

# AUF HOLZ BAUEN?

GASTPROFESSOR DR.-ING. JOCHEN STAHL

Fast + Epp itke

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**WARUM  
HOLZ?**

# Warum Holz?

## Nachhaltigkeit

- nachwachsender, heimischer Rohstoff
- Klimaschutz (z. B. IEKK): Holz bindet Kohlenstoff und reduziert die Primärenergie der Baukonstruktion
- Wertstoffkette: Holz lässt sich mehrfach recyceln

6,1

3,6

1,0

**Verhältnis CO<sub>2</sub>-Sequestrierung**  
CO<sub>2</sub>-Ausstoß bei vgl. Bauteilen



# Warum Holz?



## Ambiente & Raumklima

- Holz schafft Wärme und Wohlfühlatmosphäre
- nachgewiesener Beitrag zu einem gesunden Raumklima mit optimaler Luftfeuchtigkeit





# Warum Holz?

## Integrale Planung und BIM

- bereits heute hoher Digitalisierungsgrad im Holzbau
- integrale Planung gehört zur Holzbau-DNA
- BIM-Koordination durch den Holzbauplaner:  
Abstimmung Fachplaner/Gewerke und Kollisionsprüfung





# Warum Holz?

## Präzises & serielles Bauen

- höchste Präzision durch maschinelle Vorfabrikation
- zügig und wirtschaftlich realisierbare Konstruktionen
- Ideal für Nachverdichtungsmaßnahmen im urbanen Raum





# Warum Holz?

## Vorteile Planung & Bau

- Trocknungszeiten entfallen, Baulärm wird reduziert, Baustellenlogistik vereinfacht
- enge Terminpläne, günstige Herstellungskosten
- einfachere Gründung, Vorteile bei Erdbebenbemessung



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**WEIT  
GESPANNT**



# *Sport- und Freizeitbad Grandview Heights*

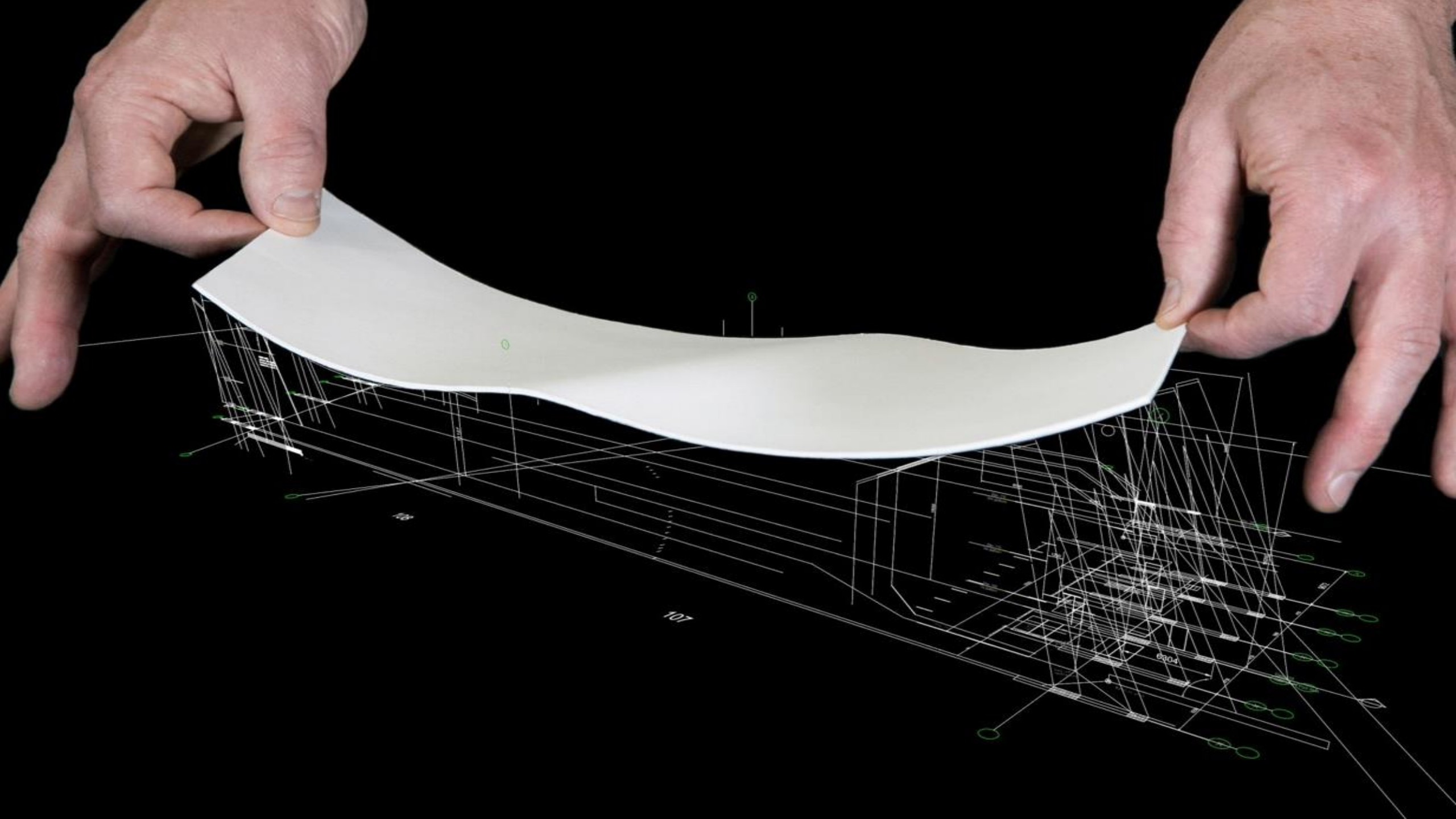
*Surrey, British Columbia, Kanada  
Hughes Condon Marler Architects*

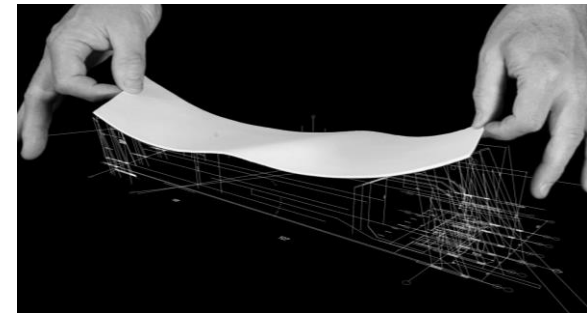
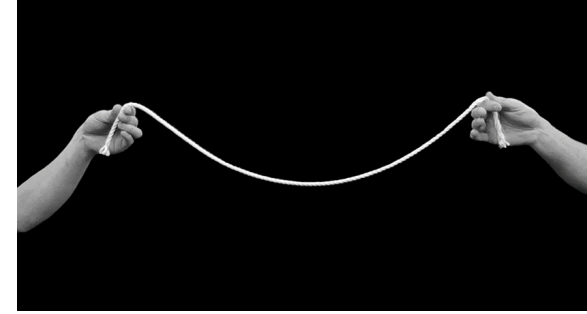
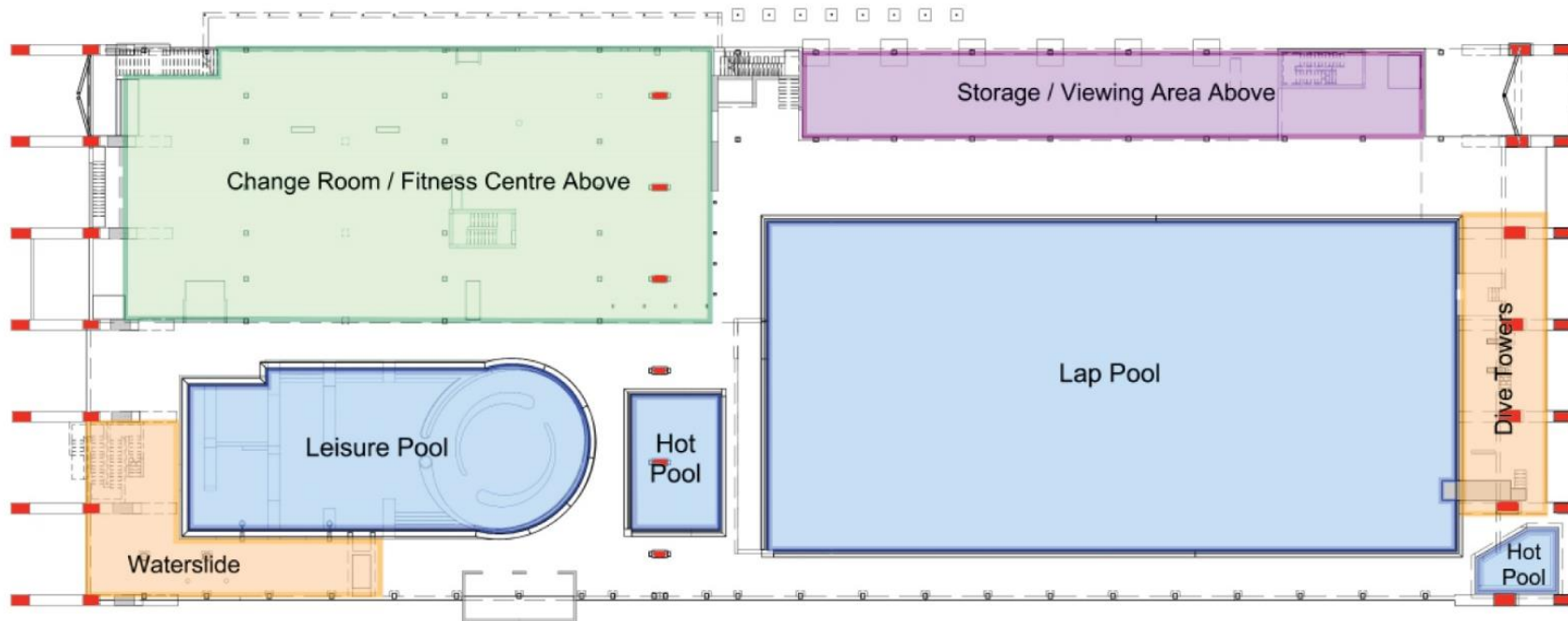
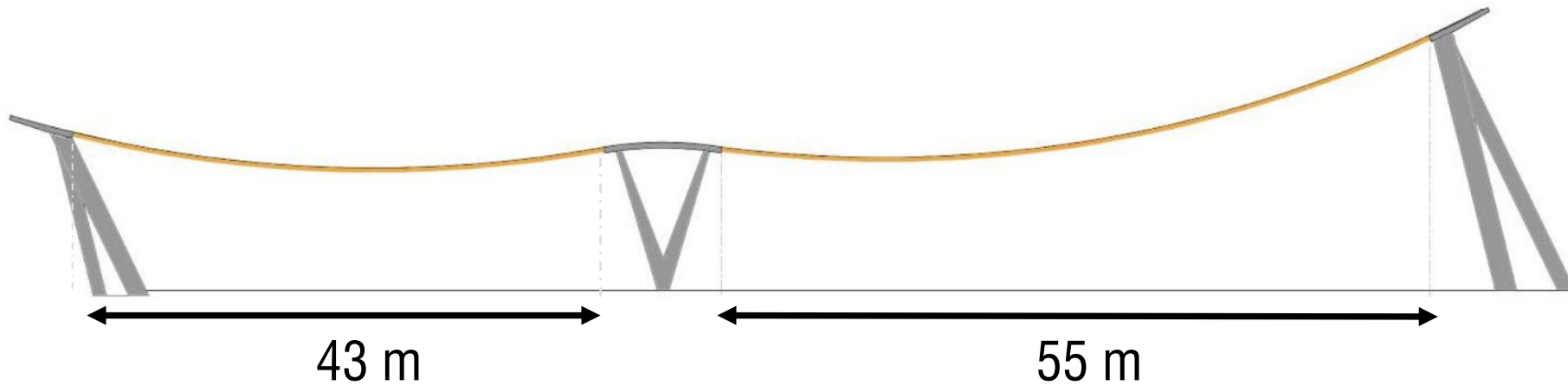


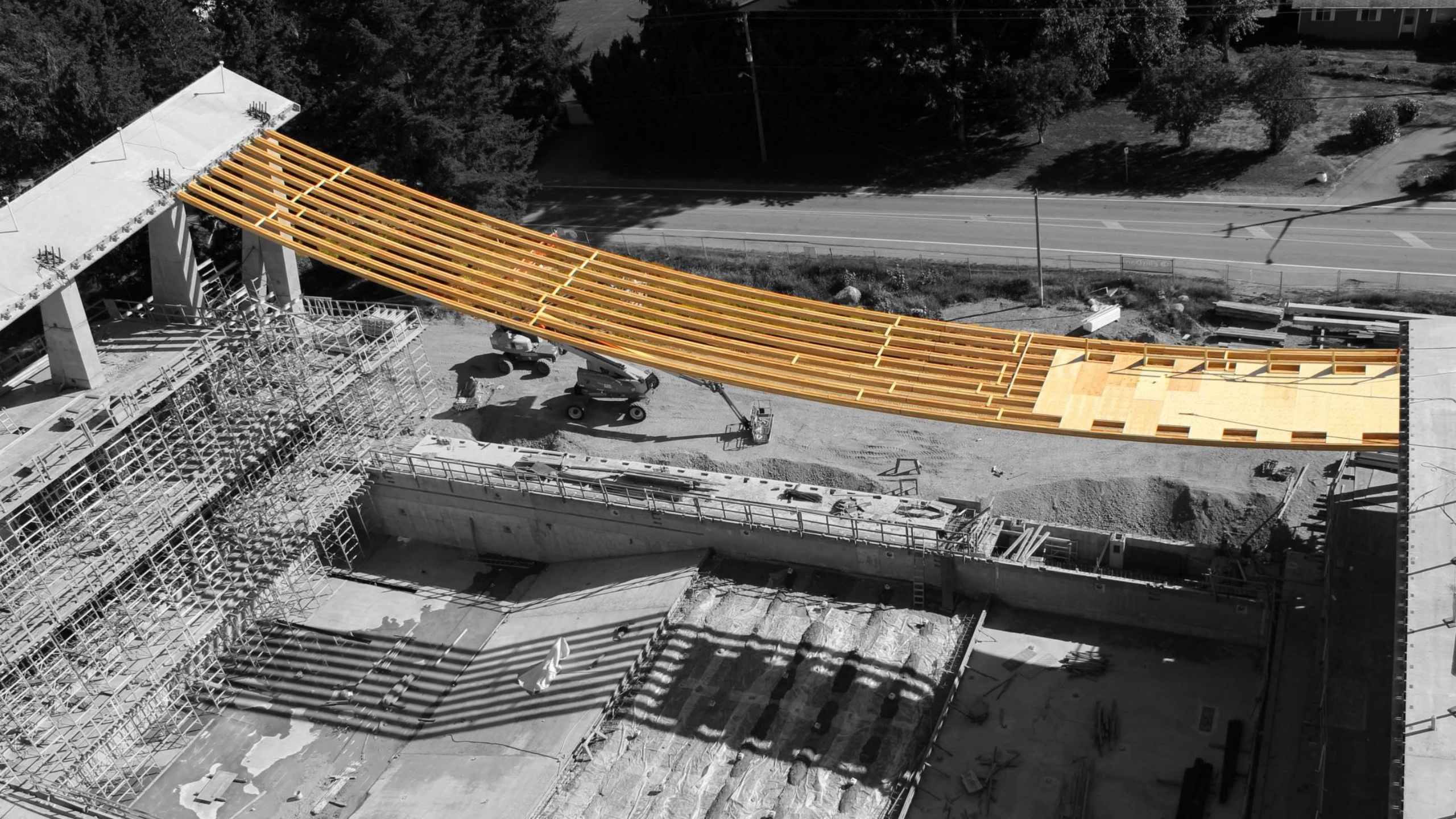
**Auch mal  
gegen den Strich!**























- längstes Holz-Spannband-Dach der Welt mit Spannweiten von bis zu 55 m
- 25 cm hohe Brettschichtholz-Bänder, abgespannt von Betonwiderlagern an den Schmalseiten des Gebäudes
- 2016 durch die Institution of Structural Engineers (GB) mit dem Supreme Award ausgezeichnet



## *Eissporthalle Olympic Oval*

Richmond, British Columbia, Canada | Cannon Design Architecture

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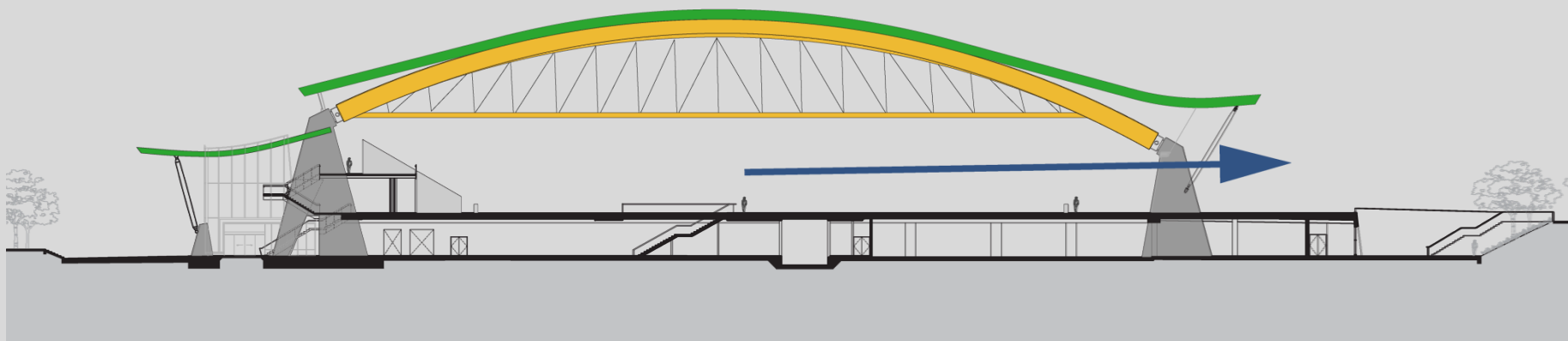


