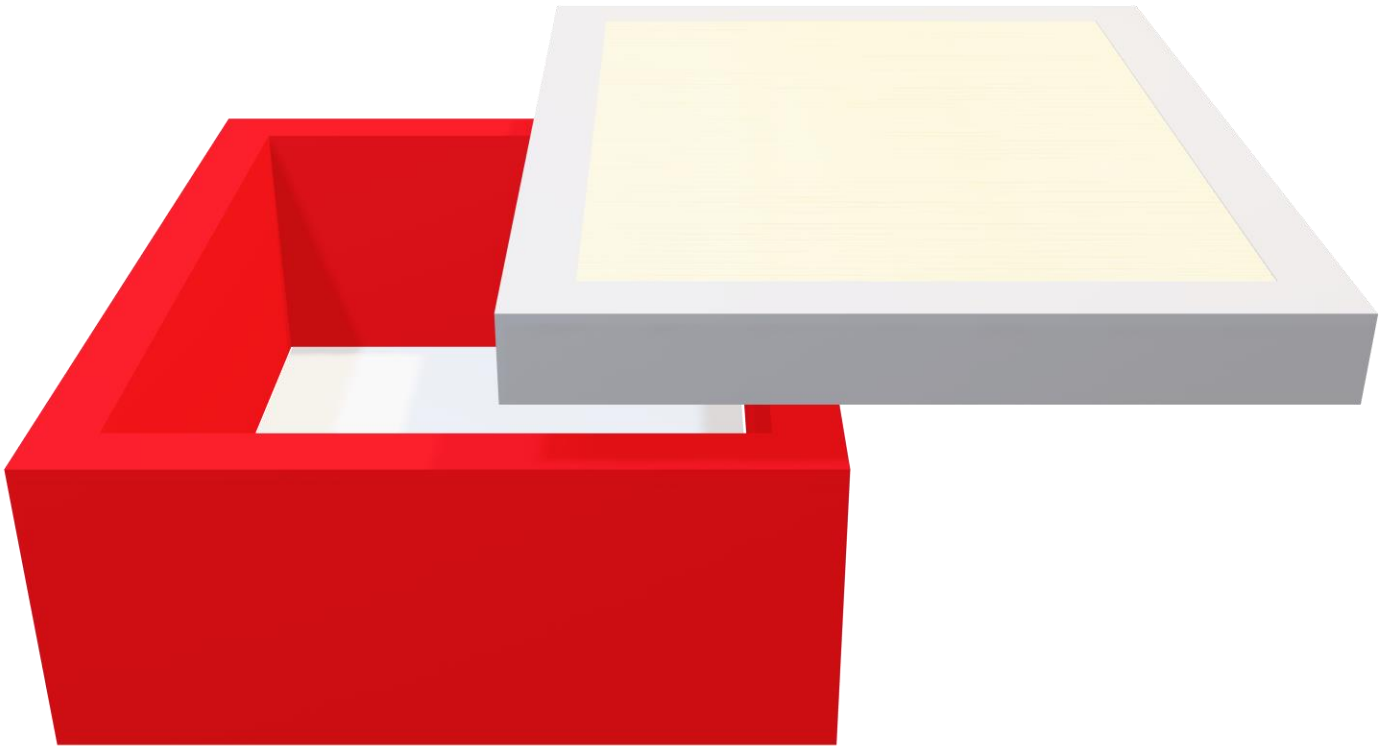


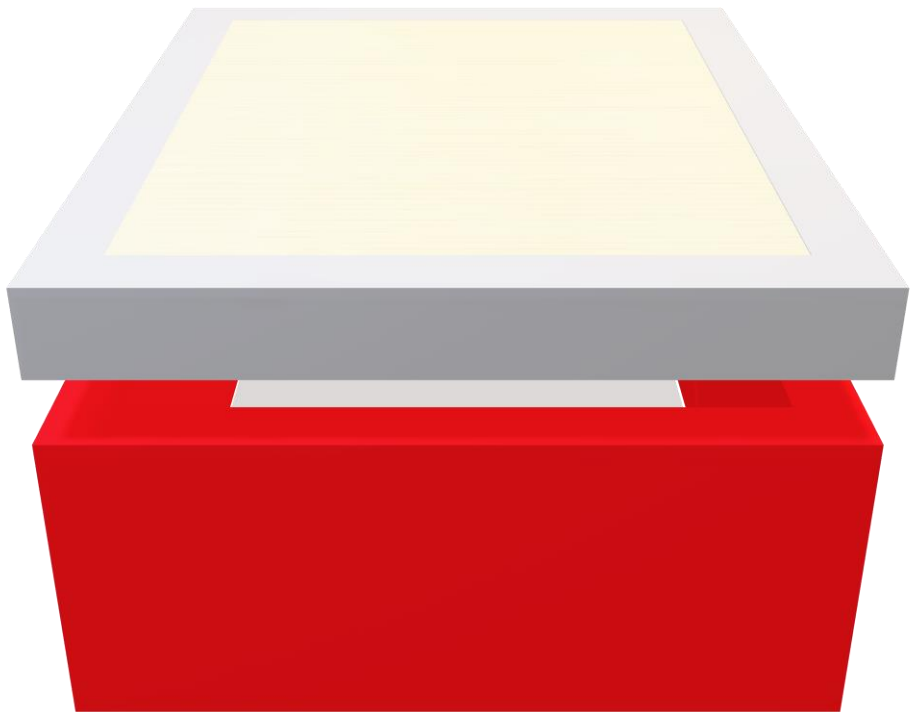


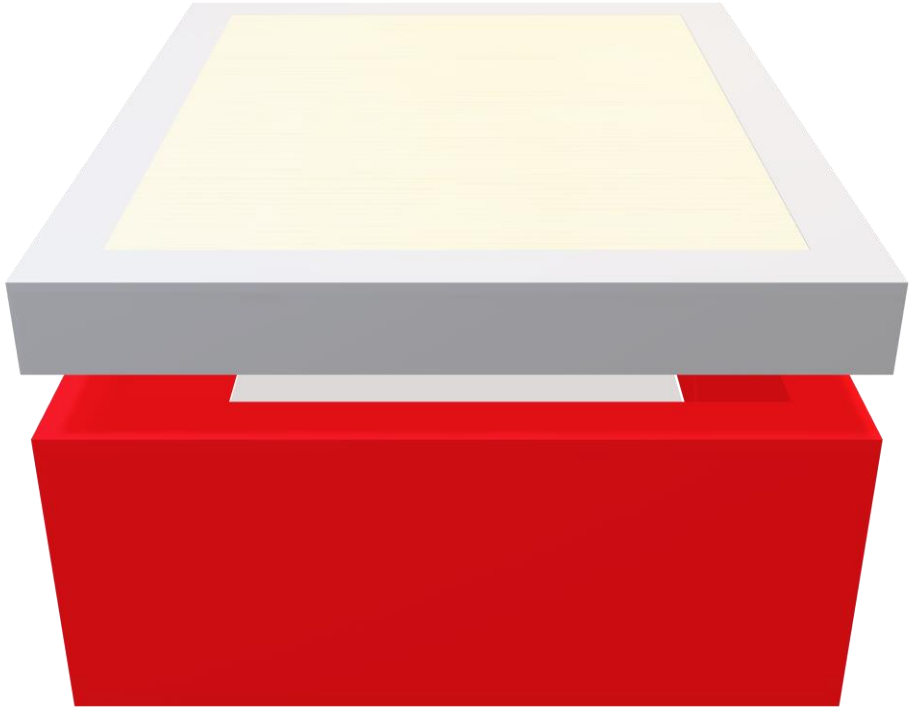


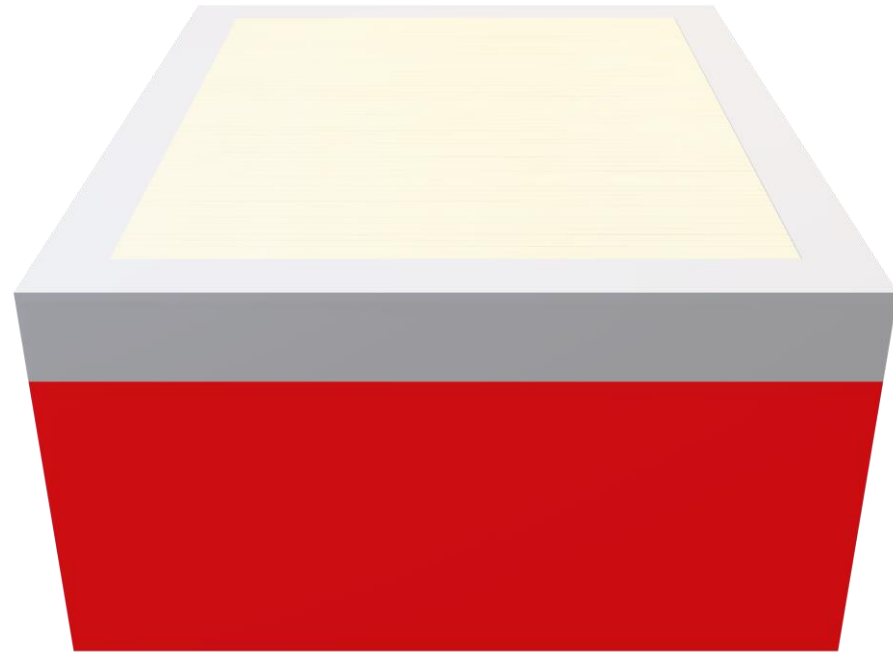


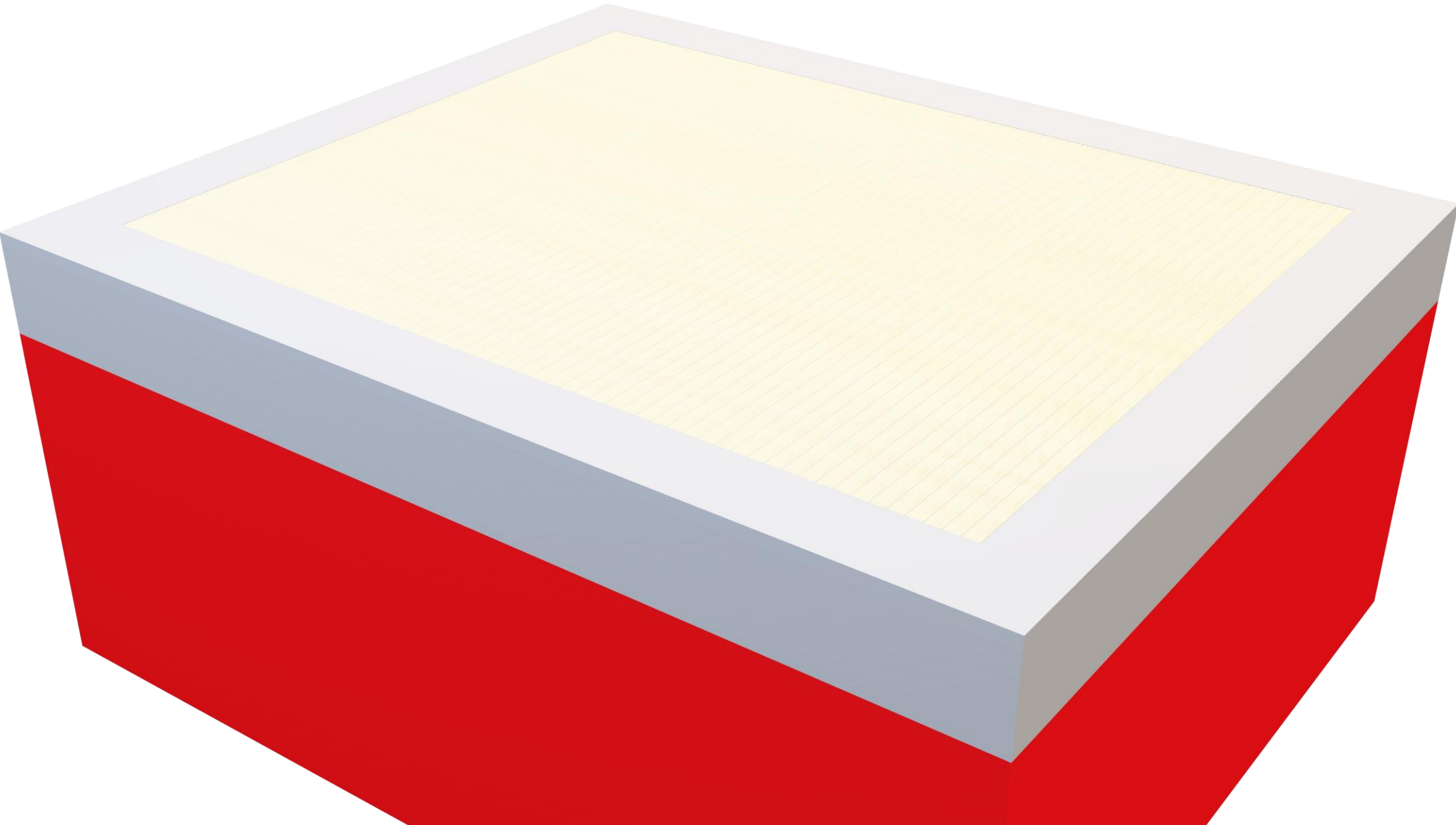


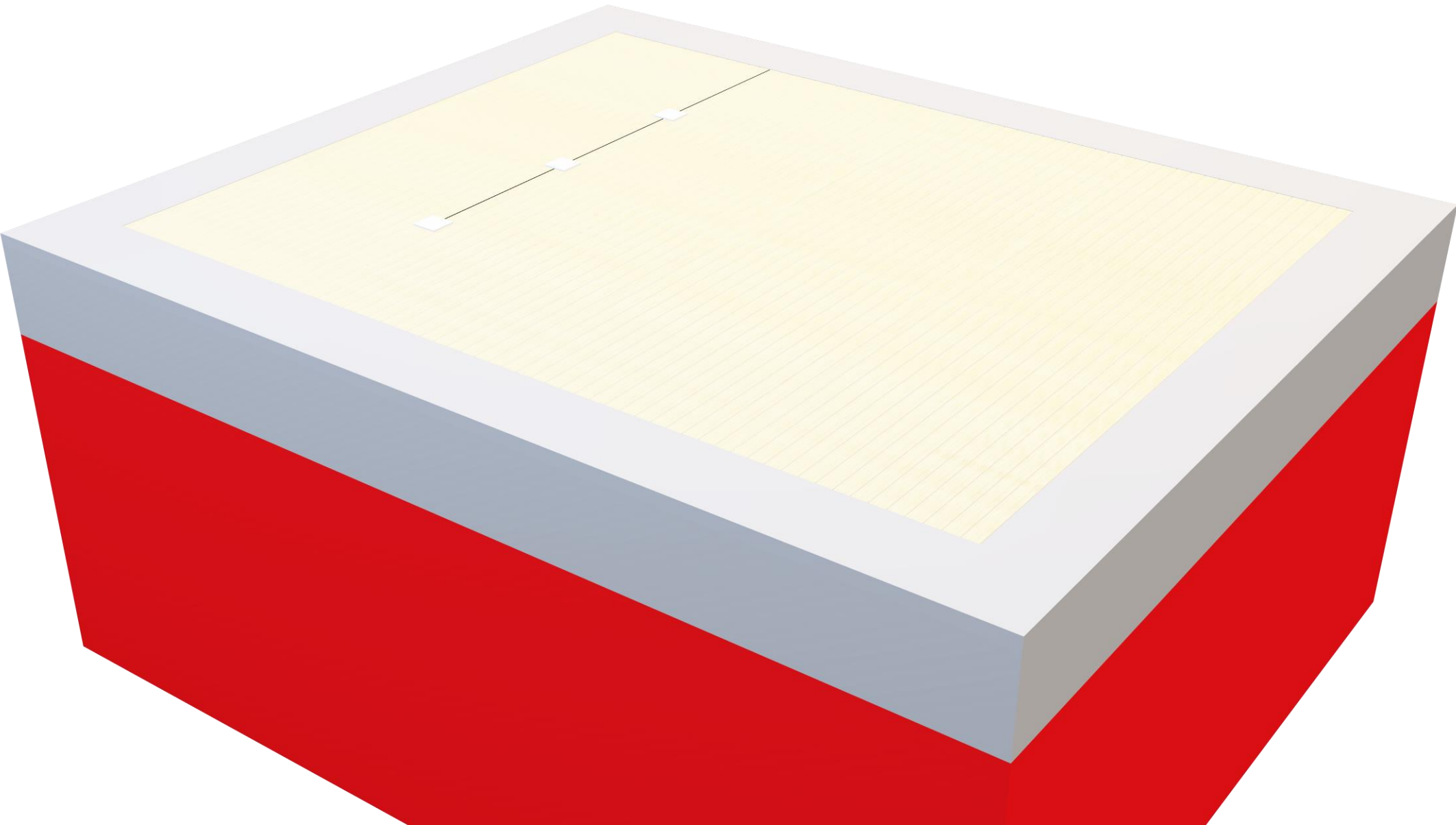


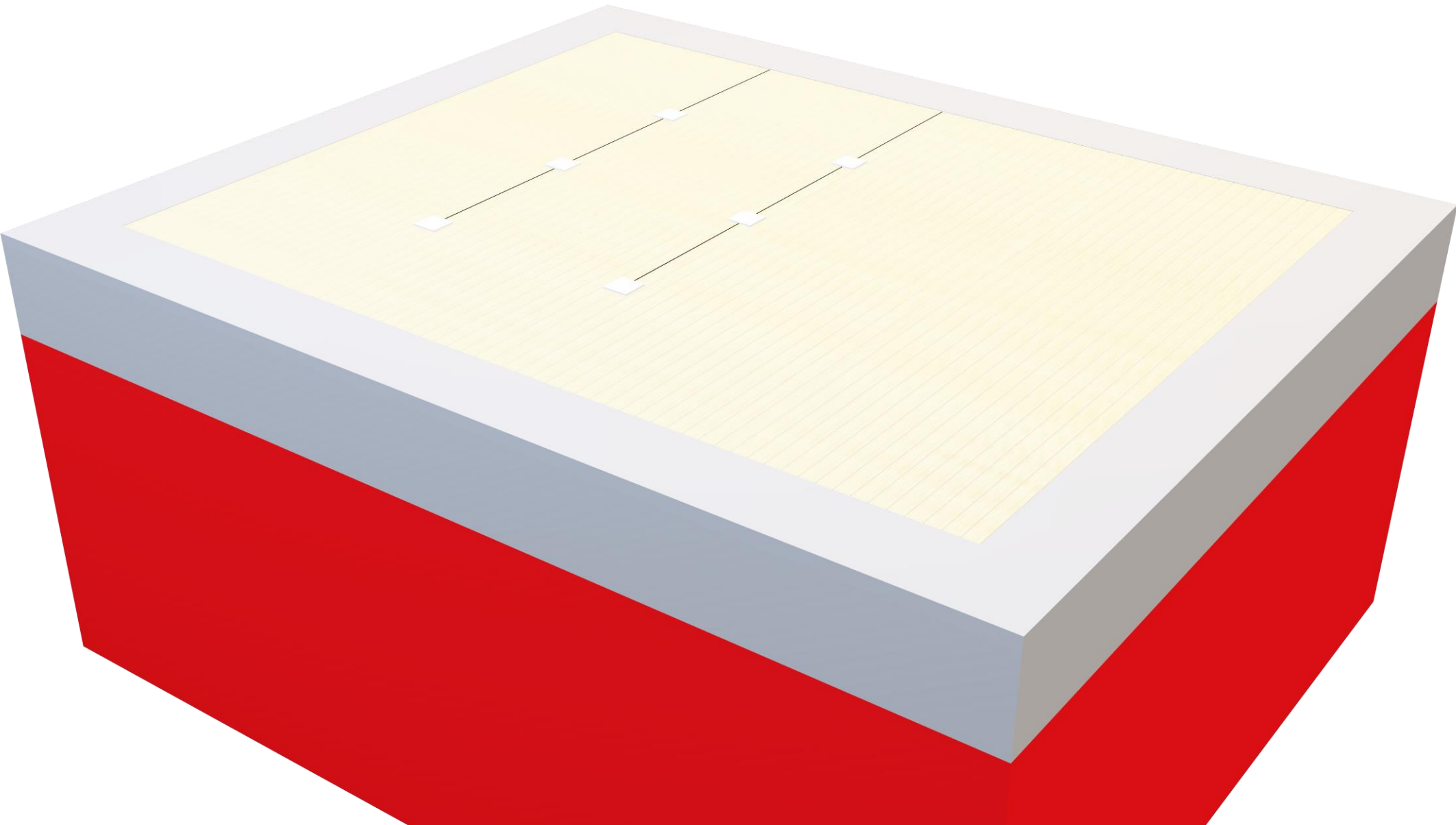


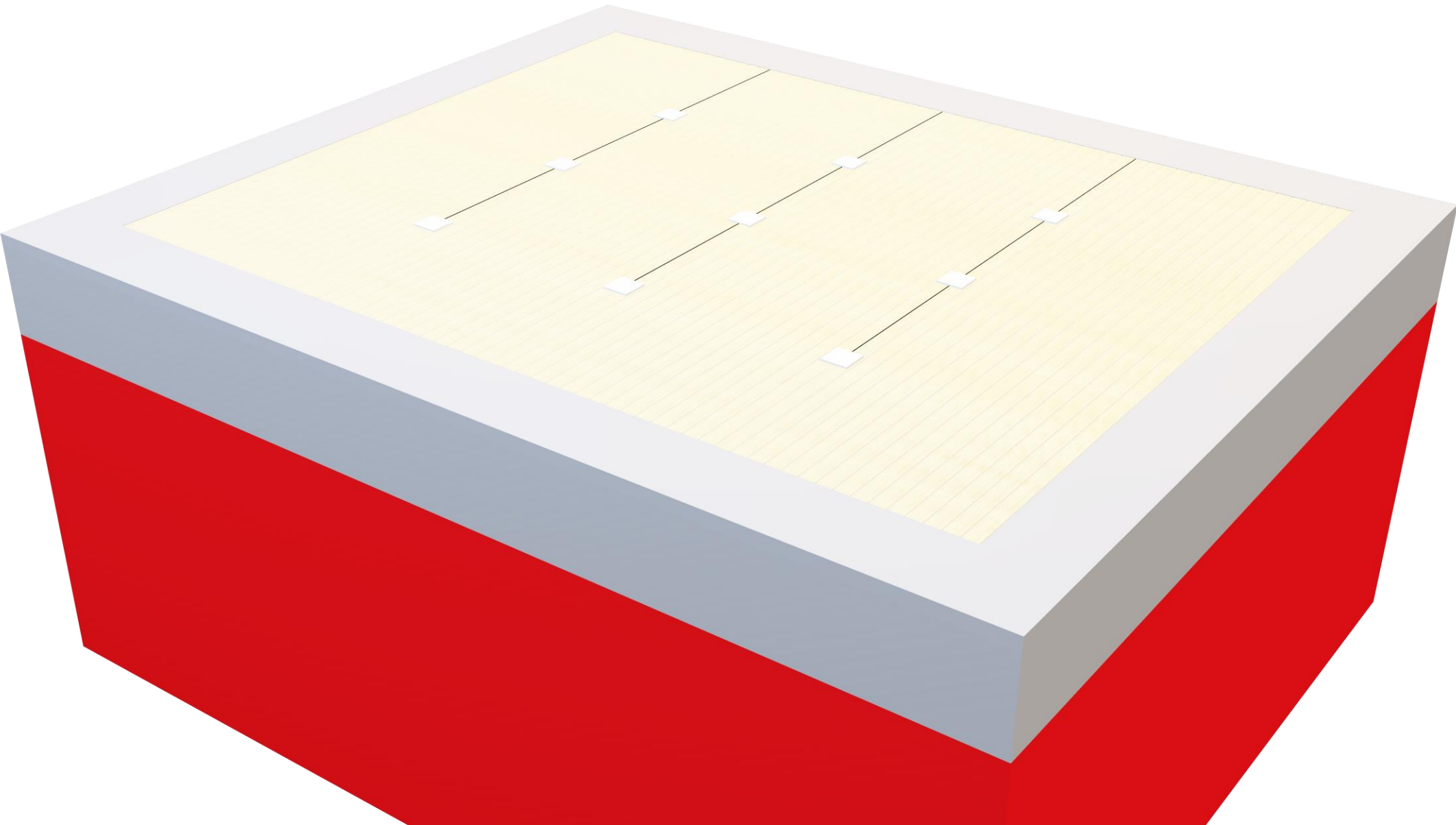


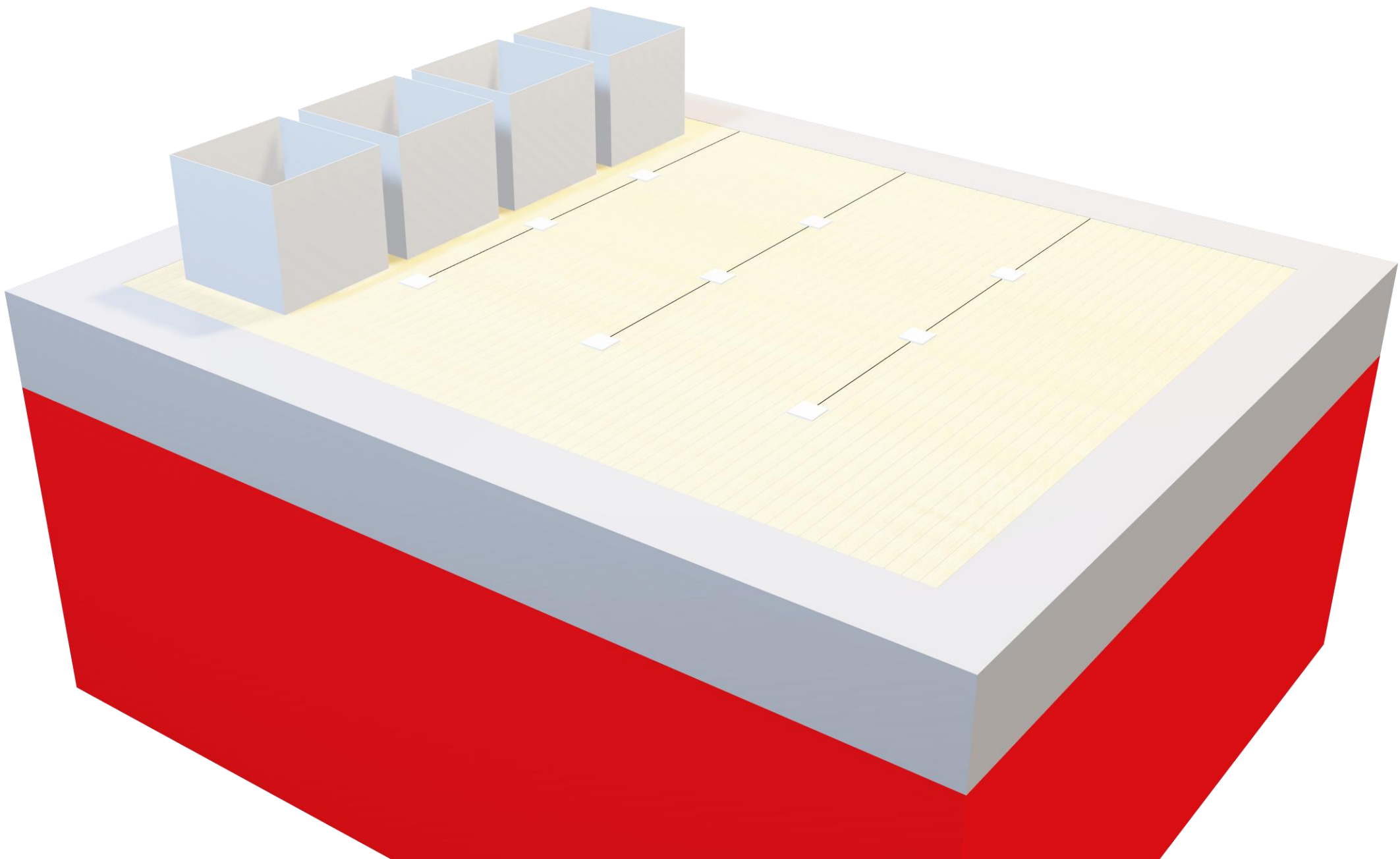


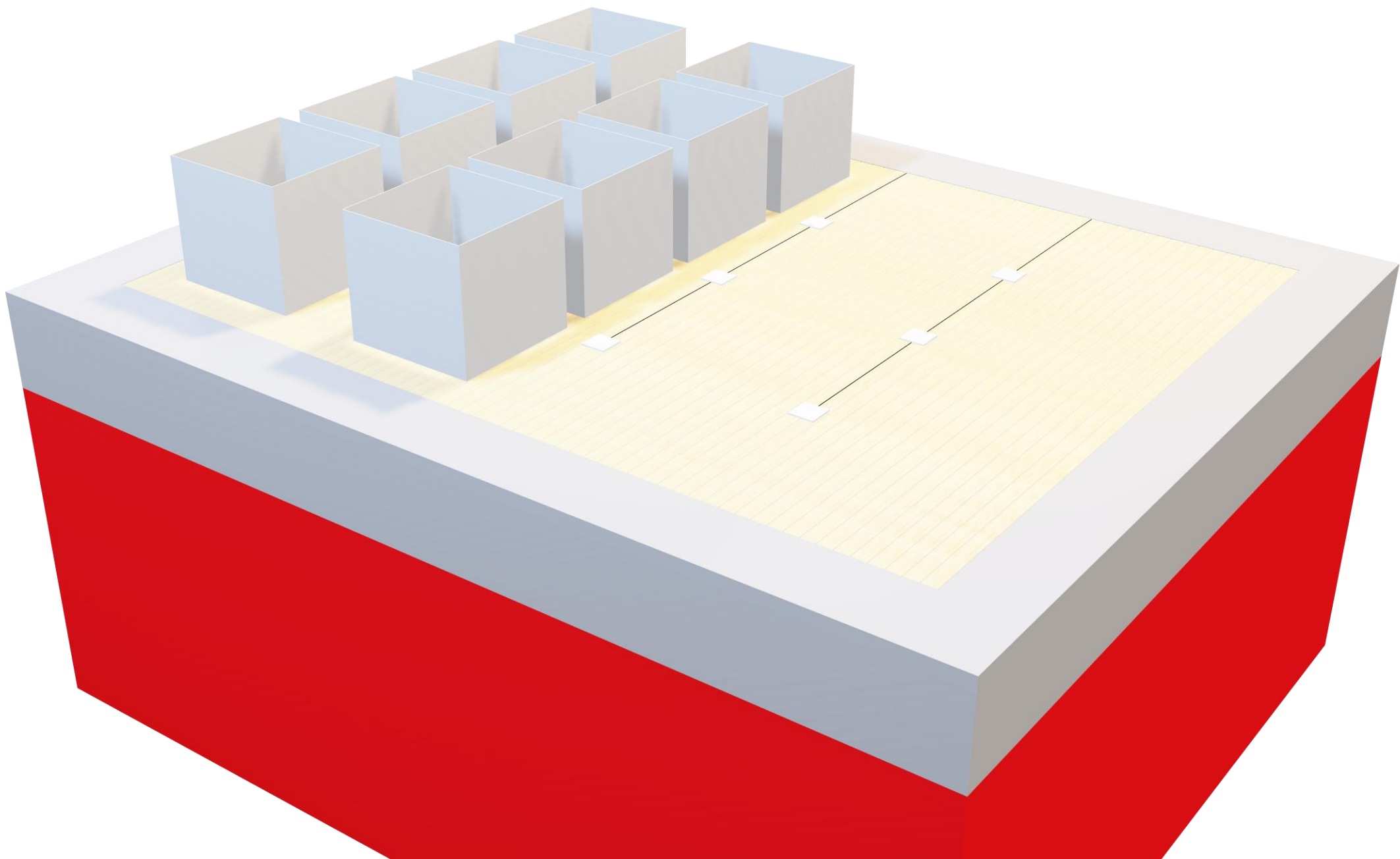


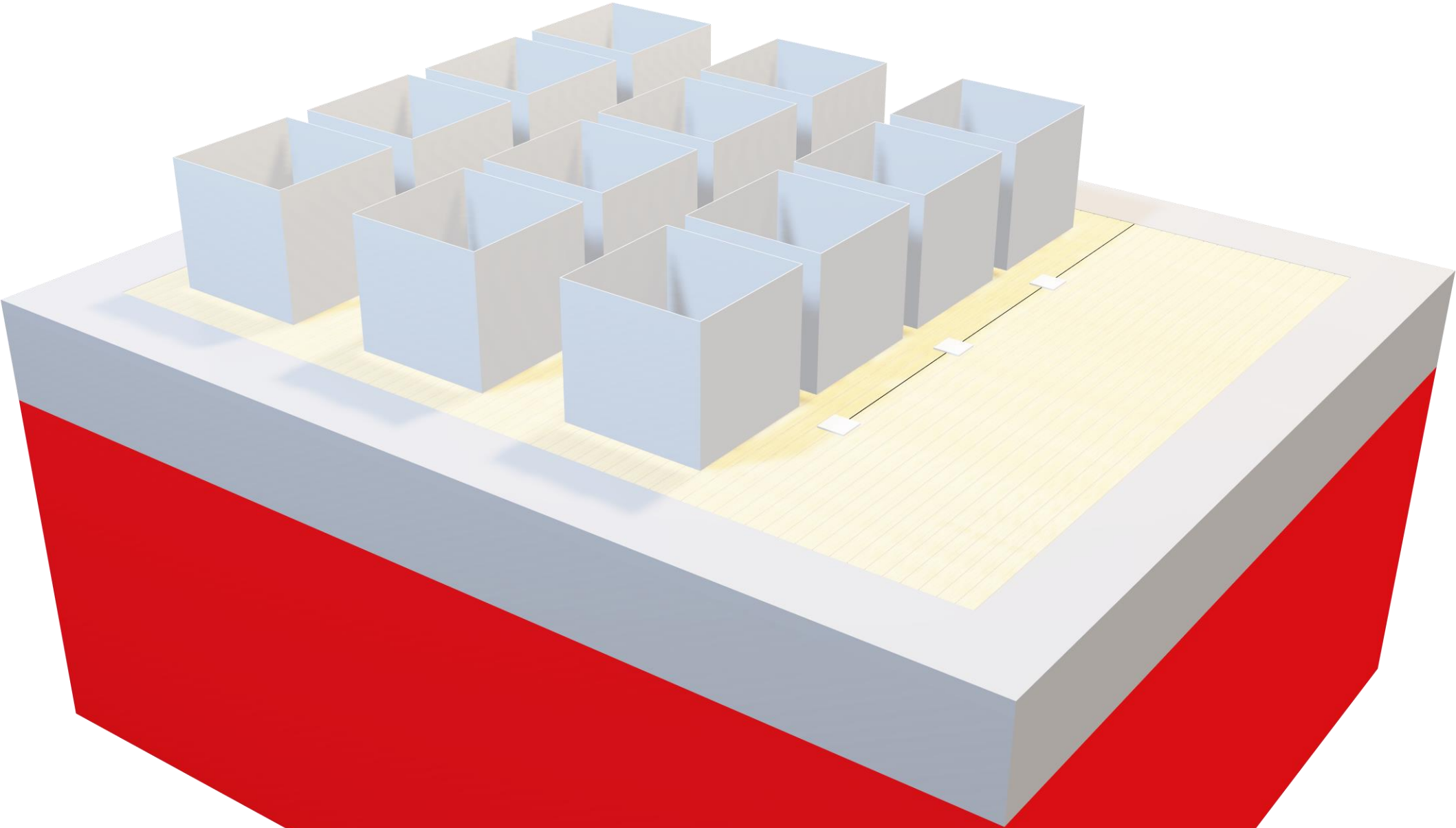