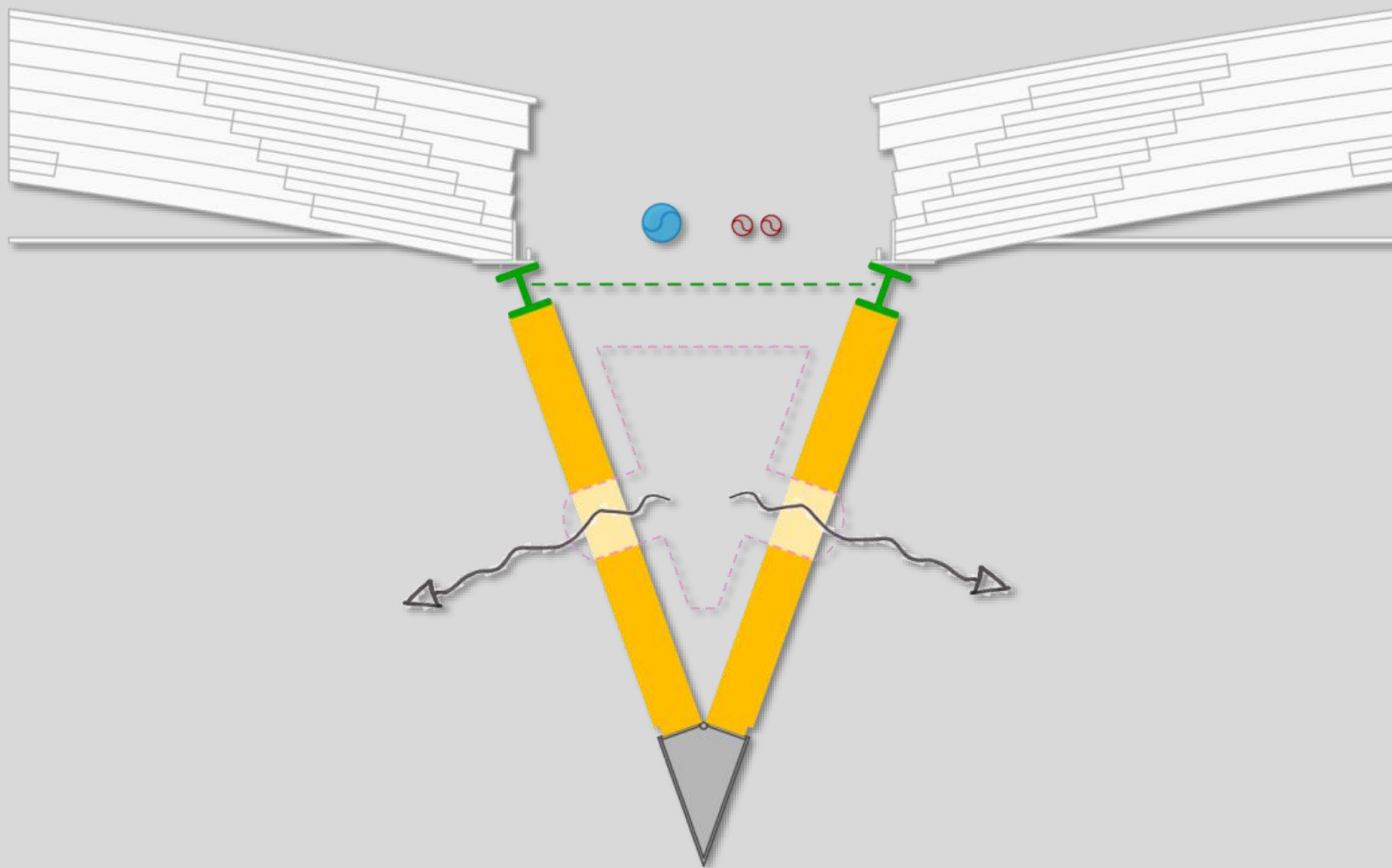
**Mehr als Tragwerk**

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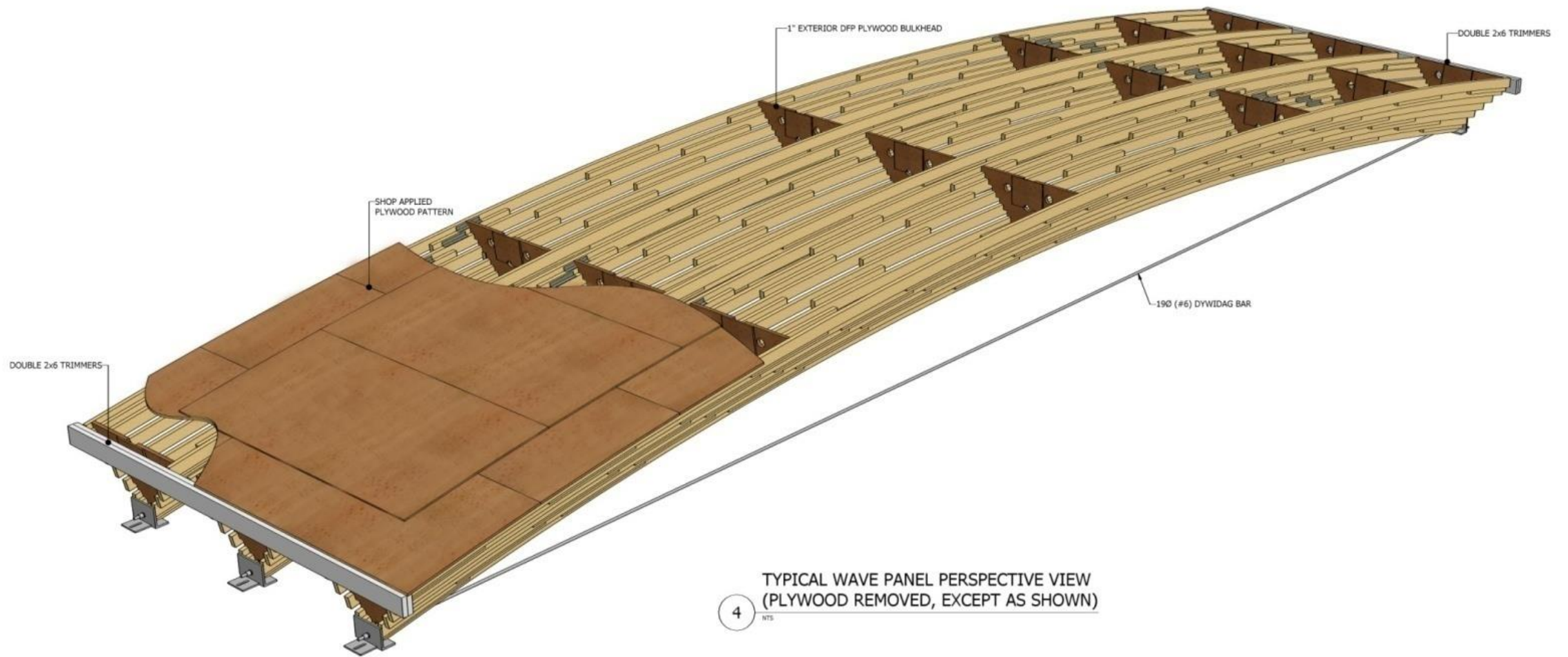




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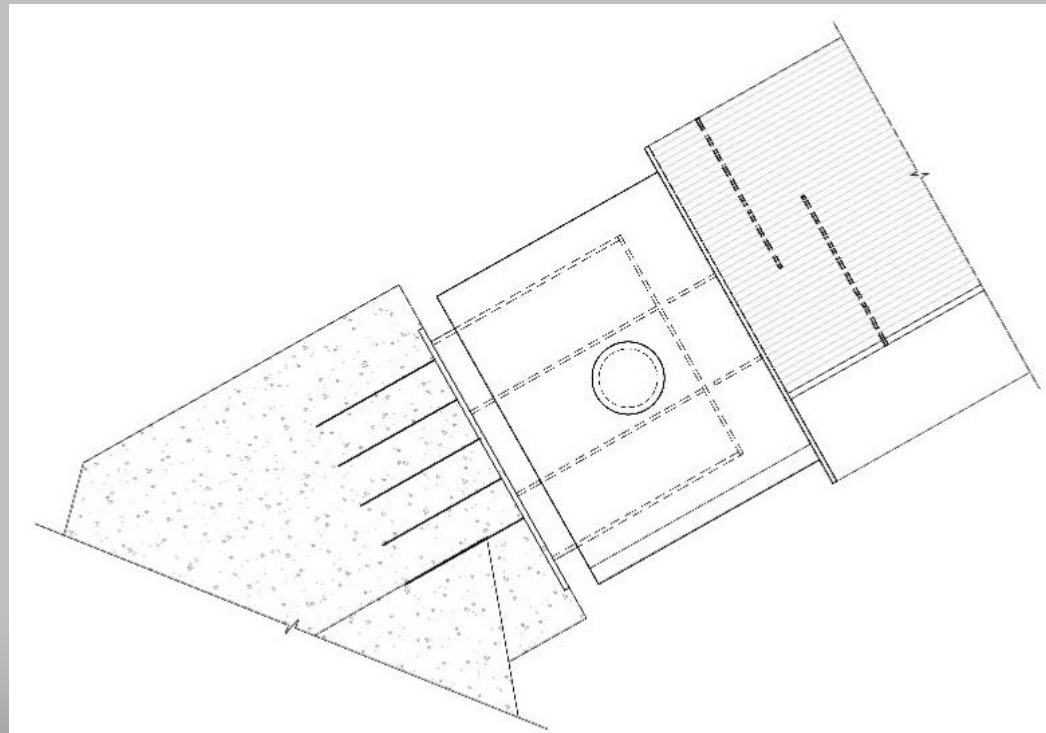
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RICHMOND  
OLYMPIC OVAL  
CANADA







- vorgefertigte Holzelemente in Wellenform aus Standardquerschnitten 2" x 4"
- Integration von Haustechnik in die dreiecksförmigen Holz-Stahl-Verbundbögen
- 2010 ausgezeichnet mit dem Canadian Consulting Engineer Award of Excellence



**HOCH  
HINAUS**



## *Tallwood House*

*University of British Columbia  
Vancouver, Kanada  
Acton Ostry Architects*



**Mache die Dinge  
so einfach wie  
möglich, aber  
nicht einfacher**

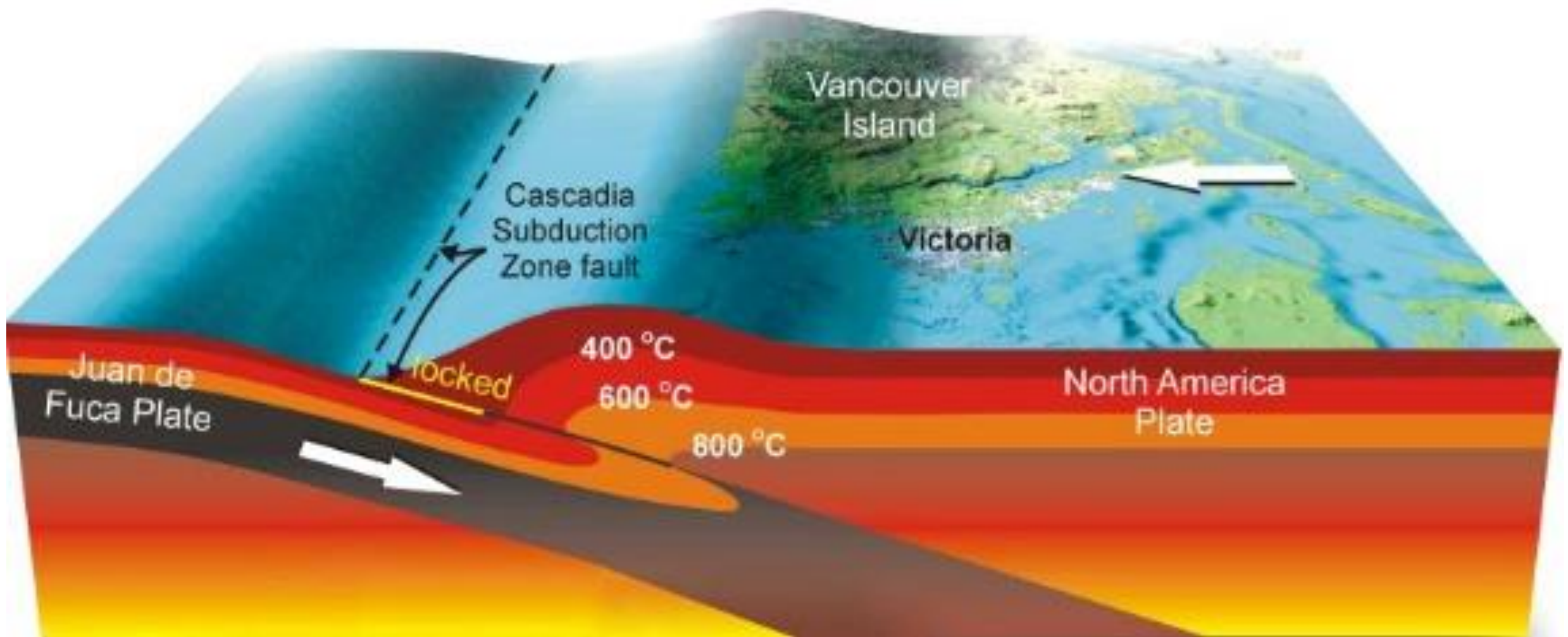
Albert Einstein

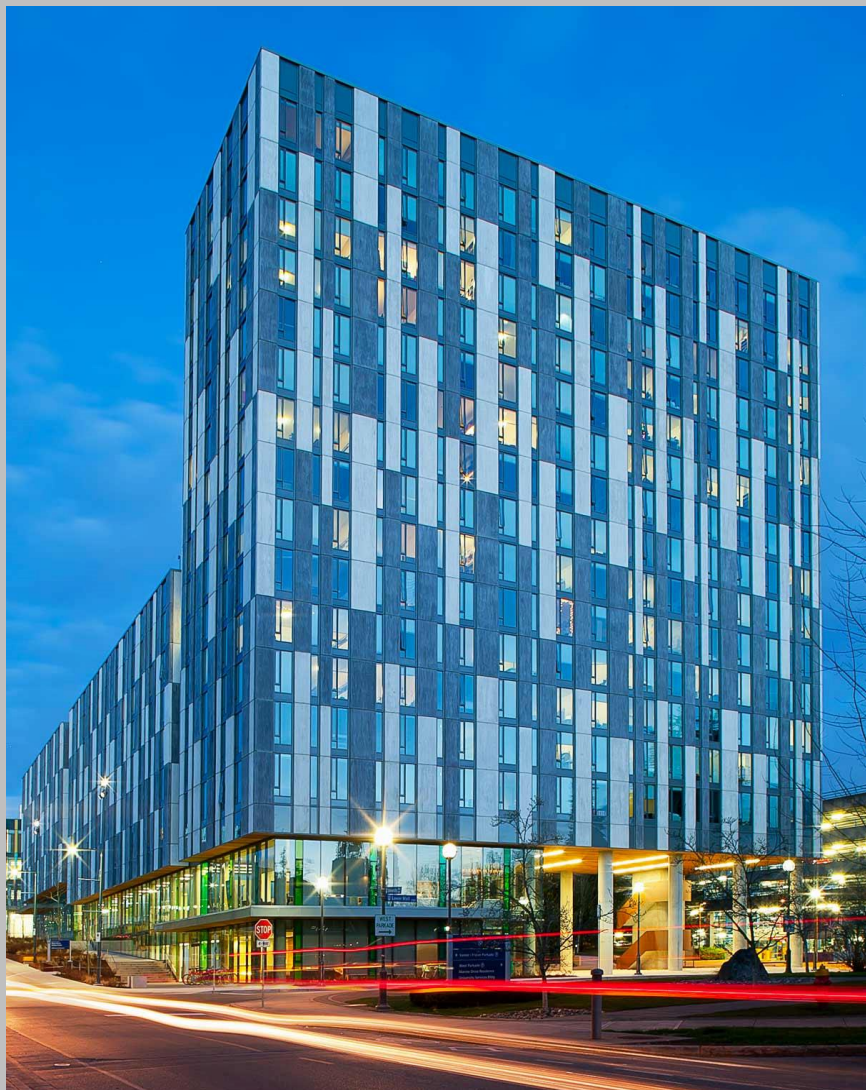


**Keep it  
simple.**

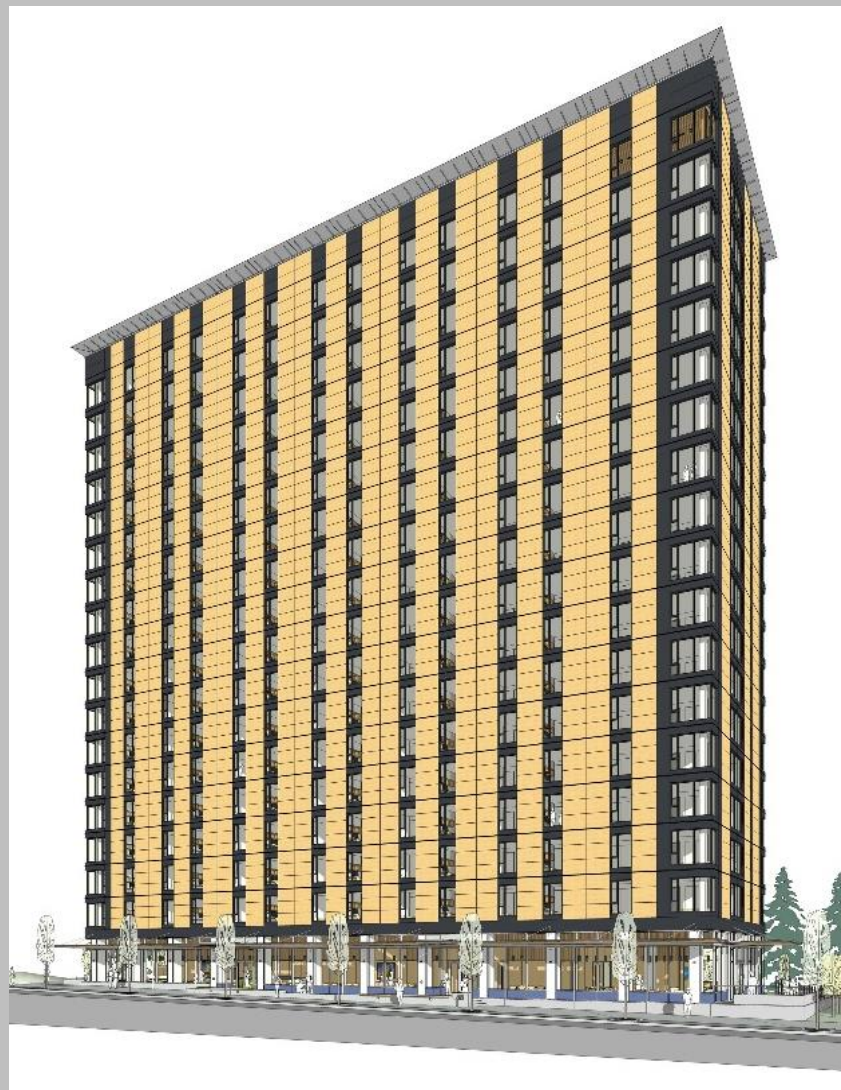
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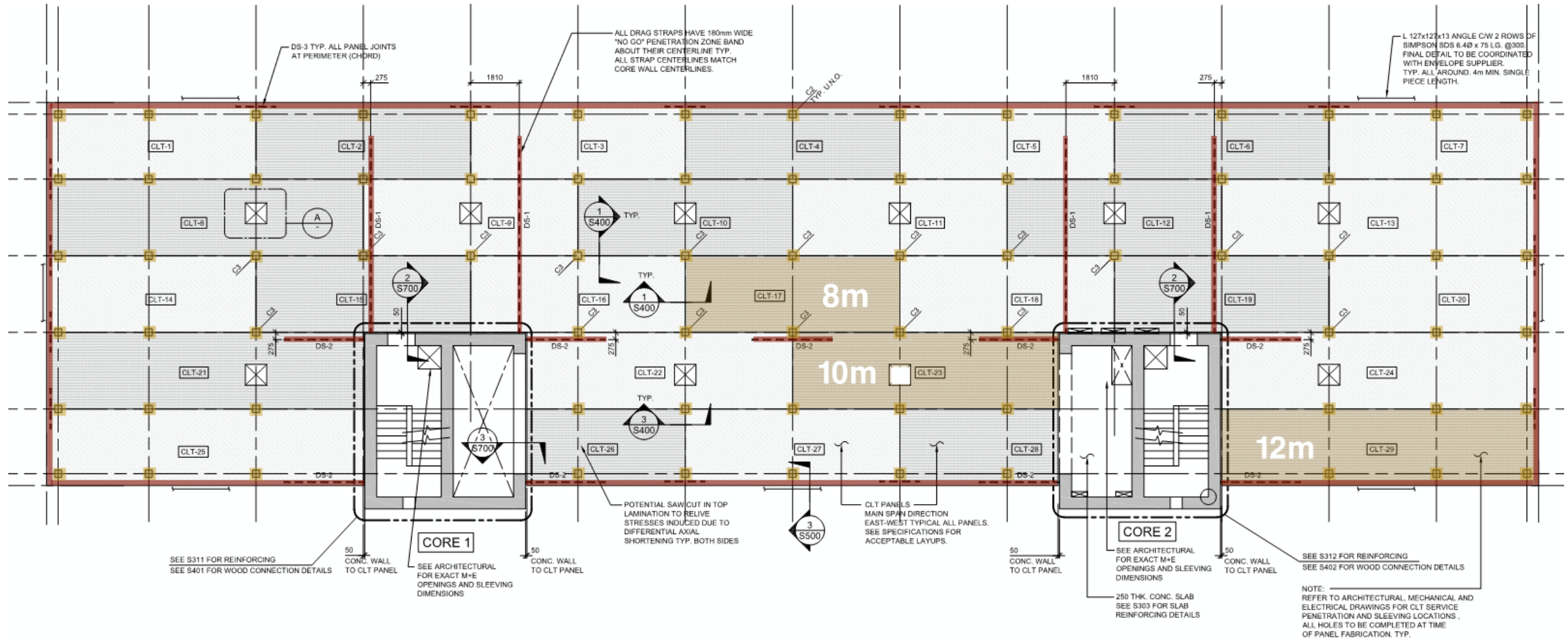