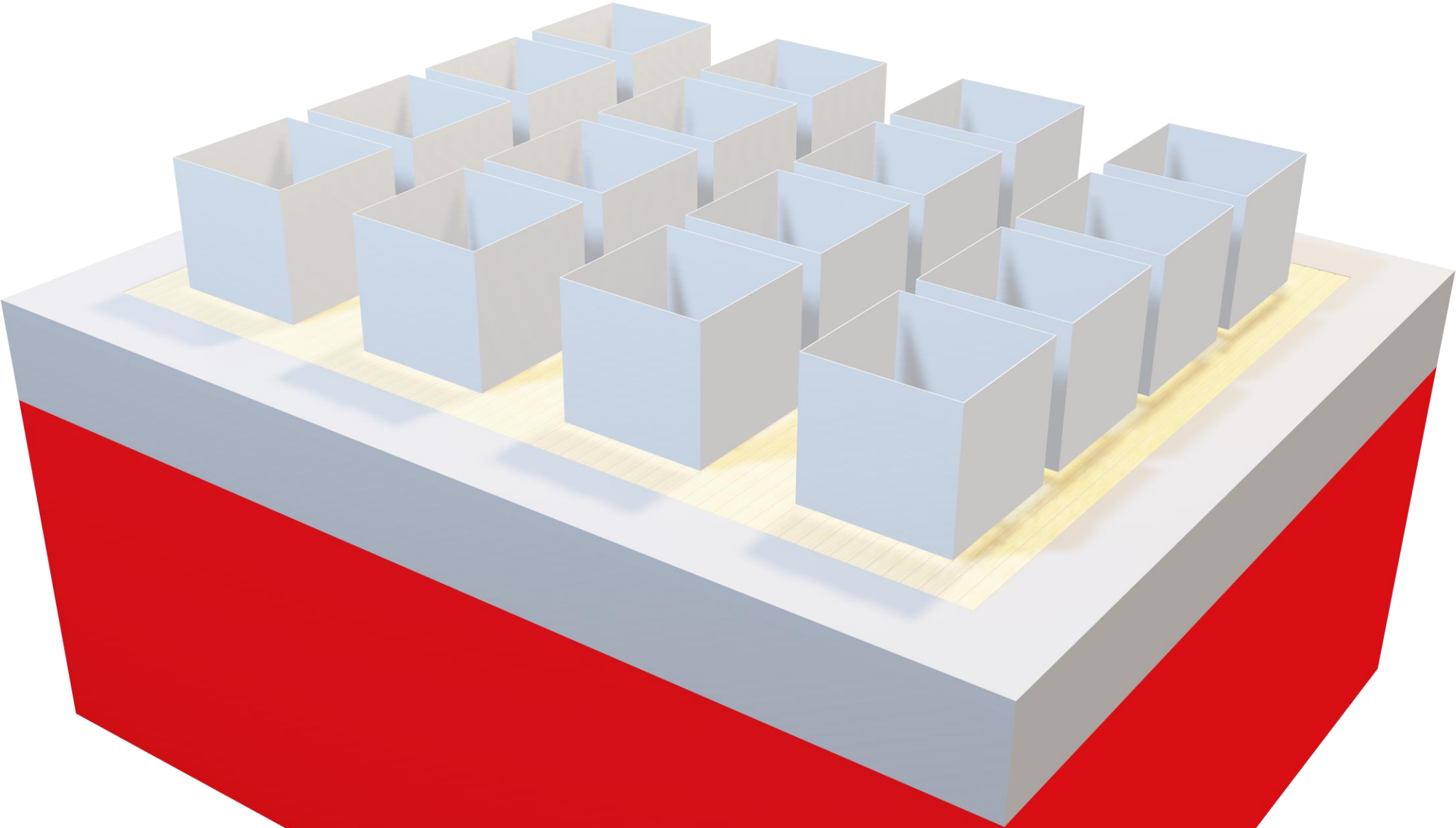


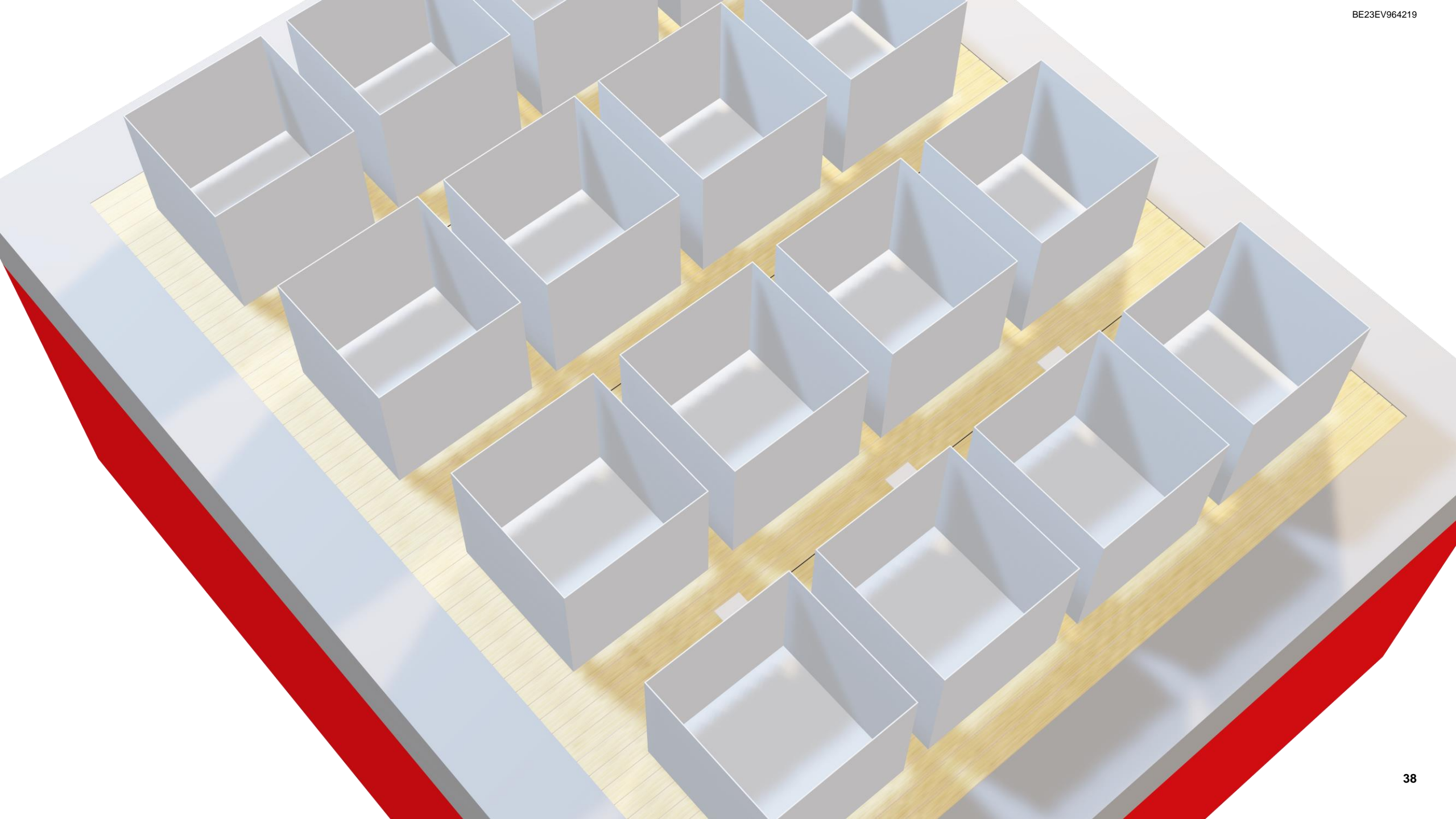


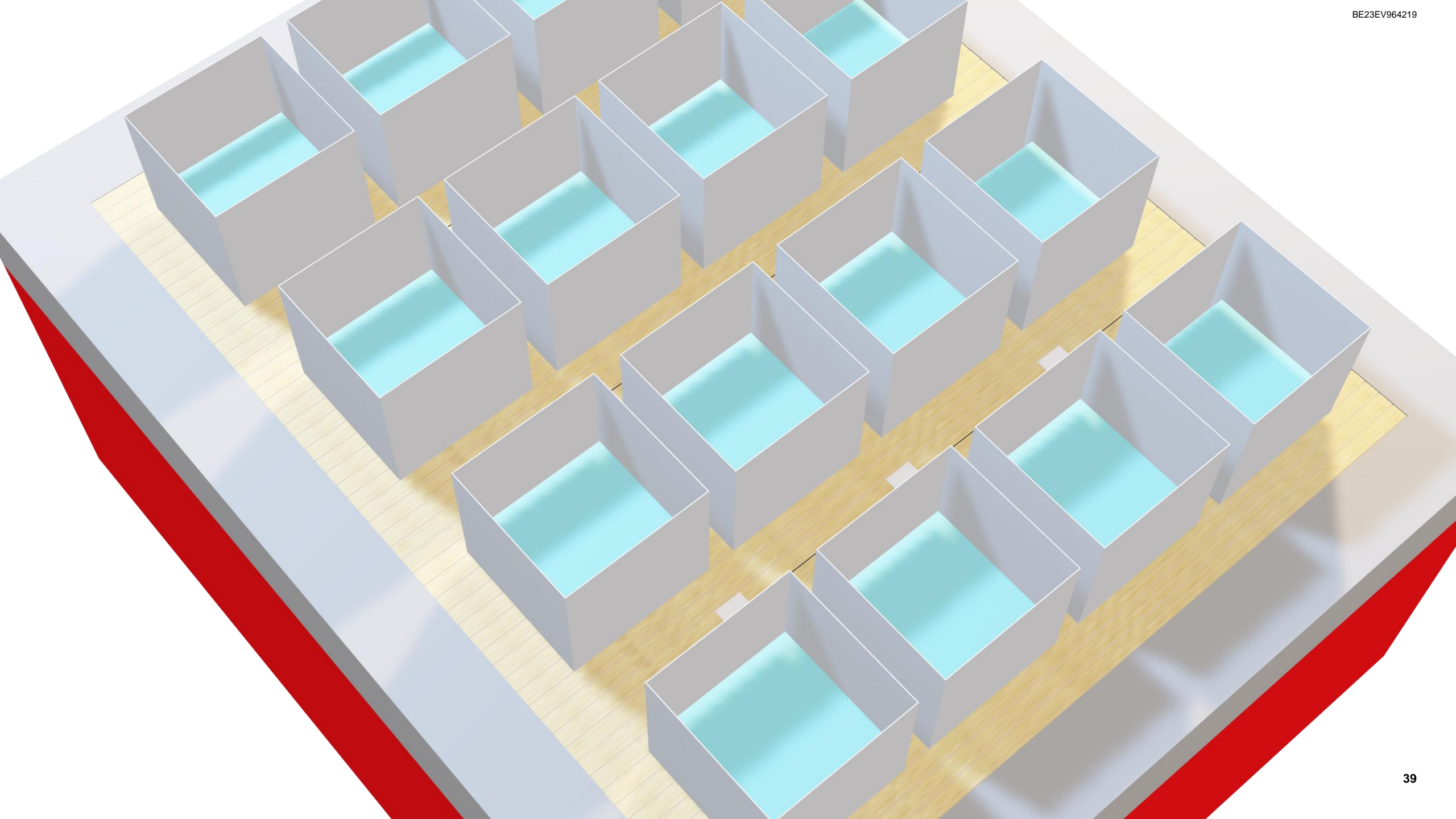


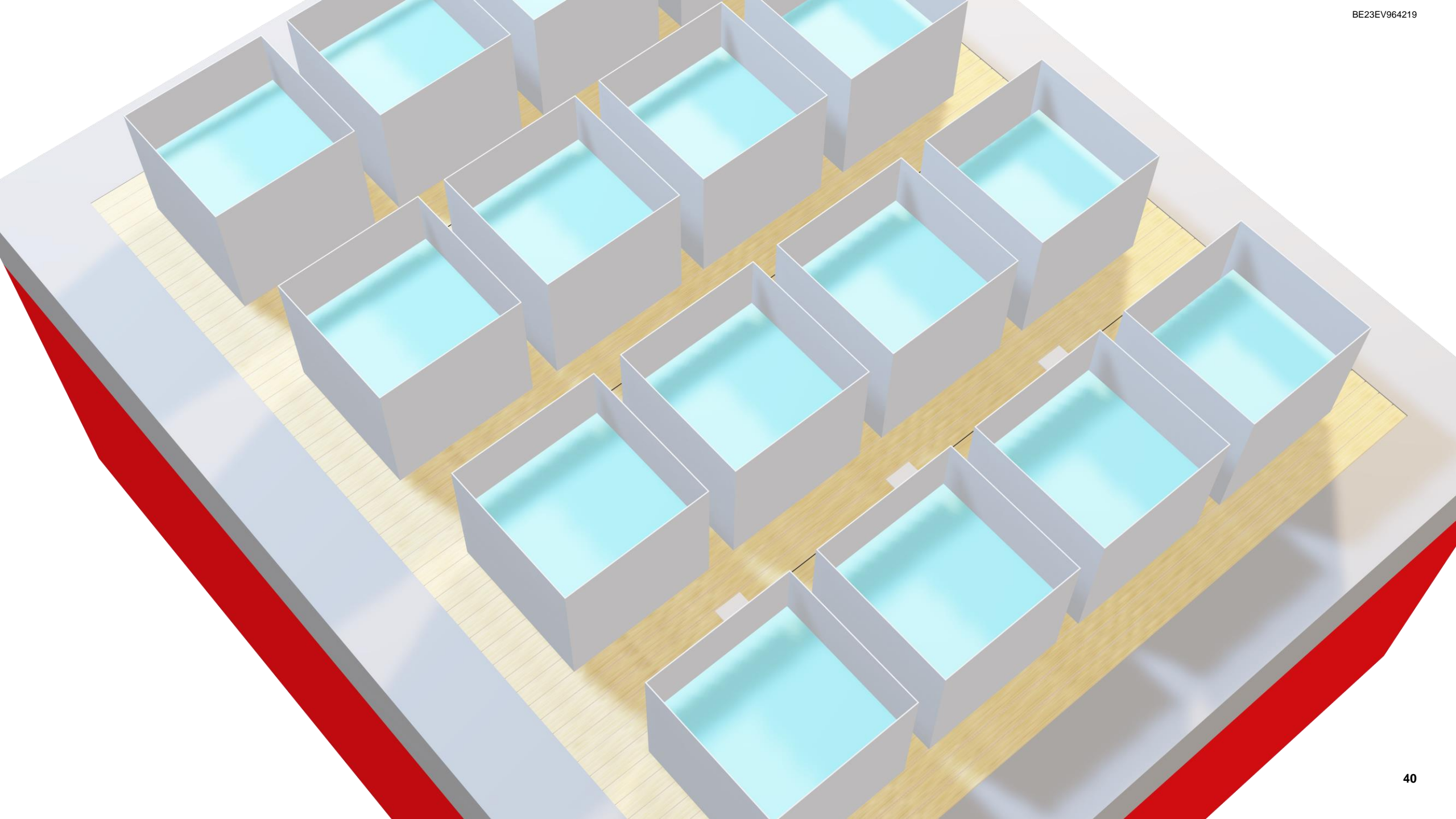


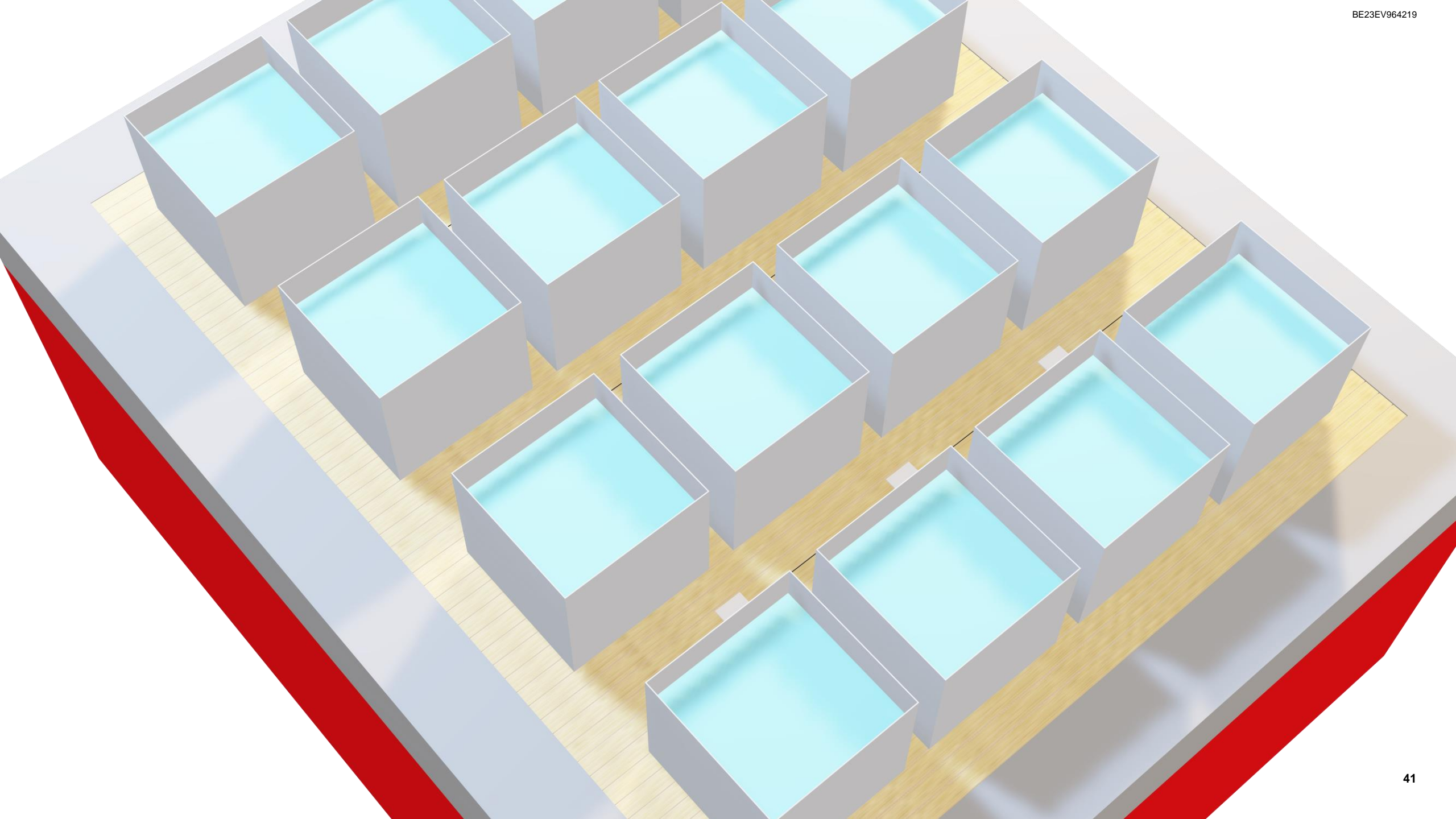


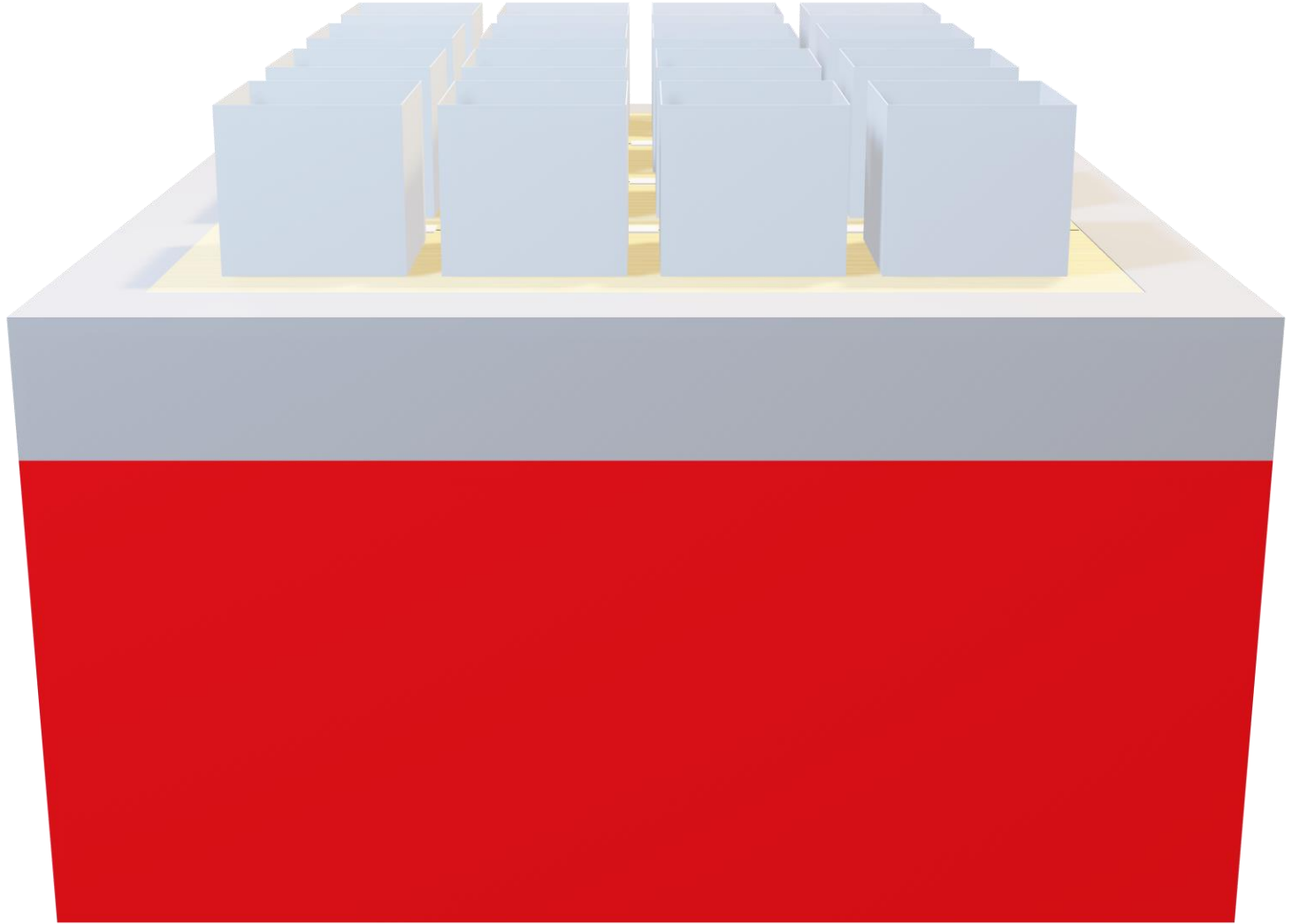


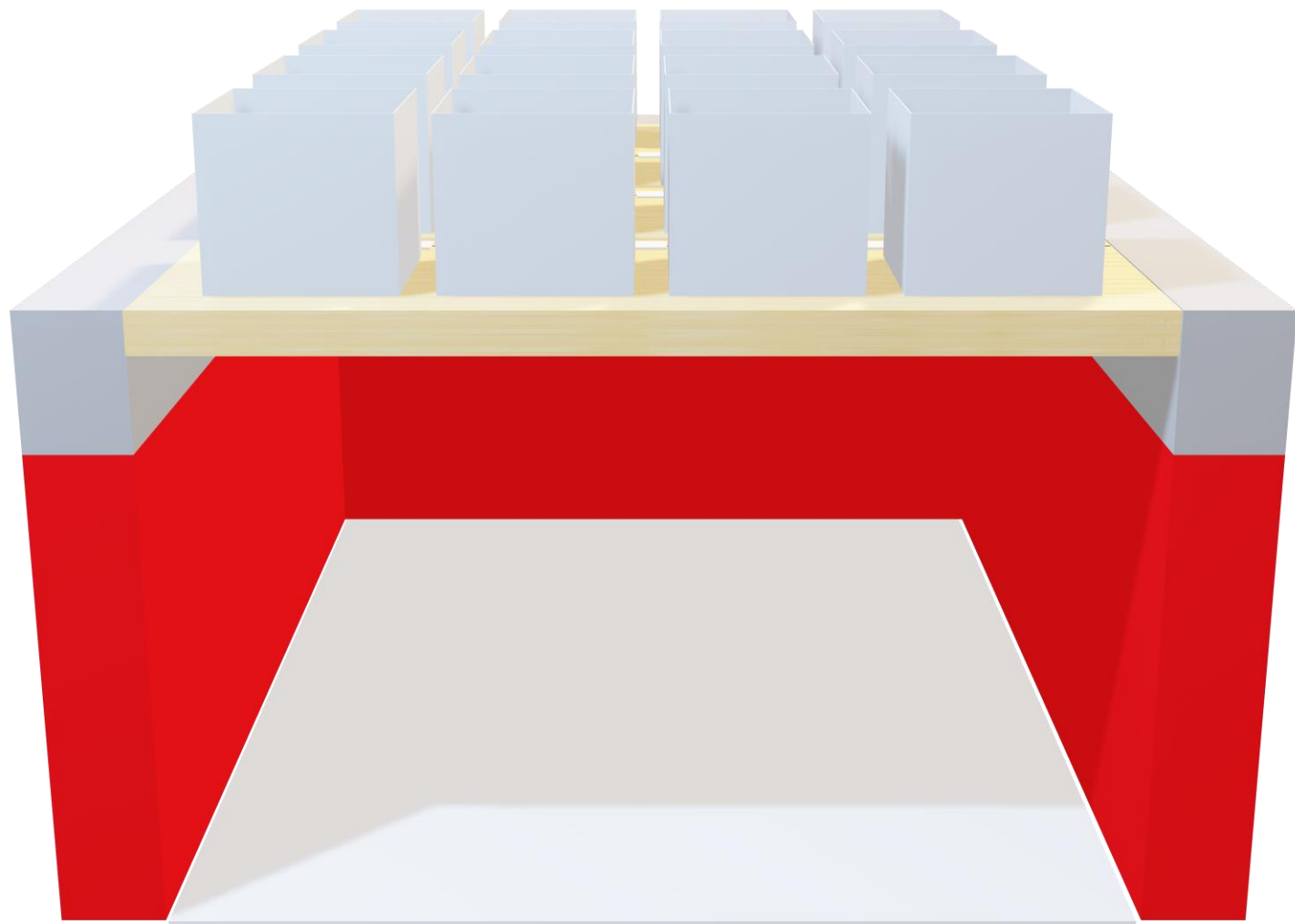


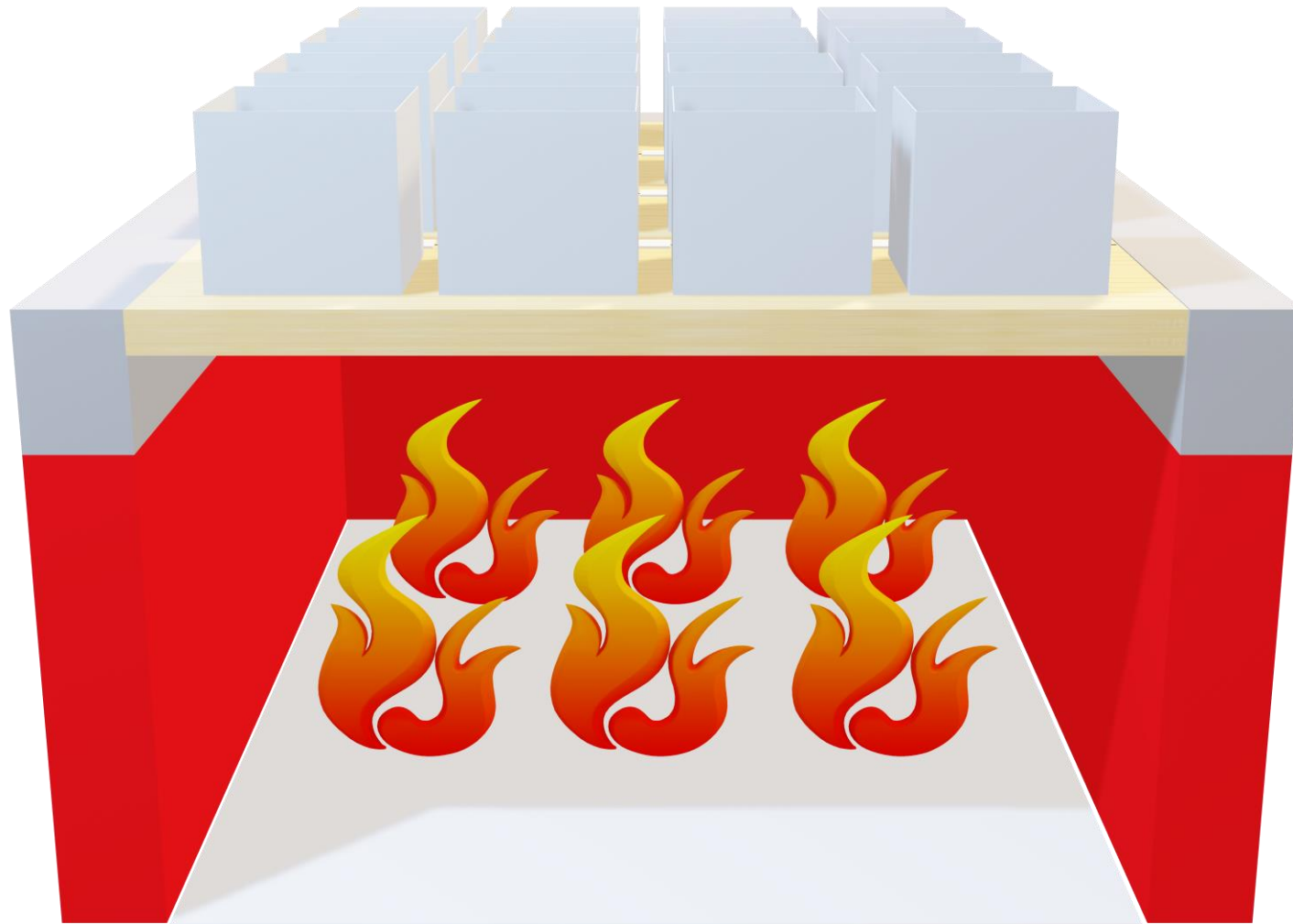




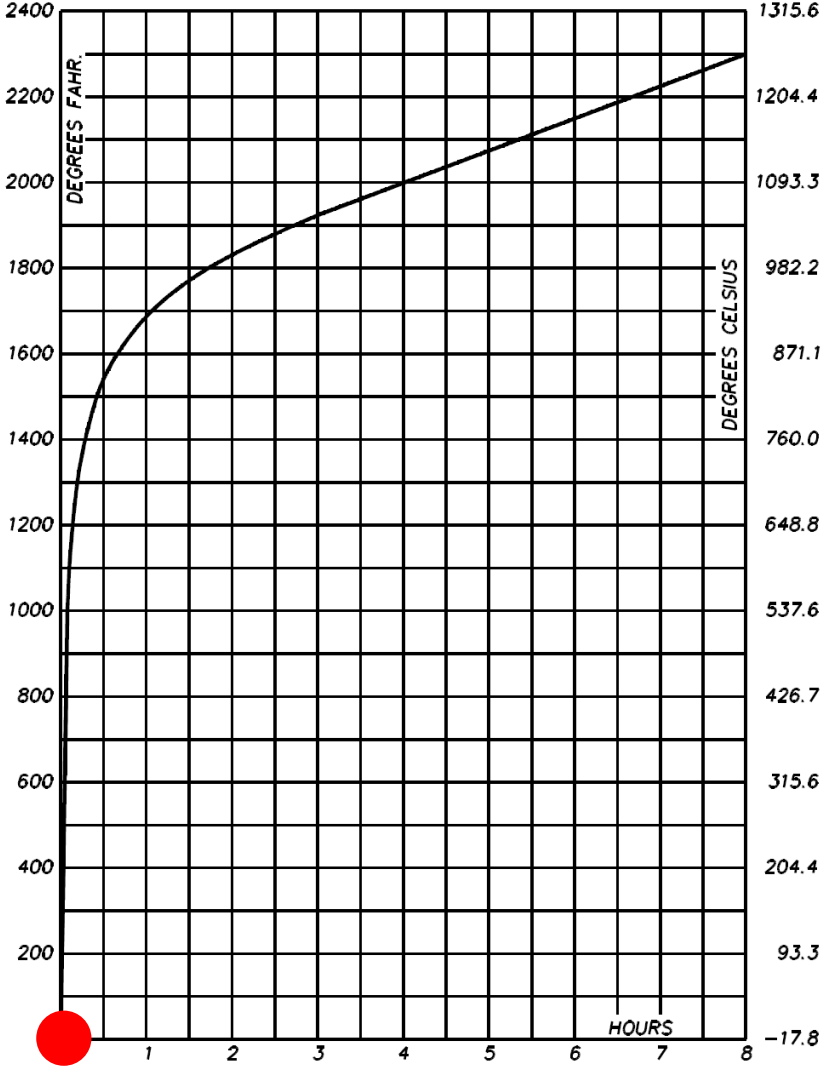








ULC S101 Furnace temperature control



Time-Temperature Curve