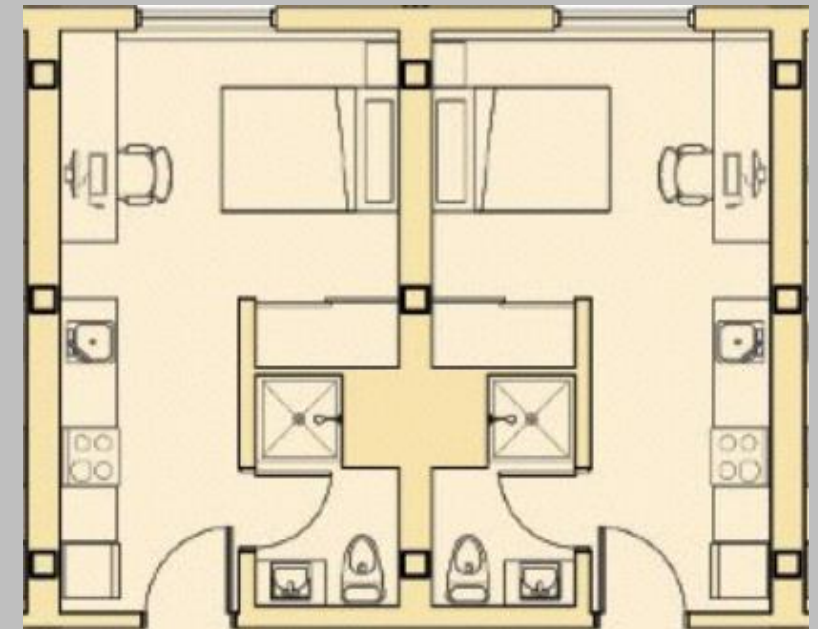
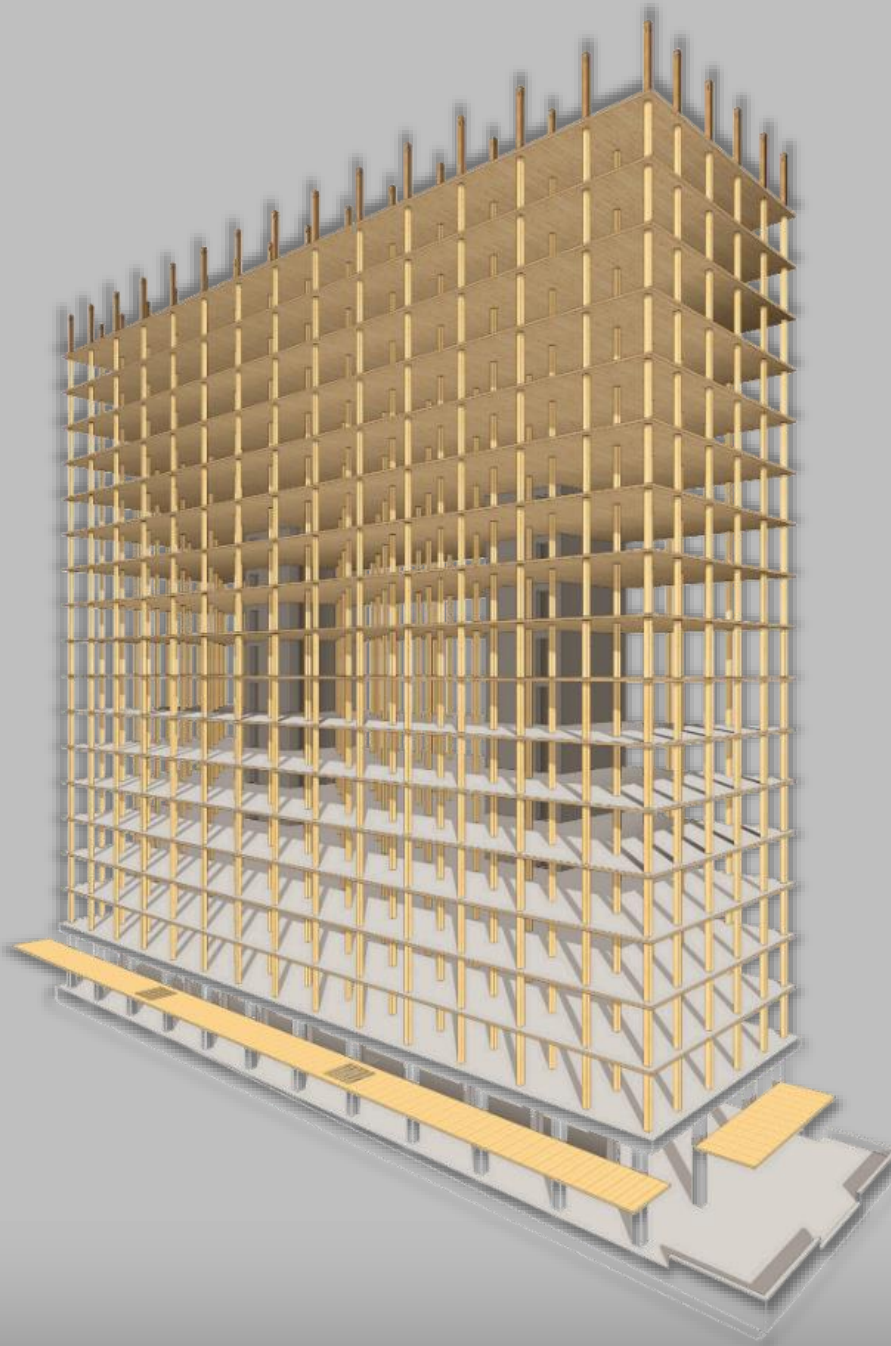
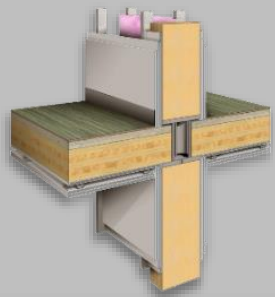
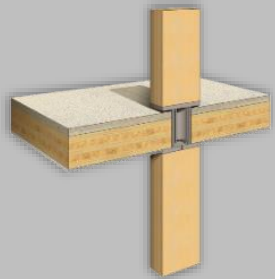
**192 \$/ft<sup>2</sup>**



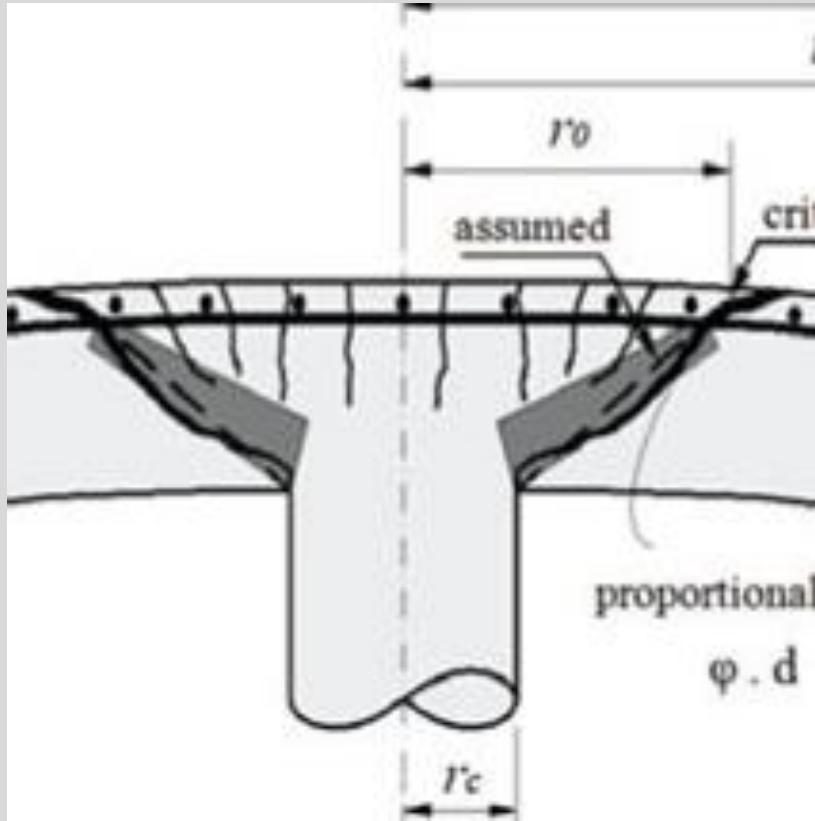
**192 \$/ft<sup>2</sup>**

Fast + Epp itke





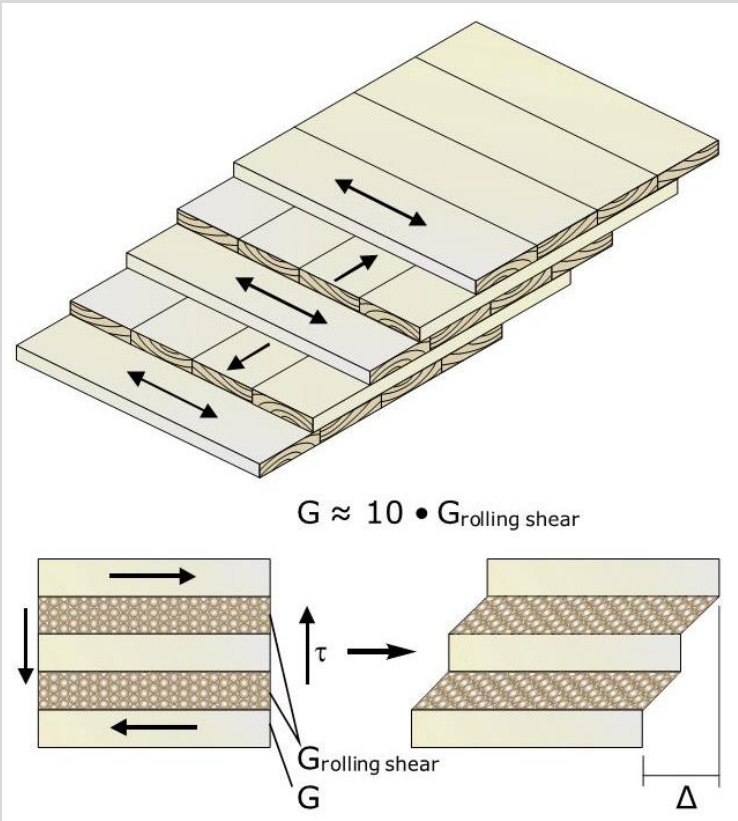
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Durchstanzen Stahlbeton

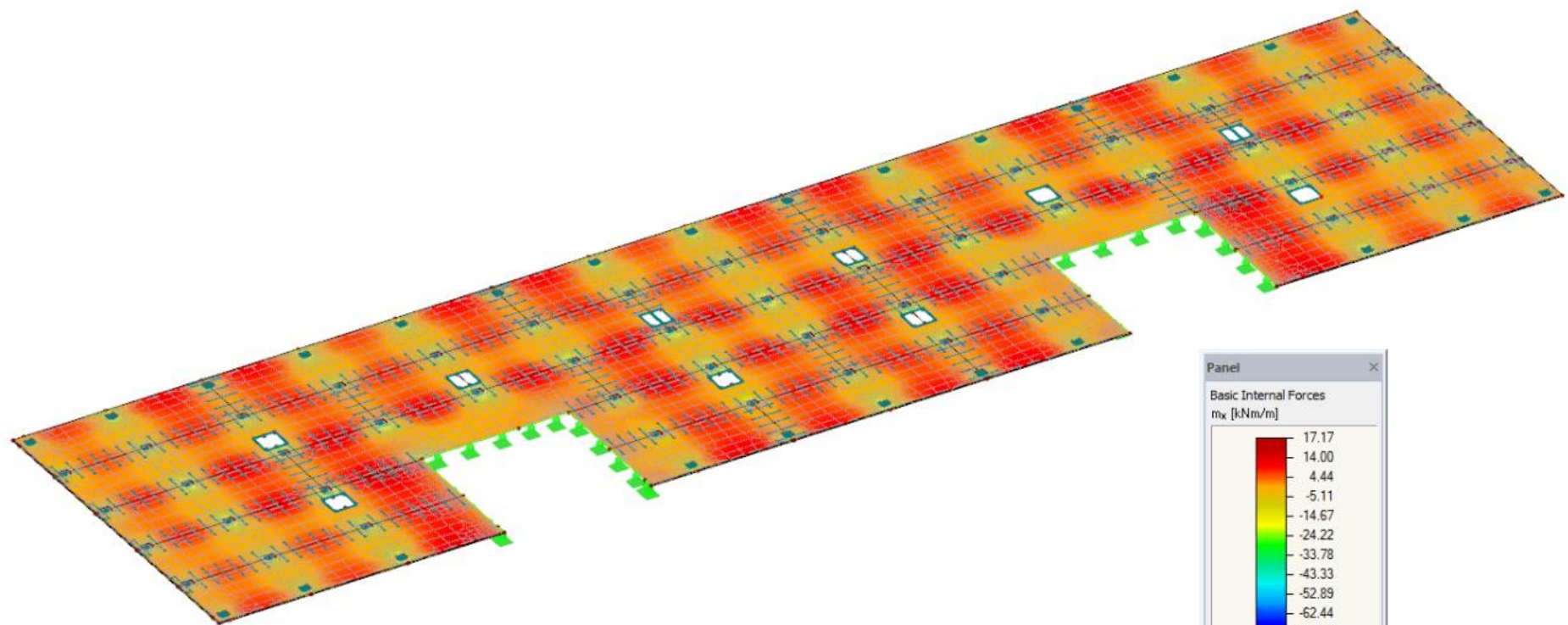


Durchstanzbewehrung



Holzbau: Rollschub

- Global Deformations
  - ☐ u
  - ☐ u<sub>x</sub>
  - ☐ u<sub>y</sub>
  - ☐ u<sub>z</sub>
  - ☐ φ<sub>x</sub>
  - ☐ φ<sub>y</sub>
  - ☐ φ<sub>z</sub>
- Members
  - ☒ Surfaces
    - Local Deformations
      - ☐ u<sub>x</sub>
      - ☐ u<sub>y</sub>
      - ☐ u<sub>z</sub>
      - ☐ φ<sub>x</sub>
      - ☐ φ<sub>y</sub>
      - ☐ φ<sub>z</sub>
    - Basic Internal Forces
      - ☒ m<sub>x</sub>
      - ☐ m<sub>y</sub>
      - ☐ m<sub>xy</sub>
      - ☐ v<sub>x</sub>
      - ☐ v<sub>y</sub>
      - ☐ n<sub>x</sub>
      - ☐ n<sub>y</sub>
      - ☐ n<sub>xy</sub>
    - Principal Internal Forces
    - Design Internal Forces
    - Stresses
    - Strains
    - Plastic Strains
    - Isotropic surface characteristics
    - Contact Stresses
    - Shape
  - Criteria
    - ☒ Nonlinearity Rate
    - ☐ Design Ratio
    - ☐ Equivalent Plastic Strain
  - Support Reactions
    - ☒ Line Supports
      - ☒ Local
        - ☐ p<sub>x</sub>
        - ☒ p<sub>y</sub>
        - ☒ p<sub>z</sub>
        - ☐ m<sub>x</sub>
        - ☐ m<sub>y</sub>
        - ☐ m<sub>z</sub>
      - ☐ Global
  - Resultant



Max m-x: 17.17, Min m-x: -92.64 kNm/m

4.15 Surfaces - Basic Internal Forces

CO1 - 1.25DL + 1.5LL

| Surface No. | Grid Point | Grid Point Coordinates [m] |        |       | Moments [kNm/m] |                |                 | Shear Forces [kN/m] |                | Axial Forces [kN/m] |                |                 |
|-------------|------------|----------------------------|--------|-------|-----------------|----------------|-----------------|---------------------|----------------|---------------------|----------------|-----------------|
|             |            | X                          | Y      | Z     | m <sub>x</sub>  | m <sub>y</sub> | m <sub>xy</sub> | v <sub>x</sub>      | v <sub>y</sub> | n <sub>x</sub>      | n <sub>y</sub> | n <sub>xy</sub> |
| 46          | 1          | 43.812                     | 11.399 | 0.000 | 0.00            | 0.13           | 0.04            | 9.92                | -1.27          | -0.19               | -0.09          | -0.41           |
|             | 2          | 44.312                     | 11.399 | 0.000 | 4.49            | -0.00          | -0.01           | 7.35                | -0.12          | -0.11               | -0.54          | -0.39           |
|             | 3          | 44.812                     | 11.399 | 0.000 | 7.51            | -0.00          | -0.02           | 4.28                | -0.29          | 0.07                | -1.11          | -0.38           |
|             | 4          | 45.312                     | 11.399 | 0.000 | 9.10            | -0.00          | -0.03           | 1.67                | -0.44          | -0.14               | -1.14          | -0.02           |
|             | 5          | 45.812                     | 11.399 | 0.000 | 9.03            | -0.09          | -0.09           | -2.74               | 0.17           | -0.07               | -0.92          | -0.08           |





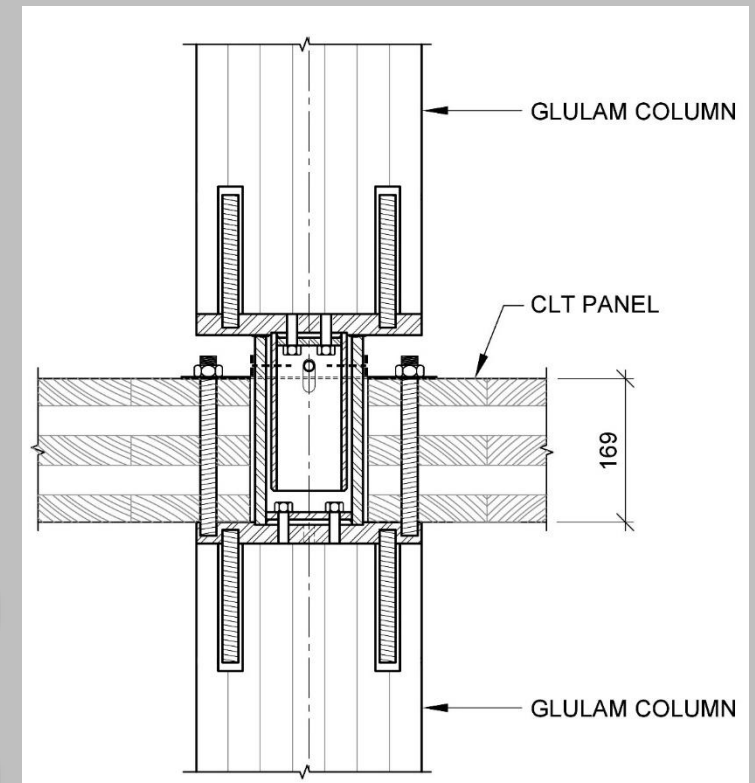


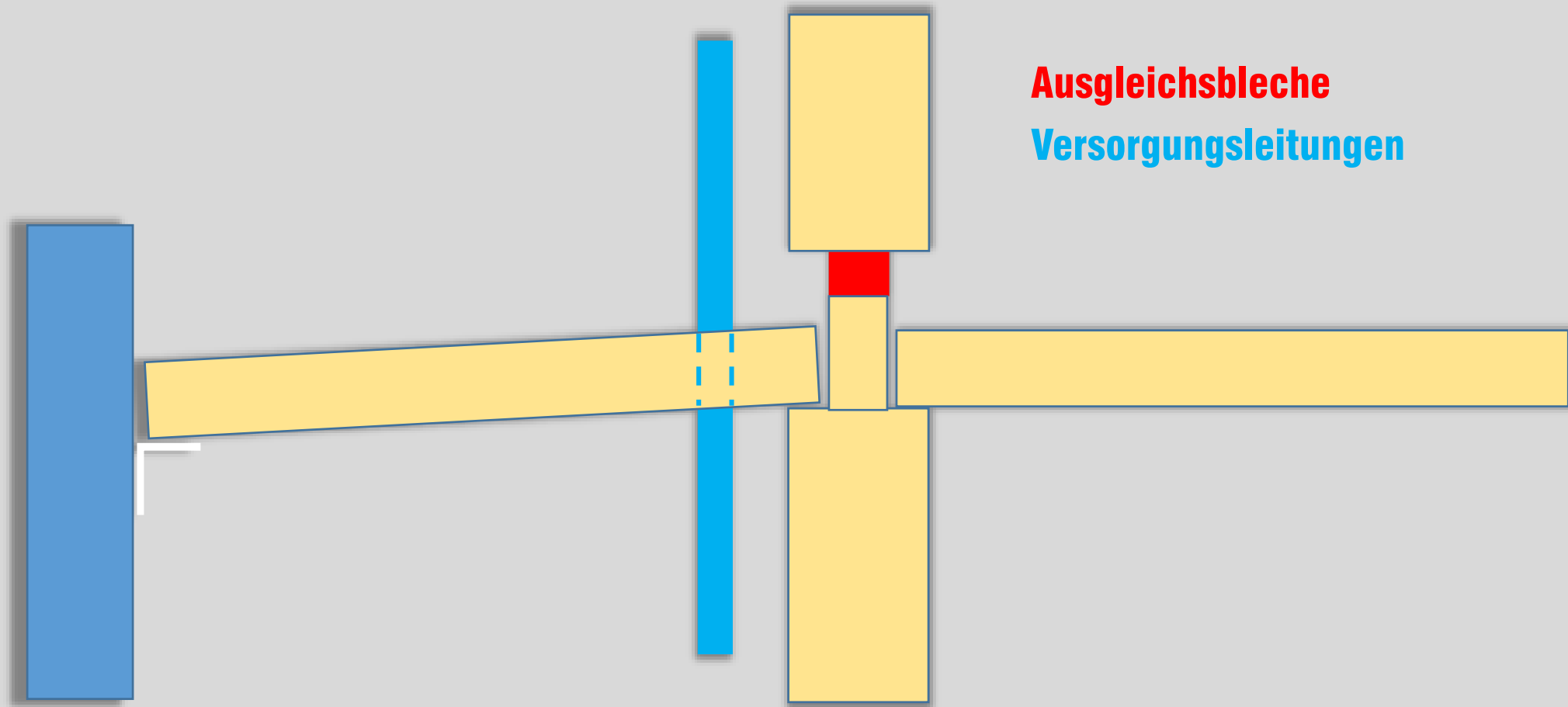
Herausforderungen  
Brandschutz und  
Integration der  
Haustechnik