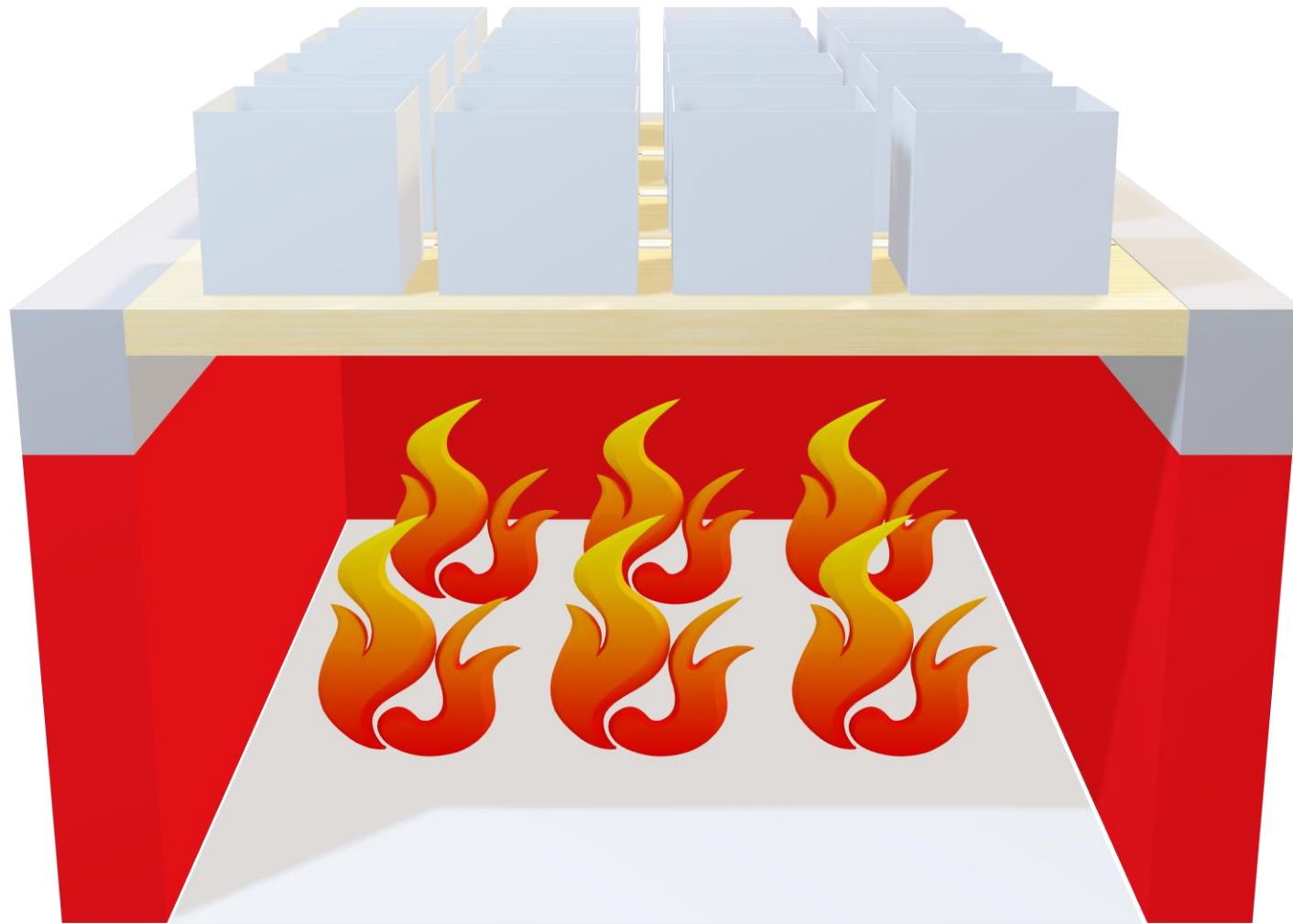
Source: UL Solutions

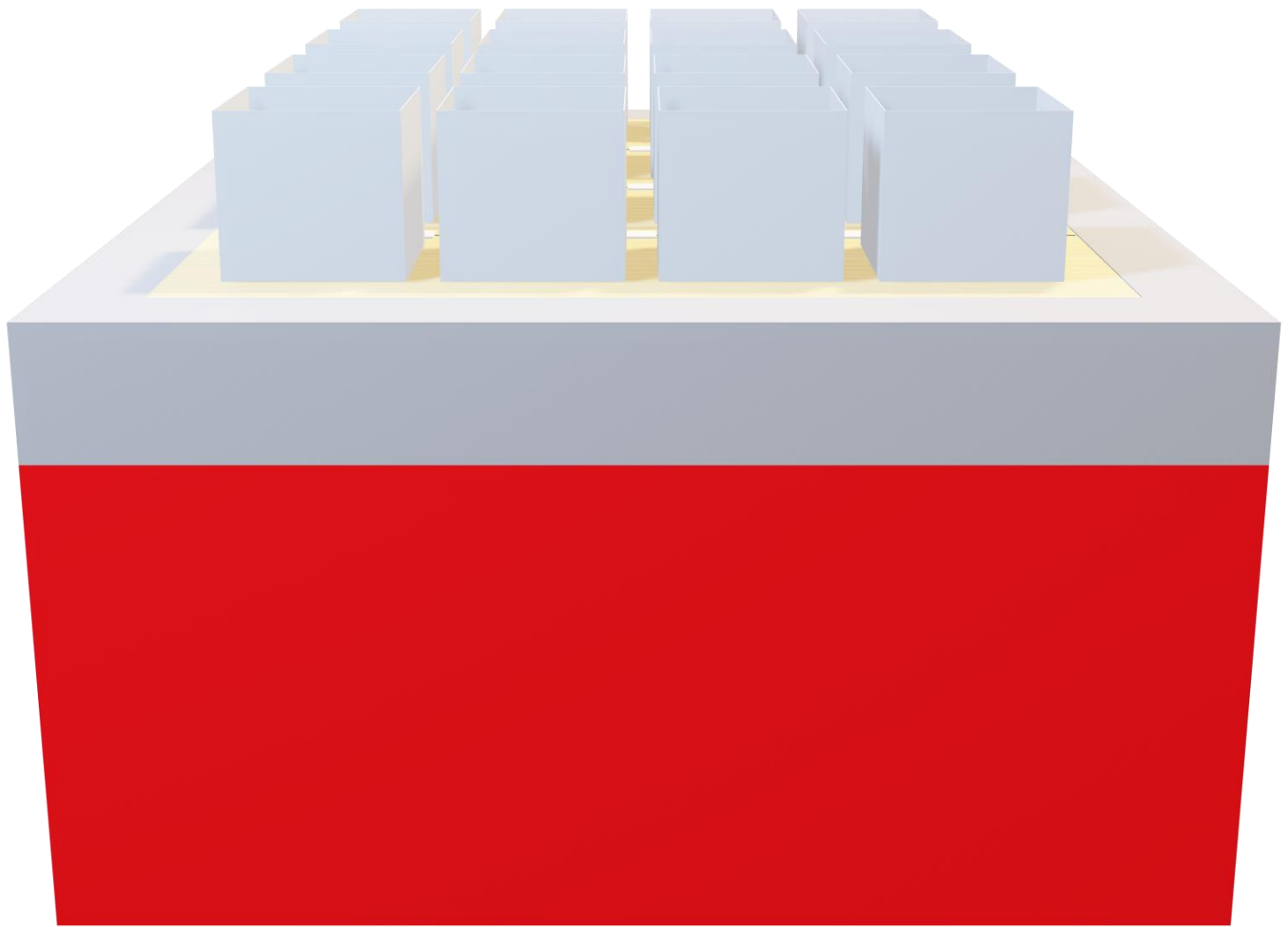
ULC S101

Acceptance criteria



- Prevent Openings and Passage of Flame and Hot Gases
- Unexposed Surface Temperature Rise Limit
- Maintain Applied Load









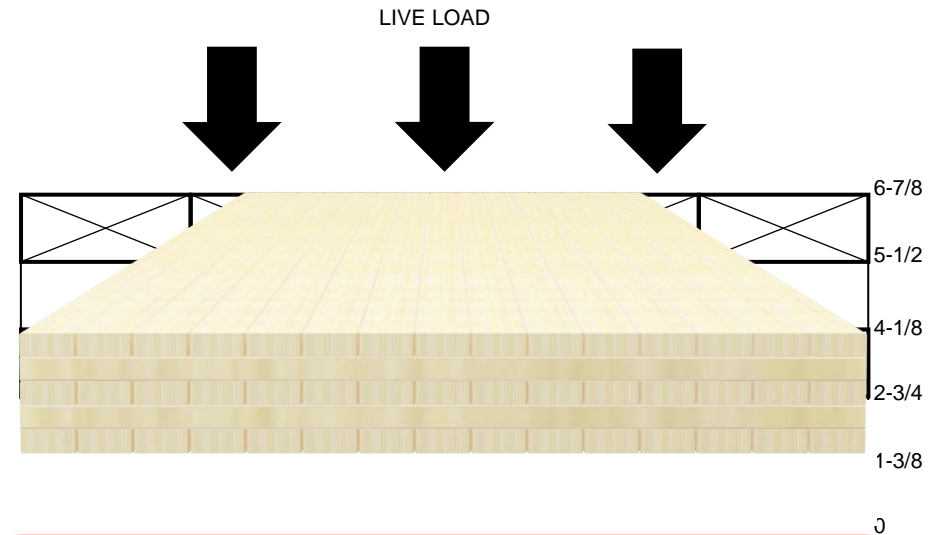
Calculated Fire Resistance – United States

- IBC Section 722: Calculated Fire Resistance
- NDS (National Design Specification) Chapter 16
 - For all CLT, assumes nominal char rate of 1.5 in. / hour
 - Effective char depth
- ANSI/APA PRG 320
 - Elevated temperature performance of adhesive
 - Provides design properties
- AWC NDS Technical Report No. 10: Calculating the Fire Resistance of Wood Members and Assemblies
 - Excellent resource



CLT floor: Fire resistance calculation example – United States

- 5-ply CLT floor
- Nominal 2x4 lumber
- Total thickness 6-7/8 in.
- Grade E1
- Design load known
- Need 60 minute fire rating
- $a_{\text{eff}} = 1.9$ in. – NDS Table 16.2.1B



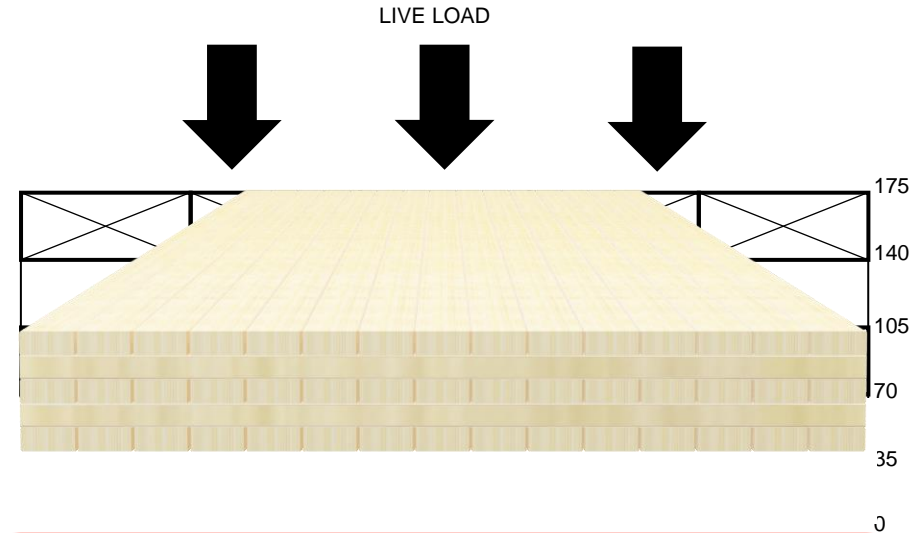
Calculated Fire Resistance – Canada

- NBC Appendix D: Fire-Performance Ratings
- CSA O86 Engineering Design in Wood, Annex B, Fire resistance of large-cross-section wood elements
 - For all CLT, assumes notional char rate of 0.80 mm / min
 - Effective cross section
 - Char layer depth
 - Zero-strength layer depth
- ANSI/APA PRG 320