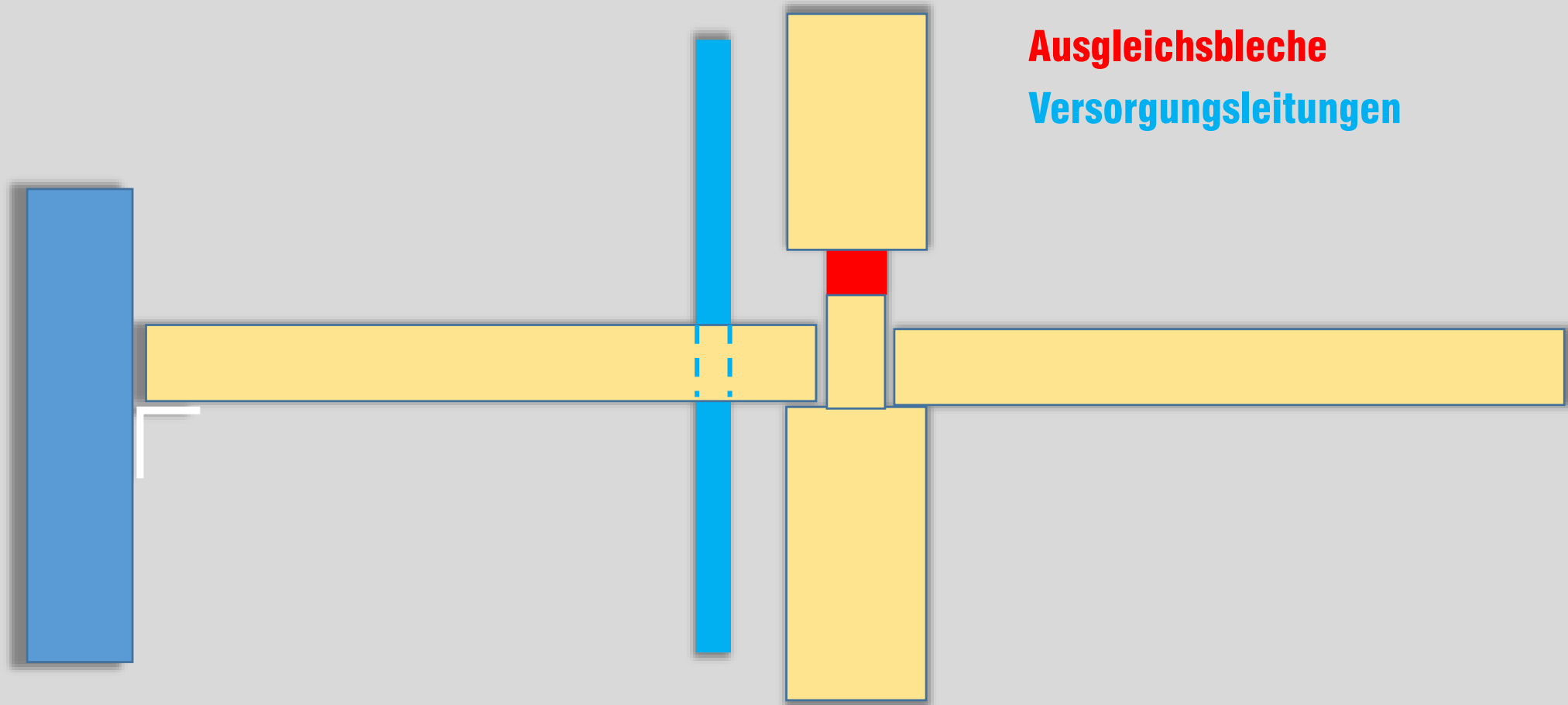


Herausforderungen  
Brandschutz und  
Integration der  
Haustechnik

# Stützenverbindungen



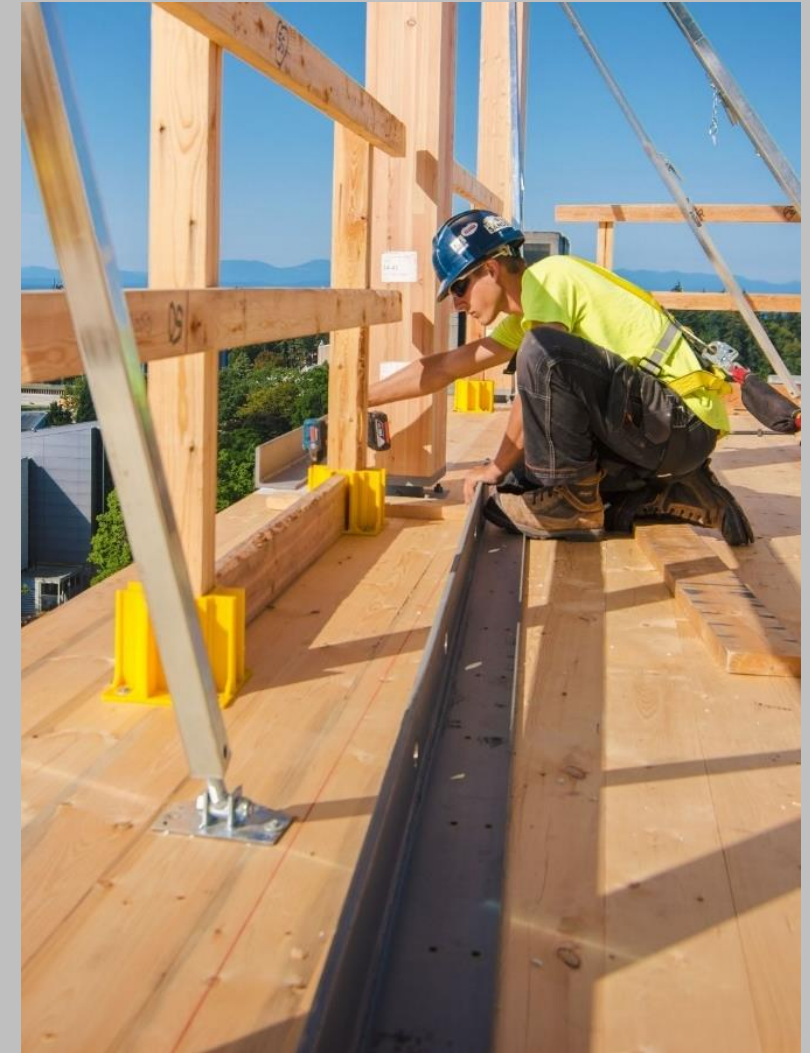
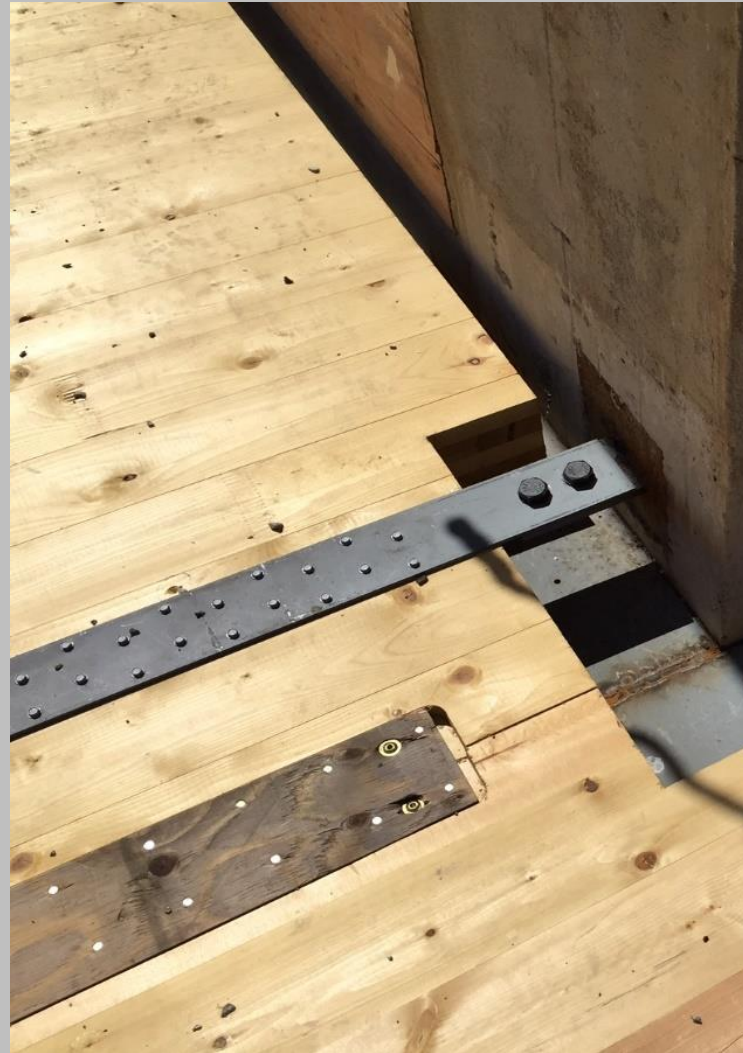




**Ausgleichsbleche**  
**Versorgungsleitungen**

# Aussteifung

## Deckenscheibenausbildung und Anschluss der CLT-Decken an die Betonkerne









**TALL WOOD at UBC BROCK COMMONS: 6 WEEKS MASS WOOD and FACADE**

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# Tallwood House at Brock Commons

## Nachhaltigkeit in Zahlen



Volumen verbautes Holz: 2.233 m<sup>3</sup>



Diese Menge wächst in kanadischen Wäldern innerhalb von 6 Minuten.



1.581 t Kohlenstoffdioxid werden in dieser Holzmenge gespeichert.




982 t Treibhausgasemissionen können so vermieden werden.



2.536 t mögliche Gesamtersparnis an Kohlenstoffdioxid-Ausstoß



Dies entspricht dem CO<sub>2</sub>-Ausstoß von 490 fahrenden Autos in 1 Jahr.

- 
- sehr effizientes Tragsystem
  - auch größeres Raster möglich
  - Keep things simple!
  - Fachplaner und Gewerke früh einbeziehen!
  - 3D-Modellierung in der Planungsphase zahlt sich aus!
  - Vorfertigung im Baukastenprinzip



Empire State Building, New York City, New York, 1931



UBC Brock Commons Student Residence, Vancouver, British Columbia, 2016

## WORLD'S TALLEST WOOD BUILDING!



Fast + Epp



SEAGATE Structures Ltd.

QUALITY + INTEGRITY

#worldstallestwoodbuilding #teamseagate  
#summer2016 #pnw #bigwood #woodworks



- 2017 mit 53 m das höchste Holzgebäude der Welt
- Baukasten-Prinzip
- 70 Tage zwischen Eintreffen der vorgefertigten Elemente und Richtfest
- mehrfach ausgezeichnet:
  - 2017 Construction Innovation, The Institution of Structural Engineers (GB)
  - 2018 Premier's Award BC Public Service

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## *The Arbour*

*George Brown College*

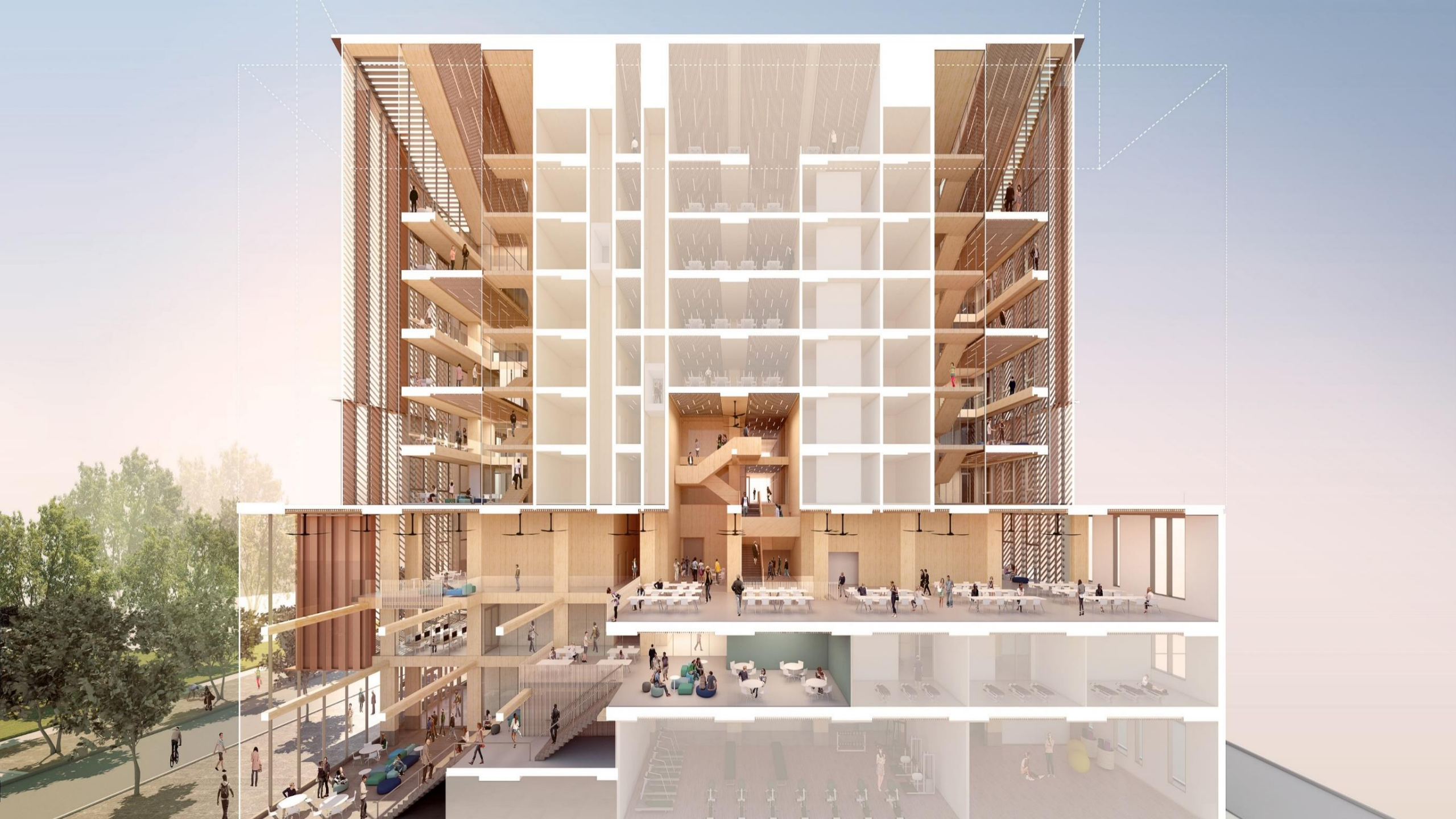
*Toronto, Ontario, Canada*

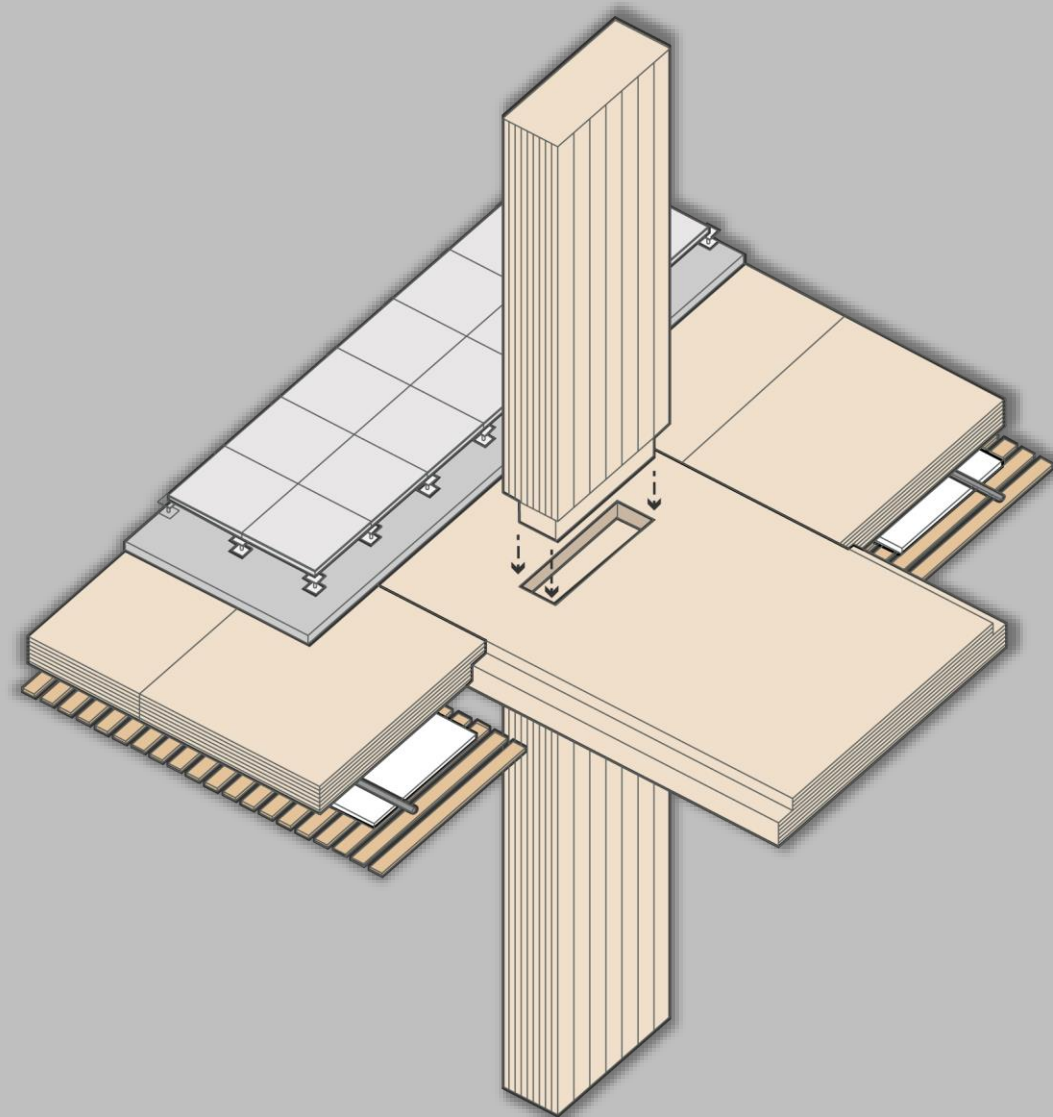
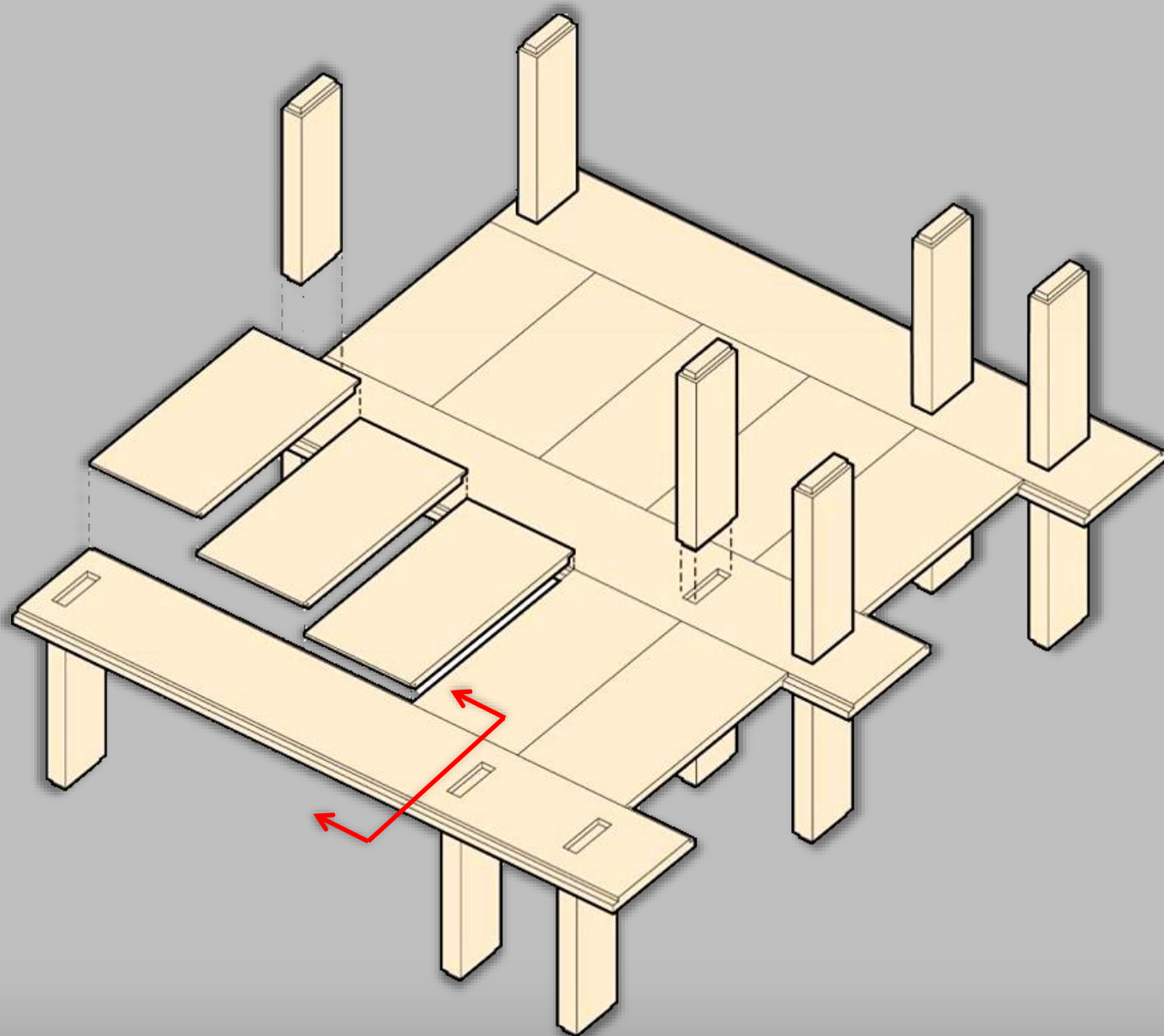
*Moriyama & Teshima Architects /*

*Acton Ostry Architects*

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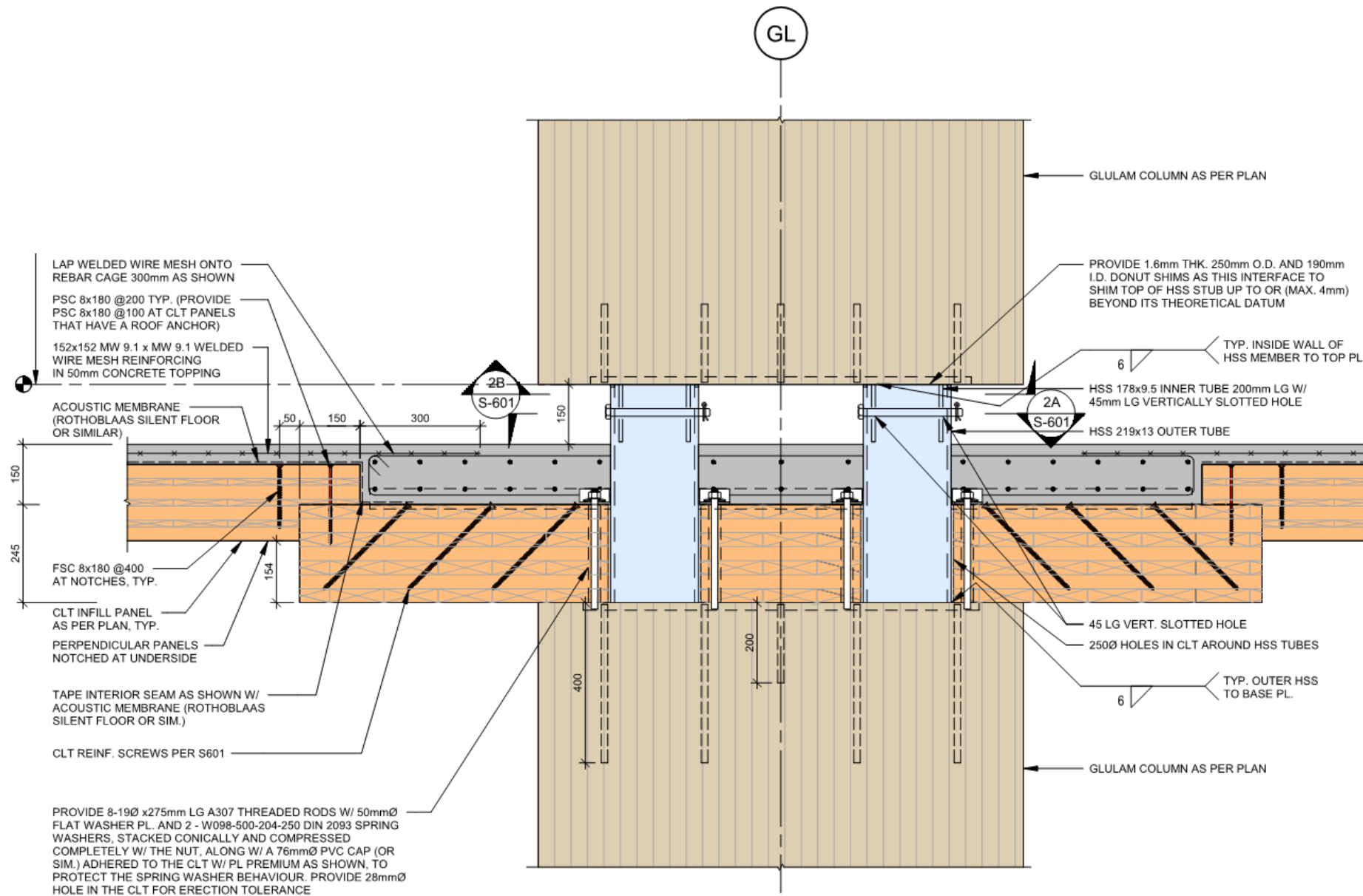






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# „Slab Band“ Stützenanschluss





Bauteiltests in  
Zusammenarbeit  
mit Kooperations-  
partnern



**STRUCTURLAM**  
Intelligence In Wood

**HBC.**  
HOCHSCHULE  
**BIBERACH**  
UNIVERSITY  
OF APPLIED SCIENCES

**UNBC** UNIVERSITY OF  
NORTHERN BRITISH COLUMBIA

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**ORGANISCH  
GEFORMT**



## *Multihalle im Herzogenriedpark*

*Mannheim | Carlfried Mutschler, Joachim Langner, Frei Otto*



**Lass uns mol  
drübr schwätza!**

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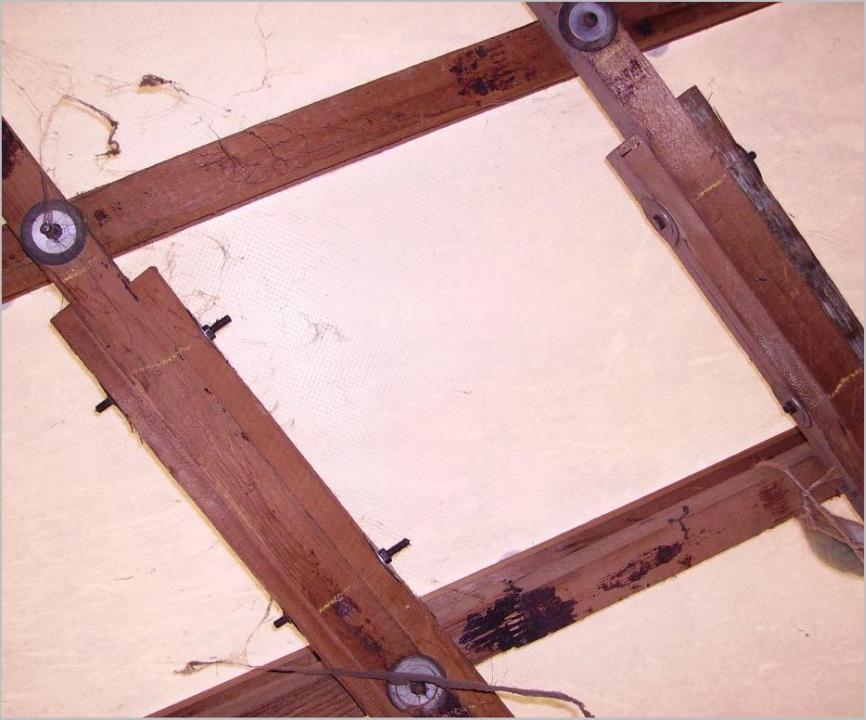
## Konservatorische Werte

Freiform

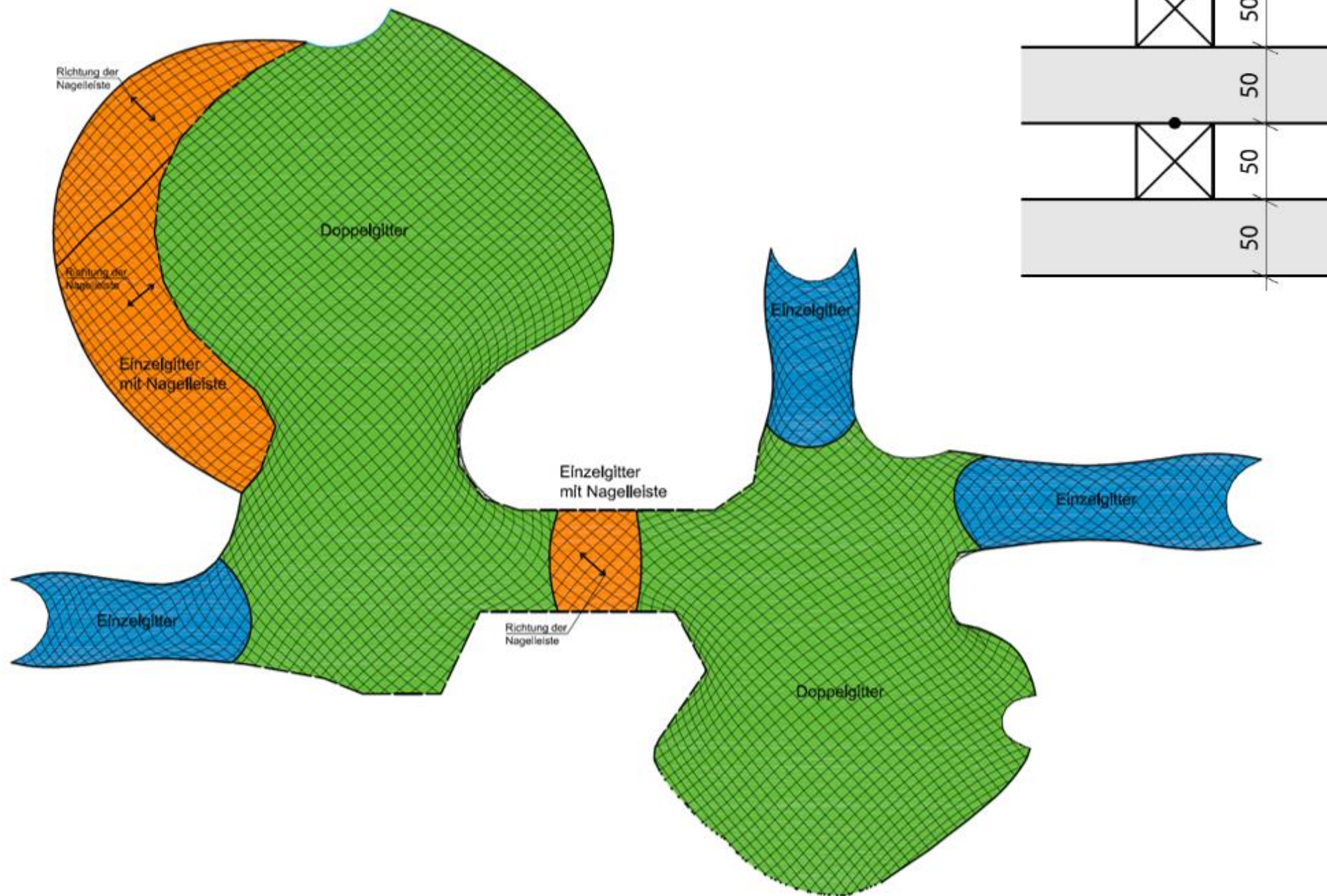
Trans-  
luzenz

Holzraute

Stützen-  
freiheit



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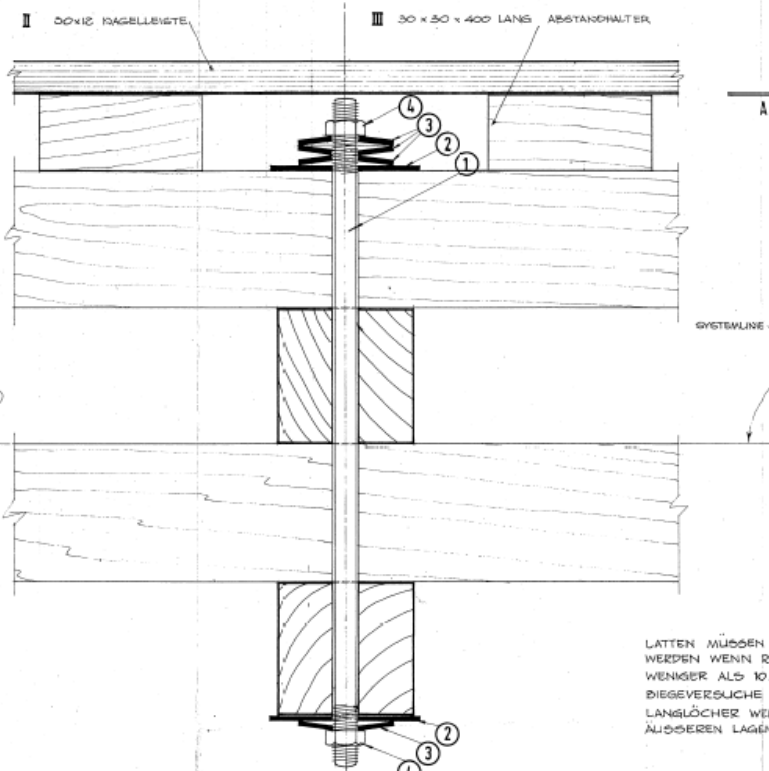


# Bauzeitliche Details und Verstärkungen

## I BOLZENSYSTEM

- ① 8 DIA. GESCHRAUBTER STAB G3 GÜTE
- ② 55 DIA. X 1MM. GLATTE UNTERLAGEPLÄTTCHEN.
- ③ 85 X 25 VIELSCHNUR SCHREIBENFEDER
- ④ M.8 MUTTER GÜTE 6.

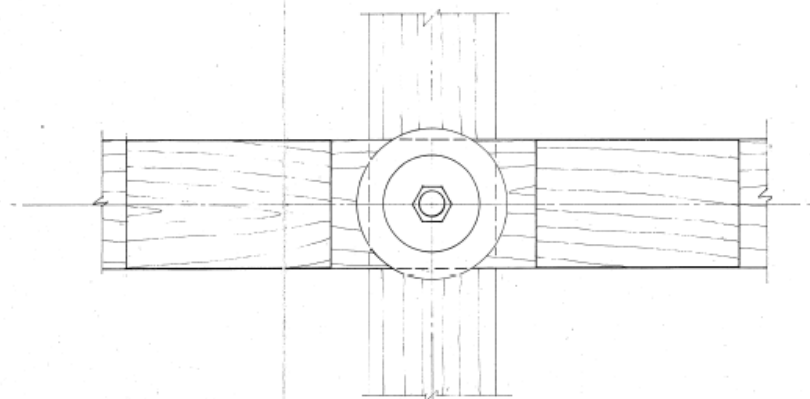
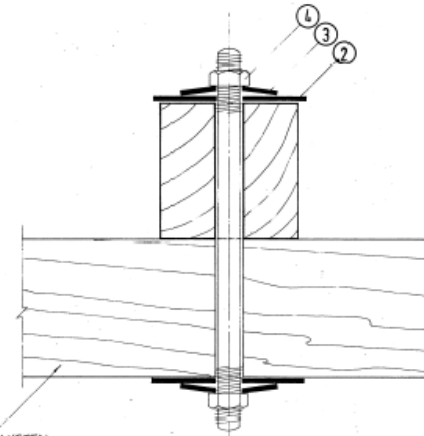
IV SYSTEMLINIE



V DER MARGEBENDE KNOTENPUNKT - SCHNITT

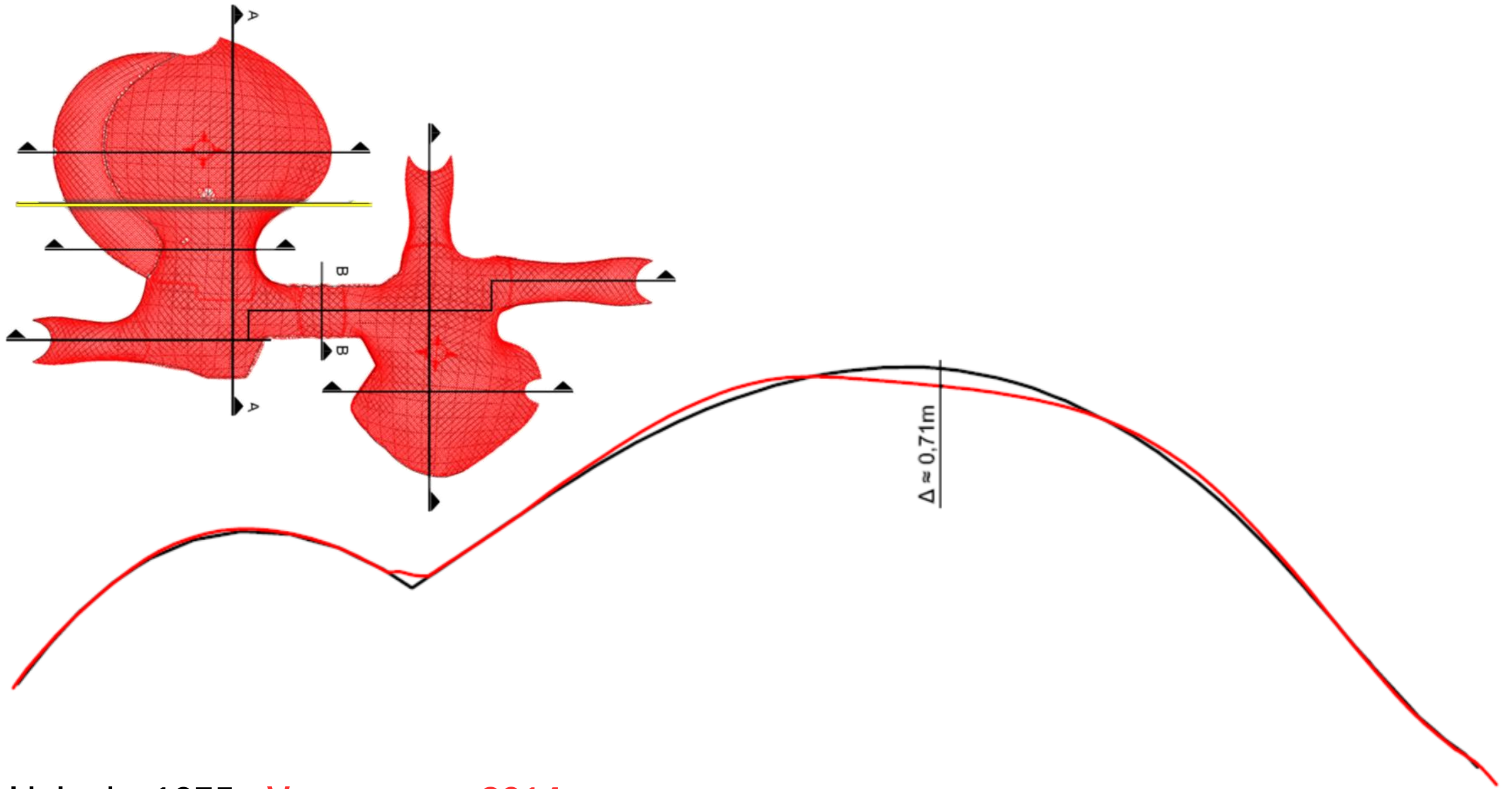
LATTEN MÜSSEN GESCHNITTEN  
WERDEN WENN RADIUS DER KRÜMMUNG  
WENIGER ALS 10 M. IST ODER ALS DURCH  
DIEGEVERSCHE ANGEZEIGT.  
LANGLÖCHER WERDEN FÜR DIE  
ÄUSSEREN LAGEN BENÖTIGT WERDEN.