- Canadian CLT Handbook
 - Excellent resource

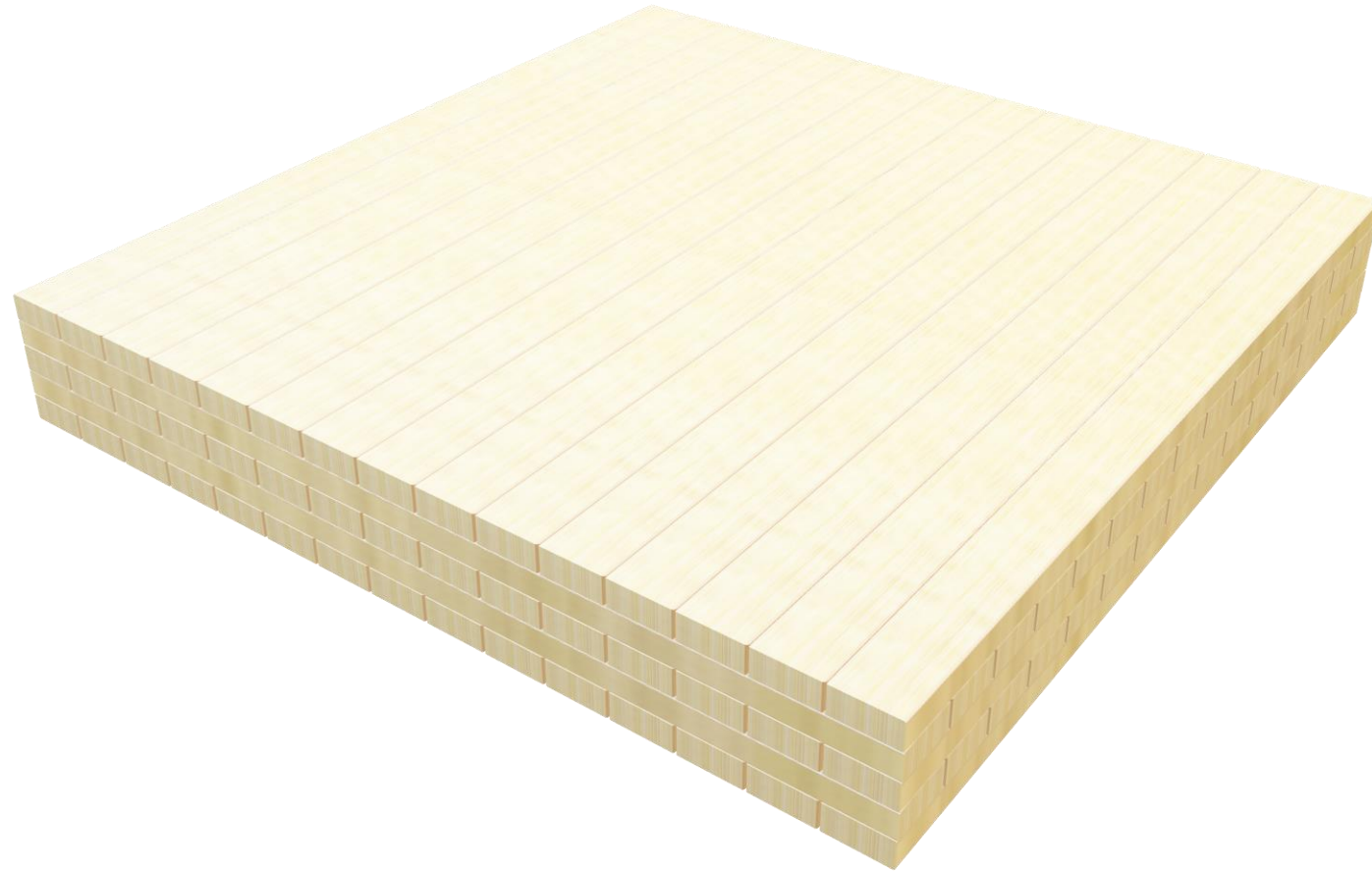


CLT floor: Fire resistance calculation example – Canada

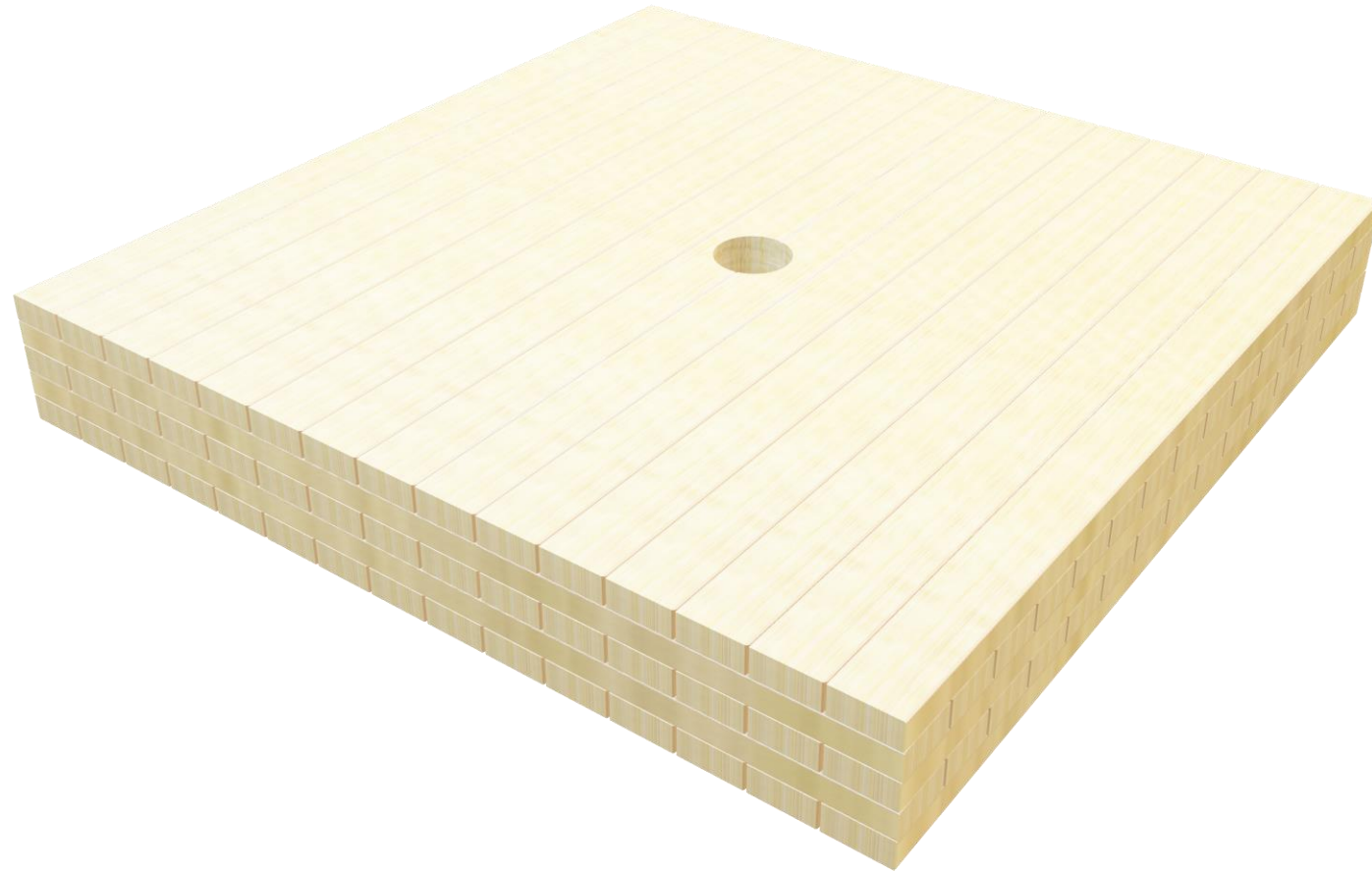
- 5-ply CLT floor
- Nominal 38 x 89 (2x4) lumber
- Total thickness 175 mm (6-7/8 in.)
- Grade E1
- Design load known
- Need 60 minute fire rating
- Char layer depth = $.80 \times 60 = 48$ mm
- Zero-strength layer depth = 7 mm
- Loss of cross section = $48 + 7 = 55$ mm