KNOTENPUNKT FÜR EINZELGITTER

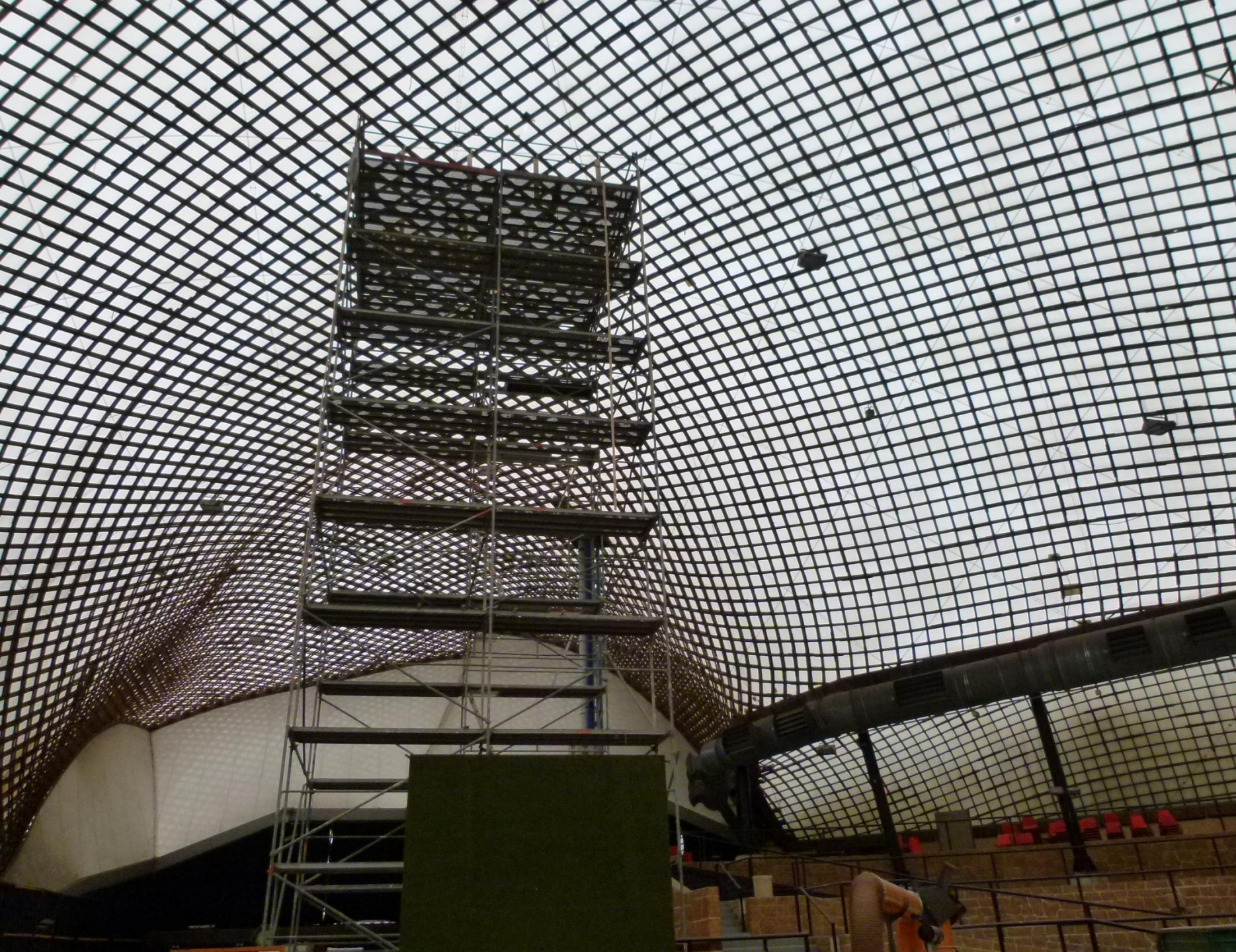


VI DRAUFSICHT - A-A





Linkwitz 1975 · Vermessung 2014



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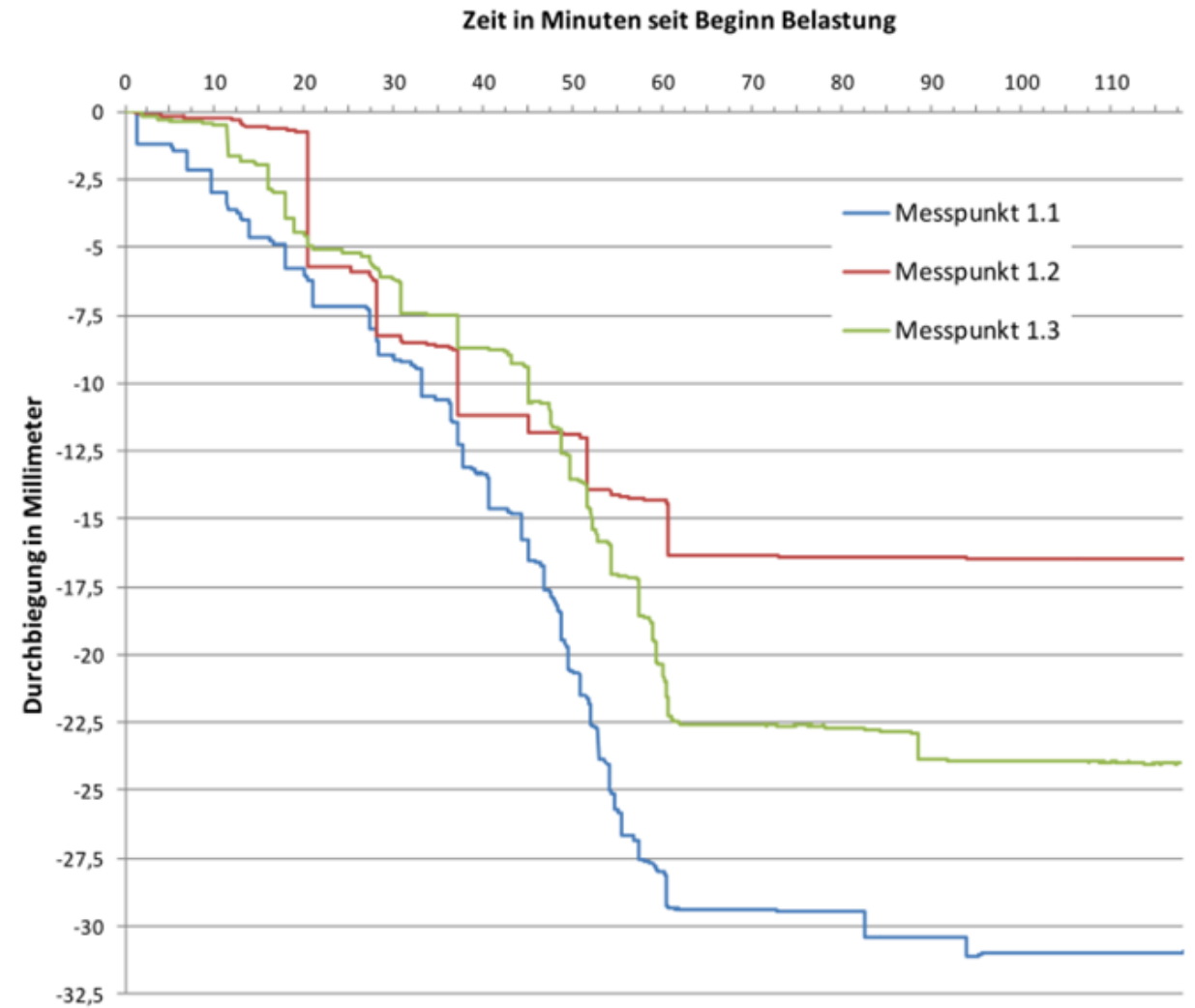


Schadensaufnahme  
aktueller Zustand



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# Tragwerksanalyse

## Verformtes System



η = 114 %; LF: 1,49

η = 93 %; LF: 1,15

η = 420 %; LF: 0,77

η = 330 %; LF: 0,98

η = 300 %

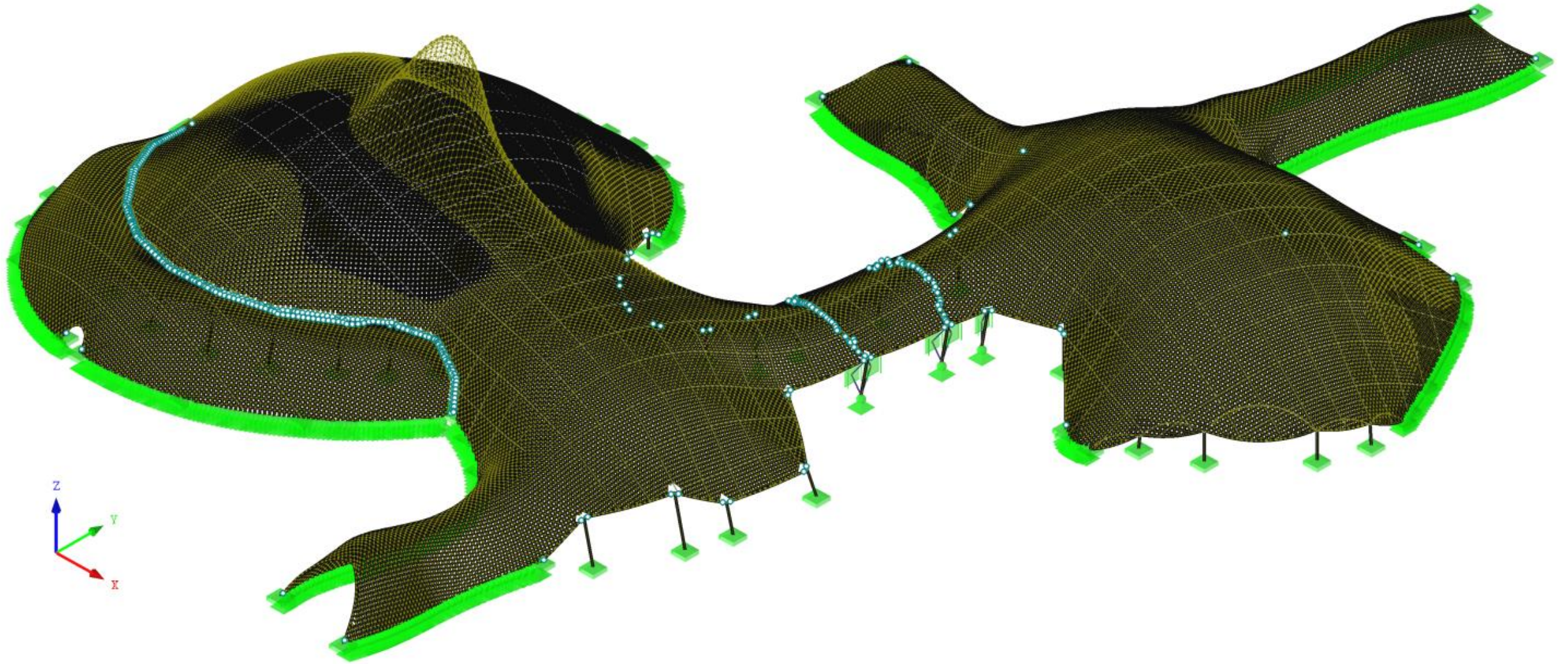
η = 114 %; LF: 1,52

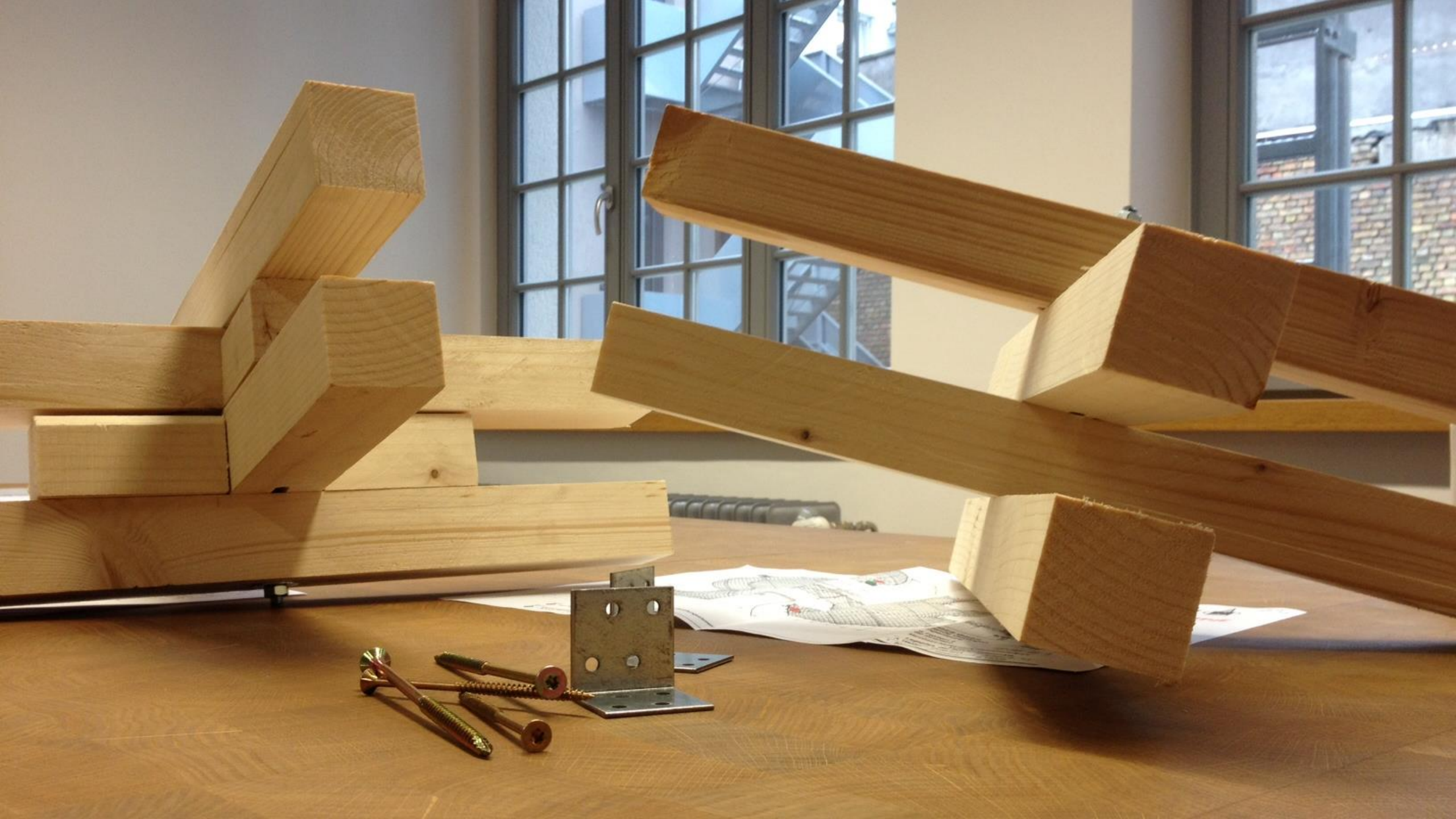
η = 86 %; LF: 1,61

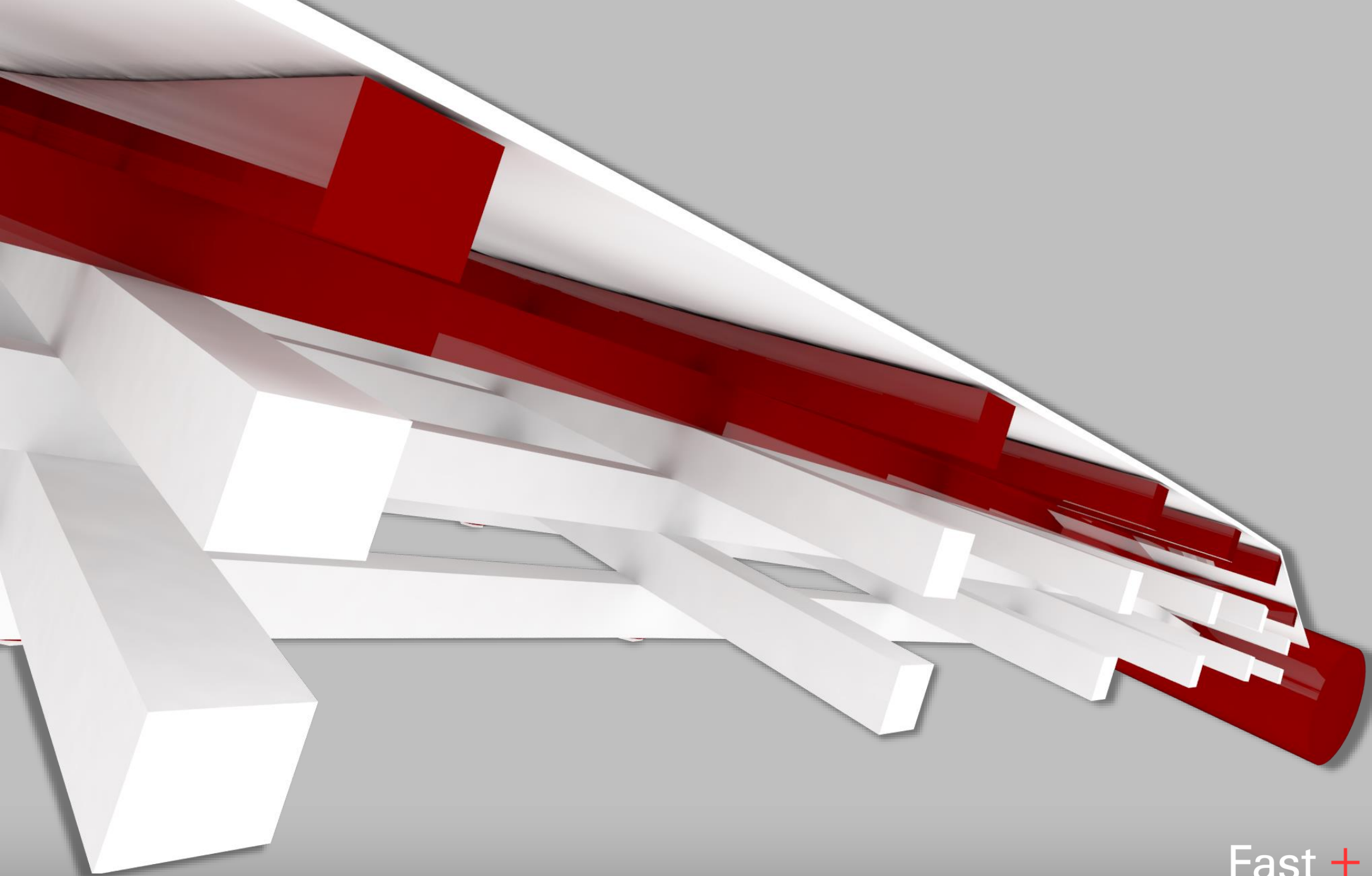
η = 166 %; LF: 1,01

η = 200 %

η Ausnutzung  
LF Lastfaktor



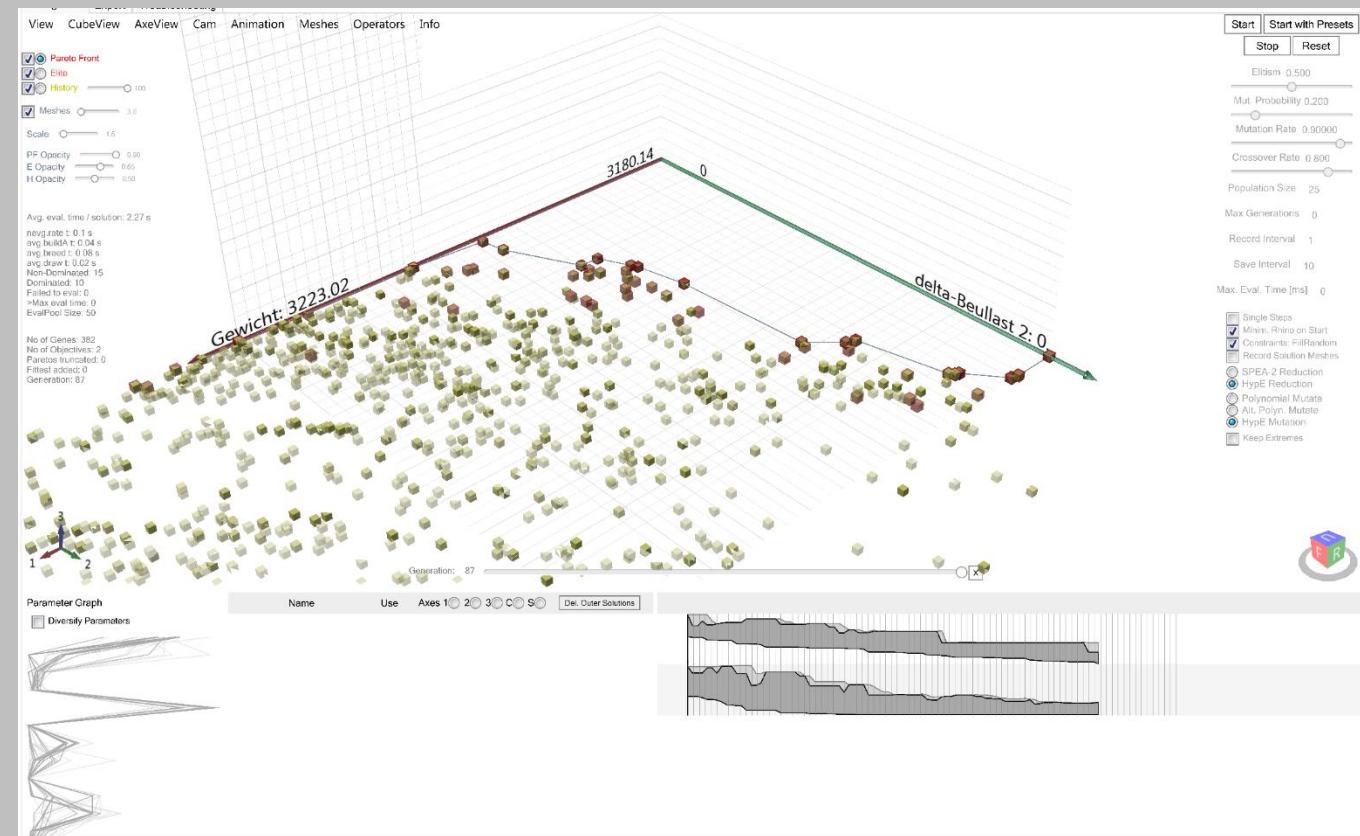
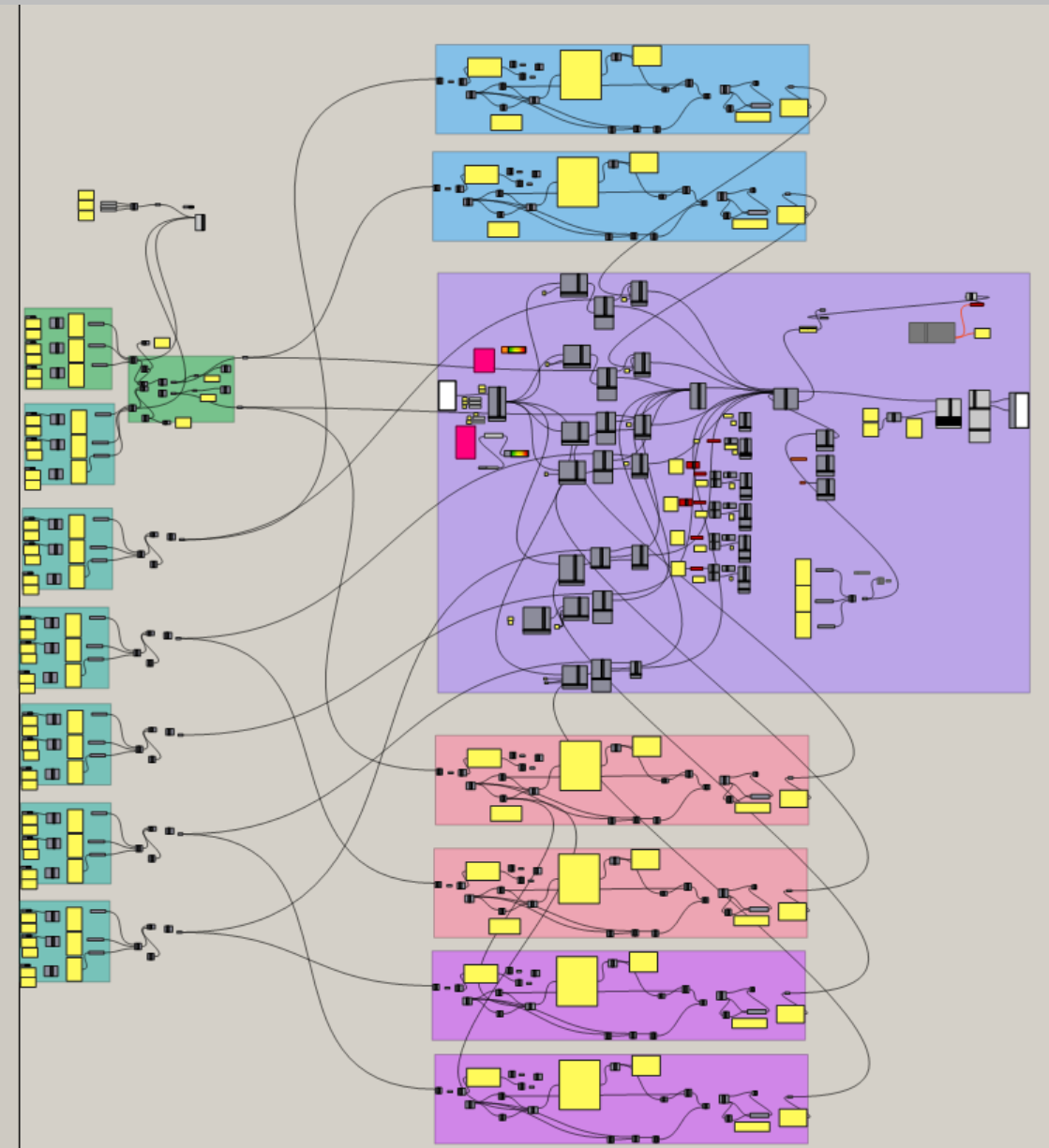




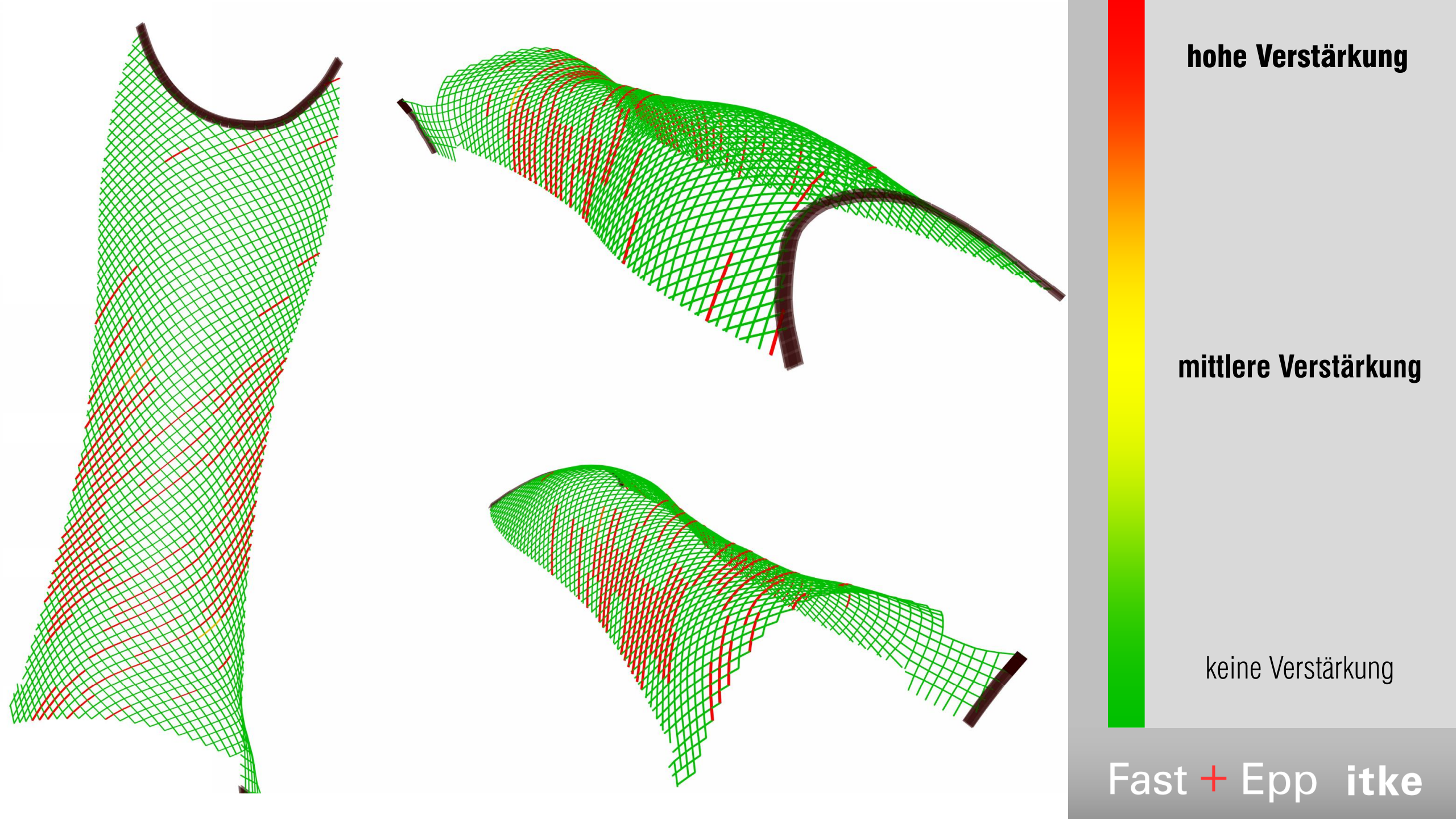
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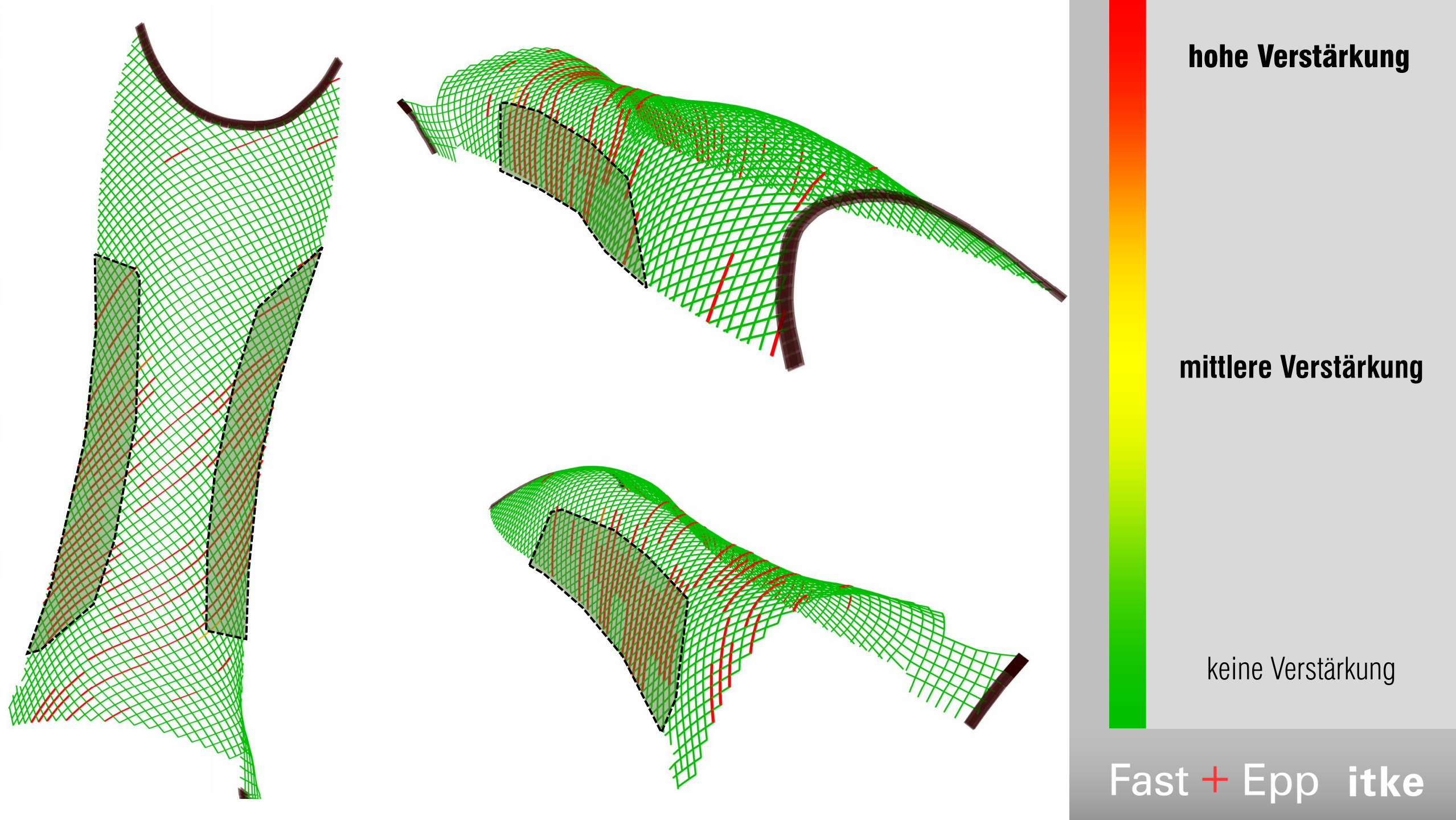
# Vorgehensweise

## Parametrische Berechnung in Grasshopper und Karamba



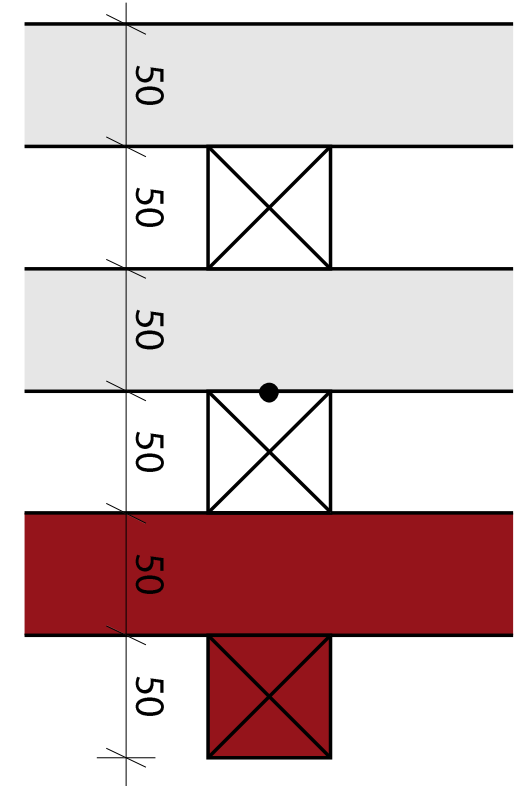
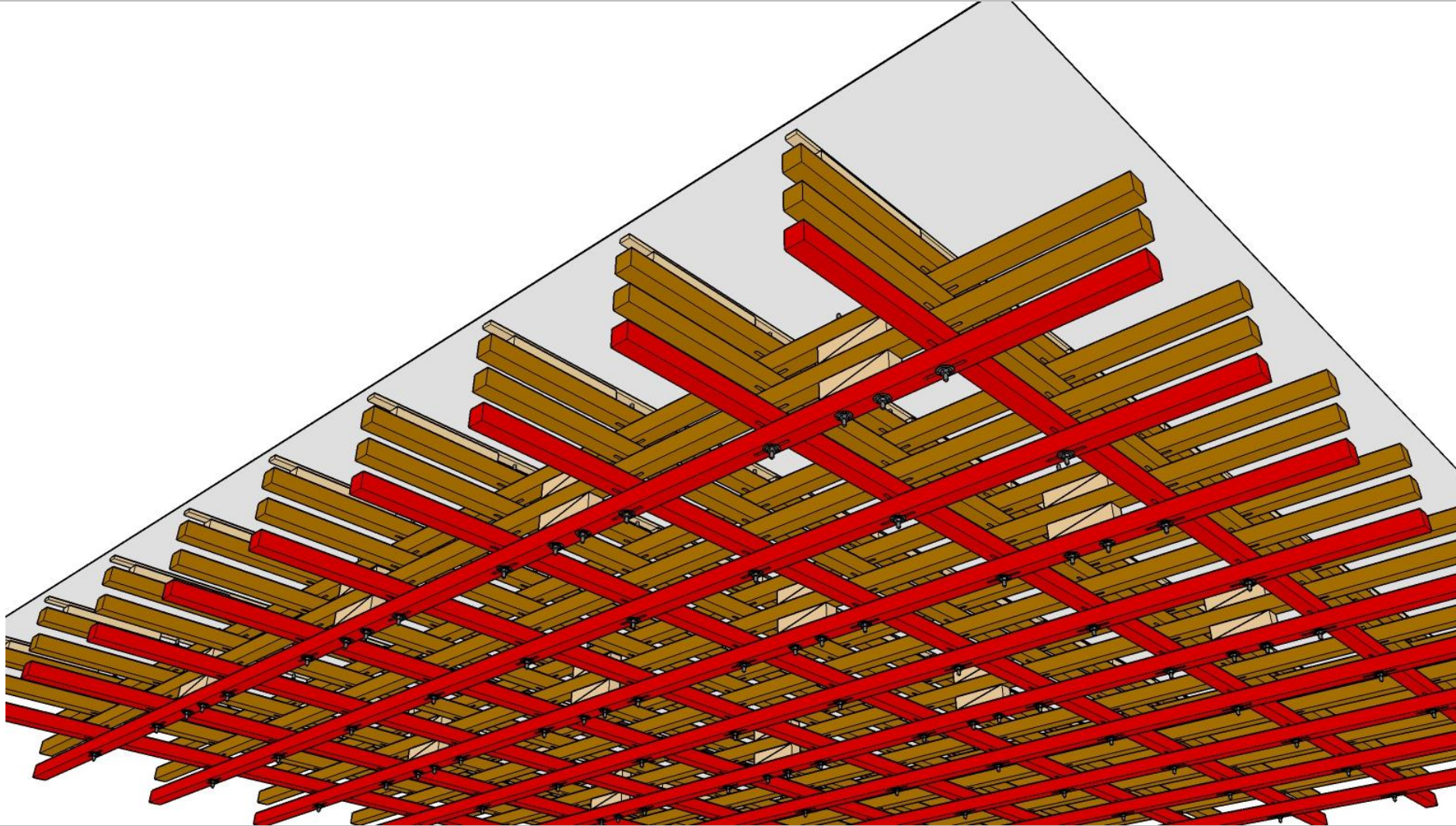
- Variation der Querschnittshöhe für einzelne Lattenabschnitte
- Optimierung des Holzgewichtes und der Beullast mittels Solver (Pareto-Optimierung)