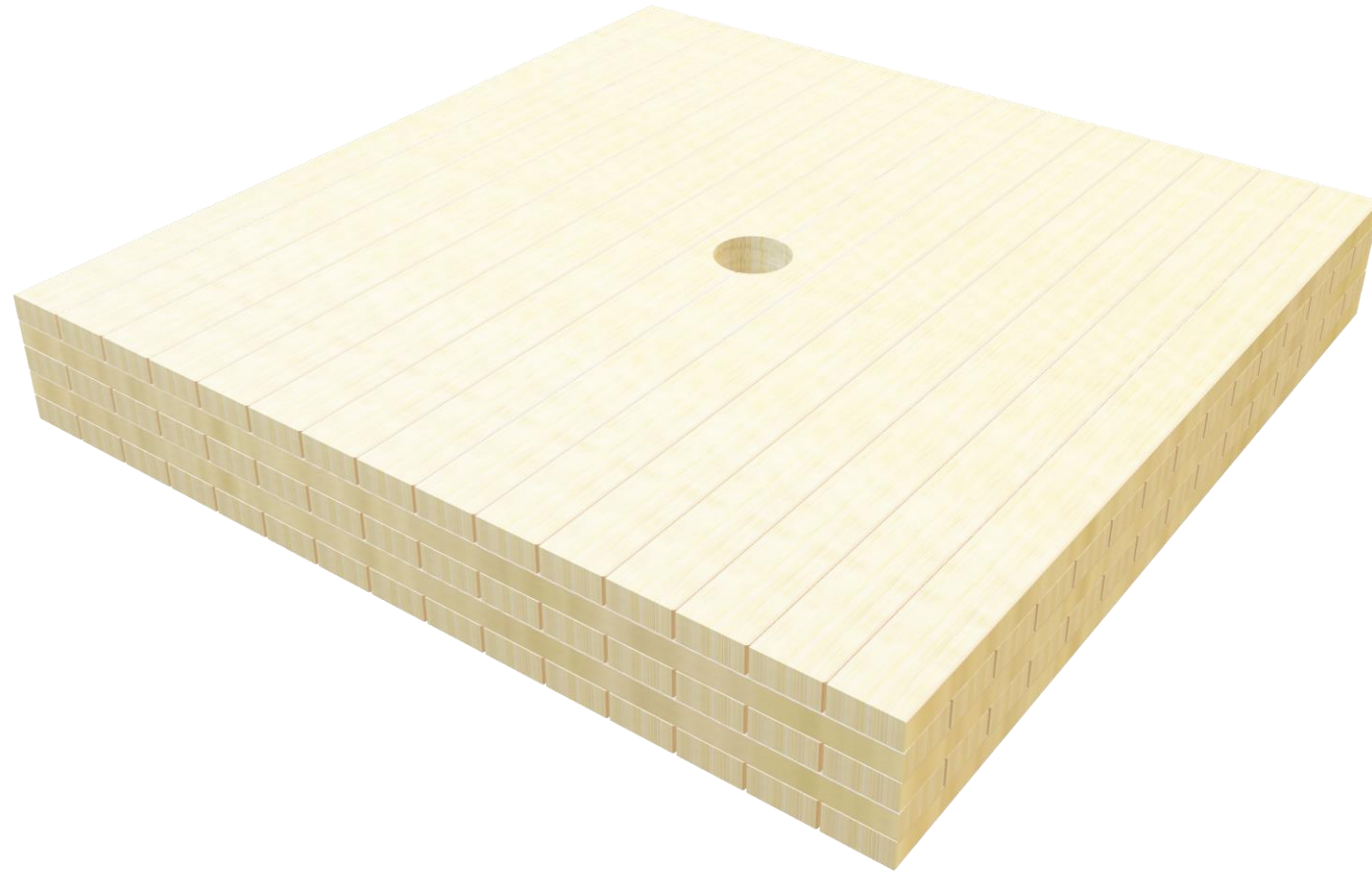
Firestop systems with CLT



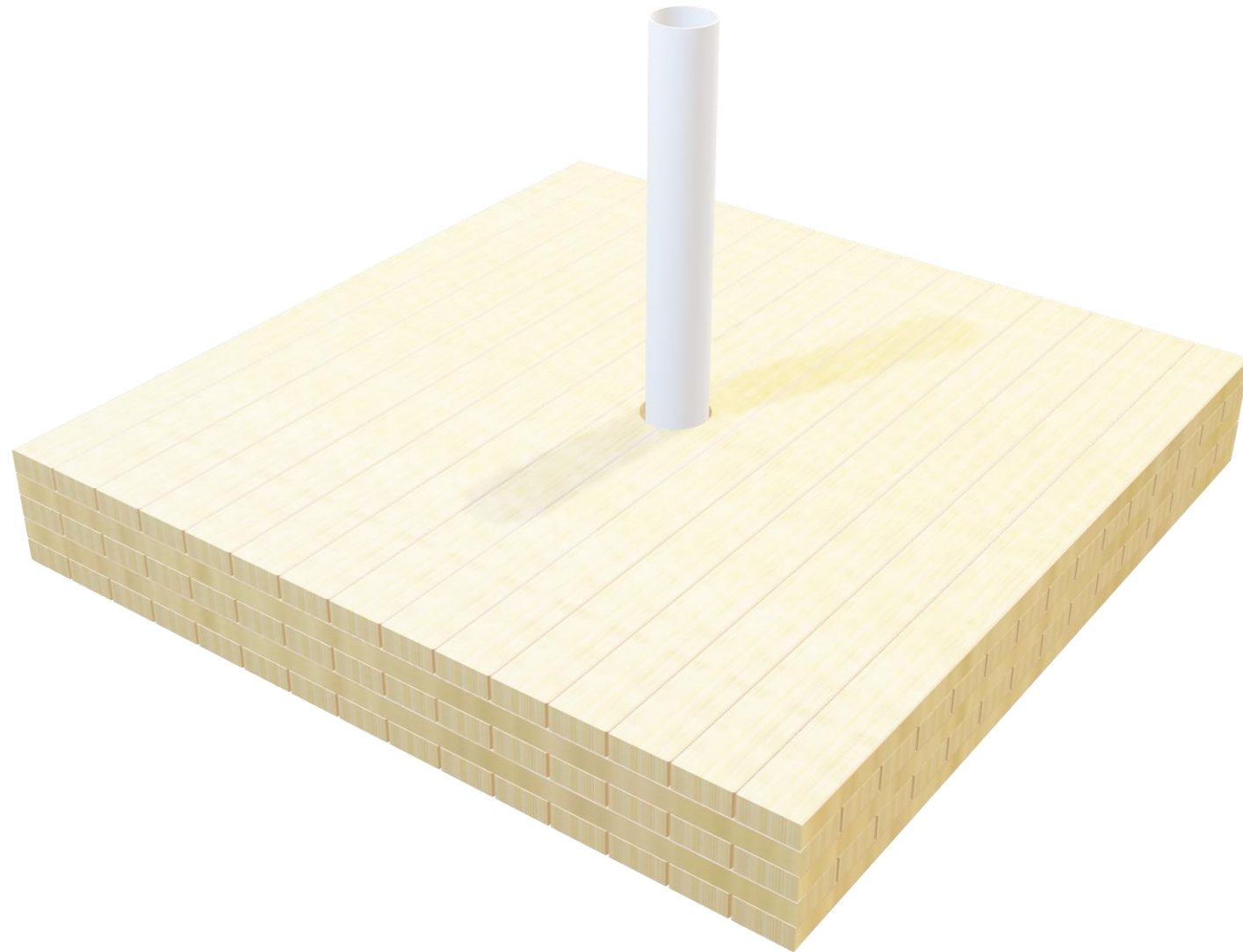
Firestop systems with CLT



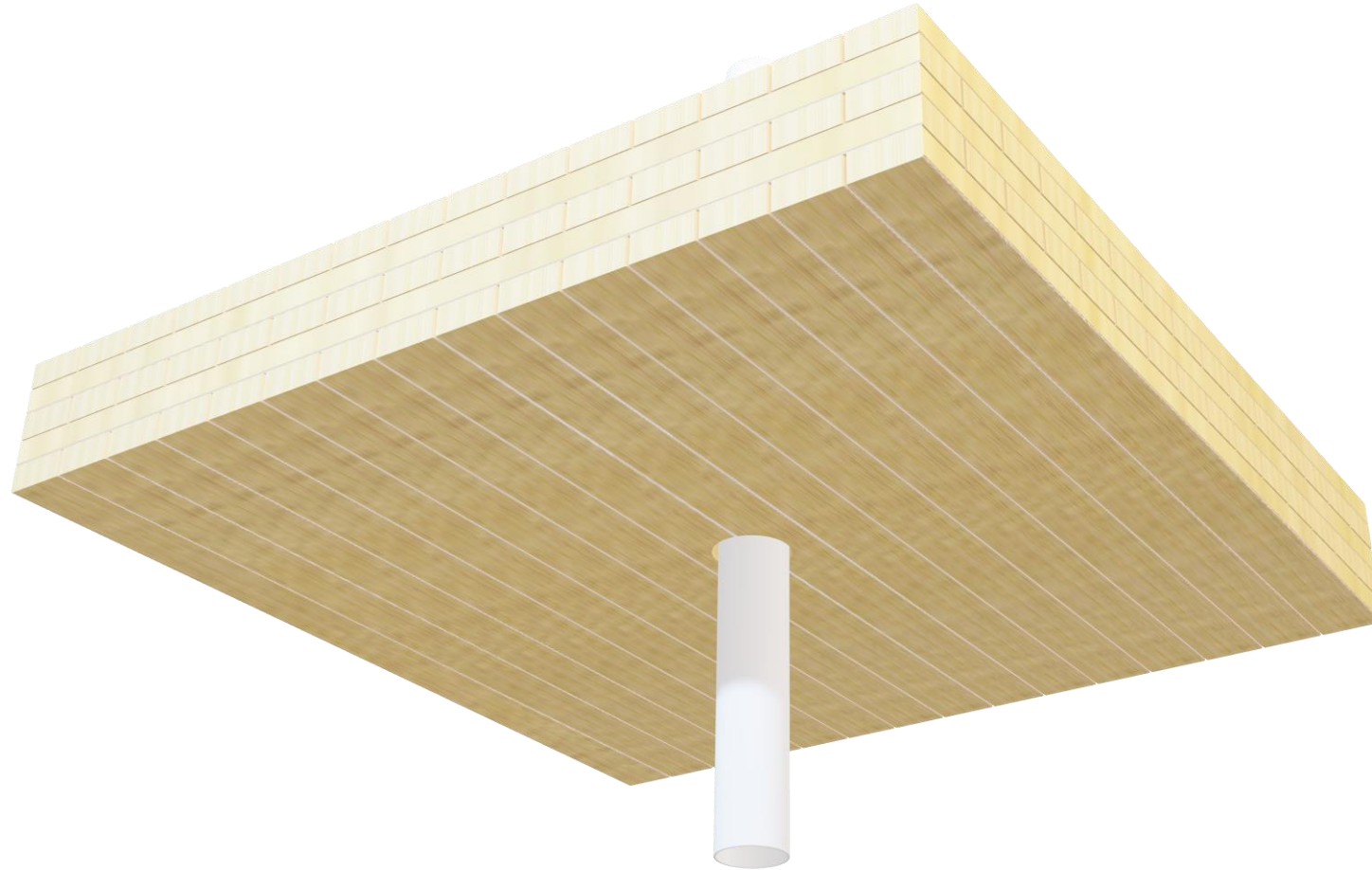
Firestop systems with CLT



Firestop systems with CLT

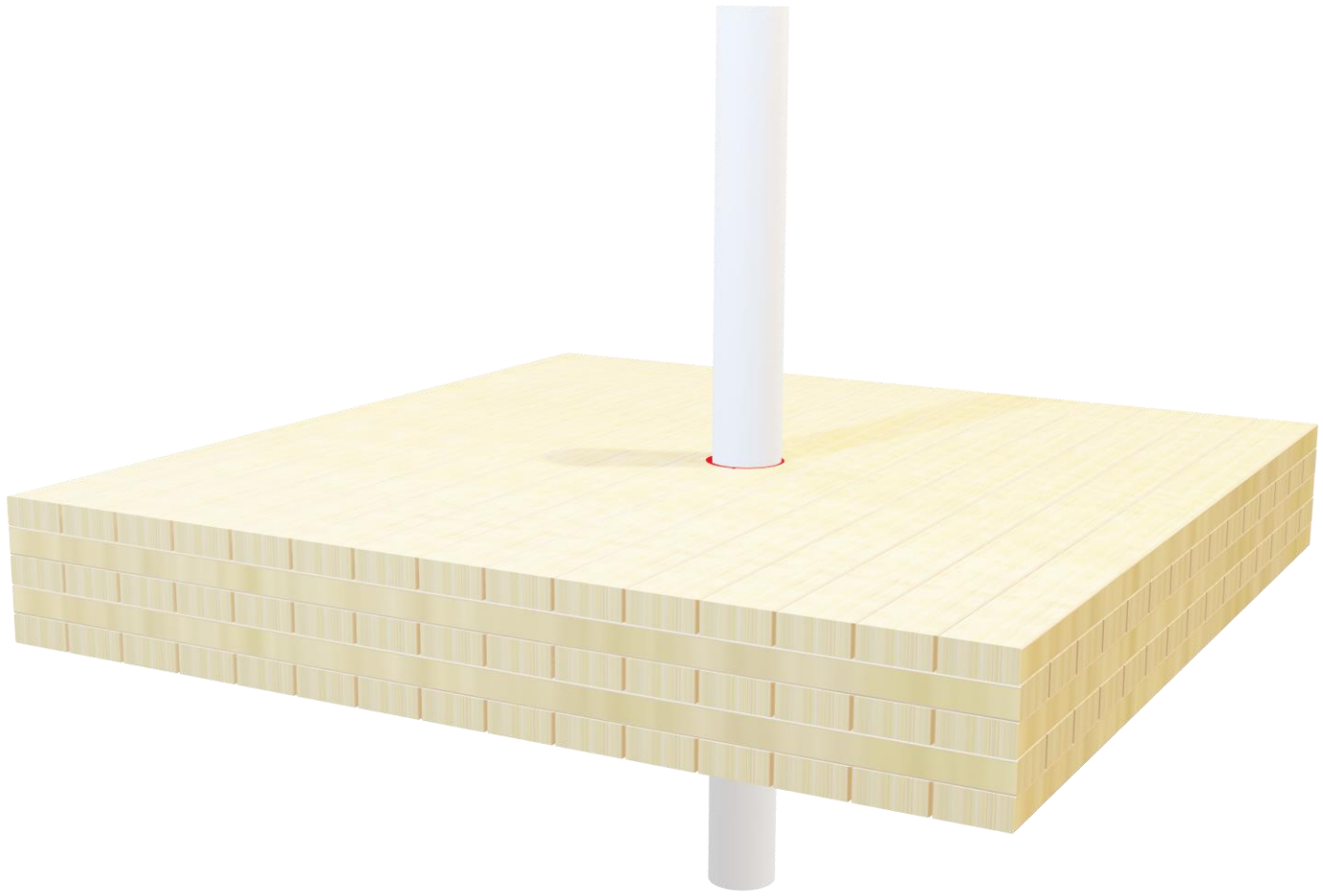


Firestop systems with CLT









Relevant Code Changes for Mass Timber

Complete
(Canada)