# Variantenfindung

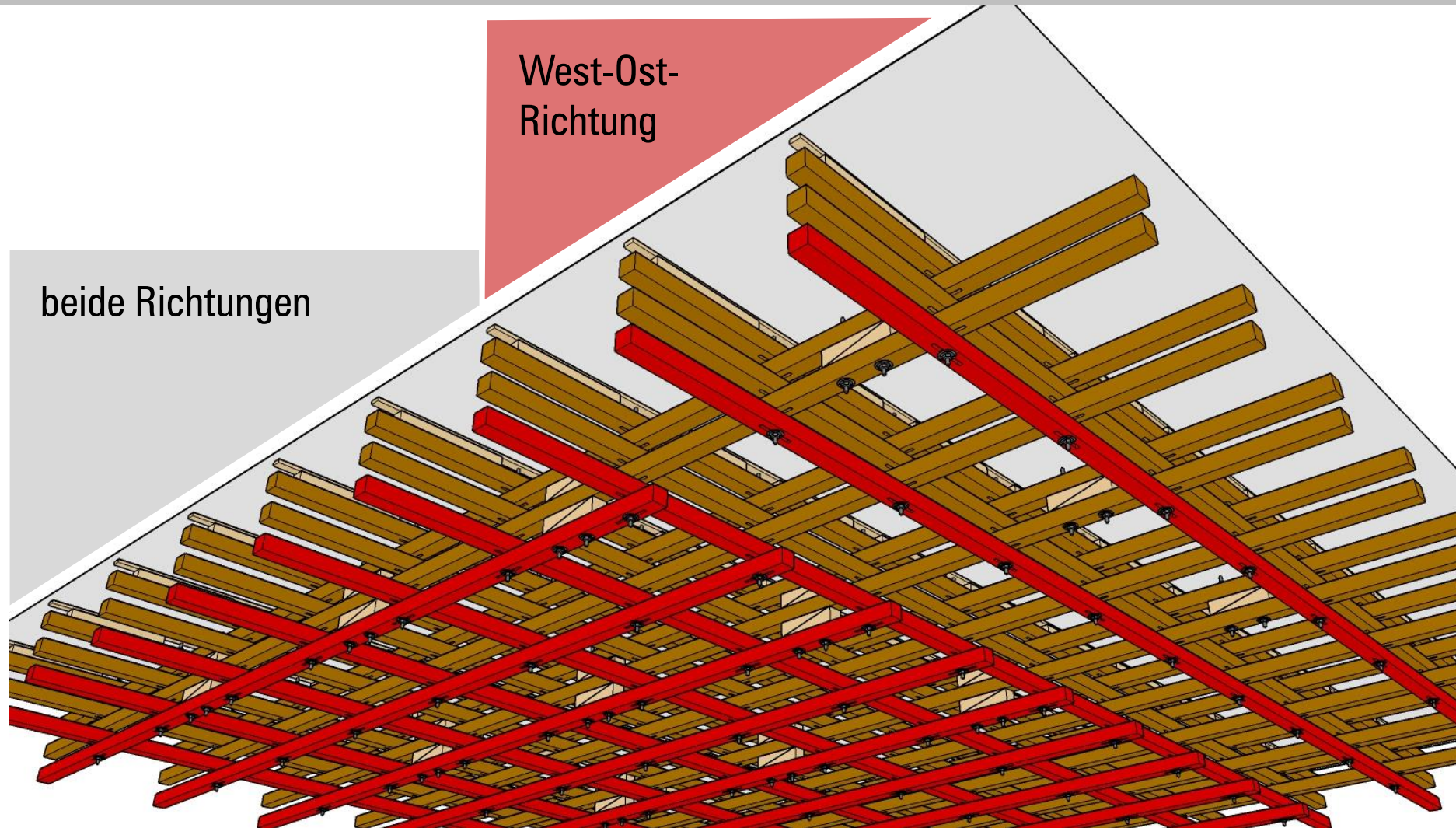
## Doppelgitter, von unten verstärkt



beide Richtungen

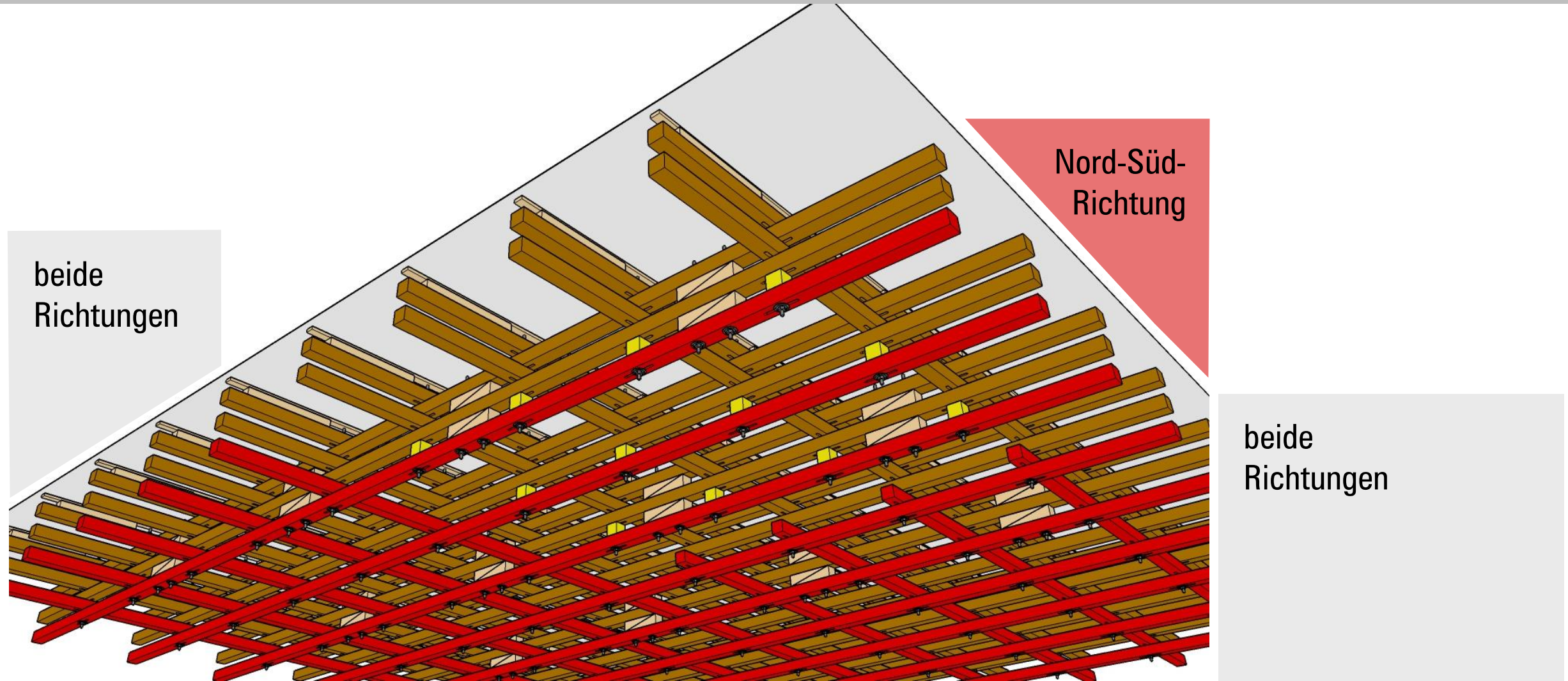
# Variantenfindung

## Doppelgitter, von unten verstärkt



# Variantenfindung

## Doppelgitter, von unten verstärkt





- Instandsetzungsplanung für die größte Holzgitterschalenkonstruktion der Welt von Frei Otto
- Umsetzung bis zur Bundesgartenschau 2023 geplant
- Minimierung durch eine parametrische Optimierungsrechnung
- mehrere Testflächen, Gutachten und Versuche



*Besucherzentrum  
Van Dusen Botanical Garden*

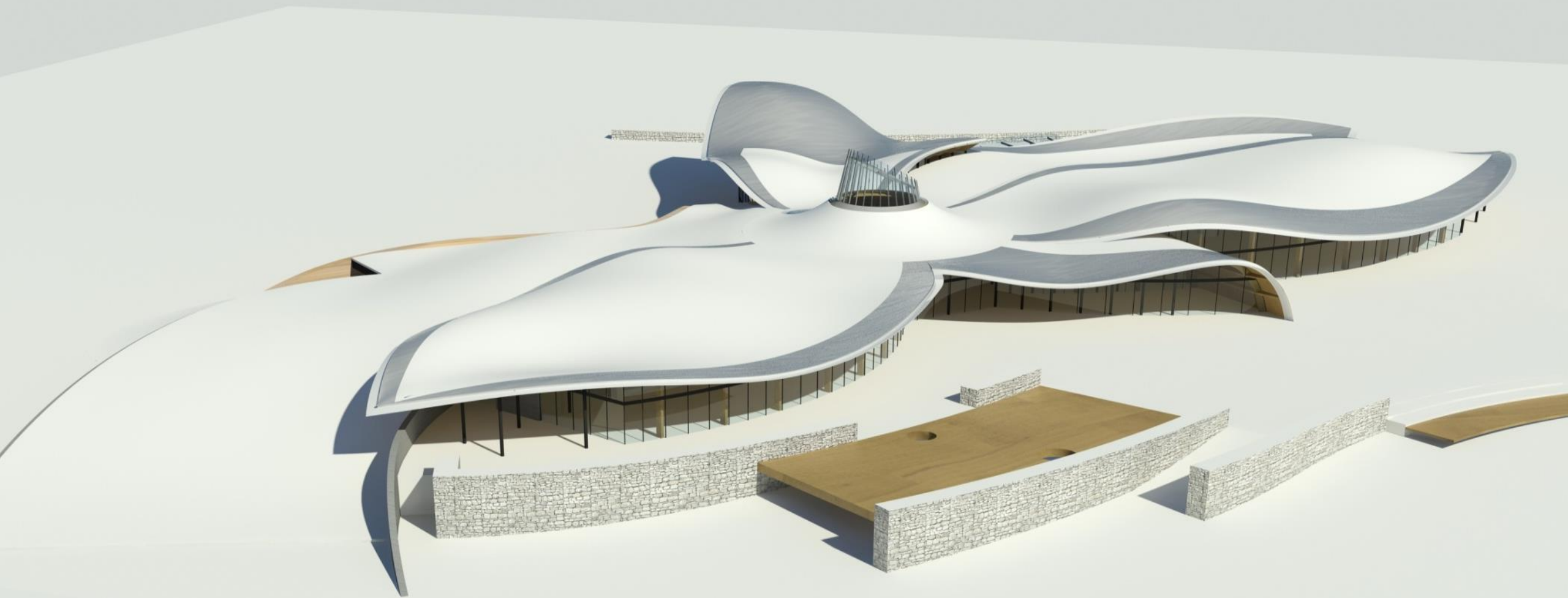
*Vancouver, Kanada | Perkins + Will Canada*

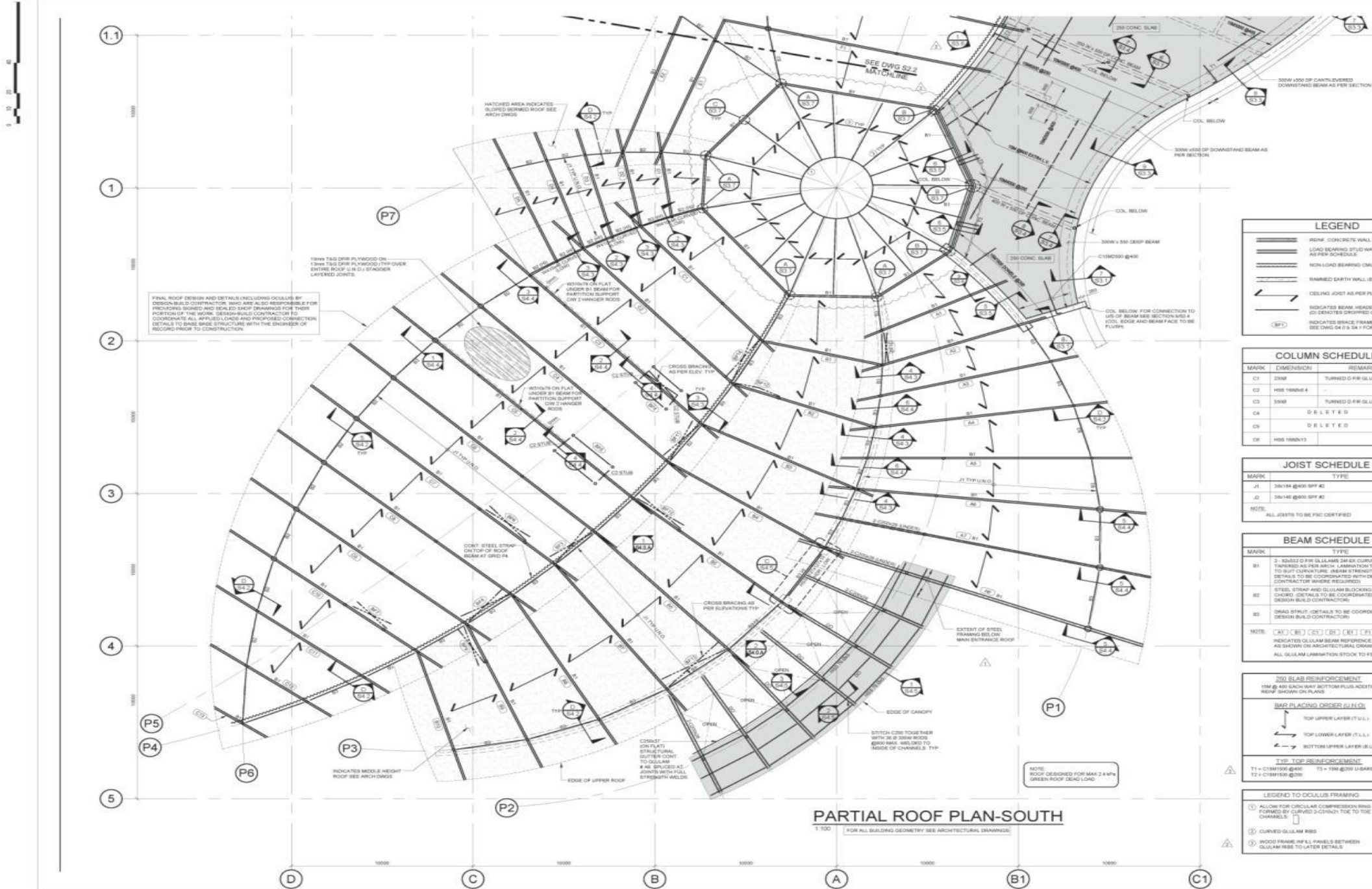


**Hält und sieht gut aus.**

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**PARTIAL ROOF PLAN-SOUTH**  
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**VanDusen Botanical Garden**

**Vancouver Board of Parks and Recreation**

5291 Oak Street  
Vancouver BC V6M 4H1

**CONTRACT DOCUMENTS**

**LEGEND**

|  |   |
|--|---|
|  | WALL, CONCRETE WALL   |
|  | LOAD BEARING STUD WALL                                      |
|  | NON-LOAD BEARING CMU WALL                                   |
|  | RAMMED EARTH WALL (BY OTHERS)                               |
|  | CEILING JOIST AS PER PLANS                                  |
|  | INDICATES BEAM HANGER OR HP JOIST DENOTES DROPPED CONDITION |
|  | INDICATES BRACE FRAME TYPE SEE DWG 04 S & S4-F FOR DETAILS  |

**COLUMN SCHEDULE**

| MARK | DIMENSION    | REMARKS                  |
|------|--------------|--------------------------|
| C1   | 2300         | TURNED 0 FIR GLULAM 16x6 |
| C2   | 1000 1800x4  | -                        |
| C3   | 3300         | TURNED 0 FIR GLULAM 16x6 |
| C4   | -            | DELETED                  |
| C5   | -            | DELETED                  |
| C6   | 1000 1800x13 | -                        |

**JOIST SCHEDULE**

| MARK | TYPE               |
|------|--------------------|
| J1   | 25x100 @900 SPT #2 |
| J2   | 25x140 @900 SPT #2 |

NOTE: ALL JOISTS TO BE FSC CERTIFIED

**BEAM SCHEDULE**

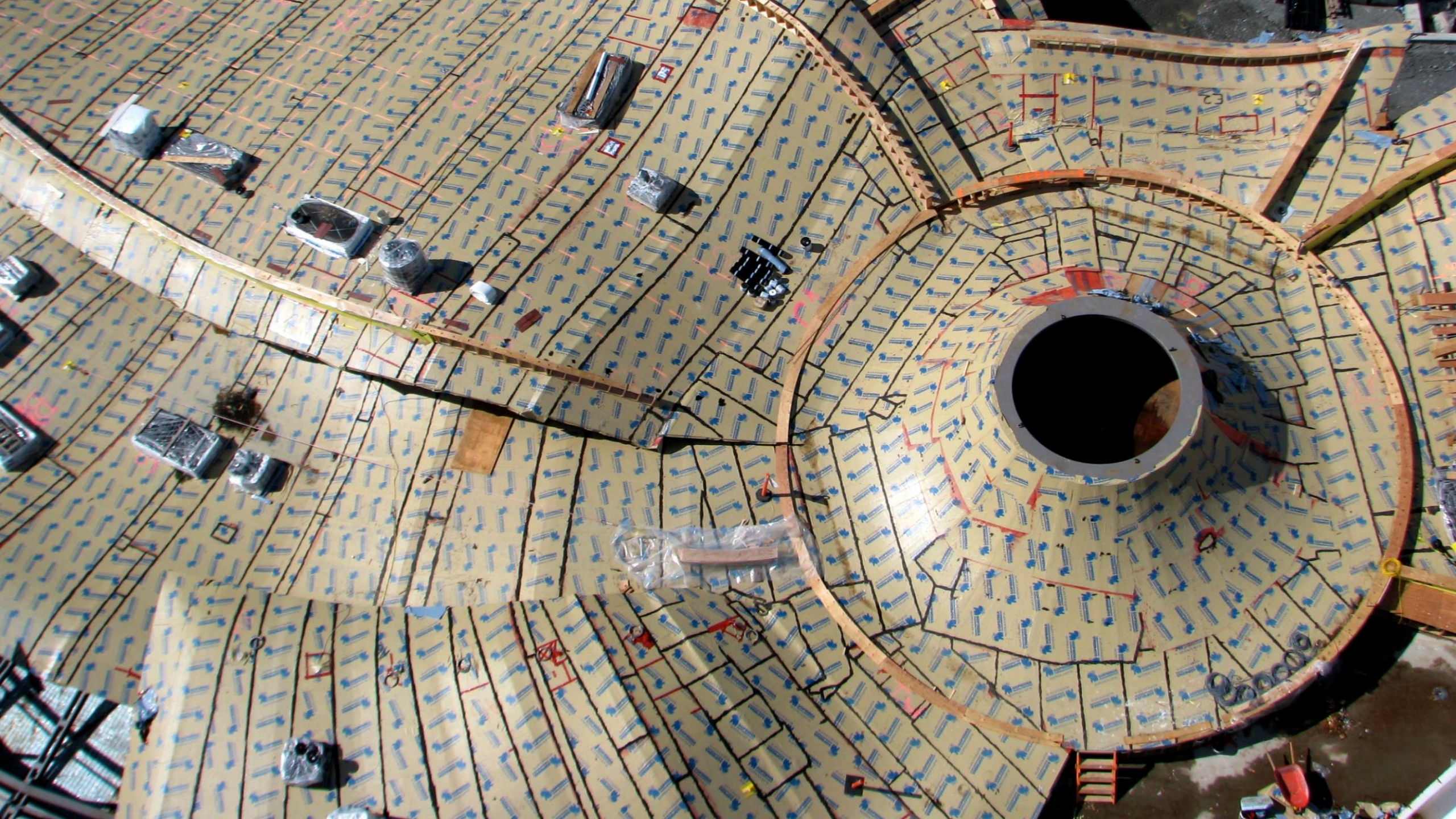
| MARK | TYPE  |
|------|---|
| B1   | 2 - 80x22 0 FIR GLULAM 24x48 CURVED & TURNED AS PER ARCH. LAMINATION THICKNESS TO SUIT CURVATURE (BEAM STRENGTHENING DETAILS TO BE COORDINATED WITH DESIGN BUILT CONTRACTOR WHERE REQUIRED) |
| B2   | STEEL STUD AND GLULAM BLOCKING DIAPHRAGM CHORD (DETAILS TO BE COORDINATED WITH DESIGN BUILT CONTRACTOR)   |
| B3   | SHAG SPRUIT (DETAILS TO BE COORDINATED WITH DESIGN BUILT CONTRACTOR)  |

NOTE: C10, C12, C13, C14, C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C38, C39, C40, C41, C42, C43, C44, C45, C46, C47, C48, C49, C50, C51, C52, C53, C54, C55, C56, C57, C58, C59, C60, C61, C62, C63, C64, C65, C66, C67, C68, C69, C70, C71, C72, C73, C74, C75, C76, C77, C78, C79, C80, C81, C82, C83, C84, C85, C86, C87, C88, C89, C90, C91, C92, C93, C94, C95, C96, C97, C98, C99, C100, C101, C102, C103, C104, C105, C106, C107, C108, C109, C110, C111, C112, C113, C114, C115, C116, C117, C118, C119, C120, C121, C122, C123, C124, C125, C126, C127, C128, C129, C130, C131, C132, C133, C134, C135, C136, C137, C138, C139, C140, C141, C142, C143, C144, C145, C146, C147, C148, C149, C150, C151, C152, C153, C154, C155, C156, C157, C158, C159, C160, C161, C162, C163, C164, C165, C166, C167, C168, C169, C170, C171, C172, C173, C174, C175, C176, C177, C178, C179, C180, C181, C182, C183, C184, C185, C186, C187, C188, C189, C190, 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GASTPROFESSOR DR.-ING. JOCHEN STAHL

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