- **2020 National Building Code of Canada (NBC)** language allows 12-story buildings that use mass timber
- Key phrase is **encapsulated mass timber construction (EMTC)**

Complete
(Canada)

- British Columbia early adoption of allowances for 12-story EMTC . Relied on technical content from 2020 NBC draft
- Ontario published “Ontario’s Tall Wood Building Reference: A Technical Resource for Developing Alternative Solutions for Ontario’s Building Code” in 2017
- Alberta has allowed a pathway to 12-storey EMTC via a STANDATA document in February 2020

Complete
(U.S)

- **2021 International Building Code (IBC)** has expanded the prescriptive capabilities of **Mass Wood Timber (MWT)** buildings
- Max 18 stories using the most stringent requirements for non-combustible protection of MWT
- Max 9 stories for exposed MWT (except for MWT used in exterior walls)

- Appendix D of the NBC provides a calculation method for fire resistance of mass timber in accordance with CSA 086, “Engineering Design in Wood”

2020 NBC Language for EMTC Dimensions		
Structural Wood Elements	Minimum Thickness, mm	Width x Depth, mm x mm
Walls that are fire separations or exterior walls	96	
Wall that require a fire resistance rating, but are no fire separations	192	
Floors or roofs	96	
Beams, columns, and arches (2- or 3-sided fire exposure)		192 x 192
Beams, columns, and arches (4-sided fire exposure)		224 x 224



Current Listings for Mass Timber Firestops

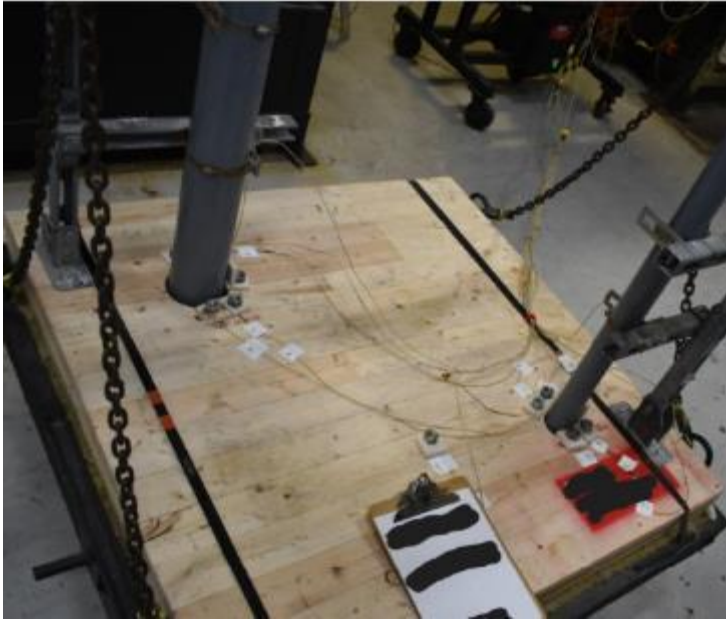
- Intertek first listed CLT firestops in October 2021
- UL first listed CLT firestops in September 2022
- Manufacturers now have a pathway to expand listings



Intertek Listings, Penetrations	UL Listings, Penetrations	Intertek Listings, Edge-of-Slab (ASTM E2307)
HI/PF 120-07	F-G-1001	HI/BPF 120-33 & 180-01
HI/PF 120-08	F-G-2001	HI/BPF 120-34
HI/PF 120-09	F-G-2002 (50 Pa)	HI/BPF 120-35 & 180-02
HI/PF 120-10	F-G-2003	HI/BPF 120-36
HI/PF 120-11	F-G-3001	STI/BPF 120-11
STI/PF 60-01 & STI/PF 120-01 (2.5 Pa)	F-G-5001	
STI/PF 60-02 & STI/PF 120-02		
STI/PF 60-03 & STI/PF 120-03		Green Shading Indicates ULC S115 and NBC Compliance.
STI/PF 60-04 & STI/PF 120-04		
STI/PF 60-05		
STI/PF 60-06 (2.5 Pa)		



F-G-2022 – 50 Pa Solution for Plastic Pipe in CLT



Nonexposed Side Before Fire Endurance



Exposed Side Before Fire Endurance



Exposed Side Before Fire Endurance



F-G-2022 – 50 Pa Solution for Plastic Pipe in CLT



Nonexposed Side During Fire Endurance



Nonexposed Side During Fire Endurance



F-G-2022 – 50 Pa Solution for Plastic Pipe in CLT



Nonexposed Side Post Fire Endurance



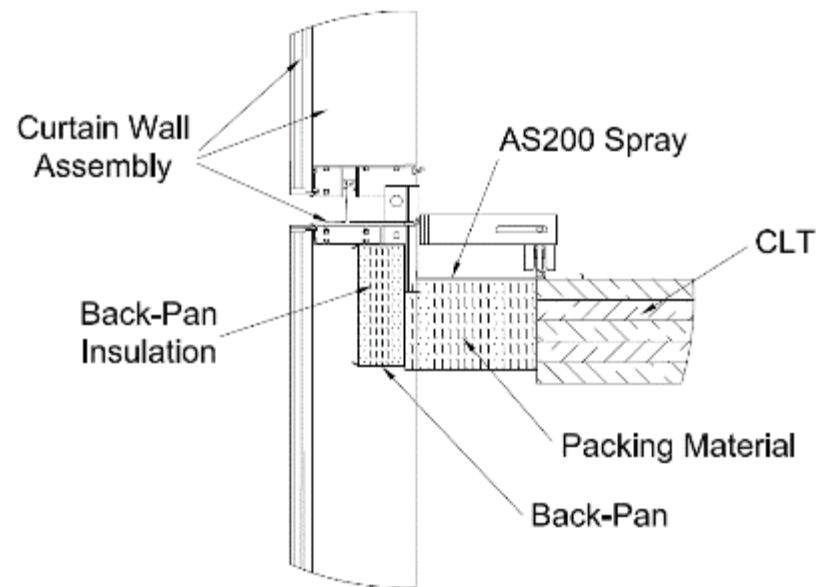
Exposed Side Post Fire Endurance,
50mm Pipe



Exposed Side Post Fire Endurance,
102mm Pipe



STI/BPF 120-11 – 2 Hour Curtain Wall System. No gypsum board required.



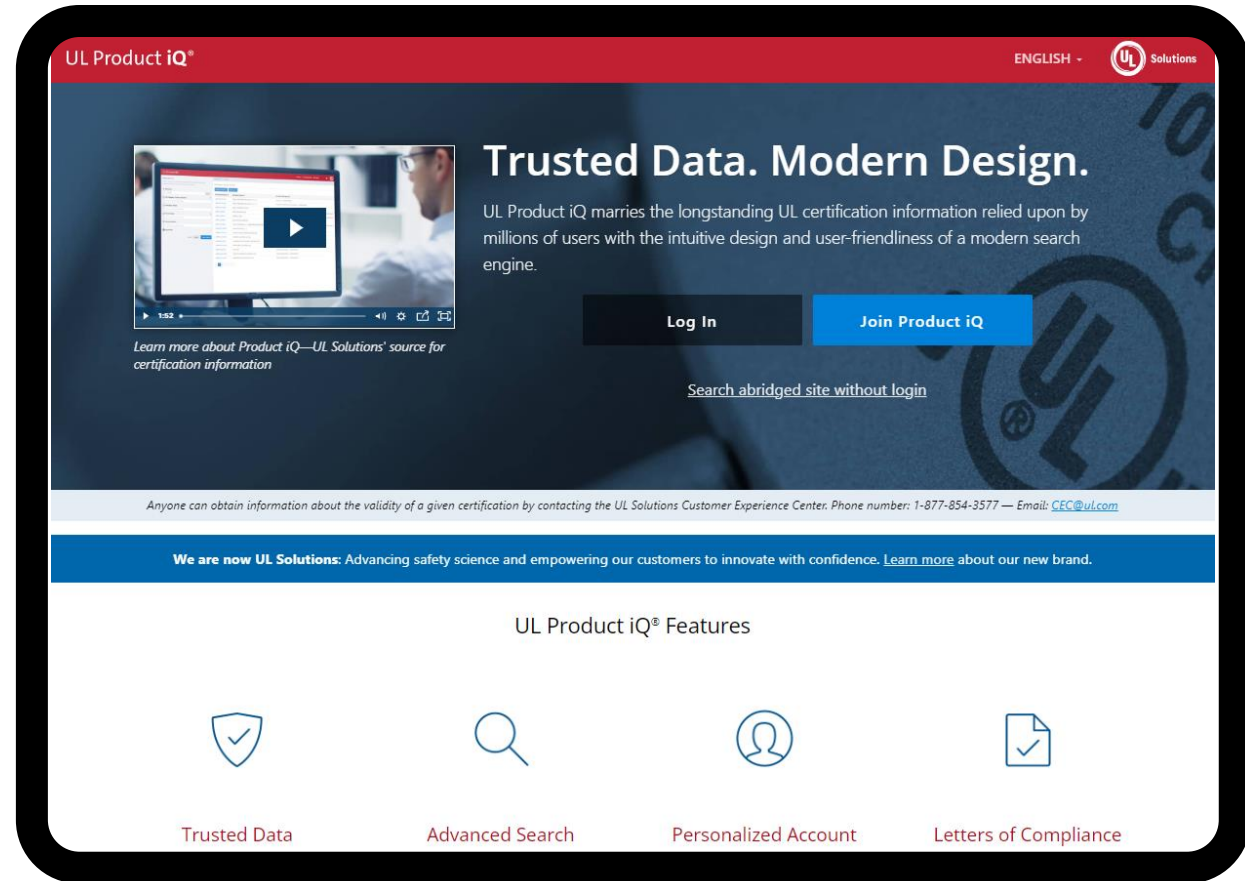
- Min 5 ply, 6-7/8" (175mm) CLT floor assemblies
- No Additional Concrete topping
- No layer(s) of gypsum wall board required
- Min 22 GA Galvanized Backpan
 - 8" high x 3" deep
- Many configurations covered



Product iQ® – The online directory

ProductiQ.UL.com

- Can help you achieve code compliance
- Continuously updated
- Basic service – no charge for use



The screenshot shows the UL Product iQ website interface. At the top, there is a navigation bar with "UL Product iQ®" on the left, "ENGLISH -" in the center, and the UL Solutions logo on the right. Below the navigation bar is a hero section featuring a video player on the left and the headline "Trusted Data. Modern Design." on the right. The text below the headline states: "UL Product iQ marries the longstanding UL certification information relied upon by millions of users with the intuitive design and user-friendliness of a modern search engine." There are two buttons: "Log In" and "Join Product iQ". Below the buttons is a search bar with the text "Search abridged site without login". A small text line at the bottom of the hero section reads: "Anyone can obtain information about the validity of a given certification by contacting the UL Solutions Customer Experience Center. Phone number: 1-877-854-3577 — Email: CEC@ul.com". Below the hero section is a blue banner with the text: "We are now UL Solutions: Advancing safety science and empowering our customers to innovate with confidence. [Learn more](#) about our new brand." Below the banner is a section titled "UL Product iQ® Features" with four icons and labels: "Trusted Data" (shield icon), "Advanced Search" (magnifying glass icon), "Personalized Account" (person icon), and "Letters of Compliance" (document icon).



Product iQ update: CLT

ProductiQ.UL.com

- Can help you achieve code compliance
- Continuously updated
- Basic service – no charge for use

Firestop Systems for Canada

UL Product iQ®

[Fire-resistance Ratings of Structural Steel Used in Petrochemical Facilities](#)

This category covers hourly fire-resistance ratings of steel columns investigated using a rapid rise fire exposure in accordance with UL 1709 and intended for use in petrochemical facilities.

[Firestop Systems](#)

Covers firestop systems certified to US based requirements, which consist of a wall or floor assembly, a penetrating item passing through an opening in the assembly, and the materials designed to prevent the spread of fire through the openings.

[Firestop Systems for Canada](#)

Covers firestop systems certified to Canadian requirements, which consist of a wall or floor assembly, a penetrating item passing through an opening in the assembly, and the materials designed to prevent the spread of fire through the openings.

[Installation Code Search](#)

Feedback



Product iQ update: CLT

Cross laminated timber (CLT)
floor assembly

UL Product iQ®

REFINE RESULTS

Build or filter your results by keyword and/or adding criteria like document type, file number and country name.

Concrete or masonry walls with a minimum thickness greater than 203.2 mm (8 in.) (43)

Concrete or masonry walls with a minimum thickness less than or equal to 203.2 mm (8 in.) (3752)

Cross laminated timber (CLT) floor assembly (1)

Floor-ceiling assemblies consisting of concrete with membrane protection (123)

Framed floors (570)

Click to view and filter values

Firestop System

Dashboard / Search

7518 Results :: Base Template: Fires

Action Display: Images

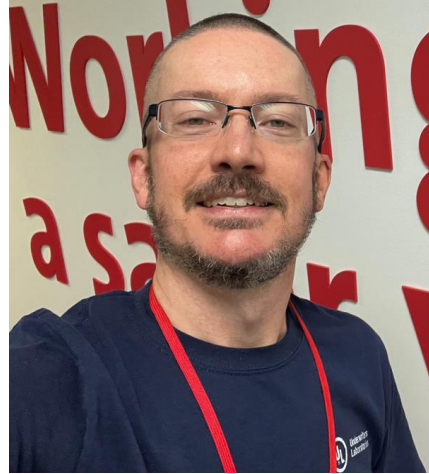
Document Name UL CCN Description

XHEZ.F-A-4026 Through-penetration

XHEZ.C- Through-p Feedback



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(STI)



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Mass Wood Timber & Fire-Resistance: Can This Work?

FCIA-NFCA Existing Building Fire-Resistance Symposium
Canada

September 2023

